FINAL

ENVIRONMENTAL STATEMENT

COLORADO RIVER
WATER QUALITY
IMPROVEMENT PROGRAM

VOLUME I

STATEMENT AND APPENDICES

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

United States Department of the Interior
BUREAU OF RECLAMATION
UPPER COLORADO REGIONAL OFFICE
P.O. BOX 11568
SALT LAKE CITY, UTAH 84111

June 1, 1977

IN REPLY REFER TO: 757
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Memorandum

To: All Those on the Attached List

From: ACTING Regional Director, Salt Lake City, Utah

Subject: Transmittal of Final Environmental Statement - Colorado River Water Quality Improvement Program

Enclosed for your information are copies consisting of 2 volumes (Volumes I and II) of the Final Environmental Statement for the Colorado River Water Quality Improvement Program. This statement has been filed with the Council on Environmental Quality.

E. J. Bywater

Enclosures

DEPARTMENT OF THE INTERIOR

DEPARTMENT OF AGRICULTURE

FINAL

ENVIRONMENTAL STATEMENT

COLORADO RIVER

WATER QUALITY

IMPROVEMENT PROGRAM

Prepared by

Bureau of Reclamation (Lead Agency)

and

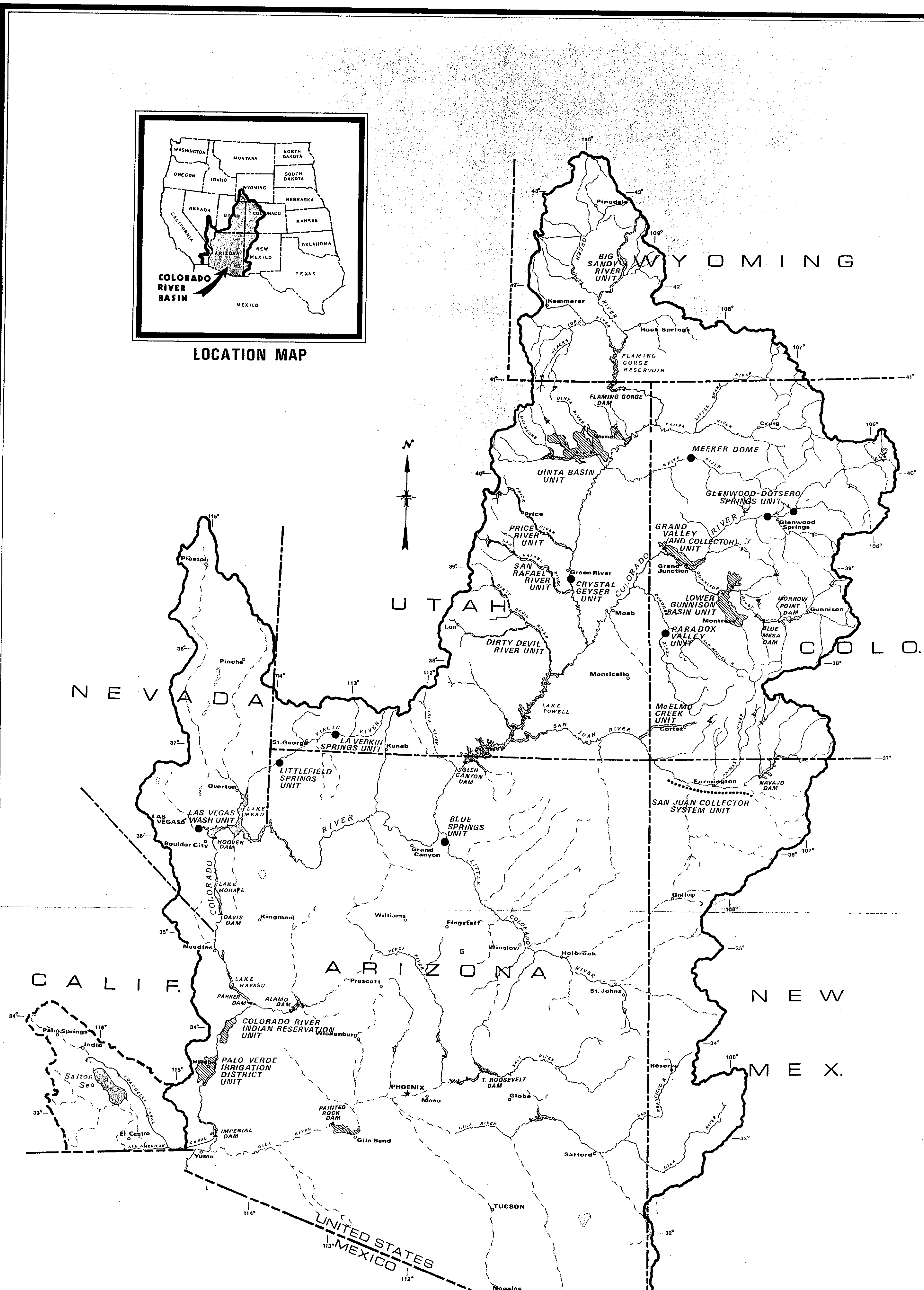
Soil Conservation Service

in support of P.L. 93-320, Title II

Volume I of II

Acting Commissioner, Bureau of Reclamation

Administrator, Soil Conservation Service



UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM

ARIZONA - CALIFORNIA - COLORADO
NEVADA - NEW MEXICO - UTAH - WYOMING

UPPER COLORADO REGION - LOWER COLORADO REGION

MAP NO. 1244-300-61

35 0 35 70 105
SCALE OF MILES

50 0 50 100 150
SCALE OF KILOMETERS

JANUARY 1975
REV. SEPTEMBER 1976

SUMMARY
( ) Draft (X) Final

Department of the Interior, Bureau of Reclamation, Engineering and Research Center (Lead Agency) and the Soil Conservation Service, USDA.

1. Type of Action: (X) Administrative ( ) Legislative

2. Brief description of action: Title II of Public Law 93-320 authorizes the construction of four salinity control units as part of the initial stage of the Colorado River Water Quality Improvement Program. These units include Paradox Valley Unit, Colorado; the Grand Valley Unit, Colorado; the Crystal Geyser Unit, Utah; and the Las Vegas Wash Unit, Nevada. Major structural features of the initial control units involve construction of facilities such as wells, dikes, pipelines, pumps, desalters, and evaporation ponds to collect and dispose of saline water. Nonstructural unit features consist of management assistance to water users for limiting excess water applications to irrigated lands. Title II also authorizes further study and research on other salinity control units for the Colorado River Basin.

This statement presents cumulative impacts of the program and detailed impacts of the Las Vegas Wash and Crystal Geyser Units sufficient to comply with N.E.P.A. requirements. In addition, preliminary information is presented for continuing investigation of other control units, and future detailed environmental statements will be provided as necessary. Program control units and related impacts will affect the Basin States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming as well as the Republic of Mexico

3. Summary of environmental impacts and adverse environmental effects: Implementation of all salinity control units addressed under Title II of P.L. 93-320 will reduce the salinity of the Colorado River at Imperial Dam by about 150 milligrams per liter (mg/ℓ). The cumulative impact of the four initial salinity control units will provide an initial reduction of 43 mg/ℓ. On an annual basis, the estimated reductions amount to 1,589,000 and 460,000 tons of salt removed from the river system for full program implementation and the initial control units, respectively. The beneficial impacts of salinity reduction will be reflected in all the Basin States in improved water quality deliveries to over 1 million acres of irrigated farmland and over 17 million people. Principal adverse effects are modification of about 8,500 acres of range lands, water loss (up to 116,000 acre-feet per year) from the river system, and additional use of energy resources (119 x 10^6 kWh/yr). Existing biota and esthetic values at the project sites will be influenced by construction of evaporation reservoirs and other physical modifications of topography and vegetation resulting from the various control unit features.

4. Alternatives considered:

a. Moratorium on future water resources development in the Basin

b. Retirement of irrigated, agricultural land

c. The alternative of no action

d. Alternative methods of river augmentation

5. List of entities from whom comments have been requested or received:

See attached list.

6. Date made available to CEQ and the public:

Draft Statement: Mar. 5, 1976 (DES 76-9)

Final Statement:

DISTRIBUTION LIST FOR FINAL ENVIRONMENTAL STATEMENT

Listing of Federal, State, Local Agencies, and private entities to whom copies of the Draft Statement have been sent with those responding indicated by "*".

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*The State Historical Society of Colorado, Denver, Colorado
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*Colorado Department of Natural Resources, Denver, Colorado
Director, Colorado Department of Highways, Denver, Colorado
Regional Manager, Colorado Division of Wildlife, Grand Junction, Colorado

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The District 10 Regional Planning Commission, Montrose, Colorado
Agricultural Research Service, Fort Collins, Colorado
Soil Conservation Service, Grand Junction, Colorado.
Regional Engineer, Region VIII, Public Health Service, Department of Health Education and Welfare, Denver, Colorado
*Director, Environmental Protection Agency, Region VIII, Denver, Colorado
*State Director, Bureau of Land Management, Denver, Colorado
U.S. Geological Survey, Rocky Mountain Region, Denver, Colorado
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Trout Unlimited, Denver, Colorado
Audubon Society, Grand Junction, Colorado
Southwest Water Conservancy District, Durango, Colorado
Mr. William Raley, Norwood, Colorado
Colorado Wildlife Federation, Denver, Colorado
Grand Junction Drainage District, Grand Junction, Colorado
Grand Valley Water Users Association, Grand Junction, Colorado
Grand Valley Irrigation Company, Grand Junction, Colorado
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Grand Valley Canal Systems, Inc., Fruita, Colorado
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*State Planning Office, Santa Fe, New Mexico

* Environmental Improvement Agency, Santa Fe, New Mexico
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Interstate Stream Commission, Santa Fe, New Mexico
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San Juan County Council of Governments, Farmington, New Mexico
New Mexico Citizens for Clean Air and Water, Santa Fe, New Mexico
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New Mexico Environmental Institute, Las Cruces, New Mexico
League of Women Voters, Los Alamos, New Mexico
Indians Against Exploitation, Gallup, New Mexico
Sierra Club, National Water Resources Committee, Santa Fe, New Mexico
National Water Resources Committee, Santa Fe, New Mexico
Public Health Service, Shiprock, New Mexico
Bureau of Land Management, Santa Fe, New Mexico
* Bureau of Outdoor Recreation, Albuquerque, New Mexico
U.S. Forest Service, Albuquerque, New Mexico
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Utah Department of Natural Resources, Salt Lake City, Utah
* Utah Department of Development Services, Salt Lake City, Utah
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Utah Division of Parks and Recreation, Salt Lake City, Utah
* Utah Division of Water Resources, Salt Lake City, Utah
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Wyoming State Department of Health, Cheyenne, Wyoming
*Wyoming Recreation Commission, Cheyenne, Wyoming
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*Arizona State Land Department, Phoenix, Arizona
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National Parks Conservation Association, Tucson, Arizona
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Manager, Power Resource Projects, Arizona Public Service Company, Phoenix, Arizona
President, Arizona State Reclamation Association, Phoenix, Arizona
President, Arizona Wildlife Federation, Phoenix, Arizona
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Arizonans for Quality Environment, Tucson, Arizona
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*Soil Conservation Service, Phoenix, Arizona
*Sierra Club, Tucson, Arizona
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Mohave County Board of Supervisors, Kingman, Arizona
Chairman, Office of the Board of Supervisors of Yuma County, Yuma, Arizona
Vice President, The Maricopa Audubon Society, Phoenix, Arizona
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Southern California Association of Governments, Los Angeles, California
Southern California Representative, Sierra Club, Los Angeles, California
President, Sierra Club, San Franciso, California
Friends of the Earth, San Francisco, California
Izaak Walton League of America, Inc., San Pedro, California
*District Engineer, Sacramento District Corps of Engineer, Department of the Army, Sacramento, California
Division Engineer, South Pacific Division Corps of Engineers, Department of the Army, San Francisco, California
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Regional Director, Region IX, Environmental Protection Agency, San Francisco, California
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Regional Director, Bureau of Outdoor Recreation, Pacific Southwest Region, San Francisco, California
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San Diego Gas and Electric Company, San Francisco, Calfornia
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Nevada

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*Las Vegas Wash Development Committee Clark County, Las Vegas, Nevada
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State Clearinghouse, Carson City, Nevada
*Administrator, Division of Colorado River Resources, Las Vegas, Nevada
*Colorado River Basin Salinity Control Forum, Las Vegas, Nevada
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*Planning Coordinator, State Capitol Building, Carson City, Nevada
*Director, Nevada Department of Fish and Game, Reno, Nevada
Regional Supervisor, Nevada Department of Fish and Game, Las Vegas, Nevada
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Planner, Clark County Comprehensive Health Planning Council, District Health Department, Las Vegas, Nevada
Department of Conservation and Natural Resources, Carson City, Nevada
Clark County Board of Supervisors, Clark County Courthouse, Las Vegas, Nevada
Director, Public Information on the Environment, University of Nevada at Las Vegas, Las Vegas, Nevada
Vice President, Nevada Power Company, Las Vegas, Nevada
Executive Director, Clark County Regional Planning Council, County Court House, Las Vegas, Nevada
*Sierra Club, Toivabe Chapter, Las Vegas, Nevada
District Manager, Las Vegas District Office, Bureau of Land Management, Las Vegas, Nevada
Superintendent, Lake Mead National Recreation Area, National Park Service, Boulder City, Nevada
*Clark County Sanitation District No. 1, Las Vegas, Nevada

Other Entities

*Environmental Defense Fund, Denver, Colorado
Executive Director, National Wildlife Federation, Washington, D.C.
President, Wildlife Management Institute, Washington, D.C.
*International Boundary and Water Commission, El Paso, Texas
*Environmental Engineer, Western Gasification Company, Los Angeles, California
*John R. Nicholson, Hemet, California

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DEFINITION OF TERMS

ACRE-FOOT - The volume of water that would cover 1 acre to a depth of 1 foot (325,850 gallons). One acre-foot per day is approximately equal to 0.5 cubic foot per second (ft^3/s).

BRINE - In general, any water containing more total dissolved solids than seawater.

CUBIC FEET PER SECOND - ft^3/s (also cfs) - Standard terminology to express flow rate, interchangeable with acre-foot per unit time (year, month, day). One ft^3/s is equal to approximately 724 acre-feet per year.

CONCENTRATION - TDS - TOTAL DISOLVED SOLIDS - SALT - SALINITY - DISSOLVED MINERALS - All synonymous terms referring to quantity of dissolved mineral salts in solution. Almost all dissolved salts in water may be considered to be salts of three metals; calcium, magnesium, or sodium in combination with nonmetallic constituents such as bicarbonates, sulfates, and chlorides.

CONCENTRATION, UNITS OF - MILLIGRAMS PER LITER (MG/L), PARTS PER MILLION (PPM) - For mildly saline waters, the weight of salts per unit volume of solution (mg/l) corresponds to weight per unit weight of solution (ppm) and is used interchangeably up to about 7,000 mg/l.

CONCENTRATION REDUCTION - In this report, mg/l reduction benefits are reported as time-weighted averages.

CRWQIP - Colorado River Water Quality Improvement Program.

DESALTING PROCESS NOMENCLATURE - Reverse Osmosis (RO), Ion Exchange (IX), Multistage Flash Distillation (MSF), Electrodialysis (ED), Vertical Tube Evaporator (VTE).

DIFFUSE SOURCE CONTROL - Involves salt loading or concentrating effects that are spread over comparatively large areas.

EVAPOTRANSPIRATION - The consumptive use of water from the soil. Water lost as vapor from a given area through the combined processes of evaporation from the soil surface and transpiration from plants plus water stored in plant tissues.

EPILIMNION - The upper, warmer portion of a lake, separated from the hypolimnion (lower layer) by a thermocline (intermediate layer).

HYPOLIMNION - The lower, colder portion of a lake, separated from the epilimnion by a thermocline.

IRRIGATION EFFICIENCY - Refers to ratio of irrigation water actually used in crop evapotranspiration to the amount of water delivered to the farm.

IRRIGATION MANAGEMENT SERVICES (IMS) - A Bureau of Reclamation program established to improve irrigation water efficiency by management techniques applied to irrigation scheduling, timing, and mode of water application.

IRRIGATION RETURN FLOW - Any water diverted for irrigation purposes that finds its way back into a source of supply (surface stream or ground water). This includes bypass water, percolation losses, runoff and seepage.

IRRIGATION SOURCE CONTROL - Involves reductions in the salt loading and concentrating effect caused by dissolution of salts in the soil and substrata and the consumptive use of water.

MONOMICTIC LAKE (WARM) - Warm water lakes which turn over once per year (winter) and where the temperature never falls below 4° C.

ONFARM IRRIGATION SYSTEMS AND MANAGEMENT IMPROVEMENT - A Soil Conservation Service (USDA) program to inventory, evaluate, and implement the structural, cultural, and management practices needed to achieve efficient onfarm irrigation.

PERCOLATION LOSSES - That portion of irrigation water applied to the land that drains below the crop root zone and is not subject to consumptive use by agricultural crops.

POINT SOURCE CONTROL - Involves salt removal from a localized area contributing an inordinately high salt load to the system.

SALT CONCENTRATION - A process that results from the reduction of dilution water which in turn increases the concentration of the remaining dissolved solids in solution.

SALT LOADING OR SALT PICKUP - Terms used to express the amount of salt added to streams from any natural or manmade source.

STRATIFIED LAKE - A lake which has three (sometimes two) layers of water as distinguished by differing water temperatures (see epilimnion, thermocline, hypolimnion).

THERMOCLINE (METALIMNION) - An obvious temperature change between the upper, warm portion of a lake and the lower, colder portion.

WATER SYSTEMS IMPROVEMENT (WSI) - A Bureau of Reclamation program to reduce saline seepage and drainage flows by structural improvements, such as canal lining, to water conveyance systems.

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CHAPTER I

GENERAL DESCRIPTION OF THE PROGRAM

CHAPTER I - GENERAL DESCRIPTION OF THE PROGRAM

A. Introduction

The Colorado River Basin Salinity Control Act of 1974, Public Law 93-320 (88 Stat. 266, June 24, 1974) provides for the construction, operation, and maintenance of certain works in the Colorado River Basin to control the salinity of water delivered to users in the United States and Mexico. Under the Act, the Secretary of the Interior is authorized and directed to proceed with a basinwide program for the enhancement and protection of the quality of Colorado River water. The Act enables the United States to meet the commitments stated in the agreement with Mexico of August 30, 1973 (Minute No. 242) and the Treaty of February 3, 1944.

Title I of the Act, which establishes the Colorado River Basin Salinity Control Project, provides for measures to enable the United States to comply with its obligations under the agreement with Mexico of August 30, 1973, Minute No. 242 of the International Boundary and Water Commission, United States and Mexico. Title II of the Act, which is essentially the Colorado River Water Quality Improvement Program (CRWQIP), provides for programs upstream of Imperial Dam necessary to stabilize the salinity of the Colorado River. (See appendix E.)

Minute No. 242 specifies that the United States shall adopt measures to assure that the water delivered to Mexico at Morelos Dam has an annual average salinity of no more than 115 mg/l plus or minus 30 mg/l greater than the average salinity of the Colorado River waters which arrive at Imperial Dam. A special report on the Colorado River International Salinity Control Project and a draft environmental statement along with the February 1972 report on the Colorado River Water Quality Improvement Program led to the authorization of the Colorado River Basin Salinity Control Project.[1]* A description of those features is contained in the final environmental statement, FES 75/57, dated June 18, 1975.

Construction of well fields for protective and regulatory groundwater pumping was authorized in Title I of the Act for the purpose of utilizing the ground waters underlying lands in the United States to the benefit of the United States' interest. These ground waters in the Yuma, Arizona area exist partly as a result of irrigation on Yuma Mesa and in the Yuma Valley. The supplement to the draft environmental statement on the Colorado River International Salinity

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* Refer to number in Reference Listing Following Chapter VIII.

Control Project was issued August 24, 1974, to provide for the protective and regulatory ground-water pumping. Minute No. 242 does not address itself to the measures required to stabilize the salinity of the Colorado River above Imperial Dam. Therefore, the report on the Colorado River International Salinity Control Project and environmental statements were limited to measures necessary downstream from Imperial Dam.

Title II of the Law provides for the construction, operation, and maintenance of four salinity control units as the initial stage of the CRWQIP, located upstream from Imperial Dam, and are identified as: the Paradox Valley Unit and the Grand Valley Unit in Colorado; the Crystal Geyser Unit, Utah; and the Las Vegas Wash Unit, Nevada. Funds were included in the Public Works Appropriation Act of 1975, for the start of advance planning activities on the four authorized units. Title II of the Law also provides for expediting the feasibility investigations and planning and implementing the other units of the CRWQIP.

The Salinity Control Act requires full coordination, cooperation, and liaison between the Departments of Interior and Agriculture in achieving improved irrigation efficiency through research and demonstrations, implementation of onfarm irrigation system improvements, better irrigation management practices, and other activities that would further the objectives of the Salinity Control Act. As such, the Soil Conservation Service, USDA, participated in the preparation of the final statement with the Bureau of Reclamation as lead agency.

This environmental statement is intended to provide a regional analysis of the basinwide alternatives and cumulative effects of both authorized and proposed salinity control works, measures, and facilities. In addition, two units of the four salinity control units authorized for initial construction under P.L. 93-320, namely Las Vegas Wash and Crystal Geyser Units, are addressed in this statement in a more detailed manner, since construction action is pending. As such, this document will serve as the environmental statement for the Las Vegas Wash Unit since this overall statement contains sufficient detail and analysis of environmental impact of the proposed unit as well as presentation of mitigation concepts, alternate proposals and other pertinent discussion. An environmental assessment of the Crystal Geyser Unit indicates that impacts associated with this unit will be minor and will not have adverse effects on the environment. The Bureau of Reclamation has prepared a Negative Determination of Environmental Impact for this unit (Aug. 6, 1976). Preliminary data and analysis is also presented on other authorized units as well as appraisal-level control plans under the CRWQIP. The other units and appraisal-level plans are discussed in more general terms to allow future decisions to proceed in the public eye before any additional construction is authorized.

Since data collection and planning is still underway on several features, it is proposed to submit individual or supplemental environmental statements or negative determination of environmental impact as more exact information becomes available on major program features except Las Vegas Wash and Crystal Geyser, prior to initiation of any Federal action.

Under Title II, Measures Upstream from Imperial Dam, the following control units are discussed in this statement:

a. The Las Vegas Wash Unit, Nevada, consisting of facilities for collecting and disposing saline ground water of Las Vegas Wash.

b. The Crystal Geyser Unit, Utah, consisting of facilities for collecting and disposing saline geyser discharges.

c. The Paradox Valley Unit, Colorado, consisting of facilities for collection and disposition of saline ground water of Paradox Valley. Wells, pumps, pipelines, solar evaporation ponds, and other necessary associated works may be included.

d. The Grand Valley Unit, Colorado, consisting of measures and works to reduce the seepage of irrigation water and limit excess water applications to irrigated lands.

In addition to these authorized control units, the Secretary is directed to expedite the investigation and planning efforts for the other units described under the CRWQIP.

These additional control units are presently under varying degrees of planning activity and are addressed in this statement according to the amount of data available. All the units under the CRWQIP are located in the following States and counties:

AUTHORIZED FOR CONSTRUCTION

Unit	State	County
Las Vegas Wash	Nevada	Clark
Crystal Geyser	Utah	Grand

Unit	State	County
Paradox Valley	Colorado	Montrose/San Miguel
Grand Valley	Colorado	Mesa

AUTHORIZED FOR FURTHER STUDY

Unit	State	County
LaVerkin Springs	Utah	Washington
Littlefield Springs	Arizona	Mohave
Glenwood-Dotsero Springs	Colorado	Garfield
Palo Verde Irrigation District	California	Imperial/Riverside
Colorado River Indian Reservation	California//Arizona	Imperial/Riverside// Yuma
Uinta Basin	Utah	Duchesne/Uintah
Lower Gunnison Basin	Colorado	Delta/Montrose/Ouray
Big Sandy River	Wyoming	Sweetwater
Price, San Rafael, and Dirty Devil Rivers	Utah	Emery/Carbon/Wayne/ Garfield
McElmo Creek	Colorado//Utah	Montezuma//San Juan

OTHER MEASURES UNDER CONSIDERATION

Unit	State	County
San Juan Collector	New Mexico	San Juan
Grand Valley Collector	Colorado	Mesa
Blue Springs	Arizona	Coconino
Meeker Dome	Colorado	Rio Blanco

Other areas are being studied where significant salt contributions are being added to the Colorado River System. Preliminary investigations would be needed to identify (1) opportunities for improving irrigation efficiency on 330,000 acres to reduce return flows and salt pickup and (2) opportunities for reducing excessive erosion and associated salt load by watershed treatment. Those areas which have a significant impact on salt loading would be selected for additional detailed study.

The direct benefits of measures taken under Title II of P.L. 93-320 will accrue mainly to the Lower Colorado River Basin States of Arizona, California, and Nevada, and to the Republic of Mexico. Potential salinity reduction will result in improved water quality for over 1 million acres of irrigated farmland and will affect over 17 million people, mostly in the lower basin of the river.

The salinity control program area under the CRWQIP is generally located within the 254,000-square-mile drainage area of the Colorado River and its principal tributaries upstream from Imperial Dam to the upper reaches of tributaries in Nevada, Utah, Colorado, New Mexico, and Wyoming. Major control units under the CRWQIP are shown in figure I-1.

This environmental statement for the CRWQIP is submitted in compliance with the National Environmental Policy Act of 1969 (83 Stat. 852, 42 U.S.C. 4321, et seg.), the Council on Environmental Quality Guidelines, Department of the Interior Guidelines, and Bureau of Reclamation revised instructions.

1. Relationships of the Colorado River Water Quality Improvement Program to Other Federal Programs

The Colorado River Water Quality Improvement Program was initiated as a general investigations program by the Bureau of Reclamation in 1971. Most of the control units under the ongoing CRWQIP investigations were either authorized for construction or expedited study by Public Law 93-320. Thus, the all-inclusive CRWQIP, with additional control measures yet to be fully evaluated, is viewed in a supportive role in carrying out the stated intent of P.L. 93-320.

The general goals and objectives governing salinity control in the basin and the CRWQIP have been established by two key pieces of Federal legislation: The Federal Water Pollution Control Act, as amended, P.L. 92-500, and P.L. 93-320.

Public Law 92-500 set forth public policy in terms of a nondegradation policy for water quality, pollution effluent discharge limitations and eventual zero pollution discharge by 1985. In response

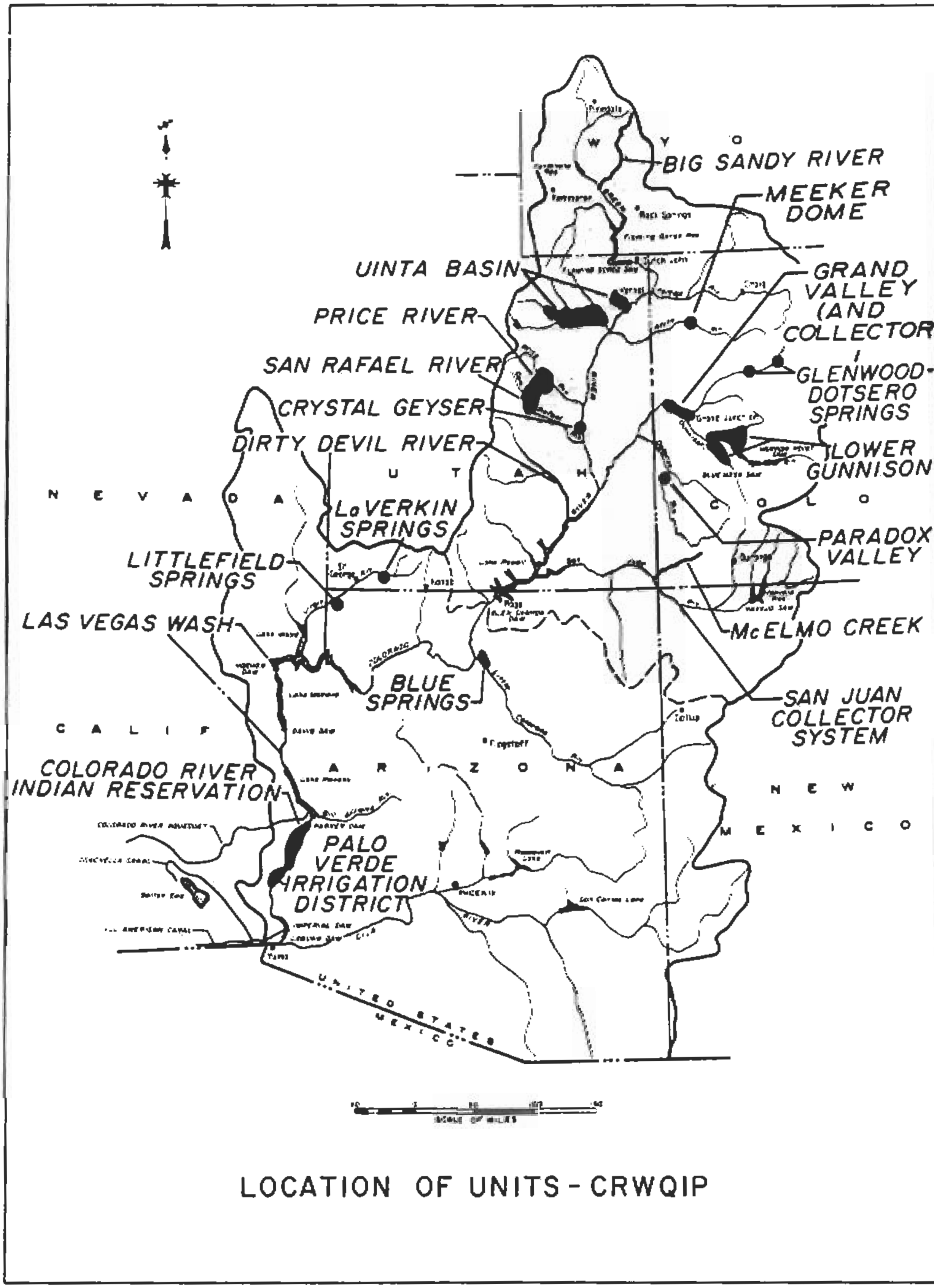

BIG SANDY RIVER
MEEKER DOME
UINTA BASIN
GRAND VALLEY (AND COLLECTOR)
PRICE RIVER
SAN RAFAEL RIVER
GLENWOOD-DOTSERO SPRINGS
CRYSTAL GEYSER
DIRTY DEVIL RIVER
LOWER GUNNISON
NEVADA
UTAH
COLO
LaVERKIN SPRINGS
PARADOX VALLEY
LITTLEFIELD SPRINGS
LAS VEGAS WASH
McELMO CREEK
BLUE SPRINGS
SAN JUAN COLLECTOR SYSTEM
CALIF
ARIZONA
COLORADO RIVER INDIAN RESERVATION
NEW MEXICO
PALO VERDE IRRIGATION DISTRICT
UNITED STATES
MEXICO
LOCATION OF UNITS - CRWQIP

Figure I-1

to this policy and related Federal and State program enforcement guidelines, the CRWQIP has the specific objective of identifying and evaluating control measures that would prevent salinity concentrations from exceeding levels presently found in the lower main stem of the river.

Thus, the two Federal Acts and related programs are compatible in that P.L. 92-500 authorizes water quality standards for receiving waters, while P.L. 93-320 authorizes construction of 4 units and studies of 12 other units that would assist in complying with salinity standards. Moreover, the control units are included as part of the proposal plan of implementation, which along with numeric criteria, make up the standards.

Another important relationship can be identified between the CRWQIP and Federal irrigation development programs, particularly in the Upper Colorado River Basin. It is readily evident that future development and utilization of the Basin water resources for expansion of irrigated agriculture, increases in population, and energy resources development will be accompanied by progressive increases in consumptive uses of water and attendent increases in river salinity. The overall goal of CRWQIP is to maintain Lower Basin water salinity at or below present levels while the Basin States continue to develop its compact-apportioned waters. As such, the Bureau of Reclamation is presently reformulating federally authorized but unconstructed projects within the Colorado River Basin to determine what changes in project features can be made to minimize salinity impacts of those irrigation projects.

There are other Federal and non-Federal programs underway to minimize salinity increases in the river. The Agriculture Research Service, USDA, is conducting research and demonstration projects aimed at improving onfarm irrigation efficiencies and reducing salt loading. Several programs of the Soil Conservation Service, USDA, would help to minimize sediment and associated salt delivered to the Colorado River. For example, the ongoing Soil Conservation Service Conservation Operations Program is providing technical assistance through local soil and water conservation districts for onfarm soil and water resource management systems.

The local soil and water conservation districts are made up of locally elected governing boards. These boards establish objectives and priorities for soil and water conservation, which outlines Soil Conservation Service assistance to landowners, operators, and groups. With the priorities and objectives established, the local soil Conservation Service staff assists individual landowners, operators, or groups to develop a conservation plan that contains: (1) a signed agreement between the landowner or operator and the district board; (2) soils maps with legend and interpretations; (3) a land use and conservation plan map; and (4) farmer's conservation decisions.

For an irrigation farm, the Soil Conservation Service provides engineering and other technical assistance for improvement of irrigation systems and an irrigation system design might be developed. The irrigation system design would vary with the complexity of the system. In simple systems, it may just be shown on the conservation plan map. The more complex systems will usually consist of a plan sheet with topographic features, soils information, existing facilities and structures to be installed, and it usually shows cropping systems. The irrigation system design is developed with the farmer, considering his desires, the alternatives that could be used, and the minimum requirements for a conservation system. In all of this, the farmer's participation is voluntary, but essential.

The Soil Conservation Service also provides techincal assistance to individual landowners and operators, as well as groups, in developing conservation plans and applying resource management systems on private woodlands, rangelands, croplands and wildlife lands. The Department of Agriculture can also provide technical and financial assistance for laterals and group water management systems through: (1) P.L. 83-566, Water Protection and Flood Prevention Act (SCS); (2) Resource Conservation and Development Projects (SCS); and (3) through the Agriculture Conservation Program (ASCS). Accelerated technical assistance for onfarm soil and water resource management systems is also available for P.L. 83-566 and Resource Conservation and Development Project areas.

The Bureau of Land Management (BLM) is studying diffuse salinity sources on lands under BLM control. The Environmental Protection Agency (EPA) in administrating P.L. 92-500, works actively with State programs to regulate saline discharges to the Colorado River Systems. Non-Federal programs include the control of saline effluents from energy development and the use of saline drainage water for powerplant cooling. Many other research programs conducted by the EPA, Agricultural Research Service, Office of Water Research and Technology, State agencies and research institutions are continuing efforts to control salinity from natural and manmade sources with either point or diffuse flow characteristics.

2. Salinity Control and Water Quality Standards

Increases in the salinity levels of western rivers is not a new or unique situation. Water quality problems in the Colorado

River were recognized as early as 1903. Although other rivers such as the Rio Grande and the Arkansas are also affected by increasing salinity levels, the overall impacts on the Colorado River have received the most attention from national and international interests.

The salinity problem in the Colorado River has been the object of several past studies and investigations. Numerous surveys of salinity sources and control measures have been pursued over the years by the U.S. Bureau of Reclamation, U.S. Geological Survey, Environmental Protection Agency and its predecessors, Water Resources Council, Colorado River Board of California, Basin States, and several universities.[2, 3, 4, 5]

In 1972, a joint Federal-State enforcement conference on the matter of pollution of interstate waters of the Colorado River and its tributaries initiated formal efforts to establish an overall salinity control policy for the river. The seven Basin State conferees and Federal agency representatives concluded that such a policy would have as its objective the maintenance of salinity concentrations at or below levels presently found in the lower main stem. The conferees recognized the rights of the States to continue development of their compact-apportioned waters and that temporary rises in salinity might occur until the control program became effective. Under the guidance of the recently established Colorado River Salinity Control Forum, the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming were required to adopt and submit for approval to the Environmental Protection Agency on October 18, 1975:

a. Water quality standards for salinity including numeric criteria for appropriate points in the Colorado River System.

b. A plan to achieve compliance with these standards as expeditiously as practicable providing that:

(1) The plan shall identify Federal and State regulatory authorities and programs necessary to achieve compliance with the plan.

(2) The salinity problem shall be treated as a basinwide problem that needs to be solved to maintain lower main stem salinity at or below 1972 levels while the Basin States continue to develop their compact-apportioned waters.

(3) The goal of the plan shall be to achieve compliance with the adopted standards by July 1, 1983. The date of

compliance with adopted standards shall take into account the necessity for Federal salinity control actions set forth in the plan. Salinity abatement measures within control of the States shall be implemented as soon as practicable.

With primary emphasis on a nondegradation policy, P.L. 92-500 provides for effluent limitations on quantities, rates, or concentrations from point sources by application of the best available control technology. Moreover, the law calls for comprehensive areawide water quality control planning and adequate financing of those facilities necessary to eliminate the discharge of manmade pollutants into navigable water by 1985.

3. Institutional Considerations

The Colorado River is one of the most physically developed and institutionally regulated rivers in the Nation. The CRWQIP is only a part of the basinwide water management program which must take into account not only salinity control but also future water supply and institutional considerations.

The Secretary of the Interior has broad responsibilities under applicable laws regarding the total water resources of the Colorado River Basin in accordance with:

a. The Colorado River Compact of 1922.

b. Commitments to Mexico under the International Water Treaty of 1944 and Minute No. 242 of the International Boundary and Water Commission.

c. The Upper Colorado River Basin Compact of 1948.

d. Requirements of the Supreme Court Decree of 1964.

e. Specific contractual obligations with water users in the United States.

f. Developing and managing water resources as directed by specific authorized legislation and in the public interest.

g. Means of protecting the recreation, fish and wildlife, and environmental values of the river system.

Within the context of these responsibilities and legal requirements, certain considerations are paramount. There will be fluctuations in the concentration of dissolved solids in the river as a result of annual variations in precipitation and the management of the available water resources. Moreover, the total available water resources of the river are allocated by interstate compacts and the international treaty. The treaties and decrees apportioned water quantity but did not directly address water quality considerations. In addition, the Department of the Interior, the Environmental Protection Agency, the Colorado River Board of California, and the Water Resources Council have all projected increases in salinity levels unless control measures are taken concurrently with the continued development of water resources in the basin.

A recognized concern within the CRWQIP is the allocation of the anticipated maximum annual depletion of 116,370 acre-feet. This issue has been an item of intense discussion among the seven Basin States. At the present time, there is no mitigation plan to address this depletion either by river augmentation or allocation. The seven Basin States in conjunction with the Bureau of Reclamation will need to resolve this issue through continuing coordination.

Salinity control actions in the future must be designed to be compatible with all the existing institutional considerations and the so-called "Law of the River."

4. <u>Salinity Impacts</u>

The Colorado River Flows for most of its length through arid and semiarid regions of the United States and Mexico. The great river and its tributaries accumulate the solution products of (1) erosion and weathering, (2) irrigation return flows, (3) municipal and industrial wastes, and (4) various point sources such as springs and wells. From headwaters to mouth, a distance of nearly 1,400 miles, the salinity of the river progressively increases.

The waters of the Colorado River System serve the common daily needs of millions of people in many ways. The river is a vital link in sustaining areas of great esthetic value to the Nation. The water is used for producing energy, providing recreation, sustaining livestock and wildlife, and supporting industry. The river is the source of water for cities within the Basin and larger metropolitan areas outside the Basin. A large variety of crops, providing a needed diversity to the national diet, is irrigated by its waters both within and outside the Basin. But the concentration of dissolved solids in the river, now among the highest of the great rivers of North America, is increasing. The increase will further impair the usefulness of the water.

In the United States, the total damages attributable to salinity in the Colorado River System for 1973 are about $53 million per year. By the year 2000, these damages will amount to $124 million per year if control measures are not applied. These economic impacts are based on recent studies by the Bureau of Reclamation,[6] which estimated total direct and indirect losses of about $230,000 per mg/l (also defined as ppm) increase in salinity at Imperial Dam. The estimates of damage do not include effects below 500 mg/l for municipal and industrial water supplies and 750 mg/l for agricultural use. The damages arise in agriculture from decreased crop yields, increased leaching requirements, increased management costs, and application of various adaptive practices. In the municipal and industrial sector, the detriments arise primarily from increased water treatment costs, accelerated pipe corrosion and appliance wear, increased use of soap and detergents, and decreased potability of drinking water.

5. Costs and Schedule

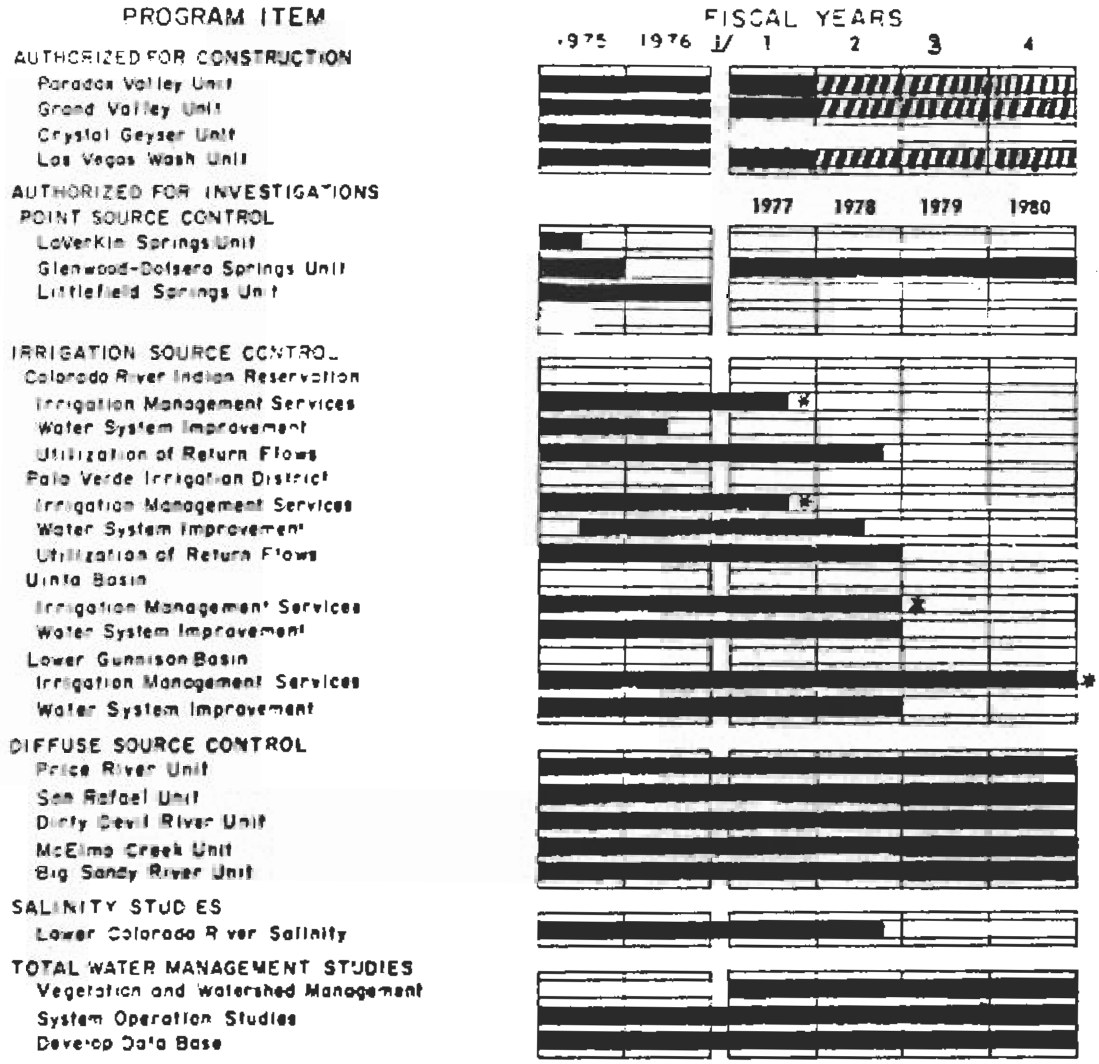
The Authorized expenditure for construction of the four initial salinity control units authorized under P.L. 93-320 is $125,100,000, based on 1973 prices. In recognition of Federal responsibility for the Colorado River as an interstate stream, international comity with Mexico, and policy embodied in the Federal Water Pollution Control Act Amendments of 1972, the authorizing legislation provides that 75 percent of the unit's total costs will be nonreimbursable. The remaining 25 percent of the unit's total costs will be allocated between the Upper Colorado River Basin Fund established by the Colorado River Storage Project Act P.L. 84-485 (70 Stat. 107) and The Lower Colorado River Basin Development Fund established by the Colorado River Basin Project Act P.L. 90-537 (82 Stat. 895). For further details, see appendix E.

Cost allocations for other control units under CRWQIP have not been identified and studies are underway to determine equitable, cost-sharing arrangements.

Initial construction of the four control units specified under Title II of P.L. 93-320 is scheduled after completion of 1976 Advance Planning Studies. Approximately 10 years will be required to complete all four units with the Grand Valley Unit requiring the longest construction time. Figure I-2 shows the proposed construction times and investigation schedules for the more advanced units and studies under the total program. This schedule is coordinated with other Federal agencies.

INVESTIGATION SCHEDULE

COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM



1/ Transition Quarter changing Fiscal Year from beginning July 1, to beginning October 1

▨ under construction

* WATER USER ORGANIZATIONS TAKE OVER PROGRAM OPERATION

Figure I-2

For control of irrigation sources, emphasis is placed on three programs: (1) Onfarm Irrigation Systems and Management Improvement, (2) scheduling irrigation through an Irrigation Management Services (IMS) program, and (3) improved conveyance systems through a Water System Improvement (WSI) program. Therefore, the investigation schedule shown in figure I-2 will ultimately reflect Onfarm Irrigation Systems and Management Improvement and investigations of total watershed area under Irrigation Source Control, and investigations of the irrigated areas under Diffuse Source Control. Investigations and planning activities for salinity control will continue through 1981 at a total expenditure of about $18 million by the Bureau of Reclamation and about $2 million by the Soil Conservation Service.

6. Future Water Resources Development and Water Quality

The overall salinity problem cannot be divorced from planned future development of the Basin's water resources and the resulting water demands that are expected to exceed the river's dependable natural supply by about 1990-95. Thus, the overriding issue of the Colorado River Basin involves the interrelationship between future water depletions and deteriorating water quality. Moreover, the rapid onset of the energy crisis is expected to result in accelerated consumption of Colorado River water to support oil shale development, electric power generation, and coal development and conversion. Subsequent energy development in the basin will directly affect water quality and emphasizes the need for an effective and comprehensive salinity control program.

Salinity control adds another dimension to River Basin planning and resources development and must be viewed in broad context with other programs such as weather modification, geothermal resources, vegetation management, water conservation, and desalting.

The long-term 1941-1972 historic average annual salinity concentration of the Colorado River at its headwaters is less than 50 mg/l. At Imperial Dam, the last major diversion point in the United States, the concentration is 762 mg/l. Modifying this historic condition to reflect all upstream existing projects assumed to be in operation for the full period 1941-1972 would again show a concentration of less than 50 mg/l at headwaters and a value of 847 mg/l at Imperial Dam. Values for selected locations in the river are shown in the following tabulation:

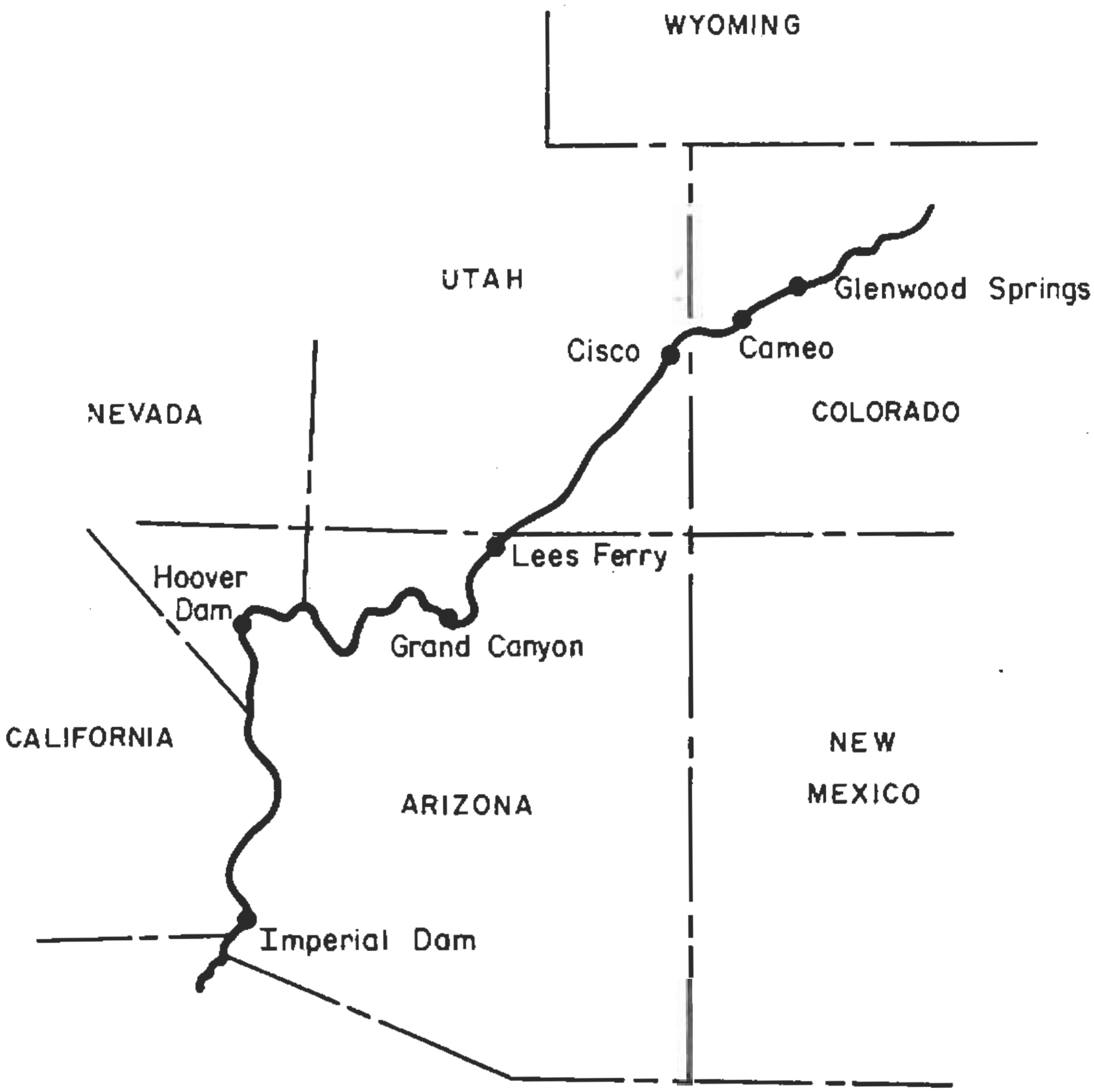
HISTORIC AND PRESENT MODIFIED QUALITY OF WATER
Colorado River - Average Values 1941-1972

Location (see figure I-3)	Concentration (mg/l) Historic	Modified conditions
Glenwood Springs, Colorado	270	301
Cameo, Colorado	405	439
Cisco, Utah	612	659
Lees Ferry, Arizona	558	607
Grand Canyon, Arizona	618	667
Hoover Dam, Arizona-Nevada	693	749
Imperial Dam, Arizona-California	762	847

It should be emphasized that when time intervals are reduced to a monthly basis, wide fluctuations can be expected. Under historic conditions at Imperial Dam, the salinity concentration for January 1957 was 1,000 mg/l and for December 1967, it was 992 mg/l. Six other months in the period 1941-1970 have had average concentrations above 960 mg/l. Moreover, under present conditions of depletion, the mean monthly concentration of 1,000 mg/l at Imperial Dam would have been exceeded in 40 months during the period 1941-70. Such monthly salinity values have greater significance than long-term means in relation to impacts on land and crops, water quality standards, and water treatment.

The salinity in the Colorado River has been the object of long-standing concern and study. Studies by various agencies converge to one simple fact - salinity will increase with continued use and development of the available water supply unless comprehensive, basinwide water quality management planning is implemented and supported by the installation of effective control measures. Projected estimates by various entities are presented in table I-1. These estimates assume that no measures are undertaken to control salinity.

It is significant that the results of studies by the various agencies all predicted that proposed developments will cause a considerable increase in the future salinity of the river. Even under current salinity conditions, many irrigators are resorting to special practices in using the water to grow salt-sensitive crops. Some areas have adverse drainage conditions which would be magnified if higher salinity water were used. Municipal and industrial users are faced with considerable expense due to water quality. Allowing the salinity of the river to increase will result in additional economic impacts.



Historic Quality of Water Sampling Sites
Colorado River System

Figure I-3

Table I-1

PROJECTED CONCENTRATIONS OF TOTAL DISSOLVED SOLIDS
(mg/l) at Imperial Dam
(Average annual values)

Source	Year		
	1980	1990	2000
EPA	1060	1110	1165
CRBC	1070	1200	1340
WRC	1260	1275	1290
USBR	923-938	1118-1174	1154-1214
C14	955	1080	1210

EPA: Environmental Protection Agency, 1972
CRBC: Colorado River Board of California, 1970
WRC: Water Resources Council (Lower Colorado Region Comprehensive Framework Study), 1971
USBR: Bureau of Reclamation, 1977 (range shown for 0 and 2 tons per acre pickup of salts from new lands)
C14: Committee of Fourteen, 1974

The differences in the values reported by the various agencies arise from assumptions made regarding completion dates for water development projects, estimates of the amount of salt loading or concentration effects produced by these projects, the period of analysis used, and estimates of the time involved for the effects to emerge at Imperial Dam.

B. Overview of the Colorado River Water Quality Improvement Program

1. Sources of Salinity

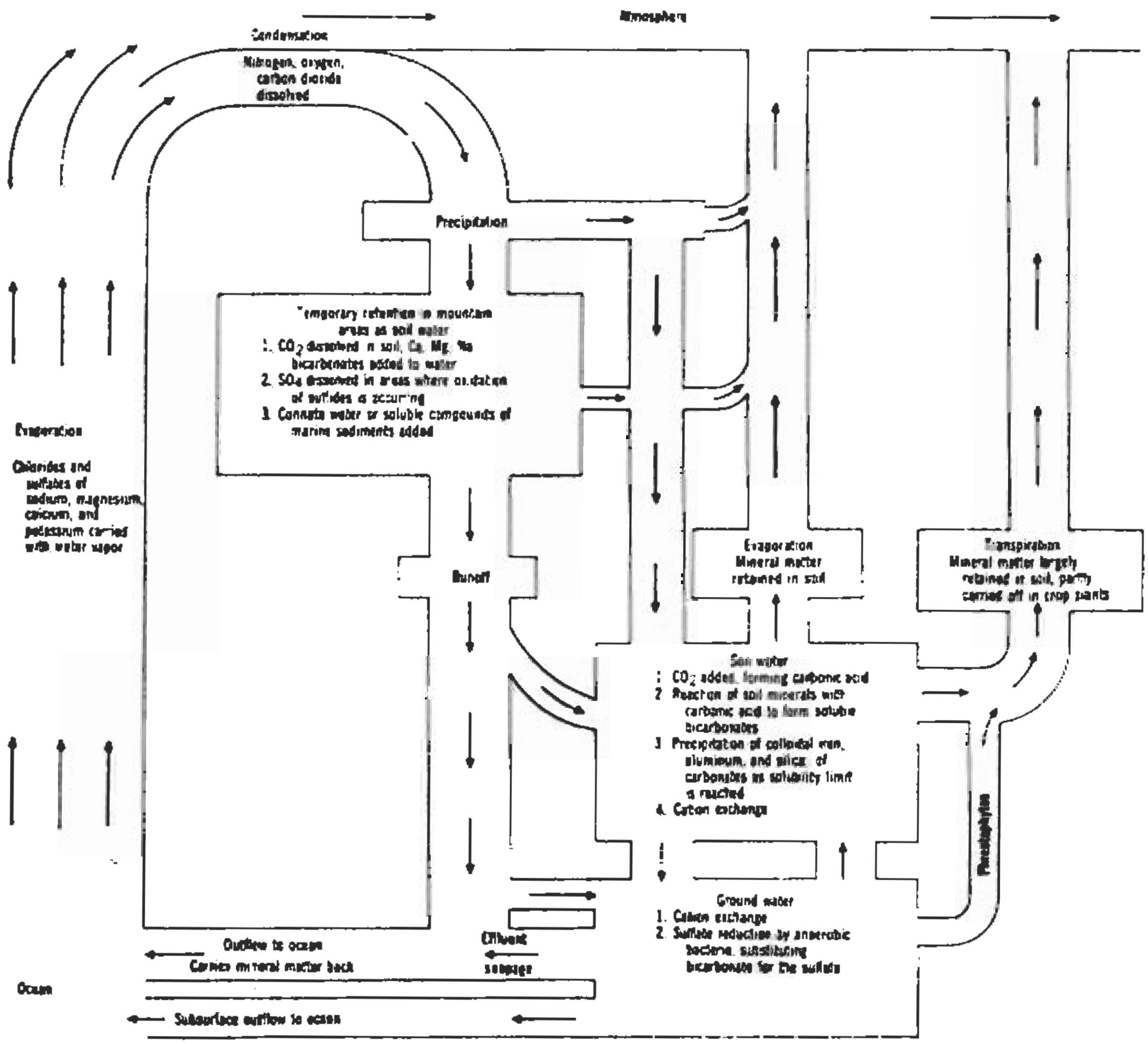
In any river system, salinity concentrations arise from a salt loading effect and a salt concentrating effect. The salt loading may be regarded as the pickup of salt due to mineral weathering and dissolution of the soluble salts residing in soil and substrata. The salt concentrating is due to the evapotranspiration of the water carrying a finite salt load or the export of high quality water out of the Basin. Generally, the application of irrigation water results in increased salt concentrations because of both loading and concentrating. The evaporated or transpired water is free of salt; hence, the ground-water return flows carry the total salt burden. Under some conditions, however, salts may be precipitated and stored in the soil. These processes operate through the geochemical cycle depicted in figure I-4. As water is evaporated from the ocean or other free water surfaces, alterations in the composition and concentration of the dissolved constituents begin to occur and continue as the concentration progressively increases during movement through the cycle.

While this process adds a large variety of dissolved matter to the water, only 10 elements make up about 99 percent of the dissolved constituents. These are hydrogen, sodium, magnesium, potassium, calcium, silicon, chlorine, oxygen, carbon, and sulfur. The elements occur in solution as various ions, molecules, or radicals. The major part of the dissolved constituents in Colorado River water is made up of the cations: calcium, magnesium, and sodium; and the anions: sulfate, chloride, and bicarbonate. These, plus minor amounts of other dissolved constituents, are commonly referred to as salinity, salt, dissolved solids, or dissolved mineral content.

Studies of the operation of the geochemical cycle suggest that the salinity concentration in the waters of the Colorado River can be distributed as shown in figure I-5. This figure [2] represents the entire 254,000-square-mile drainage of the Colorado River in the United States. An additional 2,000 square miles are in Mexico. The basin includes parts of seven states - southwestern Wyoming, western Colorado, parts of Utah, Nevada, New Mexico, nearly all of Arizona, and a small section of California. From this area, the Colorado River carries a salinity burden that has historically averaged about 10 million tons annually. The Environmental Protection Agency has estimated that irrigated agriculture in the upper basin contributes about 37 percent of the average salt load of the upper basin and appears to offer significant potential for salinity control.

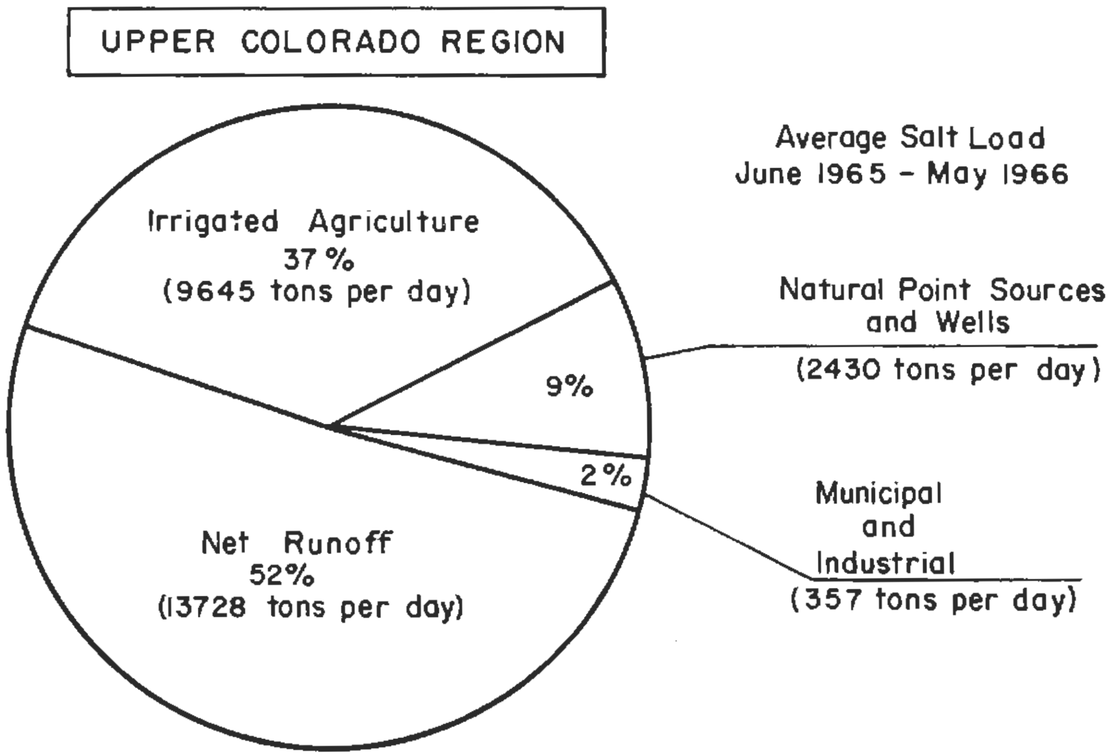
2. Economic Detriments

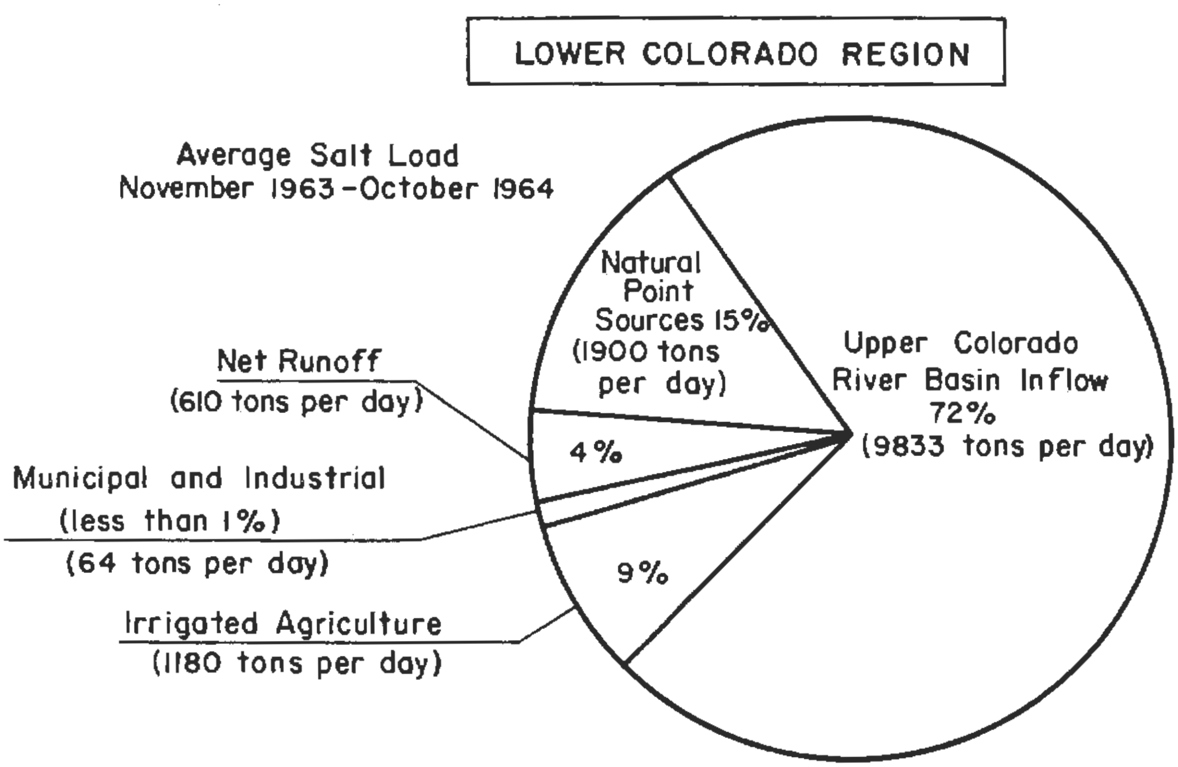
Economic detriments can be computed using the projected increases in salinity assuming that a control program would not be installed. The adverse effects would be expressed primarily in the agricultural, municipal, and industrial uses with respect to projected salinity



Geochemical cycle of surface and ground waters.

Figure I-4





Representative Distribution of Salinity Concentrations in the Colorado River Basin

Figure I-5

increases. Little or no adverse economic impacts on instream uses such as recreation, hydroelectric power generation, and propagation of aquatic life would be expected from projected increases.

The detriments in agriculture would arise from one or a combination of the following: decreased crop yields, increased leaching requirements, increased management costs, and application of various adaptive practices such as changes in crop patterns, improved drainage systems, and plantings on sloping beds. In the municipal and industrial uses, the detriments arise primarily from increased water treatment costs, accelerated pipe corrosion and appliance wear, increased use of soap and detergents, and decreased palatability of drinking water.

Based on the foregoing kinds of impacts, the damages now being experienced and those contemplated if no salinity control measures were installed have been determined and the findings are presented in the tabulation below. These figures are the relevant damages, i.e., those caused by salinity levels in excess of threshold values. The damages are based on the range of salinity increases shown in table I-1. The threshold values used for M&I and agriculture are 500 mg/l for M&I as recommended by the U.S. Public Health Service,* and an arbitrary figure of 750 mg/l which represents the point at which deleterious effects to agriculture can begin to be measured.

Range of Damages Attributable on an Annual Basis
To Salinity in the Colorado River System

Year	Low	High
1980	74,524,200	103,658,000
1990	99,070,000	133,480,000
2000	122,468,800	165,236,000

The damages reflect the impact on the entire regional economy. Damages to water users in Mexico and recreation and fishing users in the Salton Sea have not been estimated.

Applying present worth factors at 6-1/8 percent to the values from the tabulation above indicates the economic magnitude of the salinity problem on the Colorado River. The present value of future damages through the year 2000 range from about $1 billion to $1.5 billion.

* "Drinking Water Standards," U.S. Dept. of Health, Education and Welfare, Public Health Service, Publication No. 956, 1962.

3. Program Investigations

The 10-year investigation entitled "Colorado River Water Quality Improvement Program" was initiated in 1971 with the specific objective of identifying measures that would maintain salinity concentrations at or below levels presently found in the lower main stem.

The investigation schedule is shown in figure I-2. The investigations are integrated with other programs involving weather modification, geothermal resources, and desalting. Concurrent feasibility investigations are underway on various irrigation, point, and diffuse sources. The feasibility of collecting saline return flows and converting them to beneficial consumptive use within the Basin is also being studied. Related basinwide studies are scheduled to consider relationships among individual control units, assess implications of new technology, and provide guidance to the selection of implementation measures. Cost-sharing and repayment formulas are also under study.

The measures currently available for controlling salinity may be categorized as follows:

a. Point source control involves salt removal from a localized area contributing an inordinately high salt load to the system.

Point sources are generally springs, wells, geysers, or mine drainages. Several control techniques are available, including desalting, diversion and evaporation, diversion for special use, plugging of wells, and deep-well injection.

b. Diffuse source control involves land treatment, collection and desalting, collection and special use, watershed management, and phreatophyte control. Basic data are limited for some of these techniques, so, only tentative plans are available for controlling salinity from these sources. However, there are a number of Federal programs that can be used to reduce soil erosion, sedimentation, and the associated salt load. These include technical cost-sharing and credit assistance programs of the Department of Agriculture for individual landowners, operators, or groups. These programs are being carried out cooperatively with state and local organizations such as soil and water conservation districts through the efforts of landowners and operators. The Bureau of Indian Affairs provides similar assistance for tribal lands. Erosion and sediment control measures are also part of multipurpose water and land resource projects of the Corps of Engineers, Bureau of Reclamation, and the Soil Conservation Service, and multiple land use plans of the U.S. Forest Service and Bureau of Land Management.

c. <u>Irrigation source control</u> involves reductions in the salt loading and concentrating effect caused by dissolution of salts in the soil and substrata and the consumptive use of water. The techniques applicable to irrigation source control are onfarm irrigation systems and water management, improved water conveyance systems, ground-water management, and return flow management.

Beginning in FY 1974, increased emphasis was placed upon such measures as improving irrigation efficiencies, improving management of the river and water conveyance systems, utilizing saline flows, managing Federal lands for salinity control, reformulating the plans for water resource developments to minimize slat loading, examining salt precipitation phenomena in large reservoirs, and reducing evapotranspiration through treatment and management of vegetation. Some of the measures, such as improving irrigation efficiencies, are being conducted directly within the CRWQIP, while others, such as the research on salt precipitation phenomena in reservoirs and the utilization of saline flows, are being implemented by state or private entities.

Major program emphasis for control of irrigation sources is placed on the Onfarm Irrigation Systems and Management Improvement program, scheduling irrigation through an IMS program, and improved control of waterflow in canals, laterals, and drainage systems through a WSI program.

For efficient salinity control to be effective over a wide range of local conditions, the Improved Onfarm Irrigation Systems and Management Improvement, the IMS, and WSI programs must be considered under an integrated program. It is difficult to separate the relative effects of each program. Consequently, the three programs are considered as operating together for field evaluation and feasibility studies. Closely related to the programs are structural features to collect and store irrigation return flows of degraded quality for energy development.

The Onfarm Irrigation Systems and Management Improvement program includes inventorying, evaluating, and implementing the structural, cultural, and management practices needed to achieve efficient irrigation and reduce salt loading.

Suitable methods of irrigation will be selected based on the characteristics of the soils, topography, and crops to be grown. Structural needs for onfarm water measurement, conveyance, and control will be determined to achieve efficient water delivery to each field. Field water delivery will be based on flow rates and application times required for the site, the method of irrigation, and the depth of water to be applied. Field dimensions are determined consistent with soils, topography, method of irrigation, and property boundaries. The needs for land forming or leveling are assessed. The need for and location of subsurface and surface drainage facilities will be examined. Major benefits derived from the Onfarm Irrigation Systems and Management Improvement program would include increased crop yields, reduced water application, reduced deep percolation and seepage looses into underlying stratas and saline aquifers, reduced leaching, and a smaller pollutant load in the return flows of salts, nitrogen, phosphorous compounds, pesticide, and oxygens consuming organic compounds.

The IMS program is a nonstructural management technique for improving irrigation water efficiency and reducing salt loading through proper timing of irrigation and recommendations as to depth of water to be applied each irrigation. This is a demonstration type program based on the concept that the water user will take over and operate the program. Under provisions of P.L. 92-500, this practice is expected to spread to other irrigated areas in the Basin. Major benefits derived from IMS irrigation scheduling could include increased crop yields, water savings, reduced leaching of salts, and reduced drainage requirements.

The WSI program includes structural water management features for improving water delivery and conveyance, thus reducing seepage looses and saline drainage water. The lining of canals and laterals would result in decreased deep percolation looses, thus reducing water contact with highly saline soils, shales, and saline ground waters.

Concurrently, the effect of these programs can be expected to increase the salinity concentration in a lesser volume of return flows; however, the total salt loading will be reduced.

Considerable salinity research has been stimulated by the CRWQIP. This research is providing inputs to the program but is being funded through other sources. The Western Directors of the Agricultural Experiment Stations have established a regional research project entitled "Salinity Management in the Colorado River Basin." This will involve cooperation with the U.S. Department of Agriculture. The research is aimed at developing and evaluating methods for understanding and managing salinity from agricultural and diffuse natural sources in the Colorado River Basin.

In addition, the Office of Water Research and Technology (OWRT) is also sponsoring a regional research project on salinity. Through OWRT, several State Water Resources Research Institutes are investigating the economic aspects of salinity control. The research is directed toward evaluating damages caused by salinity. The Bureau of Reclamation is participating and cooperating in the research effort.

4. Present Status of Investigations

At the initiation of the CRWQI Program, previous studies [1],[2], [3],[4] of the Environmental Protection Agency, Colorado River Board of California, and the Bureau of Reclamation were reviewed to select areas for early study. These included Paradox Valley, Colorado; Grand Valley, Colorado; Crystal Geyser, Utah; Las Vegas Wash, Nevada; and LaVerkin Springs, Utah. Currently, investigations on these units are either completed, nearing completion, or are highly advanced. From these advanced studies, four control units were selected for initial construction under Title II of P.L. 93-320.

Feasibility investigations are nearing completion on LaVerkin Springs. Definite plan reports are scheduled to be completed in FY 77 for the Las Vegas Wash Unit, Crystal Geyser Unit, Paradox Valley Unit, and Grand Valley Systems Improvement Unit.

The estimated reduction in salt content of the Colorado River, by constructing the four initial units, should approach 460,000 tons per year with a corresponding decrease in salinity concentration at Imperial Dam of 43.6 mg/l. Table I-2 contains a summary of the potential effects, estimated costs, and estimated benefits that can be expected for each of the units. The annual benefits have been calculated on the basis of $230,000 per mg/l salinity improvement at Imperial Dam. Estimated interest costs during construction are available and are reflected in the Total Annual Equivalent Cost for all units.

The other continuing investigations under the CRWQIP are not enough advanced to yield comparable data to the authorized construction units. Under P.L. 93-320, the Secretary of the Interior is authorized and directed to expedite completion of the remaining 12 planning reports and submit each report named

Table I-2

AUTHORIZED SALINITY CONTROL UNITS - COLORADO RIVER BASIN

Project units	Year in operation	Impact at Imperial Dam (mg/l)	Estimated construction cost ($)	Investment cost[1] (CC + IDC) ($)	Annual OM&R ($)	Annual equivalent value at 5-5/8 discount rate ($)	Annual[2] benefits ($)
Crystal Geyser Utah	1978	-0.3	2,690,000 (July 1975)	2,841,000	20,000	234,000	69,000
Paradox Valley Colorado	1982	-16.0	21,100,000 (Oct. 1975)	23,275,000	451,000	1,765,000	3,680,000
Grand Valley[4] (WSI) Colorado	1978-1987	19.0	81,700,000 (Oct. 1975)	104,378,000	370,000	6,766,000	4,370,000
Las Vegas Wash, Nev. (First stage)	1982	-4.0	-	-	-	-	-
(total project)	2000	-8.0	56,556,000 (July 1976)	63,963,000	5,028,000	3,674,000[3]	1,840,000

[1] Construction cost plus interest during construction.
[2] Using total benefits of $230,000 per mg/l improvements at Imperial Dam as set forth in the January 1974 status report (Colorado River Water Quality Improvement Program). This report is the total impact of salinity at $230,000 per mg/l per year with a reasonable range of $194,000 to $395,000 per mg/l per year. Studies by a consortium of five western water research institutes and the Bureau of Reclamation is nearing completion. This should narrow the range with perhaps a shift toward the higher value.
[3] Computed with 30-year deferment on second stage at 6-1/8 percent.
[4] The Soil Conservation Service is developing an Onfarm Irrigation Systems and Management program that will be implemented concurrently with the Bureau of Reclamations IMS and WSI programs. The construction cost estimated in Feb. 1973, for the onfarm systems improvement is $30 million. The impact at Imperial Dam is a 14-mg/l reduction.

below promptly to the Colorado River Basin States and other appropriate parties for review and comment: It should be noted that other control units such as the San Juan Collector System are not specifically identified under P.L. 93-320, but are under active investigation under the CRWQIP.

Other salt source areas which have a significant salt contribution are being investigated to determine the need for additional detailed study. These seven areas involve an irrigated cropland base of 330,000 acres and a significant watershed area.

a. Point Source control: (see B.3.a. for category definition)

LaVerkin Springs
Littlefield Springs
Glenwood-Dotsero Springs

b. Irrigation Source control: (see B.3.c. for catetory definition)

Lower Gunnison
Uinta Basin
Colorado River Indian Reservation
Palo Verde Irrigation District

c. Diffuse Source control: (see B.3.b. for category definition)

Price River
San Rafael River
Dirty Devil River
McElmo Creek
Big Sandy River

Implementation of all 16 salinity control units outlined herein are anticipated to reduce the salinity of the Colorado River by about 150 mg/1 at Imperial Dam. The following tabulation shows the cumulative salt removal effects for each general program category.

Cumulative CRWQIP Salt Removal Effects

Removed by	Tons	mg/1
Initial Units	460,000	43.6
Point Sources	258,100	27.0
Irrigation Sources	430,000	40.0
Diffuse Sources	380,000	34.0
Total	1,528,100	144.6

This total does not include Blue Springs, as investigations have been terminated, due to serious environmental and cultural (Indian) impacts, which removes from consideration about 400,000 tons of salt and a 26-mg/l effect at Imperial Dam. Also not included in the total is the potential impact of SCS onfarm improvements which, when integrated with IMS improvements in Grand Valley, will provide an estimated 14 mg/l reduction at Imperial Dam. Other units such as the San Juan and Grand Valley return flow collector systems and Meeker Dome are not included at this time.

C. Total Water Management

The longtime average salt burden of the Colorado River at Hoover Dam has been about 10 million tons. However, the average over the past 15 years has been 8 million tons at Hoover Dam and 7 million tons at Imperial Dam. If the salinity is to be kept at or below present levels in the lower main stem, as recommended by the 1972 EPA Enforcement Conference[4], then about 2.5 million tons will need to be removed from the system each year. This may be regarded as a statement of the physical objective of a salinity control plan. However, control of the point, diffuse, and irrigation sources under program study would only provide a maximum reduction of about 1.6 million tons annually. This level represents a concentration reduction of about 150 mg/l at Imperial Dam under conditions of development anticipated by about the year 1990.

The adoption of numeric salinity criteria as proposed by the Basin States under P.L. 92-500 requirements and EPA regulations will provide even more specific program objectives. The Seven-State Colorado River Basin Salinity Control Forum has proposed the following flow-weighted average annual numeric salinity criteria for three locations in the lower main stem of the River system as follows:

	Salinity in mg/l
Below Hoover Dam	723
Below Parker Dam	747
Imperial Dam	879

A general plan of implementation includes control units under the CRWQIP as well as other additional Federal and non-Federal projects and measures to maintain the flow-weighted average annual salinity in the lower main stem at or below the recommended numeric criteria through 1990. Under varying assumptions of hydrologic conditions, future water depletions, and full implementation of needed salinity control measures, the Forum has concluded that the average salinity can be maintained at or below 1972 levels during the next 15-year period.

Obviously, additional control efforts will be needed to meet the program goals suggested from earlier enforcement efforts and the proposed numeric salinity criteria.

A salinity control program should be regarded as one facet of a comprehensive plan for management of the total water resources of the Colorado River Basin. Total water management may offer the best way to plan and control the interrelated structures and the nonstructural measures to optimize the use and development of the water resources for the good of the people. Under such management, the effects of salinity would be controlled at levels suitable for the many uses to which the water is placed. A program to accomplish this objective would entail evaluation and selection of the salinity control measures that best fit within the total water management concept. The basic concept underlying total water management involves:

- Integrating water resources management and land use planning,
- Planning and controlling of interrelated structures and physical features,
- Examining and evaluating the existing systems, institutions, and legal requirements,
- Displaying alternative plans to examine quality and quantity impacts within a river basin, and
- Deriving efficient operational and management modes for the river system.

Under this approach, more planning effort, in particular, will be placed on the evaluation of existing systems, institutions and legal frameworks to determine whether operations and facilities could or should be modified to achieve better management in light of new goals and values.

The specific areas in salinity control representing the broad spectrum of the total water management concept include:

1. Mathematical Models of the River System

Due to the complexity of the physical, legal, and operational relationships within the Colorado River Basin, a computerized model was needed to mathematically describe the behavior and improve the understanding of such a large water resource system. Through the use of such models, the physical features and processes can be adequately defined by mathematical formulas which simulate the control and flow of water through the Basin.

Three mathematical river models have been developed by the Bureau of Reclamation. The first is identified as the "Colorado River salt routing model" which uses simplified tributary inflow assumptions and permits early evaluation of the salinity impacts resulting from water developments and salinity control works. It essentially provided direction for the development of the more encompassing and complex model known as "Colorado River simulation model (CRSM)." This second model includes data analysis capability along with simulation and specific operating criteria. It is a highly sophisticated representation of the Colorado River System and is set up to analyze impacts of changes in operating criteria, effects of future developments, augmentation and other influences on the flow, including stochastic hydrology, and salinity control measures. When all parameters of the Basin are analyzed, dissolved solids are routed through all reaches and reservoirs, and are monitored for the time structure of the flow and quality at 17 gaging stations in the Colorado River Basin. The third program is known as the "Colorado River Storage Project." This model was developed primarily to incorporate detailed operating criteria and was later expanded to account for development schedule variations and water quality.

Other models such as the simulation model "CORSIM" developed by the Colorado River Water Conservation District are used by local agencies for planning purposes.

Computerized models not only aid in determining the most effective measures for salinity control, but also provide a monitoring tool for continued evaluation of completed projects.

2. Institutional and Legal Analysis

Present water laws encourage overirrigation, particularly by those having seniority, to protect the priority of their rights. These laws are inflexible and tend to discourage systems improvements, improved management, and efficient use of water.

Efforts are being made to analyze the existing and potential institutional and legal means available to control the various sources of pollution, intrabasin transfer, desalting, and water management and irrigation practices.

It is expected that the studies will result in conclusions and recommendations related to existing legislation, water-use practices, and contractual arrangements. The most efficient use of Colorado River water may require a basinwide plan of operation with strict controls on diversion and use, corrective measures provided at critical points in the system, economic incentives to encourage efficient water use, and equitable means of financing the quality enhancement program.

3. Economic Evaluation of Water Quality

Current research is intended to complement the parameters established by EPA. Existing input-output models are being improved through the use of optimization procedures, and linear programing, which internally selects the best acreage, crops, and irrigation practices in response to salinity changes. The data generated will be used to derive damage functions to be attached to the Colorado River simulation model. It will then be possible to more accurately ascertain the economic impact of various management alternatives, salinity control schemes, water resource development projects, selected future conditions, and other cultural practice modifications.

4. Desalting Processes

Current technology has made several commercial processes available for use in the treatment of saline water such as reverse osmosis, electrodialysis, and ion exchange. Process selection depends upon the quality of the saline water, volume, and the major economic factors of energy costs and brine disposal.

One alternative to controlling the salinity in the Colorado River would be to desalt the water at the points of diversion. For irrigation purposes, this would involve large desalting plants. For other M&I purposes, smaller capacity plants might be utilized. Such a program could tailor the quality of water to meet user specifications. In some diversion cases, the desired salinity concentration might involve a reduction of only 200 to 400 mg/l but also pose desalting plant capacities of 500 to 2,000 million gallons per day. Ion exchange is a desalting method that shows promise in this range of application.

In a cooperative effort with the Office of Water Research and Technology, a preliminary study on the feasibility of applying ion exchange technology was completed in 1972. The study indicated that there is a possibility of achieving large-scale river quality control at the 500-mg/l level. Product water recovery could be expected to range between 89 and 95 percent.

The study was supported by a 6-week ion exchange desalting pilot plant operation on the Colorado River below Davis Dam. The 5,000-gallon-per-day plant successfully operated on 750 mg/l water to yield a product water of 500 mg/l. Several resins and process configurations were examined. For the various processes, recommended regenerate chemicals are sulfuric acid and ammonia.

These chemicals are the most important single cost element in the economic structure of the entire process. It is conceivable that these costs could be reduced considerably by using industrial waste products from new energy development facilities and other sources within the basin.

Considerable problems can be foreseen for applying ion exchange processes on a very large scale. Therefore, in the future, attention will be directed toward developing desalting plant designs with increased capacity to treat the major diversions anticipated in future years.

5. Irrigation Efficiency Studies

Water losses can be reduced by improving farm irrigation efficiencies and minimizing losses from conveyance systems. Minimizing losses from conveyance systems is a straightforward matter of economics and operating efficiency. Available technology includes systems completely enclosed in pipes, lined channels of various materials, or the use of chemical sealants. Maximizing irrigation efficiencies is a much more difficult matter encompassing complex soil-water-plant relationships, farm economics, and individual preferences. Elimination or reduction of water loss must be accomplished in a manner and under conditions that will assure sustained productivity. To increase present average onfarm irrigation efficiencies of 30 to 40 percent to 60 to 70 percent will require capital investments of $300 or more per acre. In addition, the program will require substantial Federal incentives, increased engineering and technical assistance, research and demonstration of new technology, education and information programs, and acceptance of the program by nearly all the irrigators.

An agreement was executed on April 24, 1973, between the Bureau of Reclamation Department of the Interior, and the Agricultural Research Service (ARS), Department of Agriculture, to conduct research on irrigation application rates in relation to salinity output, from lands in the Grand Valley, Mesa County, Colorado. The reserach program will continue to June 30, 1977, at an estimated total cost of $1,294,000. The Bureau of Reclamation agreed to fund a total of $584,000 of the program, and the ARS the remaining $710,000.

Research in cooperation with the Agricultural Research Service is aimed at evaluating the potential of increasing irrigation efficiency through use of high-frequency, low-volume irrigation sprinkler applications and advance gravity application methods and relating the results of these applications to the salinity output from the irrigated areas. This will involve quantitative studies of the mineral weathering and salt precipitation as a function of irrigation management on the soils of the Grand Valley area. The research will also attempt to determine procedures needed for predicting mineral weathering and salt precipitation for representative soils and waters in other locations of the Colorado River Basin.

Preliminary review of the experimental procedure by Bureau and ARS personnel resulted in agreement to conduct additional priority investigations to: (1) locate major gaps in the knowledge of salt return flow processes in Grand Valley, and (2) determine the volumes of water entering the ground-water system as deep percolation from fields irrigated under prevailing methods. Other studies will be undertaken to estimate rates of flow and salt concentration of water exchanged between ground-water bodies and open drainages and to determine whether aquifer characteristics are amenable to pumping sufficient saline water from them so as to intercept a significant amount of water now flowing to the Colorado River.

At the time of this publication, part of this research has been completed. In the spring of 1973, ARS leased a 42-acre field near Fruita, Colorado, for studies of soil salinity under high-frequency, uniform sprinkler irrigations, and comparable studies of furrow irrigation. A center-pivot sprinkler system, modified to apply three different leaching fractions, and instrumentation to measure soil salinity, soil moisture levels, water applications, and deep percolation amounts were installed soon after. A farm ditch was modified to allow use of gated pipe to supply irrigation water to the furrowed section of the field. Salinity sensors and runoff flumes were also used on the furrow study area. A precision weighing lysimeter was installed on one of the sprinkled plots.

In the fall of 1973, six vacuum extractors were installed under furrow plots, allowing direct measurement of deep percolation. Also, in the spring of 1974, a plastic pipeline was installed to serve the furrow irrigated portion of the study area.

Subsequent to 1973, additional extractors have been installed and maintained, seepage measurements taken along the Government Highline canal, surface and ground-water samples taken and analyzed, water table observation wells maintained, salt washes mapped by infrared equipment, several lysimeters installed, flow measuring devices installed, and geological investigations made. Monitoring of all the equipment is being continued. Anual progress reports of the investigations are submitted to the Bureau of Reclamation and semi-annual reports to the EPA.

A number of other research programs and activities which have a direct bearing on the WSI and IMS programs are being conducted in the valley. Included are research on automated systems by the Colorado Water Conservation Board, cost sharing of conservation practices by the Agricultural Stabilization and Conservation Service, and technical assistance to farmers by the SCS. The SCS is making a diligent effort in contacting the individual farm units for participation in the IMS program and for collecting information on present farm efficiencies as well as potential efficiencies. The SCS supplies technical assistance to various farm units in the control of sediments and salts, as well as information on water conservation through proper irrigation practices and maintenance of facilities. The Agricultural Engineering Department, Colorado State University (CSU), is also conducting salinity research for the EPA. The Department is currently monitoring the salinity of the water before and after its use for irrigation.

The Colorado Water Conservation Board's research on automated systems includes a pilot demonstration project for automated irrigation systems in the valley. The primary objective is to test various modern onfarm irrigation systems and develop those showing the most promise for use in this area. The systems include an automated border irrigation system, an automated pump-back system and drip irrigation systems.

USDA activities and programs provide technical assistance to farmers for accomplishing onfarm irrigation systems and management improvements and improving watershed conditions to reduce erosion.

Since the middle 1930's, the Soil Conservation Service has been assisting landowners in controlling soil erosion and managing their water resources. This assistance includes conservation planning and application of conservation practices, including irrigation practices to improve onfarm irrigation efficiencies. In recent years, onfarm irrigation improvements have been emphasized as an important method of reducing salt contribution to the river from irrigated land. The Agricultural Stabilization and Conservation Service in cooperation with SCS has been involved in cost sharing of conservation practices such as ditch lining, pipelines, land leveling, drainage, and water control structures.

6. Systems Operations Studies

Systems operations studies are scheduled for the lower Colorado River. These studies will seek to develop improved management procedures that will permit operation of the reservoirs in such a manner as to improve overall water quality. These studies will use mathematical simulation models to evaluate the reaction of water quality in the reservoirs and the river to changes in operation criteria. The models will simulate the storage of water provided by Lakes Mead, Mohave, and Havasu, and the Senator Wash Reservoir and the transport of water and dissolved salts in the river sections connecting these reservoirs. Potential revisions in operation procedures that will be tested include shifting storage between reservoirs and increasing reservoir releases for the dilution of return flows during the low-flow periods.

7. Reservoir Water Quality Studies

The Lake Powell Research Project (LPRP), officially entitled "Collaborative Research on Assessment of Man's Activities in the Lake Powell Region," is being conducted by a consortium of academic institutions under the sponsorship of the Research Applied to National Needs (RANN) program of the National Science Foundation. The Project formally came into existence in 1971. The Bureau of Reclamation has cooperated with the Project by exchanging data, assisting in field work, and providing limited financial support for those subprojects that have direct application to operational programs of the reservoir. The LPRP consists of 16 subprojects covering a wide range of disciplines, four of which deal with some aspect of Lake Powell water quality. These are: (1) Cultural Eutrophication, (2) Heavy Metals, (3) Geochemistry, and (4) Physical Limnology.

The goals of the Cultural Eutrophication subproject are to develop indices of euthrphication, measures of primary productivity, and to understand the impact of man on reservoir aquatic ecology. Lake water samples are being analyzed to determine parameters for measuring phytoplankton, zooplankton, biomass, rate of carbon fixation, and coliform and other intestinal bacteria. The investigators have tentatively concluded that Lake Powell is "mildly" eutrophic.

The general goal of the Heavy Metals subproject is to establish baseline levels of concentration for certain cations in a variety of kinds of material of the aquatic ecosystem including water, soils, sediments, plants, and fish. The analysis program includes iron, calcium, lead, copper, zinc, chromium, magnesium, cadmium, and mercury.

The Geochemistry subproject is directed toward (1) examining the time-dependent distribution of chemical elements in the lake and (2) quantifying the ions added to the lake by solution and/or chemical precipitation. Activities have included: (1) sampling and analyzing main channel and bay waters, (2) recent implementation of the sampling program to include input and output waters of the lake system, (3) development of a hypsometric computer model of the lake, and (4) laboratory studies of calcium carbonate precipitation in Lake Powell water samples.

Field and laboratory studies of Lake Powell by the Project investigators suggest that precipitation of calcium carbonate is the most quantitatively important chemical process that alters water quality as a result of impoundment. The principal investigators estimate that the total reduction of salinity in the lake due to this process could reach a level of 7 to 8 percent at full reservoir capacity.

The goals of the Physical Limnology subproject are: (1) to find and understand the chemical and physical matrix provided by the lake and its subsequent effect on water quality and biological potential, and (2) to provide baseline data on circulation and currents within the lake as it approaches full volume. Samples are being obtained to determine the synoptic distribution of temperature, conductivity (salinity), oxygen, chemistry, and turbidity.

8. Vegetation and Watershed Management

A program has been developed with Arizona State University to determine the effect of phreatophyte removal upon wildlife populations with emphasis upon selective clearing and vegetation management. The effect of phreatophyte removal on wildlife populations will be studied using different clearing patterns along with vegetation management techniques, including revegetation, partial defoliation, and suppression of existing vegetation. The study program is being conducted along the 281-mile reach of the Colorado River from Davis Dam to the international boundary, and is designed to establish a record of existing conditions and to determine the changes of wildlife occupants and use following the vegetation manipulation practices. The studies will provide the following information:

a. Plant species composition and density along with obtaining phenological data in climax and successional communities,

b. Macro and microclimatic conditions in addition to the physical and chemical characteristics of the soil in both climax and successional communities,

c. The relative density and productivity of birds, mammals, reptiles, and amphibians throughout the year,

d. What types of habitat modifications are beneficail or detrimental to the various forms of wildlife utilizing the plant communities, and

e. Data to construct models so that confident predictions can be made regarding: (1) species composition and density of wildlife utilizing various plant communities, (2) what wildlife changes will occur with controlled modifications of the plant communities, and (3) what effects present and future land-use patterns may have on species composition and population densities.

Approximately 1,700 acres of Colorado River flood plain below Laguna Dam north of Yuma, Arizona, are being periodically mowed with an 84-inch rotary mower to suppress saltcedar, mesquite, willows, and arrowweed. About 150 acres in the flood plain are being periodically sprayed with herbicides. Emergent weeds must be removed from the open channel to provide capacity for irrigation return flow and storm runoff following the infrequent storms. Mowing is accomplished on a selective basis whereby designated trees along with clumps of brush are left undistrubed to provide habitat for all types of wildlife. Vegetation is not removed along the edge of the river channel, on slopes of the levee, and in marsh areas. Plants growing in these areas stabilize the soil and provide cover for wildlife.

Prior to the mowing program, the maintenance practice had been disking, chopping, and clearing with a root plow. These practices were effective but resulted in destroying all the vegetation and did not allow the annual plants to stabilize the soil. Mowing, which is required as a routine maintenance practice, encourages establishment of vegetation and does not kill all existing plants as wind erosion is reduced and damage to adjacent farmlands and crops is minimized.

In addition to the current research on phreatophyte control, such as the use of anti-transpirants, other ecologically sound vegetation and watershed management techniques could reduce the amount of sediment and dissolved mineral matter from some areas, and also increase the water yield from other areas. The research, evaluation, and implementation of this method of salinity control will probably involve many years.

9. Return Flow Utilization

The concept involves the capture of collection of poor quality irrigation return flows, then conveying and possibly treating this water for specialized nonagricultural uses. These specialized uses could range from cooling water of electric generating plants to the recharging of geothermal wells or other industrial processes. Although the use of these returns flows results in a net depletion to the river, salinity is also reduced by preventing the poor quality return flows from entering the river.

Under present conditions, the best prospects for applying desalting to return flows involves minimizing the volume, isolating, and collecting. Thus, practical desalting of return flows depends upon higher irrigation efficiencies and the economic environment of the irrigated area.

Current efforts have been primarily to review potential industries, possible siting facilities, and preliminary design of collection systems.

10. Weather Modification

By 1980, weather modification research now in progress is expected to develop a reliable and workable system for increasing precipitation. In the Colorado River Basin 1 to 2 million acre-feet per year could be made available to contribute toward salinity improvement. The favorable net benefits, the flexibility of use, and the opportunity for obtaining even greater new water yields with advanced techniques point to weather modification as a desirable tool for water resources management. A description of this pilot research program and its environmental impacts are being prepared by Division of Atmospheric Water Resources Management, Bureau of Reclamation. A brief program description is found in Chapter VIII.

11. Seawater Desalting

The coast of southern California has been under intensive study to site large-scale seawater desalting plants. Recent reconniassance studies have evaluated desalting plants at Diablo Canyon

(40 million gallons per day [Mgal/d]), Encino-San Diego (40 Mgal/d), San Diego Refuse Incinerator Project (32 Mgal/d), and Orange County Water Factory 21 (3 Mgal/d). Ultimately, large-scale, dual-purpose desalting plants may not only augment local municipal and industrial supplies but also export or exchange water to meet inland demands such as augmenting the flow of the Colorado River. As a consequence, desalting is still expected to have a role in providing future water supplies for augmentation purposes. As such, the potential impacts of seawater desalting for exchange water and water quality improvement in the Colorado River should be recognized and monitored.

12. Control of Effluent from Powerplants

Since 1970, action has been taken with respect to the effects of cooling tower blowdown water from thermal-electric powerplants on the salinity of the Colorado River. Cooling water in the towers evaporates, and salt in the remaining water becomes increasingly concentrated. The cooling water must be maintained at or below specific levels of concentration; this is accomplished by discharging, or "blowing down" a portion of the water, and replacing it with fresh water. At the present time, there are five large coal-fired thermal-electric generating plants either in operation or under construction within the Colorado River Basin, and others are planned. As a consequence of disposing of their blowdown water, the cooling water as well as its dissolved salts, will be removed from the river. The net effect, however, of water depletion alone will result in increases in river salinity downstream.

13. Other Industrial Uses

Coal gasification plants are being planned for construction in New Mexico on the Navajo Indian Reservation. Under the 1985 goal of "zero discharge" of pollutants specified for P.L. 92-500, any cooling water or other degraded industrial water would not be returned to the river system. As with the thermal-electric plants, some dissolved salts would be removed; however, there would still be some increase in salinity downstream due to the consumptive use of water by the gasification plants. The salinity impact of this depletion will depend on the number of plants and use patterns.

The Nation's increasing demand for oil has caused both industry and Government to proceed with plans for the mining of the tremendous oil shale reserves of the Upper Colorado River Basin and the extraction of oil from the shales. A final Environmental Impact Statement of the Government's oil shale leasing program was recently completed.[7] The statement recommends several measures preventing the return of processing water with dissolved salts to the river system.

In the Lower Colorado River Basin, the San Diego Gas and Electric Company has been working on plans to construct a large nuclear powerplant in the Colorado desert near Blythe, California, using the saline Palo Verde Irrigation District drain water for cooling.

It is estimated that up to 100,000 acre-feet of drain water a year could be used by electric utilities in southern California for proposed electric generating facilities.

14. Reappraisal of Authorized Bureau of Reclamation Water Development Projects

The Office of Management and Budget has directed that a reappraisal be made by the Bureau of Reclamation of presently authorized but unconstructed projects within the Upper Colorado River Basin to identify the salinity impact of such projects. In making this appraisal, the Bureau of Reclamation may change some features of the projects so that the salinity impacts will be minimized. This may be accomplished by carefully analyzing lands scheduled to receive irrigation water to assure that lands overlying saline formations will be excluded, planning onfarm facilities to reduce excess applications of water by farmers, changing use of the project water from irrigation to municipal and industrial uses which are expected to add less salt to the system, and other possible alternatives.

15. Blending of Colorado River Water

The Metropolitan Water District (MWD) of Southern California imports over 1 million acre-feet a year of Colorado River water into the southern California coastal plain, where over 10 million persons reside. Upon the 1972 completion of the first stage of the California State Water Project, the District had available to it added quanties of Northern California water containing only about one-third the salinity of Colorado River water. To reduce the salinity of the water delivered to its service area, the Distirct recently announced a program involving significant expenditures which would allow distribution of a 50-50 blend of the two waters to 75 percent of its service area. By such a blending operation, MWD can deliver better quality water to its customers and reduce Colorado River Water diversions. Reduced diversions from the river, in turn, may reduce the salt concentration effect and provide improved water quality for downstream water users.

16. Geothermal Water

Funding for geothermal research in the Imperial Valley, California, area began in 1968. This research led to the identification of several geothermal anomalies. Data obtained from test holes and test desalting plants have indicated the potential for economic production of geothermal water. Large-scale development could provide an attractive source for augmenting the flow of the Lower Colorado River.

The quality of geothermal water sampled from wells at the East Mesa Test Facilicity in the Imperial Valley of Southern California ranges from 1,800 to 20,000 mg/l total dissolved solids. Both distillation and membrane desalting technology can be applied to water in the range of chemical quality to produce product water of about 50 mg/l.

D. Authorized Program Units Under P.L. 93-320, Title II

The following sections describe the salinity control units that have been authorized for construction, feasibility investigation, or continuing study.

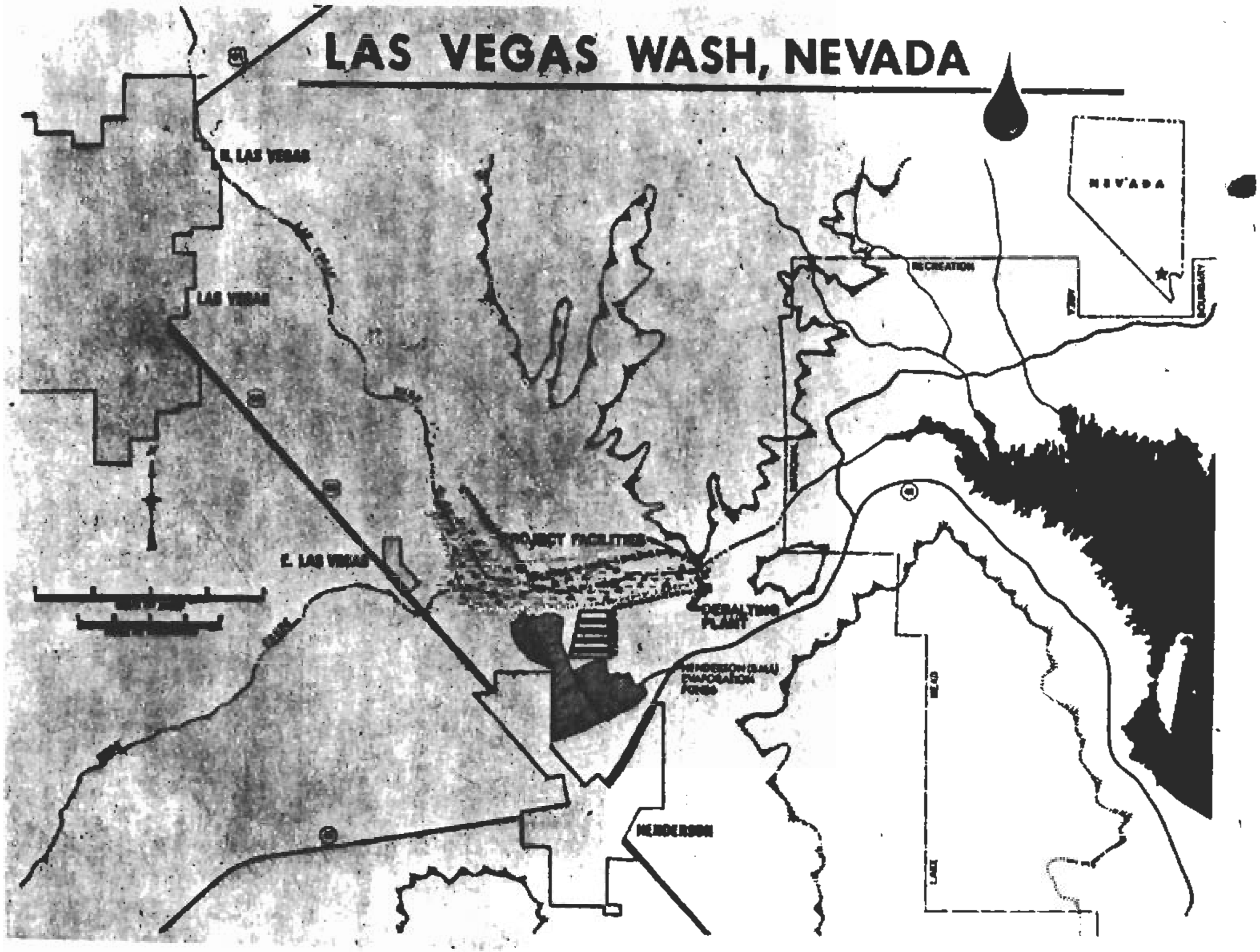
1. Initial Control Units for Construction

When installed, all four initial units will be monitored to test their effectiveness in salinity control and will provide needed data for other investigations. These initial units will reduce the salinity of the Colorado River at Imperial Dam by about 43.6 mg/l, resulting in an annual average benefit of about $10,028,000 to water users in the Lower Basin States based on USBR salinity impact studies cited previously in this chapter.

The Las Vegas Wash and Crystal Geyser Units are addressed below in more detail since environmental data was made available in advance of the other authorized units.

a. Las Vegas Wash Unit, Nevada. -

(1) Introduction and location. - Las Vegas Wash is a natural channel located in Clark County in southern Nevada. The wash drains the entire Las Vegas Valley watershed area of 2,200 square miles and discharges into the Colorado River at Las Vegas Bay of Lake Mead. The valley floor is approximately 50 miles long and from 5 to 25 miles wide and contains the largest population center in the State. The wash flows through the valley in a generally southeast direction and provides drainage for the principal cities of North Las Vegas, Las Vegas and Henderson (see fig. I-6). An aerial view of the wash leaving Las Vegas Valley is shown on figure I-7. For purposes of this unit, however, the wash is considered as being the lower 11-mile portion between Las Vegas and Lake Mead, consisting of about 2,000 acres of dense marsh and phreatophyte vegetation in a strip one-half mile wide in the



Project facilities, Las Vegas Wash, Nevada.
Figure I-6

Las Vegas Wash as it leaves Las Vegas Valley.

Figure I-7

upper portion decreasing to a narrow gorge in the lower portion. Continually increasing discharges from municipal waste-water treatment plants combined with industrial wastes, surfacing ground-water returns from agricultural irrigation, domestic irrigation, and septic tanks contribute large amounts of residual nutrient-bearing and saline water to the Lower Colorado River via Las Vegas Wash and Lake Mead. The average outflow for Las Vegas Wash during the 6-year period 1970-1975 is 43,500 acre-feet annually. These flows have discharged an annual average of nearly 202,000 tons of salt into Lake Mead and the Colorado River. Figure I-8 is a view of the wash as it enters Las Vegas Bay of Lake Mead. The effect of project facilities described in this document would be as noted in the following tabulation. Adjustments in these figures reflect the influence of other Federal programs that are further described herein.

Unit stage	Salt removed (tons)	Salinity reduction	
		Hoover Dam	Imperial Dam
First stage	46,000	4 mg/l	4 mg/l
Second stage	76,400	8 mg/l	8 mg/l

(2) History. - Prior to man's advent, Las Vegas Wash was dry except for some small local springs. The wash would discharge into the Colorado River only during periods of high rainfall and runoff. With the development of communities around the turn of the century accompanied by limited farming and mining, the character of the wash changed. Pumping from the underground aquifers began and waste waters were discharged to Las Vegas Wash. Some of the water used within the valley percolated through the soil and into the near surface aquifer and seeped into the wash as ground-water return flows.

The construction of Hoover Dam in the 1930's brought about the first major influx of people into the area. This process was accelerated in the 1940's with the construction of the industrial complex (BMI) in Henderson, Nevada, which started the first import of water from Lake Mead into the valley. Industrial waste waters from the unlined BMI evaporation ponds have seeped into the near surface aquifer over the years contributing significantly to the ground water which discharges into Las Vegas Wash. Waste water from the municipal sewage treatment plants in the valley has been continously discharged into the wash since the 1930's and 1940's.

In December 1971, the EPA initiated enforcement action through National Pollutant Discharge Elimination System (NPDES) permits against the major polluting entities in

Las Vegas Wash at Lake Mead.

Figure I-8

Las Vegas Valley. As a result of their action, the various entities responded with plans to provide workable solutions to the pollution problem.

In 1973, the Nevada Legislature empowered Clark County to assume the responsibility for the collection, disposal, and treatment of sewage and wastewater in the valley. The 1973 legislative act also assigned to the County the responsibility for the development and implementation of a pollution abatement plan for the Las Vegas Wash and Bay area.

Clark County's wastewater is a unique chemical and biological blend of Colorado River water, water from the Las Vegas ground-water basin and the water-carried waste materials from a highly tourist-oriented desert community. The unique character of the water and the very high water quality standards set for discharges from Las Vegas Wash require implementation of some of the latest and most advanced wastewater treatment (AWT) technology available. The Clark County Sanitation District has been assigned the responsibility for planning an AWT plant which will treat the sewage flows from Las Vegas and the County to meet State and Federal discharge standards for Las Vegas Wash. The sanitation district through their Waste Treatment Facilities Development Section and Nevada Environmental Consultants developed a "Design Verification Project" to evaluate on a small scale the innovative design features to be included in the construction and operation of the proposed AWT plant. The test facilities have proven quite successful, resulting in changes and improvements to the plant's final design which will have the capacity to treat up to 90 million gallons per day. The tabulation on the following page displays the results of various stages of AWT on the quality of the valley's wastewater with respect to the water quality standards for Las Vegas Wash discharges to Lake Mead. [49]

The City of Henderson will treat its own sewage to meet the required standards. The various industries at Basic Management Incorporated (BMI) and the two Nevada Power Company powerplants have developed plans to be implemented in the near future to prevent further pollution of the wash and Lake Mead.

The remaining flows in the wash are saline ground waters which in conjunction with surface return flows serve to maintain a greenbelt of phreatophytic vegetation unique to the surrounding desert environment. Maintenance of this greenbelt is paramount to the county's efforts to develop a regional natural park in the wash area.

Design verification project [49]
average test results with minimum
lime feed to the reactor-clarifier*

Sampling point	Biochemical oxygen demand (BOD_5)	Chemical oxygen demand (COD)	Suspended solids (SS)	Turbidity (JTU)	Total phosphorus (P)	Dissolved oxygen (DO)	pH units	Remarks
Aerated surge pond influent	25.6 mg/l	105.1 mg/l	19.2 mg/l	13.4 units	9-10 mg/l	4.2 mg/l	7.7 units	Phosphorus measured at secondary WTP discharge
Aerated surge pond effluent	20.9 mg/l	99.9 mg/l	18.9 mg/l	9.2 units	See remarks	5.4 mg/l	8.0 units	Early tests showed no reduction across pond measurements discontinued
Reactor clarifier effluent	8.0 mg/l	61.5 mg/l	11.1 mg/l	7.0 units	0.6 mg/l	8.2 mg/l	9.8 units	Abbreviations
Dual media filter effluent	4.0 mg/l	55.3 mg/l	0.3 mg/l	0.5 units	0.6 mg/l	8.4 mg/l	8.1 units	mg/l = milligrams per liter (8.34 lbs/million gallons)
Mixed media filter effluent	3.7 mg/l	52.8 mg/l	0.1 mg/l	0.4 units	0.6 mg/l	8.2 mg/l	8.1 units	≤ means less than or equal to ≥ means greater than or equal to
Water quality standards Las Vegas Wash discharge	≤10.0 mg/l	≤40.0 mg/l	≤2.0 mg/l	≤5.0 units	<0.5 mg/l	>5.0 mg/l	6.5-8.5 units	

* Lime feed rate to the reactor-clarifier for these tests was 200 to 250 mg/l as CaO

Historical data analysis. - Operation of computer simulation models developed for Las Vegas Wash indicate that bypassing AWT flows in conjunction with the removal of industrial wastes under EPA's NPDES permits may, in effect, deplete most of the flows in the upper wash. This would cause a probable loss in vegetation and wildlife habitat which is in direct opposition to Clark County's efforts to develop a regional natural/educational park in the wash area. The loss in vegetation would increase the potential for severe erosion in the wash which would contribute large silt loads to Las Vegas Bay of Lake Mead. Uncontrolled erosional head-cutting could eventually endanger the wash crossing of the Southern Nevada Water Project's existing Las Vegas Valley Lateral. This lateral is the main water line serving East Las Vegas, North Las Vegas, and Nellis Air Force Base.

With this concern also in mind, an analysis of the water requirements of the wash vegetation was performed. Data provided through a 5-year study on the consumptive use of water by phreatophytes and hydrophytes by the U.S. Geological Survey (Professional Paper 486-F, 1968) was used to develop monthly water use curves using the Blaney-Cirddle method. Results were then used in the computer simulation analysis to obtain a minimum flow that would provide the required maintenance for the wash greenbelt and serve the aims of salinity control. Such flows would require the release of AWT effluent in sufficient amounts to maintain an average flow of about 300 acre-feet per month at the USGS gage near Henderson and about 600 acre-feet per month at the proposed interception site described below. These flows require a modification of the project plan described in the Draft EIS. This modification consists of staging the construction schedule. Thus, the recommended plan will begin with a total evaporation scheme and later expand by adding a desalting plant. This planned flexibility is needed due to the lack of available data to accurately forecast the quantity and quality of future ground-water flows in the wash. Based on current trends and data, it is assumed that second-stage facilities would not be required before the year 2000.

(3) Description of unit features. - The first stage of the recommended plan will consist of five basic systems; i.e., (1) a monitoring system, (2) an interception system, (3) a delivery system, (4) a treatment system, and (5) a surface flow bypass system. Each system is planned for maximum efficiency under known conditions while providing the needed

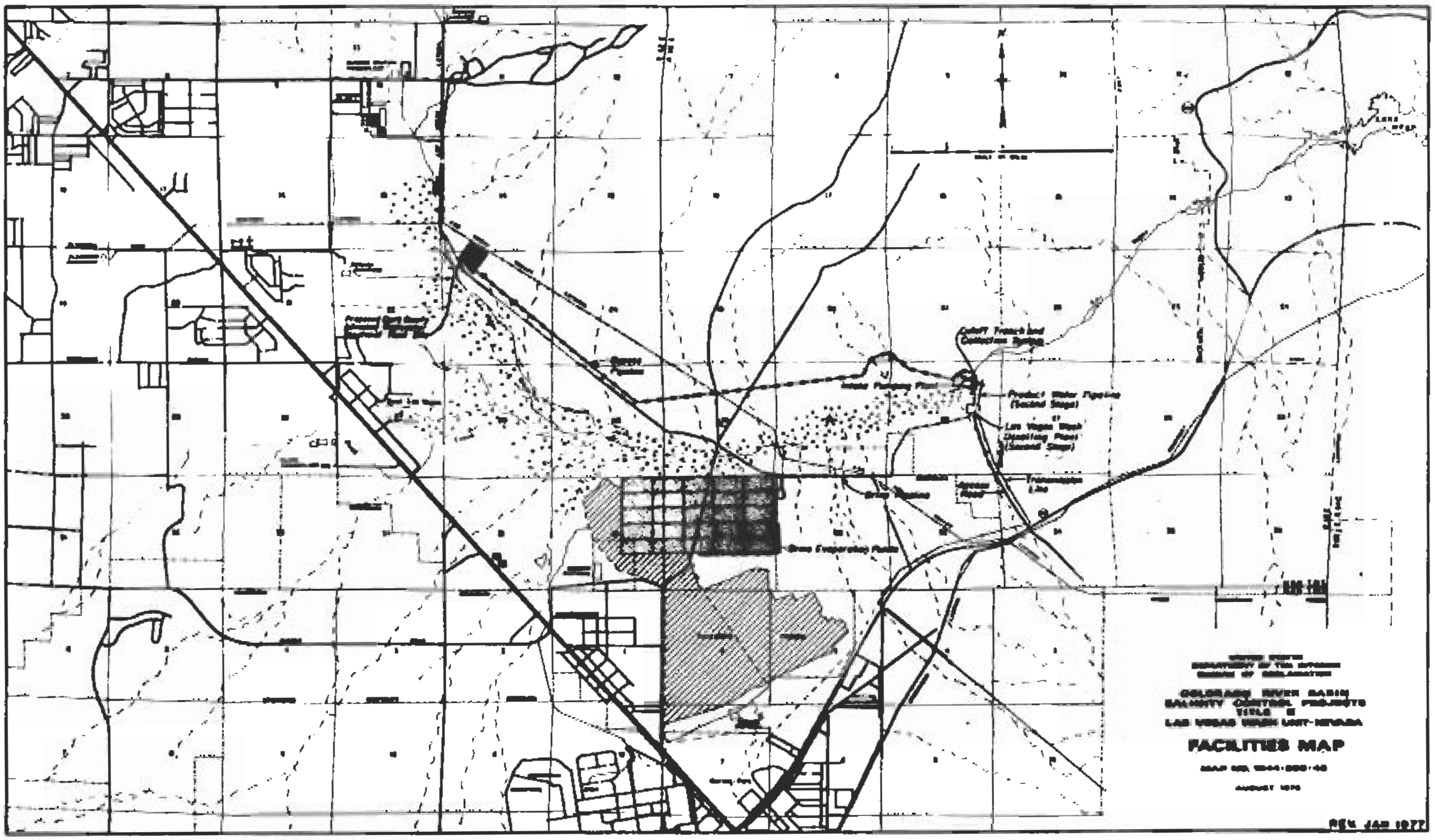
flexibility to accommodate any modification or expansion that may be required under anticipated future conditions. The basic systems are described below, and with the exception of the monitoring system are shown on figure I-9.

Monitoring System. - A monitoring system will be constructed as part of the preconstruction activities to establish an accurate record of conditions prior to project operation, and to provide the data needed for final sizing of first-stage facilities. The system will be maintained on a permanent basis to provide a continuing record for long-term trend analysis to determine time and size requirements for future second-stage facilities. After second-stage facilities are in operation, maintenance of the system will provide the data needed to establish operating criteria and maintain flexibility to accommodate changes to that criteria that may be required in response to fluctuations or changes in trend of incoming flows. In addition, the system will monitor the effectiveness of the project as well as provide a means of detecting leaks from any potential deterioration of evaporation pond linings. The monitoring system will initially consist of about 10 surface-flow gaging stations, water-quality stations, and a network of existing observation wells and piezometers. Planned flexibility in the number and location of stations will ensure a sensitive system capable of supplying highly accurate and relative data needed for operation of the Las Vegas Wash Unit.

Interception System. - The interception system basically will consist of (1) a trench excavated to bedrock across the wash and then backfilled with impervious material to form a subsurface dam to block the downstream movement of ground water, (2) a collector system composed of a large subsurface drain installed as part of the upstream portion of the subsurface dam, and (3) a surface collector drain installed parallel to the dam axis to effectively collect all flows in the wash and convey them to the delivery system. A more detailed description of these features is discussed below.

Trench

The north side of the trench axis is primarily underlain with silty sand and clay with lenses of carbonized organic



Las Vegas Wash Unit - Facilities Map.

Figure I-9

material and some gravel lenses. The south side is primarily underlain with more sand, gravel, and cobble fill. The proposed excavation would average about 50 feet in depth with a bottom width of 20 feet and a maximum top width of about 185 feet. The top width would vary with respect to depth in order to accommodate a 1-1/2:1 side slope. The total length requiring compacted backfill would be about 1,130 feet. The total estimated volume of material to be excavated would be about 120,000 cubic yards (yd^3). Details of the trench are shown in figure I-10. Also shown is a cement grout "curtain" that would be forced into cracks or fractures of the bedrock beneath the trench to seal the formation against any possible underflow.

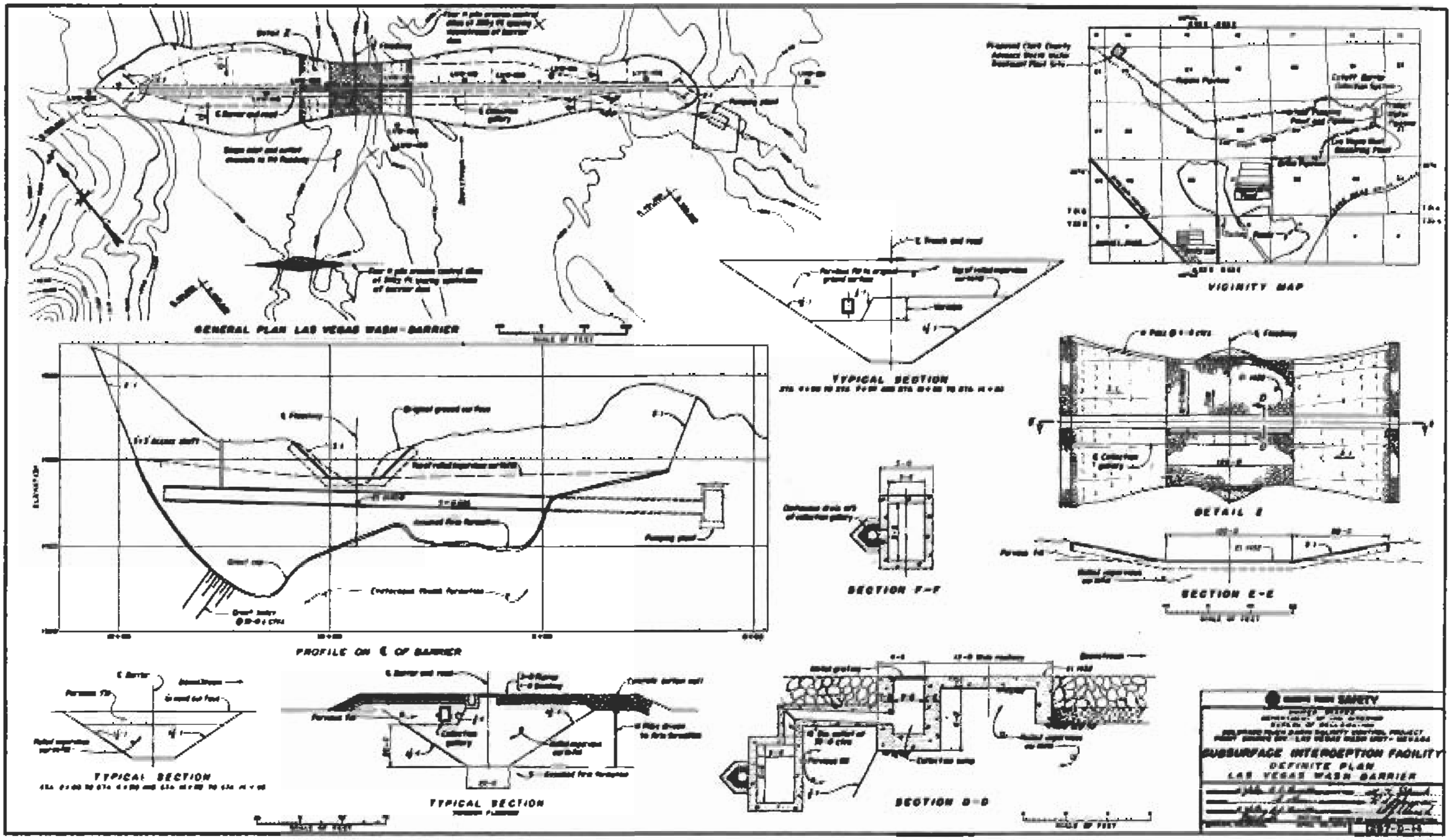
A total of 107,000 yd^3 of impervious backfill has been computed for the subsurface dam. It is expected that several thousand cubic yards of material excavated from the north side of the wash would be suitable for this purpose when blended with additional impervious clay.

The nearest known source for impervious materials is located on private land in the vicinity of existing source material excavations about 2-1/2 miles west of Pittman, Nevada. This source would require hauling over about 2 miles of existing dirt roads and 7 miles of existing paved highways.

A computed total of about 35,000 yd^3 of permeable material would be required for the pervious zones of the subsurface dam as shown on figure I-10. It is expected that much of the material excavated from the south side of the trench would be suitable for this purpose although some blending with material purchased from commercial sources may be required.

Unused excavated material would supply the fill and top soil requirements for the desalting complex site.

Computations indicate that 3,000 yd^3 of riprap would be required to protect the surface of the backfilled trench from erosion and floodflows. A source is available about 1 mile southeast of the subsurface dam in an area of former mining activity. Existing dirt roads connect the two areas.



Interception Facility.

Figure I-10

Collection System

The collection system consists of a surface drainage sump for collecting streamflows, a subsurface drain for collecting ground water, and a collection gallery for conveying all collected flows to the collection sump which is located near the right abutment. The surface drainage sump will be a concrete structure 120 feet long located in the upstream side of the floodway channel. A cover with adjustable openings would prohibit floodflows from entering the system. The subsurface drain will consist of 12-inch-diameter tile with a sand filter buried in the pervious fill upstream and parallel to the barrier axis. Drain outlets will convey flows into the 3.5- by 5.5-foot, 1,250-foot-long concrete collection gallery located upstream and parallel to the barrier axis. Details of the collection system are shown on figure I-10, while the location of the entire interception facility is shown on figure I-11.

Delivery System. - An intake pumping plant will be located at the collection sump and will lift the collected flows to a regulating tank located on the desalting plant site. This steel storage tank will be used to supply water to a reject pumping plant for the first stage, and to supply water to the desalting plant for the second stage. An 18-inch buried pipeline approximately 3.5 miles in length will deliver a maximum of 10 ft^3/s of water from the tank to the evaporation ponds for stage I. For stage II, waste brine from the desalting plant will be conveyed through the same pipe to the evaporation ponds.

Treatment System. - Under the first stage, treatment will consist of total evaporation of all collected flows. For stage II, it is anticipated that treatment would consist of processing collected flows through a desalting plant with the product water being returned to the wash below the interception facility and the waste brine being evaporated. For the second-stage, a product water pipeline 18-inches in diameter and about 1,500 feet long would be required to convey flows back to the wash where they would be discharged into a stilling basin located on the south side of the wash.

Las Vegas Wash near interception facility site.

Figure I-11

Evaporation Ponds

The maximum pond size that will be required under stage I is 625 acres. This will consist of a series of ponds connected by regulating structures. The ponds will be located near the existing tailing pond areas of the BMI industrial complex. The ponds will be lined with polyvinyl chloride sheets to prevent seepage back into the wash. This sheeting will be covered with a protective layer of sand and gravel. The ponds are designed to provide for 100 years of salt accumulations. It is possible that the salt accumulations may have economic importance worthy of salvage. However, if such a market were not available at the end of the project life, the ponds could be covered with several feet of earth and the land used for some beneficial purpose. The proposed design for the evaporation ponds is shown in figure I-11A.

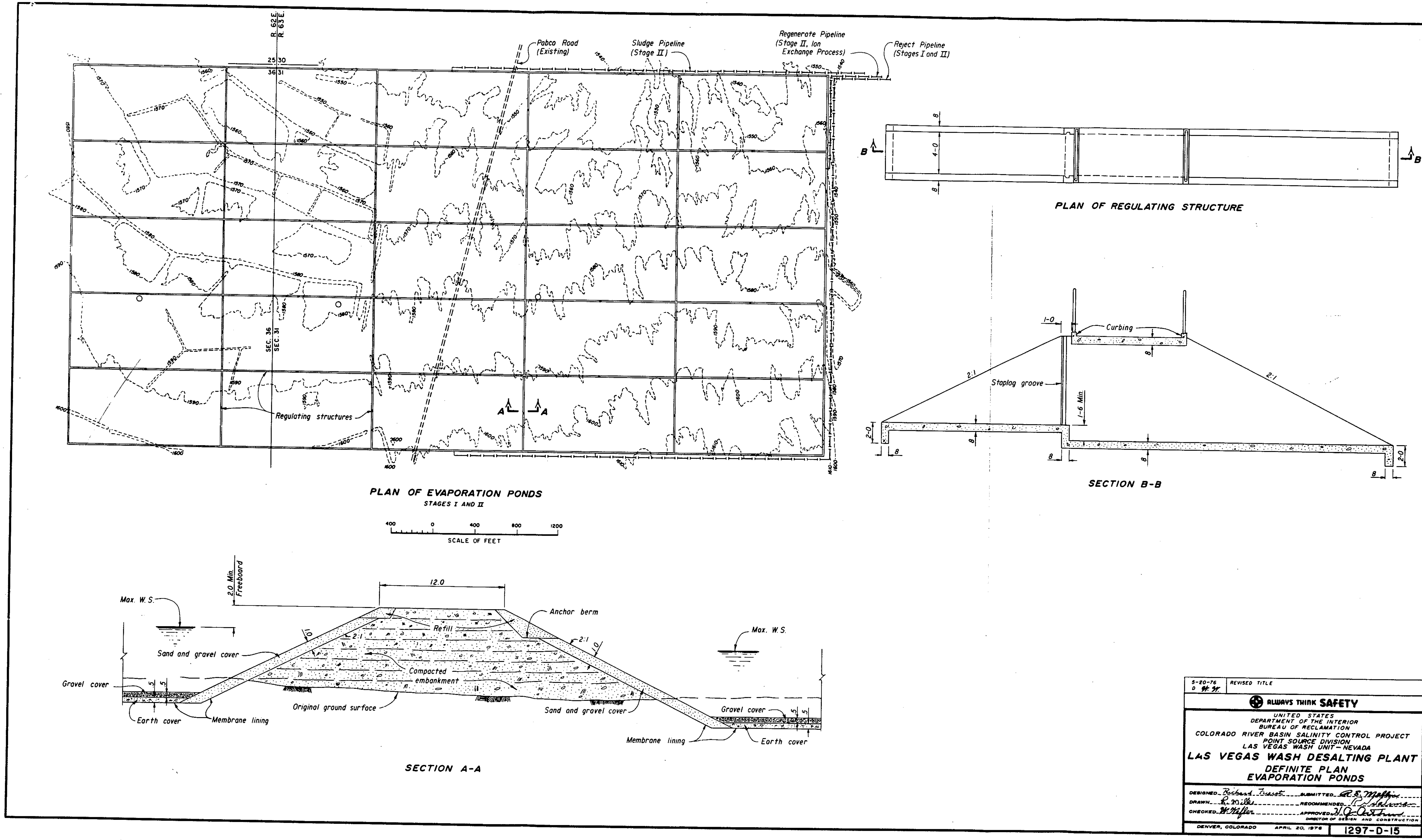
Construction of the ponds would be a balanced cut-and-fill operation with no disposal sites or borrow material required.

To assure the safety of both the public and wildlife, the entire evaporation pond area will be enclosed within a security fence.

Desalting Plant - Second Stage

The desalting plant would be located on Federal land on the south side of Las Vegas Wash adjacent to the interception area as shown on the project map, figure I-9. Although a modular reverse-osmosis (RO) desalting system appears to be the most viable at present, the time frame in which the need for the plant is anticipated may show such technological advancements as to warrant some other method. For purposes of estimating costs and potential impacts, however, a conceptual RO plant is considered.

Due to the chemical characteristics of the water in the wash, pretreatment would be required. Based on present analyses it appears that a lime-soda ash pretreatment process would provide the most satisfactory results. Pretreatment facilities would include calcium reduction and filtration. A receiving or feed tank, clarifiers, and a series of gravity filters would be located outdoors adjacent to the plant. A chemical storage building



Evaporation Pond Design

Figure I-11a

would also be required. A conceptual layout for the treatment facility is shown on figure I-12. Approximately 7.5 acres of land would be needed for the desalting plant and attendant facilities.

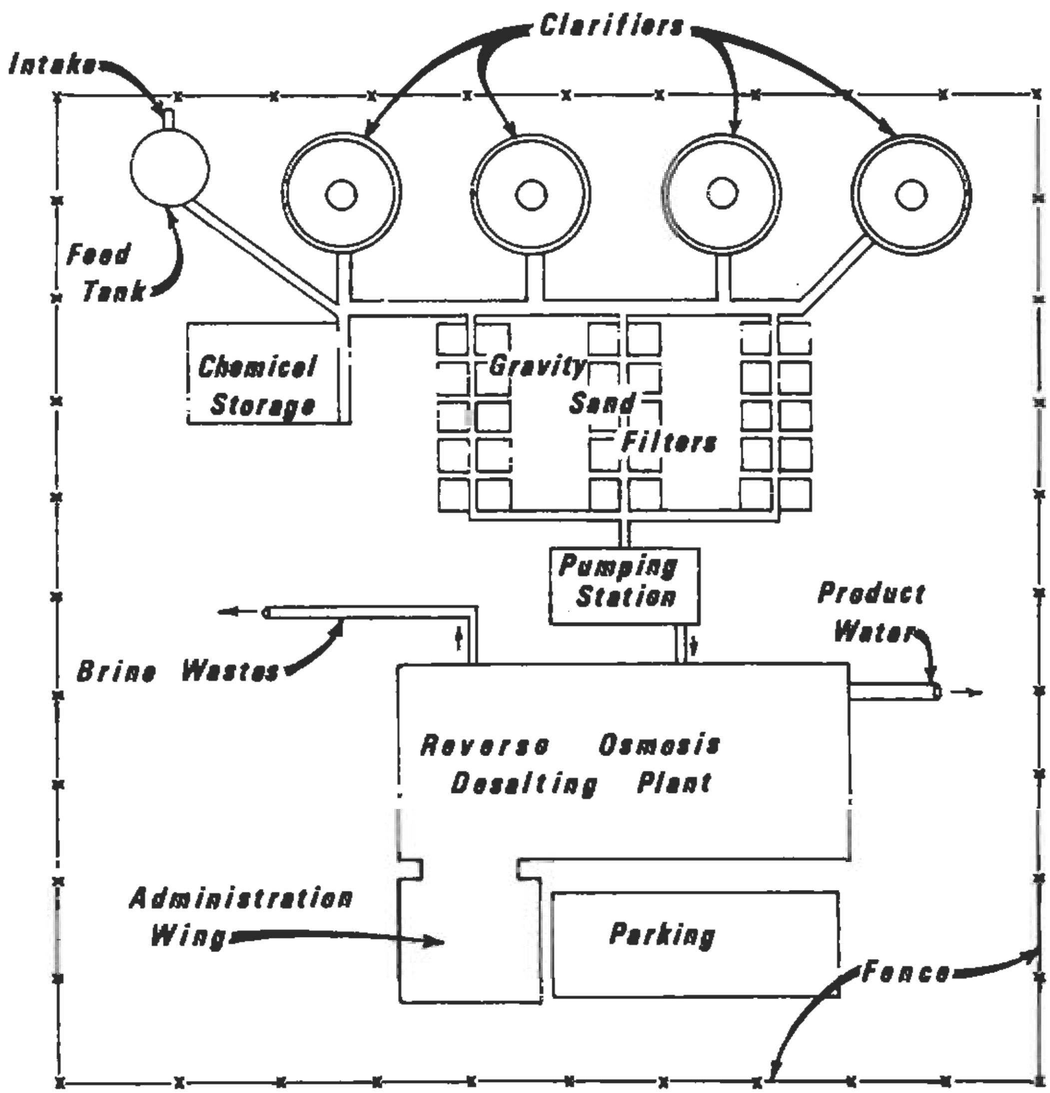
Surface Flow Bypass System. - To more effectively collect and isolate the saline flows in the wash, it will be necessary to bypass most surface flows (mainly municipal wastewater). To accomplish this, a buried 5-mile-long bypass pipeline will be constructed to convey municipal wastewater along the north side of the wash from the County's forthcoming AWT plant to a point immediately below the project's facilities. At this point the wastewater, which the County will have treated to meet both State and Federal standards, will be discharged back into the wash. At 60 inches in diameter, the pipeline will handle any increase in flow due to future population growth.

An energy dissipation structure, such as a stilling basin, will be situated at the end of the pipeline just below the interception area. This dissipation structure will be required to prevent undue erosion as the bypassed flows are discharged back into the wash.

It is anticipated that the County will release treated effluent into the upper reach of the wash for maintenance of the wash ecosystem as recommended by the Las Vegas Wash development Committee.[50] Clark County recently contracted with Nevada Power Company to supply up to 50 Mgal/d of AWT effluent from their proposed plant. This water would be used outside the Las Vegas Valley for cooling water purposes at the proposed Allen Powerplant. Other in-valley uses of AWT effluent have been proposed, such as the "In-Valley Irrigation System." All sewage effluent not required for maintenance of the wash or for other beneficial uses will be bypassed.

(4) Attendant facilities. - Attendant facilities for this project include access roads for both construction and operation, and powerlines to provide electric service to project facilities. The access roads required are discussed under section (6). Electric energy will be required locally to operate the desalting complex and intake pumping plant.

A transmission line is currently being designed for the project. The line would begin as a tap on an existing 69-kV line



Conceptual Layout for a Reverse Osmosis Desalting Plant.

Figure I-12

supplying power to Lincoln County through Nevada Power Company's Reid Gardener Power Plant. The proposed tap would be located where the existing line crosses Lake Mead Drive (State Highway 41) about 6,600 feet west of the intersection of the proposed access road and Lake Mead Drive. This tapped energy would be carried on single poles approximately 60 feet high and would be located within existing right-of-way. From Lake Mead Drive the line will parallel the access road a distance of about 6,600 feet to the project facilities. A substation would be located at the site to convert the 69-kV source to a more useable 13.2 kV. From the substation, an additional line about 1,000 feet long would convey electric energy to the intake pumping plant. It is estimated that less than 2-1/2 miles of powerline will be needed to service this project.

(5) Construction schedule. - Detailed planning documents are essentially completed, and Congress has appropriated funds to begin construction of the Las Vegas Wash Project during fiscal year 1977. Following approval of this EIS, it is anticipated that the awarding of contracts and the physical construction of the unit's facilities will begin. These processes are currently scheduled to take place over a 5-year time period for first stage facilities at a cost of about $32 million (April 1976 prices). Maximum expenditures during any one year are not expected to exceed 30 percent of this total amount.

At such time as second stage facilities are required, an additional 3 years of construction is anticipated. Total expenditures for second stage facilities are currently estimated at about $25 million (April 1976 prices).

(6) Rights-of-way. - Unit facilities will require a combined total of about 826 acres of private, county, and Federal lands for rights-of-way. About 6 percent of this acreage is classed as federally withdrawn reclamation land. The remaining 94 percent is private and county land.

The single largest commitment is land for the evaporation ponds. These are necessarily large to provide for the standard 100-year life designed into Bureau of Reclamation projects.

Rights-of-way acquired for pipelines will include sufficient area to accommodate temporary construction access roads. Only one road will remain as a permanent fixture following project completion. This road will be a paved or graded access from Lake Mead Drive to the interception area. This road will be about 1-1/4 miles long. The required power-line will parallel this access. The combined right-of-way will require about 15 acres of Federal land.

A temporary storage area for material excavated from the cutoff trench will be required. An 8-acre area immediately downstream of the trench site on the south side of the existing channel could be utilized. If necessary, the area would be suitable for permanent disposal of some of the excavated material.

Rights-of-way will be acquired either through an easement procedure or through fee-title purchase. The following tabulation shows the quantity and type of land required for each of the projects facilities.

(7) Operation and maintenance. - Both the operation and maintenance of the completed project will be accomplished by personnel of the Lower Colorado Regional Office of the Bureau of Reclamation. A summary of the general operation is presented below:

"First Stage"

The operation of the project has been designed with as much automation as possible. The water level in the collection gallery will be used to control the pumps in the intake pumping plant. Other automatic monitoring instruments will be used in the evaporation ponds area. Only routine inspection will be required until the salinity in the ponds reaches a concentration that would prove harmful to waterfowl that might use the ponds. With proper pond management, this condition may not occur for several years. However, at such time as pond salinity reaches this level, daily inspection of the ponds during the critical migration season may be required to prevent undue loss of waterfowl. The average service life of

Rights-of-Way Requirements
Las Vegas Wash Unit, Nevada

Feature	Land - (acres)*			
	Private	County	Federal	Total
"First-stage features"				
Monitoring system	**	**	**	**
Interception and collection system	2	78	5	85
Delivery system	2	--	13	15
Treatment system	650	--	--	650
Bypass pipeline	2	--	29	31
Subtotal	656	78	47	781
"Second-stage features"				
Desalting complex	1	39	5	45
Total	657	117	52	826

* Includes areas required for access roads, transmission lines, and materials storage and disposal. Also, includes an excess of land not affected by the project but acquired due to relative position.

** All rights-of-way consist of very small areas located within existing rights-of-way. Total area is less than one-fourth-acre.

some items used in the design for replacement reserve are shown below:

Item	Average life (years)
Meters, valves, controls, and metalwork	20
Pumps and motors	25
Accessory electrical equipment, etc.	30

The estimated energy required for first stage operation is 3,575,000 kilowatthours per year (kWh/yr) and will be supplied by the Nevada Power Company.

Various operating modes can be applied to increase the efficiency of the unit, and maintain flexibility to accommodate annual and seasonal variations in consumptive use of water by vegetation in the wash. An analysis to illustrate the effect of variable operating modes is shown below:

Operating mode	Salt removal (tons)	River depletion (acre-feet)	Salinity reduction Hoover Dam (mg/l)	Salinity reduction Imperial Dam (mg/l)
12 months diversion 300 acre-ft/month	31,000	3,600	3	3
6 months diversion (May-October) 600 acre-ft/month	46,000	3,600	4	4

Varying types of AWT releases; i.e., constant, intermittent, and slug will be investigated to best preserve the present vegetative growth in the wash and maximize the removal of salt.

"Second Stage"

The second-stage operation will be modified with the addition of the desalting and pretreatment plant. Second-stage pretreatment plant operating procedures would be supplemented by the manufacturers' operation instructions. These operating instructions would be constantly improved on the job by the operating personnel to obtain the desired pretreated water quality for the membrane desalting units. The amount of chemicals to be stored for the pretreatment process will be dependent on the future quality and rate of flow to be ultimately treated. In general, the types of chemicals required for this operation, and the recommended days of storage supply for plant operation are as follows:

Chemical	Days of supply
90% hydrated lime	10
Soda ash	7
Chlorine	35
Sulfuric acid	30
Sodium hexametaphosphate	30

Automated controls monitored by computer would feed the chemicals to the pretreatment facilities as required. Sludge produced by the pretreatment process would be collected and pumped to the evaporation ponds.

The second-stage desalting plant would be manned 24 hours per day, 7 days a week. The plant control system would be operated by computer. The computer would utilize preprogramed programs and a sophisticated monitoring system. Under the second stage, proper maintenance of plant equipment and instrumentation to assure good plant performance and economy of operation will be enhanced through color-coded system to facilitate tracing individual pipes through the maze of pipelines and conduits. Periodical checks of all measuring devices used to measure waterflow and chemical feed in the pretreatment plant would be performed to ensure proper operation. For second-stage facilities, the major replacement of pumps is expected on a 15- to 20-year basis. When the pretreatment plant is operated and maintained properly, it is expected that the equipment will have a life cycle of 20 years including the major equipment in the solids contact reactors, thickener, dual-media gravity filters, and various chemical feed systems. The filter media is expected to last approximately 10 to 15 years. Replacement life of the desalting plant RO membranes is expected to be approximately 5 years.

Energy requirements for second-stage operation is estimated at 68,155,000 kWh/yr.

Due to the nature of membrane desalting plants, it is necessary to maintain a constant flow of at least 0.5 ft^3/s through the plant to keep the membranes moist and cool. A minimum flow of about 2.5 ft^3/s is needed to efficiently operate the pretreatment facilities. Because of these requirements, it is anticipated that the desalting plant would be in a continuous operating mode throughout the year. Since the need for desalting is projected to be after the year 2000, the future effect of this second stage was analyzed for that year based on the projections noted in the Department of Interior's publication "Quality of Water, Colorado River Basin - Progress Report No. 7" dated January 1975. Under these conditions the desalting plant would remove an estimated 76,400 tons of salt and would reduce the future salinity at both Hoover and Imperial Dams by about 8 mg/l.

(8) Interrelationship with other projects or proposals. - The interrelationship of the Las Vegas Wash Unit is discussed below under four general headings, i.e., Federal, State, Local, and Private.

Federal Projects

Preconstruction planning is currently underway on the second stage of the Southern Nevada Water Project. This project was initially planned for staged construction to provide municipal and industrial water for the growing communities in southern Nevada. The first stage was completed in 1971 and has the capability of diverting up to 132,000 acre-feet per year from Lake Mead. The second stage will interface with certain features of the first stage which were initially constructed to ultimate capacity. Other first-stage features will be modified. New features will consist of a parallel main aqueduct about 4 miles long, 30 miles of additional pipeline laterals and five new pumping plants.

The second stage, as currently planned, will develop Nevada's remaining entitlement to the waters of the Colorado River for municipal and industrial purposes. Scheduled completion is the early 1980's.

This project interrelates with the Las Vegas Wash Unit in two ways: First, Nevada's entitlement to Colorado River water is 300,000 acre-feet per year. This is a net diversion which means that credit for return flows can be allowed so as to effectually give Nevada the right to initially divert more than 300,000 acre-feet. Since all return flows are conveyed through Las Vegas Wash, the desalinization project may have a bearing on the quantity and quality of those return flows; Secondly, the increased municipal and industrial water delivered to Las Vegas Valley consumers will increase the amount of return flow water to be either treated or bypassed.

State Projects

The State of Nevada, through its Division of Colorado River Resources, is currently planning the second-stage expansion of the existing Alfred Merritt Smith Water Treatment Facility. This facility provides the treatment required for Lake Mead water delivered to Las Vegas Valley consumers through the Bureau of Reclamation's Southern Nevada Water Project facilities. The State's second stage expansion is being planned in tandem with the second stage of the Southern Nevada Water Project.

Local Government Projects

(a) The Clark County Sanitation District is currently conducting preconstruction planning of an advanced wastewater treatment plant. The plant is being designed to provide additional treatment for sewage wastes from all the urban areas of Las Vegas Valley except Henderson in order to meet EPA requirements for the quality of surface waters discharged through Las Vegas Wash to Lake Mead.

To effectively collect the saline ground waters, the Las Vegas Wash Unit will have to bypass the effluent from the AWT plant, with the exception of a given quantity of effluent that will be used by the County to maintain the ecology of the wash, and an amount up to 50 Mgal/d which has been contracted for by Nevada Power Company for cooling purposes at a proposed powerplant north of Las Vegas. At some future date there may be some of this effluent allocated for in-valley irrigation or for some other beneficial use. Such allocations would reduce the amount of effluent that would have to be bypassed.

(b) The Las Vegas Wash Development Committee, appointed by the Clark County Board of County Commissioners has published a report[50] in which it recommends development and preservation of Las Vegas Wash as an open space resource for recreational and educational purposes. It was also stated in the report that the Las Vegas Wash desalinization project would be compatible with the committee's proposals.

(c) Under the direction of the Clark County Board of County Commissioners, preparation of the Clark County 208 Areawide Waste Treatment Management Plan is currently being conducted. Salinity control activities of the Bureau of Reclamation in southern Nevada are being coordinated with the 208 planning process.

Private Projects

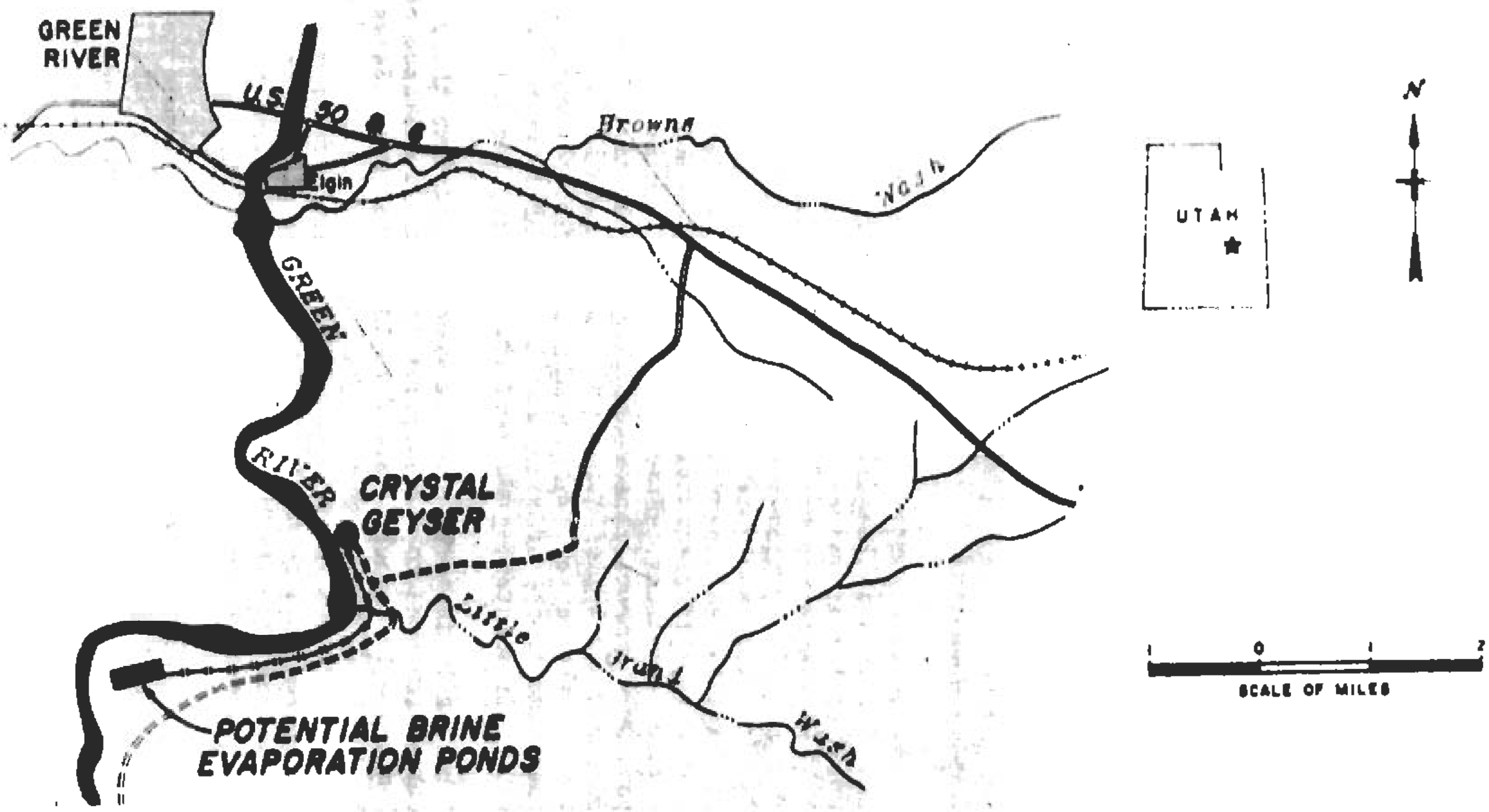
Downstream from the unit's facilities is an area that has been recently annexed by the city of Henderson. Private development of a planned community called "Lake Adair" has been proposed for this area.

Recent correspondence from the Nevada State Office of Planning Coordination indicated that there would be no conflict between the Las Vegas Wash Unit and any other proposals that have been processed through that office.

b. Crystal Geyser Unit, Utah. -

(1) Introduction. - Crystal Geyser is a privately owned abandoned oil test well located 3.5 miles south of the town of Green River, Utah, as shown in figure I-13. The geyser is situated about 200 feet from the edge of the Green River, a major tributary of the Colorado River. In addition to the main geyser, there are two other openings which eject water during an eruption. One of the holes is referred to as the north spring and is located about 100 feet north of the well; the other is referred to as the east spring and is located

CRYSTAL GEYSER, UTAH



Crystal Geyser - location map.

Figure I-13

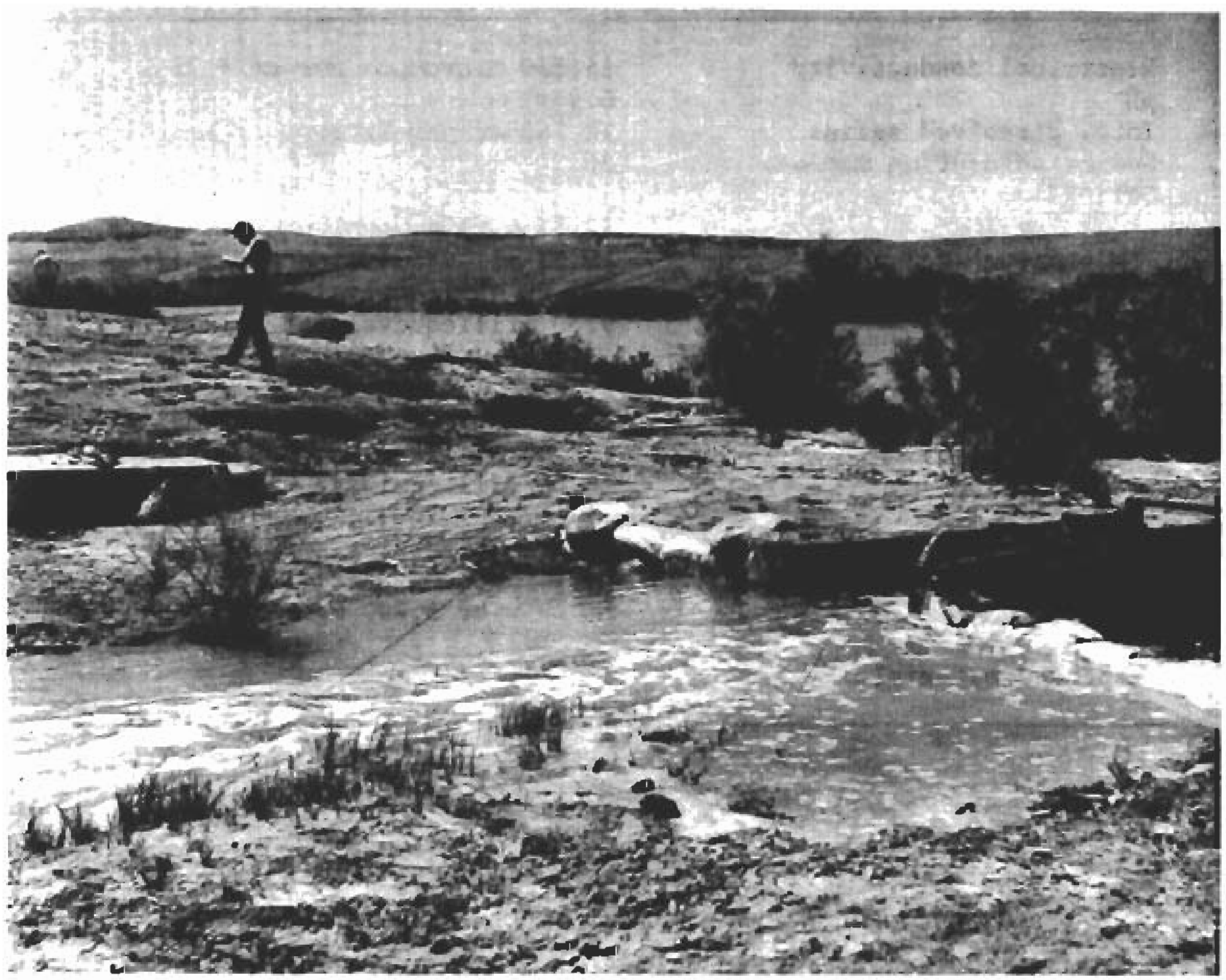
about 50 feet east of the well. In 1968, water from the geyser discharged to the Green River at the rate of 200 acre-feet per year. By 1972, the amount had decreased to about 150 acre-feet per year. Figure I-14 shows measurements being made during an eruption. The water is saturated with carbon dioxide and contains from 11,000 to over 14,000 mg/l of total dissolved solids. This results in an annual contribution of 3,000 tons of salt to the Colorado River System based on 1972 measurements. Table I-3 shows the total dissolved solids of water samples taken during 1968 and 1972 and a detailed analysis of the water's constituents.

(2) <u>Location and description of unit features</u>. - Development plans to prevent the geyser flows from entering the Green River include a pond to collect water during geyser eruption, and a pipeline extending to evaporation ponds located about 3 miles downstream.

The collection pond would be formed by a compacted earth embankment 340 feet in length with a maximum height of 12 feet, a top width of 8 feet and would be lined with a plastic membrane to prevent seepage to the Green River. Borrow material would come from the proposed evaporation pond area. A concrete outlet structure would allow water stored in the pond to enter the pipeline to the evaporation ponds. The collection pond would also have sufficient capacity to store the volume of water from several eruptions. Flows from the east spring would enter the pond in a channel excavated through an existing dike and tufa deposits. A bypass channel is planned in a small drainage area east of the geyser, which would carry runoff around the collection pond to the Green River. This channel would prevent storm runoff from entering the pond and damaging the earth embankment.

A buried 10-inch PVC pipeline would extend from the geyser collection pond to the evaporation ponds, a distance of about 3 miles. The pipeline would be located in secs. 34 and 35, T. 21 A., R. 16E., and secs. 2, 3, and 4, T. 22S., R. 16 E. The pipe trench would have a minimum width of 2 feet and a minimum cover of 3 feet over the pipe. The pipeline would have sufficient capacity to empty the collection pond in the interval between eruptions.

Studies indicate that four evaporation ponds would be required to handle the anticipated flow from the geyser. The construction of these four ponds including dikes would require an area of approximately 160 acres located in secs. 4 and 5, T. 22 S., R. 16 E. The water surface area within the ponds would be



Water measurement during eruption, Crystal Geyser Unit.

Figure I-14

Table I-3

QUALITY OF THE WATER FROM THE POOL
AROUND THE MAIN GEYSER

November 3, 1972

Electrical conductivity	15,130 micromhos per cm @ 25 C
pH	6.9
Total dissolved solids	14,550 mg per liter
Sodium adsorption ratio	30
CATIONS	
Calcium (Ca)	49.53 milliequivalents per liter
Magnesium (Mg)	19.33 milliequivalents per liter
Sodium (Na)	177.00 milliequivalents per liter
Potassium (K)	9.30 milliequivalents per liter
ANIONS	
Carbonate (CO_3)	none
Bicarbonate (HCO_3)	75.80 milliequivalents per liter
Chloride (Cl)	122.43 milliequivalents per liter
Sulfate (SO_4)	48.00 milliequivalents per liter
Total alkalinity	75.80 milliequivalents per liter $CaCO_3$ per liter or 3,790 mg/l as $CaCO_3$.
Suspended material	iron

approximately 100 acres, which would provide about 150 acre-feet of evaporation per year. An annual evaporation rate of approximately 18 inches is based on the net evaporation rate for Green River Airway adjusted for expected saline conditions of the ponds.

The ponds would be formed by compacted earth embankments with a top width of 12 feet and a height of 5.7 feet. Borrow for the embankment would come from the evaporation pond area. Based on field infiltration tests, the ponds require lining to prevent seepage of the geyser water to the Green River. A flexible polyvinyl chloride lining with a sand and gravel cover on the embankments and earth cover on the pond bottoms is planned. The ponds would be fenced to prevent access to wildlife and livestock.

The ponds have been designed to be operated with a water depth of 1.5 feet. A depth of 2.2 feet has been allowed in the bottom of the ponds for eventual salt accumulation. The pipeline from the geyser parallels the south edge of the ponds. Each pond would have an intake structure which allows water from the pipeline to enter one or more ponds. Water could be allowed to flow to an adjacent pond through regulating structure. In addition, monitoring of ground water near the brine ponds may be required.

About 160 acres of land at the evaporation ponds site will be purchased. Approximately 11 acres of land in the vicinity of the geyser will be obtained through a right-of-way easement or purchased, in order to construct the features of the collection pond. Easements required for construction and maintenance of the pipeline will consist of 4 acres of Utah State land, 5 acres of private land and 2.5 acres of vacant public land.

Figure I-15 shows the location of the pipeline and evaporating ponds. Table I-4 shows a summary of the physical features of the geyser and construction works. Completion of the project will reduce the salinity of the Colorado River at Imperial Dam by 0.3 mg/l.

2. Other Control Units for Construction

The two control units in this category have been authorized for construction but specific planning data and accompanying environmental impact information are considered to be incomplete. Individual Environmental Impact Statements or assessments will be made available for these units before initiation of construction activity.

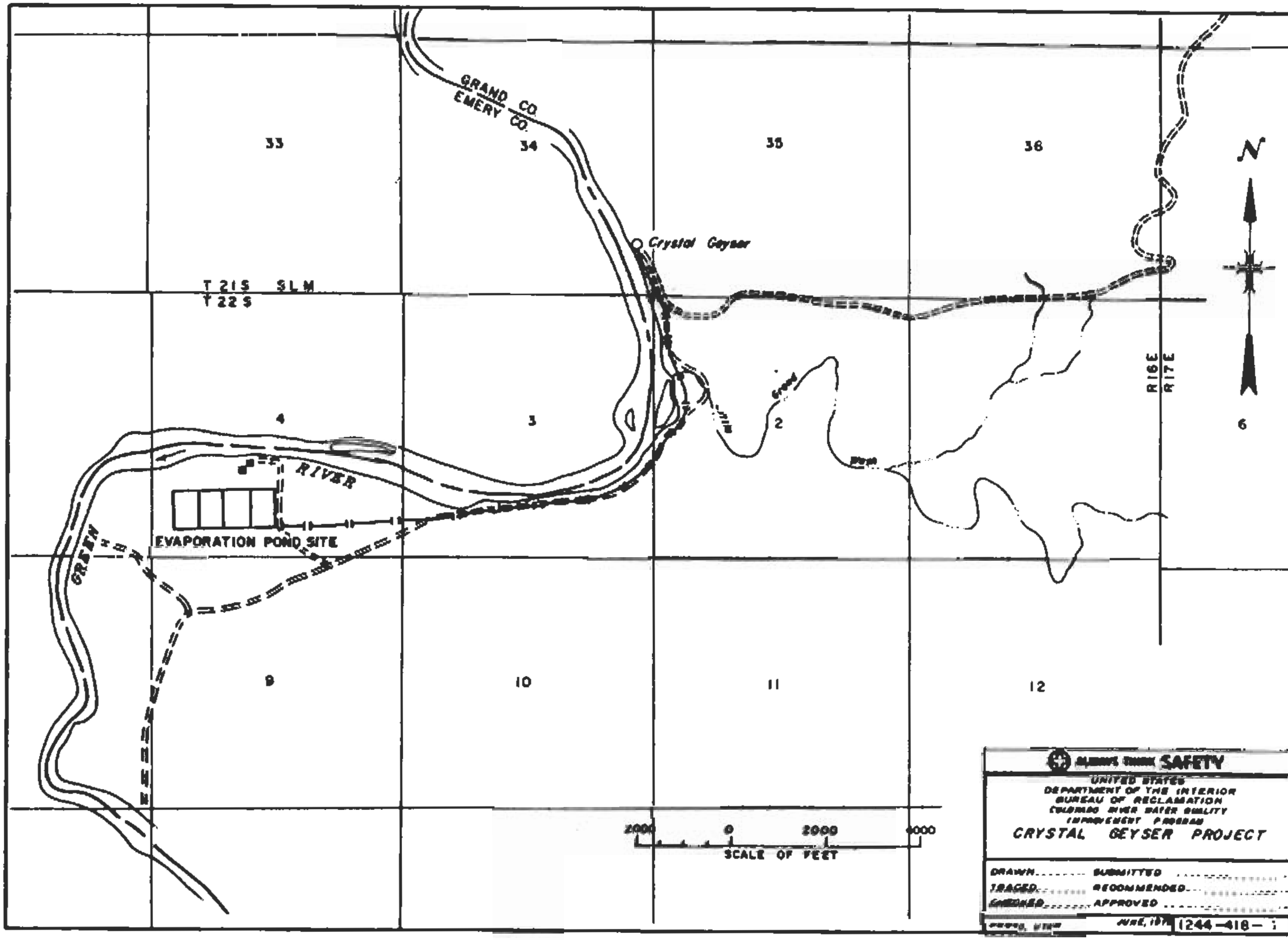

GRAND CO.
EMERY CO.
33
34
35
36
N
Crystal Geyser
T 21 S SLM
T 22 S
R16E
R17E
4
3
2
6
RIVER
GREEN
EVAPORATION POND SITE
9
10
11
12
2000
0
2000
4000
SCALE OF FEET
SAFETY
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
CRYSTAL GEYSER PROJECT
DRAWN
RECOMMENDED
APPROVED
1244-418-

Figure I-15

Table I-4

SUMMARY DISPLAY OF PHYSICAL FACTORS
Crystal Geyser

Item		
I. Water		
Water erupted annually based on 1972 measurements		150 ac-ft
Capacity of retention pond		.7 ac-ft
Capacity of evaporation ponds - all water evaporated	Initial	370 ac-ft
	After 100 yr.	150 ac-ft
Total dissolved solids		11,000 to 14,000 mg/l
Maximum flow during eruption		15 ft^3/s
Duration of eruption		6-8 min.
Time interval between eruptions		5-6 hrs.
II. Structural measures		
Retention pond dike		Compacted earthfill with plastic membrane
Pipeline to evaporating ponds		10" dia. PVC
Pipeline distance to evaporating pond		3.0 mi.
Evaporation pond dikes		Compacted earthfill with plastic membrane

a. Paradox Valley Unit, Colorado. -

(1) Introduction. - Paradox Valley, as shown on figure I-16, is a major natural source of salinity, contributing an estimated 200,000 tons of salt each year to the Dolores River as it crosses the valley enroute to its confluence with the Colorado River in southeastern Utah.

Investigations were initiated in FY 1972, when stream gaging and water quality stations were established at three sites: on the river at Bedrock (as it entered the valley), on West Paradox Creek (a tributary in the valley), and on the river as it leaves the valley. Three years of continuous flow measurements and weekly water quality samplings have indicated a salt pickup of 200,000 tons annually. During this period, the salt concentration of the river has ranged from 140 to 3,700 mg/l at the entrance to the valley and from 170 to 166,000 mg/l at the exit. The highest reading occurred during a period of no riverflow, when the water in the channel was composed entirely of surfacing ground water and irrigation return flows.

To determine the depth and areal extent of the saline ground-water body, a resistivity survey was conducted along the river late in FY 1972. Based on information obtained from this test, exploratory and observation wells were drilled to acquire additional data concerning subsurface water conditions. In FY 1973, 12 exploratory wells were drilled along both sides of the river in unconsolidated riverfill material. Perforated casings were installed so that water quality samples could be obtained and the water-table elevation and brine interface observed during a subsequent well pumping program. Also during FY 1973, five locations on the east side of the river were core drilled into the consolidated residual rocks of the valley floor at depths ranging from 74 to 200 feet.

Data obtained during the studies indicate that the shallow overburden of alluvial deposits along the flood plain of the river covers a brecciated gypsiferous formation, rich in sodium chloride salt. This formation is believed to be the residual cap of a collapsing salt anticline, or dome, which underlies the valley. Saturated brine lies within a few feet of the surface along the east side of the river and extends down to a depth of about 100 feet within a mile west of the river (fig. I-17). A shallow layer of relatively fresh ground water overlies the brine on the west side of the stream. Figure I-18 shows a view

PARADOX VALLEY, COLORADO

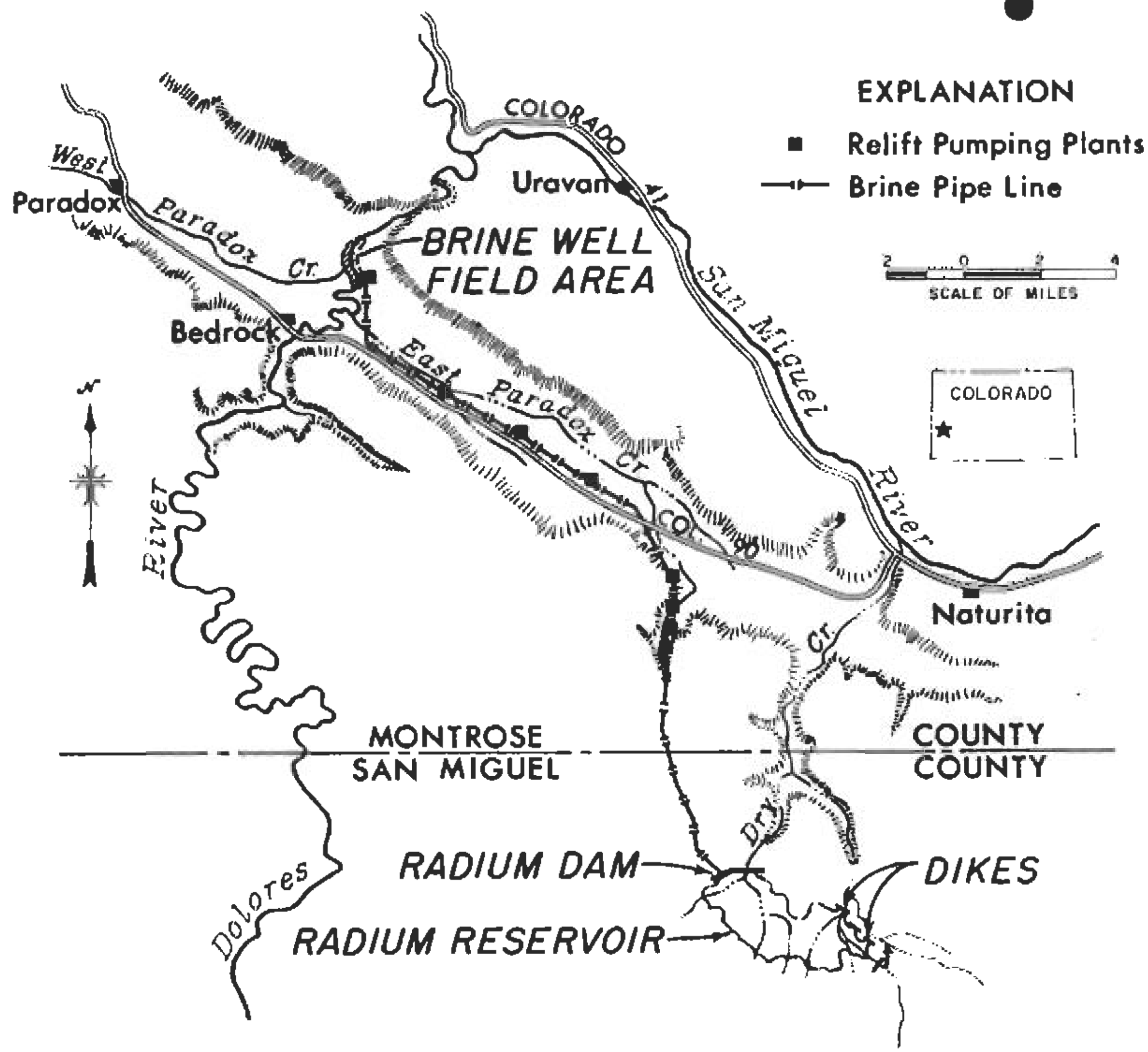
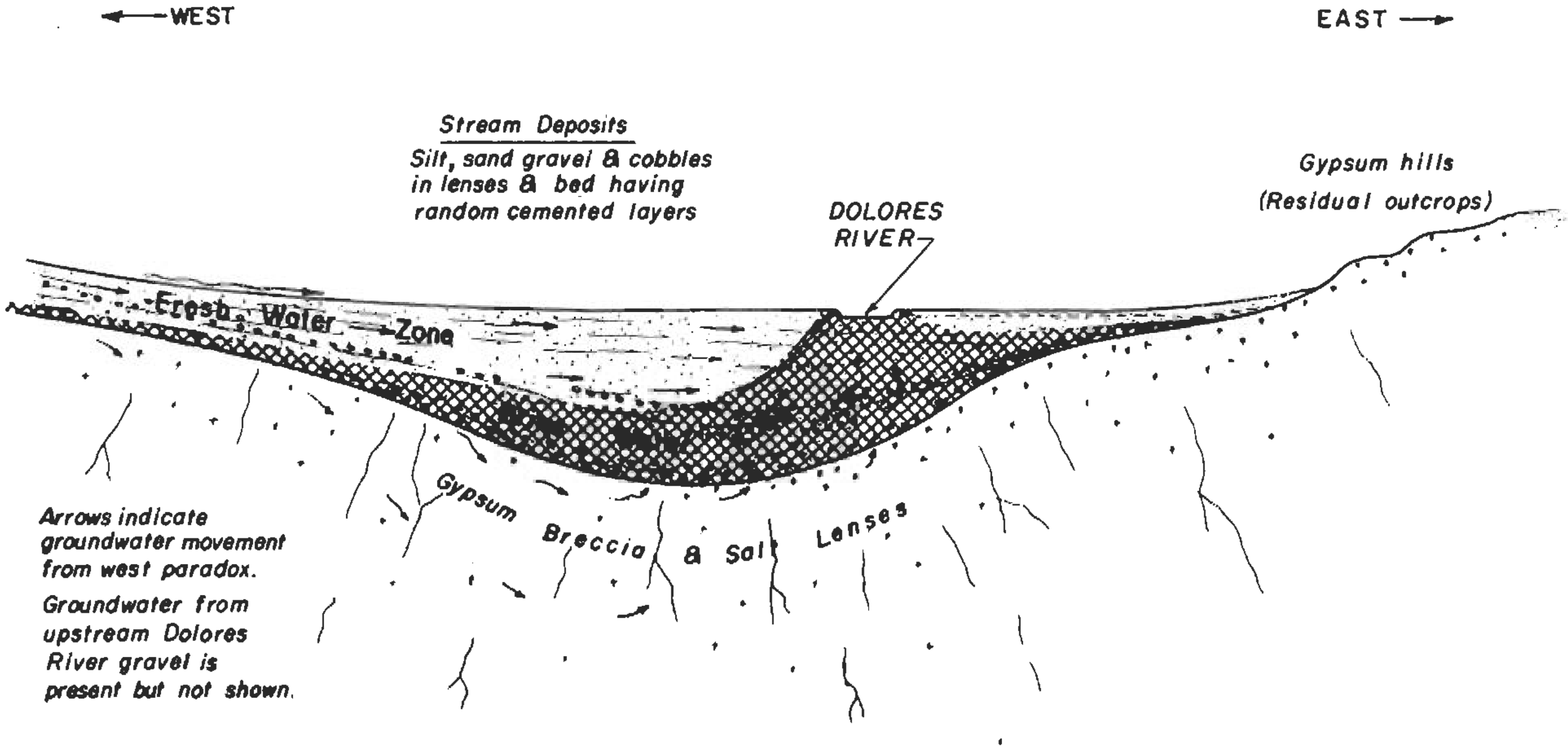


Figure I-16



SCHEMATIC SECTION ALONG PARADOX VALLEY
(LOOKING DOWNSTREAM)
Colorado River Water Quality Improvement Program
Paradox Valley Unit, Colorado

Figure I-17

Aerial view of Paradox Valley.

Figure I-18

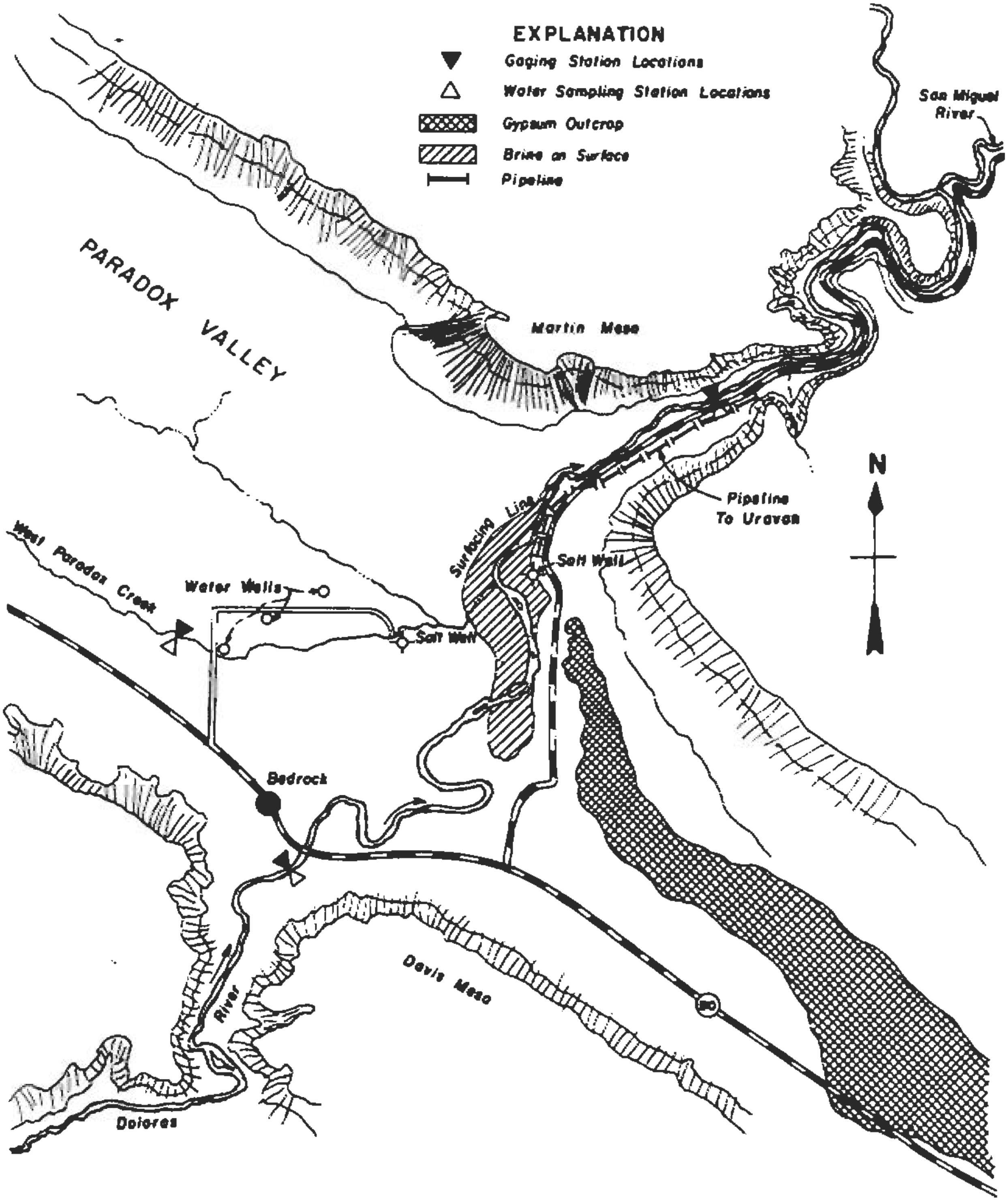
looking upstream (southwest) across the valley, with the salt flats left by evaporating brine along the river channel.

The alluvial materials are shallow on the sides of the valley and increase to a depth of 100 feet near the middle. Consisting of sand and silt near the surface grading to coarser gravel near the bottom, these deposits have replaced salts which have been leached from the underlying breccia, probably by ground water surfacing into the river. Figure I-19 shows the area along the stream where brine is found near the surface. The western margin of the area represents the surfacing line of the brine, and the remainder is essentially a stable impoundment. Data on the hydraulic characteristics of the brine-producing aquifers were obtained from pump tests conducted during FY 1974.

The plan of salinity control specified under item (2) below will reduce the salt contribution of the valley by about 180,000 tons, thus reducing the salinity of the Colorado River at Imperail Dam by about 16.3 mg/l.

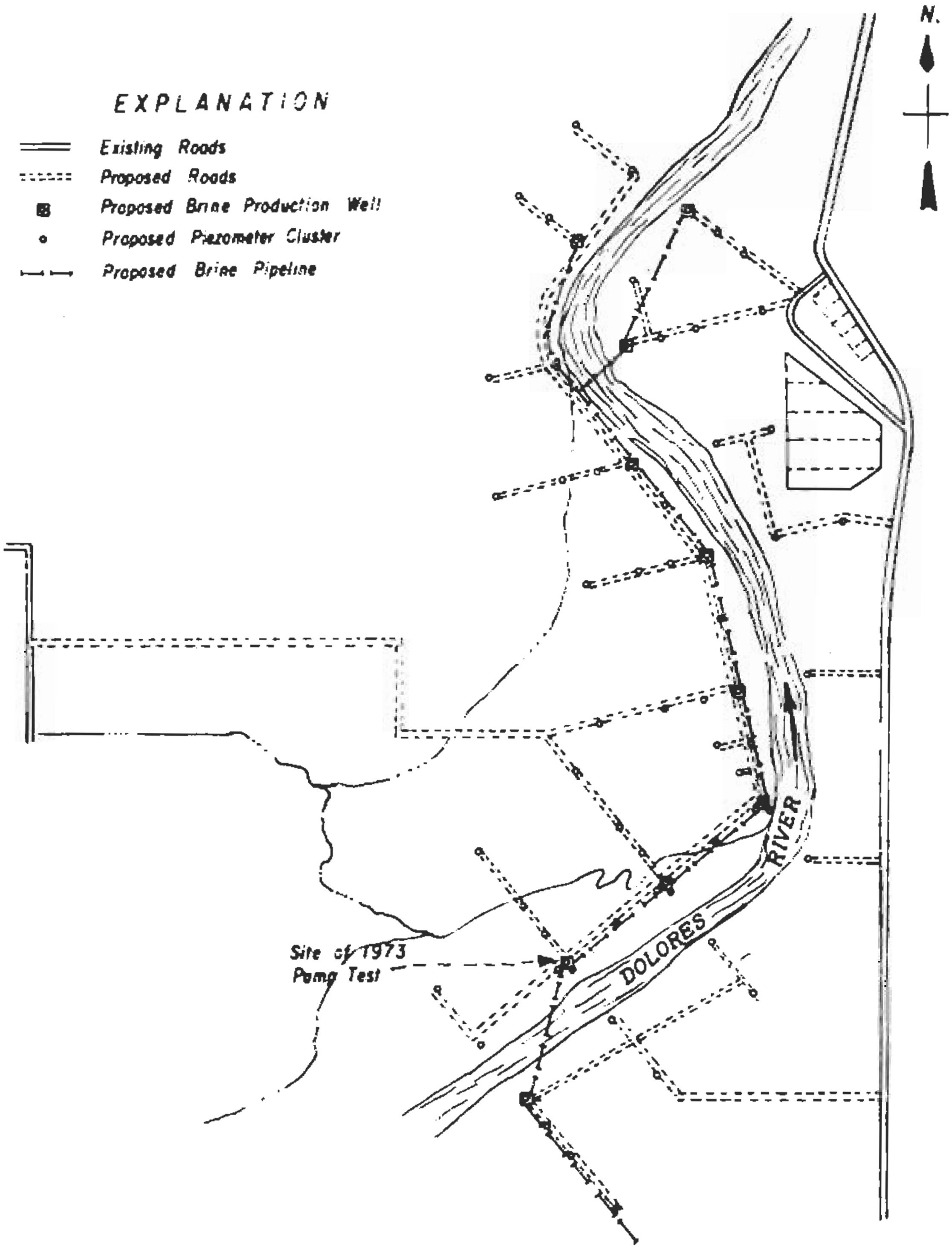
(2) <u>Location and description of unit features</u>. - The influx of salt into the Dolores River will be substantially reduced by drilling wells along both sides of the stream and pumping from the brine-producing zones to lower the interface between the layer of fresh ground water and the underlying brine. This could require as many as 18 wells, 10 along the west side of the river and 8 along the east side, with a combined pumping rate of up to 5 cubic feet per second (ft^3/s). The project is to be constructed and tested in three stages to determine the exact number of wells needed, the most effective locations, and rates of pumping for the individual wells.

(a) <u>First stage</u>. - In the advance-planning stage, a monitoring system has been established, consisting of multiple lines of piezometer clusters in the southern part of the well field (fig. I-20). The lines would extend outward from each side of the river. The clusters would total about 26, each consisting of 3 piezometers to gage a shallow zone at 0 to 20 feet and brine zones at 80 to 100 feet and 200 to 220 feet. In addition to the 26 observation holes, three exploratory wells will be drilled with each containing a piezometer and a groundwater observation pipe.



LOCATION OF SURFACING BRINE
Colorado River Water Quality Improvement Program
Paradox Valley Unit, Colorado

Figure I-19



WELL FIELD LOCATION

Colorado River Water Quality Improvement Program
Paradox Valley Unit Colorado

Figure I-20

(b) Second stage. - During this stage, approximately 18 wells will be drilled into the river gravels and each will be tested as it is completed. When all the wells are completed, the wells will be tested by pumping all or part of the wells in different combinations. The brine pumped during this testing period would be stored in a temporary pond located below the well field. Data obtained during this stage will be used in final sizing and design of the brine well field, stripping plant, pipeline and pumping plants, and Radium Evaporation Pond.

(c) Third stage. - During this construction stage, the remaining portion of the monitoring system will be constructed, any additional wells will be drilled, the brine pipeline laid, and the evaporation pond completed. The anticipated distribution of the wells and monitoring system (piezometers) is shown in figure I-20. Each well will be about 80 feet deep and lined with a corrosion-resistant material. The wells will be perforated adjacent to the production zone at 40 to 80 feet. A probable maximum of about 150 gallons per minute (gal/m) would be pumped at each location.

The brine is to be piped from the wells to a central collection point, where hydrogen sulfide gas will be converted to elemental sulfur and water in an oxidation process. This could require air stripping towers, pumps, chemical storage facilities, sand filters, and appurtenant facilities. The converted sulfur will then be piped to the evaporation pond with the brine, or used commercially.

A buried pipeline of reinforced plastic mortar will carry the brine from the well field to the Radium Evaporation Pond. The pipeline will be about 20.5 miles long, extending to the southeast along State Highway No. 90, then crossing the divide between Paradox Valley and Dry Creek Basin and terminating at the evaporation pond. Eight pumping plants and regulating tanks will be required to achieve the total dynamic lift of about 2,300 feet between the well field and the top of the divide, with the first plant located adjacent to the hydrogen sulfide treatment facilities.

Access roads will be constructed along both sides of the river and along each line of piezometer clusters. The three brine relift pumping plants adjacent to State Highway No. 90 in the valley will be accessible by short spurs constructed from the highway, while the plants located on the slope of the divide will require new roads.

The pumps required for the project will have a power demand of 2,230 kilowatts and will consume about 18.8 million kilowatt hours of electrical power each year. This energy can be delivered from existing transmission lines along the axis of the valley. Power for the well field, the hydrogen sulfide treatment facilities, and the first relift pumping plant will be supplied through a connection with the present line near the intersection of Highway No. 90 and the Dolores River. The three pumping plants along the highway will be served by three short lines, while a longer transmission line along the alinement to the top of the divide will be required for the last four plants.

The evaporation pond will be located on the West Fork of Dry Creek, a normally dry channel which drains into the San Miguel River, approximately 8 miles southwest of Naturita, Colorado. A shallow natural basin at the site will be enclosed by the construction of two dams across stream channels on the northern edge of the area and four dikes across low saddles on the eastern edge. The dams will be rolled earthfill structures founded on firm Dakota Sandstone, one rising about 92 feet and the other 71 feet above the streambeds. One dam would have a length of 6,200 feet and a crest width of 30 feet, while the other will have a length of 800 feet and a crest width of 30 feet. The dike will consist of two rolled earthfill sections with crest widths of 20 feet. The northern section will be 26 feet high and 2,500 feet long, while the southeastern section will be 13 feet high and 950 feet long. A concrete overflow structure on the dike will serve as an emergency spillway.

The evaporation pond will have a maximum surface area of 3,375 acres with a capacity of 99,300 acre-feet. A volume of 86,700 acre-feet with a surface of 3,200 acres will be allocated for the evaporation of brine and natural inflow and the accumulation of precipitated salts.

About 12,600 acre-feet of the remaining capacity is to be reserved for flood inflow. The pond will grow quite rapidly during the initial years of project operations, reaching a capacity of about 32,000 acre-feet with a surface of about 2,200 acres after approximately 10 years. The maximum salinity of 312,000 mg/l will be reached after about 13 years. The rate of filling will gradually decrease over the years, since the surface area will increase more rapidly than the volume, thus increasing the ratio of evaporation to inflow. At the end of the 50th year, the pond and salt deposits will cover an area of approximately 2,900 acres with a volume of about 58,000 acre-feet. An equilibrium between average annual inflow and evaporation will be reached shortly after 60 years. The actual growth of the pond will also fluctuate in response to variations from the average climatological conditions and the average annual rate of evaporation. Seasonal fluctuations are expected each year, since evaporation is much greater in the summer than in the winter. This could produce extensive salt flats on the edge of the pond during the summer months in the latter portion of the 100-year period of project operations.

b. Grand Valley Unit, Colorado. -

(1) Introduction. - There are about 71,000 acres of irrigable land in the Grand Valley, of which 57,500 are presently being irrigated. These irrigated lands of the valley, as shown on the Grand Valley Basin Unit map, figure I-21, are one of the major contributors of salt loading to the Colorado River. All sources in the Grand Valley are estimated to contribute an annual average of about 600,000 tons of salt to the Colorado River. (See table I-4a.) Most of these salts are leached from the valley's soil and highly saline shale formations and carried into the river by deep percolation. Water losses from conveyance systems and excess application of irrigation water are primarily responsible for this deep percolation. High water tables and salt buildup have reduced the agricultural productivity in the valley. Erosion along canals, laterals, washes, drains, and from irrigated fields is also a problem associated with the existing irrigation systems in the valley.

To control the salinity, three integrated plans of action have been considered, all of which require the cooperation

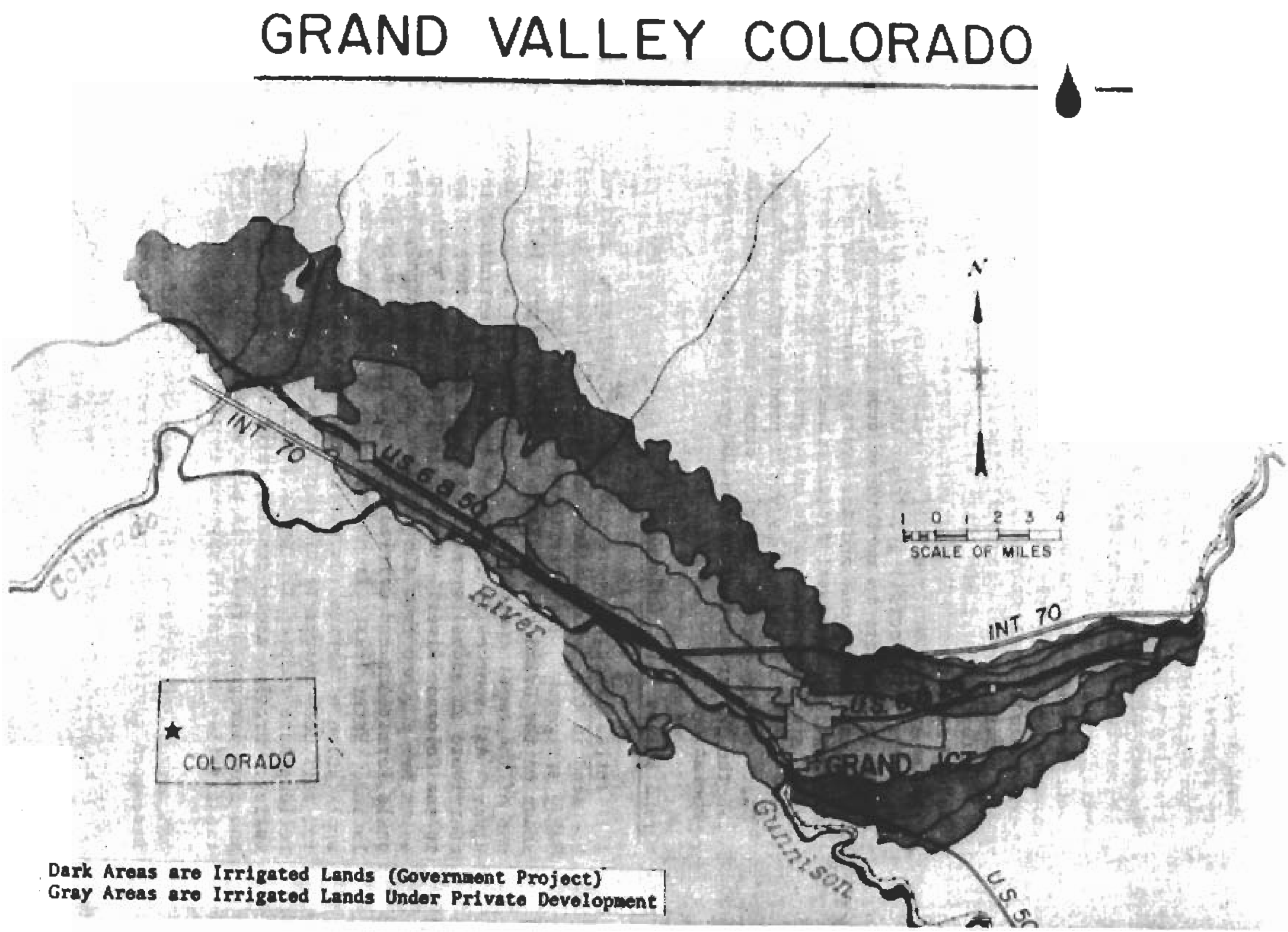

GRAND VALLEY COLORADO
INT 70
US 6 & 50
Colorado
River
SCALE OF MILES
INT 70
US 6
GRAND JCT
Gunnison
US 50
COLORADO
Dark Areas are Irrigated Lands (Government Project)
Gray Areas are Irrigated Lands Under Private Development

Figure I-21

Table I-4a

SALT PICKUP FROM THE GRAND VALLEY AREA (1,000 tons)

Water Year	Pickup to Stateline Gage[1]	Pickup to Cisco, Utah Gage[2]
1952	294	706
1953	497	622
1954	449	618
1955	584	461
1956	672	577
1957	271	623
1958	425	716
1959	523	522
1960	805	524
1961	628	578
1962	1,105	765
1963	580	650
1964	611	511
1965	740	701
1966	645	644
1967	660	760
1968	762	381
1969	849	60
1970	670	121
1971	898	31
1972	854	380
1973	1,026	628
1974	814	60
Total	15,362	11,644
Avg.	668	506

Remarks

[1] Salt load of the Colorado River near Stateline minus loads of Colorado River near Cameo and Gunnison River near Grand Junction and Pleateau Creek near Cameo.

[2] Salt load of the Colorado River near Cisco minus loads of the Colorado River near Cameo, Plateau Creek near Cameo, Gunnison River near Grand Junction and Dolores River near Cisco.

of the irrigators. The first is a Water Systems Improvement (WSI) program; second, an Irrigation Management Services (IMS) program; and third, an Onfarm Irrigation System and Management Improvement program. Investigations of a fourth plan of action, that of utilization of poor quality return flow are scheduled for FY 1977.

(2) Water Systems Improvement Program (WSI). - There are approximately 213 miles of canals and 503 miles of laterals in the valley (see fig. I-21) with only a few of the laterals and parts of some canals presently concrete or gunite lined. Figures I-22 and I-23 are views of an unlined lateral and canal which are typical of the condition of the present water delivery systems.

Some of the concrete- and gunite-lined sections of canals and laterals would be rehabilitated in the WSI program. It is anticipated that the first 6.3 miles of the Government Highline Canal and 1.7 miles of the Redlands Power Canal would be left in open, unlined sections because seepage from either of the two canals in these reaches returns directly to the river. Structures in these reaches of canals would similarly not be rehabilitated in connection with the WSI program.

The designs for the WSI program are based on using the present alinements for the canals and laterals, using current Bureau of Reclamation design standards for lining and structures, and using present water delivery elevations. Figure I-24 is a view of a lateral which has recently been lined with concrete by a group of farmers with engineering assistance from the Soil Conservation Service and cost sharing under the Agricultural Conservation Program. This construction is an example of the type of construction anticipated under WSI. For purposes of preparing a feasibility cost estimate, the Grand Valley Unit was divided into 12 subareas. Each subarea includes a major canal or section of major canal and all laterals under that canal. Figure I-21 shows the major irrigated land areas of the valley.

Table I-5 shows the initial capacities, lengths, and number of structures as they would be reconstructed in each of the 12 subareas under the WSI program. In addition to the structures shown on table I-5, 21 cross-drainage culverts would be replaced, 300 feet of elevated flume constructed across drainages, 1,040 feet of pipe sections constructed along canals, and 76,095 feet of pipelines constructed to replace

Grand Valley Basin Unit, unlined lateral.

Figure I-22

Grand Valley Basin Unit, unlined canal.

Figure I-23

Grand Valley Basin Unit, concrete-lined lateral.

Figure I-24

Table 1-5

CANAL AND LATERAL DATA - GRAND VALLEY BASIN UNIT

System name	Initial capacity, ft^3/s	Length miles	Road crossings	Concrete canal bridges	Turn-outs	Measuring devices	Drops and chutes	Checks	Irrigation crossings
Canals									
Government Highline	600	46.9[1]		33	144			11	34
Grand Valley	650	12.3		13	132		2	3	9
Grand Valley Mainline	250	13.8	8	10	114		1	12	18
Grand Valley Highline[2]	300	38.7	8	46	294			11	26
Mesa County	40	4.2	1		33	1	3	1	4
Independent Ranchmens	70	11.7	6	5	96	1	8	6	2
Price	100	9.0	5	14	167			8	16
Stubb	30	10.2	12		99		1	4	3
Orchard Mesa Power	850	2.4[3]		4	18				
Orchard Mesa No. 1	110	16.3	17	29	141		1	7	25
Orchard Mesa No. 2	70	17.3	16		124				1
Redlands:									
Redlands Power	850	1.8[4]			20				
Redlands Service	60	19.5			80				
Total		204.1	73	154	1,462	2	16	63	138
Laterals									
Government Highline	2-50	160.0	496		1,035	809	653	281	48
Grand Valley	2- 8	29.2	130		182	201		91	3
Grand Valley Mainline	2-30	62.1	174		186	401	23	57	11
Grand Valley Highline	2-20	98.0	241		631	682	21	253	3
Mesa County	2- 8	14.1	96		99	99		45	
Independent Ranchmens	2-15	28.0	53		109	130		40	
Price	2- 8	40.1	194		322	355	174	123	
Stubb	2- 6	6.6	19		53	64		17	
Orchard Mesa Power	2	4.0			5	10			
Orchard Mesa No. 1	2-30	25.2	86		132	165	3	25	
Orchard Mesa No. 2	2- 6	18.1	23		50	140		3	
Redlands:									
Redlands Power	2	0.5			4	4			
Redlands Service	2	17.4			21	21			
Total		503.3	1,512		2,829	3,081	874	935	65

[1] Length is from outlet of Tunnel No. 3 to end of canal. Total length of canal is 53.2 miles.
[2] Includes Keifer Extension.
[3] Length to be lined. Total length is 3.5 miles.
[4] Length to be lined. Total length is 3.5 miles.

existing unlined laterals. The road crossings and pipe sections would be buried concrete pipe sections, and the irrigation crossings would consist of steel and corrugated-metal pipe spanning across the canals and laterals. Some existing structures on canals would not need replacing under the WSI.

Table I-6 shows the lengths, initial dimensions, and terminal dimensions for canals and lateral systems at they would be reconstructed in each of the 12 subareas. There are a number of laterals under each canal system with varying initial capacities. The figures shown in table I-6 in the column "initial dimensions" are for the largest lateral under the system. The initial capacities of the laterals range from the figures shown, down to a capacity of 2 ft^3/s.

There are a very limited number of measuring devices on either the turnouts to the laterals from the canals, or the turnouts to the individual farms from the laterals. The WSI program includes construction of measuring devices at all turnouts from canals and laterals.

Design flow capacities of the canals and laterals were computed, based on crop consumptive use, cropping patterns, climatic data for the valley, and an irrigation efficienty of 60 percent (obtainable under controlled irrigation management). These computed capacities shown in tables I-5 and I-6 for the canal compare quite closely with the present diversion capacities. Cross sections of the existing canals and laterals are larger than those required for the proposed concrete-lined sections. Very little excavation would be required during construction. In areas where two or more laterals closely parallel each other, consideration will be given to combining these laterals.

Material required for embankment would be obtained as close to the point of utilization as practical from a geological, economical, and environmental standpoint. Potential areas are located north of the Government Highline Canal, south of Orchard Mesa Canal No. 2, along the Colorado River, and along the alinements of the existing canals and laterals. Access roads would have to be constructed to the areas north of the Government Highline Canal and south of Orchard Mesa Canal No. 2. Sand and gravel for concrete aggregate would be obtained from existing pits in the Grand Junction, Fruita, and Whitewater areas. Cement, steel, pipe, and other prepared construction materials would be imported.

Table 1-6

CANAL AND LATERAL DIMENSIONS - GRAND VALLEY BASIN UNIT

System name	Lengths (miles)				Initial dimensions				Terminal dimensions			
	Total length	Open unlined	Concrete lined	Inline structures	Capacity ft^3/s	Water depth, ft.	Water width, ft.	Lining height, ft.	Capacity ft^3/s	Water depth, ft.	Water width, ft.	Lining height, ft.
Canals												
Government Highline	46.9[1]	45.8		1.1	600	6.65	36.95	8.0	25	2.07	7.14	2.5
Grand Valley	12.3	12.3			650	5.12	31.36	7.0	500	5.33	20.0	6.75
Grand Valley Mainline	13.8	13.5		0.3	250	4.14	18.42	5.25	25	1.98	6.96	2.5
Grand Valley Highline[2]	38.7	38.3	0.1	0.3	300	4.44	19.32	5.5	25	1.86	6.72	2.5
Mesa County	4.2	2.5	1.3	0.4	40	2.00	9.0	2.8	2	.72	2.44	1.3
Independent Ranchmens	11.7	10.8	.6	0.3	70	2.9	14.7	5.5	30	2.22	9.7	2.75
Price	9.0	5.9	3.0	0.1	100	4.0	17.0	4.5	10	1.32	4.64	2.0
Stubb	10.2	7.0	3.1	.1	30	1.82	8.5	2.5	4	1.0	3.0	1.7
Orchard Mesa Power	2.4[3]	2.4			850	8.8	38.3	10.25	850	8.8	38.3	10.25
Orchard Mesa No. 1	16.3	15.0		1.3	110	3.6	15.8	4.0	6	1.2	4.4	1.75
Orchard Mesa No. 2	17.3	16.2		1.1	70	3.0	13.0	3.5	6	1.0	4.0	1.5
Redlands:												
Redlands Power	1.8[4]	1.8			850	7.4	38.2	9.0	850	7.4	38.2	9.0
Redlands Service	19.5	6.7	11.5	1.3	60	2.3	9.9	3.2	2	.72	2.44	1.3
Total	204.1	178.2	19.6	6.3								
Laterals												
Government Highline	160.0	152.1	3.2	4.7	[5] 50	2.2	9.6	3.0	2	.72	2.44	1.3
Grand Valley	29.2	19.2	4.1	5.9	8	1.1	4.2	1.67	2	.72	2.44	1.3
Grand Valley Mainline	62.1	31.4	28.7	2.0	30	1.64	7.9	2.5	2	.72	2.44	1.3
Grand Valley Highline	98.0	81.7	13.2	3.1	20	1.5	5.0	2.3	2	.72	2.44	1.3
Mesa County	14.1	13.2	0.2	.7	8	1.1	4.2	1.67	2	.72	2.44	1.3
Independent Ranchmens	28.0	15.6	5.0	7.4	15	1.32	4.64	2.16	2	.72	2.44	1.3
Price	40.1	26.4	4.6	9.1	8	1.1	4.2	1.67	2	.72	2.44	1.3
Stubb	6.6	2.8	0.1	3.7	6	1.2	3.4	1.8	2	.72	2.44	1.3
Orchard Mesa Power	4.0	.5	1.7	1.8	2	.72	2.44	1.3	2	.72	2.44	1.3
Orchard Mesa No. 1	25.2	18.8	2.5	3.9	30	1.64	7.9	2.5	2	.72	2.44	1.3
Orchard Mesa No. 2	18.1	5.4	1.1	11.6	6	1.2	3.4	2.16	2	.72	2.44	1.3
Redlands:												
Redlands Power	0.5	0.5			2	.72	2.44	1.3	2	.72	2.44	1.3
Redlands Service	17.4	9.9	1.8	5.7	2	.72	2.44	1.3	2	.72	2.44	1.3
Total	503.3	377.5	66.2	59.6								

[1] Length is from outlet of Tunnel No. 3 to end of canal. Total canal length is 53.2 miles.
[2] Includes Keifer Extension.
[3] Length to be lined. Total length is 3.5 miles.
[4] Length to be lined. Total length is 3.5 miles.
[5] The lateral initial capacity given is for the largest lateral under the system.

Small amounts of riprap would be needed on wasteways and on small drops along parts of the alinements of the Independent Ranchmens Ditch and the Mesa County Ditch where these canals follow natural drainage channels. It is planned to use broken concrete from replaced structures along the canals and laterals as much as possible for this riprap.

(a) Rights-of-way. - The rights-of-way along the existing canals, laterals, and drains consist of reserve right-of-way and deeded or dedicated rights-of-way. In areas where the Soil Conservation Service has lined existing laterals, the lateral owners have obtained construction rights-of-way by easements. Under WSI, where existing canals and laterals are to be lined, the irrigation entities would obtain the required rights-of-way for construction.

(b) Construction program. - A detailed construction program has not been prepared for the Grand Valley WSI program. Most construction work will have to be performed during the nonirrigation season in the spring and fall of the year.

(3) Grand Valley Irrigation Management Services (IMS). - The ongoing Grand Valley IMS program complements the Systems Improvement program and the Onfarm Irrigation Systems and Management Improvement program. In the Grand Valley, IMS is expected to improve the efficiency of water use and thereby reduce the salt loading from irrigated lands.

The IMS program focuses on advising the irrigator of when to irrigate and the amount of soil moisture needed to be replaced. Computer printouts showing daily soil moisture, recommended optimum irrigation date, and the amount of soil moisture to be replaced at the next irrigation are given to irrigators. Then the irrigators follow the predictions as closely as workloads and available water permit.

The initiation of the irrigation scheduling activities required the assembly of considerable input data and the adjustment of the computer program to fit Grand Valley conditions. Emphasis was placed on proper characterization of the soil properties related to moisture retention and movement. Climatic data were obtained from the National Weather Service Office at the Grand Junction airport; however, conditions there are not representative of those in the irrigated fields. A complete weather station was therefore established within the irrigated area to obtain data for the scheduling program (see fig. I-25).

Each field is visited weekly by a field representative to compare the computer output prediction with actual field conditions. During a farm visit, such items as crop condition, root zone, water table, soil moisture, irrigation applications, and efficiencies are observed. Participating farmers are given assistance on ways to improve efficiencies through adjustment in the irrigation schedule and amounts of soil moisture to replace.

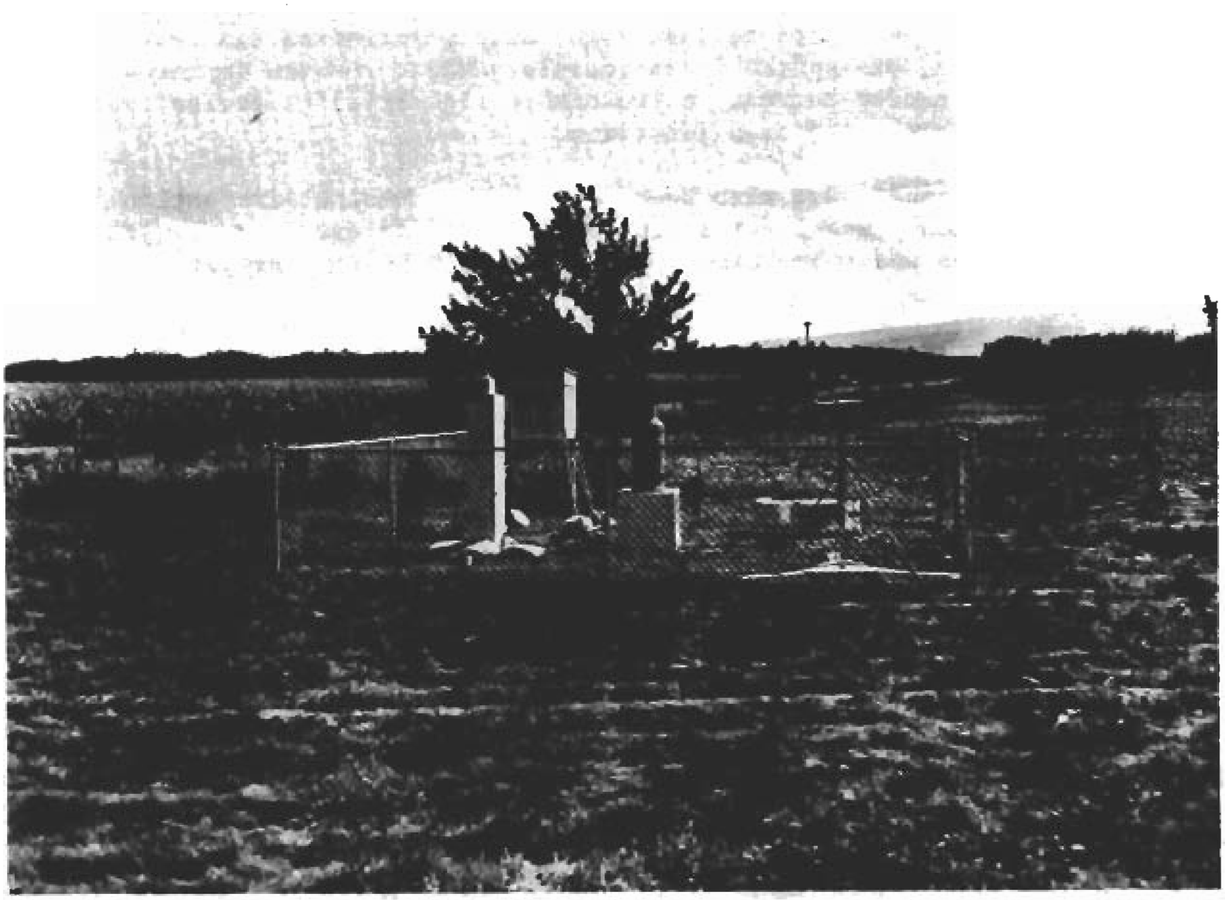
In association with the IMS program, ground-water observation wells have been installed in many fields to determine the effects of high water tables on crop consumptive use and to determine whether these water tables are caused by over-irrigation and/or canal seepage. Additional wells will be installed jointly for the IMS and WSI programs as they continue.

One hundred twenty farms participated in scheduled irrigation operations during the 1973 irrigation season. These included 43 participants carried over from the 1972 season. All returning participants increased the acreage to be scheduled, with some including their entire farm operation. During the 1973 and 1974 seasons, about 7,000 acres were scheduled, comprising approximately 10 percent of the Grand Valley area. The 1973 level of participation was maintained in 1974 with the goal of increasing onfarm water management and irrigator cooperation.

Federal participation is to be concluded in 1977, at which time most of the irrigable land in Grand Valley will be covered by an IMS program, administered and financed locally.

(4) Onfarm Irrigation Systems and Management Improvement. - The Grand Valley onfarm investigations have involved a review and analysis of available data on water delivery, irrigation methods and characteristics, irrigation management, irrigation systems, crops grown, and the agricultural economy in the valley. Available data was supplemented by field investigations. The onfarm inventory of present irrigation practices, needed systems improvement and other conservation needs is nearly complete.

Data has been gathered on nearly all fields utilizing soil surveys, aerial photos, conservation farm plans and field



Grand Valley Basin Unit, weather station.

Figure I-25

studies. Contacts with individual farmers have totaled 2,210 and represents an inventory on 125,000 acres including 64,750 acres of irrigated cropland. Data collected included: soil series and phases in each field; field layouts; linear feet of lined and unlined farm ditches; field slopes; size, type and number of onfarm water control structures; and existing drainage, and occurrence of fields with high water tables.

The present seasonal irrigation efficiency for each field and the amount of tailwater and deep percolation has been computed, using the field inventory data. System improvements needed to reach a reasonably high level of irrigation efficiency have been identified.

Projections have also been made of the seasonal irrigation efficiency and the resulting tailwater and deep percolation volumes under improved conditions, to provide a comparison with existing conditions.

(5) Effects. - In Grand Valley, the combined effects of these programs is expected to improve the efficiency of water conveyance and onfarm use.

Onfarm irrigation application efficiencies currently average about 33 percent. With a full implementation of onfarm system improvements, use of cutback heads, pump back facilities, a high level of irrigation management, and full participation of the irrigators in the IMS program, it is possible that the average onfarm application efficiency could be increased to about 60 percent.

Conveyance efficiencies in the onfarm field ditch systems and main canal and lateral systems are also expected to be improved with implementation of the programs, resulting in a reduction in seepage losses and management spills.

It is expected that the combined WSI and IMS programs will remove 200,000 tons of salt from the Colorado River System and thus reduce the salinity at Imperial Dam by 19 mg/l.

It is expected that the combined programs will reduce the salt load pickup by 340,000 tons from the Grand Valley irrigated area and reduce the salinity concentration at Imperial Dam by 33 mg/l.

3. Authorized Feasibility Studies

Pursuant to P.L. 93-320, the Secretary has undertaken a program to expedite the completion of any additional salinity control unit studies that have not progressed to the state of qualifying for construction. These additional control units have been classified into three general categories:

Point source control studies. - These are units where the discharges of saline waters are concentrated in a relatively small area.

Irrigation sources. - Those areas where the implementation of WSI, IMS, Onfarm Irrigation System and Management Improvement Program and return-flow utilization programs can reduce the volume of saline irrigation return flows to the river system. These also include adjacent watershed areas that contribute salt to the Colorado River System.

Diffuse source control. - These have been identified primarily as tributary subbasins whose rivers or streams accumulated excessive salts as a result of pickup of dissolved solids from salt-producing geologic formations and associated soils in the watershed area, saline seeps, and irrigation return flows.

a. Point source studies. - The following three units have been identified as point source contributors of salt to the Colorado River. They consist primarily of thermal springs containing a large concentration of dissolved salts. Control of these three sources of salinity would result in a combined reduction of 319,700 tons of salt to the Colorado River, which would reduce the salinity at Imperial Dam by 32 mg/l.

(1) LaVerkin Springs Unit, Utah. -

(a) Introduction. - Several springs, sometimes referred to as Dixie Hot Springs, are scattered along a 2,000-foot reach of the Virgin River between Hurricane and LaVerkin near the lower end of Timpoweap Canyon. During the late summer and fall, these springs constitute nearly all of the riverflow downstream from the discharge points. Measurements indicate that in the spring the maximum flow is 12 ft^3/s. An average flow of 11.5 ft^3/s was adopted for evaluating the effects of the project on water quantity and quality.

Chemical analyses of 17 sites (fig. I-28) indicated a maximum probable salinity of 10,000 mg/l, and an average value of 9,650 mg/l. Based on an average flow of 11.5 ft^3/s at 9,650 mg/l, the salt contribution to the Virgin River averages 109,000 tons per year. Water temperatures of the springs range from 100° to 109° F. The Environmental Protection Agency has indicated that the spring flows contain, in addition to salts, the radioactive element radium-226 in average concentrations of about 37 picocuries per liter (pc/l).[13]

The development of the proposed unit would consist of facilities for removing approximately 94 percent of the dissolved salts from the spring flows. A bypass system would be constructed to route the Virgin River around the springs, and the spring flows would be collected and desalted. The product water would be returned to the river, and the brine resulting from the treatment would be pumped to an evaporation pond. The project area is shown in figures I-26 and I-27. The LaVerkin Springs Unit would remove about 103,000 tons of salt per year from the Lower Colorado River system which would ultimately result in a decrease of 11 mg/l in the quality of water at Imperial Dam. However, it is recognized that benefits actually observed downstream depend to a large extent on complex chemical and hydrologic interactions associated with intervening projects and natural conditions.

Use of the high quality product water would particularly enhance local agriculture and reduce farm labor on those lands served by irrigation diversions below the springs. Much of this would result from the reduced need for off-season leaching of accumulated salts from irrigated lands.

(b) Location and description of unit features. -

Bypass system. - The proposed bypass system would consist of a concrete upper diversion dam and a bypass pipeline. The diversion dam would be located above the springs. This would be about 2,400 feet above the mouth of Timpoweap Canyon. The system is designed to handle a 100-year flood of 23,500 ft^3/s. An inlet structure protected by an appropriate trashrack will be incorporated in the right abutment. A 96-inch reinforced concrete pipe will begin at this point and carry the diverted flows around the springs.

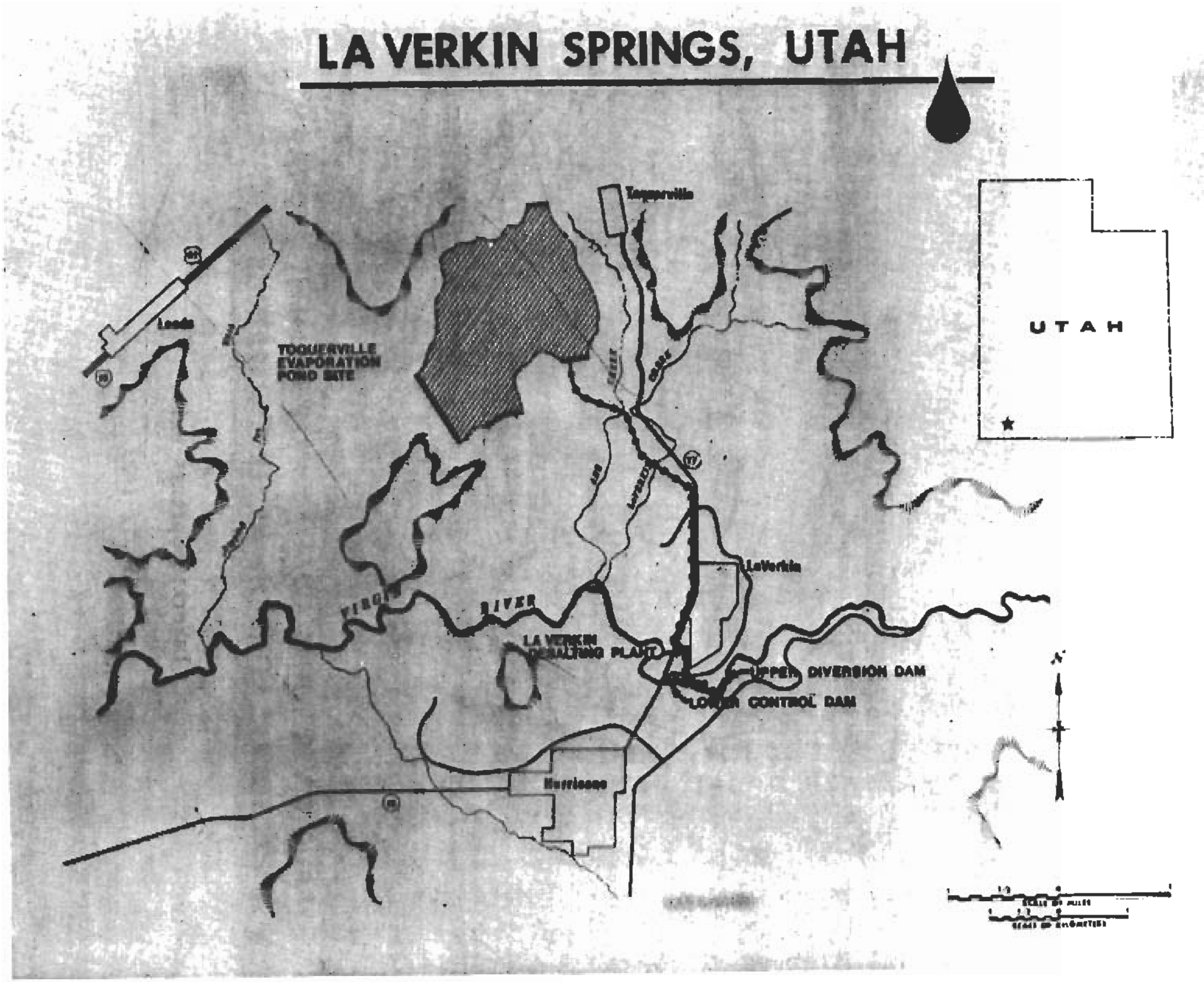
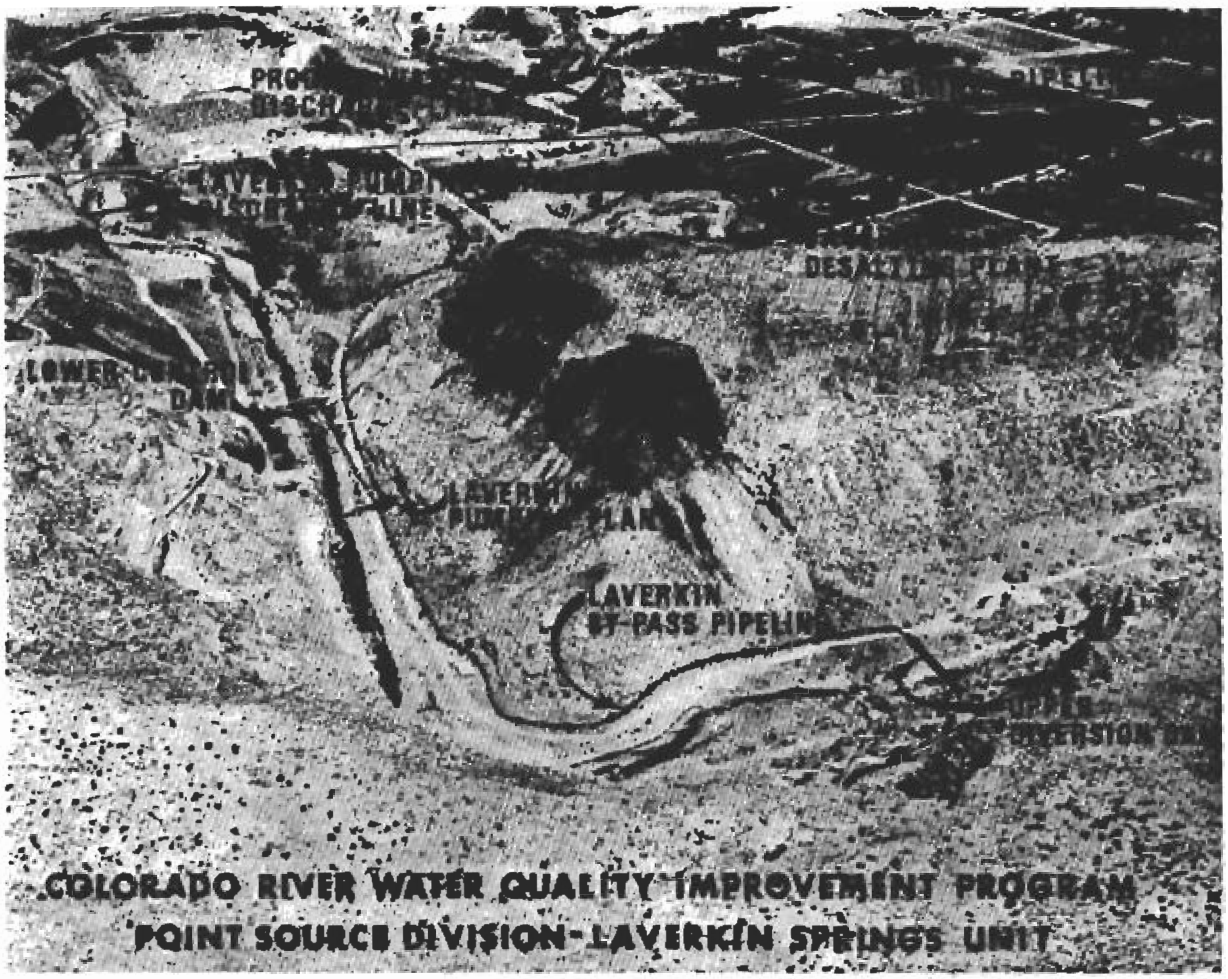

LAVERKIN SPRINGS, UTAH
Toquerville
Leeds
TOQUERVILLE
EVAPORATION
POND SITE
UTAH
LaVerkin
VIRGIN RIVER
LA VERKIN
DESALTING PLANT
UPPER DIVERSION DAM
LOWER CONTROL DAM
Hurricane

Figure I-26



LaVerkin Springs Unit.

Figure I-27

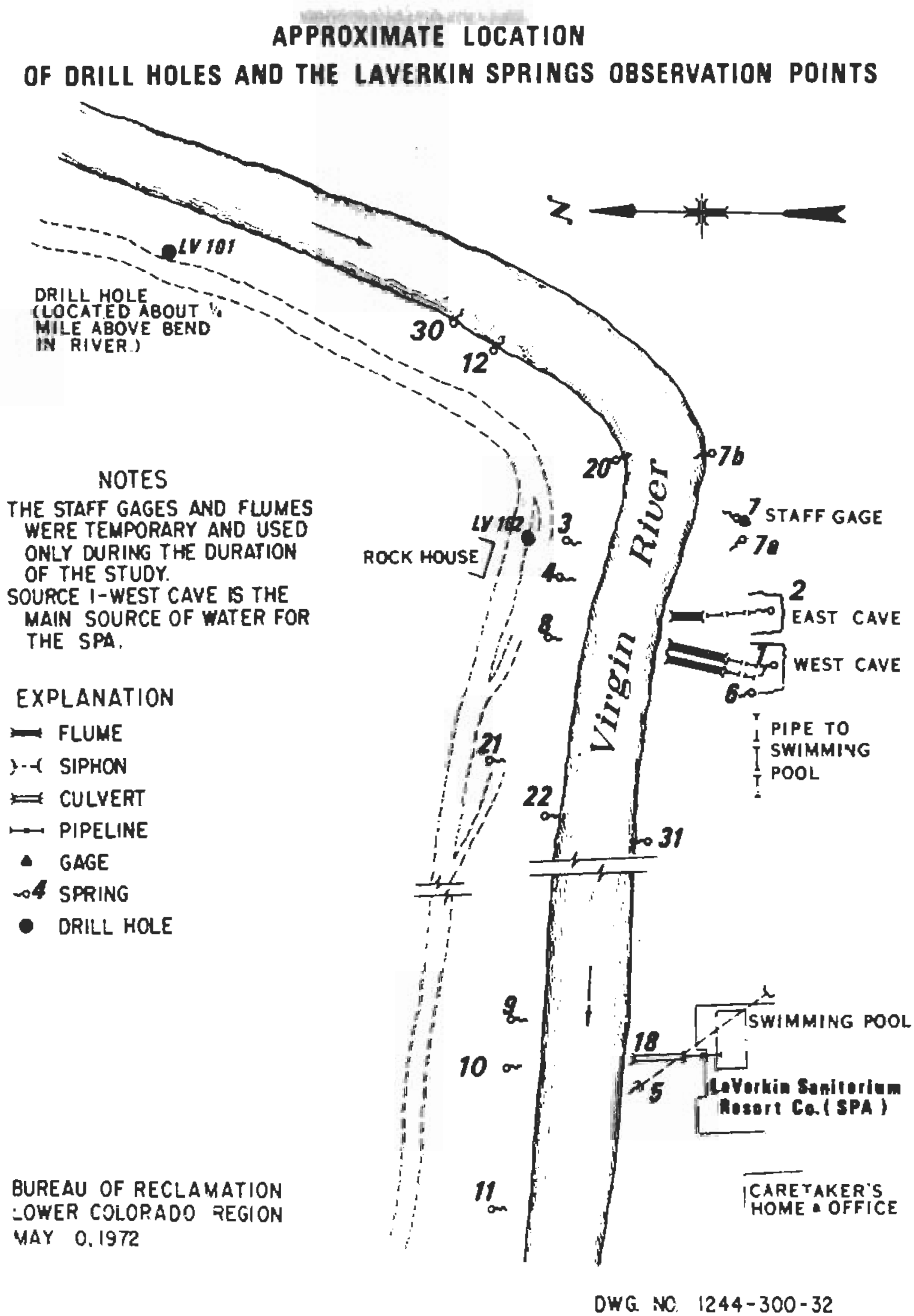

APPROXIMATE LOCATION
OF DRILL HOLES AND THE LAVERKIN SPRINGS OBSERVATION POINTS
N
LV 101
DRILL HOLE (LOCATED ABOUT ¼ MILE ABOVE BEND IN RIVER.)
30
12
20
7b
NOTES
THE STAFF GAGES AND FLUMES WERE TEMPORARY AND USED ONLY DURING THE DURATION OF THE STUDY.
SOURCE I-WEST CAVE IS THE MAIN SOURCE OF WATER FOR THE SPA.
LV 102
3
7 STAFF GAGE
7a
ROCK HOUSE
4
Virgin River
2
EAST CAVE
8
1
WEST CAVE
6
EXPLANATION
FLUME
SIPHON
CULVERT
PIPELINE
GAGE
4 SPRING
DRILL HOLE
PIPE TO SWIMMING POOL
21
22
31
9
SWIMMING POOL
18
10
5
LaVerkin Sanitorium Resort Co. (SPA)
BUREAU OF RECLAMATION
LOWER COLORADO REGION
MAY 0, 1972
11
CARETAKER'S HOME & OFFICE
DWG. NO. 1244-300-32

Figure I-28

Access is provided along an existing dirt road. The bypass pipeline will be buried along the same right-of-way as the access road. Figure I-29 shows the general area of the diversion dam.

Collection system. - A lower control dam, pumping plant, and discharge pipeline form the collection system. The proposed lower control dam would be located on the river below LaVerkin Springs and just upstream from the old lower bridge, about 2,300 feet downstream from the upper diversion damsite. It would consist of a fiber-fabric rubber inflatable tube affixed to a concrete apron and cutoff wall in the excavated streambed. The dam would be filled (inflated) with either river water or culinary water from the desalting plant. The spring discharges would then be ponded, forming a forebay for the pumping plant.

During periods of high floodflow when the upper dam is spilling, the lower dam would be deflated to allow the flows to pass downstream without ponding above present water levels. This action would also clear the pond area of debris and sediment deposition. Figure I-30 shows this damsite.

To lift the ponded spring discharges to the treatment facilities, a pumping plant would be located on the north bank of the ponded area upstream from the inflatable lower control dam. Spring discharges would be conveyed to the proposed desalting plant through a buried 21-inch-diameter discharge pipeline.

Treatment and disposal system. - Treatment of the spring water would be accomplished through a desalting plant located on a low plateau above the river in the town of LaVerkin, Utah. Access to the plant would be along existing roads. The plant would utilize a reverse-osmosis (RO) process and would include pretreatment in the form of calcium reduction, cooling, and filtration. The design capacities are based on a maximum spring flow of 12 ft^3/s with a salinity of 10,000 mg/l of dissolved solids.

Following pretreatment and desalting in the RO plant the treated product water, containing about 500 mg/l,

LaVerkin Springs Unit - view of upper diversion damsite.

Figure I-29

LaVerkin Springs Unit - view of lower control damsite.

Figure I-30

would be returned to the river through an 18-inch-diameter, 1,600-foot-long buried pipeline. The pipe would have a baffled outlet. A 12-inch-diameter pipeline would convey the brine wastes to the Toquerville Evaporation Pond. This pipeline would consist of about 18,120 feet of buried reinforced concrete pressure pipe and about 800 feet of specially treated steel pipe as required for bridge crossings. Other types of pipe such as plastic reinforced mortar pipe will be evaluated.

The Toquerville Evaporation Pond would consist of a pond area of 440 acres located in a natural depression southwest of Toquerville, Utah. Four rolled earthfill dikes would be required. Seepage would be prevented through the installation of 10-mil polyvinyl chloride (PVC) sheeting protected with an earth covering. An additional 210 acres would be required as a buffer zone for operation and maintenance purposes.

(c) Rights-of-way. - The lands required for surface structures and for rights-of-way would total about 681.1 acres. This would include about 11.9 acres for the collection system, 2 acres for the feeder pipeline, 17.2 acres for the desalting plant, product water, and brine pipelines, and 650 acres for the evaporation pond.

(d) Construction materials. - There are sufficient quantities of impervious materials and concrete aggregate for construction purposes within the immediate area of the project features. Some of these materials are available from commercial sources. At the Toquerville Evaporation Pond site, quantities of impervious, semipervious, and riprap materials are available in the reservoir area and along the surrounding ridges.

(2) Littlefield Springs Unit, Arizona. -

(a) Introduction. - The Littlefield Springs are a widely scattered group of springs located along the south side of the Virgin River about 1 mile upstream from Littlefield, Mohave County, Arizona (see fig. I-31). The springs are classified as a point source of salinity. Feasibility investigations were started in Fiscal Year 1974 and are scheduled to be completed in Fiscal Year 1976.

LITTLEFIELD SPRINGS, ARIZONA

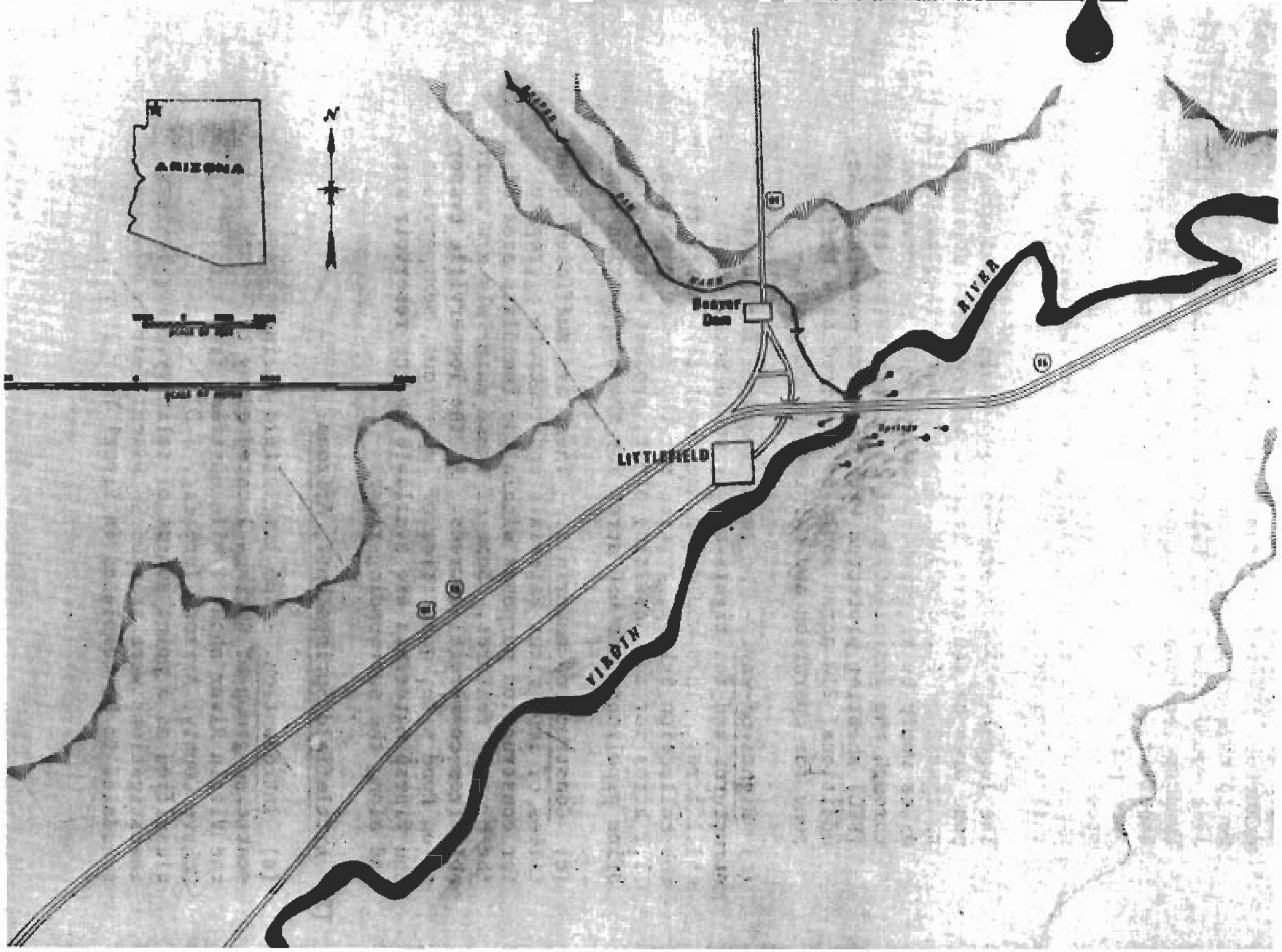
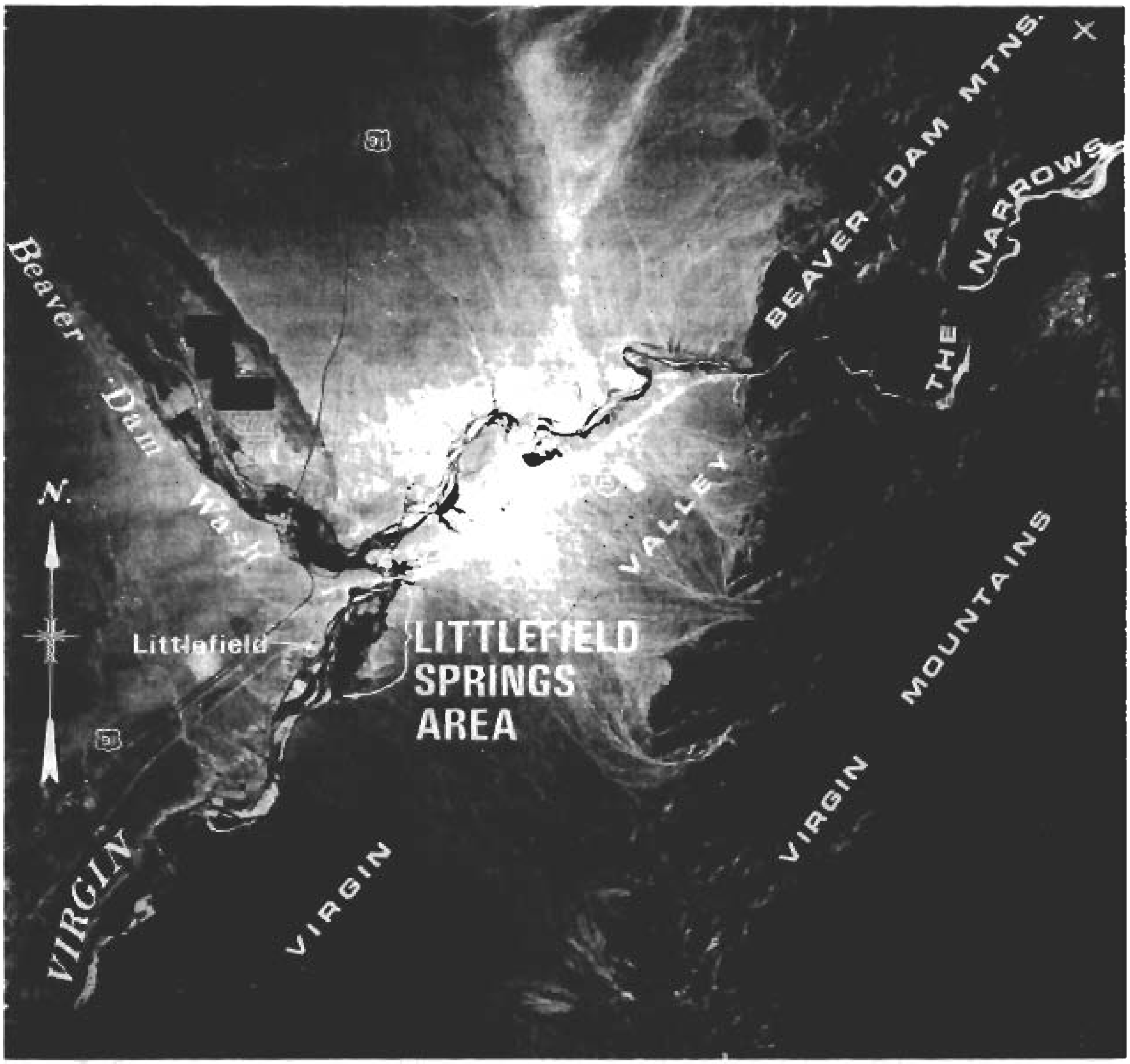


Figure I-31

The area being studied includes the reach of the Virgin River where it enters the First Narrows Canyon above the Arizona-Utah State line to the vicinity of Littlefield (see fig. I-32). The relationship between the Virgin River and saline spring flows in the Littlefield, Arizona, area is complex and not fully understood at this time. However, this much is known: As the river enters the rugged canyon near the state boundary between Utah and Arizona, it loses up to 70 ft^3/s of its flow to the alluvium of the bed. During periods of low flow, from May to October, the Virgin River flows underground through the upper part of The Narrows. Surface flow begins to reappear about 1 mile above the mouth of The Narrows in the form of springs discharging from the riverbed and from the adjacent banks. Flows of 20 ft^3/s at an average salinity of 2,915 mg/l were measured at the mouth of the canyon in 1973. At a point 2 miles downstream, the flow increased to 43 ft^3/s with an average salinity of 2,900 mg/l. The stream continues to gain in volume, and at the Geological Survey's gaging station at Littlefield, the flow was 70 ft^3/s and the salinity decreased to 2,470 mg/l. The salinity improvement is attributed, in part, to an inflow of about 3 ft^3/s of high quality water from Beaver Dam Wash and from springs on the north bank of the river above the gage. These upwelling springs in the Littlefield area appear to have their origin in the flows lost by the river at the upper end of the canyon. However, the flows have been modified in that the springs have a nearly uniform year-round salt concentration and are thermal in nature with a temperature of about 78° F.

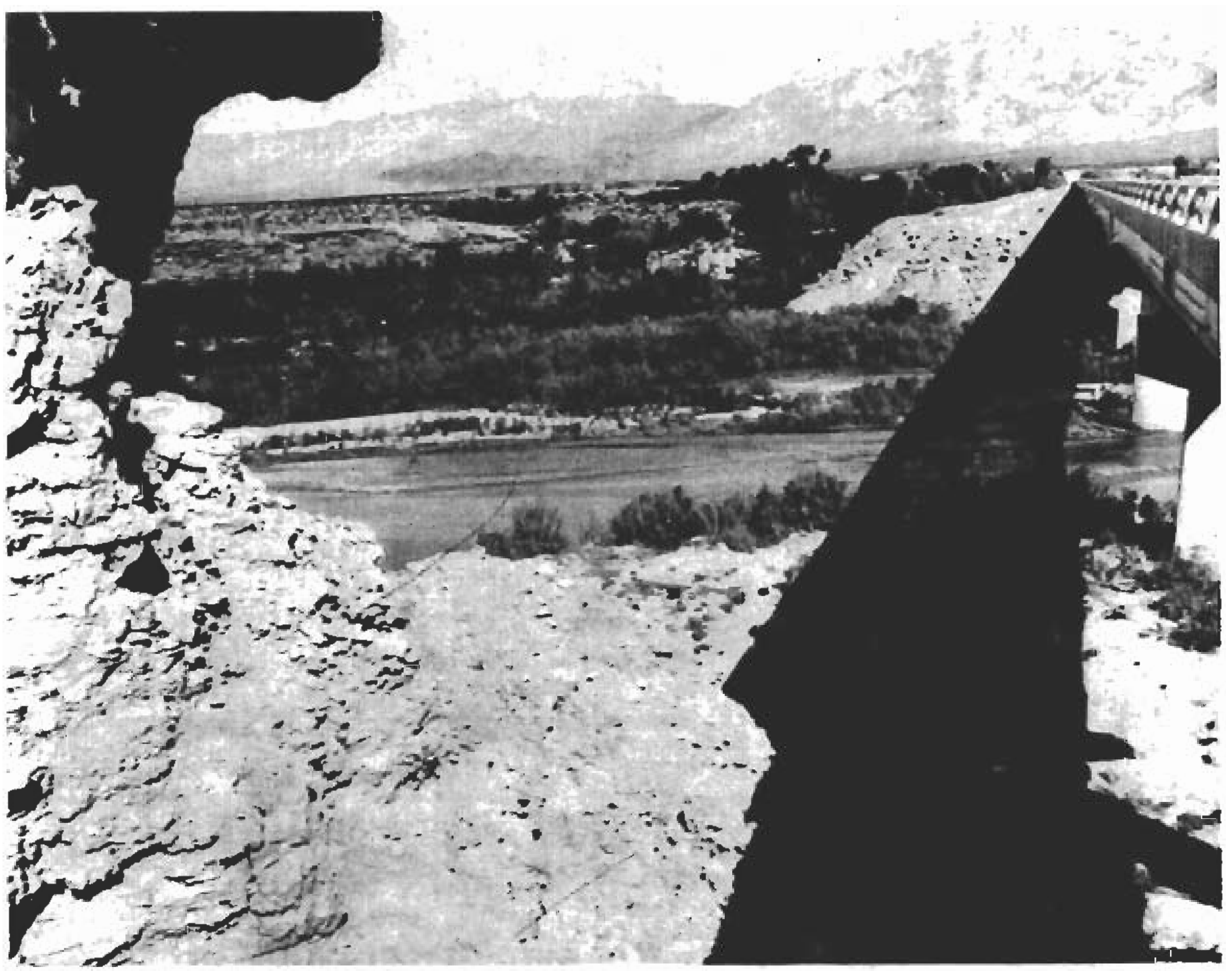
A group of these springs located about 1 mile upstream from Littlefield, Arizona, along the bluffs on the east side of the river, near the east end of the bridge from Interstate Highway No. 15, are commonly referred to as the Littlefield Springs (see fig. I-33). A closeup view of a typical spring in the Littlefield area is shown on figure I-34. Two fairly large springs flow into the side ditches of the interstate highway on top of the bluffs. The largest spring of the group rises along the base of the bluffs about 1,000 feet south of the bridge.

A specific program for sampling the flow of the springs near Littlefield was started in August 1973. Water samples and measurements indicate an average combined flow of 5.7 ft^3/s and an average salinity of 2,960 mg/l. Flow rates were found to be fairly constant while the amount



Aerial view of the Littlefield Springs area.

Figure I-32



Littlefield Springs issuing into Virgin River.

Figure I-33

View of Littlefield Springs typical spring.

Figure I-34

of dissolved solids ranged from 2,830 to 3,050 mg/l. Based on this, the salt contribution from these springs to the lower Colorado River averages 16,700 tons per year. The mineral salts in the spring discharges are chiefly carbonates, sulfates, and chlorides of calcium and sodium. The springs are unsatisfactory for domestic use, but they are used to irrigate salt-tolerant crops. Feasibility studies are not sufficiently advanced to determine a recommended plan for salinity control. However, based on measurements of the larger springs and estimates of the smaller ones, it appears that the spring flows could be collected and alternative methods for collecting and disposing of the spring discharges are under study.

(b) Description of unit features. - One of the more favorable proposals is to collect the spring flows, convey them to a suitable location where the water would be evaporated, and the remaining salts stored. This would result in the removal of about 16,700 tons of salt per year from the lower Colorado River System and would improve the salinity at Imperial Dam by about 2 mg/l. The features of this proposal will include collection facilities, delivery tank and pipelines, and evaporation ponds. The collection facilities would consist of concrete tanks to collect the flow and to provide basins for the collection pumps. The flow from small springs and seep areas would be collected by ditches and conveyed by gravity flow to the centralized tanks. The size of these collection tanks will vary according to the amount of flow they collect, but generally they would be small and would be buried underground. Since the flows are comparatively small, the pumps used to deliver the collected water to the delivery tank would also be small and can be installed in underground pits beside the tanks.

From the collection basins, the spring flows would be pumped to a concrete delivery tank about 20 feet in diameter and 10 feet deep located on top of the bluffs south of the highway. This tank could be entirely buried. A single pipeline would then convey the collected flow to the evaporation ponds.

The evaporation ponds could be located on the outwash plains from the Virgin Mountains to the east of the bluffs and south of the highway. To prevent seepage, the ponds would be lined. They would be designed to follow the contour of the land and would have a maximum depth of about 5 feet with a total surface area of about 680 acres. This surface area is the amount required to evaporate the springs discharge of 4,100 acre-feet per year with the estimated average annual evaporation of 6.4 feet per year at this location. To protect the evaporation ponds from occasional flash floods caused by heavy thunderstorm rainfall, a system of interception channels would be required to collect and transport the floodflow around the ponds. This total evaporation proposal would deplete the Virgin River by about 4,100 acre-feet annually.

Design requirements have not been completely formulated; therefore, specific data on power sources and capacities, transmission lines, construction time, total cost, operation and maintenance and other factors are not fully known. This information and other significant data pertinent to this project will be included in the investigations report.

(c) Rights-of-way. - Approximately 750 acres, consisting primarily of privately owned desert rangeland, would be required for the project. Of this amount, about 680 acres would be required for the evaporation pond, and 70 acres would be required for pipelines, storage tanks, pumping plants, and access roads.

(d) Construction materials. - Materials for concrete aggregate would be readily available by reopening pits developed for the recent construction of Interstate Highway No. 15. Other materials, such as impervious fill and riprap as would be required for dikes, are also locally available.

(3) Glenwood-Dotsero Springs Unit, Colorado. -

(a) Introduction. - The largest point source contributors of dissolved solids to the Upper Colorado River are in the reach of the Colorado River between the mouth of the Eagle River near Dotsero and the mouth of the Roaring Fork River at Glenwood Springs. These dissolved solids contributions are from thermal springs rising in and near the riverbed and from ground water entering this reach of the river. The springs are located in Eagle and Garfield Counties of west-central Colorado. Figure I-35 shows the locations of the springs. Within this reach of the Colorado River, measurements indicate that the springs contribute about 25,000 acre-feet of water containing over

GLENWOOD-DOTSERO SPRINGS, COLORADO

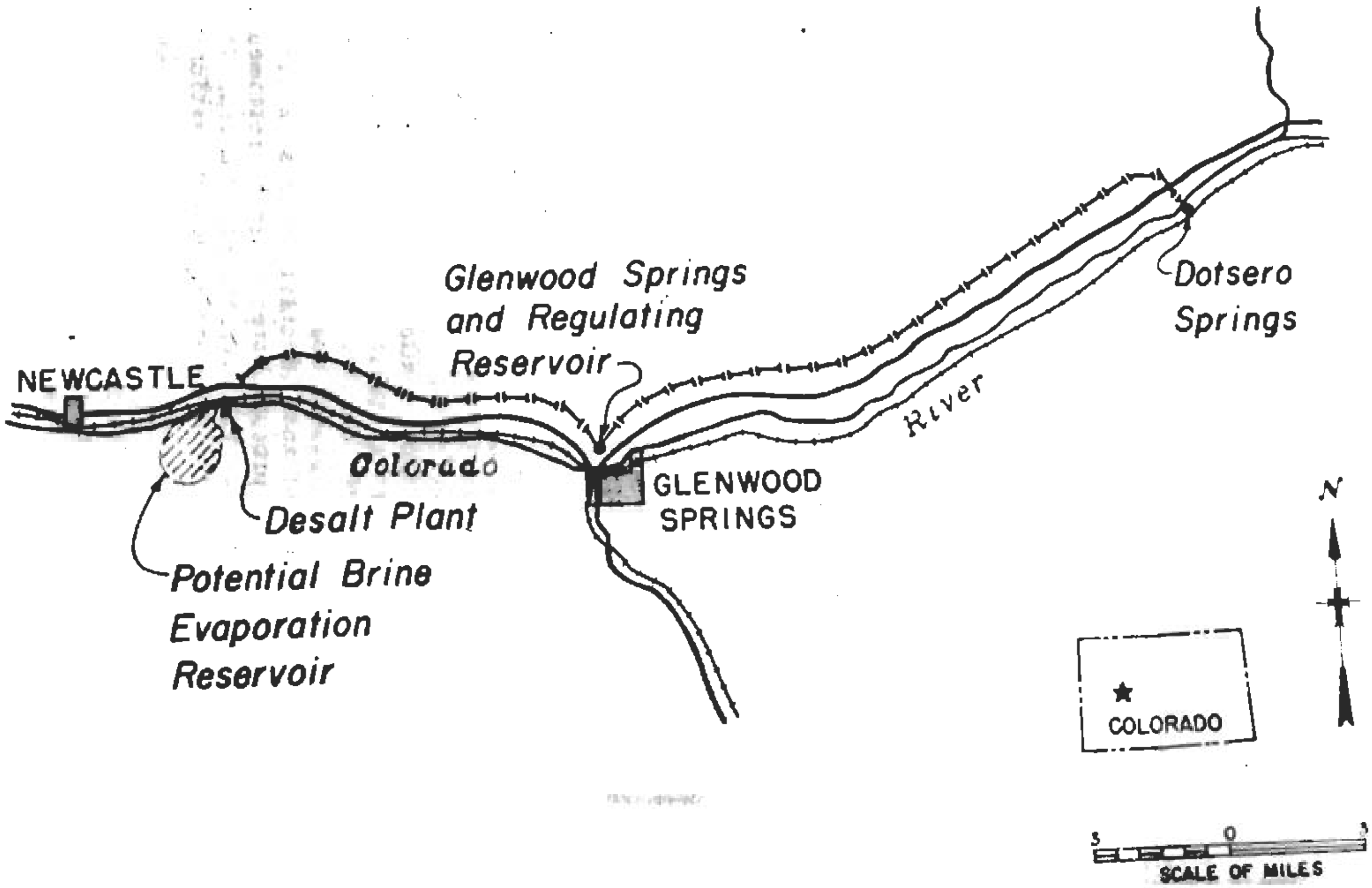


Figure I-35

500,000 tons of dissolved solids annually. Of the springs that could be identified and measured, a 1-year period of data collection indicated a combined flow of 16 ft^3/s and an average dissolved mineral content of approximately 14,200 mg/l (table I-7). These flows carry about 225,000 tons of dissolved solids into the Colorado River annually. Water temperature of the Glenwood Springs averages about 120° F while the temperature of the Dotsero Springs averages about 90° F. Some of the springs have been developed for commercial swimming pools while others have been modified by highway and other construction activities. These flows are generally piped into the river as shown in figure I-36. Those springs whose flows are considered collectible by conventional methods are clustered near the town of Glenwood Springs and also at a point about 2.5 miles downstream from Dotsero, a small rural community at the mouth of the Eagle River. Approximately 16 miles separate the two spring areas. Figure I-37 shows one of the springs near Dotsero.

(b) Location and description of unit features. - Due to the existing conditions and quality of the Glenwood and Dotsero Springs, a desalting plant using a multistage flash distillation process appears to be the most feasible method of treating the spring discharges. The spring flows would be collected by conventional methods such as impounding and collecting, or piping discharge outlets of commercial operations. The specific method used on individual or group springs will be evaluated during the feasibility investigations. These flows could then be conveyed to either one desalting plant to treat the combined flows of both spring areas, or to two desalting plants - one located near Dotsero and the other located downstream from Glenwood Springs. The location of these facilities is shown in figure I-38. The resulting product water could be returned to the Colorado River or distributed for other uses. The waste brine would be conveyed to lined evaporation ponds for disposal.

Implementation of this preliminary plan would reduce the salt contribution to the Colorado River by about 200,000 tons per year, resulting in a salinity reduction at Imperial Dam of 19 mg/l.

b. Irrigation source control. - This section represents a description of the action being taken on five areas that contribute salt to the Colorado River System through saline irrigation return flows. The technique for controlling these saline

Table I-7

SUMMARY OF POINT SOURCE SALINITY DATA
GLENWOOD-DOTSERO SPRINGS

Date	Q (ft^3/s)	TDS (mg/l)[1]	Load (tons) Daily	Load (tons) Annual
		Dotsero Area		
4/25 & 26-1972	3.0[2]	9,533		
7/11 & 12	2.3[2]	9,738		
8/2 & 3	2.2[2]	9,369		
8/30 & 31	6.1	9,088	150	54,750
10/4 & 5	6.7	8,926	161	58,765
11/8 & 9	6.7	9,346	169	61,685
12/4 & 5	6.2	9,217	154	56,210
1/15 & 16-1973	5.8	9,128	143	52,195
2/13 & 14	6.7	9,339	169	61,685
3/12 & 13	7.4	9,255	185	67,525
Average	6.5	9,174	161	58,974
		Glenwood Springs Area		
4/25 & 26-1972	12.0	17,961	582	212,430
7/11 & 12	7.5	18,070	366	133,590
8/2 & 3	11.6	15,391	482	175,930
8/30 & 31	8.5	19,153	440	160,600
10/4 & 5	8.2	17,508	388	141,620
11/8 & 9	9.3	18,749	471	171,915
12/4 & 5	8.2	18,153	402	146,730
1/15 & 16-1973	9.0	18,926	460	167,900
2/13 & 14	9.0	18,662	453	165,345
3/12 & 13	9.8	18,641	493	179,945
Average	9.3	18,080	454	165,600

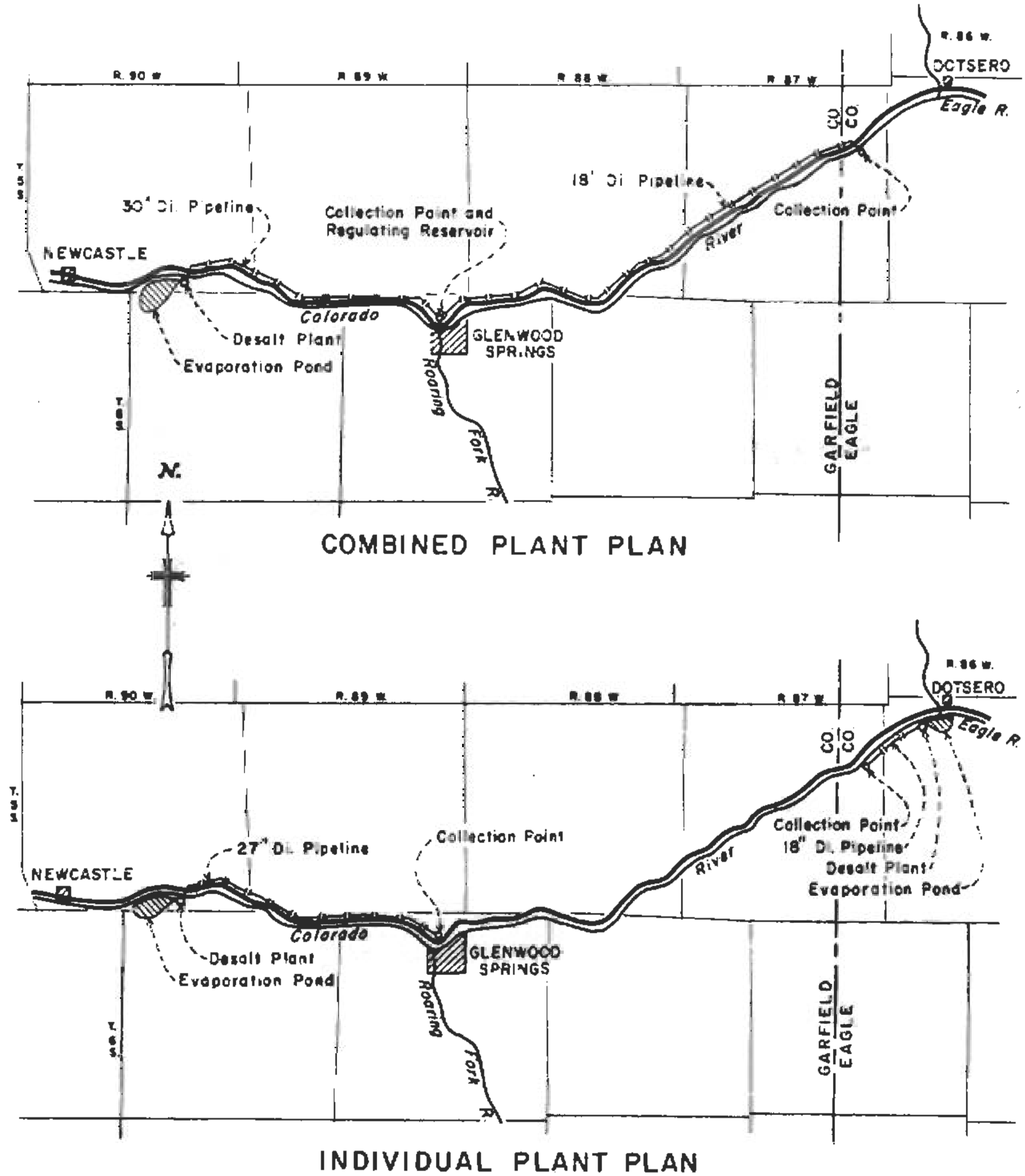
[1] Weighted Average
[2] These values do not reflect the total flow of all the Dotsero Springs

Hot mineral springs in the Glenwood Springs area.

Figure I-36

View of the hot springs issuing into the Colorado River.

Figure I-37



COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM
GLENWOOD-DOTSERO SPRINGS UNIT
RECONNAISSANCE DESALINATION PLANS

Figure I-38

flows involves the cooperation of the irrigators. These techniques include (1) water systems improvement (WSI), (2) irrigation management services (IMS), (3) Onfarm Irrigation Systems and Management Improvement and (4) return flow utilization.

In general the WSI, IMS, and Onfarm Irrigation Systems and Management Improvement programs include determination of soil characteristics; cropping patterns, local climatic data; crop water requirements; surface and ground water quality, and drainage requirements; frequency and amount of applied irrigation water; onfarm irrigation system and management needs; farm delivery flow rate requirements; and lateral and canal sizing and location determinations.

Specifically, the WSI program is one of rehabilitation, and involves the lining or piping of canals to reduce conveyance or seepage losses; the construction of measuring devices, turnouts, and other structures that will improve the efficiency of water deliveries and, subsequently, reduce the volume of saline return flows.

The USDA estimates that there are 705,000 acres of irrigated land upon which onfarm irrigation efficiency improvement programs could be applied. In the estimated acreage, there is a potential to increase irrigation efficiency if systems are improved and water supplies are assured.

The IMS program is a nonstructural demonstration program designed to increase the quality and quantity of crop yields by scheduling the time and amount of applied irrigation water to the actual needs of the crop. Efficiency in the use of irrigation water can be greatly increased through this program, and this is expected to reduce the amount of saline return flows.

Some problems were encountered in implementing the IMS program. However, solutions are being found for these problems as the program expands. Some of the initial problems are:

1. Lack of adequate water measurement devices, which limits the accuracy of determining the amount of water used by the individual users.

2. Water use that is on a rotation basis rather than on a need basis, which makes it difficult for the farmer to schedule water when called for by the computer.

3. Lack of adequate water storage to assure the user a firm late season supply of irrigation water.

4. Scheduling the irrigation of small irregularly shaped fields, which requires more time to visit than if scheduling were done only on large fields.

5. Difficulty in obtaining accurate soil moisture measurements that would be representative for an entire field.

6. The necessity of installing observation wells on fields where ground water contributed to a high-water table.

The Onfarm Irrigation System and Management Improvement program involves inventorying, evaluating, and implementing the structural, cultural, and management practices needed on the irrigation farms to achieve efficient irrigation and reduce salt loading.

Despite improved efficiencies gained from the programs mentioned above, there still will be a considerable amount of saline irrigation return flows that are returned to parent streams. A few specialized industries can use water of poor quality for cooling or other specialized use. With the advent of increased need for electric generating and fuel producing entities, these return flows have assumed new importance. The return flow utilization program is designed to identify these return flows and to assess their potential for beneficial industrial use or of treatment to improve the quality of existing streams.

Although the control units listed herein are in a continuing investigations status, the problems and solutions are similar to those discussed for the Grand Valley Unit, Colorado. It is estimated that the combined reduction in salt loading of the Colorado River resulting from the full development of these four units would be 430,000 tons annually, which is equivalent to 40 mg/l at Imperial Dam.

(1) Palo Verde Irrigation District Unit, California. -

(a) Introduction. - The Palo Verde Irrigation District is a privately developed district located downstream from Parker Dam, adjacent to the Colorado River in Riverside and Imperial Counties, California. The unit area is shown in figure I-39. In 1972, 886,220 acre-feet of water was diverted for irrigation from the Colorado River at Palo Verde Diversion Dam. This water was conveyed through

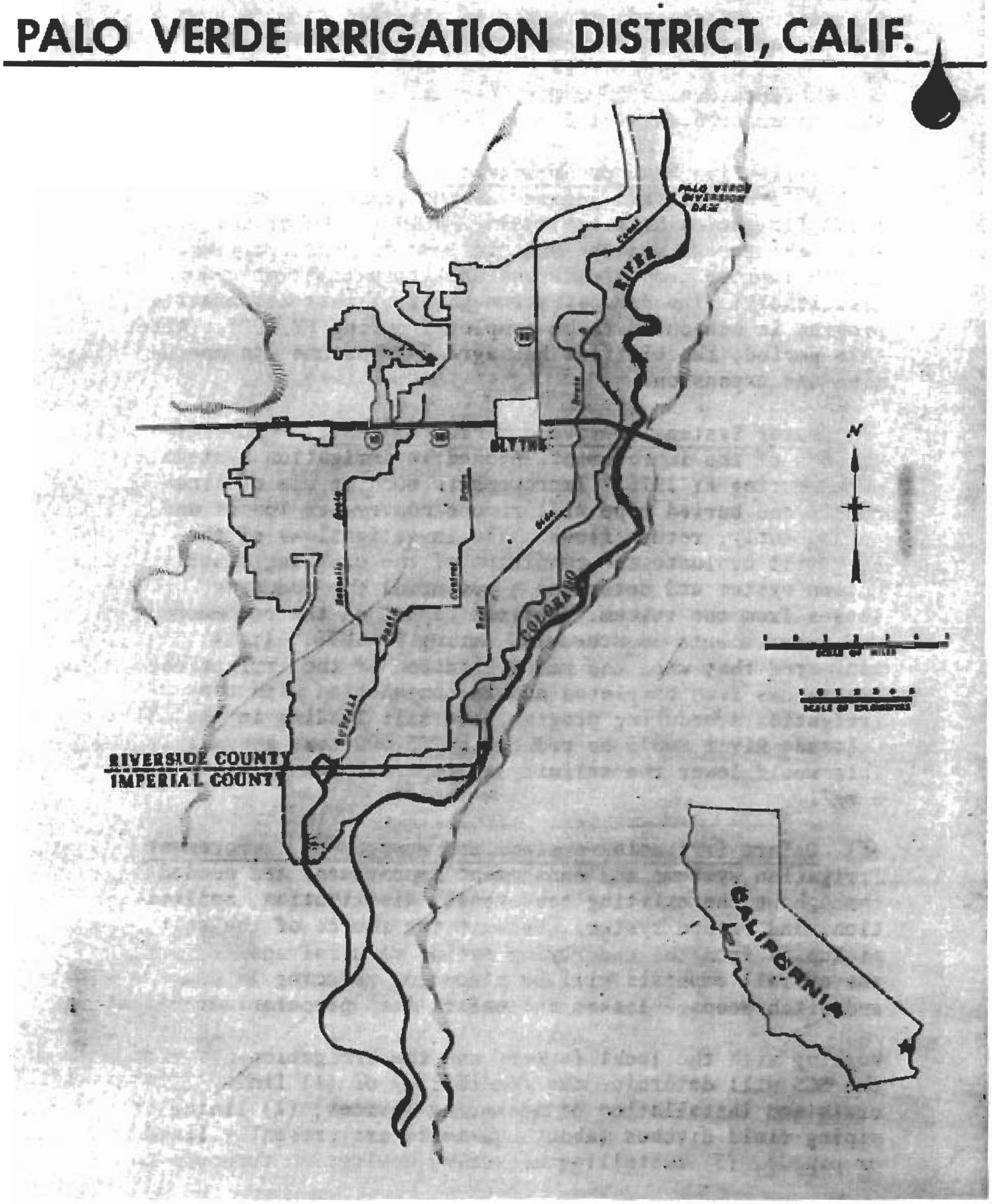

PALO VERDE IRRIGATION DISTRICT, CALIF.
PALO VERDE DIVERSION DAM
RIVER
BLYTHE
COLORADO
N
RIVERSIDE COUNTY
IMPERIAL COUNTY
CALIFORNIA

Figure I-39

295 miles of unlined main canal and laterals to serve approximately 91,400 acres of irrigated land within the District. Of the amount diverted, 439,640 acre-feet were considered as being consumptively used. A 153-mile drainage system collected 446,580 acre-feet of irrigation return flows during 1972 that were returned to the Colorado River (see figs. I-40 and I-41).

(b) Irrigation Management Services. - The IMS program in the Lower Colorado Region was implemented in the Palo Verde Irrigation District during FY 1973. Under the program, the Bureau and the District are cooperatively working to improve crop yields and use irrigation water more efficiently. The demonstration phase of this cooperative program is scheduled to be completed during FY 1977. After this period, the District has agreed to assume its operation and expansion.

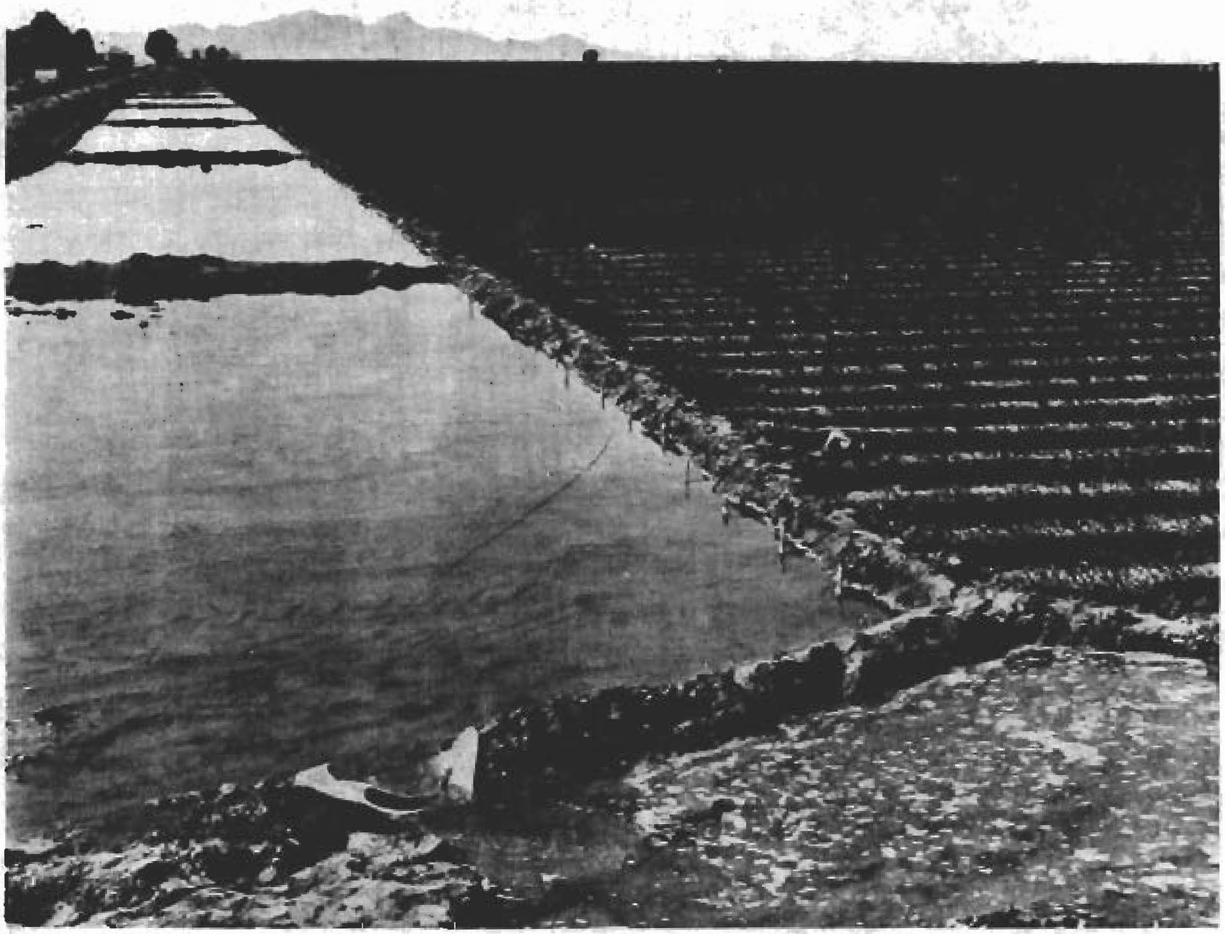
(c) Water Systems Improvement Program (WSI). - Investigations of the improvements needed in irrigation systems began during FY 1975. Improvements such as use of lined canals and buried pipe will reduce conveyance losses and, subsequently, return flows. The investigations of the unit will evaluate the condition of the existing distribution system and determine a potential for reducing losses from the system. A final report on the recommended improvements is scheduled during FY 1978. It is estimated that when the rehabilitation of the irrigation system has been completed and in conjunction with the irrigation scheduling program, the salt loading in the Colorado River would be reduced by 23,000 tons annually. This would lower the salinity at Imperial Dam by about 3 mg/l.

(d) Onfarm irrigation systems and management improvement. Irrigation systems and management improvement are needed throughout the existing conveyance, distribution, application, and return system. Because the source of the salt pickup is from the underlying saline alluvial aquifers, the overall emphasis will be placed on reducing lateral and ditch seepage losses and onfarm deep percolation.

Working with the local farmers and the irrigation district, the SCS will determine the feasibility of (1) lining laterals and installation of measuring devices, (2) lining or piping field ditches (about one-third are presently lined or piped), (3) installing measuring devices on turnouts to

Palo Verde Diversion Dam.

Figure I-40



Palo Verde irrigation.

Figure I-41

the fields and (4) improving field irrigation system layouts to provide for proper lengths of run, application times and application flow rates for the method of irrigation, the soil types, and the crops grown.

Opportunities for technological improvements, such as automated sprinkler, bubbler or drip irrigation systems, and automated turnouts to level basins, will be explored as a means of reducing deep percolation and tailwater return flow. Drainage requirements and impacts will be evaluated as one of the specific improvement programs. The irrigation guide will be updated to reflect SCS criteria on graded and level borders.

The study of onfarm irrigation systems and water management improvement needs will provide information inputs for use in the water and salt budgets, determination of specific program needs, cost and return evaluations, and form the base for development of conservation irrigation plans on the individual farms. The study of onfarm irrigation system and water management improvement needs will be coordinated with the USBR IMS program for scheduling irrigation for specific crops and fields.

(e) Diffuse area watershed management improvement needs. - Evaluation of diffuse source area problems will concentrate on land treatment to reduce erosion, sediment, and floodflows from high yield areas. Ongoing or completed feasibility studies will be used to complete this study. The treatment opportunities and program will be coordinated with the Bureau of Land Management to achieve the most effective program on private and Federal lands.

(2) Colorado River Indian Reservation Unit, Arizona. -

(a) Introduction. - The Colorado River Indian Reservation is located along the Colorado River in northern Yuma County, Arizona, and San Bernardino and Riverside Counties, California. Although the reservation contains approximately 268,850 acres - 225,914 acres in Arizona and 42,936 acres in California - irrigation is limited to a maximum development of 107,588 acres. The water right is either the quantity required to irrigate 107,588 acres or a diversion of 717,148 acre-feet per year, whichever of the two quantities is less.[14] (See figures I-42 and I-43.)

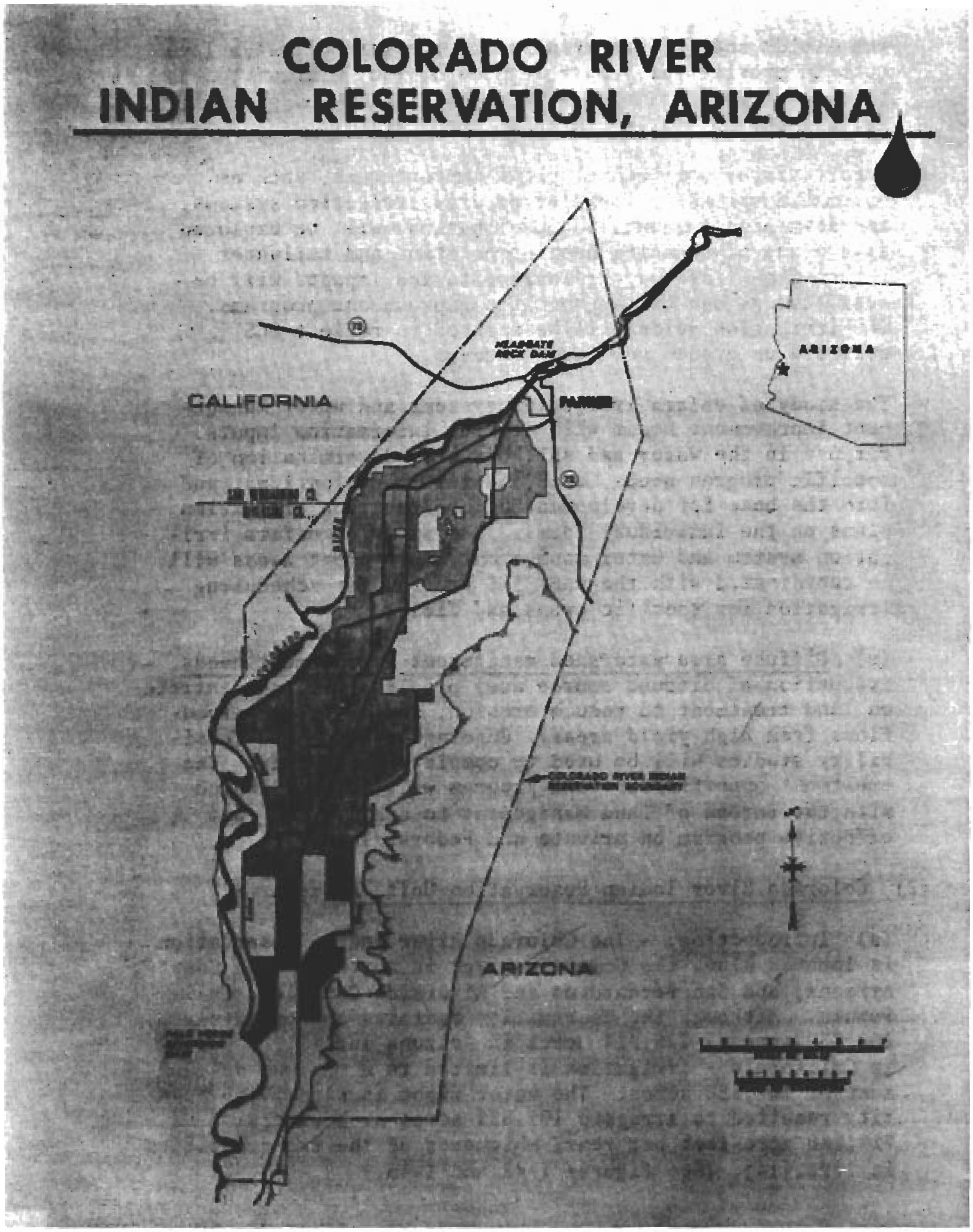

COLORADO RIVER
INDIAN RESERVATION, ARIZONA
CALIFORNIA
ARIZONA
ARIZONA

Figure I-42

Colorado River Indian Reservation - irrigation scheduling.

Figure I-43

Irrigation water for the Arizona portion is diverted from the Colorado River at Headgate Rock Dam in the northern part of the reservation. The diversion dam is located 170 miles below Hoover Dam and 15 miles below Parker Dam on the main channel of the Colorado River. The diversion dam is owned by the United States and is operated by the Department of the Interior, Bureau of Indian Affairs. Lake Moovalya, formed by Headgate Rock Dam, is used for recreational purposes.

The main canal for the Arizona part of the reservation has its headworks at Headgate Rock Dam and proceeds southwesterly, entering the valley just west of Parker, Arizona. Its total length is approximately 17 miles and it has a capacity of 2,100 ft^3/s at the headworks. The canal, which is partially lined, ends in a wasteway. The depth of the water in the canal intake is less than the depth of the river so that only the top water flows into the diversion works, thus minimizing the silt problem. Water is delivered through a complex, and largely unlined, distribution system.

The project is a major agricultural area in the Lower Colorado River Basin, enjoying a year-round growing season. Irrigation return flows are collected in a 100-mile drainage system and returned to the river. It is estimated that the return flows from the reservation contribute to the salt load to the Colorado River by 30,000 tons annually.

(b) Irrigation Management Services (IMS). - An IMS program was started in FY 1973. Under this program, the Bureau of Reclamation, the Bureau of Indian Affairs, and the Colorado River Indian Tribes are cooperatively conducting the program. After completion of the demonstration period in FY 1977 the Bureau of Indian Affairs and the Colorado River Indian Tribes will take over implementation of the program.

(c) Water Systems Improvement (WSI). - In 1972, about 240 miles of canals and laterals were used to convey water to irrigate about 57,400 acres. Another 2,600 acres are irrigated by water pumped from the river. It is projected that within the next 9 to 10 years this irrigation system will be expanded to supply water to irrigate 93,046 acres in the valley and 6,329 acres on the mesa in Arizona.

(d) Onfarm irrigation systems and management improvements. - Using an updated irrigation guide, soil interpretations, present system and irrigation efficiency inventories, and field evaluations, potential irrigation improvements will be determined. To achieve a high level of irrigation efficiency and reduce seepage and deep percolation will involve improvements in both systems and water management.

The overall emphasis, because the source of the salt pickup is from the underlying saline aquifer, will be placed on (1) reducing the estimated 20 to 30 percent seepage and spill losses in off farm canals and laterals, and (2) improving the present 40 to 45 percent application efficiency to reduce onfarm loss from ditch seepage, deep percolation, and tailwater. Increasing onfarm efficiency and reducing seepage losses to a minimum will require studies to determine the need for (1) installation of lined ditches and pipelines; (2) installation of measuring devices on turnouts to the field; (3) improved design and layout of irrigation and drainage systems; (4) adaptation of the irrigation system to the soil and crops grown; and (5) initiating irrigation water management principles in the field to meet crop consumptive use requirements.

Studies were started during FY 1973 to identify the improvements needed in the irrigation distribution system to reduce seepage losses. As determined by these studies, various structural improvements will be recommended in a report scheduled for FY 1979. These may include lining of canals and laterals; installing pipelines; and realinement and sizing of canals and laterals.

Concrete-lined canals are presently being installed to serve newly developed lands, but there is a need to rehabilitate much of the existing distribution system to reduce seepage losses and restore the capacity in the system. It is proposed to serve lands that are now irrigated with water pumped from the river from the rehabilitated and expanded distribution system.

The combined programs will reduce the salt loading of the Colorado River by about 7,000 tons annually. This will lower the salt concentration at Imperial Dam by about 1 mg/l.

(e) Return flow utilization. - As yet, there have been no proposals to use the return flows from this project. Reuse of this water involves problems in that there is not a presently available source of replacement water to exchange for depletions to the flow of the Colorado River. Until some type of Colorado River augmentation becomes available, these return flows could be depleted only if Arizona accepts the use as a charge against its entitlement to Colorado River water.

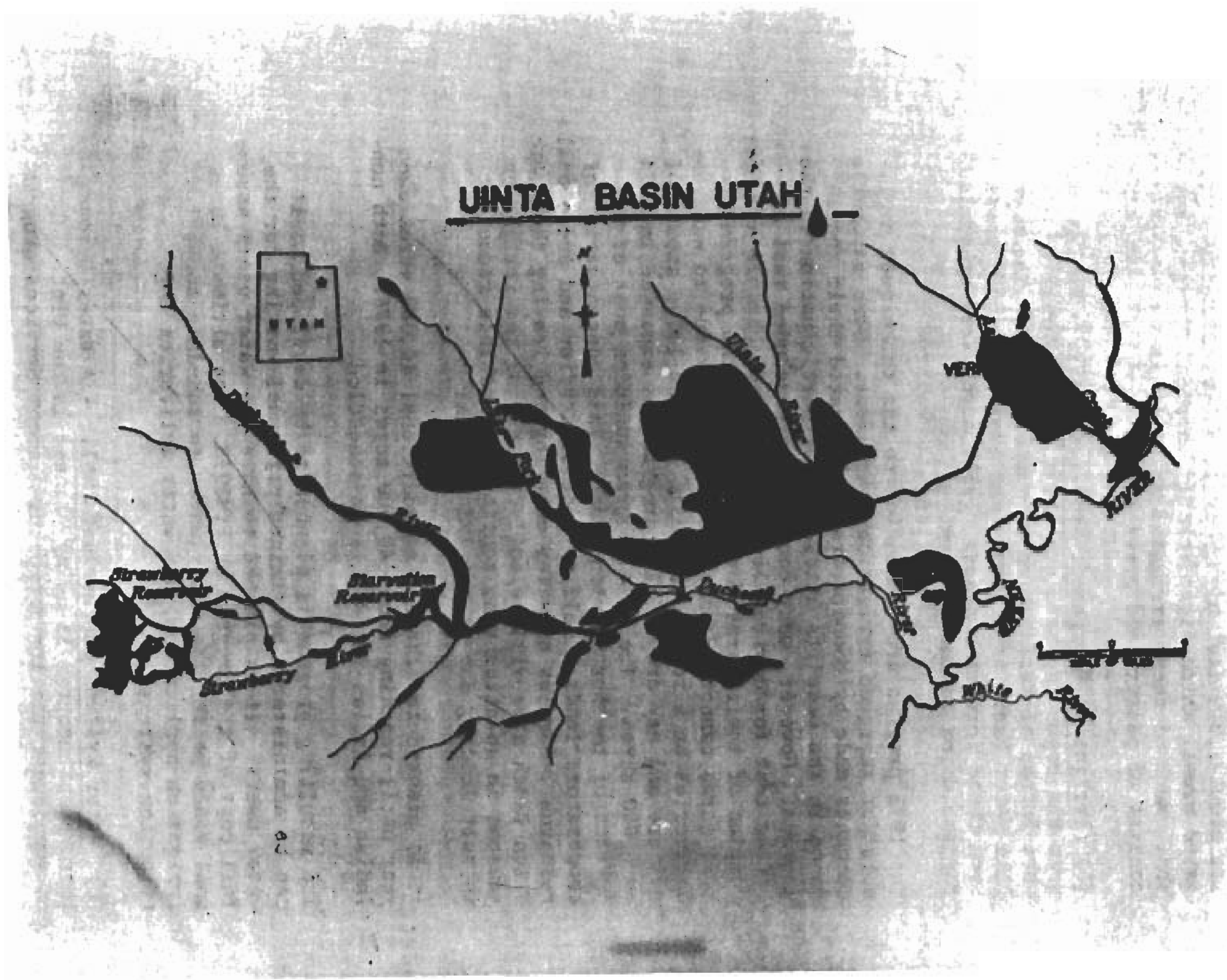
(3) Uinta Basin Unit, Utah. -

(a) Introduction. - The quality of water entering the Uinta Basin from the Uinta Mountains is excellent, because it originates from snows that accumulate during the winter months and from summer thundershowers. In the mountains, the water flows over sands and gravel usually composed of quartzite, thus the mineral content of the water remains low, as quartzite (SiO_2) does not dissolve readily in water. However, once the water is used for irrigation, there is a sharp increase in the mineral content of the water. This is especially true where the Uinta Formation is exposed because the formation contains many beds of gypsiferous salts and beds of marine shale that readily dissolve in water.

Streams originating from the southern part of the basin (Badland Cliffs region) consistently carry a sodium sulfate (Na_2SO_4) type of water, and they flow wholly upon the Uinta Formation. Much of the land surface along the floodplain of the Duchesne River contains white efflorescent deposits of alkali - mostly sodium sulfate salts - that were leached from the subsurface. Much of this is due to water that remained standing on the fields for prolonged periods of time. This problem probably could be alleviated by drainage of the soils and by controlling the frequency and quantity of water applied during irrigation.

The Uinta Basin contributes about 450,000 tons of salt annually to the Colorado River System. Much of this contribution is from the return flows of 170,000 acres of irrigated land. (See location map, fig. I-44.)

These lands occur primarily in valleys adjacent to perennial streams and on higher benchlands. The bench areas



Uinta Basin - location map.

Figure I-44

are about 1,300 feet higher in elevation than other irrigated areas, which significantly shortens the growing season. Much of these irrigated areas (shaded in fig. I-44) consist of pasture and grass hay.

(b) Irrigation Management Services (IMS). - An IMS program was begun in the Uinta Basin in the spring of 1973, when Bureau of Reclamation personnel met with the Moon Lake Water Users Association and explained the proposal. From these initial contacts, 1,312 acres were scheduled for inclusion in the program.

The 1973 program drew attention to the techniques available for improved irrigation management. Some favorable comments made by cooperators demonstrated their confidence in the benefits attainable by participation in the program. However, many cooperators concluded that a better test for desirability would be to schedule a larger portion of their farms for inclusion in the program. Most farms cannot be scheduled completely due to water deliveries on a rotational basis and the large amount of pasture and hay crops. The program was expanded in 1974 to 5,000 acres. The 1974 program includes most of the farmers of the North Myton Bench. This concentration of cooperators lends itself to special studies and additional research. Samples of water entering and leaving the North Myton Bench area will be collected during the irrigation seasons in an attempt to monitor the possible reduction in salt loading due to the IMS program.

It is planned to schedule an additional 10,000 acres each year until reaching about 40,000 acres in 1978. Both non-Indian and Indian lands will be scheduled.

The resulting program is planned to be developed so it can be administered by trained personnel working for the water users. It is planned to have the water users assume full cost of the program by FY 1978. The ultimate Bureau goal would be for the water users to schedule not only irrigation application, but water deliveries through distribution systems.

(c) Water Systems Improvement (WSI). - A Water Systems Improvement program is being planned in the Uinta Unit to supplement the Irrigation Management Services program.

These plans, however, are not sufficiently advanced to identify definite construction features. A study was initiated by the Bureau of Reclamation in June 1973 in cooperation with the Bureau of Indian Affairs on Indian canals located on the Duchesne River flood plain near Roosevelt, Myton, and Fort Duchesne, Utah. During the 1973 season, seepage loss measurements were made on Dry Gulch, South Fork Dry Gulch, and Myton Townsite Canals; and quality of water samples were taken at 17 stations located on canals, natural drains, and streams in the study area. Figure I-45 shows an area of seepage loss below a canal while figure I-46 shows typical weed infestation along a ditch. Both of these conditions will be improved with implementation of the WSI program.

During the 1974 season, a study reach on the Payne Canal was added to the program which should be typical for canals located in the cobble material found on the south flank of the Uinta Mountains. Quality of water samples are currently being collected at 28 sampling sites to better define the movement and sources of salts within the Uinta Basin.

Data collection for the WSI program in the Uinta Basin will continue through FY 1976, with emphasis on canals which have not been previously studied. The SCS, by contract, is studying seepage losses on six canal systems during the 1976 season to identify specific reaches of canals and laterals where excessive seepage occurs.

(d) <u>Onfarm irrigation systems and management improvement</u>. - The irrigation systems in the Uinta Basin are dependent on spring snowmelt for a major portion of their water supply. Seasonal storage facilities are inadequate throughout most of the area. This dependency leads to the practice of irrigating as much land as possible with the early spring runoff. As the water supply diminishes, it is used only on high priority crops such as corn and to establish new plantings of alfalfa and pasture.

The onfarm improvement needs will be evaluated under present systems of delivery. The storage facilities proposed in the USBR's central Utah project will be included in the plan.

Soil surveys are being conducted in portions of the Ashley Valley and Duchesne River areas where information on the characteristics of the soils is lacking.

Seeped area below one of the canals - Uinta Basin.

Figure I-45

Diversion structure infested with weeds - Uinta Basin.

Figure I-46

Inventories as to existing conditions and investigations on the need for specific onfarm improvements to secure high onfarm irrigation efficiency will be conducted on a sampling basis. Included will be the needs for water conveyance, control, and measuring structures; drainage; irrigation methods suited to the soils, crops, and topography; field realinement, shaping, and leveling; management of irrigation water applications; and cultural practice requirements.

It is expected that full implementation of the IMS, WSI, and onfarm programs will remove 100,000 tons of salt from the Colorado River and improve the salinity at Imperial Dam by 9 mg/l.

(e) Return flow utilization. - Because of the wide scattering of farm units, the magnitude of irrigation return flow is not concentrated. A few evaporation ponds could be used to intercept some of the poorer quality water from badland areas and some drainage wasteways. This is being investigated in conjunction with the WSI studies.

The Uinta Basin is rapidly expanding into a major oil-producing area in the State of Utah. Producing oil wells and oil shale resources hold much potential for industrial development. Within local areas, irrigation return flows may assume added importance as reinjection water for secondary oil recovery or some other specialized use.

(f) Diffuse area, land treatment, and management improvement. - Preliminary studies indicate that the National Forest lands within the Uinta Basin do not in general contribute an appreciable amount of salt to the Colorado River System. There are localized areas, however, which contribute large quantities of salt. For example, water quality measurements show a weighted average TDS of 2,754 ppm on Antelope Creek at Highway No. 40. Land treatment improvements should be considered in these areas.

The conservation needs inventory indicates there are about 350,000 acres of private rangelands in the basin which need brush control and/or revegetation. These areas plus some of the National Forest lands in the pinyon-juniper area yield as much as 3,500,000 tons of sediment from sheet and rill erosion and 455,000 tons of sediment from gully and streambank erosion each year. With an estimated three-fourths of 1 percent by weight of soluble salt contained in the sediment, the area could contribute an estimated 30,000 tons of salt annually to the Colorado River System.

These areas will be investigated and analyzed to determine specific diffuse areas needing improvement within the basin. The salinity reduction benefits of such practices need to be identified.

(4) Lower Gunnison Basin Unit, Colorado. -

(a) Introduction. - The lower Gunnison Basin Unit encompasses the Gunnison River drainage area below the Black Canyon. The unit includes portions of Ouray, Montrose, and Delta Counties. Within this area there are a number of private and Federal projects presently irrigating approximately 158,000 acres. Also included in the area is an additional 21,000 acres of presently nonirrigated land that would be irrigated under authorized projects. Figure I-47 shows the location of the unit and table I-8 shows the allocation by projects of the separate acreages.

The lower Gunnison area contributes an estimated 1,100,000 tons of salt to the Colorado River annually. As in the Grand Valley area, it is believed that salts washed from the area by excessive irrigation applications and system losses contribute significantly to this total.

(b) Irrigation Management Services (IMS). - The IMS program conducted by the Bureau of Reclamation, Western Colorado Projects Office, began early in 1974. This program is conducted in conjunction with the program already in operation in the Grand Valley Unit. The program began with approximately 1,500 acres on 15 farms. At present all irrigation scheduling is within the Uncompahgre Project. Selection of the initial participants for irrigation scheduling was made by the Uncompahgre Valley Water Users Association. A contract has also been negotiated by the Water Users organization to furnish a field representative to work with the IMS program.

(c) Water Systems Improvements (WSI). - In FY 1973, a feasibility study was begun to determine the best method of increasing water delivery efficiency in the lower Gunnison area with the purpose of eliminating a part of those return flows containing high concentrations of salt, thereby reducing the salinity of the Colorado River. A


LOWER GUNNISON BASIN COLORADO
FORK
U.S. 50
RIVER
BLACK CANYON OF THE GUNNISON NATIONAL
CRYSTAL DAM
MORROW POINT DAM
U.S. 50
N
COLORADO
SCALE OF MILES

Figure I-47

Table I-8
PARTICIPATING PROJECTS AND ACREAGES
Lower Gunnison Basin Unit

Project	Acres presently irrigated	Additional acres to be irrigated by potential projects	Total acres
Uncompahgre Project (Government)	83,800		83,800
Fruitgrowers Dam Project (Government)	2,662		2,662
Paonia Project (Government)	15,300		15,300
Smith Fork Project (Government)	8,240		8,240
Bostwick Park Project (Government)	4,500	1,610	6,110
Grand Mesa Project (Potential)	20,840		28,270
Dallas Creek Project (Authorized)	2,850	7,430	2,850
Fruitland Mesa Project (Authorized)	6,310	11,940	18,250
Other Private Lands	13,260		13,260
Total	157,762	20,980	178,742

feasibility report is scheduled for completion by June 1977. No cost estimates have been made for the Lower Gunnison Systems Improvement Program.

All canals and laterals which are in areas of highly saline soils and shales could be concrete lined or replaced by pipe sections. Rehabilitation of structures on the canals and laterals are being investigated; surface- and ground-water sources and quality, and drainage requirements will be studied.

(d) Onfarm irrigation systems and management improvement. - The SCS has established a study team to make interagency coordinated investigations for improving irrigation water use to reduce salt loading from the Lower Gunnison Basin. The average 1941 to 1973 salt load of the Gunnison River to the Colorado River is 1.4 million tons of salt. A reduction in irrigation return flow will have a significant impact on the estimated 840,000 tons of salt added annually in the irrigated area.

Federal Reclamation projects are providing water for about 128,000 acres or 81 percent of the irrigated cropland in the Lower Gunnison Unit. The Fruitgrowers Dam, Paonia Project, and Smith Fork Project were designed to provide supplemental irrigation water supplies, while the Uncompahgre Project is a full-service system.

Because the source of a large portion of the salt pickup is from the underlying Mancos Shale Formation and saline alluvial aquifers, the overall emphasis will be placed on reducing canal and lateral seepage losses, deep percolation, and in maintaining positive control over return flows to eliminate erosion from fields and drains. Based on the SCS field inventory in 1973, the following needs were identified. The consolidation, realinement, lining and piping of 500 miles of canals and laterals, plus the addition of 5,500 control structures and 29 miles of main drainage canals are needed off farm. Onfarm opportunities include installation of 738 miles of field ditch lining or pipeline, 146,000 acres land leveling or smoothing, 21,100 control sturctures, 33,000 acres of drainage systems, and change in irrigation methods and extensive improvement in water management on 119,000 acres.

(e) Diffuse area land treatment and management improvement needs. - Critical erosion and sediment problems exist on the shale badlands or shale-derived alluvium entrenched by gullies. Most of these critical areas are also associated with irrigation canal waste or field tailwater return systems. High sediment yields are generally associated with soils underlain at shallow depths by shales of the Mancos Formation. These areas generally contain soils with a saline substratum and through the erosion process are responsible for a large part of the salt pickup by irrigation return flows. The very high sediment yield supplies a suspended load of clay and silt particles, and a salt loading of calcium, sulphate, sodium, and chlorides. High sediment yields on 584,000 acres account for 48 percent of the basins 2.7-million-ton annual yield.

Also, serious streambank erosion occurs on about 180 streambank miles and moderate erosion on about 170 streambank miles in the Lower Gunnison Basin Unit. This results in an estimated 408,000 tons of soil loss annually.

Full implementation of both the IMS and WSI programs could result in a reduction in total salts of 300,000 tons per year. This is equivalent to approximately 27 mg/l improvement in salt concentration at Imperial Dam. Additional reductions in salt load can be expected from the SCS onfarm programs.

c. Diffuse source control. - Five tributaries of the Colorado River accumulate large quantities of salts from irrigation return flows, saline seeps, and salt-producing geologic formations. These tributaries (Big Sandy River, Wyoming; Price, San Rafael, and Dirty Devil Rivers, Utah; McElmo Creek, Colorado) contribute a combined total of 960,000 tons of salt to the Colorado River System. It is estimated that control measures could remove as much as 380,000 tons of this salt from the Colorado River, resulting in a salinity reduction at Imperial Dam of 34 mg/l.

(1) Big Sandy River Unit, Wyoming. - The Big Sandy River in Wyoming accumulates salts from irrigation return flows of the Eden Project and from saline seeps scattered along the channel. No single point source contributes a large amount of salt. However, the river annually discharges about 180,000 tons of salt to the Colorado River System. It is

estimated that about 80,000 tons could be removed by treatment, which would reduce the salinity at Imperial Dam by about 7 mg/l.

Plans are not yet definite on the method of eliminating the salts from the Big Sandy River. A freezing method to desalt the water by taking advantage of low winter temperatures appears to be an alternative which is one of the more promising. Small-scale experiments have been conducted by Professor Donal L. Stinson of the University of Wyoming in which sprinklers were used to spray the water into the air where it partially freezes and falls and with further freezing forms an ice pile. The ice crystals which separate out are almost pure water and the unfrozen brine contains nearly all the salt. The experiments were successful in producing a very low salinity concentration in the product water. The Bureau is also investigating a well relief system to decrease artesian ground-water pressures and prevent salt seeps from entering the river.

To determine the feasibility of the freezing method, a research contract was negotiated with the Univeristy of Wyoming for Professor Stinson to conduct a pilot demonstration during the winter of 1973-74 in the vicinity of Gasson Bridge, which is halfway between Farson and Fontenelle and 36 miles northwest of Rock Springs, Wyoming (fig. I-48). The necessary ponds and pipelines for conducting the test were constructed but various delays were encountered. Testing was initiated during February 1974. Water was pumped from the Big Sandy River, sprinkled to produce ice piles, and then the brine and product water were separated by natural aging and thawing. A schematic layout of the system is shown on figure I-49. The pilot operation was expected to provide needed information regarding: (1) the capability of freezing, (2) effectiveness of the sprinkler equipment, (3) configuration for the best ice formation, (4) the amount of salt that can be removed, (5) cost per ton of salt removed, (6) quality of the product water, and (7) environmental impact of the process.

Due to the late start caused by various problems in obtaining and installing equipment, a complete and satisfactory pilot demonstration could not be made. Some information, however, was obtained which would be valuable in a continuation of the demonstration. Problems encountered were: (1) determining the proper type of nozzles and other fittings, (2) permeable soil under the ice pack absorbed the

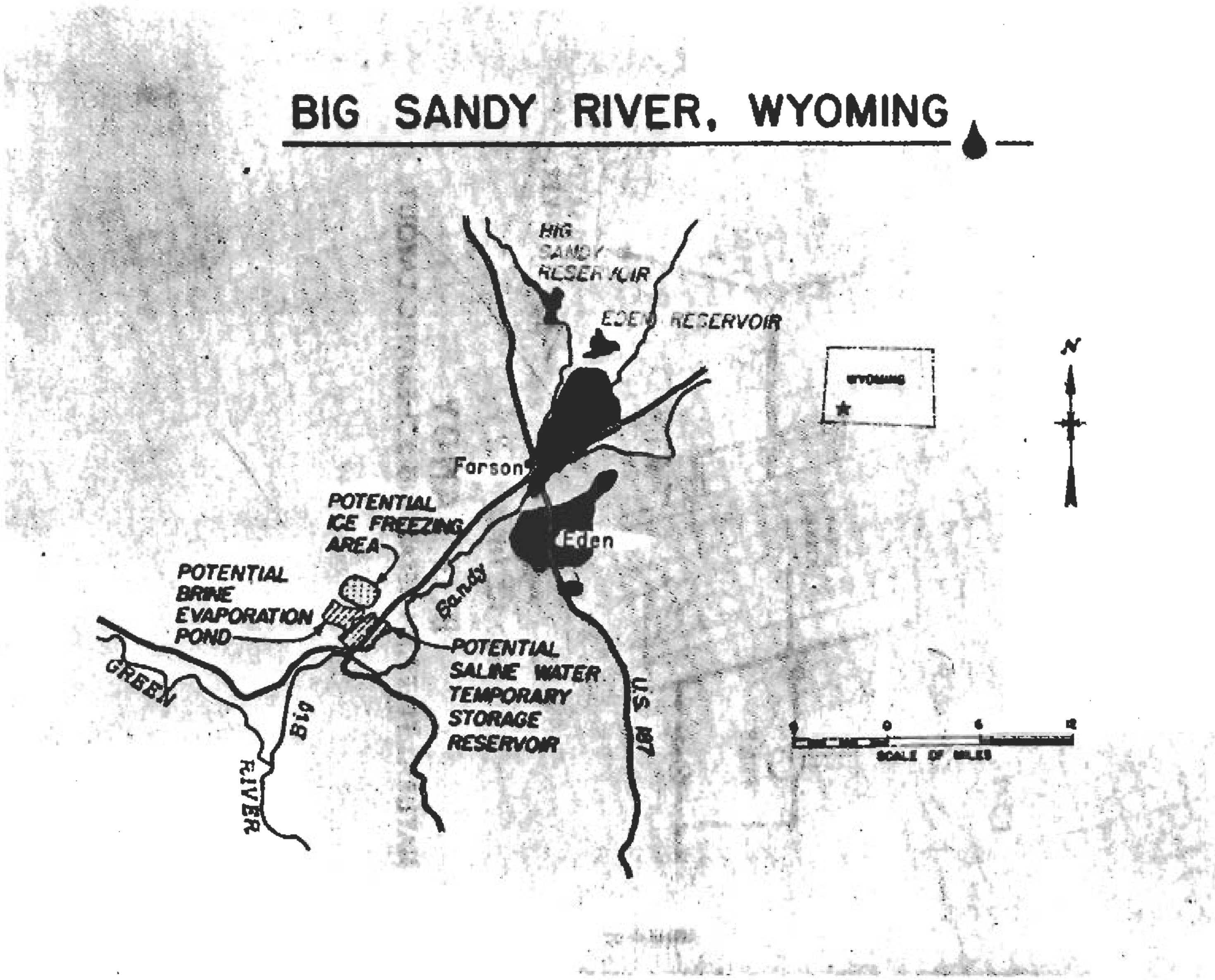
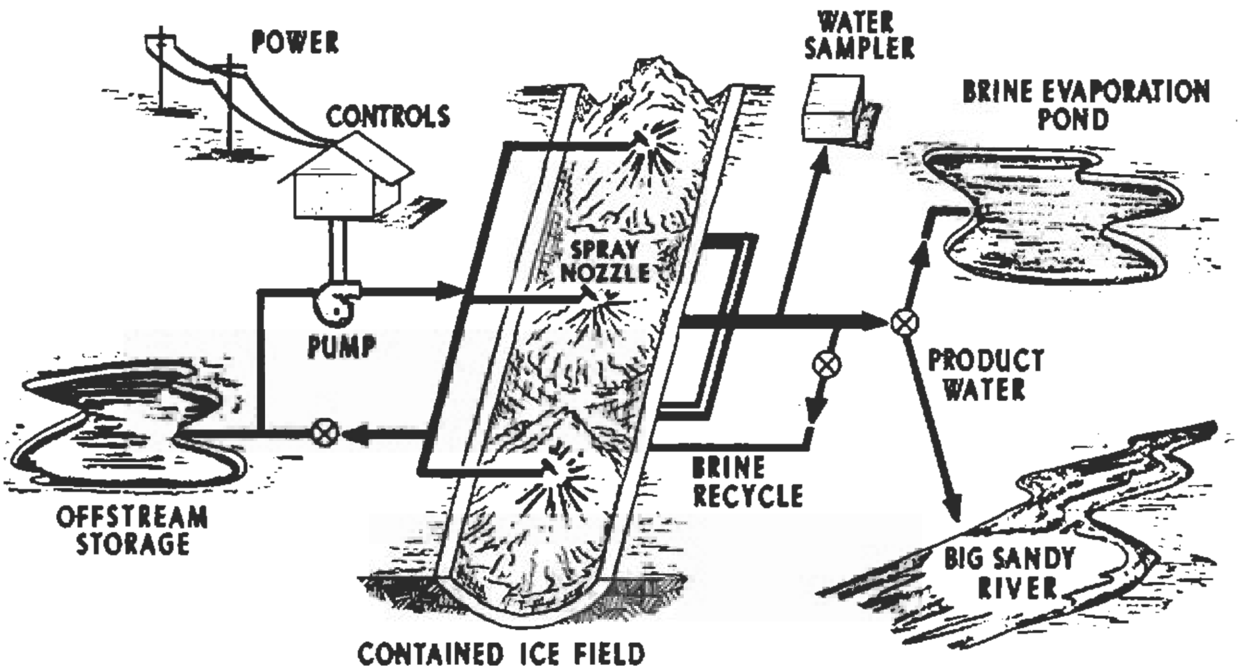

BIG SANDY RIVER, WYOMING
BIG SANDY RESERVOIR
EDEN RESERVOIR
WYOMING
N
Farson
POTENTIAL ICE FREEZING AREA
Eden
POTENTIAL BRINE EVAPORATION POND
Sandy
POTENTIAL SALINE WATER TEMPORARY STORAGE RESERVOIR
GREEN
Big
RIVER
US 187
SCALE OF MILES

Figure I-48



BIG SANDY
NATURAL FREEZING DESALTING-SCHEMATIC LAYOUT

Figure I-49

water rather than allowing it to flow, (3) inability to make the sprinklers work properly under varying freezing temperatures, (4) loss of prime on pump due to river fluctuations and, (5) delays in obtaining repair parts.

Investigations have not advanced sufficiently to estimate the cost of a proposed plan. The pilot study will provide much of the needed data for the freezing plan. Other plans will also be evaluated and costs estimated before final selection is made.

Most of the Big Sandy water supply, which averages 96,000 acre-feet annually, originates at high elevations in the Wind River Range and is of excellent quality (less than 100 mg/l) as it flows into the Eden Valley Irrigated project area. The 15,000-acre Eden Valley Irrigation Project is typical of many areas developed in the arid west over saline tertiary lakebed materials. An unlimited supply of salt is available for pickup by the 69,000 acre-feet of deep percolating irrigation water. Return flows have total dissolved salt concentrations of 2,500 to 4,500 mg/l averaging about 3,200 mg/l. Based upon the estimated return flow and average salt concentration, about 250,000 tons of salt are picked up in the irrigated reach or enroute to the confluence with the Green River. SCS studies will be oriented to improving the present estimated 20 percent irrigation system efficiency, to reduce, seepage and deep percolation into underlying saline aquifers.

(a) <u>Onfarm irrigation systems and management improvement</u>. - Improved water management is needed throughout the conveyance, distribution, onfarm application, and return systems. Emphasis will be directed toward diverting the correct amount of water for plant requirements and avoiding seepage and spillage losses. Because the salt pickup to the Big Sandy River may be from the ground-water aquifers, the overall system analysis for improvement should be geared to efforts of reducing deep percolation and return flow to the stream system.

The degree of control over seepage losses from off-farm conveyance and return flow systems and from onfarm irrigation systems will be analyzed. Lined canal and surface drainage ditches could be utilized throughout the off-farm system, whereas onfarm, the water has to be applied to the land, thereby providing opportunity for some deep percolation and salt pickup even under high management practices.

The principles that must be applied in securing a high farm irrigation efficiency involve (1) installing lined ditches or pipelines; (2) using the irrigation methods best adapted to the soil and crops grown; (3) utilizing soils information in design and layout of irrigation and drainage systems; (4) applying the proper amount of water at the proper time, to meet crop concumptive use plus cultural practice requirements. Consideration should also be given to the effect of shifting approximately 1,500 acres of subirrigated cropland to another method of irrigation to reduce the ground-water recharge in this area; and (5) reduce the water losses from phreatophytes and other incidental areas.

(b) Diffused area land treatment and management improvement needs. - A preliminary evaluation indicates that contribution of salt to the Colorado River System by the watershed areas above the irrigated cropland is generally low. The greatest benefit from improving the upper watershed conditions would be additional production of range forage.

Much of the Eden Project area not under cultivation, and areas below the Eden Project, are located on some of the higher sediment and salt-producing drainages; however, the annual precipitation and sediment and salt yields are low.

Several problems of resource use exist in the management of the range and forest lands. Prominent among these are: (1) lack of adequately dispersed livestock water; (2) lack of fencing for the control of livestock grazing; (3) overgrazing along the same perennial streams; (4) wild or loose horses, increasing at an annual rate of about 25 percent, for which no rangeland feed is legally available; and (5) successive public use in the Bridger Wilderness Area.

The study will investigate and analyze these areas to determine the specific diffused areas needing improvement within the Big Sandy River Watershed. Management practices will be identified which need to be established. The salinity reduction benefits of such practices will also be identified. Close cooperation in the planning and implementation process will be needed between the Bureau of Land Management and Department of Agriculture to develop consistent recommendations for treatment of both public and private lands.

(2) <u>Price River, San Rafael River and Dirty Devil River Units, Utah</u>. - The estimated total dissolved solids contributed by the Price, San Rafael, and Dirty Devil Rivers are 240,000, 190,000, and 200,000 tons, respectively. The geological formations in these river basins consist primarily of sedimentary rock. About 60 percent of the Dirty Devil drainage and 75 percent of the Price and San Rafael drainages are composed of mudstones, claystones, and shales which are the main source of salt loading in these rivers (see fig. I-50). Much of the irrigated lands are located on salt-producing formations particularly in the upper portions of the Price and San Rafael drainages. (See location map, fig. I-51.)

Investigations thus far have included review of previous studies and investigations, field surveys, and data gathering. Streamflow and water quality data are currently being obtained at several locations on each of the rivers. The water quality sampling points are shown on the general location map, figure I-52. Locations of these points depend on identification of geologic formations which appear to be salt producing and water samples taken during field investigations.

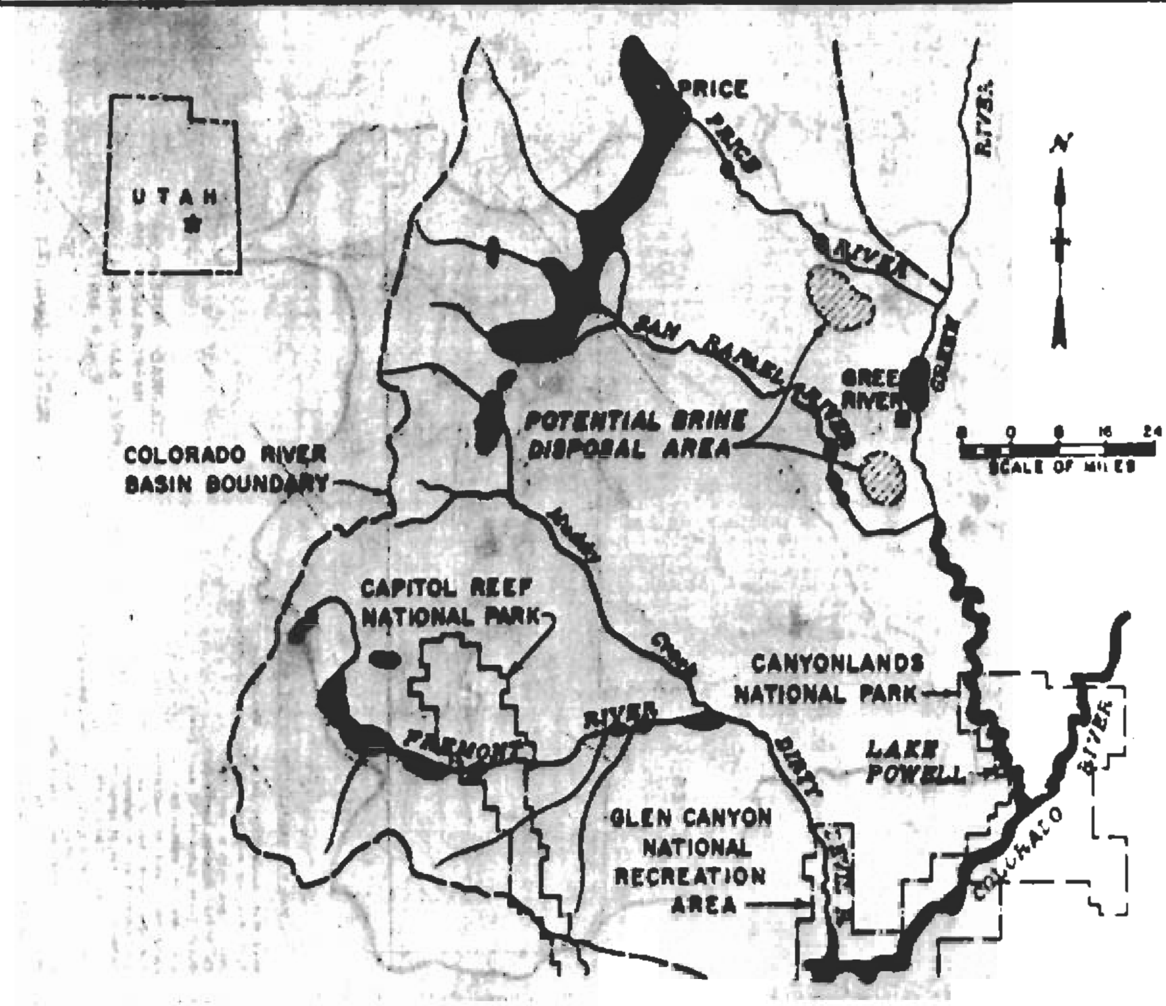
The Price River Basin has a drainage area of about 1,900 square miles and the runoff from the upper watershed is degraded in chemical water quality as it makes its way over marine shales of Cretaceous Age to the Green River. The dissolved solids content of water in the headwaters is usually less than 200 mg/l, but in the lower reaches the weighted average dissolved solids concentration is generally between 2,000 and 4,000 mg/l. About 240,000 tons of salt are contributed to the Green River annually. Much of the area is in poor watershed condition and suspended sediment discharge to the Green River is estimated at over 1 million tons per year. Opportunities exist for improving irrigation efficiency on 23,000 acres of irrigated land and erosion control on the watershed lands to reduce the contribution of salts.

The San Rafael River Basin encompasses 1,670 square miles of semiarid to arid watershed underlain with sedimentary rocks composed of mudstones, claystones, and shales which are the source of salt loading in this river. Weighted average TDS concentration of the San Rafael River flow to the Green River is about 2,500 mg/l, and about 190,000 tons of salt are contributed annually. Much of the area has high soil loss and sediment and salt production is great.

Topography through the San Rafael Swell.

Figure I-50

PRICE, SAN RAFAEL, DIRTY DEVIL RIVERS, UTAH



Location Map for Price, San Rafael, and Dirty Devil Rivers, Units

Figure I-51

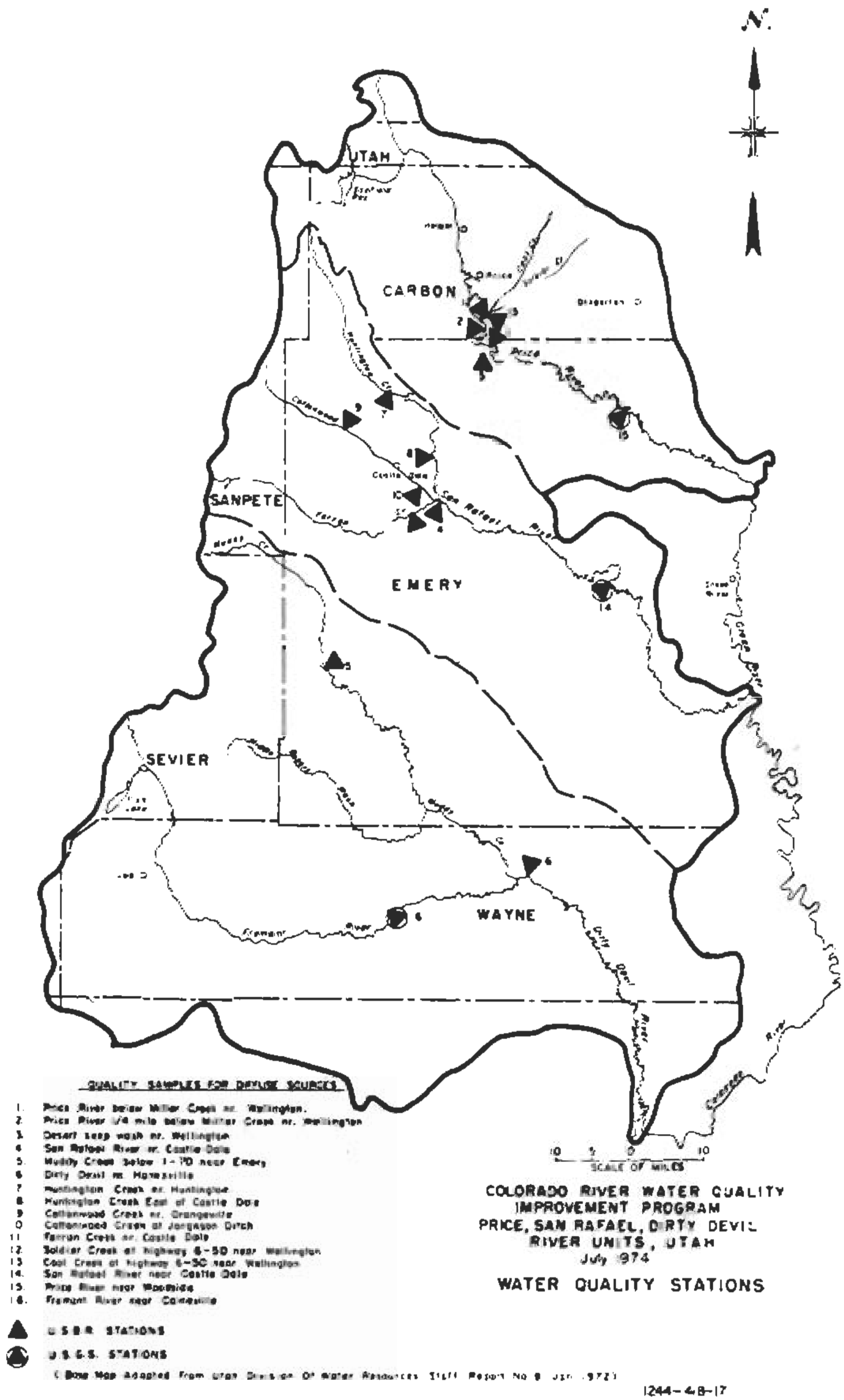

N
UTAH
CARBON
SANPETE
EMERY
SEVIER
WAYNE
QUALITY SAMPLES FOR DIFFUSE SOURCES
1. Price River below Miller Creek nr. Wellington.
2. Price River 1/4 mile below Miller Creek nr. Wellington
3. Desert Seep wash nr. Wellington
4. San Rafael River nr. Castle Dale
5. Muddy Creek below I-70 near Emery
6. Dirty Devil nr. Hanksville
7. Huntington Creek nr. Huntington
8. Huntington Creek East of Castle Dale
9. Cottonwood Creek nr. Orangeville
10. Cottonwood Creek at Jorgensen Ditch
11. Ferron Creek nr. Castle Dale
12. Soldier Creek at highway 6-50 near Wellington
13. Coal Creek at highway 6-50 near Wellington
14. San Rafael River near Castle Dale
15. Price River near Woodside
16. Fremont River near Caineville
U.S.B.R. STATIONS
U.S.G.S. STATIONS
SCALE OF MILES
COLORADO RIVER WATER QUALITY IMPROVEMENT PROGRAM
PRICE, SAN RAFAEL, DIRTY DEVIL RIVER UNITS, UTAH
July 1974
WATER QUALITY STATIONS
1244-48-17

Figure I-52

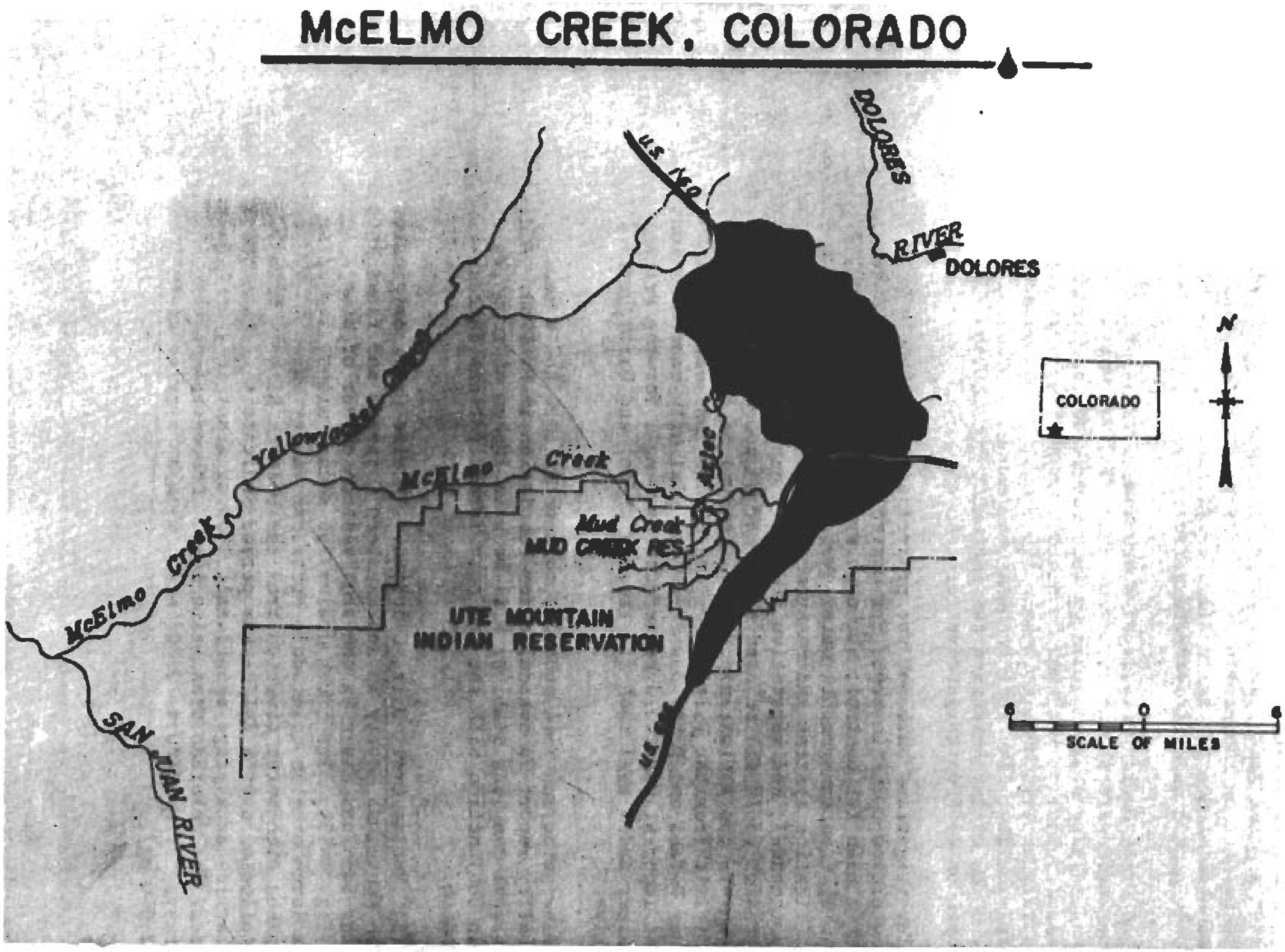
A watershed treatment program to control erosion can reduce salt and sediment loading. Investigations will include an assessment on the potential to improve irrigation water management and systems on 41,000 irrigated acres to reduce salt pickup in drainage return flows.

The Dirty Devil drainage of 4,410 square miles of arid to semiarid watershed contributes about 200,000 tons of salt and a large sediment load to Lake Powell on the Colorado River. Much of the area is subject to high erosion and a watershed treatment program will be analyzed to determine feasibility. The salt load may be reduced by controlling erosion of the watershed and improving irrigation efficiencies on 26,000 irrigated acres.

Investigations have not yet progressed sufficiently to determine specific areas for control or to develop a general plan for control; although evaporation, desalting, irrigation management, water systems improvement, onfarm irrigation systems and management improvement, selective withdrawal, and vegetative and range management to control erosion could all be used singly or in combination to achieve the estimated potential removal of 100,000 tons of salt from the Price River and 80,000 tons each for the San Rafael and Dirty Devil Rivers. Salinity concentrations at Imperial Dam could be reduced by 9 mg/l for the Price River and 7 mg/l each for the San Rafael and Dirty Devil Rivers.

Data gathering will continue through FY 1978 and a feasibility report is scheduled for completion in FY 1980. Additional sampling stations will be established as required in conjunction with the geologic investigations in each basin.

(3) McElmo Creek Unit, Colorado. - McElmo Creek originates in Montezuma County in southwestern Colorado and flows into the San Juan River in the southeastern corner of Utah (fig. I-53). The creek drains 350 square miles, including a large area in Colorado's Montezuma Valley which is irrigated with water diverted from the Dolores River. Data collected over a 3-1/2-year period indicate that the stream carries an average annual salt load of about 150,000 tons near the Colorado-Utah State line. Concentrations have ranged from 1,500 to 3,700 mg/l, with an average of 2,650 mg/l.



McElmo Creek Unit, Colorado - location map.

Figure I-53

Irrigation return flows from Montezuma Valley contribute a substantial amount of salt to McElmo Creek and Mud Creek, a tributary of McElmo Creek which drains the southern part of the valley. The land is derived from and underlain by Mancos Shale, a brackish, impervious formation. Based on 1 year of data, the annual salt pickup from Montezuma Valley is approximately 135,000 tons.

Several methods of removing salt from McElmo Creek are being studies by the Bureau. One possibility would be to selectively withdraw and evaporate the flows of upper McElmo Creek and Mud Creek during periods of high salinity and low flow. A second would be to desalt these flows. A site on Mud Creek could be used to evaporate either the saline flows or the brine discharge from a desalting plant. A third possibility would be to combine either of the above methods with a program of increased irrigation efficiency in Montezuma Valley. This would require the agreement of the irrigators in the area. It is estimated that any one selected control measure could remove about 40,000 tons of salt per year and reduce the salinity at Imperial Dam by 4 mg/l.

The SCS plans to cooperate in the interagency study on the 720-square-mile drainage of McElmo Creek. Investigations will identify the potential to reduce deep percolation and seepage from the 44,000 acres of irrigated land and the opportunities to reduce erosion which puts salts into solution. Concentrations of salt in the irrigation water supply imported annually from the Dolores River average about 140 mg/l. Residual irrigation return flows coupled with a small amount of local runoff in McElmo Creek at the Colorado-Utah State line average about 2,650 mg/l of dissolved minerals.

Gaging stations were installed and water sampling initiated in FY 1972. Data collection will continue and a feasibility report is scheduled for FY 1978.

If a desalting plant were used to remove salt, the product water could be used for municipal or industrial purposes. The annual depletion of water would amount to approximately 6,200 acre-feet for complete evaporation of the flows and 3,700 acre-feet for the evaporation of brine from a desalting plant.

E. Other Authorized Studies Under the CRWQIP

1. Introduction

The salinity control facilities and measures considered below were not authorized per se under P.L. 93-320 but are under present consideration and continuing investigation under the CRWQIP. Due to limited planning information and environmental data, only preliminary planning concepts are discussed in this statement. Associated impacts will not be discussed further.

2. Return Flow Utilization

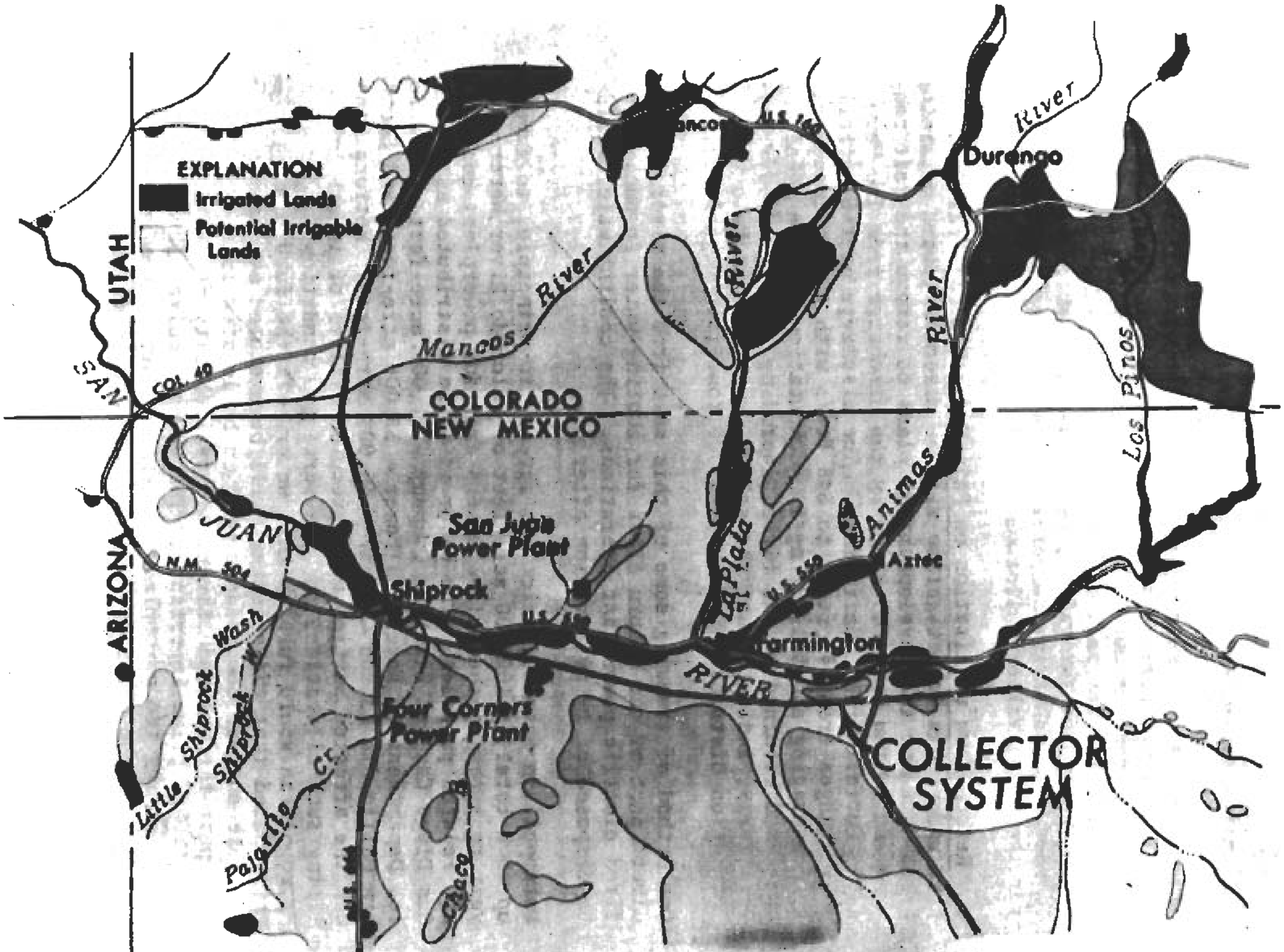
This concept involves the capture or collection of saline irrigation return flows, then conveying and possibly treating this water for specialized nonagricultural uses. These specialized uses could range from cooling water of electric generating plants to the recharging of geothermal wells or other industrial processes.

a. San Juan Collector System, New Mexico. - Investigations for the San Juan Collector System were begun by FY 1974. Studies are currently underway to evaluate the various legal and institutional constraints involved.

It is estimated that when the Navajo Indian Irrigation Project is completed, there will be a combined wastewater source of about 104,000 acre-feet per year. Uses of this water vary, and studies are underway to determine those that would be the most feasible. Reclaimed wastewaters are considered to be of acceptable quality, that would be of value to industries such as coal gasification and power generation plants. Figure I-54 shows the general area served by the proposed collector system. Investigations have not progressed sufficiently to determine the potential quality of these return flows or of the ultimate effect that their utilization would have on the Colorado River.

b. Return flow utilization in Grand Valley, Colorado. - Investigations are to commence in fiscal year 1976 to evaluate plans for collecting the highly saline flows from irrigation return water from the Grand Valley prior to their entry into the Colorado, and to either treat these flows by evaporation, desalting, or to utilize the water for some beneficial purpose.

The drainage leading to the Colorado River presently carries surface runoff, irrigation wastewater, and water from subsurface drainage. The flows from ground water are highly saline, while the other flows contain much less dissolved solids. Studies may



SAN JUAN COLLECTOR SYSTEM

igure I-54

show that selective collection of the water may be desirable, with the saline water being processed and the less saline flows being returned directly to the river.

One method of selective collection of water is by constructing tile drains in the bottom of present open drainages to collect the saline water, and construct an open concrete-lined channel near the ground surface to collect the surface runoff and wastewater. Another method of collection is by pumping the saline ground water. The saline water could be stored at a site in the lower end of the valley, be partially desalted, or possibly be used for industrial purposes. No costs have been estimated for the Grand Valley Collector System.

c. Return flow utilization on Palo Verde Drain. - The activities under this investigation will be directed toward obtaining basic data for the development of plans to remove the salt contributed to the Colorado River by the discharge from the Palo Verde Outfall Drain, California. The discharge of the outfall drain ranges from 447 ft^3/s to 648 ft^3/s with a salt concentration averaging about 1,827 mg/l. Computations of the total salt load returned to the river, including the river above Taylors Ferry, indicate that the salt pickup from the Palo Verde Irrigation District was about 148,000 tons (see fig. I-55).

One method of removing some of this salt from the river it to divert part of the return flows for cooling water in nuclear-fired electric powerplant operations. The cooling water would be disposed of by evaporation after use.

Metropolitan Water District has agreed, in principle, to furnish up to a total of 100,000 acre-feet of Colorado River Water each year to sites in the Mojave Desert area for powerplant cooling and related purposes. The water is to be distributed as follows: San Diego Gas and Electric Company - 17,000 acre-feet; Los Angeles Department of Water and Power - 33,000 acre-feet; and Southern California Edison Company - 50,000 acre-feet. Metropolitan and the affected parties have executed letters of intent formalizing such allocation, and the terms and conditions under which Metropolitan would furnish this water. In the future, it is anticipated that these letters will be executed as contracts. If these nuclear powerplants were to be located in the desert area near the Colorado River, the availability of cooling water would be of prime importance. The water requirement could be met by siting the powerplants so that a part of the return flows conveyed to the Colorado River by the Palo Verde drain could be used for cooling purposes. Such a plan would require that the

Return flow utilization - view of Palo Verde outfall drain.

Figure I-55

cooling water be reused until it became too salty for recycling, at which time it would be discharged to evaporation ponds for final disposal. However, since all of the waters of the Colorado River, including this return flow, are committed to present water uses, a plan which depletes the return flow can be used only if the water can be replaced from another source. It is physically possible to replace Colorado River return flows used in California with water supplied from the California State Water Project through an exchange agreement with the Metropolitan Water District. Such an exchange agreement would require ratification by present users of Colorado River water.

Assuming that the above exchange were made, the result would be to replace water with an average salinity of 1,827 mg/l with Metropolitan Water District Colorado River releases averaging 751 mg/l. If each powerplant unit were to use 20,000 acre-feet of return flow the annual salt reduction to the river would average 29,000 tons and the salinity at Imperial Dam would be reduced by 4 mg/l.

3. Blue Springs Unit, Arizona

Preliminary investigations of salt contributors to the Colorado River have led to the designation of some units for initial construction and others for continued investigations. During these preliminary studies, it was found that the feasibility and/or environmental impacts of some units were of such a nature as to preclude the development of a project. At some future date economic, environmental and social values may change and the project may be reevaluated. As a consequence of current findings, further studies have been terminated. Due to this termination, only a brief summary is presented in this section. A detailed description of environmental impacts will not be prepared until such time as the project demonstrates feasibility.

Introduction

The Blue Springs area is located on the Navajo Indian Reservation in Coconino County, Arizona, about 25 miles northwest of Cameron and about 65 miles north of Flagstaff. The springs are located in a nearly inaccessible gorge of the Little Colorado River and appear in the first 14 miles upstream from its confluence with the Colorado River at the northeastern boundary of Grand Canyon National Park (see fig. I-56).

In the Blue Springs area, the Little Colorado River flows through a half-mile-deep, mile-wide meandering gorge carved in sandstone,

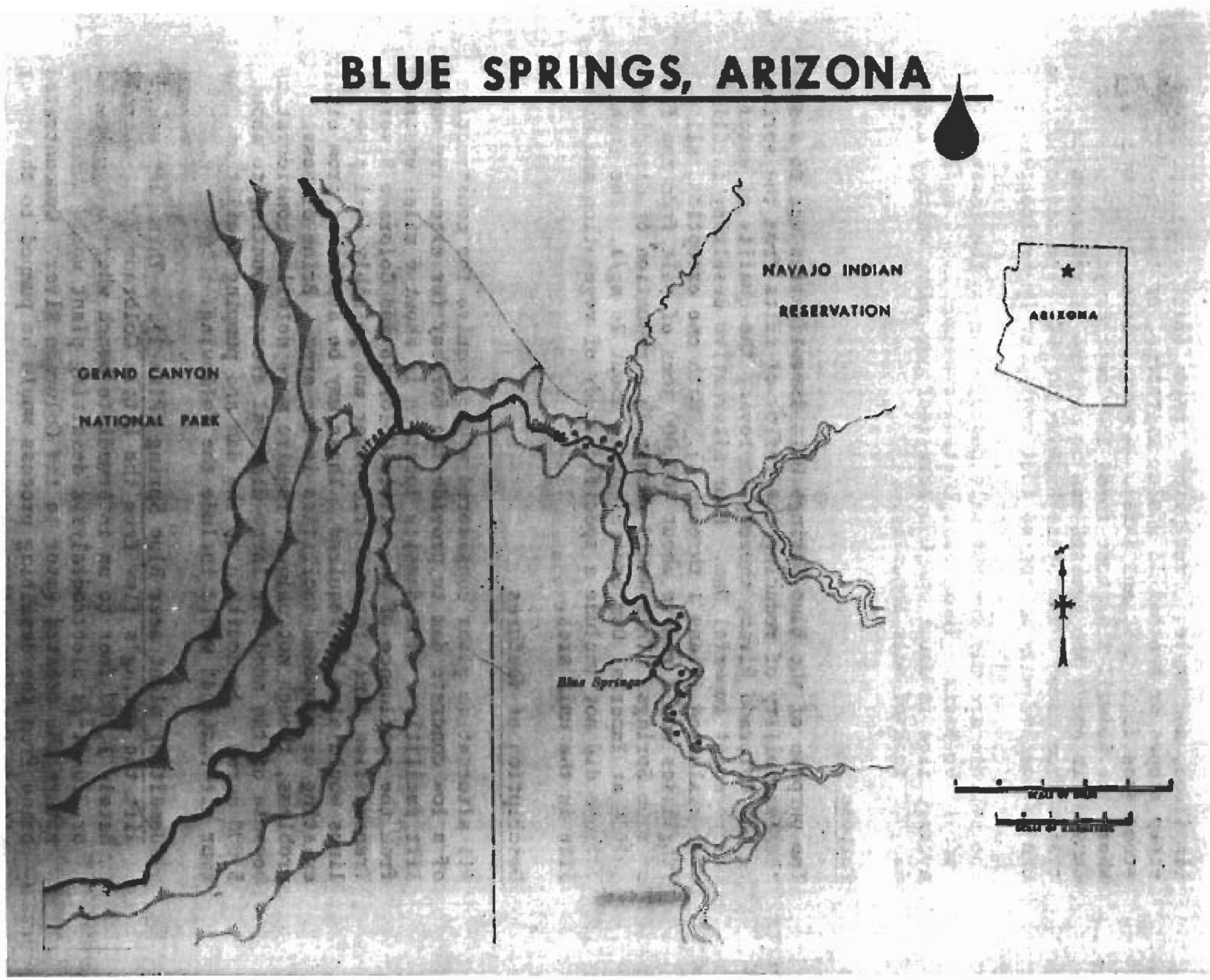

BLUE SPRINGS, ARIZONA
NAVAJO INDIAN
RESERVATION
GRAND CANYON
NATIONAL PARK
ARIZONA
Blue Springs

Figure I-56

limestone, and shale. Precipitous canyon walls are separated by steep slopes or benches in shale, siltstone, or thin-bedded sandstone (see figs. I-57 and I-58). A narrow inner gorge occurs where the Redwall limestone forms the lower canyon walls. The canyon rim above the springs can be reached by vehicle over trails from Cameron and State Highway No. 64. The canyon bottom can be reached only by rugged foot trail, or by helicopter.

The springs are the largest salt contributor to the Lower Colorado River Basin. Their salt content averages 2,500 mg/l while average flow is about 160,000 acre-feet per year, which yields 550,000 tons of salt annually.

Purpose

The purpose of the Blue Springs Unit investigation was to assess the feasibility of reducing the inflow of salts from the springs to the Colorado River, thereby improving the quality of water delivered at Imperial Dam. Four alternative desalting facilities were evaluated (Plans 1 through 4). With one exception, all facilities would remove about 400,000 tons of salt from the flows of Blue Springs. This would result in a reduction of dissolved solids at Imperial Dam equivalent to about 26 mg/l. The investigations did not include a specific study of vegetation and wildlife in the unit area.

Description of features

All alternative plans considered would require the construction of a low concrete dam to provide the forebay for extensive pump-lift facilities. The damsite location is about 6 miles upstream from the confluence of the Little Colorado and Colorado Rivers. Transmission lines for electric power and possibly fuel pipelines would also be required. These may be available from either existing or proposed facilities in the area. Brine disposal problems, though not unique, require more detailed consideration because of the need for large disposal areas amounting to about 5,000 acres. In addition to the dam and pumping facilities, the four alternatives would include the following:

Desalting plant near Blue Spring (Plan 1). - This plan would lift the spring's flow from the Little Colorado River approximately 1,000 feet to an intermediate bench where a 140-Mgal/d or 220-ft^3/s electrodialysis desalting plant would desalt and return the treated water to the Colorado River. Concentrated brine from the desalting process would be pumped to the upper plateau for disposal.

Little Colorado River confluence with Colorado River.

Figure I-57

Vicinity of Gold Hill - canyon area.

Figure I-58

Navajo desalting scheme (Plan 2). - Water from the Blue Springs would be lifted and conveyed about 55 miles northeast to the Navajo Generating Station now under construction. About 50 ft^3/s of the water would be consumed by the generating station for cooling purposes. The remaining water would be conveyed to a 126-Mgal/d vertical tube evaporator-multistage flash (VTE-MSF) desalting plant which would utilize waste heat from the generating station as a portion of its heat energy requirement. Approximately 100 Mgal/d of desalted water would be piped back into the Colorado River. Brine waste would be pumped about 15 miles to a brine disposal reservoir.

Navajo thermal cooling plan (Plan 3). - This plan would lift and convey about 50 ft^3/s of the Blue Springs flow to the Navajo Generation Plant for use as cooling. Plan 3 is a simplified modification of Plan 2. By physically removing about 11 percent of the Little Colorado River's average annual flow of 310,000 acre-feet, a 14-percent reduction in salt contribution can be realized. This concept could be used for the cooling requirement of any other generating station within economical conveyance distance.

Power-pump storage desalting plan (Plan 4). - This plan represents the integrated operations of a pumped-storage generation complex and a 140-Mgal/d electrodialysis desalting plant. Features would include a combination pump-generation plant to lift the springs flow to the desalting plant. Treated product water would then be conveyed to a storage reservoir for later release to the generating plant. Brine waste would be conveyed 16 miles to an evaporation reservoir.

General

Although the Blue Springs area lies within the Navajo Indian Reservation, the lands are claimed to have been originally settled by Hopi ancestors. The Hopi people regard the Blue Springs area as a sacred place. More than half of the Hopi's believe their ancestors entered this world through a hole in the sky of a "lower world." Although most agree that the location of the "sipapuni" or "sipapu," as this opening is called, has long been forgotten, some of the clans place the physical point at a mineral spring mound located at Mile 4.7 in the Little Colorado River gorge. The mound is about 10 feet high and approximately 30 feet in diameter, and is composed of precipitated carbonates.

Historically, the Hopi's have gathered salt from ledges on the left bank of the Colorado River and about 2 miles below the confluence of the Little Colorado River. To reach this remote area, the Indians generally traversed a perilous trail from Moenkopi to the north side of the Little Colorado River, thence descending nearly 3,000 feet through Salt Trail Canyon to the Little Colorado River gorge and the region of the Blue Springs. They then traveled through the gorge to the Colorado River, generally returning by the same route. These salt gathering expeditions were pilgramages with religious rites performed enroute; clan symbols were inscribed on the rocks and offerings were placed at various wayside shrines. Many Hopi's still make these religious pilgrimages.

The extensive facilities required, along with high initial construction and operating cost factors, brine disposal problems, and sediment loads in the Little Colorado River that would limit project operation to those times when the riverflows do not exceed 700 ft^3/s, result in severe negative economic factors. The possibility of combining a desalting facility with a pumped-storage generating complex would have merit only if the environmental impediments would be negotiated and sufficient future offpeak capacity obtained.

The project would have a major estetic impact on a very scenic portion of the Grand Canyon country.

The project would greatly interfere with a historical religious observance of the Hopi Indians.

These factors combined with the potential depletion of water that would be available for downstream users has effectively removed this unit from further program investigation at this time.

4. Meeker Dome Investigation

The Meeker Dome is an anticline mound located about 3 miles east of Meeker, Colorado. An oil test well drilled in 1915 on the south side of the dome produced about 3 ft^3/s of saline water which flowed into the adjacent White River. The well was plugged by the Bureau of Reclamation and the Federal Water Pollution Control Administration in 1968 in hopes of controlling this flow. It now appears that much of the saline water which had been flowing from the well, escapes through other fractures and pathways and seeps into the White River both upstream and downstream from the plugged well. An alternative feature for possible addition to the CRWQIP would be to prevent the salts of this dome from entering the White River. It is estimated that the brine flow at a concentration of about 19,000 mg/l contributes about 57,000 tons of salt to the river each year. Plans have not yet been formulated as to the method of control for this source of salt although it is recognized as an area of heavy contribution to the Colorado River system. Since the flows could possibly be collected in a point source by reopening the Meeker well or drilling an alternate well, evaporation in a pond or processing through a desalting plant appear to have promise at this time.

CHAPTER II

ENVIRONMENTAL SETTING

CHAPTER II - ENVIRONMENTAL SETTING

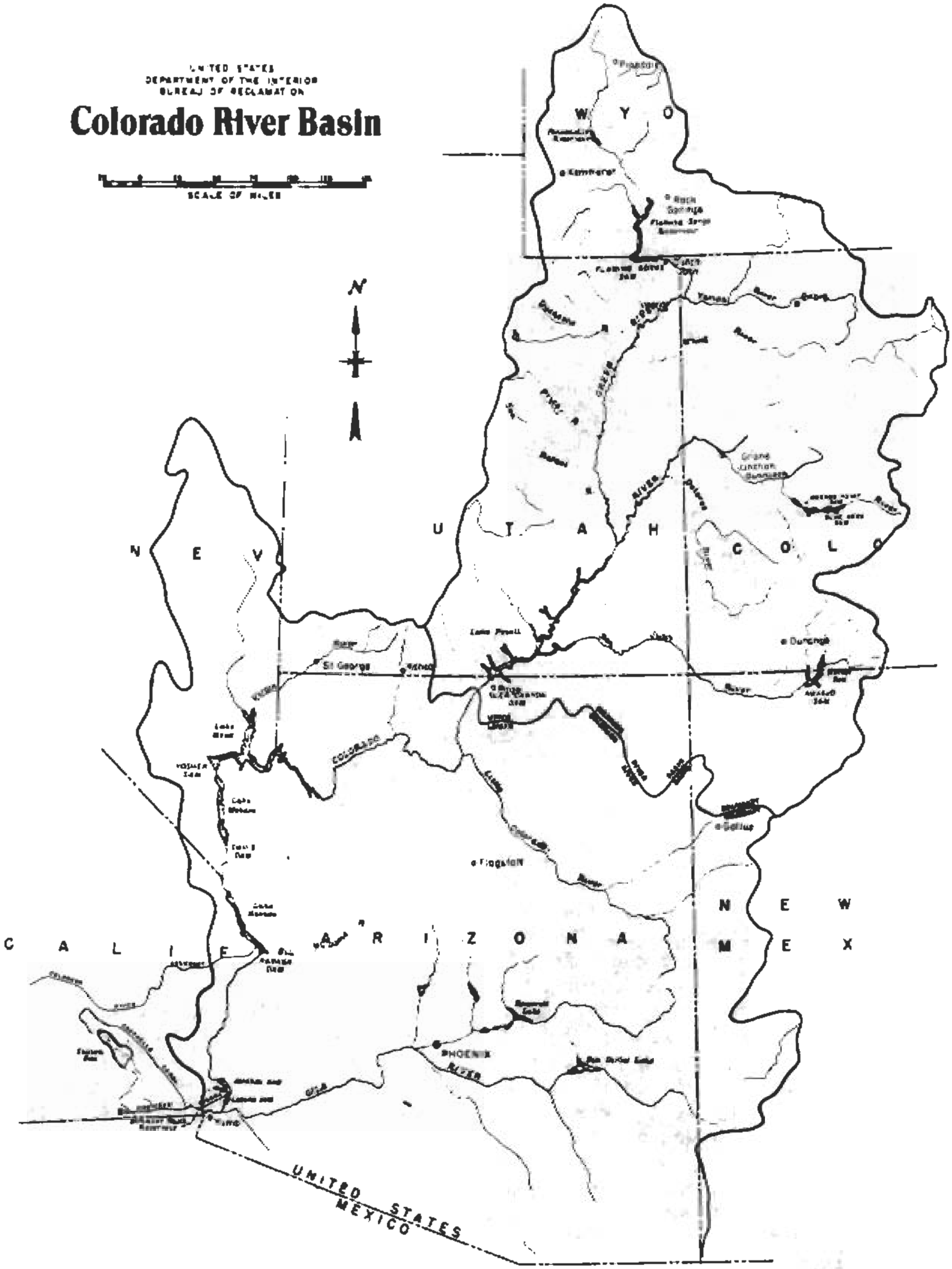
A. Introduction

The Colorado River is situated in the Southwestern United States and extends 1,400 miles from the Continental Divide in the Rocky Mountains of north-central Colorado to the Gulf of California (fig. II-1). The river is a water and power resource that supports the needs of 17 million people. The Colorado River Basin covers an area of 254,000 square miles, approximately one-twelfth of the continental United States. The Colorado River Basin includes parts of seven states: Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

The Colorado River Compact of November 1922 divides the entire Colorado River Basin into two parts, the Upper Basin and the Lower Basin. These basins are separated at a point on the river in northern Arizona known as Lee Ferry, which is located 1 river mile below the confluence of the Paria and the Colorado Rivers and is approximately 17 miles downstream from Glen Canyon Dam (fig. II-1). The purpose of the Compact is to provide for equitable division and apportionment of the use of the waters of the Colorado River System and for legal, political, institutional, and hydrological purposes.

The Colorado River Compact defines the Upper Basin as the part of the Colorado River Basin within and from which water naturally drains to the Colorado River System above Lee Ferry and the Lower Basin as that part of the Basin within and from which waters naturally drain into the Colorado River System below Lee Ferry. The Upper Colorado River Basin and the Lower Colorado River Basin are also referred to in this environmental statement as the Upper Colorado Region and the Lower Colorado Region, respectively (see fig. II-1). The Upper Colorado Region encompasses about 45 percent of the drainage area of the Colorado River Basin. The Upper Colorado Region is represented by the drainage basin of the Colorado River above Lee Ferry, just below Glen Canyon Dam. The region is on the west side of the Continental Divide and includes parts of Arizona, Colorado, New Mexico, Utah, and Wyoming. It encompasses an area of 113,496 square miles, including 109,580 square miles in the Upper Colorado River drainage. The region is bounded on the east and north by mountains forming the Continental Divide and on the west by the Wasatch Mountains. On the south it opens to the Lower Colorado Region at Lee Ferry in northern Arizona.

The Lower Colorado Region, with a total area of 141,137 square miles, embraces 106,982 square miles of Arizona, 13,355 square miles of New Mexico, 17,310 square miles of Nevada, and 3,490 square miles of Utah. Excluding a portion in southern California, the Region is hydrologically defined by the drainage area of the Colorado River in the United States below Lee Ferry. In addition, it includes several closed



Map of Colorado River Basin.

Figure II-1

basins in Arizona, New Mexico, and Nevada, and some areas in Arizona and New Mexico that drain into Mexico. In area, the lower Region represents about 4.8 percent of the contiguous United States and about 7.1 percent of the area west of the Mississippi River.

B. General Environment of the Colorado River Basin

The Colorado River rises high on the Continental Divide at altitudes of over 14,000 feet, and flows generally southwestward, leaving the United States at an elevation of about 75 feet above sea level. The Colorado River Basin is composed of a complex of rugged mountains, high plateaus, deep canyons, deserts, and plains. Principal physical characteristics of the region are its variety of landforms, topography, and geology.

1. History

The prehistory of the region spans about 11,000 years and it is anticipated that still earlier evidences of the presence of man may be found. The Lithic Stage commenced about 9,000 B.C. and is characterized by finely chipped Clovis Fluted projectile points, the well-known Folsom points, and the delicately flaked leaf-shaped Eden and Angostura points. Man subsisted by big game hunting during this period. The Archaic Stage, which dates from about 2,000 B.C., followed. Artifacts indicate man had adapted to a hunting and plant-gathering subsistence in a harsh desert and semi-arid environment. During the Archaic Stage, man began to specialize into regionally identifiable cultural groupings out of which the later period and better-known Anasazi and Fremont cultures emerged. The Anasazi culture, which ranges from the 5th to the 14th century, A.D., is known for impressive achievements in architecture, ceramics, horticulture, and a highly developed religious system.

There is a discontinuity between the prehistoric cultures and the Indian populations existing at the time the first European explorers entered the Region. Navajos, situated in the southern portion of the Region, are latecomers who arrived during the last 500 years.

In 1869, Major John Wesley Powell explored 500 miles of the Colorado River System from Green River, Wyoming, to the mouth of the Virgin River within the present area of Lake Mead. Powell's studies and recommendations were the first scientific explorations and for many years were the most significant in shaping policy and legislation for adapting the arid lands of the West to agriculture.

One of the first permanent settlements was the fort built by Antoine Robidoux in 1832 near the confluence of the Uinta and Duchesne

Rivers in the Green River drainage area. John Robertson established a trading post on Blacks Fork about 1834 and induced Jim Bridger to settle nearby along the immigrant trail to Oregon and later to California. Fort Bridger became an important resupply point for the Mormon pioneers in 1847 and succeeding years and for California-bound travelers following the gold discovery of 1849.

Gold attracted early prospectors and miners to the Region. It was discovered near Breckenridge, Colorado, in 1859, and numerous placer mines quickly flourished. Other gold and silver strikes followed. During the next few years there was considerable development throughout the Colorado part of the Region and the population increased rapidly.

Mining activity and commercial requirements of the booming populations associated with the industry attracted the early railroad development. Even the construction of the Union Pacific was partially based on the influences of gold and silver discoveries in California and Nevada in the mid-1800's. Similar discoveries in the Colorado Rockies and the desperate need for transportation to the mining camps led to the construction of a great network of railroads, mostly of narrow gage design to cope with the mountain conditions. These, in turn, produced a demand for wood for railroad ties and bridge timbers and for fuel. Coal replaced wood as a domestic and industrial fuel source and led to the expanding coal mining industries of Colorado, Utah, and Wyoming.

Early settlements were confined at first to mining camps in the upper reaches of the rivers and to limited agricultural areas that developed to supply the nearby camps and the travelers on the overland trails to the West. With the decline of mining enterprises, agriculture became the basic industry of the Region. Many miners, disappointed in their search for gold and silver, turned to stock-raising and the growing of crops as a means of livelihood. Towns and cities were developed mainly near farms and mines and at important railroad points. Statehood was achieved by Colorado in 1876, Wyoming in 1890, Utah in 1896, and New Mexico and Arizona in 1912.

2. Economics

The economics of the Basin have varied widely since the beginning of recorded time. Historians and archeologists estimate that prior to the birth of Christ, the Gila and Salt River Valleys in central Arizona had a thriving Indian population oriented around agriculture that may have irrigated in excess of 100,000 acres. Exactly how many people were here is conjectural, but certainly several tens of thousands must have lived and worked in this economy. However, by the time Spanish explorers entered the area in the middle-16th century, this prior civilization was gone and only small settlements of Indians remained, but the economic base was still agriculture.

Settlement of Mormon pioneers established the pattern of small agricultural communities along river valleys where more favorable farming land could be cultivated and irrigated and where livestock could be grazed on nearby forest and rangelands. The livestock industry soon became an important sector of the agricultural economy.

It was soon found that irrigation was essential to successful crop production in most parts of the Basin. The rate of irrigation development was slow, however, because of difficult construction methods and generally low crop values. By 1900, most of the readily available sources of irrigation water had been developed by private individuals and small irrigation companies. Shortly after the turn of the century, the first Federal reclamation projects were undertaken in the Basin and these have been the nuclei around which today's larger irrigated farming communities and trading centers have evolved. There are now numerous Federal and State projects throughout the Basin, many of which provide stability to former private developments by providing supplemental water and eliminating water-supply shortages during periods of deficient streamflows.

In the late 1800's and early 1900's the growing populations, both within the Colorado River Basin and in the adjacent metropolitan areas, provided an expanding coal market for heating and industrial uses. For a time, coal production was of major economic importance. With the war, substitution of gas for coal as a fuel and the adoption of diesel power on the railroads resulted in major decline in coal mining. Also, at this time a more diversified and expanding economy began to evolve. Hoover Dam's Powerplant produced an abundant new source of electricity for municipal and industrial growth in the Southwest. Climate was favorable for military training activities and the arrival of air conditioning tempered the harshness of hot summer months. Gambling and related entertainment industry started in Las Vegas, Nevada. Lake Mead, Lake Havasu, and the Lake Mohave on the Colorado River as well as those lakes formed behind the dams on the Salt, Verde, and Gila Rivers in central Arizona evolved into great attractions for recreationists, hunters, and fishermen. The affluent economy that developed during the 1940's started a tourist influx to the arid Southwest to escape the cold winter months in the Northern states. Light industry followed to capture a readily available labor pool and utilize the year-long working environment.

Early enterprise was principally centered around mining such metals as copper, gold, and silver. Then, with improved water storage, delivery, and management, irrigated agriculture came into equal prominence. More recently, light manufacturing industries have grown into major economic importance and presently contribute nearly twice the combined dollar value of the mining and agriculture sectors.

Impetus to hydroelectric power generation was given by the mineral industry. The first hydroelectric development was at Aspen, Colorado, in 1885. In 1891, the Ames Plant, located in the upper portion of the Dolores drainage in Colorado, was among the first hydroelectric plants to transmit alternating current at high voltage. As the area became settled and the need for electricity grew, several small hydroelectric plants were built.

It was not until the 1950's that steam-electric power production had significant growth. In 1950 only six small steam-electric plants with an installed capacity of about 56,000 kilowatts were operated by utilities. By 1960 five additional steam-electric plants had been built, bringing the capacity to about 400,000 kilowatts. In the following 5 years, the installed capacity was increased by 233 percent to 1,335,000 kilowatts as large steam-electric units were built at the Four Corners (New Mexico, Hayden (Colorado), and Naughton (Wyoming)) plants. These plants were located primarily to take advantage of the availability of low-cost coal. Most of their output is exported to load centers outside the Colorado River Basin.

It was also in the 1950's that the Colorado River Storage Project and Participating Projects were authorized by the Congress. Primarily for water conservation, the development was aided financially by the addition of hydroelectric power generating units at several reservoirs constructed under the authorization. By December 1965, 820,500 kilowatts of generating capacity had been installed at the Glen Canyon and Flaming Gorge Powerplants. By December 1968 the capacity had reached 1,128,000 kilowatts with the installation of additional capacity at the Glen Canyon Powerplant and installation of the Blue Mesa and Fontenelle Powerplants. Plants of the storage project and participating projects comprise about 93 percent of the total hydroelectric power capacity operating in the Colorado River Basin. At the present time most of the power generated at federally owned plants is exported from the area. These exports will continue until load growth in the Colorado River Basin makes power generated there salable in the area.

In the future, the Colorado River Basin must be regarded as a major national storehouse for energy. The basin is rich in coal, oil, and natural gas and contains the largest oil shale deposits anywhere in the world. Economic development of these resources particularly in the Upper Basin is a very complex and controversial public issue. Aside from the economic, legal, and institutional aspects of anticipated large-scale energy development, one of the major constraints or impacts will be on water supply. According to a recent study by the Department of the Interior[15] pending energy development in the Upper Basin could require about 870,000 acre-feet of water by the year 2000. The distribution of pending energy development by type and location is presented in the following tabulation:

Summary of Pending Energy Development in the Upper Colorado River Basin by the year 2000.[15]

State	Coal-fired electric generation (MW)	Oil shale (KBCD)	Coal gasification (MCFD)	
Wyoming	5,360	125	250	
Colorado	8,970	1,090	-	
Utah	10,630	300	864	
New Mexico	6,850	-	1,788	
Arizona	2,310	-	-	
	34,120	1,515	2,902	
	AF/YR	AF/YR	AF/YR	Total
Wyoming	79,500	22,000	15,000	116,500
Colorado	134,600	191,000	-	325,600
Utah	144,950	46,000	52,500	243,450
New Mexico	82,000	-	72,000	154,000
Arizona	34,100	-	-	34,100
	475,150	259,000	139,500	873,650

MW = Megawatts or 1,000 kilowatts
KBCD = 1,000 barrels of crude (oil) per day
MCFD = Million cubic feet per day of gas
AF/YR = Acre-feet per year

The present economy of the Upper Colorado Region is largely resource oriented. This orientation is not restricted entirely to agriculture, forestry, and mining, but includes the area's vast recreational endowment. The mineral industry overshadows activities of the agricultural and forestry sectors. The major effects of outdoor recreation and tourism are reflected in the tertiary or noncommodity producing industries which, as a group, contribute the greatest share to total Upper Basin economic activity.

Since 1965, the Lower Colorado Region population has been increasing at the rate of about 4 to 5 percent per year. Nevada and Arizona were ranked No. 1 and No. 3 in national standing for rates of increase.

New employment opportunities for the expanding population were principally in the manufacturing, trades, and services-type industries. Agricultural and mining employment was in a stable-to-slightly declining trend. Personal income per capita for the Lower Colorado Region was near the national average.

The Lower Colorado Region is experiencing a vigorous, healthy upswinging trend of development in the manufacturing, wholesaling, construction, and the trades and services industries. Only the Little Colorado area, which is still primarily a rural area, lagged behind this trend. The combination of climate, employment opportunities, the great variety of striking scenery, and recreation opportunities have attracted residents from all parts of the United States. Immigration accounted for nearly two-thirds of the population growth of the Region during the 1960's and early 1970's.

The role of irrigated agriculture in the Lower Colorado Region's economy is expected to continue and grow in the future; however, its dollar contribution will decrease in importance to the total economy. It is expected that the irrigated harvested acreage will increase from 1,226,000 acres in 1965 to 1,584,000 acres in 2020; employment, 39,000 to 43,000; and total value added, $232 million to $647 million. These estimates are based on projections resulting from developments during the last two decades. The area has also experienced a significant transition from an agricultural-mining base to a manufacturing-service base. Growth in the manufacturing sectors has been one of the major factors in the overall economic growth. Important light manufacturing categories are electrical equipment, aircraft and parts, primary metals industries, food and kindred products, printing and publishing, and chemicals. At present parts of the Lower Colorado Region have become meccas for retirement, recreation, and entertainment which have boosted the noncommodity dollar output to more than the combined amount from all other regional economic sectors.

3. Land Use Aspects

Land use patterns are affected by elevation, climate, industry, and agricultural uses, as well as the natural history and political-cultural developments in the region. Land uses affect water quality (1) as runoff enters streams, (2) from human habitation and related activities, (3) recreational pursuits, and (4) agricultural uses, and (5) industrial-mining-energy activities. Salinity, nutrients, sediments, BOD and coliforms, heavy metals and toxic organics all result from these activities and certain problem areas in the basin can be linked with quality parameters which are affected by the activities.

The greatest area of land in the basin is classified as rangeland. Early growth of the livestock industry resulted from a naturally favorable condition for raising cattle. In general, because of "unlimited" forage, the range animals did well without conscious aid and husbanding by the ranchers. Phenomenal increases in cattle numbers occurred until about 1885, then numbers leveled off. This is in contrast to the sheep industry which did not reach peak numbers on western ranges until about 1910.

Over the period from about 1860, when cattle grazing on the public domain became general, until 1934, when the Taylor Grazing Act was passed, little provision was made for administering the grazing resources of western land (the national forests were somewhat of an exception).

In general, the land use of the Colorado River Basin has been one of continuous evolvement. In particular, recent emphasis has focused attention on new wilderness areas, recreation areas, parks, and other public use of Federal lands. Over the past several years, significant advances have been made in land treatment, management practices, and techniques by landowners and public land managers. Recent management programs and measures were installed on public and private lands for reducing erosion and sedimentation, and controlling runoff. Measures have been initiated for improving livestock forage and timber production. Vegetative and resource management have been provided on over 2,500 square miles of forest land for increased water yield and livestock forage. Management technique and practices are expected to improve and intensify within the coming years in response to resource conservation and pollution control trends.

The Upper Colorado Region has 72,234,000 acres of land, of which about 24 million acres are in forests and woodlands, 46 million acres are in grass and browse rangelands, barren areas, and urban and metropolitan areas, and approximately 1,621,500 acres are under irrigation, including idle land. This land is used mainly to produce feed to support the livestock industry. Certain locations such as Grand Valley, the Gunnison Valley, and the Uncompahgre Valley are suitable for additional commercial crops, such as sugar beets, malting barley, feed barley, grain, corn, sorghum, dry beans, vegetables, and orchard fruits.

An inventory of existing recreation resources, by class, is provided below:

Class		Acreage
I	High-density recreation areas	1,057
II	General recreation areas	283,749
III	Natural environment areas	46,031,581
IV	Unique natural areas	998,049
V	Primitive areas	1,413,978
VI	Historic and cultural sites	228,868
	Regional total (all classes)	48,957,282

Public lands, most of which are administered by Federal agencies, constitute nearly 90 percent of the recreational acreage in this region. One-third of the land is privately owned, with slightly more than half of this owned by corporations and individuals, and the remainder in Indian tribal or individual ownerships held in trust by the Bureau of Indian Affairs.

Much of the land in the area is managed under a multiple-use concept, where the largest possible amounts of goods and services may be produced from the resource base. Resource uses of the Upper Colorado Region include crop production, domestic livestock grazing, outdoor recreation, mineral production, timber production, and the conservation and preservation of wilderness and other public values.

The Lower Colorado Region has approximately 1,816,000 acres of cropland under irrigation. Most of the irrigated areas are around Phoenix, southeast of the Casa Grande area and Santa Cruz Valleys, and along the Lower Colorado River. The long growing season makes it possible to produce crops on most of this irrigated land any time during the year. Therefore, vegetables and small grains are grown during the cooler months and such crops as cotton and sorghum are grown during the warmer months. Of the four main sources of income (manufacturing, mining, agriculture, and tourism), agriculture produces about 20 percent of the total and employs about 7.2 percent of the Region's labor force.

Grazing by domestic animals utilizes about 76 million acres of both private and public lands. This comprises about 84 percent of the land area of the Region.

About 64 percent of the Lower Colorado Region is in public ownership. Of this, about 30 million acres are classified as forest lands. Over 24 million acres of these forest lands are nonproductive for commercial timber products. Nearly all the 5.5 million acres of commercial timber are in national forest (69 percent) or on the Indian reservations (23 percent). In summary, there are approximately 162 million acres of land in the Colorado River Basin, of which, approximately 3 million acres are irrigated at the present time. This amounts to 1.5 percent of the area of the basin. The irrigated area is about equally divided between the upper and lower basins.

4. Population Distribution

The Colorado River Basin is sparsely populated compared to national averages. In 1970, the estimated population was nearly 2.5 million. The average density was about 9 persons per square mile compared with a national average of 64. About 2.1 million or 84 percent of the total Basin population lives in the Lower Colorado Region with about 70 percent of these people residing in the metropolitan areas of Las Vegas, Nevada, and Phoenix and Tucson, Arizona. The population of the Colorado River Basin is estimated to be about 4.28 million by the year 2000.[42] Population distribution is classified 74 percent urban and 26 percent rural. In the Little Colorado Area, which contains no large cities, the ratio of urban to rural is almost exactly reverse that of the Region, being 72 percent rural and 28 percent urban.

In 1970, the population of the Upper Basin was abut 346,000. The average density was about three persons per square mile compared with the national average of 64. In contrast, Lower Basin density was about 14 persons per square mile.

On the basis of estimates for 1970, only two communities in the Upper Colorado Region had populations of more than 20,000 - Grand Junction, Colorado, with 20,178 and Farmington, New Mexico, with 21,979. The next largest towns are Durango, Colorado, with a population of 10,400 and Rock Springs, Wyoming, with 11,657. All of the other communities have populations of less than 10,000.

Only about 37 percent of the residents live in towns with populations of more than 2,500 inhabitants and the remainder are in rural areas.

In the Lower Region, in 1970, there were 10 cities which had populations greater than 20,000. Three of these cities, Phoenix, Tucson, and Las Vegas, had metropolitan area populations in excess of 100,000. In addition to the population within the basin, the Colorado River serves major centers which lie outside the basin, including Denver, Salt Lake City, Los Angeles, and San Diego.

5. Climate and Air Quality

Climate extremes in the Basin range from hot and arid in the desert areas to cold and humid in the mountain ranges. Precipitation is largely controlled by elevation and the orographic effects of mountain ranges. At low elevations or in the rain shadow of coastal mountain ranges, desert areas may receive as little as 3 inches of precipitation annually while high mountain areas may receive more than 60 inches.

The climate in the Upper Colorado Region is semiarid to arid and consists generally of four seasons. Wide variations in precipitation, temperature, and wind movement result primarily from varied topography and to a lesser extent from the rather wide range in latitude.

Precipitation from late October through mid-April consists primarily of snow, particularly at higher elevations. Snow accumulations occasionally exceed 100 inches at the higher elevations and do not completely melt until late summer.

Temperatures vary widely with extremes being recorded from minus 60° F at Taylor Park, Colorado, to 115° F at Lee Ferry, Arizona. Mean monthly temperatures are lowest in January and highest in July and generally show about 50° F seasonal difference. The average frost-free period or consecutive period with temperatures above 32° F ranges from 20 days or less at elevations about 8500 feet to more than 180 days at elevations below 5000 feet. The growing season in the Upper Colorado Region is slightly longer than the frost-free period for the grass and alfalfa crops which predominate on the higher elevation lands.

Winds over the area move generally from west to east, but the wind movement is greatly modified by local topographical influences. Average annual wind velocity ranges from about 8 to 14 miles an hour while strong winds associated with local thunderstorms have reached velocities of 80 to 90 miles per hour.

Annual evaporation from lakes and reservoirs is estimated to range from less than 30 inches at higher elevations to about 60 inches in the lower valleys.

The Lower Colorado Region's climate varies widely as a result of the large differences in elevation, a considerable range in latitude, and the distribution of mountain ranges and highlands. Mean annual temperatures range from 43° F at Alpine in the mountainous area of eastern Arizona, to 72° F in the desert area of Gila Bend, Arizona. In the desert areas, temperatures in excess of 100° F are common during much of the summer. In the mountainous areas above 7,000 feet, normal summer daytime temperatures range in the 70's while winter temperatures below zero occur regularly. Frost-free periods range from less than 60 days in the high mountains to nearly year long in the desert valleys.

The climate of densely populated areas of the lower region, such as Las Vegas, Nevada, and Phoenix, Tucson, and Yuma, Arizona, is generally characterized by mild to warm annual temperatures, low to moderate humidity, and low annual precipitation. Rainfall is predominantly in the form of thundershowers which are sometimes very intense and produce flash flooding locally. Yuma, Arizona, has experienced several years in succession without a killing frost. These climate factors are very favorable to the irrigated agriculture concentrated in the lower elevations.

There are two distinct moisture sources. Winter precipitation is associated with moisture moving into the area from the Pacific Ocean while the Gulf of Mexico is the source of much of the summer rainfall.

Air quality throughout the Colorado River Basin varies considerably in different locales. Throughout most of the Region air quality is good but at some areas, particularly close to metropolitan or urban areas, the atmosphere has undergone some degradation due to both natural and manmade reasons.

In areas of urban development or intensive agricultural activity the incidence of high concentrations of suspended particulates, nitrous oxides, and/or photochemical oxidants approach or even exceed national primary or secondary ambient air quality standards. Standards for particulate concentrations are often exceeded during periods of high winds in areas where the surface has been disturbed.

In general, the air quality in the vicinity of the authorized project features is well within the national standards. Detailed discussion will be provided on individual units as additional environmental documents are developed.

6. Topography, Geology, Minerals and Soils

The Upper Colorado Region is comprised of highly dissected mountainous plateaus, typified by deep canyons, mesas, river valleys, and rolling hills. The region is bounded by mountains studded with high rugged peaks, with elevations ranging from 3100 feet at Lee Ferry, Arizona, to more than 14,000 feet at some of the higher mountain peaks. The landscape has been scoured and eroded by rivers and streams, augmented to some extent by glaciation and winds. Stream erosion as the principal weathering agent has produced cuts where various rock layers of all ages are exposed. Geologic formations, ranging in age from Recent to Precambrian, occur within the Region. These dramatic erosional features, together with the brilliant colors of the formations, have been the basis for designating several national parks and monuments. The Colorado Rocky Mountains, including the San Juan Mountains at the south end of the Region, are impressive from both a scenic and geologic viewpoint, as are many other mountain ranges in the Region. Regional uplifting and intrusion have exposed an assortment of igneous and metamorphic rocks which are among the oldest known. Above 8,000 feet the mountains and plateaus are for the most part heavily forested; however, the timberline ends at about 11,500 feet and above that elevation alpine and barren areas occur.

The east-west trending Uinta Mountains are a broad anticlinal arch of sedimentary rocks with the crest of the range composed of very old quartzites. This range is in the Green River Subregion and separates the Green River Basin of Wyoming from the Uinta Basin of Utah. The Wind River Range, which forms the northeast boundary of the Green River Basin, is similar to the Colorado Rockies. Uplifting with accelerated erosion has exposed the oldest known crystalline granites as the crest and core of the mountains.

Glaciers occupied all the mountains above an elevation of about 10,000 feet during the Pleistocene Epoch. These bodies of ice greatly modified the shape of the higher stream valleys and left extensive deposits of terminal glacial debris.

The Upper Main Stem and San Juan-Colorado Subregions are predominantly characterized by severely eroded sedimentary rocks. It is judged that several thousand vertical feet of sedimentary rocks have been removed by erosion and carried away to the Gulf of California. Alternating resistant sandstones and soft shales which lie nearly horizontally have weathered into cliffs, ledges, and slopes. This spectacular topography of high flat-topped plateaus and mesas separated by narrow, nearly vertical-walled canyons is referred to as the Colorado Plateau physiographic province. Streams as the principal erosional agent have produced deep cuts which expose rock layers of all ages.

The natural quality of the Colorado River, determined by the nature of the rocks and soils the river drains, relates to the stratigraphy of the Colorado Plateaus. These plateaus are carved from thick strata of sandstones and shales, deeply dissected by the river and its tributaries. It is the marine shales that primarily degrade downstream water quality. Faults crossing streambeds also bring up deeply circulating saline water to the river, and salt domes that lie directly in the path of some tributaries make a salt contribution.

The shales of the Colorado Plateaus were deposited in shallow seas that were often confined, containing high concentrations of calcium sulphate, sodium chloride, and potassium salts. Significant shale formations are found in Colorado in the Four Corners area and Glenwood-Dotsero area, in Arizona near Blue Springs, and in eastern Utah. It is the gypsiferous Mancos Shales in the eastern Utah area and western parts of Colorado that account for much of the natural salt load of the badlands.

The Green River Subregion is underlain mostly by sedimentary rocks of Tertiary and Mesozoic age. These rocks contain vast deposits of coal, oil, and oil shale. During Tertiary times the Green River Basin and Uinta Basin within the subregion were occupied by two large freshwater lakes. The Green River Formation which contains the oil shale deposits and also valuable trona deposits was laid down in these lake beds. Mesozoic rocks near Rock Springs, Wyoming, contain both oil and gas in significant amounts. The topography of the Green River Subregion is more gentle than that of the Upper Main Stem and San Juan-Colorado Subregions. Rolling plains with shallow stream valleys predominate.

In hundreds of square miles of the region there is no soil cover, and bare sandstone and shale are exposed to the elements. Associated with the outcrops are large acreages of shallow soils that are less than a foot deep. The shallow soils are extensive at lower elevations, particularly in the Upper Main Stem and San Juan-Colorado Subregions. Soils that are several feet deep are mainly along stream valleys, on old pediment surfaces and on uplands mantled by wind-deposited or loessial soils.

The Lower Colorado Region is composed of a complex of plateaus, mountains, canyons, deserts, and plains, with elevations ranging from 75 feet above sea level near Yuma, Arizona, to over 12,600 feet above sea level at Humphreys Peak near Flagstaff, Arizona. The Region also lies within two of the major physiographic provinces of the southwest, the Basin and Range province and the Colorado Plateau province.

The Basin and Range province occupies the southern and western portions of the Region and is characterized by mountain chains and alluviated valleys. Most of the province is within the drainage area of the Colorado River or its main tributary, the Gila River. In the mountain ranges, these streams and their tributaries have cut deep gorges. The part of the province bordering the Colorado Plateau, south of the Mogollon Rim, is a mountainous area with some small valleys. Many of the streams head in narrow canyons. In the southwestern part of the Region, however, the buttes and ranges are of generally small areal extent protruding above wide alluviated plains and valleys. The valleys consist of a series of interlocking basins partly filled by alluvium. The basin rims are formed by mountain ranges, which consist of all types of rocks - sedimentary, granitic, volcanic, and metamorphic - that usually have been subjected to recurrent faulting and tilting. As a result, many ranges consist of masses of rock that are strongly inclined, lying on end, or locally overturned. Differential erosion of these rocks has givon the ranges an irregular appearance.

The Colorado Plateau province occupies the northern and northeastern portions of the Region and is characterized by alternating cliffs and slopes formed as a result of variations in resistance to erosion. Ledges, cliffs, or rock benches formed of resistant beds of sandstone and limestone are separated by slopes, valleys, and badlands carved on the weaker intervening shaly strata. The whole province has similar rock formations of wide areal extent which are inclined slightly or are nearly horizontal. In areas adjacent to the Colorado River, canyon lands are developed extensively. In the area surrounding the canyon lands and in part of the upland adjoining the canyon rims, rock terraces form a series of platforms such as the Marble Platform, plateaus such as the Coconino Plateau, and high cliffs such as the Grand Wash Cliffs. In the southern part of the province beyond the belt of rock terraces and plateaus, the relief is rather subdued and broad slopes and low mesa-like features predominate.

In many valleys the basement rocks are overlain by a coarse material of generally low permeability, which has eroded from the nearby highlands. Concurrent with this sedimentation, faulting occurred and volcanic eruptions deposited lavas.

The Colorado Plateau province is underlain by sedimentary rocks ranging in thickness from 1,000 to 10,000 feet that overlie igneous and metamorphic basement rocks.

The Colorado River became a through-flowing stream in late Cenozoic time. Downcutting by the river and its tributaries have caused deep entrenchment of the entire system resulting in spectacular canyons. The occurrence of natural solute erosion of halite beds and solution phenomena associated with marine shales such as the Mancos Shale Formation contributes an inordinate amount of salt to the river system.

The geology of the Lower Colorado Region includes a broad spectrum of sedimentary, metamorphic, and igneous rocks which produce a wide variety of soils locally and along stream courses. In short, the principal physical characteristics of the Region are its great variety of land forms, topography, and geology.

Forty-three mineral commodities have been produced commercially in the Upper Colorado Region. Gold and silver dominated the early mineral industry, while fuel (petroleum) has been the leading mineral commodity since about 1946.

The Lower Colorado Region also had significant gold and silver strikes in the early 1870's. Large-scale copper production began in the middle 1880's and is still very active today.

Critical diffuse salt source areas occur in much of the semiarid to arid portions of the basin. They are frequently associated with outcrop areas or soils derived from soft shales, siltstones, claystones and lake bed deposits in valley alluvium. Over half the average annual 10.7 million tons of salt in the Colorado River is from natural diffuse salt source areas. These areas include 30 percent of the Green River Basin in Wyoming and the semiarid areas of eastern Utah and western Colorado which have extensive areas underlain by shales of the Mancos and Wasatch Formations. In areas along the Little Colorado River, Gila River, Vermillion Cliffs, San Simon Creek, and San Carlos Rivers in Arizona and the Virgin River in Nevada and Utah, there are outcrops of the Chinle and Moenkopi Formations where significant areas of saline soils exist.

Sediment and salt loading problems occur in rangeland, grassland, forest, cropland, and urban areas in the basin; but they are greatly accelerated where man's activity has modified the vegetative cover. Average annual sediment yield greater than 0.5 acre-feet per square mile, the point at which serious erosion is assumed, occurs on 60,500 square miles or 24 percent of the area of the Colorado Basin. Another aspect of the problem is that serious erosion is found on 8,100 miles and moderate erosion along 42,100 miles of stream channels in the basin.

Sediment, the product of erosion, may cause damage during transport along streams, rivers, lakes, and wherever it is deposited. Sediment can result in overwash, swamping, and increased flooding. It accumulates in reservoirs, increases treatment costs of municipal and industrial supplies, impairs navigable streams, clogs irrigation and drainage improvements, smothers growing plants, and destroys harvestable crops, increases maintenance costs of utility and transportation facilities, decreases the recreational value of water, and adversely affects the fishery resource.

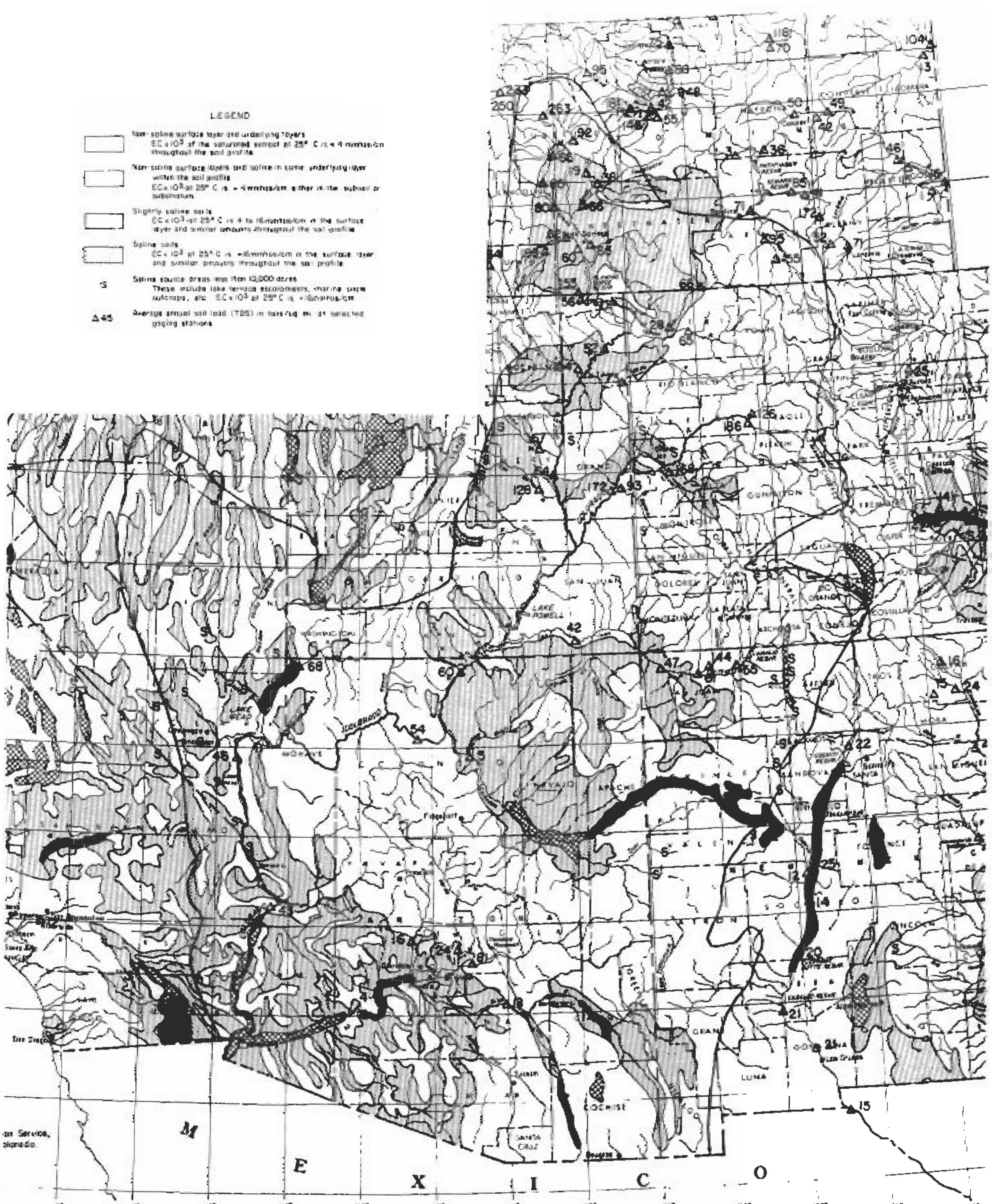
Water quality is directly related to suspended sediment and salt transported from surface and subsurface areas except where point sources contribute substantial amounts. Saline soils occurring on sloping terrain are usually high contributors of both salt and sediment, particularly when gully and channel erosion occur. In the water erosion of saline soils, significant salts are removed through solution and the sediment is detached and moved as suspended solids or bedload.

A review of the available water quality records indicates that annual sediment or salt load can vary by a factor 15, depending on runoff. For example, the salt load (TDS) on the Rio Grande at the El Paso gage has varied from 84,000 to 1,200,000 tons per year for water years 1936 to 1959. Evaluation of selected streams indicates a high correlation in annual runoff to associated salt and sediment loading. About 90 percent of the annual variance in salt and sediment load is explained by annual variance in runoff.

Very little data are available in most of the states for relating sediment to salt loading. Recent records show a small percent of the gaging stations measuring both sediment and salt load from such sources as return flow from irrigation, subsurface runoff from saline aquifers, saline springs, etc. Techniques for continuous and accurate monitoring of sediment and salt are expensive and generally beyond the reach of broad stream coverage. Many states are instituting programs to collect additional data on water quality and this information will be valuable to future studies.

An interpretive saline soils map, figure II-1A, based upon delineations of the "Soil of the Western United States, 1964," and standard soil surveys was prepared using the following classes of nonsaline and saline soils:

Nonsaline surface layer and underlying layers - EC x 10^3 of the saturated extract at 25° C is < 4 mmhos/cm throughout the soil profile.



Saline Soil Western United States

Figure II-1A

Nonsaline surface layers and saline in some underlying layer within the soil profile - EC x 10^3 at 25° C is < 4 mmhos/cm in the surface layer but > 4 mmhos/cm either in the subsoil or substratum.

Slightly saline soils - EC x 10^3 at 25° C is 4 to 16 mmhos/cm in the surface layer and similar amounts throughout the soil profile.

Saline soils - EC x 10^3 at 25° C is > 16 mmhos/cm in the surface layer and similar amounts throughout the soil profile.

Spot symbol "S" was used to delineate saline source areas of sediments that are too small to delineate as a separate entity. Examples of these might include Pleistocene lake terrace escarpments, Miocene lake terrace escarpments, shale outcrops, etc. Each symbol is to equal 10,000 acres or less.

Characteristic average salt load at key gaging stations were used to identify high salt contributing areas. The occurrence of surface geologic formations such as soft shales and lacustrine or terrestrial lakebeds which contribute substantial salt loads to streams must be considered.

7. Vegetation

The Colorado River Basin has a wide variation in vegetative cover types. The type of vegetative cover depends upon the precipitation, topography, soil, and climate; in addition, each type is limited to rather specific ranges in elevation. The forest type covers approximately one-third of the land area in the Upper Colorado Region and extends from the small alpine areas on top of Mount Baldy in the White Mountains, the tip of Humphrey Peak in the San Francisco Peaks, and the crest of Charleston Mountain, Nevada; through the coniferous forest zones of spruce-fir, ponderosa pine, and the pinion-juniper and oak woodlands, and the Chaparral types. The rangeland type extends from the forest type through the Northern and Southern desert shrubs, the northern and desert grasslands, down through a small area of true desert near the mouth of the Colorado River on the boundary between Mexico and Arizona. Irrigated pasture and cultivated land are scattered throughout the basin area.

The Lower Colorado Region in 1965 had a percentage of vegetal cover that was about 2 percent cropland; 64 percent pastures and range; 33 percent forest and woodland; and less than 1 percent in urban, transportation, utilities, etc. The region has a wide variation in vegetation cover types and related categories that determine the resources, uses, and developments that exist or may be projected.

The natural vegetation ranges from desert through the chaparral and mountain brush, pinion-juniper and oak woodlands, to the yellow-pine and spruce-fir forest, to alpine and tundra type on top of the highest mountains. (See Appendix A for specific listings.)

8. Fish and Wildlife/Recreation

a. Fisheries. - Distribution of fish populations of the Colorado River Basin is determined to a great extent by elevation of the river system because of the relationship between elevation and temperature. Although fish species operate within a given temperature range, in some cases quite wide, temperature is a major limiting factor of species distribution. Temperatures at the same elevation gradually increase downstream toward the southerly latitudes of the basin resulting in some warm-water fisheries being mixed with the predominantly cold-water ones.

Most of the higher elevation tributaries of the basin are considered trout fisheries (fig. II-1B). These result largely from temperature-related phenomena but also reflect clear water, good food chain development, and usually high gradient streams.

In the next lower reaches of the river system a transition zone exists between trout waters and the mainstream stretches. Whitefish characterize this zone of water. Whitefish require high quality water and have relatively strict habitat requirements which make them a good index of the effects of human activities on the river ecosystem.

This transition zone is followed by meandering stream reaches which generally are found in agriculturally developed areas, have higher silt loads, and have various species of minnows, catfish, and carp. Carp are an introduced species which have become established as an important part of the Colorado River Basin fisheries.

Silt loads, stream gradient, and food chains have major impacts on fish populations and these are reflected in the distribution of fishes of the basin (fig. II-1B). If significant input of natural or man-induced concentrations of materials which affect adult fish directly, their life cycles, or their food chains and their habits occurs, then the habitat would either be absent of fishes or have sparsely distributed populations.

Canyon reaches have the highest silt load and fish (e.g., humpback sucker) in these reaches (exclusive of fish-eating fishes) are generally dependent on food materials which are washed in

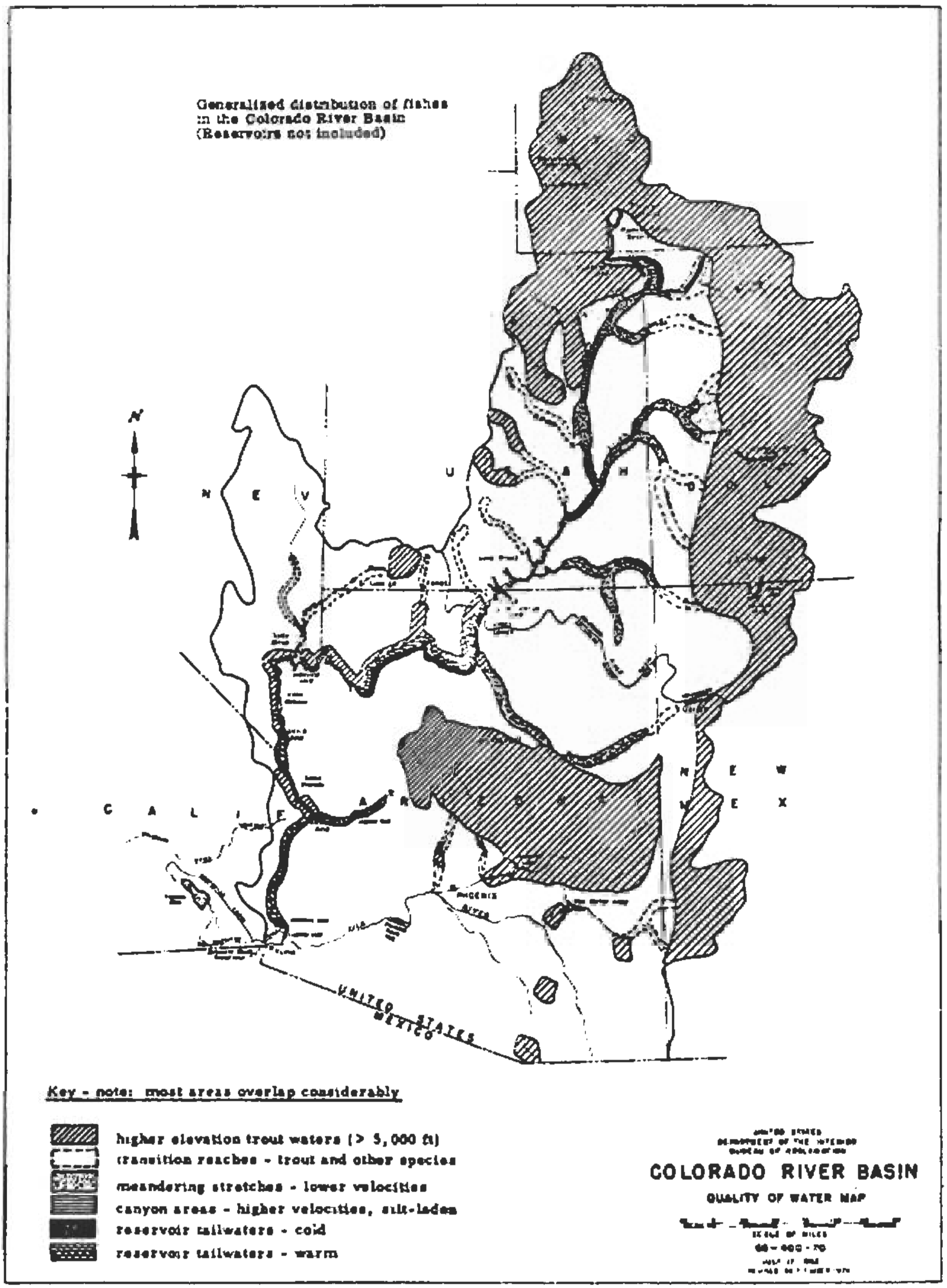

Generalized distribution of fishes
in the Colorado River Basin
(Reservoirs not included)
N
N E V
U T A H
C O L O
N E W
M E X
C A L I F
A R I Z O N A
PHOENIX
UNITED STATES
MEXICO
Key - note: most areas overlap considerably
higher elevation trout waters (> 5,000 ft)
transition reaches - trout and other species
meandering stretches - lower velocities
canyon areas - higher velocities, silt-laden
reservoir tailwaters - cold
reservoir tailwaters - warm
COLORADO RIVER BASIN
QUALITY OF WATER MAP

Figure II-1B

from tributary streams. For example, data on macroinvertebrates in these canyon reaches indicate that insectivorous fish would be dependent on insects washed into these reaches of the main stem. It is also apparent that suspended sediments and shifting stream sediments are largely responsible for the lack of main stem productivity.

Thus, the Colorado River Basin can be characterized as a drainage system which is typically oriented toward trout habitat in the Wyoming, northern Utah, and western slope of the Colorado and New Mexico Rocky Mountain regions plus a restricted habitat in the Arizona Plateau between the Little Colorado River and the Gila River. The upper reaches of the Green, the Duschesne, the Little Snake and the Yampa, the White, the Colorado main stem, the Gunnison, Dolores and the San Juan are the major streams constributing to this trout habitat. Upper reaches of the Salt, Verde, and Gila (New Mexico) are major drainages in the lower basin which furnish trout habitat.

Other reaches provide habitat which is not typical of trout but which are not less "natural" for the particular environmental conditions which exist in those reaches.

Reservoirs are classified separately and range from principally lake types of trout populations such as in Flaming Gorge, Blue Mesa, and Navajo Reservoirs, to the mixed fishery of Lake Powell and Lake Mead, and the warm water fisheries of the reservoirs downstream of Hoover Dam.

Stream gradient is an important aspect of water quality and the type of ecosystem and biological community which develops. These rates of fall shown in the following tabulation show no sharp demarcations but indicate the great diversity within the river system. High gradients (> 15 feet/river mile) correspond to higher elevation trout water in figure II-1A. Intermediate gradients correspond to the transition reaches plus some of the meandering and canyon reaches. Although one canyon reach and the warm tailwaters are found in low gradient areas, there is no direct casual relationship as found in high gradient reaches.

Stream Gradients For Selected Reaches in the Colorado River Basin (data from USDI, 1946)

	Feet per river mile
<u>High gradients (high stream velocities)</u>	
Los Pinos River[1] (Emerald Lakes to Navajo Dam)	60.0
Uncompahgre (headwaters to Gunnison River)	57.0
Gunnison[1] (headwaters to Colorado River)	35.0
Colorado (headwaters to Gunnison River)	17.0
<u>Intermediate gradients</u>	
Salt River[1] (headwaters to Gila River)	12.0
Yampa (headwaters to Green River)	10.0
San Juan (Navajo Dam to Colorado River)	9.0
Colorado (Lee Ferry to Lake Mead backwaters)	8.0
Gila[1] (headwaters to Colorado River downstream of Imperial Dam)	7.6
Colorado (Gunnison River to Green River)	5.1
Green (Green River, Wyoming to Colorado River)	4.6
<u>Low gradients (low stream velocities)</u>	
Colorado[1] (Green River to Lee Ferry)	3.2
Colorado[1] (Hoover Dam to Imperial Dam)	1.8

[1] Includes reservoirs which significantly affect resulting fish population.

<u>Major species</u>. - The cutthroat trout and mountain whitefish are the only game fish native to the Upper Colorado River drainage. These original inhabitants have been supplemented, and in the case of the cutthroat, largely replaced by introduced species suitable to the cold waters of the basin. Rainbow trout are the most numerous newcomers to the basin. There is very little warm water in the region; therefore, those waters at the lower elevations tend to be marginal and may have both cold- and warm-water fish. Channel catfish have been widely planted as have the largemouth bass.

There are approximately 85 species of fish in the Lower Colorado River Basin. Of these, about 56 species have been introduced. These fish are generally divided into two classes: Sport or game fish and nongame fish. About 60 species are classed as nongame fish. These are of value for forage fish, scientific investigations, and possibly a commercial fishery source. The remaining

25 species are classed as game fish. The notable introductions of game fishes include all the common warm-water sport and commercial fishes and all trout, except the endangered Gila and Apache trout. The introduced warm-water species include striped bass, white bass, bluegill, crappie, channel catfish, flathead catfish, yellow perch, tilapia, walleye, and Northern pike. (See appendix A for listing.)

Endangered Fish - Upper Colorado Basin[1]

Humpback chub - *Gila cypha*
Colorado River squawfish - *Ptychocheilus lucius*
Kendall warm springs dace - *Rhinichthys osculus thermalis*

Endangered Fish - Lower Colorado Basin[1]

Gila trout - *Salmo gilae*
Arizona (Apache) trout - *Salmo* sp.
Humpback chub - *Gila cypha*
Moapa dace - *Moapa coriacea*
Colorado River squawfish - *Ptychocheilus lucius*
Gila top minnow - *Poeciliopsis occidentalis*
Woundfin - *Plagopterus argentissimus*

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[1] Endangered and Threatened Wildlife and Plants - Federal Register, Sept. 26, 1975, April 28, 1976, June 1, 1976, and June 14, 1976.

b. Wildlife. - The Upper Colorado Basin has a variety of big game animals including the mule deer, elk, moose, antelope, bighorn sheep, mountain goat, Barbarry sheep, black bear, cougar, and two free-ranging buffalo herds. Some of the more important small game species are the sage grouse, chukar partridge, pheasant, mourning doves, ruffed grouse, blue grouse, wild turkey, rabbits, and snowshoe hares. Fur animals hunted generally are raccoons, foxes, bobcats, and coyotes. There are also a wide variety of animals such as marmots, ground squirrels, prairie dogs, and procupines.

In the Lower Colorado Basin, the big game species include the mule deer, white-tailed deer, elk, pronghorn antelope, desert bighorn sheep, black bears, wild turkey, javelina, and buffalo. The dominant game bird species are white-winged dove, mourning doves, and Gambel's quail. These are often found in high concentrations and support an extensive hunter population. Waterfowl frequent portions of the area and also receive some hunting pressure. (See appendix A for listing.)

Endangered Wildlife - Upper Colorado Basin

Utah prairie dog - *Cynomys parvidens*
American peregrine falcon - *Falco peregrinus anatum*
Blackfooted ferret - *Mustela nigripes*

Endangered Wildlife - Lower Colorado Basin

Sonoran pronghorn - *Antilocarpra americana sonoritensis*
Mexican duck - *Anas diazi*
American peregrine falcon - *Falco peregrinus anatum*
Masked bobwhite - *Colinus vierginianus ridgwayi*
Yuma clapper rail - *Rallus longirostris yumanensis*
Southern bald eagle - *Haliaeetus leucocephalus*
Blackfooted ferret - *Mustela nigripes*

Endangered and Threatened Wildlife and Plants - Federal Register, Vol. 40, No. 188, Part 11, Friday, September 26, 1975.

c. Recreation. - The recreational facilities in the Colorado River Basin contribute greatly to the economy of the West. Parts of the Basin have become meccas for retirement which have boosted the areas noncommodity dollar. Vacationers and outsiders are attracted to the area by several national forest and other public lands with outstanding recreational opportunities. Also popular as recreation spots are numerous state parks, private developments, and winter sports areas.

Under the Wild and Scenic Rivers Act as amended through Public Law 93-621 (January 3, 1975), the Bureau of Reclamation is cognizant of numerous river systems which are being proposed for wild and scenic status. Proposed salinity control programs in the Colorado River Basin will not impact any river segment proposed under this law.

The Basin is particularly renown for its concentration of national parks, monuments, and recreational areas. A listing of these is shown in the following tabulation:

NATIONALLY VALUED SCENIC AND RECREATIONAL RESOURCES OF THE COLORADO RIVER BASIN

National Monuments

- Rainbow Bridge, Utah
- Natural Bridges, Utah
- Hovenweep, Utah-Colorado
- Dinosaur, Utah-Colorado
- Black Canyon of the Gunnison, Colorado
- Colorado National Monument, Colorado
- Canyon de Chelly, Arizona
- Tuzigoot, Arizona
- Walnut Canyon, Arizona
- Chiricahua, Arizona
- Montezuma Castle, Arizona
- Navajo, Arizona
- Pipe Spring, Arizona
- Tonto, Arizona
- Grand Ruins, Arizona
- Wupatki, Arizona
- Sunset Crater, Arizona
- Organ Pipe Cactus, Arizona
- Saguaro, Arizona
- Grand Canyon, Arizona
- Gila Cliff Dwellings, New Mexico
- Chaco Canyon, New Mexico
- Aztec Ruins, New Mexico

National Parks

- Zion, Utah
- Bryce Canyon, Utah
- Capitol Reef, Utah
- Canyonlands, Utah
- Arches, Utah
- Rocky Mountain, Colorado
- Mesa Verde, Colorado
- Petrified Forest, Arizona
- Grand Canyon, Arizona

National Recreation Areas

- Flaming Gorge, Wyoming-Utah
- Glen Canyon, Arizona-Utah
- Lake Mead, Nevada-Arizona
- Curecanti, Colorado

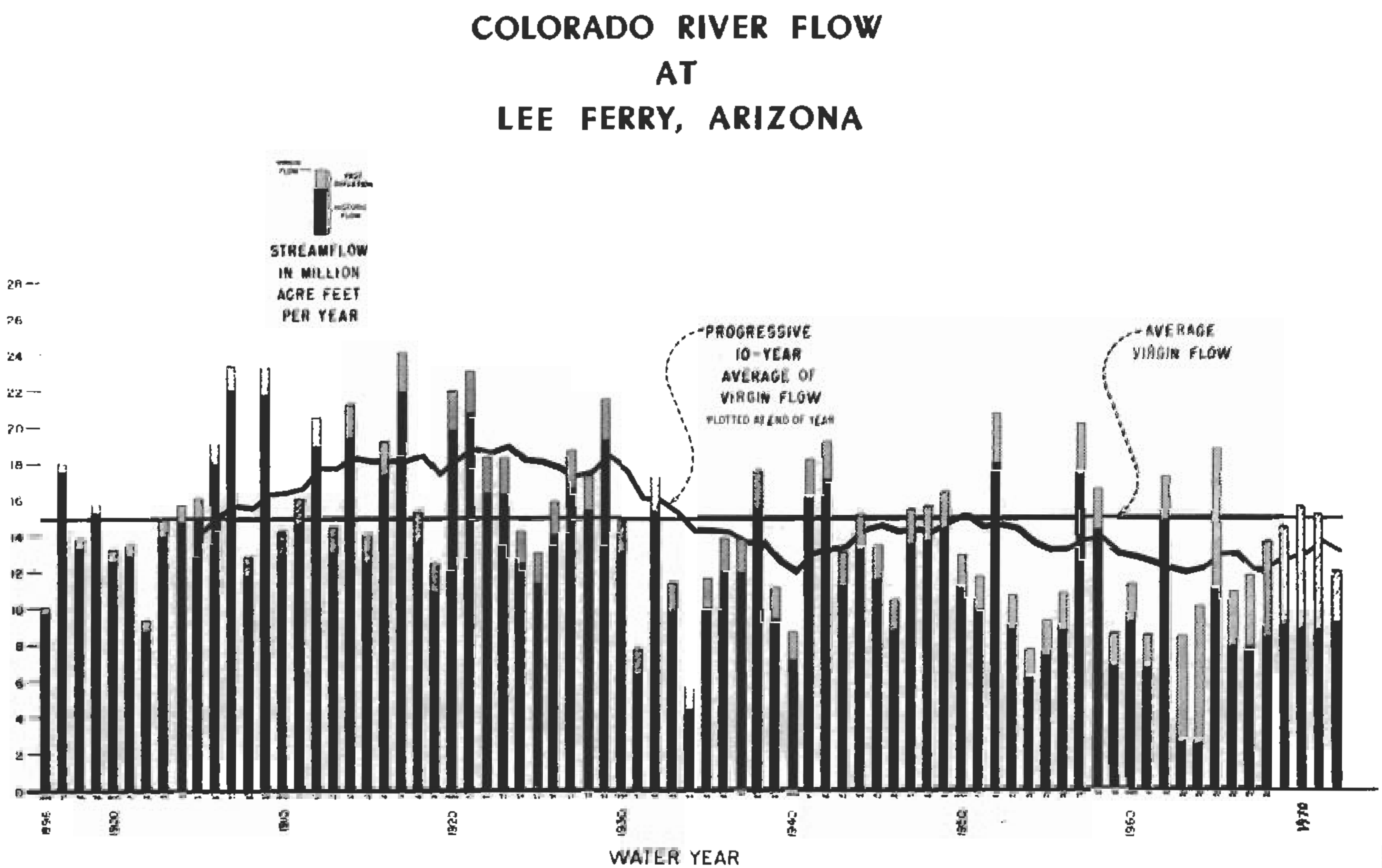
9. Basin Hydrology

a. Water supply. - The most universally used index of the Basin's water yield is the "virgin" flow of the Colorado River at Lee Ferry, Arizona, Annual Flows vary widely. Figure II-2 indicates that the virgin flow at Lee Ferry has ranged between about 5.6 and 24 million acre-feet per year since 1896 with a long-term average of about 15 million acre-feet. However, during the low historical period of 1931 to 1964, this flow averaged only 12.9 million acre-feet per year. Legal apportionment of annual beneficial consumptive use calls for 7.5 million acre-feet of the natural flows of the Colorado River to each of the Upper and Lower Basins, while 1.5 million acre-feet has been allocated to Mexico. Since the projected water deamnds of the Colorado River Basin greatly exceeds the most conservative estimates of supply and since the legal entitlements of the Upper and Lower Basin States and Mexico exceed the long-term annual virgin flow, the approximate 2.0 million acre-foot shortfall or 13 percent variation from the long-term average is of vital importance.

In short, two primary factors have lead to the present water supply problems of the Colorado Basin: (1) negotiators of the Colorado River Compact and the Mexican Water Treaty apportioned a water resource that at the time of negotiations, appeared much larger than the river has subsequently yielded; and (2) the Colorado River Basin simply does not yield sufficient water on a natural basis to permit full development of the Basin's vast land and mineral resources to provide for all projected water needs.

The unprecedented population growth in the southwest since World War II, resulting largely from interstate migration, has drastically increased the rate of consumptive use demands. More recently, potential water shortages have been identified[15] in connection with the important role of water in energy development of oil shale and coal in the Upper Basin.

At present, and in the short term, the Colorado River should be able to meet all quantitative, physical water demands. Assuming average runoff conditions for the next few years, both Lake Powell and Lake Mead have a reasonable probability of releasing excess water for consumptive use in the United States and Mexico. However, even when assuming the long-term average annual supply of about 15 million acre-feet, full development of all planned use of Colorado River water will so deplete the river that it will not yield sufficient water to meet all the demands placed upon it. Thus, the Colorado River Basin faces future water shortages unless the natural flows are augmented or Basin



Colorado River flow at Lee Ferry, Arizona.

development is curtailed. The extent and timing of these shortages will depend upon the rate of future consumptive use development and the Basin's water yield.

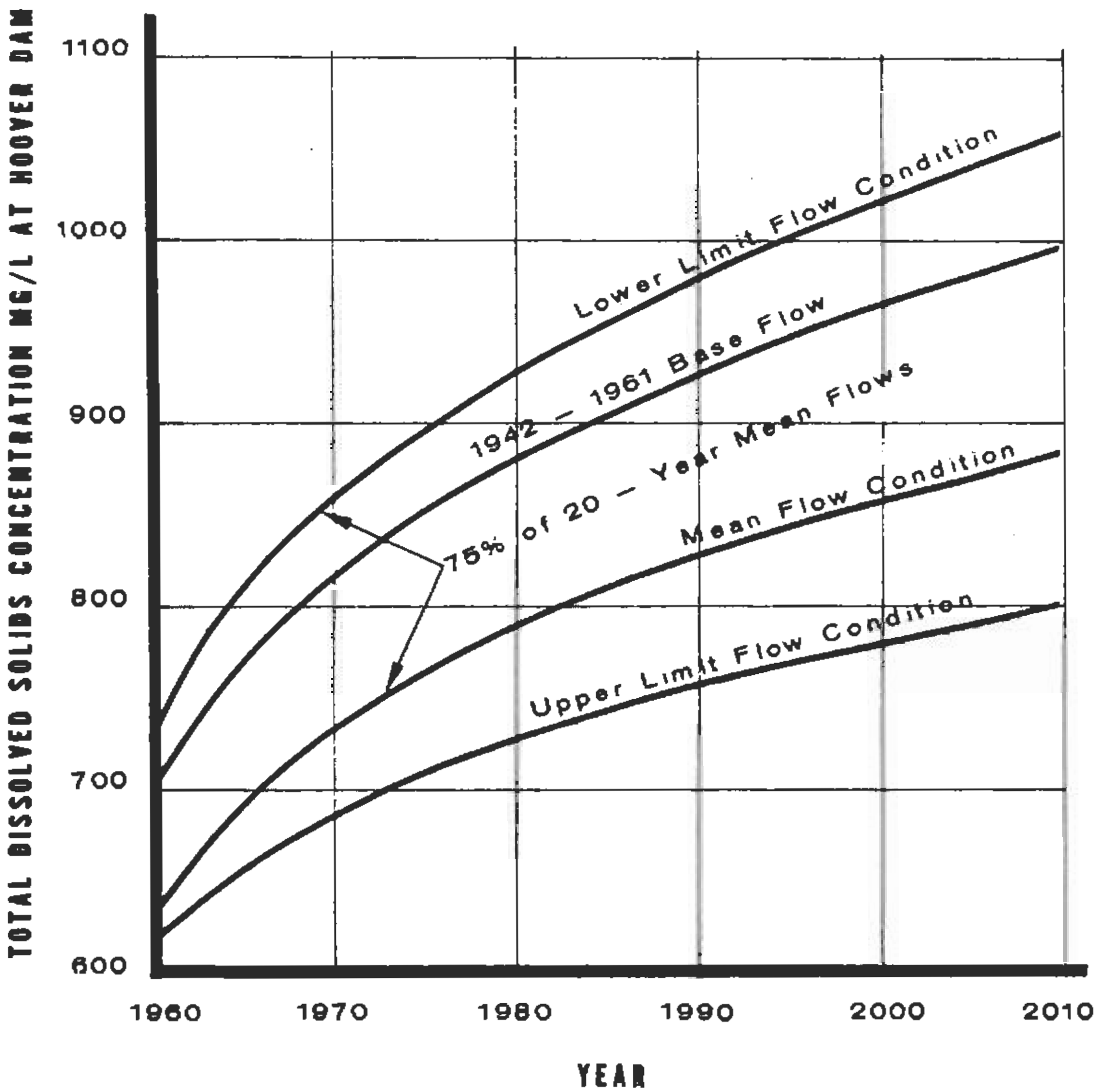
b. Water use. - The major use of water within the Basin is for agricultural, municipal, and industrial purposes. At present, over 60 percent of the long-term average supply of 15 million acre-feet per year of surface water serves irrigated agriculture and other users within the Basin. Approximately three-fourths of the water consumptively used in the Basin each year is depleted by agricultural uses. Minor quantities of water (less than 200,000 acre-feet per year) are presently used for hydroelectric and thermal power production, recreation, fish and wildlife, rural-domestic needs, and livestock. In the urban areas of the Basin, municipal and industrial uses are increasing significantly due to the rapid rate of population growth.

Surface evaporation from storage reservoirs also depletes the available water in the basin. It is estimated that over 2.0 million acre-feet of water evaporates annually from the lakes and reservoirs of the Basin, mostly from major storage reservoirs on the main stem of the Colorado River.

c. Relationship between water supply, depletions and salinity. - Such factors as the period of hydrological records and the rate of increase of consumptive use resulting from water resource development produce significant variations in projections of future river salinity levels. The interdependence of water quantity and quality becomes more visible when the sensitivity of salinity to variations in mean annual streamflow and future depletion of streamflow are examined.

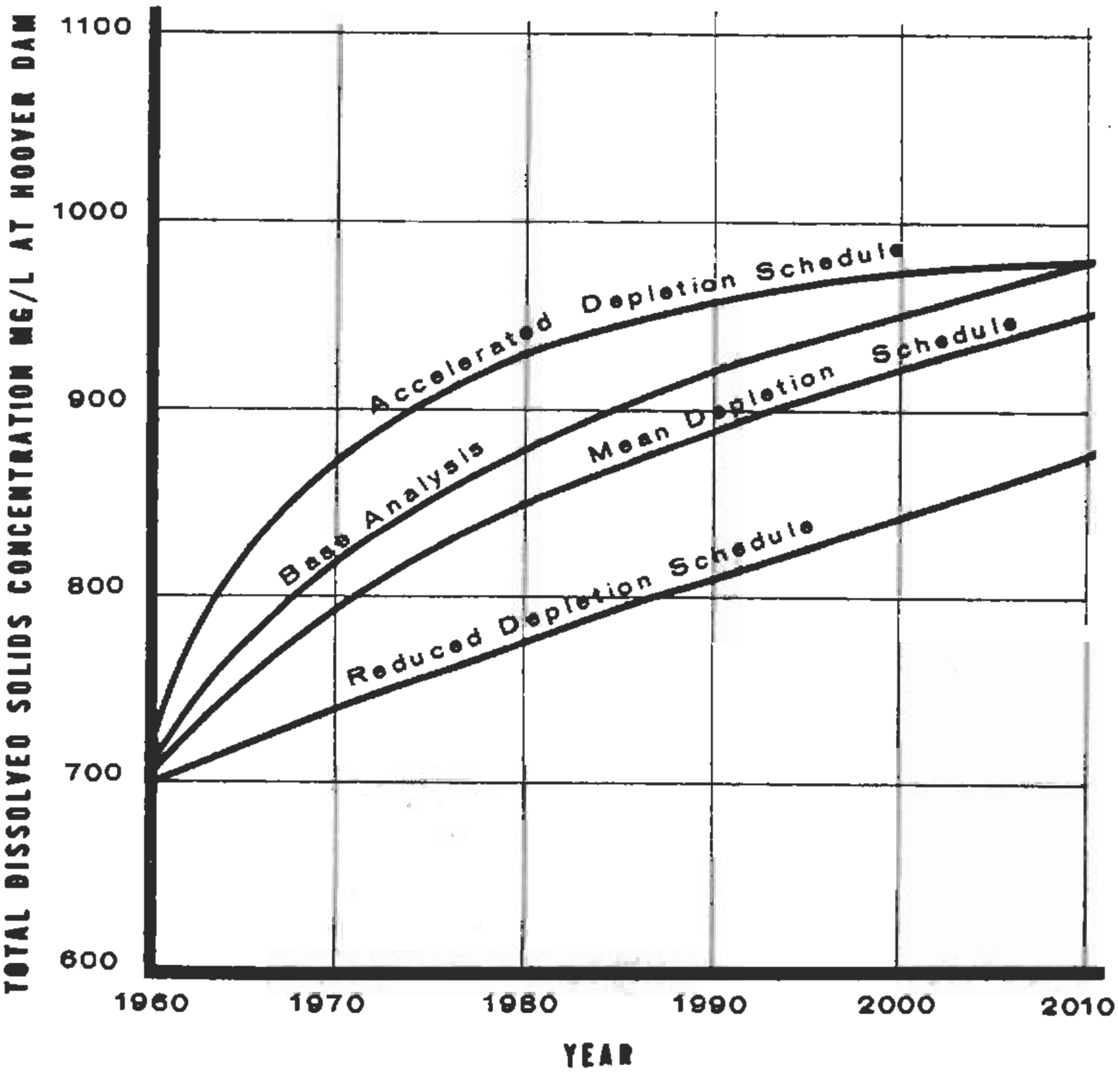
According to Environmental Protection Agency, figure II-3[4] shows the general sensitivity of salinity projections to base flow variations without implementation of any salinity control measures. In this case, a virgin flow of 16.8 million acre-feet is assumed as an upper limit with a lower limit of about 13.2 million acre-feet. For the year 2000 conditions, the total variation of salinity attributable to base flows could be as high as 250 mg/l.

Figure II-4[4] shows the sensitivity of salinity projections to depletion schedule variations without implementation of any salinity control measures. Representative schedules were selected to cover considerable differences of agency and State opinion over the rate at which upper basin water resource development will proceed. Actual development to date has been



Sensitivity of salinity projections to base flow variations.

Figure II-3



Sensitivity of salinity projections to depletion schedule variations.

Figure II-4

slightly slower due to fiscal constraints. For the year 2000 conditions, the total variation of salinity due to differences in depletion schedules could be about 125 mg/l. Thus, the smaller range between upper and lower limits on these projections would indicate a lower degree of sensitivity than that exhibited by variations in base riverflows.

d. Water quality. - Historic records have documented the gradual increase in salinity of the Colorado River. However, there has been no clear delineation of those changes in water quality which are associated with normal fluctuations in hydrologic patterns and those changes attributable to man's activities.[4]

In general, the salinity parameters can usually be described by a statement of whether they represent historical, present modified, or future conditions of the water of the Colorado River.

Historical salinity levels are determined by tabulating the recorded or estimated past condition at the water quality stations. The present modified condition includes adjustment of the historic condition to reflect depletions for the entire period for all developments operating at the present time. The future condition is an estimated projection after the presently authorized developments, projects proposed for authorization, and others which are anticipated to be developed by the future projected time are placed in operation.

Under historic conditions, the average concentration of dissolved solids of the Colorado River at Imperial Dam was about 766 mg/l for the 1941-74 period.

Under present (1974) modified conditions, the average concentrations would have been about 861 mg/l at Imperial Dam.

Under future conditions, without salinity control projects, predicted concentrations of 1,154 mg/l and higher have been made for the year 2000. Concentrations depend upon the projected future time, estimated future depletions, estimated future salt pickup, and many other factors.

In the Upper Colorado Region, water quality samples are being collected daily, monthly, or quarterly from approximately 100 sites on the rivers, canals, drains, and sloughs by the Bureau of Reclamation and by the Geological Survey. This program is in addition to the regular Geological Survey network. Samples are collected at various locations for the purpose of evaluating effects of future water resource projects on the river system, identifying sources of salinity for water quality improvement projects, obtaining basic data for research projects, and acquiring long-term records to determine trends, and observe overall changes in the salinity of the river system. This monitoring system will be especially valuable in providing data for the newly instituted CRWQIP in the Basin.

Recent water quality record studies show that during the period 1926-62, the chemical regimen of the Colorado River at Grand Canyon and upstream, although probably somewhat different from the virgin flow regimen, was relatively stable. There may have been small increases in average mineral concentrations, particularly toward the end of the period, caused by construction of reservoirs, increased irrigation and out-of-basin diversions.

The research also found that most of the mineral burden as well as the water of the Colorado River originates in the Upper Basin. The largest individual increment to the mineral burden of the Colorado River below the compact point and above Imperial Dam was found to be Blue Springs near the mouth of the Little Colorado River. The studies also show that cultivated lands in Parker and Palo Verde Valleys together with out-of-basin diversions contribute to increasing salinity in the lower reaches of the river below Hoover Dam.

Data collection programs are being continued. In addition, the latest salinity monitoring equipment is being tested on a trial basis to determine the feasibility of application to conditions along the Lower Colorado River. Data from the program are being used to develop a prediction model of salinity movement in the river.

C. Future Basin Environment Without the Program

Generally, environmental conditions in the Colorado River Basin are expected to remain as previously described or continue to be modified by trends unrelated to the CRWQIP. The following sections describe some of the current trends that are expected to continue into the future. Other consequences of no salinity control action under CRWQIP are described in Part A.3 of Chapter VIII.

1. Physiography

The Colorado River Basin is not expected to change dramatically over the next 50 years (the expected life of the control units under the program). The area is expected to continue to have a relatively lower population density with wide expanses of area managed for public use programs. With increased public use of the area's natural resources, the environmental characteristics of the area may be changed in the relatively small areas where intensive use occurs. However, there will continue to be large areas where environmental characteristics are largely unaffected by man's activities.

2. Land Use

The general trend toward improvements in land management techniques and practices is expected to continue in response to emphasis on resource protection and pollution control. Basin farmers and ranchers are expected to adopt more conservation and pollution control practices in both land management and water use. Improved cropping patterns, additional land leveling and improved drainage systems will enhance agricultural productivity and more attention will be given to complete resource management programs for farmland. Improved management of public lands is anticipated to provide additional timber harvest, and to accommodate increased recreational usage. Agricultural lands near urban areas will continue to be subdivided but at a slower rate than experienced during the past decade. Some marginal or supplemental agricultural land may be brought into production in response to demands for increased production of food and fiber.

Without a positive action program to maintain a suitable salinity level in the Colorado River, the productivity of some agricultural lands irrigated from the lower reaches of the river may be reduced. Unless salt tolerant plants are grown, these lands could, in the long term, return to desert conditions through successive stages. In the near term, there may be incremental problems with reduced crop yields until farming practices are modified.

3. Population and Economy

The basin population is projected to be more than 4 million by the year 2000,[42] with most of the increase occurring in the lower region. Growth of this magnitude is expected to occur whether or not the CRWQIP is implemented.

The economy of the basin is based on manufacturing, irrigated agriculture, mining, forestry, oil and gas production, livestock, and tourism. In the upper region, the mineral industry now overshadows activities of the agricultural and forestry sectors and this trend is expected to continue in the future. The major effects of outdoor recreation and tourism are reflected in the tertiary or noncommodity producing industries which, as a group, contribute the greatest share to the area's total economic activity. As such, salinity control would not affect recreation and tourism, but lack of the CRWQIP may result in additional restraints on water use for energy and mineral development in the upper region.

In the lower region, the economy has experienced a significant transition from an agricultural-mining base to a manufacturing-service base. Growth in the manufacturing sectors has been one of the major factors in the overall economic growth of the lower region and this trend is expected to continue. Agriculture will continue to play an important role in the lower region's economy along with the fast-growing industrial and commercial activity.

4. Water Supply

If current trends continue unaltered, there would be a general reduction in the amount of water available for new uses in the basin and in the quality of water available for all uses. There would be a continued increase in the salinity of the Colorado River water flowing to the lower region and Mexico as the States of the Upper Basin continue to develop their compact-apportioned water supplies. In the municipal and industrial sector, there would be a reduction in the overall availability and an increase in the costs of water treatment. In agriculture, the increased salinity could cause farmers to incur higher costs to maintain crop yields. In both sectors, ground-water reservoirs fed by Colorado River water would continue to accumulate salts and leave a legacy of saline ground water for future, more limited use.

5. Archeological and Historical Resources

Weathering and the trend toward vandalism will continue to endanger or destroy the value of archeological resources. While those resources in or near prospective construction sites of the CRWQIP would remain unaffected by that program, their values may be reduced by other activities.

6. Fish and Wildlife

The general trend toward increasing use of the areas fish and wildlife resources as well as the trend toward reduction of habitat due to man's activities is expected to continue. Those species now considered to be threatened or endangered would continue in those categories and other species may be added. The increasing competition for water supplies may result in less water being available to support instream flows and wetland areas. Strict water conservation efforts required to reduce salinity and other pollutants can be expected to reduce excess agricultural wastewater and associated marshes or wetlands that usually provide wildlife habitat.

7. Control Unit Areas

The projected future environments of specific salinity control areas would remain similar to present conditions. In the absence of separate control unit authorizations to meet program needs, construction and program related impacts would not occur. However, the areas may be changed by other activities that would modify environmental conditions.

D. General Environment of the Authorized Program Units under P.L. 93-320, Title II

1. Initial Control Units for Construction

a. Las Vegas Wash Unit, Nevada. -

(1) Introduction. - The Las Vegas Unit area encompasses a wide array of ecological situations and landscapes ranging from essentially natural to various stages of urban development. The general setting of the area is typical barren Mojave Desert dotted with islands of urban development.

Las Vegas Wash represents the lower portion of a natural drainage system, Pluvial Las Vegas River, which drains into the Colorado River at the Las Vegas Bay arm of Lake Mead. This ancient stream course can be traced from Indian Springs south to Corn Creek Spring, Tule Springs, Las Vegas Creek and into Las Vegas Wash. Recent studies provide a general picture of environmental changes over the last 30,000 years. At the beginning of this time span, Pluvial Las Vegas River was fully functional, discharging into the Colorado River. From approximately 30,000 to 15,000 years ago, Pluvial Lake Las Vegas occurred as a widespread, shallow lake over much of the valley. During the period 14,000-6,000 years ago, Indian Springs, Corn Creek Spring, Tule Springs and numerous springs in the vicinity of present day Las Vegas were active and drained into Pluvial Las Vegas River. Later, with increased aridity and lowering of the water table, spring activity decreased and sometime between 4,000 and 1,000 years ago Pluvial Las Vegas River became largely a dry wash. Rapid population growth and increased water utilization since the 1930's have resulted in a rapid and continuing decline in ground-water levels. Few springs in Las Vegas Valley are now active and Vegas Creek, the last remnant of Pluvial Las Vegas River, largely dried up in the late 1940's. Water now entering Las Vegas Wash is largely effluent and some underground seepage.

The present transitional riparian, marsh and open water communities are now maintained largely through effluent and underground seepage. As a result of the bulk of water being nutrient rich, effluent marsh communities exhibit a higher productivity and standing crop than stands originally occurring in Las Vegas Wash before sewage treatment plants were present.[51] In 1955, approximately 800 acres of phreatophytes were established in the wash below the sewage treatment facilities. This vegetation has increased markedly with the increase in wastewater flow due to the expanding urban area. At the present time the wash related vegetation totals about 2,000 acres.

(2) Climate. - The climate of the regional area is typical for the Mohave Desert, featuring low humidity, little precipitation, and high summer temperatures. In Las Vegas Valley, weather observations are taken at McCarran Airport, 7 miles south of downtown Las Vegas, and about 5 miles southwest and 300 feet higher than the lower portions of the valley. Since mountains encircle the valley, drainage winds are usually downslope toward the center, or lowest portion of the valley. This condition also affects minimum temperatures, which in lower portions of the valley can be from 15° to 25° colder than recorded at the airport on clear, calm nights. The four seasons are usually well defined. Freezing weather is not uncommon, but extremes of cold are rare, with minimum winter temperatures averaging 35° F. Snow falls nearly every year, but usually melts as it falls or shortly thereafter. Summers are typically "desert" with maximum temperatures usually over 100° F. The nearby mountains help influence relatively cool nights, with minimums in the summer months between 70° and 75° F. For the 71-year period of 1903-1974, inclusive, the mean annual temperature was 66.7° F, and the average annual precipitation was 4.06 inches Most of the rain falls gently during the winter months and little runs off. In summer and early fall, local thunderstorms and cloudbursts cause flash floods with rapid runoff and severe erosion. The frost-free period is about 241 days. The relative humidity averages 28 percent. Evaporation at Lake Mead averages about 83 inches per year with three-fourths of this occurring during the 6 summer months. Strong winds reach the valley from both the southwest and the northwest.

Winds over 50 miles per hour are infrequent, but are particularly damaging and troublesome because of blowing dust and sand.

(3) Geology. - The project lies within the Basin and Range physiographic province. In general the relief of an extensive area surrounding the project is characterized by isolated mountain ranges trending north-south with extensive intervening basins or valleys floored with detrital materials. Rocks range in age from Precambrian to Recent. The dominant geologic features of the project area are the sediments in the Las Vegas basin and the volcanics of the River Mountains.

Las Vegas Wash drains a total area of about 2,200 square miles from the McCullough Range, the Spring Mountains, and the Sheep Range. The drainage collects in the wash southeast of Las Vegas, then flows about 11 miles to the east between the Frenchman Mountains on the north and the River Mountains on the south, discharging into Las Vegas Bay of Lake Mead.

The Frenchman Mountains are composed of high ridges on the eastern edge of Las Vegas Valley and rise about 2,000 feet above the valley floor. The exposed rocks of the ridges range in age from Precambrian granitics on the west base to Cretaceous and Tertiary sediments on the southeastern slope adjacent to Las Vegas Wash.

The River Mountains to the south side of the wash comprise a small range that extends on the western border of Lake Mead. In the area bordering Las Vegas Wash, the rocks are of both igneous and sedimentary origin. The igneous sequence are of the Mount Davis and Golden Door Formation consisting of both intrusive and extrusive flows and dikes of andesite, rhyodacite, and rhyolite which will also be used as the source of riprap for the interception facility. The sedimentary sequence contains both pryroclastic and bedded sediments. The pyroclastics are tuffaceous sandstone and tuff which separate rhyodacite and rhyolite flows. The sedimentary rocks consist of limy sandstone and limestone.

The upper reach of Las Vegas Wash is located on the relatively flat-lying eastward extension of Las Vegas Valley and is characterized by a wide, dense marsh-type area. As the wash cuts through the steep, rocky alluvial slopes between the Frenchman and River Mountains, it becomes a deeply entrenched channel with steep canyon walls. The wash is the only tributary which enters Lake Mead in the vicinity of Las Vegas Bay. The bay itself is highly irregular with many small coves and inlets. There are a few beach areas.

Stratigraphy. - The lithologic character of the formation rocks and unconsolidated materials that underlie project features are discussed below from oldest to youngest.

Thumb Formation. - These rocks would form the left abutment and the lower portion of the right abutment of the proposed impervious cutoff trench. At this site the rocks are red-brown fine-grained sandstone, siltstone, and mudstone. The rocks are well indurated to brittle in hardness. They are thinly bedded and vary from 1/8 to 4 inches thick at the site of the cutoff trench and are thicker in other places. Mud cracks, solution vugs, and ripple marks are common along the bedding planes, which part easily. There are a few dark andesite beds and vertical ribs that are associated with green tuffaceous sandstone and white ash beds, which range up to 4 feet in thickness. The Thumb Formation is very jointed in the area, and the joint planes are mostly open on the surface. The joints have separated the rock into fragments from 1/2 to 1-1/2 cubic feet in size. Other rocks making up the formation rock section are conglomerate, freshwater limestone, and gypsum. Total thickness is between 2,000 and 3,000 feet. The rock commonly weathers to a depth of 15 feet.

This formation, in conjunction with volcanics of the River Mountains, make up about 40 percent of the material traversed by the brine disposal pipeline.

Horse Spring Formation. - The rocks lie with erosional unconformity on the Thumb Formation. These two formations make up about 5 percent of the material traversed by the bypass pipeline. In addition, the Horse Springs Formation constitutes a significant portion of the right abutment of the impervious cutoff trench. By projection, the rock is classified as dolomitic at the base of the formation and grades into a fine-grained, tan-to-buff colored sandstone and siltstone in the upper section. These rocks are separated by beds of weak to moderately cemented gypsiferous silty sand. On the surface, solution cavities (6- to 18-inch holes) are not uncommon in the gypsiferous materials. The formation is folded, with many depositional changes and indistinguishable bedding planes. The structure is complex, with an estimated maximum thickness of 4,000 feet or more. The rock commonly weathers to a depth of 15 to 20 feet.

Muddy Creek Formation. - The formation composes the upper portion of the right abutment of the cutoff trench and is composed of poorly consolidated fine-grained sandstone containing several gypsum veinlets along bedding planes and at random. There are occasional interbeds of conglomerate with a moderately cemented limy matrix. The gravel and few cobbles in the conglomerate are volcanic and granitic, subangular to subrounded. The rock is flat-lying, massive, lenticular, and cross-bedded. Other rocks included in the formation are silty flagstone, mudstone, clay, and evaporites. The formation unconformably overlies the Horse Spring Formation and weathers to a depth of 20 feet.

Older alluvium. - These deposits are unconsolidated and have been lumped together for convenience from combinations of talus, slopewash, colluvium, and alluvial fans. The talus materials are found along the mountain slopes and are composed of angular gravel to boulder-sized sandstones or volcanics. The slopewash deposits are mixtures of talus and silty sand deposits along the lower slopes. The alluvial fans are mixtures of silty sand, gravel, and cobbles that coalesce at the base of the extensive high mountains in the region. The older alluvial deposits make up about 5 percent of the material traversed by the bypass pipeline. A deposit of impermeable material classified as lean to fat clay with lesser amounts of stratified sand and gravel has been identified about 9 miles west of the project's interception facilities. Usable material extends to ground water at a depth of about 38 feet. Caliche cemented silt and sand caps most of the area to a depth of 5 feet. Logs from test holes indicate volumes in excess of 250,000 yd^3. This material would be suitable for use as impermeable backfill for the cutoff trench.

Younger alluvium. - These deposits are unconsolidated and composed of stratified, fine-to-coarse sand, silt, gravel, and cobbles largely composed of sandstone and volcanic rocks. These materials are limy and alkali-stained, and there are a few lenses and streaks of black organic silt. This younger alluvial material makes up about 90 percent of the material traversed by the bypass pipeline, 100 percent of the evaporation pond site, 100 percent of the material to be excavated from the cutoff trench, and in minor amounts, overlies the Thumb and Muddy Creek Formations in the vicinity of the wash.

Most of the alluvial deposits confined to the immediate flood plain of the wash near the interception facility are classified as stratified silty-to-clayey sand on the south side of the channel to stratified sandy silt and clay on the north side of the channel. These deposits contain lenses of partially carbonized organic silt that range up to 16 percent of the total volume in places. The south side of the channel also contains an estimate of more than 70,000 yd^3 of permeable sands, gravel, and cobbles in the vicinity of the interception site.

Minerals. - Las Vegas Wash lies in the Las Vegas and Virgin River Mining District. The principal mineral mined in the district is manganese. Total production of this ore has exceeded 1,000,000 tons. Low-grade manganese ore has been intermittently mined from a site about 3 to 4 miles southeast of the planned interception facility since 1917. Small amounts of lead, copper, silver and gold have also been produced in the district. Nonmetallic minerals produced by the district include gypsum, limestone, dolomite, bentonite, borates, feldspar, magnesite, perlite, building stone, sand, and gravel. There is a sizeable gravel pit and processing operation immediately east of the planned evaporation ponds near the wash.

Seismicity. - The Las Vegas Wash area is located approximately 120 miles east of the active California-western Nevada seismic zone. Many of the major earthquakes in Nevada have been associated with this zone. The general area has experienced earthquakes in the past. In May 1939, an earthquake of magnitude 5 (on the Richter scale) occurred near Boulder City. Subsequent aftershocks ranged between magnitude 3.5 and 4.0. Local seismic activity in the vicinity of Lake Mead has been fairly continuous since 1936, reaching a peak of activity in 1954. This activity has been associated with the filling of Lake Mead. Another source of earthquakes in the vicinity has been the underground detonations of nuclear devices at the Nevada Test Site. Seismic activity can be reasonably expected in the future. However, the area is classed as zone 2 on the

U.S. Gelological Survey's Seismic Risk Map of the United States, and groundshaking activity in this zone is usually not associated with damage to concrete pipes or other well-engineered facilities.

(4) Vegetation. - The biotic communities described below were obtained from a contracted study.[51] Since the study was completed, Bureau of Reclamation personnel obtained large-scale orthophotographs and colored infra-red photographs of Las Vegas Wash. These were used to detail in great depth the acreage and density of the phreatophytic and hydrophytic growth for use in natural water consumptive use analyses. The hydrologic area considered in this analysis may not completely agree with the area inventoried by the contractor. Actual acreage of these plants consituted 2,047 acres. They consume an estimated 9,210 acre-feet of water annually.

Biotic communities are natural assemblages of plants and animals which occupy a particular area. Since many animals, particularly vertebrates, occupy more than one community, biotic communities are best recognized and determined on the basis of vegetation. Biotic communities of southern Nevada have been classified and with some modification are listed in the tabulation below and shown on figure II-5. Brief characteristics of each community are given below. Approximately 14,500 acres were included in the Las Vegas Wash study area. The acreage for each biotic community is also tabulated.

Creosote bush community. - Creosote bush communities are widespread and make up the dominant biotic community at elevations below 4000 feet in the Mojave desert. This is the most commonly encountered community in the study area occupying approximately 9,960 acres (68.6 percent of the total area). It is found in both flat and mountainous terrain except in areas of large rock outcroppings (barren areas) or well-developed dry wash systems. Codominants of this community are creosote bush (*Larrea divaricata*) and white bursage (*Franseria dumosa*). Commonly, white bursage is more abundant and occupies more foliar cover than creosote bush, however, the community is named for more widespread species. Vegetative cover is sparse and usually varies between 1 to 5 percent ground cover.

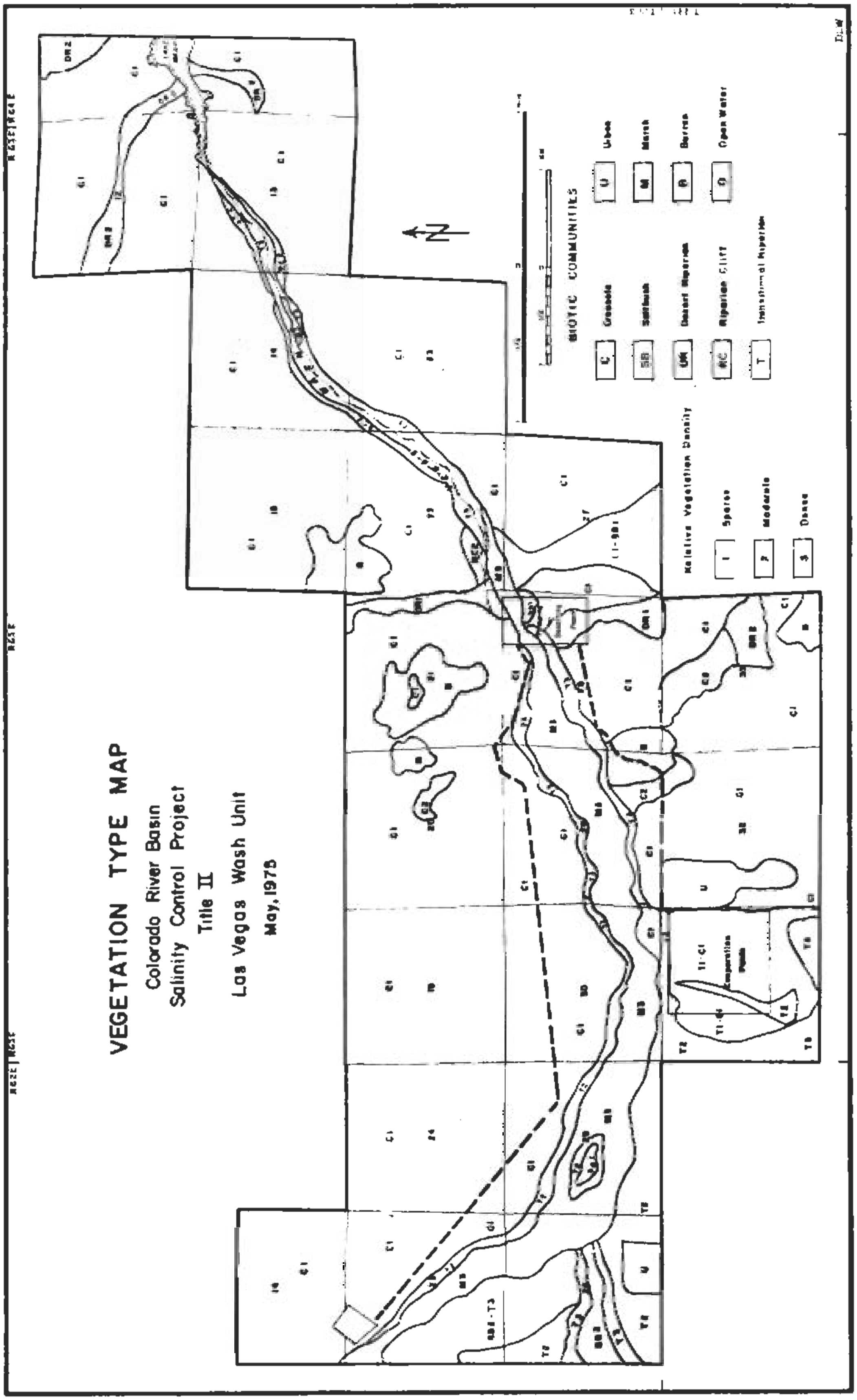

VEGETATION TYPE MAP
Colorado River Basin
Salinity Control Project
Title II
Las Vegas Wash Unit
May, 1975
BIOTIC COMMUNITIES
C Creosote
SB Saltbush
DR Desert Riparian
RC Riparian Cliff
T Transitional Riparian
U Urban
M Marsh
B Barren
O Open Water
Relative Vegetation Density
1 Sparse
2 Moderate
3 Dense
Evaporation Ponds

Figure II-5

Classification of biotic communities for the study areas of the Las Vegas Wash Unit, Colorado River Basin Salinity Control Act, Title II, Study Area.

Biotic Community
I. Terrestrial
Zonal Community Type
Desert Shrub Vegetation Type
Creosote Bush Community
Transzonal Community Type
Desert Shrub Vegetation Type
Saltbush Vegetation Community
Shrub and Woodland Vegetation Type
Desert Riparian Community
Riparian and Cliff Community
Transitional Riparian Community
Azonal Community Type
Barren Community
Urban Community
II. Hydric and Aquatic
Marsh Community
Open Water Community
(1) Ponded (including Las Vegas Bay)
(2) Moving

Total acres and percent of total acreage of biotic communities in the Las Vegas Wash Unit, Colorado River Basin Salinity Control Act, Title II, Study Area

Biotic community	Total acres	Percent of* total acreage
Creosote Bush	9,960	68.6
Saltbush	420	2.9
Desert Riparian	480	3.3
Riparian Cliff	200	1.4
Transitional Riparian	1,650	11.4
Barren	410	2.8
Urban	220	1.5
Marsh	1,100	7.6
Open Water	60	0.4

* Due to the rounding of numbers, the total percentage equals 99.9 instead of 100.

Saltbush community. - Saltbush communities commonly occur as a mosaic in relation to the drainage systems where some accumulation of soil salts occur. Common plant indicators are species of *Atriplex*, commonly called saltbush, particularly shadscale (*Atriplex confertifolia*), fourwing saltbush (*Atriplex canescens*), cattle spinach (*Atriplex polycarpa*), and quailbush (*Atriplex lentiformis*). In more saline portions of the community, halophytes such as inkweed (*Suaeda torreyana*) and pickleweed (*Allenrolfea occidentalis*) dominate. Ground cover is usually high compared to creosote bush community, ranging from 6 to 20 percent. Stands of this community are widely scattered throughout the study area occupying approximately 420 acres (2.9 percent of the total area).

Desert riparian community. - Desert riparian communities are associated with drainage systems where there is significant wash expansion and associated moist soil conditions. Vegetative composition may be similar to that of the creosote bush community, but exhibits more luxuriant growth and higher plant cover. In larger washes, however, there are definite plant indicators such as cheesebush (*Hymenoclea salsola*), mesquite (*Prosopis juliflora*), catclaw (*Acacia greggii*), desert willow (*Chilopsis linearis*), and occasionally salt cedar (*Tamarix pentandra*). Plant cover usually varies between 5 to 40 percent. Approximate acreage for this community in the study area is 480 (3.3 percent of the total area).

Riparian cliff community. - This community commonly occurs along washes, canyons, cliffs and rimrock areas at elevations above 5000 feet. Small areas of cliff and rimrock found on the study area might be considered as lower extensions of this community, however, vegetative composition is primarily that of associated communities. These areas are so small in extent that they are not mappable at the scale of the vegetative map. Ground cover in this community varies between 3 to 10 percent. Approximate acreage for this community within the study area is 200 (1.4 percent of the total).

Transitional riparian community. - The transitional riparian community occupies various areas adjacent to the Las Vegas Wash where permanent water is found. It is also encountered in other sections of the study area where the water table is near the surface. The vegetative structure is either shrub woodland or woodland depending upon location. Dominant woodland species include salt cedar, honey mesquite and occasionally cottonwood (*Populis fremontii*). Associated shrubs are usually halophytes such as inkweed, pickleweed or quailbush. Cover varies greatly ranging from approximately 15 to 100 percent. Approximate acreage for this community within the study area is 1,650 (11.4 percent of the total area).

Barren community. - Barren communities are those which largely lack vegetative cover and occur in association with areas of extreme rock exposure. Approximate acreage for this community is 410 (2.8 percent of the total).

Urban community. - This community is best characterized by the presence of manmade development, i.e., housing, roads or disturbance of the naturally occurring vegetative community usually in the form of grading or ground leveling. This community occurs in many forms ranging from closely spaced housing developments to widely spaced many acred ranches. Quite often, the urban development of an area forms a mosaic pattern interspersed with the natural vegetation. In these situations, vegetative mapping is difficult and separation of the urban sections from surrounding plant communities was impossible to show on paper. This form of development occupies 220 acres (1.5 percent of the total area) within the study area.

Marsh community. - This community is restricted in distribution to the drainage system commonly referred to as Las Vegas Wash. It is characterized by emergent hydrophytic plant species which are associated with standing water or extremely wet soil. The dominant plant species are cattail (*Typha angustifolia*) and bulrush (*Scirpus paludosus*) and in some instances, common reed grass (*Phragmites communis*). Plant growth varies greatly in size and may, in some instances, form extensive stands of tangled growth, with successive stacks which provide 100 percent ground cover. Figure II-6 shows a portion of this dense growth. This community occupies approximately 1,100 acres (7.6 percent of the total study area).

Open water community. - This community is found along the stream portion of Las Vegas Wash and Las Vegas Bay as included in this report. It may be separated into the stream portion representing moving water and areas of standing water including Las Vegas Bay. There are also many small ponds along the Las Vegas Wash including man-made tailing and evaporation ponds below the County and City Sanitation plants. These ponds are considered open-standing water and the vegetation associated with them is the same described for the marsh community.

The vegetation along the shoreline of Las Vegas Bay is primarily transitional riparian although some marsh vegatation does occur at the mouth of the larger coves and inlets.

Exclusive of Las Vegas Bay, mapping of open water was impossible in that the bodies of open water found on the study area are all very restricted in size. With the exception of the BMI evaporation ponds, most of which are dry, no significant body of open water (40 acres or greater) exists in Las Vegas Wash.

Las Vegas Wash near Pabco Road.

Figure II-6

A crude estimate of the acreage of open water exclusive of Las Vegas Bay, is 60 acres (0.4 percent of total area) within the study area.

Vascular plants. - A total of 227 species representing 41 families are included in the basic list. The more important families are Compositae (49 species), Graminae (21 species), Cruciferae (13 species), Leguminosae (12 species) and Palemoneaceae (11 species). This is a reasonable representation of the number of families and species in a desert area. Some additional species, especially annuals, could be added to the checklist by intensive study. This is particularly true for creosote bush and desert reparian communities.

A list of plant species and their distribution in the various biotic communities is given in appendix B-1 and a comparison of plant species diversity is shown in the following tabulation. The low number of probable and hypothetical species on the list are due to: (1) a reasonably adequate knowledge of species distributions for the biotic communities except barren and urban and, (2) a conservative approach for listing probable and hypothetical distributions. With adequate study, a much larger list of weedy species associated with urban habitats could be developed. Creosote bush and desert riparian communities show the highest plant species diversity with many abundant and common species. Both communities are widespread and share many species in common and represent the bulk of plant species found in the lower desert. The saltbush community which ranks third in total species has a relatively low species diversity, especially of annuals, due to an increased perennial cover and high salinity which is unsuitable for germination of many desert species. Transitional riparian and marsh communities are low in diversity due to the greatly increased plant cover of dominant species. The low species diversity for open water and barren communities is apparent, since they represent unsuitable habitats for terrestrial plant development. The riparian cliff community is not well established and extremely limited in area due to the low elevation, hence plant species diversity is low.

(5) Fish and wildlife. - [51] The ecological distribution and characterization of natural histories for the various forms of fish and wildlife are discussed below in appropriate sections by class.

Comparison of plant species diversity in different biotic communities in the Las Vegas Wash Unit, Colorado River Basin Salinity Control Act, Title II, Study Area.

Abundance and occurrence	Creosote bush	Salt-bush	Desert riparian	Riparian and cliff	Transis-tional riparian	Marsh	Open water	Barren	Urban
Abundant	111	33	76	5	8	5	1	8	4
Common	81	17	65	7	9	1	0	5	13
Rare	14	3	15	0	2	1	0	3	2
Probable	4	11	14	4	6	1	0	0	0
Hypothetical	0	1	3	1	0	5	4	0	0
Total	210	65	173	17	25	13	5	16	19

Fish

Habitat description. - Waters in Las Vegas Wash are characteristically high in nutrients and total disolved solids (TDS) and flow through a Cattail-Bulrush Marsh community. The Clark County and Las Vegas sewage treatments contribute both to the total flow and nutrients in Las Vegas Bay.

Nutrient enrichment from Las Vegas Wash has resulted in algal blooms and polluted eutrophic conditions in Las Vegas Bay. Conditions in Boulder Basin have remained naturally eutrophic because of dilution and utilization of nutrients in Las Vegas Bay. Nutrient levels are summarized in the following tabulation.

Lake Mead is a warm monomictic lake with thermal stratification developing in May. A thermocline becomes established at 15-20 meters in July and August when water temperatures reach 30-35° C. Mixing begins in September and is completed by December when water temperatures are 9-10° C.

During summer stratification a negative heterograde oxygen profile develops in association with the thermocline throughout Lake Mead. Metalimnetic oxygen depletion has been most severe in Las Vegas Bay where oxygen levels below 1 mg/l have been found. In Boulder Basin oxygen levels usually do not fall below 2 mg/l in the metalimnion. Oxygen concentrations in the hypolimnion do not become depleted, remaining 60-70 percent saturated through summer stratification.

Distribution and natural histories. - A biological inventory performed by the University of Nevada at Las Vegas indicated that four species of fish may be found in the wash. The inventory included the goldfish, European carp, mosquitofish, and bluegill. The distribution and natural history of fishes in Las Vegas Wash and Boulder Basin are summarized in appendix B-2.

The western golden shiner (*Notemigonus chrysoleucas*) and the bonytail chub (*Gila robusta*) have been reported in the lower basin, however, the presence of the latter has not been reported recently and probably no longer occurs in the lower basin. The western golden shiner has been heavily used as live bait and may have established small populations in Lake Mead.

Phosphorus and nitrogen concentration in mg/l at Las Vegas Wash (LVW), Las Vegas Bay (LVB) and Boulder Basin (BB) for 1974.

Date	Depth (m)	Total phosphorus Station LVW	Total phosphorus Station LVB	Total phosphorus Station BB	Nitrite-nitrate nitrogen Station LVW	Nitrite-nitrate nitrogen Station LVB	Nitrite-nitrate nitrogen Station BB
May 24	0	4.86	0.057	0.020	7.73	0.16	.22
	10		0.067	0.021		0.17	.20
	20		0.162	0.021		0.33	.31
	30		0.308	0.019		0.41	.41
July 12	0	4.98	0.030	0.012	9.07	0.03	.05
	10		0.025	0.017		0.04	.05
	20		0.052	0.013		0.40	.31
	30		0.026	0.012		0.51	.44
Sept. 13	0	4.07	0.025	0.011	8.45	.02	.06
	10		0.044	0.012		.02	.02
	20		0.059	0.012		.39	.45
	30		0.086	0.012		.41	.51
Nov. 15	0	4.69	0.043	0.013	5.54	.21	.23
	10		0.040	0.013		.17	.22
	20		0.043	0.017		.16	.20
	30		0.044	0.016		.17	.06

There are a number of factors limiting or regulating reproduction and distribution of fishes in Lake Mead. Fluctuating water levels, wind and wave action, water temperature and predation can affect nesting success of largemouth bass (*Micropterus salmoides*) and poor survival of fry may be the result of limited food supply. These factors would also affect green sunfish (*Lepomis macrochirus*), bluegill (*Lepomis cyanellus*), and black crappie (*Pomoxis nigromaculatus*) which utilize very similar habitat. Reproduction of salmonids does not occur because of the absence of migratory streams although they do become reproductively active in the fall. High water temperatures in the epilimnion and low oxygen levels in the metalimnion limit the distribution of salmonids to the hypolimnion during summer stratification. Oxygen levels also limit the occurrence of warm water fishes in the metalimnion for any extended period although large populations of shad have been ovserved in this region.

Biological and economical importance. - Of the 12 species of fish in Boulder Basin, only three are nongame fish, threadfin shad (*Dorosoma pentenense*), humpback sucker (*Xyrauchen texanus*), and carp (*Cyprinus carpio*). Threadfin shad are the main forage base for most of the game fish and its introduction has helped improve the fisheries in Lake Mead. The carp is a very abundant and undesirable fish and has been reported as predators on largemouth bass nests and may have some effect on game fish populations.

Largemouth bass made up 40 percent of the catch composition in 1974 and were the most important game fish followed by black crappie, channel catfish (*Ictalurus punctatus*), rainbow trout (*Salmo gairdneri*), and bluegill. Coho salmon (*Oncorhynchus kisutch*), cutthroat trout (*Salmo clarki*), and stripped bass (*Roccus saxitilis*) made up less than 3 percent of the 1974 catch.

The mosquitofish (*Gambusia affinis*) has been introduced as a means of mosquito control. Its presence in Las Vegas Wash may have some limited effects on insect populations.

Of the 12 species of fish found in the Boulder Basin, one, the native humpback sucker, is listed as threatened on the State of Nevada threatened and endangered species list.

Amphibians

The ecologic distribution and comparative abundance of amphibians by biotic community is given in appendix B-3. Woodhouse's toad (*Bufo woodhousei*) is the only amphibian which may be found within the more mesic portions of terrestrial communities which are not in close contact with marsh or open water. All of the species listed occur in marsh, open water, and transitional riparian communities with the exception of the tiger salamander (*Ambystoma tigrium*), whereas the more aquatic species, the bullfrog (*Rana catesbiana*), leopard frog (*Rana pipiens*), red-spotted toad (*Bufo punctatus*), and pacific tree frog (*Hyla regilla*) are most abundant in marsh and open water. The introduced tiger salamander represents a special case in that it was first found in the middle 1960's in Las Vegas in association with urban development. At the present time, the species also occurs in marsh and open water.

In the 1973 edition of the U.S. Fish and Wildlife Service's publication "Threatened Species of the United States," the endemic subspecies Las Vegas Valley leopard frog (*Rana pipiens fisheri*) is listed as not having been reported since 1942 and may be extinct. However, one unofficial sighting is claimed for the year 1972. A letter detailing the circumstances of that claim is appended to this statement.

Natural history information for amphibians is given in appendix B-4. All species show reduced activity and/or hibernation during the colder months in the Las Vegas area. The only species with a special status is the bullfrog, which is protected by State game laws. No amphibian species are listed as threatened, rare or endangered on either the Federal or State lists.

Reptiles

Distribution and relative abundance of reptiles is given in appendix B-5. There are no reptile species which are characteristic of marsh or aquatic water communities except the western soft shell turtle. Fourteen species of snakes occur on the study area with their primary associations in terrestrial communities, especially creosote bush and desert riparian. In some instances, however, certain species such as the red racer (*Masticophis flagellum*), the gopher snake (*Pituophis catenifer*), and the sidewinder (*Crotalus cerastes*) are abundant in habitats adjacent to water such as riparian cliff and transitional riparian as these areas have an abundant food supply. Several snakes, including the sidewinder, are present in the urban community.

Thirteen species of lizards are found on the study area and with few exceptions, are most abundant in creosote bush or desert riparian communities. The chuckawallas (*Sauromalus obseus*) find suitable habitat in some areas considered as barren. The yucca night lizard (*Xantusia vigilis*) is common in transitional riparian and urban habitats where litter is available for shelter.

The desert tortoise (*Gopherus agassizi*) is common in creosote bush, desert riparian and urban communities. This species is protected by State law and is considered by some authorities to be threatened or endangered because it is often killed while crossing highways and is often kept in captivity by man.

The gila monster, like the desert tortoise, is also protected by State law.

Natural history information for reptiles is shown in appendix B-6. As expected, due to their nature, reptiles are largely inactive or in hibernation during the colder months. Smaller species, however, such as the side-blotched lizard and sidewinder do exhibit some above-ground activity on warm days during the winter months.

Birds

The seasonal use, occurrence and abundance of the avifauna in the study are given in appendix B-7.

The diversity of birds within the study area is quite high. A total of 252 species representing 53 families occur here, representing nearly 63 percent of the total number of species found in the State and 67 percent of the total species found in southern Nevada. The heaviest utilization of both the developed area of Las Vegas and the marsh condition found in Las Vegas Wash is seasonal in spring and fall when normal migration occurs. A large number of the total species which occur here are transient in one or more of the biotic communities found in the study area and this accounts for the seasonality of use. The creosote, saltbush and desert riparian are the most heavily utilized communities by the majority of permanent and winter resident species excluding water birds. The latter group is restricted almost entirely to the aquatic environment found in marsh and open water communities. This is particularly true of many waterfowl which require standing water for feeding.

The total density of birds within the study area is variable depending on season. A tabulation of total bird densities for creosote bush, desert riparian, transitional riparian and marsh communities are given by season on page II-59. No data are available for the other five communities in the study area. These data give some indication of community use by birds, both yearly and by season. The total density of birds is highest in the marsh community if water birds are included in this figure. If these species are excluded, the desert riparian and transitional riparian communities have the highest density, particularly during migration.

Natural history data for birds found in the study area are presented in appendix B-8. The categories of primary use of habitat and primary food habits are given for each species known to occur in the study area. Primary nest placement is listed only for those species which breed in one of the biotic communities found within the area. Species which do breed there are also expected to feed, water and rest within the same area. In those instances, the latter three categories are not listed under primary habitat use. Special status where applicable is also given for each species. Unusual or accidental occurrence is also listed for some species.

The hunting seasons for some birds as established by the Nevada Fish and Game Commission for 1974 are presented on page II-60.

Many bird species are protected by State and Federal law and two species, the southern bald eagle (*Haliaeetus leucocephalus*) and the American peregrin falcon (*Falco peregrinus*) are listed on both the State and Federal endangered list. These two species are not common in the study area and probably occur only as transients.

In general, the occurrence and abundance of avian species with the Las Vegas Valley is unusually high for a desert environment. Seasonal use and overall mobility of this group of animals accounts for this situation somewhat. The occurrence of a large mesic-hydric environment such as Las Vegas Wash, however, is undoubtedly the controlling factor in the overall avian distribution in the study area.

Mammals

The distribution and relative abundance of mammals by biotic community is shown in appendix B-9. A total of 48 species of mammal (1 shrew, 18 bats, 2 rabbits, 17 rodents, 9 carnivores and 1 ungulate) are found on the study area. They vary greatly to the extent that they are habitat (community) specific in their distribution. For example, Crawford's desert shrew, muskrat, house mouse, western harvest mouse, and deer mouse are largely restricted to marsh or immediately adjacent communities, whereas almost all bat species are found in all communities. Carnivores and desert sheep, in general have a wide ecologic distribution and individuals may range through more than one community during their regular activities. Certain carnivores, such as skunks (*Spilogale gracilis* and *Mephitis mephitis*), and racoon (*Procyo lator*) are most abundant in the more mesic communities including marsh. The majority of rodents have their main distribution in the more arid, desert communities, but in some instances have their highest densities adjacent to the more mesic communities including marsh, where more food, especially green vegetation, is reasonably available. Green vegetation available for browse is necessary for successful reproduction for many desert rodents.

The Las Vegas office of the U.S. Fish and Wildlife Service indicates that beaver (*Caster canadensis*) are present in the wash. Observations have been made by personnel of that office of runs, cuttings, and bank diggings in the area below Pabco Road. They also report that one large male beaver was apparently struck by a gravel truck near Pabco Road in 1973, and that commercial trappers reported trapping a young beaver in 1974 and again in 1975.

Natural history information for mammals is given in appendix B-10. Hunting and trapping seasons for mammals found on the study area were previously noted. Of particular

Total bird densities by season for selected biotic communities in the Las Vegas Wash Unit Colorado River Basin Salinity Control Act, Title II, Study Area. Values expressed as number per 100 acres.

	Creosote bush	Desert riparian	Transitional riparian	Marsh
<u>Spring</u>				
March thru May	21.5	110.7	79.3	103.1
<u>Summer</u>				
June thru August	14.7	117.6	76.4	153.5
<u>Fall</u>				
September thru November	28.7	47.7	64.6	53.8
<u>Winter</u>				
December thru February	29.9	99.9	110.0	81.1

Hunting and trapping seasons established for game animals by Nevada Fish and Game Commission for 1974.

Animal	Season open	Season closed
Hunting season		
Duck (split season)	28 Sept. 16 Nov.	25 Oct. 19 Jan.
Geese	16 Nov.	19 Jan.
Dove	1 Sept.	20 Oct.
Quail	28 Sept.	1 Dec.
Rabbit	28 Sept.	28 Feb.
Bighorn sheep (Bombing range)	16 Nov. 14 Dec.	15 Dec. 29 Dec.
Trapping season		
Fur bearer	26 Oct.	16 Mar.

significance are those species which do not exhibit year-round activity. For example, several rodents enter seasonal hibernation whereas most bats under suitable low temperature conditions enter both daily and seasonal hibernation. Several other species of bats are migratory and spend only a portion of the year in the Las Vegas area. The primary habitat usage by community is given in some detail in appendix B-11. It is apparent that mesic or hydric communities such as riparian and cliff, transitional riparian, marsh and open water are used for feeding and watering, whereas the more characteristic desert communities are used for resting, hibernation and breeding as suitable shelter in the form of rock crevices, caves and mine tunnels occur in these communities. Most species also find both food, water, and in some instances, shelter under urban conditions. The combination of few and relatively unsuitable hibernals has forced several species into year-round flight activity (watering and feeding) even in the winter months. Several species of tree bats such as the silvery-haired bat (*Lasionycteris noctivagans*), the red bat (*Lasiurus borealis*), and the hoary bat (*Lasiurus cinereus*) find shelter (resting, daily hibernating) in trees and only occur in the more typical desert communities during migration.

Other species, for example most rodents, exhibit year-round activity and due to limited home range size, individuals occur only in one community except in ectonal regions between communities. Most rodents are opportunistic or tend toward being omnivorous, although seeds and foliage usually are the most important food items. Even carnivores, in some instances are somewhat omnivorous, and ingest varying amounts of vegetative material, especially fruits.

Only one species, the spotted bat (*Euderma maculatum*), found in the study area is listed on the threatened and endangered list of Nevada Fish and Game Commission.

Rare or Endangered Species

A tabulation of fish, amphibians, reptiles, birds and mammals that appear as rare, endangered, or threatened on either State or Federal lists are summarized in the following table.

State and Federally protected animals in the Las Vegas Wash Unit, Study Area
(Including Las Vegas Bay of Lake Mead)

Species by family	Protected by State Game Law	State endangered, threatened or protected	Federal endangered, threatened or protected	Enacted by
Fish				
Salmonidae				
Coho salmon	Year-round season			General Regulation No. 1 Ammendment No. 5 Ammendment
Cutthroat trout	Same as above			Same as above
Rainbow trout	Same as above			Same as above
Catostomidae				
Humpback sucker		Threatened		Sections 501.110 and 501.065 Nevada Revised Statutes
Ictaluridae				
Channel cat-fish	Year-round season			General Regulation No. 1 Ammendment
Serranidae				No. 5 Ammendment
Stripped bass	Same as above			Same as above

Species by family	Protected by State Game Law	State endangered, threatened or protected	Federal endangered, threatened or protected	Enacted by
Centrarchidae				
Bluegill	Same as above			Same as above
Green sunfish	Same as above			Same as above
Largemouth bass	Same as above			Same as above
Black crappie	Same as above			Same as above
Amphibians				
Ranidae				
Bullfrog	Year-round season			General Regulation No. 1 Ammendment No. 5
Reptiles				
Helodermatidae				
Gila monster		Threatened		501.110 NRS
Testudinidae				
Desert tortoise		Threatened		501.110 NRS

Species by family	Protected by State Game Law	State endangered, threatened or protected	Federal endangered, threatened or protected	Enacted by
Birds (All migratory birds are afforded protection by Federal Law under the provisions of the Migratory Bird Treaty Act of July 3, 1918 as amended)				
Pelecanidae				
Pelicans and allies		Protected		501.065 NRS
Brown pelican			Endangered	Endangered Species Act. 1973 (P.L. 93-205; 87 Stat. 884)
Falconiformes				
Vultures, hawks, falcons and eagles		Protected		501.065 NRS
Southern bald eagle		Endangered	Endangered	Endangered species Act 1973 (P.L. 93-205; 87 Stat. 884)
Peregrine falcon		Endangered	Endangered	
Strigiformes				
Owls		Protected		501.065 NRS

Species by family	Protected by State Game Law	State endangered, threatened or protected	Federal endangered, threatened or protected	Enacted by
Cruidae				
Little brown crane			Protected	Migratory Bird Treaty Act 40 Stat 735 16 U.S.C. 703-711
Rallidae				
Rails, coots and gallinules			Protected	Same as above
Scolopacidae				
Woodcock and snipe			Protected	Same as above
Columbidae				
Wild doves and pigeons			Protected	Same as above
Cuculidae				
Roadrunner		Protected		501.065 NRS

Species by family	Protected by State Game Law	State endangered, threatened or protected	Federal endangered, threatened or protected	Enacted by
Anatidae			Protected	Migratory Bird Treaty Act 40 Stat 735; 16 U.S.C. 703-711
Ducks	See table			
Geese	Same as above			
Phasianidae				
Gambels quail	Same as above			
Mammals				
Leporidae				
Rabbits (except black-tailed jackrabbit)	See table			General Regulation No. 1, Amendment No. 5
Bovidae				
Mountain sheep	See table			Same as above

Species by family	Protected by State Game Law	State endangered, threatened or protected	Federal endangered, threatened or protected	Enacted by
Canidae				
Kit fox		Protected		501.110 NRS
Castoridae beaver	See table	Protected		Same as above
Vespertillionidae				
Spotted bat		Threatened		Same as above

1. State laws are taken from the Nevada Fish and Game Commission General Regulation Number 1, effective May 15, 1974.

2. Federal laws are taken from the Federal Register, Vol. 40, No. 188, Part 11, Friday, September 26, 1975, titled, Endangered and Threatened Wildlife and Plants, supplemented by the Federal Register of April 28, June 1, and June 14, 1976.

(6) Air quality. - The air quality of the region is generally good except in some of the areas of urban development. All urban areas have a high percentage of particulate matter in the air due to dust from a disturbed desert environment. In the desert a fine crust is formed on the top layer of soil after each rain. Breaking this crust allows the fine, dry soil to be blown away. In all areas of the region, construction and dirt road driving combined with high winds will create a dust problem.

Although noted for clean air and great visibility on calm days, nitrogen dioxide, carbon monoxide and hydrocarbon counts are steadily increasing in the urban areas causing growing concern. Air quality in these areas is considered poor relative to the standards adopted by the EPA. The topographic features of the region aggravate atmospheric pollution problems. Atmospheric inversion conditions prevail for about 3,600 hours annually from November through January; periods of stagnation often last for several days. The most complete measurements of air pollutants are taken by the Clark County District Health Department. These measurements are concerned with monitoring the pollutant levels in the urban areas of Las Vegas Valley.

The annual arithmetic mean of nitrogen dioxides measured at the Health Department in 1971 was 36 micrograms per cubic meter ($\mu g/m^3$). This compares with the maximum annual arithmetic mean allowed under the National Primary Ambient Standard for nitrogen dioxides of 100 $\mu g/m^3$.

The annual 1971 arithmetic mean of suspended particulates measured at the Health Department was 70 $\mu g/m^3$, compared with the National Primary Ambient Standard of 75 $\mu g/m^3$. This mean value of suspended particulates at the Health Department tends to increase near more congested metropolitan areas, and tends to decrease away from the central city area.

The measurements of particulates at the Health Department reached a maximum of 240 $\mu g/m^3$ for one 24-hour period in 1971, compared with the National Primary Ambient Standard of 260 $\mu g/m^3$.

Photochemical oxidants are presently the most excessive form of air pollutants in the Las Vegas area. The National Primary Ambient Standard states that photochemical oxidants should not exceed 160 $\mu g/m^3$ for a 1-hour period more than once during any one year. At the Health Department station, the quantity of photochemical oxidants exceeded the Standard for 1,304 hours during 1971, and on one occasion reached a 1-hour maximum of 478 $\mu g/m^3$. It would appear that the above average amount of sunshine in the Las Vegas area is a factor in the formation of photochemical oxidants.

Due to the lack of vegetation and scant precipitation the natural desert environment is prone to contribute high amounts of particulate matter during high winds. Activities on dirt roads and beaches adds to the natural problems.

Las Vegas Wash is the primary air drainage corridor for the valley, hence air quality frequently appears poorer than the surrounding region. No measurements of air quality are made in the local area of Las Vegas Wash, nor are they made for the larger Lake Mead area.

(7) Water supply and quality. - There are three general categories of inflow to Las Vegas Wash: (1) the direct discharge of partially treated wastewater as surface flows, (2) ground water which moves to the wash through the valley aquifers, and (3) infrequent surface runoff caused by precipitation. Only about 4 inches of precipitation falls on the valley annually; as a result, the total volume of inflow from this source is relatively minor.

The Corps of Engineers has issued a flood plain information report[52] on the Lower Las Vegas Wash which contains an estimate of the size and frequency of major flood events. These estimates were considered during the design of project facilities. According to the Corps' report, a 100-year flood in Las Vegas Wash would create a depth of flow ranging from 2 to 12 feet with velocities ranging from 4 to 8 feet per second (ft/s). Velocities greater than 3 ft/s combined with depths of 3 feet or more are generally considered hazardous. In the reach of the wash just below the evaporation ponds, a 100-year flood would cause a depth of flow from 4 to 5 feet and velocities of 4 to 8 ft/s. Cross sections of this area indicate there is sufficient channelization to adequately contain a 100-year flood. Additionally, the growth and spread of phreatophytic vegetation has effectively dampened the peak floodflows that may pass a given point along the lower wash. Studies by the Bureau of Reclamation indicate the probable maximum 100-year flood at the interception facility site would be about 15,000 ft^3/s. By comparison, the flood that occurred in Las Vegas Valley July 3 and 4, 1975, registered peak flows of 6,500 ft^3/s at the gage near Henderson above the interception site and 2,400 ft^3/s at the gage near Boulder City (North Shore Road) below the interception site.

The channel of Las Vegas Wash is essentially stable over most of its length due to the fairly flat slope and the tendency of phreatophytes to reduce the velocity of downstream flow. However, about 2,000 feet above the interception site there is a rapid downcutting of the channel. At this point the upper channel is 25 feet above the lower channel. Flows cascading over this section undercut the upper channel, causing an upstream headcutting erosion that is greatly accelerated during flood periods. This action also results in a local lowering of the water table which has a progressive and negative influence on the distribution of phreatophytes and to some extent is a threat to the character of the wash.

Surface inflows. - Direct surface discharges to the wash are made from two sewage treatment plants and other industrial sources. These inflows average over 66 ft^3/s. The Las Vegas Sewage Treatment Plant is the largest contributor by volume, and available samples of its discharge indicate that the TDS have ranged from 645 to 1,200 mg/l, with a mean value of about 1,017 mg/l. The return from the Clark County Sewage Treatment Plant contains somewhat higher dissolved solids (average 1,502 mg/l) and the industrial returns are even higher. Figure II-7 shows the confluence of the two effluent ditches in the upper Las Vegas Wash area.

Ground-water inflows. - The movement of ground water into Las Vegas Wash is controlled by several geologic factors. The most significant of these are the general decrease in permeability of sediments at lower elevations in Las Vegas Valley, i.e., approaching the wash, and a north-south trending escarpment that has displaced permeable strata in the central part of the valley. This displacement has contributed to the formation of springs and a sustained high water table. Historically, overflow from the springs as well as the high water table, supported heavy stands of mesquite. This ground water was apparently consumed by evapotranspiration. If any of the water escaped down Las Vegas Wash to the Colorado River, it was by deep percolation through the underlying rock formations. Such historical flow probably never exceeded 250 acre-feet per year.

The escarpment boundary on the west transmits a constant ground-water inflow, having been totally saturated to the

Aerial view of upper Las Vegas Wash.

Figure II-7

surface at all times. The land between the escarpment and the wash and the land to the north is underlain with a ground-water body contained in relatively low yielding materials. The hydraulic gradient toward the wash is low and the water table is near the surface.[53][54] At present, the ground-water/surface-water system is in apparent equilibrium with all available ground water being consumed by phreatophytes.[55] Increased development in these areas will result in the surfacing of ground-water returns. Such flows would add continuing support to the expansion of phreatophytic vegetation in Las Vegas Wash.

Ground-water inflow within the lower Las Vegas Wash is primarily industrial effluent from the BMI complex in Henderson. This industrial effluent is disposed of in unlined evaporation ponds that have been constructed on top of porous alluvial fan material. Some additional inflow is derived from two municipal sewage treatment plants that also discharge effluent to these ponds. About 9,800 acre-feet of ground-water inflow has been estimated to enter the lower wash on an annual basis. About 2,100 acre-feet of this inflow is consumed by phreatophytes. The following tabulations show a budget analysis of inflow and outflow of both water flows and salt loading in the Las Vegas Wash. Figure II-8 is a view of the mouth of Las Vegas Wash as it enters Las Vegas Bay of Lake Mead.

Projected inflow to Las Vegas Wash. - Future conditions of the quantity and quality of inflows to Las Vegas Wash will be significantly different from present conditions. Some changes can be estimated within fairly close limits. Others, particularly those that depend on political and funding decisions can only be conjectured.

By the early 1980's, the second stage of the Southern Nevada Water Project will be delivering additional Colorado River water to Las Vegas Valley. This water will significantly affect the quantity and quality of return flows to Las Vegas Wash. By the year 2000, the ratio of Colorado River water used in the valley as compared to the projected use of ground water will be about 6:1. This is compared to the 1975 ratio of nearly 1:1. The projected salinity of municipal wastewater resulting from the increased use of poorer quality river water ranges up to 1,700 mg/l. This reflects an increase of up to 400 mg/l over the quality of effluent currently discharged to Las Vegas Wash and Lake Mead.

Mouth of Las Vegas Wash.

Figure II-8

Flow Budget 1970-1975 Average (Acre-feet)
Colorado River Basin Salinity Control Project - Title II
Las Vegas Wash Unit, Nevada

Identified source	Inflow	Consumptive use	Outflow Computed	Outflow Recorded
Area above Henderson Gage (Pabco Road)				
Clark County STP	17,041			
Las Vegas STP	30,932			
Henderson STP No. 1	591			
Flood inflow	1,516			
Clark Powerplant		1,664		
Sunrise Powerplant		866		
Farms		3,427		
Winterwood Golf Course		461		
Paradise Golf Course		461		
Phreatophytes				
Saltcedars		4,903		
Marshlands		2,206		
Evaporation (lower BMI ponds)		190		
Reach subtotal	50,080	14,178		
Total - gage near Henderson	50,080	14,178	35,902	35,785
Area above Boulder City Gage (North Shore Road)				
Henderson STP No. 2	3,030			
Black Mountain Golf Course (return flow)	162			
BMI Industries	6,483			
Flood inflow	290			
Phreatophytes				
Saltcedars		1,806		
Marshlands		289		
Evaporation (upper BMI ponds)		104		
Reach subtotal	9,965	2,199		
Total - gage near Boulder City	60,045	16,377	43,688	43,511

Salt Budget 1970-1975 Average (Tons)
Colorado River Basin Salinity Control Project - Title II
Las Vegas Wash Unit, Nevada

Identified source	Inflow	Outflow Computed	Outflow Recorded
Area above Henderson Gage (Pabco Road)			
Clark County STP	34,082		
Las Vegas City STP	61,864		
Henderson STP No. 1	1,182		
Flood inflow	4,479		
Reach subtotal	101,607		
Total - gage near Henderson		101,607	98,792
Area above Boulder City Gage (North Shore Road)			
Henderson STP No. 2	6,060		
Black Mountain Golf Course	238		
BMI Industries	92,741		
Flood inflow	826		
Reach subtotal	99,865		
Total - gage near Boulder City		201,472	201,791

The Environmental Protection Agency (EPA) has issued "National Pollutant Discharge Elimination System" (NPDES) permits to all the major industries currently discharging saline wastes into Las Vegas Wash. Compliance with these permits will eliminate the discharge of industrial wastes to Las Vegas Wash and subsequently to Lake Mead. Such compliance is scheduled to be effective during the same time frame in which the second stage of the Southern Nevada Water Project is scheduled to begin water deliveries.

In conjunction with the wash project, a digital (computer) model was developed to simulate the flows in the wash and calculate the effects of various future activities on those flows. Predicted flows passing the USGS gage near Boulder City (North Shore Road) by the year 2000 would be about 128,000 acre-feet per year. Tons of salt entering Lake Mead and the Lower Colorado River System would amount to about 311,000 tons. This represents a salinity concentration of wash discharge of about 1,786 mg/l. This is essentially a condition in which development of water use has occurred via the Southern Nevada Water Project to utilize all of Nevada's entitlement to Colorado River water.

(8) Noise. - Although there have been no noise level studies done in the regional area, various "noise corridors" are known to exist. Within the regional area is Interstate 15, a major freeway for traffic traveling to Salt Lake City, Utah, or southern California. This freeway crosses through North Las Vegas and just west of the downtown area of the city of Las Vegas. Located next to the freeway is the Union Pacific Railroad. Beginning east of Las Vegas is the Boulder Highway which crosses through Henderson to Boulder City. From Boulder Highway in Henderson to Las Vegas Bay is Lake Mead Drive. This road generally parallels the wash but at a distance of from one-half to 1 mile. The North Shore Road originates from Lake Mead Drive and crosses Las Vegas Wash about 1 mile upstream from Las Vegas Bay. These roads are known to carry heavy traffic volumes at various times particularly on holidays and weekends.

McCarron International Airport, south of the city of Las Vegas serves both commercial and private aircraft. The main east-west runway of this airport requires an approach route that directs air traffic between the River and Frenchman Mountains directly above Las Vegas Wash. The region away from the noise corridors is quiet. Although windy at times, there is little vegetation to generate wind noise.

(9) Esthetics. - Flowing streams and greenbelt areas are not common to the southwest desert regions of the United States. In this respect Las Vegas Wash is unique. Its close proximity to the major population centers of southern Nevada increases its potential value. On August 6, 1973, the Board of County Commissioners for Clark County, recognized the importance of the possible future development of the Las Vegas Wash as a park, bird sanctuary, or other beneficial development and authorized the formation of the Las Vegas Wash Development Committee. In its April 1974 report[50] the Committee proposed a plan that would essentially accomplish the following purposes:

Maintain the unique ecology of the area;

Enhance the natural area for plants and animals;

Enhance the educational and recreational experiences for the community; and,

Keep the wash in harmony with its flood-plain status within the valley.

The open space and greenbelt provided by the wash is unique to southern Nevada and contributes greatly to the esthetic values of the area. This value would increase with the adoption of the Las Vegas Wash Development Committee recommendation to preserve and enhance the wash environment as a natural wildlife education/recreation area.

The Navajo-McCullough 500-KV transmission line crosses the wash area approximately 1,000 feet downstrem from the proposed interception facility. The line is carried on metal towers clearly visible from both air and ground. The Lincoln County Power District has a 69-KV line crossing the wash in the vicinity of Pabco Road.

(10) Archeological and historical resources. - It is known that there were at least five periods of occupation in the Mojave Desert area which includes Las Vegas Valley and Las Vegas Wash, all with distinct cultural expression and all are probably represented in archeological remains in the wash and adjacent areas. These periods were as follows:

I. Early Man - 10,000 to 12,000 years ago

II. Pinto Culture - 4,000 to 9,000 years ago

III. Gypsum Culture - 1,500 to 4,000 years ago

IV. Pueblo Occupation - 800 to 1,500 years ago

V. Paiute Culture - recent to 800 years ago

An archeological survey of the project area was conducted in compliance with the provisions of the 1966 Historic Preservation Act, Executive Order 11593 and Public Law 93-291. The survey was coordinated through the National Park Service, Arizona Archeological Center, and the State of Nevada Historic Preservation Officer. Field work and assessment was performed by staff members of the Nevada Archeological Survey, Southern Division, University of Nevada, Las Vegas. The survey and assessment covered a total area of about 4,200 acres and was conducted from November 1974 to June 1975.[56] The survey located 44 archeological and historic sites in the 4,200-acre study area. These included concentrations of lithic material, rock shelters, and scattered surface features such as circular stone alinements or "sleeping circles." The exact relation of these archeological sites to the previous mentioned chronology has not been determined. The historic sites are of recent origin. To date, none of the sites located have been determined as eligible for nomination to the National Register of Historic Places. However, evaluation of the findings is still underway to determine eligibility using the criteria in 36 CFR 800.

Methodology

The archeological survey strategy employed placed emphasis on the areas of high site density and on areas that would be disturbed by the proposed construction. Areas considered to have a high site density were those areas known to have a greater number of sites and those that were in environmental situations that are known to have high site potential. This strategy was designed with the prime consideration of assisting the Bureau of Reclamation in defining the significance of archeological sites and how they can best be protected or the construction effects mitigated. The amount of time spent in each area was allocated according to these considerations.

The various sections surveyed were divided by terrain features or artificial boundaries into segments that were examined on foot. When archeological manifestations were found, the immediate vicinity of the find was thoroughly searched. If the find merited, it was designated as a site and recorded by use of NAS standard site data forms, which include site description (feature measurements, etc.), location, substrata character, site condition, vegetation and relation to the project area. Selected sites were then photographed and the locations of all sites were recorded on a site map constructed from aerial photographs. Collection of representative artifacts, especially pottery, was made in some site locations. Data obtained in this way has been condensed and collated and is included as appendix C. A glossary of terms used is included to facilitate understanding of the report.

In portions of this project area, the surface was obscured by vegetation. Effective survey was precluded in these areas because of the dense plant growth cover. It was not possible to determine if there were any archeological manifestations in these areas.

(11) Social and economic characteristics[57]. - Las Vegas Valley and its communities represent a virtual island or oasis in the middle of a vast desert wilderness. These urban areas are an average of over 330 miles from the nearest major metropolitan centers. This isolation in a desert environment as well as the near proximity of Lake Mead has a tremendous influence on the social and economic characteristics of the area.

The area influenced by the project and its alternatives is the Las Vegas, Nevada Standard Metropolitan Statistical Area (S.M.S.A.). This area is the major population center along the Colorado River. Geographically the Las Vegas S.M.S.A. encompasses the entire 7,874 square miles of Clark County, Nevada. In practical terms, however, the primary area is Las Vegas Valley in which nearly 97 percent of the S.M.S.A.'s inhabitants resided in 1972.

History

Explorers traversed the region as far back as the late 16th century. In 1830 Antonio Armijos conducted an expedition that established the Spanish Trail between Santa Fe and the missions of California. For 20 years the trail led travelers through Las Vegas Valley where the green meadows and natural springs were a welcome relief from the dry heat of the desert. In 1855 the valley was settled by a small band of "Mormons" who used the waters of the springs to irrigate a small area of land. This was the first attempt at agriculture in the valley. In 1905 the area gained its first prominence with the announcement of a major railroad development through Las Vegas and the southwest.

The later growth of the community was stimulated by a series of Federal Government projects and installations. These began with the construction of Hoover Dam in the 1930's and continued with the 1941 opening of the Las Vegas Aerial Gunnery School (now Nellis Air Force Base), the development, also in 1941, of Basic Magnesium Industries in Henderson, and the opening of the Nevada Test Site in 1951. Legalized gaming and the resort industry began in the early 1930's and after World War II expanded to become the dominant industry in the Las Vegas Valley.

Population

The population of the area has increased by 90 percent or more between each census since 1930. The bulk of the S.M.S.A.'s new population has consistently settled in Las Vegas Valley. Between 1930 and 1940, however, almost 37 percent of new S.M.S.A. residents settled in Boulder City, which was established because of Hoover Dam construction during that decade.

Henderson's growth rate during the 1950's lagged the 163 percent growth rate for the S.M.S.A. as a whole. From 1960 to 1970, when the Las Vegas S.M.S.A. experienced a 115 percent population increase, Henderson's population grew by only 31 percent to 16,395 persons. Estimated population growth in Henderson since the 1970 census to 17,300 persons in 1974 or 5.5 percent more than in 1970, compares with an estimated 27.3 percent increase for the rest of Las Vegas Valley over this same period, evidencing a continuing tendency for Henderson growth to lag growth in the rest of the impact area.

The city of Las Vegas, centrally situated in Las Vegas Valley, had a 1970 population of 125,787. New residential development since 1970, however, has been predominently outside the city's limits in the more sparsely settled areas of Las Vegas Valley. From less than 5,000 people in 1920, the Las Vegas S.M.S.A. has grown to an estimated 330,000 people in 1974. Rapid growth and varying opinions as to when growth may level out have produced a wide range of estimates for future population. Of these projections, only the population projections prepared by the Clark County Regional Planning Council (CCRPC) in 1972 have been approved and adopted for utilization among the local governments within the regional planning jurisdiction and are tabulated on the following page.

These projections have a good general correlation with 1990 employment and economic projections, and fit within the spread of most previous studies. In view of this correlation and the general acceptance of these projections by the members of CCRPC, representing local government, it was concluded that the December 1972 CCRPC populations projections would be used.

The distribution of population within the County by the year 2000 is still open to question. The CCRPC has calculated that if the median projection of 750,000 people were to inhabit Clark County in 2000, 93 percent (700,000) of the population would be in the Las Vegas Valley. Extrapolating these population components for the Las Vegas Valley out, 295,000 people would be in the city of Las Vegas, 284,000 would be in the unincorporated areas, 91,000 would be in North Las Vegas and 30,000 would be in Henderson.

Annexations, governmental consolidations or the development of totally planned communities, similar to that currently being considered in Henderson, could materially affect the distribution of population among the various governmental jurisdictions. Recent demographic projections for the city of Henderson suggest that the city population could approach 44,000 people by the year 2000, and that new planned communities such as Green Valley and Lake Adair could potentially increase the population of the Henderson area to about 160,000 by 2000. Henderson presently represents approximately 5.4 percent of the total Las Vegas Valley population, and is projected to maintain 4.3 percent of the valley population in the year 2000 based on CCRPC figures. If future populations shifted to the Henderson area, this distribution percent could change significantly.

In addition to the permanent population, there is present in the Las Vegas Valley a large transient population. A

Clark County Regional Planning Council
Population Projections, 1970-2000

	Population in thousand persons			
Clark County	1970[a]	1980	1990	2000
High growth		460	650	850
Medium growth	273	435	600	750
Low growth		420	560	700
Las Vegas Valley				
High growth		446	621	805
Medium growth	261	421	563	700
Low growth		403	530	661
Henderson, Nevada				
High growth		24	32	50
Medium growth	16.4	21	25	30
Low growth		19	23	26

[a] Known 1970 Census figure.

substantial portion of demand placed on public services comes from this tourist and transient segment. Transient population for 1973 showed a winter low of about 29,000 people, a summer high of about 57,000 people and a daily average transient population of about 45,400 people.

This transient population averages about 10 percent of the total population during winter months and about 20 percent during summer months.

Demographic and Ethnic Background

Compared with the U.S. distribution of population by age class, the Las Vegas S.M.S.A.'s 1970 population was comprised of disproportionately large numbers of 20 to 44 year-olds, considered to be persons of prime working age. There was a disproportionately large number of children under 10 years of age as well, as would be expected of a population with relatively many women of childbearing age. The disproportionately small number of persons over 55 years of age in Las Vegas' 1970 population is explained by the area's rapid growth.

The racial composition of Las Vegas S.M.S.A.'s 1970 population was 89.5 percent white, 9.1 percent black, and 1.4 percent other nonwhite. American Indians accounted for 0.4 percent of the total S.M.S.A. population. This is in close conformity with the national percentage distribution of 1970 census population by race, which was 87.5 percent white, 11.1 percent black, and 1.4 percent other nonwhite, including 0.4 percent American Indian. Henderson's 1970 population of 16,395 persons was comprised of 95.8 percent whites, 3.5 percent blacks, and 0.8 percent other nonwhites.

There are no European or oriental ethnic neighborhoods in the Las Vegas S.M.S.A. The metropolitan area's ethnic diversity is evidenced, however, by Spanish, German, French, Greek, and polish language Sunday broadcasts on the C.B.S. Radio affiliate and by Greek Festival and Bastile Day celebrations in which Las Vegans of all ethnic backgrounds participate.

In 1970, 5.5 percent of the Las Vegas S.M.S.A.'s population was of Spanish heritage, 26 percent of whom resided in North Las Vegas, accounting for 11 percent of that entity's census population. Las Vegas' black population was heavily concentrated in five census tracts with more than 85 percent black residents. At that time 83 percent of black Las Vegans lived in the westside community within Las Vegas city boundaries and in adjacent neighborhoods in North Las Vegas.

Employment

Economic activities in an area are divided into two classes: basic activities and support activities. The outputs of basic activities are sold to households and enterprises outside of the area, providing area residents with purchasing power. The outputs of support activities are sold to area residents. The following table shows the general employment profile of the Las Vegas S.M.S.A. area.

Resort Industry

The Las Vegas S.M.S.A. is far removed from other metropolitan areas. Yet over eight and one-half million persons from the United States and abroad visited Las Vegas

Las Vegas Employment Profile

Basic industries	1974 employment (000)[a]	Percent of total employment[a]
Resort	44.2	27.8
Military-nuclear testing	14.0	8.8
Basic manufacturing	2.5	1.6
Total basic	60.7	38.0
Support industries		
Contract construction	9.7	6.1
Support manufacturing	2.4	1.5
Transport and public utilities	8.8	5.5
Wholesale trade	3.6	2.3
Retail trade	23.3	14.6
Finance, insurance and real estate	5.8	3.6
Nonresort, nonNTS services	16.2	10.2
Government		
Nonmilitary Federal	2.6	1.6
State and local	14.8	9.3
Other	11.7	7.3
Total support	98.9	62.0
Total civilian and military	159.6	100.0
Total establishment based industrial employment	140.4	88.0

[a] Figures may not add due to rounding.

in 1974, attracted by the entertainment, gaming, and convention facilities offered by the area's resort industry. Each visitor spent an average of 2.7 nights in Las Vegas: the resort industry, therefore, extended its hospitality to over 23 million visitor-nights in 1974. This industry is the mainstay of the Las Vegas economy. Its growth largely explains the dramatic employment and population growth experienced by the Las Vegas S.M.S.A. over the past 25 years.

Las Vegas resort employment has also been stable in the face of downturns in national economic activity. Resort employment consistently increased from year to year from 1957 to 1974 regardless of the state of the national economy. In fact, during the 1960, 1970, and late 1974 economic downturns, resort employment exceeded its trend growth levels. Such resort industry growth has provided job opportunities for those who would otherwise have been unemployed in Las Vegas and elsewhere.

Nellis Air Force Base and Nevada Test Site

The geographic isolation of Las Vegas and its environs makes the area suitable for military training and weapons testing. In 1941, an Army Corps Gunnery School was established 8 miles northeast of Las Vegas to train flyers in the use of weaponry. The base was closed in 1947 but reopened as Nellis Air Force Base in 1950 to train fighter pilots for the Korean conflict.

Nellis Air Force Base is responsible for devising combat air tactics for fighter aircraft and for operating a combat-ready wing of F-111 aircraft. It currently employs nearly 7,500 military personnel and 1,500 civilians, making the Air Force Nevada's largest single employer.

The Nevada Test Site (N.T.S.) was established in 1951 by the Atomic Energy Commission to facilitate nuclear weapons testing. It has also been used to explore peaceful uses of nuclear devices, e.g., Operation Plowshare, and for research into nuclear propulsion, e.g., Nuclear Rocket Development Station.

Employment at N.T.S. rose sharply in 1962 in anticipation of the 1963 limited test ban treaty prohibiting above-ground detonation of nuclear devices. Underground testing requires a large construction workforce to prepare and instrument the site of detonation.

Annual N.T.S. employment peaked at 10,200 in 1968 and then declined with a reduction in weapons testing and discontinuance of the Nuclear Rocket Development Station. N.T.S. employment has remained level at about 5,000 since 1973, with 3,500 employees at the Test Site and 1,500 support personnel located in Las Vegas Valley. Site employees typicaly live in Las Vegas and commute to work.

Las Vegas S.M.S.A. Manufacturing Activity

Manufacturing employment in the Las Vegas S.M.S.A. averaged 4,900 in 1974, or 3.2 percent of total civilian employment. Of this total, approximately 1,500 were employed in food processing and printing and publishing for local consumption. The remaining 3,400 manufacturing workers were involved in the production of chemicals, metals, and other durable goods for export throughout the United States. Most of these were employed at Henderson's Basic Management, Inc.'s industrial complex where titanium is refined and liquid chlorine, caustic soda, ammonium perchlorate, and various other chemicals are produced. The strong influence of manufacturing activity on Henderson's socioeconomic character is evidenced by the high percentage of its employed residents working in manufacturing: 19.1 percent compared with 3.7 percent for the remainder of Las Vegas' urbanized area in 1970.

Support Industries

Over 60 percent of Las Vegas workers, however, are employed in support industries, including contract construction, nonbasic manufacturing, transportation and public utilities, wholesale and retail trade, finance, insurance and real estate, personal and business services apart from the resort industry and N.T.S. related business services, and government.

Small numbers of workers are engaged in agriculture (approximately 800 in 1974) and mining (approximately 200).

Construction employment accounts for a high percentage of total employment in the Las Vegas economy. In 1974, it was 6.9 percent of total establishment based employment in Las Vegas, compared to 4.6 percent nationwide. The high intensity of construction activity in Las Vegas is explained by the dynamic growth of the area's economy and the associated demands for new resort, public, commercial, and residential structures.

The 1970 industrial employment profile of Henderson residents differed substantially from that for the S.M.S.A. as a whole. Twelve percent were employed in construction compared with the corresponding 1970 S.M.S.A. percentage of

8.5 percent. Only 2.4 percent of employed Henderson residents were engaged in finance, insurance, and real estate, compared with 4.1 percent for the S.M.S.A. and only 11.6 percent of Henderson's workers were in the personal services category encompassing the Las Vegas resort industry, compared with 23.7 percent for the S.M.S.A. in 1970.

Las Vegas S.M.S.A. incomes are well above national average on family, per worker, and per capita basis. Las Vegas incomes are expected to remain above national levels. This is explained by the high work force participation rate in Las Vegas, owing in part to Las Vegas' age distribution and, in part, to the many employment opportunities enjoyed by Las Vegas females.

Unemployment

Las Vegas S.M.S.A. unemployment rates have consistently exceeded national unemployment rates, as tabulated below. The area's higher than average national unemployment rates are explained by the large weight of the volatile construction industry in the Las Vegas S.M.S.A.'s industrial structure and by the dynamic growth of the Las Vegas economy.

New arrivals into the Las Vegas area are classified as unemployed until employment is secured. Unemployment in the area is heightened during national economic downturns when unemployed immigrants seek work in "booming" Las Vegas. In 1970, Henderson's male unemployment rate was slightly above that for the S.M.S.A. while its female unemployment rate was substantially below the rate for the S.M.S.A.

Minority economic status in the Las Vegas S.M.S.A. is relatively high. At the time of the 1970 census the median family income of black families in Las Vegas was $6,746, 11 percent above the $6,067 black median throughout the United States. The unemployment rate among the Las Vegas S.M.S.A.'s black workforce was 5.4 percent compared with a white unemployment rate of 5.1 percent. Nationally the black unemployment rate was 8.2 percent, 80 percent above the white rate of 4.5 percent.

Social Services

Five general purpose governments which now exist in Clark County are: Boulder City, County of Clark, Henderson, Las

Las Vegas and U.S. Unemployment Rates

	Las Vegas (percent)	U.S. (percent)
1957	6.4	4.3
1958	8.9	6.8
1959	6.5	5.5
1960	5.2	5.5
1961	6.1	6.7
1962	4.1	5.5
1963	4.6	5.7
1964	5.9	5.2
1965	6.2	4.5
1966	6.3	3.8
1967	6.1	3.8
1968	5.2	3.6
1969	4.5	3.5
1970	5.9	4.9
1971	7.5	5.9
1972	7.7	5.6
1973	6.7	4.9
1974	7.9	5.6

Vegas, and North Las Vegas. The structures of the four city governments are shown below:

Boulder City	Henderson
Mayor	Mayor
Assistant Mayor	Four Councilmen
Five Councilmen	Municipal Judge
Municipal Judge	City Attorney
City Attorney	City Manager
City Manager	City Clerk
City Clerk	

City of Las Vegas	City of North Las Vegas
Mayor	Mayor
Four City Commissioners	Three Councilmen
Two Municipal Judges	Municipal Judge
City Attorney	City Attorney
City Manager	Two Chief Deputy City Attorneys
City Clerk	City Manager
	City Clerk

Within Clark County there are many special purpose districts. A list of some of these districts which seem most relevant to this study is used to demonstrate the breadth of the governmental services and functions offered. The partial list follows:

1. Desert Water District
2. Clark County School District
3. Clark County Library District
4. Henderson Library District
5. Boulder City Swimming Pool District
6. Clark County Sanitation District No. 1
7. Boulder City Library District
8. Las Vegas Valley Water District
9. Clark County Flood Control District
10. Clark County District Board of Health
11. Clark County Regional Streets and Highways
12. Southern Nevada Memorial Hospital
13. Las Vegas Artesian Basin District
14. Colorado River Commission
15. Las Vegas Taxicab Authority
16. Regional Planning Council
17. Disaster Control Board
18. Comprehensive Health Planning Council
19. Clark County Welfare Advisory Board
20. Metropolitan Police Commission

Water Use

Prior to 1970, the primary water supply for the southern Nevada area was pumped from wells. As the communities in the valley grew, the amount of water taken from the underground basin began to exceed considerably its long-term capability. Since the late 1950's more ground water has been pumped from the Las Vegas Basin than nature can replenish or recharge. This overpumping has resulted in a general lowering of the water table with consequent surface settlement in some areas. This overpumping reached a withdrawal rate equal to three times the estimated natural recharge in 1969. The first stage of the Southern Nevada Water System, jointly constructed by the Nevada State Division of Colorado River Resources and the Bureau of Reclamation, went online in 1971. The first stage has the capability to deliver up to 44 percent of Nevada's Colorado River entitlement. This amounts to 132,000 acre-feet per year. The system currently provides water for Boulder City, Henderson, North Las Vegas, Nellis Air Force Base, and the greater Las Vegas area (through the facilities of the Las Vegas Valley Water District). During 1974, the system provided nearly 19 billion gallons of water with a peak delivery rate of nearly 180 million gallons per day. Based on current per capita use, existing wells will support a population of about 122,000 people. This is assuming a stabilized rate of withdrawal from the ground-water basin of about 50,000 acre-feet per year, which is about one-half the rate pumped during 1969 and 1970. Although this amount of pumping includes some overdraft, various water resource agencies feel that stabilization at 50,000 acre-feet will allow many years of productivity without serious adverse effects to the underground basin. The first stage of the Southern Nevada Water System increases the water accommodation to about 443,000 people. The growth curve for the area indicates that first stage water and people will meet head on in the early 1980's instead of 1990 as was originally projected.

The second stage of the Southern Nevada Water System is currently being planned to provide the remaining portion of Nevada's Colorado River entitlement by the early 1980's.

Energy Use

The Las Vegas Valley is currently served by one natural gas company and two electric utility companies.

The Southwest Gas Corporation is a Las Vegas based firm which supplies natural gas to portions of Nevada, California, and Arizona. The greatest growth of commercial customers for the utility has been in the southern Nevada area. During 1973, customer accounts totaled nearly 50,000 with total gas sales (1,000 ft^3) of over 40 million.

The California-Pacific Utilities Company currently provides electric service to the city of Henderson from Hoover Dam.

The Parker-Davis and Colorado River Storage Hydroelectric projects supply electrical power to the BMI industrial complex near Henderson. This power and energy, supplemented by power and energy from the Nevada Power Company (discussed below) is administered by the State through the Division of Colorado River Resources.

The Nevada Power Company is an investor-owned utility development. It receives power from Hoover Dam as well as other sources. In 1953 the energy received from Hoover Dam (263-million kWh) constituted 100 percent of the company's service-area requirements. In 1970 the energy received from Hoover Dam constituted only 11 percent of the service-area requirements. The company currently provides service for all of Las Vegas Valley, except Henderson, which includes Las Vegas and North Las Vegas, and other areas in Southern Nevada. Electric energy during the year 1973 for sales (1,000 kWh) for residential use was 1,792,688, for commercial and industrial use 1,983,701, and other uses 290,422. Customer accounts totaled 108,088.[58]

The dramatic growth of the Las Vegas Valley communities, as previously described, has resulted in large increases in electric power consumption. To provide for this increased consumption the total available power for the valley was increased from 929 megawatts to 1,241 megawatts in 1974. This was further increased to 1,353 megawatts in June 1975. The following tabulation[63] shows the current available power to Las Vegas Valley and a projection of power availability in the year 2000.

Recreation/Cultural Resources

Long-term trends toward greater affluence, not only in the United States but also in much of the rest of the world, have made recreation and leisure time use in general

Power-Generating Plants
For Las Vegas Valley

	Name of plant and location	Megawatts presently available	Megawatts available to Nevada by year 2000	Type of plant and purpose
1.	Clark Station Las Vegas Valley	195	195	Steam electric main load (nat. gas and fuel oil)
2.	Sunrise Station Las Vegas Valley	85	85	Steam electric main load (nat. gas and fuel oil)
3.	Mohave Station near Davis Dam	211	211	Steam electric main load (coal)
4.	Westside Las Vegas Valley	30	30	Diesel electric peak, emerg.
5.	Gas turbines Las Vegas Valley	58 +67 (May 1974)	125	Gas turbines peak, emerg.
6.	Hoover Dam at the Dam	100	100	Hydroelectric main load
7.	Navajo Station near Page, Arizona	261 (June 1974)	261	Steam electric main load (coal)
8.	Reid Gardner Moapa Valley	234 +112 (June 1975)	448 (1977)	Steam electric main load (coal)
9.	Allen Power Project (proposed)		2,000*	Steam electric main load (coal)
	Total nominal generating capacity in megawatts	1,241 mid 1974 1,353 mid 1975	3,455	

* 500 megawatts proposed to be available in 1979 with proposed expansion to 2,000 megawatts by 1983

increasingly important. Not only do people have more time for leisure and recreation, but they also are able to use an increasingly large share of their income in support of recreational activity. Recreation and leisure time use are especially important to the Las Vegas Valley as the basis of the valley's principal industry. Recreational and leisure facilities and offerings to valley residents not only constitute an obviously important component of the current quality of life but also are very important, through their special effects on youth, to social wellbeing in the future.

An inventory conducted in 1971 showed a total of 63 neighborhood parks (serving 3 to 6 thousand people, each), 23 community parks (serving 20 to 40 thousand people, each), 9 regional parks (serving the entire valley) and 19 special purpose recreational areas. The following tabulation shows the distribution of these parks by community. Minimum standards for the size and location of public park lands have been adopted for Clark County. These are also displayed on the following table. In comparison to the standards adopted, the important neighborhood and community parks show significant deficiencies in both acreage and location. By 1990, the acreage required for these parks will be about double the 1971 level.

There are four major recreational areas outside the Las Vegas Valley itself which are used extensively both by Las Vegas residents and by visitors to the Las Vegas Valley. These four are Red Rock Canyon, the Las Vegas Ranger District of the Toiyabe National Forest, the Valley of Fire State Park, and the Lake Mead National Recreational Area. The locations of these areas are:

The Red Rock Canyon area, now a Nevada State Park, is about 20 miles west of Las Vegas and is readily accessible by a paved loop road. It offers a number of recreational sites generally regarded as highly attractive and some sites of special geologic and archeological interest. Although 17 specific sites in Red Rock Canyon have been proposed for future development, it remains largely undeveloped. 1974 visitors to Red Rock Canyon totaled 24,615.

The Las Vegas Ranger District of the Toiyabe National Forest includes the Charleston Mountains, which in their higher portions are heavily forested, and in winter covered with snow supporting winter sports. The area has

Summation of General Recreation
User-Oriented Areas

Location	Neighborhood Parks*		Community Parks*		Regional Parks	
	Number	Acreage	Number	Acreage	Number	Acreage
Las Vegas	28	135.46	8	246.30	3	2,900.0
North Las Vegas	13	38.32	5	110.50	2	1,720.0
Henderson	5	18.17	2	29.20	2	1,660.0
Boulder City	4	17.79	1	5.17	-	-
Clark County metropolitan area	13	58.50	4	39.00	2	485.0
Clark County	-	-	3	52.00	-	-
Total	63	268.24	23	482.17	9	6,760.0

* Includes developed park-school facilities

User-Oriented Park and Recreation Standards
(As established by the Clark County Regional Planning Council)

Types of parks	Area per 1,000 pop. (acres)	Size of park (acres)	Service radius (miles)	Population served each park (average)
Tot lots	.2	1,500-5,000 3,500 average (square feet)	1/8-1/4	2,500
Neighborhood parks	2.0	5-10 7.5 average	1/4-1/2	4,500
Community parks	3.0	20-60 40 average	1-1-1/2	30,000
Major urban parks	2.5	100-200 40 minimum	2-3	60,000
Regional parks	10.0	500-1,000 750 average	60 min. driving time	Entire urban area
Special purpose areas	5.0	Varies - sports area, golf courses, athletic fields, etc.		

significant private development and supports a variety of dispersed recreation activities, including hiking, back-packing and mountain climbing.

The Valley of Fire State Park is about 75 miles northeast of Las Vegas and contains about 26,000 acres. The park is focused on a central core of heavily eroded sandstone with iron content providing, in different levels of leaching, strong and varying color patterns. There is an interpretive center in which the history, geology and ecology of the region is explained through visual exhibits. In 1974, 134,943 persons visited the Valley of Fire State Park.

The Lake Mead National Recreation area is based on the two large lakes created through the construction of Hoover and Davis Dams on the Colorado River. The area covers over 3,000 square miles in Nevada and Arizona, much of it canyon-cut picturesque desert. The area offers year-round water recreation with the peak season occurring during the summer, despite high summer temperatures. Both lakes offer a variety of fishing. The National Park Service, which administers the area, leases land to private firms to provide marinas and living sites adjacent to the lakes. Six separate business organizations provide trailer parks, boat docks and restaurants in generally well-developed installations. There are 11 such installations scattered roughly every 10-15 miles on the north shore of Lake Mead, the most easily accessible from Las Vegas. In 1974, the Lake Mead Recreational Area had 5.9 million visitors with 1.7 million overnight stays. For the past several years, Hoover Dam has been visited by an average of 1,750 visitors daily, although in 1974 the daily average fell to 1,589. The facilities at Lake Mead Recreation Area and in the other three major recreational areas discussed above are described on the following table.

There is a potential fifth major recreational area for Las Vegas Valley residents and visitors in the Las Vegas Wash. The Las Vegas Wash itself is some 42 miles in length serving as the main drainage channel for the valley. The Las Vegas Wash Development Committee, a study and recommending group appointed by the Board of County Commissioners of Clark County, has identified the lower

Facilities in the Area

	Boating	Hunting	Lodging	Skiing	Store	Hiking	Overnight Camping (units)	Picnicking (units)	Swimming
National Park Service									
Lake Mead:									
Boulder Beach	X		X		X		338	80	X
Las Vegas Bay	X				X		89	40	
Calville Bay	X				X		X		
Echo Bay	X		X		X		166		
Roger Springs								X	
Overton Beach	X		X		X		20		
Temple Bar	X		X		X		X		
Lake Mojave:									
Willow Beach	X		X		X		X	X	
Cottonwood Cove	X		X		X		149		
Katherine	X		X		X		X	X	X
National Forest Service									
Toiyabe National Forest									
Kyle Canyon		X				X	34	102	
Fletcher View		X				X	12		
Cathedral Rock		X				X		108	
Mary Jane Falls		X				X	50	X	
Hilltop		X				X	36	X	
Mohogany Grove		X				X		4	
Deer Creek		X				X		11	X
McWilliams (Lee Canyon)		X	X	X	X		62	63	
State Parks:									
Valley of Fire						2 mile trails	30	3 gr. areas	
Red Rock Canyon							X	3 gt. areas	
Cold Creek							6		X
Willow Creek							15		

11 miles of the wash beginning at the Las Vegas Wastewater Treatment Plant as the portion of the wash suitable for extensive recreational development and preservation as a natural area.[50]

Private outdoor recreational facilities include some which are essentially nonprofit in nature, and which serve in much the same manner as sites operated by or owned by Governmental agencies. The Boulder Dam Area Council of the Boy Scouts of America operates two summer camps attended by approximately 700 youths yearly and a weekend camp at Potosi in the Spring Mountains visited by substantially larger numbers of Scouts during its year-round operation. In 1974 the Council's summer camping days exceeded 49,000.

Private outdoor recreational facilities also include those operated wholly on a profit-making basis in themselves or as a service facility for resort hotels. Golf courses comprise the most important of the facilities in this category. There are 12 private golf courses and one 18-hole military golf course in the valley, 10 of which are designed and kept at championship levels of quality. All of these courses are irrigated, 10 with water taken from the basin through onsite wells and 3 with treated sewage effluent.

Private outdoor recreational facilities also include riding stables, a motor speedway, archery lanes, gun clubs, tennis facilities (including temperature controlled indoor courts), an ice rink, flying and glider-flying clubs and airports and numerous smaller outdoor facilities. The Las Vegas Valley is liberally served by private swimming pools, both in condominiums and apartments, almost all of which have pools open generally from the beginning of May through September. An estimated 15 percent of all single family homes have private swimming pools.

Nonparticipatory and indoor recreational activity include a wide variety of public and privately provided programs. Attendance at sports events of the University of Nevada, Las Vegas (UNLV) and of the Clark County School System comprises one major category of such recreational activity.

Nonsports presentations for audiences by the university and, to a lesser extent by the school system, supplemented by the dramatic and musical presentations of the Reed Whipple Cultural Arts Center provide a second major category of indoor and nonparticipatory recreation. The UNLV

Judy Bayley Theatre and a second, smaller theatre stage some 60 to 70 performances annually with total ticket sales of more than 20,000. In addition, the Confederated Students of the university arrange a wide variety of speeches, entertainment and other presentations at the Student Union. Still further public entertainment at the university is provided in the several auditoriums, including lecture series.

Cultural recreational activities in addition to the above include approximately 100 smaller activities based around such formal organizations and looser organizations as historical and collector's groups, festival groups, music centers, poetry clubs, dance clubs and competitions, ethnic groups, drama groups, labor union social activities and church or other religious groupings.

Libraries within the Las Vegas Valley include the James Dickinson Library at UNLV, the Clark County Main Library and three Clark County branch libraries, the North Las Vegas Library, the Las Vegas Library and the Boulder City Public Library. The Clark County Library District also provides bookmobile service.

Private indoor recreational facilities are dominated by those of the resort industry. Intended primarily for visitors but available to residents are 24 major hotel/casinos offering major shows and lounge shows with entertainment by nationally acclaimed performers. More conventional indoor entertainment is provided by 46 separate motion picture screens in the area. Church recreational activity is also extensively provided by the 145 churches and 3 synagogues in the valley. Radio and television stations add a different dimension to private-enterprise provided entertainment.

(12) Land use. - As noted in the foregoing, recreation constitutes the major allocation of land for man's activities. In addition to the specific recreational areas, the urban communities are surrounded by desert wilderness. Most of this wilderness is managed by the Bureau of Land Management. These areas provide abundant recreational value for hikers, rock collectors, off-road vehicle activity, motorcycles, and horseback riding. There has been an attitude of "no value" toward many portions of the area. There are numerous trails cut by motor vehicle for convenience or sport with disregard for the environment. Trash and abandoned cars are found piled along the roads and trails and along the periphery of Las Vegas Wash.

Due to the lack of precipitation and the high summer heat, great quantities of water are required for the irrigation of lawns, gardens, and agricultural land. Urban communities have expanded and with their priority for water use, little is available for agriculture. Most farmland in the area is irrigated with treated sewage effluent. During 1954 only about 1,600 acres of irrigated crops and pasture were grown. This figure has decreased to a current use of about 1,000 acres.

Vast expanses of land in Nevada are uninhabited, barren desert or semiarid mountain terrain. These areas have proven ideal for use by the military and related operations. About one-half million acres have been reserved for these purposes. However, only about 19,000 acres are located in Clark County.

The annexed urbanized areas in Las Vegas Valley encompassed about 162 square miles in 1972. Other more direct uses are tabulated below (1972).

Use	Acres
Single family	16,310
Multiple family	2,820
Commercial	3,570
Industrial	2,080
Public	15,170

b. Crystal Geyser Unit. - The Crystal Geyser is located in a natural spring area adjacent to the Green River and about 3.5 miles south of the town of Green River, Utah. The location is on the river flood plain near the northeast end of the San Rafael Desert.

In August 1972, geologists of the Brigham Young University Center for Environmental Studies, confirmed that the geyser was the principal outlet for salt-laden water averaging 11,000 to 14,000 mg/l. Water also issued from two other springs: one east of the geyser and one north of the geyser. During eruption, water comes from all three openings and some minor activity was observed in the river. The combined yield contributes 150 acre-feet and about 3,000 tons of salt per year to the Colorado River System. Figure II-9 shows water from the geyser flowing into the Green River.

(1) Historical and archeological. - In 1869, when John Wesley Powell passed this area on his historic trip down the Green River, he reported the existence of rocks deposited by mineral springs, but that the springs no longer flowed. A. H. Thompson,

Crystal Geyser eruption water flowing into the Green River.

Figure II-9

who was with Powell on a later trip, said that there were effervescent flows of alkaline water rising in the bed of the river at this spot.

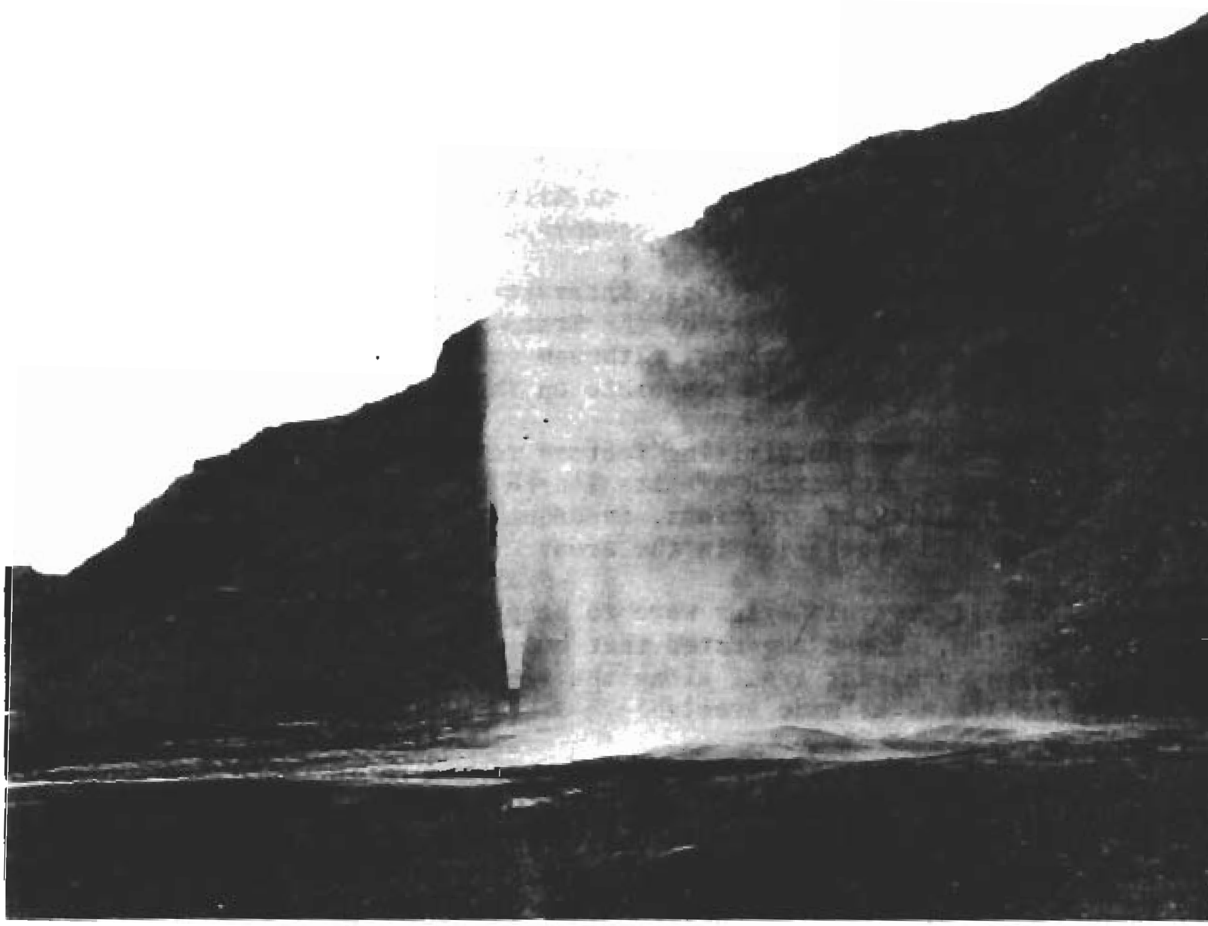
In November 1935 to July 1936, a 16-inch well was drilled to a depth of 2,627 feet by Glen Ruby and others at the site of the mineral springs reported by Powell. This was designated in USGS Bulletin 908 as No. 1-X (State) well. It was located on the crest of a small anticlinal structure following the discovery of gas and petroleum seeps in the vicinity. No casing record is available, but the well was probably surface cased for a distance of less than 100 feet. Since drilling of the well, water has issued from the hole in quite spectacular periodic eruptions.

Figure II-10 shows the geyser during an eruption. Eruptions are reported to have occurred about every hour when the well was first drilled; but by 1972, the interval had extended to about 5 to 5-1/2 hours. Local residents say the well has been dynamited several times and a great deal of debris thrown down the hole.

The well is located on property consisting of 11.1 acres of land and was purchased exclusive of mineral rights by Mr. Stephen Cook from the State of Utah in 1945. After being used as a commercial facility for a few years, it was abandoned in favor of the Woodside Geyser located just off Highways No. 6 and 50 between Green River and Price, Utah, about 28 miles north of the Crystal Geyser.

A survey conducted by the Utah State Historic Preservation Office in June 1974 revealed five archeological sites, three of which are within the boundaries of the proposed evaporation pond. Based on the data available, none of the sites appeared to be of National Register quality. However, should any cultural resources not already identified be encountered during construction, then the Bureau of Reclamation would evaluate the resource in terms of eligibility for nomination to the National Register of Historic Places in accordance with the criteria in 36 CFR 800.

(2) Economics. - A survey of businesses in Green River, Utah, was made by Brigham Young University as part of the Crystal Geyser investigations. The survey involved interviewing owners and managers of service stations, motels and restaurants, the combination of which represented about 90 percent



Eruptions from abandoned well - Crystal Geyser Unit.

Figure II-10

of the business conducted with tourists. Tourism and recreation are now probably the largest economic factors in Green River, Utah. Conclusions reached from the interviews were:

(a) Tourists make only an overnight stop in Green River.

(b) Additional privately funded facilities would be needed to induce tourists to remain longer. Some of these could be a movie theater, bowling alley, golf course, and other recreational facilities as well as restaurants. Facilities which would make guided tours available to such areas as Goblin Valley, Crystal Geyser, Arches National Park, Dead Horse Point, Canyonlands National Park, and Capitol Reef National Park as well as river trips down the Green River would give impetus to the economy of the area.

(c) The majority of those interviewed favored the development of Crystal Geyser by the State rather than Federal, city, or private groups, although some believed that all organizations should cooperate on the project.

(d) Some of the limiting factors toward making the geyser a tourist attraction are its length of time between and irregularity of eruptions, inadequate roads, and lack of trees and vegetation in the area.

(e) If crystal Geyser were to be privately developed for tourism, it was suggested that bus and jeep tours, boat trips, a hiking trail along the river, and horse riding facilities be made available.

(f) Practically all businesses reported an increase in tourist trade from 1970 to 1972. Expanded recreational areas in Grand and San Juan Counties together with completion of parts of I-70, the annual Friendship Cruise from Green River to Moab and general uptrend in tourist activities have increased business acitivities in Green River. During the summer months in 1972, all motels were filled to capacity. Some of these are open only in the summer, others year round.

(g) Motel and camping facilities are being expanded because of the increase in tourist trade. Additional public utilities are being planned by community leaders.

(3) Land use/cultural factors. - The land surrounding the well is not used at present except for occasional visitors who

come to see the geyser. About 50 percent of the area where the evaporation reservoir will be located is presently under cultivation.

(4) Population distribution. - In 1970, the population of Green River, Utah, was 1,033. The area near the Crystal Geyser has no permanent residences. An occasional tourist or visitor may remain at the geyser for a few hours. There is some overnight camping, and group parties have been held at the site on occasion.

(5) Climate. - The climate at the geyser is of a desert type, being hot and dry during the late spring, summer, and early fall and generally cold but dry in the winter. The mean monthly temperatures range from a low of 24° F in January to a high of 78° F in July. The average annual precipitation for the past 23 years, as recorded at the Green River airport nearby, is about 6 inches. The maximum annual precipitation for this period occurred in 1957 with almost 12 inches and the minimum occurred in 1956 with slightly more than 2 inches. Evaporation records over the 1948-72 period show an average annual evaporation of 54.80 inches. With the average annual precipitation as 6.01 inches, the annual net freshwater evaporation at Crystal Geyser is 48.8 inches or about 4 feet. However, as the salt concentration in ponded water increases, the evaporation rate decreases. Eventually, as salt accumulates in evaporation ponds the concentrations approach saturation loads. A net evaporation rate for the geyser area as affected by the salt accumulation was estimated about 1.5 feet per year.

(6) Soils, topography, geology, and minerals. - Crystal Geyser is located on a tufa cone with sandstone and shale ridges on three sides. Soils further away from the geyser and along the proposed pipeline vary between loose sandy alluvial deposits in Little Grand Wash and shallow soils, and raw Mancos Shale outcroppings along the steep cutback exposed by the river. Soils near the evaporation pond site have developed in alluvium (with textures ranging from coarse gravels to clay). Most surface textures are sandy loam to clay loam. Lining of the ponds will be required to prevent leakage to the river.

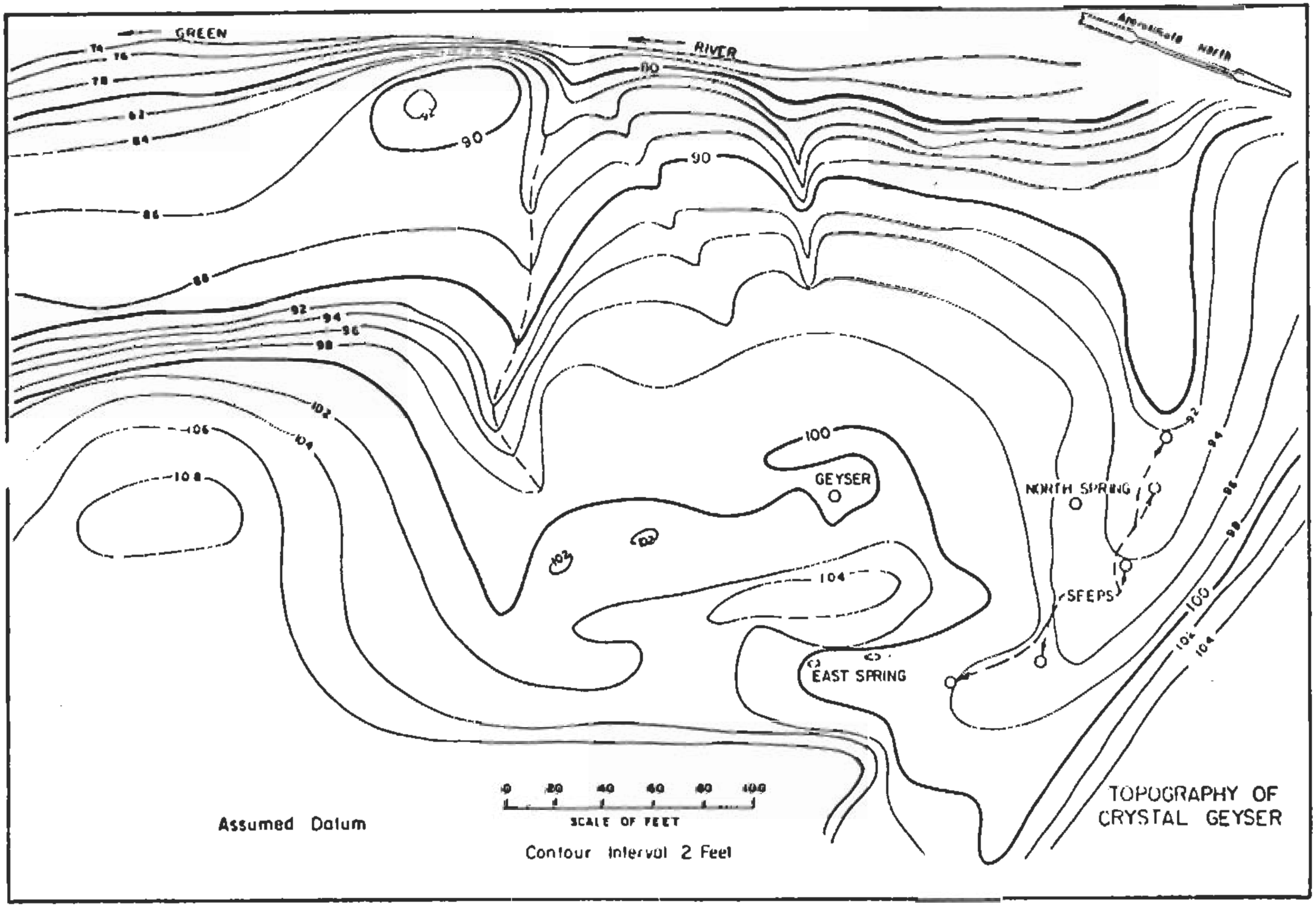
Steep slopes are found immediately east of the geyser. The Little Grand Wash Fault crosses the Green River at the well location. The lower part of the tufa cone near Green River was built up by the geyser. Other tufa cones built up by springs along the fault surface are evident for 1.5 miles eastward and on the west side of Green River. The tufa materials have changed the topography in the vicinity of the geyser by creating a layered effect with each layer dropping in elevation toward the river. Figure II-11 shows the topography of the Crystal Geyser area.

Investigations have disclosed that three general ages of tufa development are recognized at the Crystal site. All three ages of tufa are along the Little Grand Wash Fault, a major east-west fault. The structural break in the general vicinity of the geyser area is a fault zone, with several minor faults but two major ones separated by approximately 400 feet along most of their trend. Towards the east, the two major faults merge and at about this point the tufa cones terminate. The tufa deposits owe their origin to springs developed along the fault surface which offered channel-ways through the impervious lower Entrada and Carmel Formations. The occurrence of all three stages of tufa deposition along the fault indicate considerable spring activity over the past several thousand years well back into Pleistocene time. The youngest tufas are currently being formed and are associated with the presently active geyser and springs.

The only geologic records available on the Crystal Geyser well are driller's logs. Interpretation of the data suggests that the well was drilled approximately 70 feet through tufa at which or near which the well apparently crossed the controlling Little Grand Wash Fault. The lower part of the well was drilled in the north upthrown block of the fault structure composed of Triassic (T) and Jurassic (J) materials and is shown on figure II-12. The well merely offers a local relief point for dissolved carbon dioxide and water trapped in deep formations. The small springs north and east of the geyser are probably natural openings near the line of emergence of the fault along the east and north side of the active tufa cones.

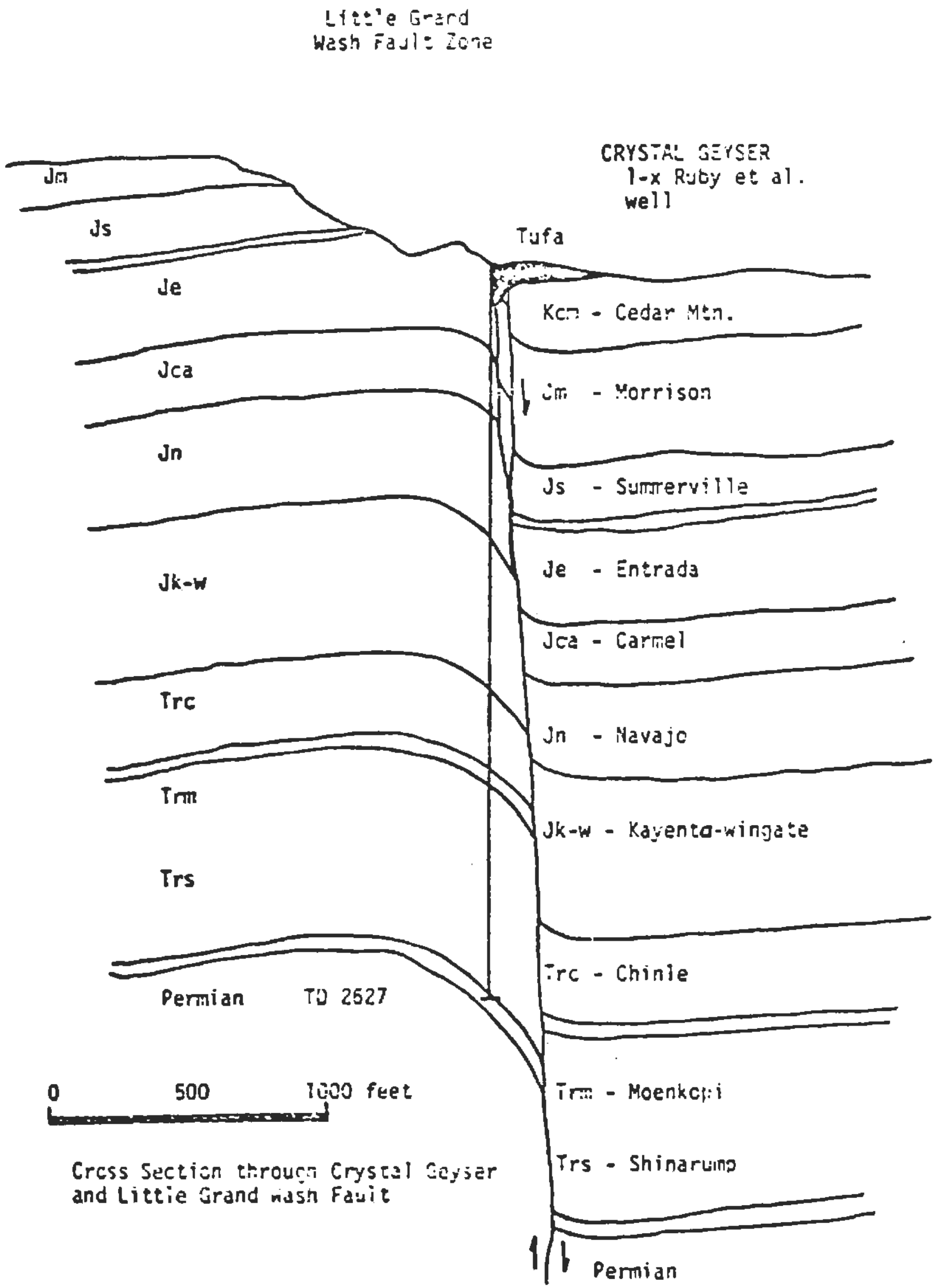
The source of erupted water is in close proximity of a major fault zone. According to the driller's log, water was first encountered at a depth of 270 feet; no water was mentioned in the log below 290 feet. The water, however, could be coming from the Navajo Formation below 700 feet by flowing along the fault line and emerging at the 270- to 290-foot depth.

The Navajo Sandstone produces carbon dioxide saturated water at the Woodside Geyser 28 miles to the north, which is used



Topography of Crystal Geyser.

Figure II-11



Cross section through Crystal Geyser and Little Grand Wash fault.

Figure II-12

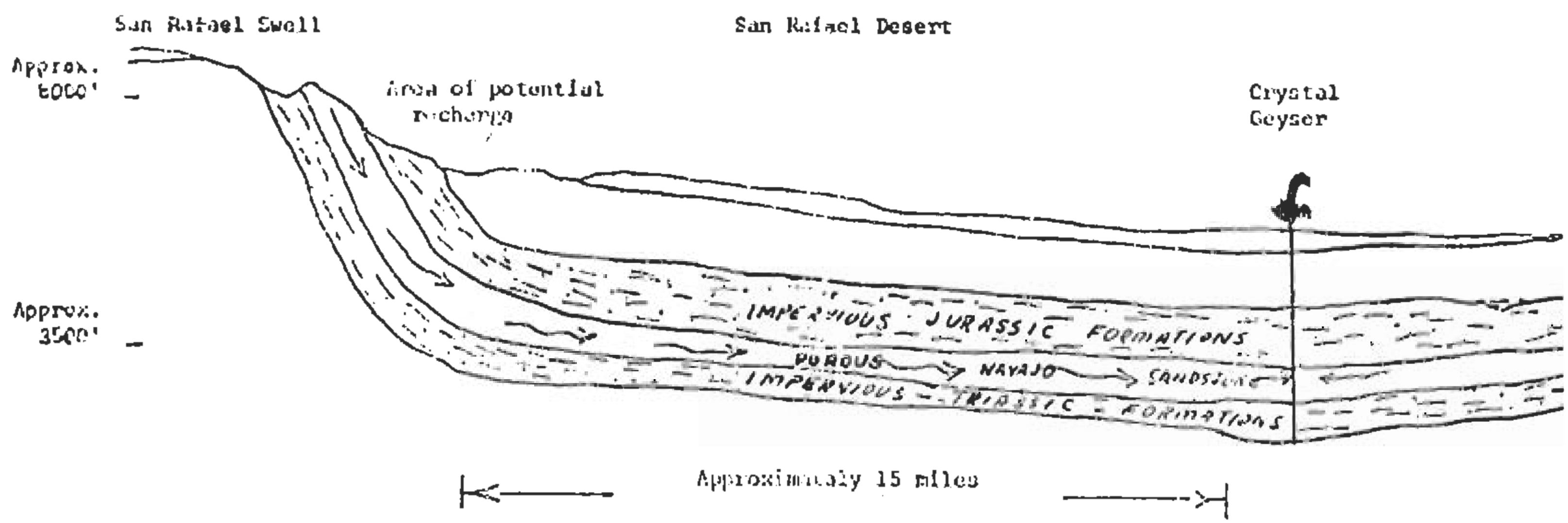
for commercial production of carbon dioxide. The water could have its origin as precipitation percolating into the exposed Navajo Sandstone along the east side of the San Rafael Swell (see fig. II-13). This formation has an eastward sloping natural gradient from the high San Rafael Swell to a low point at about the position of the geyser. Faults of the Salt Wash Graben and the Little Grand Wash Fault effectively seal off the sandstone aquifer thereby trapping both water and dissolved carbon dioxide.

Mineral production in the immediate vicinity of the geyser is nonexistent. There are numerous exploratory oil and gas wells in the surrounding area although none are commercially productive. Uranium claims have also been established at many surrounding sites.

(7) Vegetation. - Vegetation found in the geyser area although sparse includes cactus in several varieties, Mormon tea, greasewood, and shadscale. Tamarisk and scattered cottonwood are some of the trees found along the edges of the Green River and on the flood plain of Little Grand Wash. Scattered clumps of low growing shadscale along with grass tufts are found in a portion of the evaporation pond site. Alfalfa is currently growing in about 50 percent of the site. Refer to appendix D for a list of common and scientific names of plants characteristic of Crystal Geyser.

(8) Fish and wildlife/recreation. - A 1973 survey of the distribution and abundance of fish in the Green River in the 65 river mile reach above its mouth (mostly in Canyonlands National Park) showed the following fish and the survey's classification as to their population: bonytail chub, rare; Colorado squawfish, rare; speckled dace, rare; fathead minnow, common; carp, common; red shiner, abundant; flannelmouth sucker, abundant; bluehead sucker, rare; humpback sucker, rare; channel catfish, abundant; black bullhead, common; green sunfish, rare; and flannelmouth sucker-humpback sucker hybrid, rare.

Appendix D contains a listing of birds, mammals, fishes, reptiles, and amphibians in the Crystal Geyser area. These lists were prepared from a literature search and field studies of the Crystal Geyser area by Brigham Young University in June of 1975. A total of 73 bird species were listed as resident species and 13 as game species. Representative game species



Diagrammatic cross section of Navajo-Wingate Sandstone aquifer showing possible recharge area and flow path of water produced by Crystal Geyser.

Figure II-13

include the Canada goose, numerous species of waterfowl, sage grouse, quail, pheasant, chukar, and mourning dove.

A total of 48 mammal species were noted as ranging within the project area. Of this total, 43 were listed as residents and 5 were considered game species. Game species include the desert cottontail, beaver, bobcat, mountain lion, and mule deer. No signs of mule deer were observed in the Brigham Young University studies of the area.

Twenty species of reptiles and amphibians were listed as having a range overlapping the Crystal Geyser area. Quantitative data indicate that the numbers of amphibians and reptiles are relatively low.

The endangered Colorado squawfish and humpback chub are reported in the literature to occur within the Green River. Also, the range of the endangered American peregrine falcon may extend into the project area but was not observed during this study.

Recreation at present consists mostly of tourist activities, sightseeing, boating down the Green River, picnicking and camping. Activities at the Crystal Geyser site itself are very limited. This is because of the inaccessibility to the site, lack of shade trees and other desirable facilities, and the infrequent eruptions of the geyser.

(9) Hydrology. - The Crystal Geyser discharges an estimated 150 acre-feet of water a year to the Colorado River. The water is not used directly as it discharges from the geyser due to its salinity, but is used in the lower Colorado River Basin following mixing with the Green and Colorado Rivers.

2. Other Control Units for Construction.

a. Paradox Valley Unit. -

Introduction. - The project area is located in the eastern portion of the Colorado Plateau physiographic province. This is a scenic and sparsely populated region topographically characterized by narrow mesas, broad plateaus, buttes, wide valleys bordered by steep cliffs, and deeply entrenched canyons and gorges. The most prominent features in the vicinity of the project are the La Sal Mountains, a domed uplift rising to elevations of over 12,000 feet to the northwest, and the Uncompahgre Plateau, a broad uplift of between 8500 and

10,000 feet in elevation to the northeast. The Dolores River enters Paradox Valley from a 50-mile stretch of narrow and deep canyon which twists its way through high mesas. Segments of the river, both upstream and downstream from Paradox Valley are being studied for possible inclusion in the National Wild and Scenic River System. That segment of the river 1 mile above Bedrock (fig. I-16), to the confluence of the San Miguel River has been excluded from the study by Congress.

Historical and archeological sites. - The brine well area along the Dolores River of the Paradox Valley Unit was examined by the Bureau of Reclamation archeologists for historical and archeological sites. No such sites were encountered in that part of the proposed project area. Archeologists from Fort Lewis College, Colo. (under contract with the Bureau of Reclamation), will continue to inventory the area prior to construction of the project in accordance with Executive Order 11593. If any cultural resources are located, the procedure contained in 36 CFR, parts 60, 63, and 800 will be followed.

Economics. - The most important agricultural product is beef cattle, and livestock feeds constitute the major crops. Some malting barley is grown as a cash crop.

A sawmill in the northwestern portion of the valley utilizes timber from the nearby La Sal Mountains and the Uncompahgre Plateau, but does not provide a large amount of employment. There are three privately owned brine wells near the Dolores River. The brine is used in the Union Carbide Corporation's uranium processing plant at Uravan and as a drilling fluid for oil exploration in the vicinity of the project. Although the mining industry provides some employment, most of the young people in the area are forced to find work elsewhere.

Land use/cultural factors. - Approximately 50 percent of the west Paradox watershed is privately owned, with the remainder under Federal jurisdiction. About 3,600 acres are presently irrigated with water supplies from West Paradox Creek, a tributary of the Dolores River, and from wells. A limited amount of storage is provided by the 1,600-acre-foot Buckeye Reservoir on the eastern slope of the La Sal Mountains.

The portion of Paradox Valley to the east of the Dolores River also contains both privately and publicly owned land. The use of the area is limited primarily to late winter and early spring grazing.

The drainage area of the West Fork of Dry Creek, where the proposed evaporation pond would be located, is largely under Federal jurisdiction and has not been developed. The area is used for a limited amount of late winter and early spring grazing. There are substantial acreages of privately owned land in the eastern portion of Dry Creek Basin. The State of Colorado owns a small amount of land on Dry Creek downstream from the project area.

Population distribution. - The project area is very sparsely populated and contains no incorporated towns. There are less than 100 people in Paradox Valley, including the small farming community of Paradox in the northwestern portion of the valley. There are no residents in the western portion of Dry Creek Basin, where the evaporation pond would be located. The town of Uravan, located on the San Miguel River to the immediate east of Paradox Valley, has a population of about 750 according to the 1970 census. The nearest trade centers are Moab, Utah, approximately 60 miles northwest of the valley, and Montrose, Colorado, about 70 miles to the northeast.

Climate. - The climate of the project area is characteristic of the semiarid southwestern United States, with low precipitation, high evaporation, strong spring winds, and wide variations in temperature. The average annual precipitation is from 12 to 16 inches in Dry Creek Basin and is slightly less in Paradox Valley. Much of this occurs during the summer, primarily from thunderstorms of brief duration.

Strong winds from the southwest are common throughout the spring and may extend into the summer. This, in combination with high summer temperatures, results in a pan evaporation rate of about 35 to 45 inches per year.

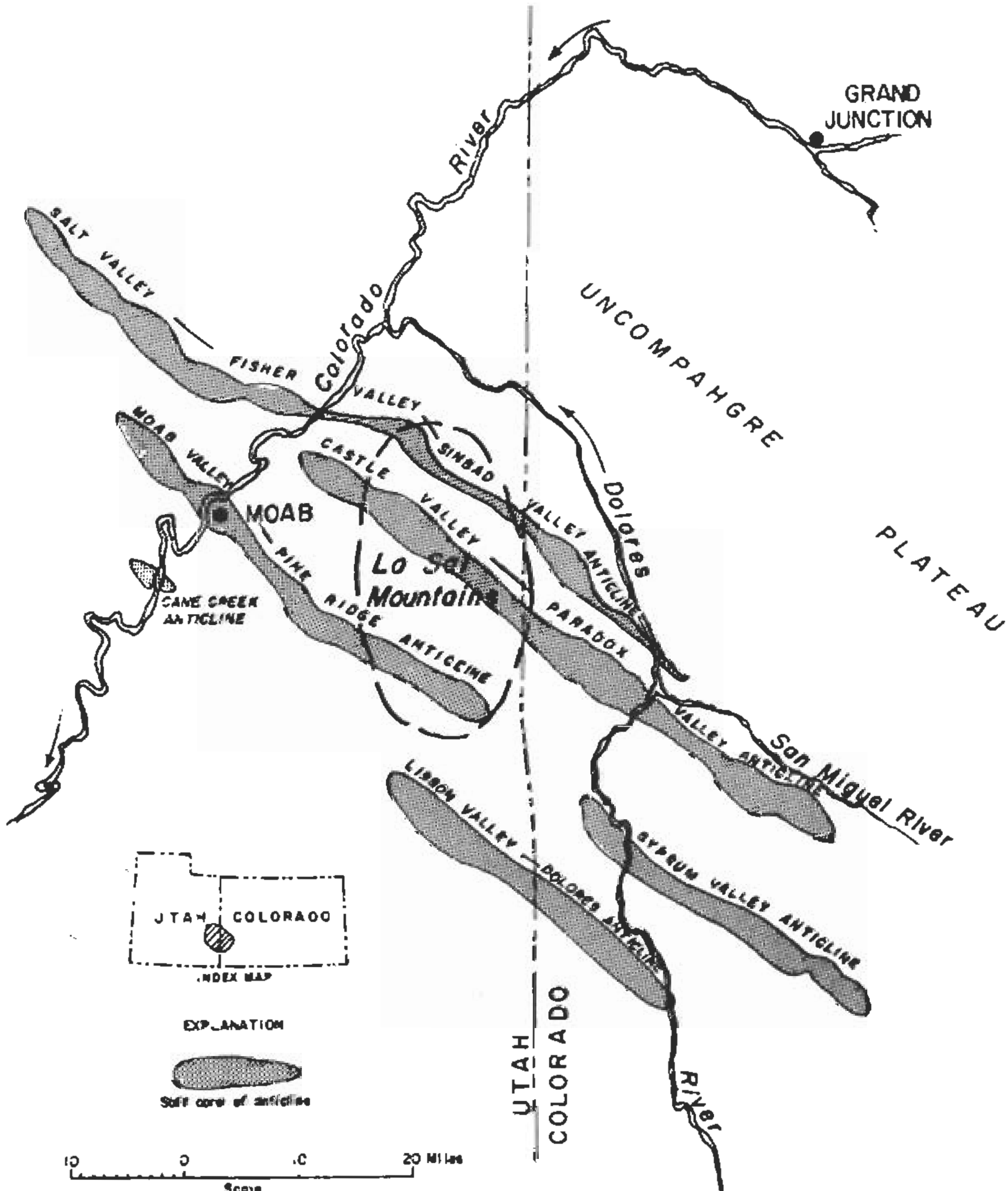
The nearest National Weather Service Climatological station with a long period of operation is located at Norwood, Colorado, about 25 miles east of the project area. The elevation of the station is about 7000 feet, compared to about 5000 feet along the Dolores River in Paradox Valley and 6300 feet at the evaporation pond site in Dry Creek Basin. During the 1942-1972 recording period, the average annual temperature at Norwood was approximately 44° F, with a July average of 66° F and a January average of 23° F.

Soils, topography, geology, and minerals. - The entire unit area lies within the Uravan Mineral Belt, a 200-mile-long region trending north-south in eastern Utah and western Colorado. The mining district has been extensively developed, primarily during the 1950's for carnotite, a yellow-colored mineral containing the radioactive elements vanadium, uranium, and radium. The ore is processed at Uravan, to the east of the project area. Although activity has declined substantially from the peak years, interest has recently been renewed as a result of a staged leasing program now being conducted by the Atomic Energy Commission (now the Energy Research and Development Administration). Active mines are located on the mesas around the periphery of Paradox Valley, and a few undeveloped claims have been found in Dry Creek Basin near the proposed site of the evaporation pond. There are also a large number of inactive mines throughout the general area.

Paradox Valley is one of five major collapsed salt anticlines (elongated swells) in southwestern Colorado and southeastern Utah (fig. II-14). The region is about 100 miles long and is marked by the extrusive mass of the La Sal Mountains perched prominently over its center. Paradox Valley, a northwest-southeast trending elliptical valley about 24 miles long and from 3 to 5 miles wide, lies in the southeast portion of the area along the axis of the largest anticline, and has been formed by the erosion of faulted and uplifted sandstone and shale formations. This has exposed a residual gypsum cap which covers about 14,000 feet of pure salt and salt-rich shale. The process is illustrated in figures II-15 and II-16. The emergence of mountainous uplifts on each side of the area has placed intense lateral pressures on the intervening sedimentary formations, resulting in faulting and fracturing along weak axial zones. Under these pressures and the weight of the overlying strata, a deeply buried layer of saline material has flowed upward into the faulted area to create an elongated swell known as an anticline. The Dolores River has remained in its original streambed during this time and, in combination with other erosional forces, has removed the collapsing upper materials to form the valley. These processes, which may have begun as much as 200,000,000 years ago, are still active.

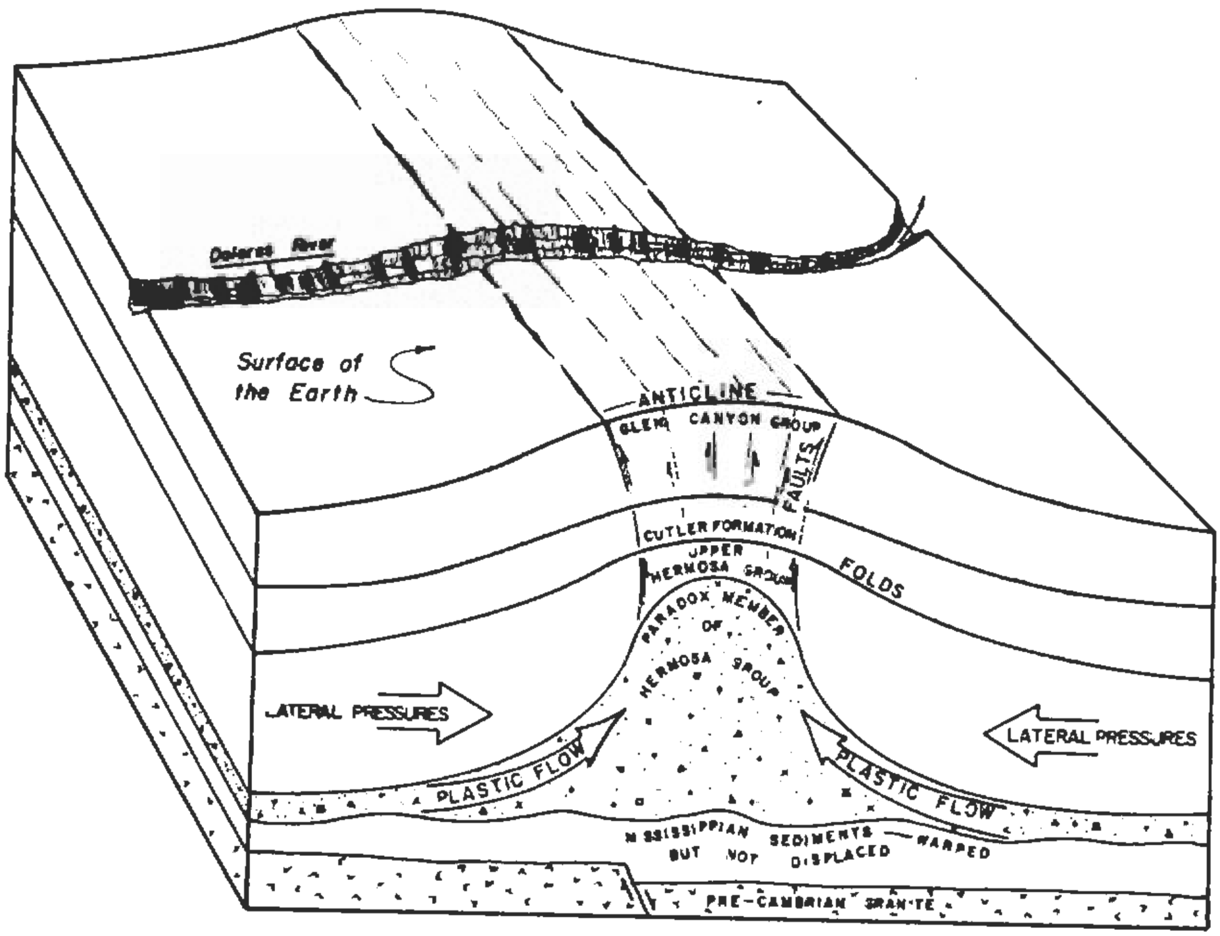
The floor of the valley is relatively flat and smooth, sloping gradually from both ends toward the Dolores River near the middle. In the southeastern half, the surface is broken by low outcrops of gypsum. The surrounding walls are nearly vertical and in some places rise nearly 1,500 feet above the floor, exposing brilliantly colored strata of sandstone and shale. Landslide materials and talus slopes are common along the bases of the slopes.

Dry Creek Basin, southeast of Paradox Valley is separated from the valley by high mesas which have developed from the



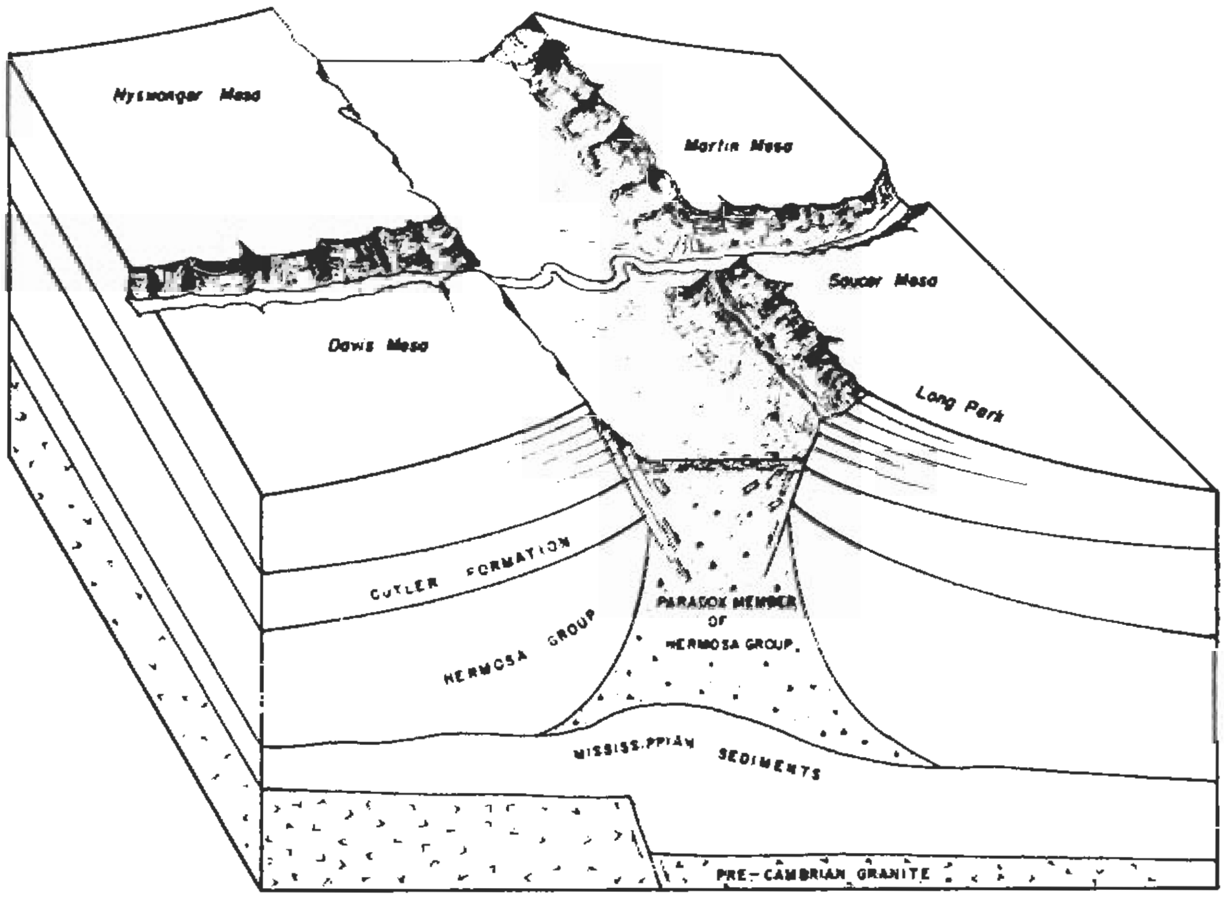
SALT ANTICLINE REGION
Colorado River Basin Salinity Control Project
Paradox Valley Unit, Colorado

Figure II-14



PARADOX ANTICLINE
EARLY STAGE OF DEVELOPMENT
Colorado River Basin Salinity Control Project
Paradox Valley Unit, Colorado

Figure II-15



PARADOX ANTICLINE
PRESENT STAGE OF DEVELOPMENT
Colorado River Basin Salinity Control Project
Paradox Valley Unit, Colorado

Figure II-16

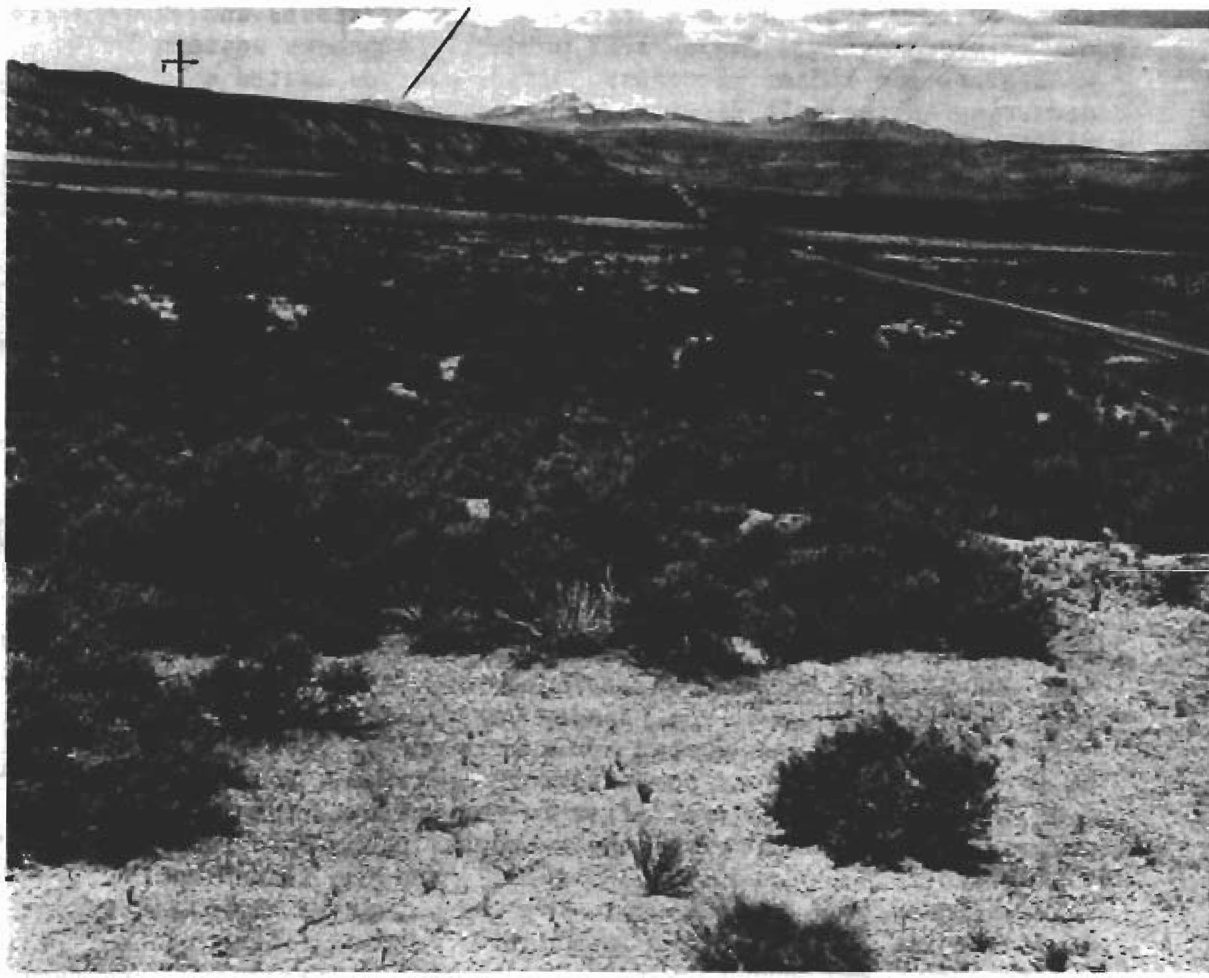
uplifted sedimentary flanks of the salt anticline. The West Fork of Dry Creek lies in a shallow structural syncline, or natural basin, with gently rolling slopes. Mancos Shale, a brackish and impervious marine formation, underlies most of the Basin and is frequently found in remnant form on the surface. The bedrock formation, consisting of Dakota Sandstone, is exposed around the edge of the Basin and dips sharply toward the center, disappearing under the shale. The area is topographically breached on the north side, where the West Fork flows through to join Dry Creek. Both of the streams are intermittent and lie within the drainage of the San Miguel River. The natural drainage into the evaporation pond site is limited to a watershed area of about 16,580 acres. Flows from 4,610 acres would be diverted around the site, leaving an effective drainage area of 11,970 acres.

There are two distinct groups of soil in the area. Reddish-brown soils characterize the long, gently sloping fans which form the periphery of the Basin. These are primarily alluvial, but have been modified to varying degrees by eolian deposition. Grayish soils are found in the center of the basin and have been derived from the underlying Mancos Shale bedrock.

Vegetation. - Native vegetation in the Unit area varies according to differences in soils, elevations, and moisture conditions. Based on appearance and vegetative composition, the area can be divided into five categories: (1) riparian vegetation along the Dolores River flood plain, (2) a typical salt desert community on the floor of Paradox Valley, (3) a foothills region that extends up to the top of the mesa, (4) a pinion-juniper woodland on the rocky ridges, and (5) intermixed sagebrush and grass in Dry Creek Basin.

In the area adjacent to the Dolores River, saltcedar dominates. Cottonwoods and willows make up the other portion of the apparent riparian overstory, while various salt grasses and bluegrass compose the understory. The growth is generally quite dense.

The salt desert community covers most of the eastern half of the valley and is dominated by shrubs, primarily sagebrush. A typical view is shown in figure II-17. The major shrub species found on loamy soils are bud sage, winterfat, shadscale, big sage, and small rabbitbrush. On clayey soils, mat saltbrush and Gardener saltbrush predominate. Grasses form the understory vegetation in this area. The major species are galleta, Salina wildrye, Indian ricegrass, needle-and-thread grass, thickspike wheatgrass, squirreltail grass, and Sandberg bluegrass.



Typical view of Paradox Valley land vegetation.

Figure II-17

The major forbs are globemallow, phlox, buckwheat, loco, and various asters. In gullied areas of the salt desert, alkali sacaton, galleta and sand dropseed are the primary grasses. The primary shrubs are big sage, fourwing saltbrush and a scattering of greasewood.

Big sagebrush dominates the low foothills of the valley. On loamy soil, this species is associated with snowberry, fringed and black sage, and bitterbrush. The major grasses on the loamy soils are slender-and-thick-spike wheatgrasses and native bluegrasses. Clayey soil primarily supports western wheatgrass and Indian ricegrass. Other grasses listed as occurring in the salt desert area are secondary in this region.

The ridges in the Unit area are dominated by pinion pine and juniper (fig. II-18). The lower limits of this area support an association of rabbitbrush and snakeweed, Indian ricegrass, blue-grama, galleta, and fleabane. Towards the upper elevation limits, mountain mahogany, sedge, serviceberry, and big sage shrubs become a midstory intermixed with the pinion-juniper. Indian ricegrass and muttongrass are the primary grasses.

In Dry Creek Basin, the vegetation consists of intermixed sagebrush and grass. Big sagebrush dominates, along with a few widely scattered juniper trees and greasewood shrubs The major grass species are blue-grama, needle-and-thread grass, and galleta.

Fish and wildlife/recreation. - The Dolores River in and immediately downstream from Paradox Valley is characterized by extremely low flows during the summer months as a result of irrigation diversions some distance upstream. Four species of fish have been identified in the valley: the red shiner (*Notropis lutrensis*), the roundtail chub (*Gila robusta*), the speckled dace (*Rhinichthys osculus*), and the flannelmouth sucker (*Catostomus latipinnis*). The red shiner is an introduced species, and the others are native to the Colorado River System. No endangered or threatened species have been identified in the project area.

The generally sparse vegetation of the area does not support large populations of wildlife, but there is a diversity of species present. Paradox Valley and Dry Creek Basin provide a limited amount of both summer and winter range for mule deer, the most abundant large animal in the area. A very small number of elk and antelope may inhabit the surrounding area. Prairie dogs are the most abundant small animals. There are

Typical view of Paradox Valley vegetation along ridge area.

Figure II-18

also jackrabbits, cottontail rabbits, and deer mice. The major predators, the coyote and bobcat, are primarily found in the higher elevations of the area.

Ring-necked pheasants are fairly abundant near the Dolores River and on the agricultural lands in the western portion of Paradox Valley. Sage grouse and mourning doves inhabit the entire area. Several birds of prey, including the golden eagle, the red-tailed hawk and the bald eagle, are known to inhabit or visit the area. Golden and bald eagles and other raptors are protected by Federal laws.

Ducks and geese winter on ponds in the flood plain of the Dolores River in Paradox Valley and feed on the farmlands to the west. There is also a permanent population of these species. The waterfowl include: redhead, ringneck duck, mallard duck, green-winged teal, shoveler, American coot, ruddy duck, bufflehead, and Canada goose.

Recreation in the Unit area is limited to those activities involving open space. Hunting, hiking, horseback riding, and camping constitute most of these activities. No major recreational area is present in the Unit area. Most of the recreational hours spent in the area are by local inhabitants. The major scenic attraction is the upper reach of the Dolores River which is under study for possible inclusion in the National Wild and Scenic River System.

An 8-mile reach between Gateway and the Colorado-Utah State line is potentially eligible and may be added to the National System at such time as the Utah portion of the river is included. Based on available knowledge of the Dolores Wild and Scenic River proposal, it appears the Paradox Valley salinity control unit will improve water quality for outdoor recreation in the downstream segments and not significantly affect streamflows.

Water supply and use. - Water in the Dolores River is used above Paradox Valley mainly for irrigation which depletes the stream in the late summer to almost no flow. When the Dolores Project is completed, the total annual runoff will also be reduced. Present flows from the saline springs or seeps are not used directly but are diluted by flows of the Dolores, San Miguel, and Colorado Rivers.

Water quality conditions. - The average annual salinity of the Dolores River is about 273 mg/l as it enters the valley and about 775 mg/l as it leaves. These values are based on the total volume of water passing through the valley. The average daily salinity (not taking into account the volume of water) is about 660 mg/l at the entrance to the valley and 10,090 mg/l at the exit. Some of this water is pumped from the river and used for irrigation in the lower valley. A few residents of the valley near the river obtain water of adequate quality from wells. In the northwestern portion of the area, domestic and irrigation supplies of adequate quality are obtained from Buckeye Reservoir, wells, and springs.

The future environment without the proposed action. - The environmental quality of Paradox Valley and Dry Creek Basin would probably remain in its present condition without the project. With the exception of the fluctuating mining conditions, which should not be affected with or without the project, the status of development in the area has not changed much in the past and would probably not do so in the foreseeable future.

The influx of salt in Paradox Valley would continue to affect the quality of water in the Dolores and Colorado Rivers. Increasing salinity levels in the Lower Colorado Basin could cause increased economic damages as the Upper Basin States develop their compact-apportioned water supplies.

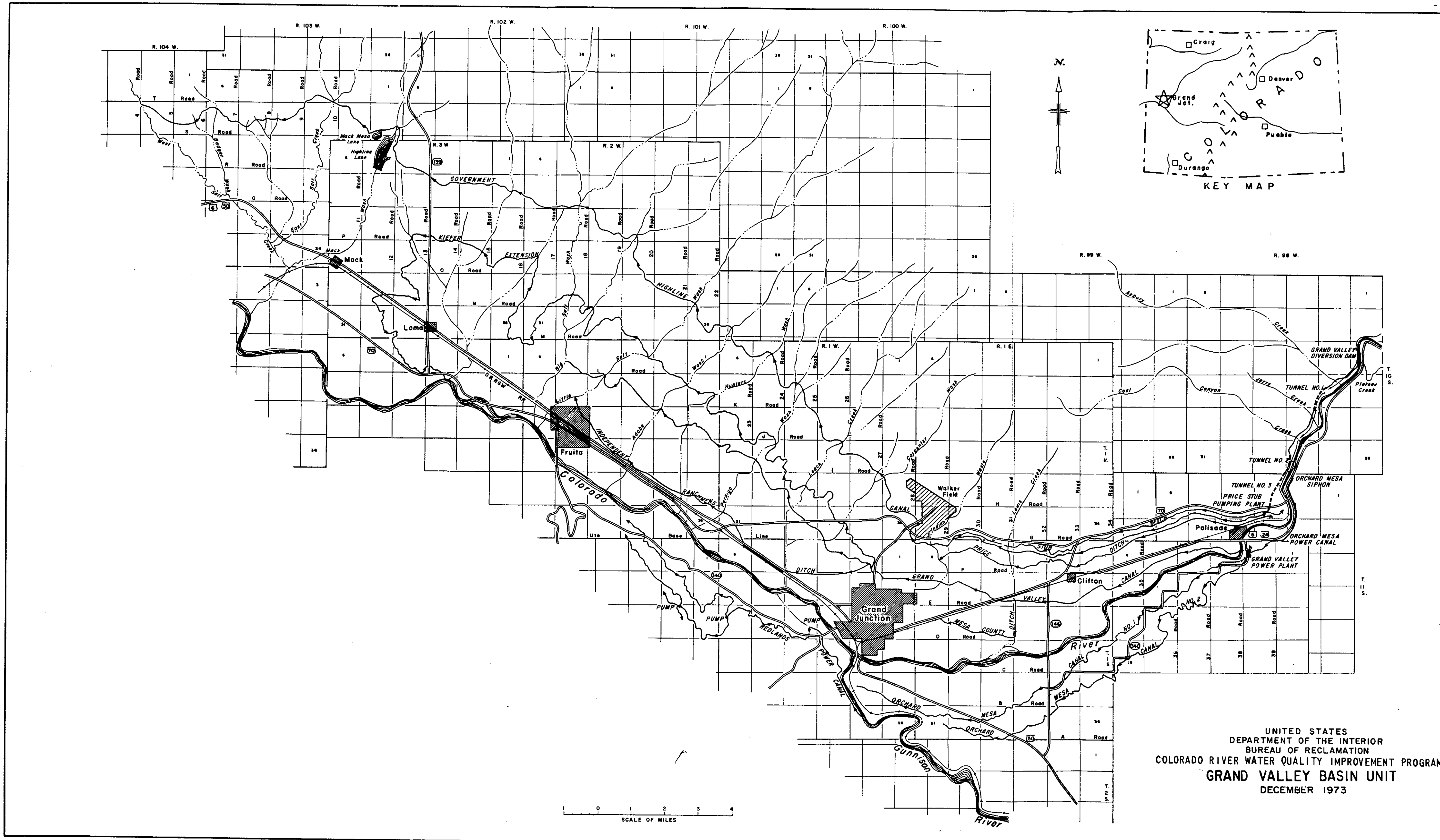
b. Grand Valley Unit. -

Introduction. - The Grand Valley Unit is located in the Grand Valley in west-central Colorado. The valley, located in Mesa County, is the site of the confluence of the Colorado and Gunnison Rivers. Interstate Highway No. 70 and Federal Highways No. 6 and 50 traverse the valley, and there are networks of paved and graveled county roads throughout the irrigated portion of the valley. The Denver and Rio Grande Western Railroad connects the area with major east and west markets, and a modern airport in the valley is served by two major airlines. The city of Grand Junction is located in the valley and is the industrial and commercial center of western Colorado. The town of Palisade is located at the upper end of the valley while the small communities of Loma and Mack are located at the lower end. The town of Fruita is located between Grand Junction and Loma. Figure II-19 is a general view of the valley showing project lands. Figure II-20 is a general map of the area.

Historical and archeological sites. - The Grand Valley was first settled in 1881 and settlers began work on ditches to irrigate low lands adjacent to the Colorado River. By 1886, the Grand Valley Canal was completed and the canal system

Aerial view looking west over Grand Valley Basin Unit project lands.

Figure II-19



Grand Valley Project area map.

Figure II-20

expanded to serve approximately 45,000 acres of land. Later, irrigation developments expanded this acreage. The area will be evaluated by an archeologist or other appropriate professional who will make a determination in consultation with the appropriate State Historic Preservation Officer regarding the property's eligibility for inclusion in the National Register of Historic Places. Should the property be determined eligible for inclusion in the National Register of Historic Places, the Bureau of Reclamation will follow the procedure outlined in 36 CFR 800. The National Register of Historic Places does not list any sites for the Grand Valley area. In general, farming activity and urban development throughout the project area precludes any surface indications of archeological sites in the irrigated area.

Economics. - Irrigated agriculture is the primary industry of the project area generating gross crop values of about $12,000,000 per year. The area is also located on an important tourist circuit. Grand Junction supplies most of the retail services required by the tourist trade. The following tabulation lists the number of people employed in the various industries.

Mesa County Work Force
1972

	Number	Percent
Total civilian work force	22,480	100
Unemployed	1,050	4.7
Total employed	21,430	95.3
Agriculture	1,940	8.6
Mining	370	1.7
Contract construction	1,140	5.1
Manufacturing	1,960	8.7
Transportation and utilities	1,330	5.9
Wholesale and retail trade	4,530	20.0
Finance, insurance, and real estate	510	2.3
Services	3,200	14.2
Government	4,190	18.7
All other	2,260	10.1

Source: Colorado Division of Employment

Land use/cultural factors. - Cultural factors and land use have historically been tied to farming operations and irrigation development. Early businesses and services were oriented around the needs of agriculture, and while these needs are still present, industries and services catering to social and tourist requirements have become prevalent. Grand Junction has become the education center for western Colorado. The following tabulation summarizes the use of land in the Grand Valley area.

Land Use Survey - 1973

Classification	Total acres
Irrigated cropland	57,492
Farmsteads	2,470
Suburbs/residential	2,836
Urban	7,707
Stockyards	816
Industrial	725
Natural ponds	3,806
Phreatophytes	20,344
Other	25,936
Total acres:	122,132

In the eastern end of the valley (where the valley is narrow) orchards are the dominant crop. In the center of the valley in the proximity of Grand Junction, where most of the people live on small unit farms and either work in Grand Junction or nearby, the land is primarily pasture and/or alfalfa. Finally, in the western end of the valley due to the shorter growing season, deeper soils, and fairly good drainage, the land is almost exclusively used for corn, alfalfa and sugar beets as money crops. From the 1973 Bureau of Reclamation survey, it would appear that about 25 percent of the available irrigable acreage in the valley has become unproductive. This is due to a combination of several factors such as high water table, encroachment of homes, roads, and urban areas, and conversion of irrigated lands to other uses such as pasture.

Population distribution. - Mesa County, in which the Grand Valley is located, has an estimated July 1972 population of 56,300. This figure represents an increase of 3.5 percent over the official 1970 census and an 11 percent increase above the 1960 census. The bulk of the county's population, some 54,000 people, live in the Grand Valley within the confines of the unit area.

The census Bureau has defined six census county divisions in or near the area. These are the Clifton, Fruita, Grand Junction, Orchard Mesa, Palisade, and Redlands divisions. Present populations of these divisions and projected population of cities therein are summarized in the tabulation on the following page.[16][17]

Climate. - The climate of the Grand Valley is generally described as semiarid with annual precipitation averaging around 8 inches. Growing season varies throughout the valley, averaging 191 days in the city of Grand Junction near the center of the valley. Temperatures in the summer months reach a maximum of around 100° F and a minimum of about 60° F. Winters are cold with only light snowfall. About one-third of the winters have no readings below zero. The Grand Valley is ringed by mountains and due to this protective topography sudden and severe weather changes are infrequent.

Soils, topography, geology and minerals. - The Grand Valley is a broad, northwest-southeast trending valley about 12 miles wide and 35 miles long. The valley has been formed where the Colorado River cuts across the Uncompahgre Arch. The Grand Valley proper is underlain entirely by highly saline Mancos Formation which is easily eroded and forms low-relief topography. All of the irrigated lands are underlain by the Mancos Formation except for a small area at the southwest corner of the valley known as the Redlands, which is formed on sandstone and shale of the Morrison, Burro Canyon, and Dakota Formations. Low, rolling hills and broad expanses of gently sloping alluvium dominate the topography within the valley. A series of intermittent washes and gulches, each trending southwest into the Colorado River, drain the valley. These drainages are generally incised 10 to 30 feet into the alluvium or shale; examples are Lewis Wash, Leach Creek, Big Salt Wash, and Badger Wash. The alluvium within the valley is mostly heavy clay soil derived from Mancos Formation and is generally shallow in depth. Plateaus, precipitous cliffs, and mountains up to elevations of 10,000 feet ring the valley and are a sharp

Grand Valley Census Tabulation[17]

	Past and present			Projections		
	1960	1970	Percent change	1980	1990	2000
Mesa County	50,715	54,374	7.2	60,000	80,000	100,000
Clifton Division	1,935	3,554	83.7			
Fruita Division	4,934	5,837	18.3			
Grand Junction Division	18,684	28,527	52.6			
Orchard Mesa Division	6,481	6,890	6.3			
Palisade Division	2,757	1,964	-28.8			
Redlands Division	2,741	4,446	62.2			
Fruita	1,830	1,822	-0.4	2,100	2,200	2,500
Grand Junction	18,694	20,170	7.9	25,951	28,546	31,400
Palisade	860	874	1.6	1,500	2,500	4,000

contrast to flat-lying valley floor. It is estimated that 30 percent of the presently available acreage of the Grand Valley is affected by high water tables.

Drainage problems are generally the result of the low permeability of the Mancos Formation and soils. The surface of the Mancos Formation is uneven and undulating. Underground dams or pockets are formed that restrict water movement and allow the accumulation of underground water. This water accumulation contributes to high water tables in certain areas. The low permeability of the soils also impedes the movement of water sufficiently to hinder the natural subsurface drainage.

The buildup of ground water is accompanied by an increase in salts within the soil profile. Many of these areas are clearly evident by a white encrustation of salts on the soil surface. These salty zones are detrimental to crop growth in the valley.

Mineral deposits are scarce in the Grand Valley proper compared to many nearby areas.[18] In contrast to the large producing area southwest of the Uncompahgre Plateau, no commercial deposits of uranium or vanadium have been found in the Grand Valley or immediately adjacent to the valley. Coal mines are operating at the east end of the area. Sand and gravel suitable for concrete aggregate and other uses is presently being obtained from several pits along the Colorado and Gunnison Rivers, and rather extensive deposits occur along these river channels and on adjacent stream terraces. Tests for oil or gas have been unsuccessful in the southern part of the valley, but commercial production of gas is occurring to the north along the base of the Book Cliffs.

Vegetation. - A flora and fauna field study of the Grand Valley Salinity Control Unit has recently been completed.[1] This study points out that major vegetation changes have taken place in the Grand Valley in the last century. Prior to irrigation developments around the turn of the century, the native vegetation of the Grand Valley Salinity Control Unit was composed primarily of the desert shrub communities and of the river-floodplain woodlands dominated by stands of cottonwood trees. Three desert shrub communities existed: the shadscale-desert

1 Ecology Consultants Inc. 1976. Final Report on Flora and Terrestrial Vertebrate Studies of the Grand Valley Unit. Fort Collins, Colo. 469 pp.

grassland community, the Nuttall saltbush community, and the black greasewood community. The river-floodplain woodlands along the Gunnison and Colorado Rivers were a sharp contrast to the desert shrub communities. Cottonwood trees were the dominant species in this woodland and were essentially limited to bands and groves along the rivers where favorable moisture conditions developed.

Irrigation development has changed the plant composition throughout the Grand Valley Salinity Control Unit by artificially providing additional moisture which has enabled the local ranges of certain plant species to be extended and certain exotic species to become well established. Plant cover has increased markedly.

The portion of the Grand Valley included in the flora and fauna study contains approximately 175,000 acres and includes all of the irrigated area plus a zone of surrounding nonirrigated lands. Approximately 80,000 acres of this area are in natural vegetation. The following table contains a breakdown of the seven vegetation types that make up the 80,000 acres.

Vegetation type	Average	Percent of total valley acreage
Greasewood	8,068	4.6
Sagebrush-saltbrush	13,822	7.9
Saltbush	46,348	26.5
Cottonwood	1,558	0.9
Tamarisk	5,008	2.9
Pinon-juniper	4,504	2.6
Marsh	722	0.4
Total	88,030	45.8

Vegetation is continually being manipulated in the Grand Valley Salinity Control Unit. Ditchbanks, road ditches, and fence rows are often cleared in rural areas to facilitate farming or canal and lateral operations. Drainage programs reduce water tables in localized areas to improve crop production and thus modify the habitat of phreatophytes. In some areas increasing soil salinity favors salt tolerant species while the rising water table encourages the establishment of phreatophytic shrub species in some areas. Construction of new homes and industries also continually encroaches onto farmland. The scouring effect of the Colorado River has been reduced by upstream impoundments and diversions and shore areas, once annually scoured clean, are becoming permanently vegetated with saltcedar, willows, and other phreatophytes.

Fish and wildlife. - Eight major habitat types have been identified in the Grand Valley: desert shrub, pinon-juniper woodland, phreatophytic shrub, river woodland, marsh, aquatic, agricultural, and residential. The animal life of the Grand Valley adapted to these habitat types consists of a mixture of native and introduced species.

There are approximately 60,000 acres of desert shrub habitat in the study area. It occurs primarily in areas immediately adjacent to irrigated lands and in isolated patches throughout the valley. The habitat provides limited food and cover and water may be a critical factor to some species. Representative wildlife species that live in this habitat include antelope, coyotes, deer mice, whitetail antelope, ground squirrels, cottontail rabbits, lark sparrows, mourning doves, and burrowing owls.

The pinon-juniper woodland habitat occurs on approximately 4,500 acres, generally south of the Colorado River and above the valley's irrigation system. Representative species of this habitat include the mule deer, coyote, whitetail antelope, ground squirrel, cottontail rabbit, Bewick's wren, and the chipping sparrow.

The phreatophytic shrub habitat includes subtypes of tamarisk, greasewood, and Russian olive. It occurs along all washes and in waste areas within agricultural areas. There are approximately 10,800 acres of this habitat type in the valley and it represents one of the most valuable types for wildlife. A small resident herd of mule deer utilizes this habitat along the larger washes in the valley. Other representative species include the cottontail, coyote, raccoon, harvest mouse, rock squirrel, pheasant, Gambel's quail, mourning dove, warbling vireo, yellow warbler, and Brewer's sparrow.

The river woodland habitat is dominated by mixtures of Rio Grande cottonwoods, tamarisk, and skunkbush sumac; and it is represented by less than 3,900 acres along the Colorado and Gunnison Rivers. Studies in other areas of the west and southwest have demonstrated the importance of this habitat type to wildlife. Along with the phreatophytic shrub, it is probably the most important wildlife habitat in the valley. The valley's small resident deer herd utilizes this habitat type. Other representative species include the raccoon, beaver, gray fox, rock squirrel, dove, Gambel's quail, bald eagle, red-tailed hawk, western tanager, lark sparrow, and white crowned sparrow.

The marsh habitat in the valley includes approximately 700 acres scattered across the valley. A major portion of this type results from seepage areas along the canals. Plants such as cattails, bulrushes, reeds, and willows grow in these areas. Muskrat, skunks, long-tailed voles, pheasants, rails, redwinged bladkbirds, and other species utilize this habitat type.

The aquatic habitat type makes up approximately 3,800 acres in the valley and includes major canals in addition to ponds, rivers, and larger washes. This habitat type is valuable to species such as muskrats and mink. It provides watering areas for deer, antelope, and other animals. The waterfowl and water birds in the valley are very dependent on this habitat type.

The Colorado and Lower Gunnison Rivers in the project area are considered warmwater streams from a fishery standpoint. Fish present include a few native species and numerous introduced species. The more common species present include the roundtail chub, speckled dace, fathead minnow, redfin shiner, sand shiner, carp, flannelmouth sucker, bluehead sucker, white sucker, channel catfish, black bullhead large-mouth bass, and the green sunfish. The Colorado River squawfish and the humpback chub, which are endangered species according to the Fish and Wildlife Service, occur in or near the project area; and the humpback sucker, which is an endangered species according to the State of Colorado, is found in the project area.

The agricultural habitat type is the most extensive type in the valley and includes roughly 80,000 acres of crops such as hay, orchards, sugar beets, and corn and also includes farmyards and field edges. The major variability in the value of this habitat to wildlife is related to two factors - type of crop and distribution of "waste" areas.

The distribution of ditches, field edges, and canal banks provide valuable cover for wildlife. Muskrats, raccoons, and various mice utilize this habitat type. Orchards provide valuable nesting, feeding, and roosting areas for birds. Pheasant, doves, geese, and ducks utilize the agricultural habitat for feeding.

The "residential" habitat in the valley includes the towns and suburbs and makes up approximately 13,600 acres in the valley. Wildlife in this type are adapted to areas of high human activities, and this habitat is generally not considered of high value to wildlife although some species such as the rock dove, mourning dove, and other birds are well suited to it.

Recreation. - Small game and waterfowl hunting is popular in the valley, although there is little public land open to hunting. Drainage programs, burning and clearing of fence rows and ditchbanks, urban and rural development, highway construction, and other factors are constantly reducing wildlife habitat in the valley and thus restricting hunting.

Fishing is limited in the project area. The Colorado and Gunnison Rivers have sport fishing potential but are not used extensively.

Transcontinental U.S. Highways No. 6, 24, and 50 and Interstate No. 70 pass through the area, and the transient recreation population is high. The project area is not typically the final destination of tourists, but motels, restaurants, and other tourist facilities flourish. The Colorado National Monument, of national significance, is located just west of Grand Junction.

At present, all the incorporated communities in the Grand Valley maintain their own parks. Highline State Recreation Area near Loma provides swimming, boating, picnicking, bird watching, and other activities and is of regional significance. The Colorado Division of Wildlife has also established the Walker Wildlife Area between Grand Junction and Fruita as a wildlife refuge.

According to the Colorado Outdoor Recreation Plan,[20] additional facilities are presently needed in Mesa County for swimming, boating, hunting, picnicking, golf, tennis, group camping, skiing, and skating. Open space, park, and recreation areas will be needed in the growth areas.

There appears to be no adverse impacts of this project on the Colorado Wild and Scenic River study area downstream or on a proposed 12-mile greenbelt park (Colorado River Park) along the Colorado and Gunnison Rivers in the immediate vicinity of Grand Junction.

From the project area, the Book Cliffs, Colorado National Monument, Grand Mesa, and the Uncompahgre Plateau provide a scenic backdrop. Irrigated croplands, orchards, and associated phreatophytes provide a contrast to the semiarid, sparsely vegetated lands above the canal systems. Riparian vegetation along the Gunnison and Colorado Rivers has been greatly altered by man's activities but still provides a greenbelt through the project area. Urban and county sprawl, erosion, loss of crop and orchard lands to other uses, road construction, and use of riverbanks for junkyards and other uses are all factors diminishing the esthetic values of the project area.

Small game hunting opportunities will probably decrease due to land use changes and land closures. There is a possibility that a greenbelt park along the major river systems may be established.

Water quality. - In general, there is a degradation of the quality of the Colorado River water as it moves through the Grand Valley. This degradation is due primarily to two factors: salt loading and salt concentration. Salt concentration is caused primarily by the removal of water by consumptive use of irrigated crops and phreatophytes. Salt loading occurs as excessive deep percolation from onfarm irrigation practices and seepage losses from canals and laterals. This seepage water then dissolves minerals and carries them in solution to the river by an underground route. Of the two, salt loading is the primary cause of water quality degradation through the Grand Valley.

Several figures have been presented for the magnitude of salt loading ranging from 5 to 8 tons of salt per irrigated acre per year. Special studies indicate certain portions of the valley may contribute as much as 12 tons per acre per year. A figure of 600,000 tons per year or about 8.5 tons per acre per year seems consistent with available data on outflows from the major washes and drains.

The total dissolved solids in the washes and drains in the Grand Valley are much higher than in the diverted irrigation water due to degradation in quality of the surface return flows and the poor quality of ground-water inflows. The average dissolved solids content of the drains and washes is about 2,800 mg/l, and may range form over 9,000 mg/l in some drains to less than 1,000 mg/l in other drains, depending upon the time of year. The concentrations are lowest in the summer months due to the dilution effect of system wastes and large return flows, and highest during the winter months due to the poor quality of ground water which comprises most of the remaining base flow.

Other contributions of dissolved solids to the Colorado River in the Grand Valley include the discharge of municipal and industrial wastes. In the period 1965-66, two sewage treatment plants were contributing approximately 16 tons per day, and the American Gilsonite plant near Fruita was adding about

9 tons of salt per day to the river. Population in the valley has increased since then and has, no doubt, affected the sewage treatment facilities.

Water supply and use. - Most investigators feel that ground-water inflow from outside the irrigated area in the Grand Valley is extremely small. First, the low average annual precipitation is not enough to recharge a significant ground-water reservoir. The small tributaries that head in the Book Cliffs and flow across the valley are mostly dry washes and provide little water to maintain a ground-water reservoir. The few tributaries that drain the Uncompahgre uplift are deeply incised in rocks of the Glen Canyon group, some having eroded into the Precambrian complex. Very little ground water is contributed to these streams; therefore, most likely little ground water from this area is contributed directly to the alluvial aquifers in the valley. Recharge to the shallow aquifers by irrigation practices is by far the most important source of ground water in the Grand Valley.

3. Authorized Feasibility Studies

a. Point source control studies. -

(1) LaVerkin Springs Unit, Utah. -

Introduction. - The project area lies within the Virgin River Basin of southwestern Utah, a scenic area of extremely varied and frequently spectacular natural beauty. The river follows along the southern rim of the Markagunt Plateau in Utah, flows through Zion National Park in its route across the southwest corner of the State, crosses the northwest corner of Arizona, and discharges into Lake Mead in southeastern Nevada having traversed approximately 200 miles. In Zion National Park, the actions of the river and other natural forces have carved deep gorges and rugged massive erosional forms in multicolored layers of sandstone, forming a colorful recreation attraction. To the west of the park and crossing the project area is the Hurricane Fault Escarpment, a dominant structural feature marking the western boundary of the high Colorado Plateau region. This feature begins to the north near Beaver, Utah, and extends south for a distance of some 225 miles, crossing the Virgin River near Hurricane. The area has experienced other geologic displacements and comparatively recent volcanic activity. Lava flows and volcanic cones are salient aspects of the region.

Historical and archeological. - The lands surrounding the project area have been developed primarily for irrigated agriculture. The original settlement, which began in about 1852, was accomplished by Mormon pioneers with the objective of raising cotton and grapes. Due to the mild climate and the cultivation of cotton, the area was consequently referred to as Utah's "Dixie." St. George, the largest town in the area and the seat of Washington County, was established in 1861.

Farms were originally located in valley bottom lands adjacent to streams. Irrigation was accomplished with simple canal systems and diversion dams. The development of the higher benchlands, such as the LaVerkin and Hurricane areas, was more difficult and occurred at later dates. These areas were less accessible, and more elaborate diversion and canal systems were required. The LaVerkin Canal was not constructed until 1906, the Hurricane Canal was constructed soon after. Both of these facilities were built by hand in extremely difficult terrain along canyon walls.

Some of the finest examples of Utah's pioneer heritage are reflected in stories of such local men as Jacob Hamblin, and in the architecture of the St. George Temple and other churches, homes, and buildings throughout the area. Many historic monuments have been erected as reminders of the past. Other historic landmarks include those left by nature such as the Hurricane Fault Ridge, the Virgin River Gorge, and Zion National Park.

Archeological and historic sites have been investigated by the University of Utah under contract with the National Park Service.[22] They found no sites that would be affected by the proposed LaVerkin Springs project.

Economics. - Agriculture, consisting of range livestock, and irrigated farming has historically been the most important enterprise in the area. However, in recent years there has been a transition from an agricultural economy to one dominated by trades, public administration, tourism, and private services. Food processing firms, including bakeries, locker plants, and bottling plants are located in St. George and Hurricane. Also located in St. George is the Dixie Junior College. This accredited institution has an annual enrollment of about 1,200 students and makes a significant contribution to the economy of the area.

In recent years the trend in manufacturing has been toward the shipment of a large percentage of goods and materials by truck. With the completion of the interstate highway system through Utah, Nevada, Arizona, and California, the accessibility of Washington County by truckline to metropolitan area market places has been improved to such an extent that it is highly probable that light manufacturing operations will be expanded in the County.

The area is strategically located on an important tourist circuit with connecting roads to all of the National Parks and recreation areas of southern Utah, as well as to points north, east, and south. As a result, there has been a steady increase in the amount of income derived from the tourist business and related transportation and service industries. A substantial portion of the County labor force is employed during the summer months by businesses catering to tourists.

Land use aspects. - The major types of land use are livestock grazing and irrigation. The presently irrigated acreage is principally served from surface diversions of streams. Adjacent lands are primarily undeveloped desert which have only limited value for livestock grazing. A considerable amount of feed for livestock is obtained from irrigated pastures and forage crops, but by far the larger amount of livestock feed in the general Dixie area is obtained from privately owned range, National Forests and public domain lands. The mountainous sections surrounding the project area provide summer grazing and the lower desert areas provide winter grazing.

The second largest commitment of land use is for recreation. Due to the multiple-use concept of State and Federal agencies, our National Forests and public domain lands are often utilized at the same time for both grazing and recreation. An increasing amount of agricultural lands are being used for retirement and leisure villages.

Population distribution. - The destribution of the area population is shown in the following tabulation:

POPULATION DISTRIBUTION - WASHINGTON COUNTY, UTAH
Colorado River Water Quality Improvement Program
Point Source Division, LaVerkin Springs Unit, Utah

Community	1970	Age group	1970
Bloomington	94	0 to 4	1,338
Central	32	5 to 14	3,054
Enterprise	844	15 to 19	1,522
Hilldale	480	20 to 24	1,296
Hurricane	1,408	25 to 44	2,432
LaVerkin	463	45 to 64	2,297
Leeds	151	65 and over	1,680
New Harmony	78		
Springdale	172		
Toquerville	185		
Virgin	119		
Ivins	137		
St. George	7,097		
Santa Clara	271		
Washington	750		
Other areas	1,388		
Total	13,669		13,669

Climate. - The climate of the project area is characterized by a small amount of precipitation, an abundance of sunshine, short mild winters, long hot summers, low relative humidity, high evaporation rates, flash flooding, high erosion, and wide extremes in daily temperatures. The mean annual precipitation in the highest parts of the Virgin River drainage basin is about 25 to 30 inches. Runoff from these high elevation areas provides the majority of the water used for irrigation.

The climatological data summarized in the following tabulation are based on 26 years of records of the National Weather Service Station at St. George. This station has the longest period of record, starting in 1888, and is considered fairly representative of the project area. The average annual precipitation of 7.74 inches occurs mostly as rainfall with 3.52 inches of this amount occurring during the growing season. The average frost-free period is 213 days and the growing season averages 242 days.

SUMMARY OF CLIMATOLOGICAL DATA
National Weather Service Station[1]
Colorado River Water Quality Improvement Program
Point Source Division, LaVerkin Springs Unit, Utah

Elevation of station	2,760 feet
Precipitation[2]	
Mean annual	7.74 inches
April through October (frost-free period)	3.52 inches
Temperature[2]	
Mean annual average	61.2°
Maximum of record	116°
Minimum of record	-11°
Average frost-free period	213 days

[1] Temperature station established in 1888 and the precipitation station was established in 1890.
[2] Study period 1940-1965.

Soils, topography, geology, and minerals. -

Soils. - The soils of the project area are derived from sedimentary rocks of Jurassic and Triassic ages. They principally occur in three physiographic divisions. These are: (1) alluvial flood plain soils along the major rivers, (2) soils of the bench areas which are principally alluvial in origin, but have some colluvial and eolian influence, and (3) alluvial and eolian materials along the major tributary drainageways of the Virgin River. All these soils have developed under arid conditions and are primarily Aridisols, Entisols, or Mollisols may also be present. Analytical tests show the soils are low in soluble salts. Exchangeable sodium is low. Gypsum and lime are present but not in sufficient amounts to be deleterious to plant growth.

Topography. - The topography through most of the area is controlled by the tilted and warped underlying strata. Combined erosion, crustal deformation, faulting, and volcanic flows have formed many steep-sided buttes, hogbacks, and flat-topped benches. The benches have been dissected by streams, which have formed narrow valleys and vertical-walled canyons.

The headwaters of the Virgin River begin 35 to 40 miles east of LaVerkin Springs at elevations of from 7,000 to 10,000 feet. The North Fork of the Virgin River flows through spectacular Zion Canyon National Park. The general direction of the drainages is to the southwest.

Geology. - Aside from volcanic cinder cones and associated lava flows, most of the formations in the area are sedimentary rocks of Mesozoic age. They are generally highly fractured, jointed, and folded. The most prominent structural feature being the Hurricane Fault.

The Hurricane Fault zone is approximately 225 miles long, extending from central Utah to northwestern Arizona. The fault marks the boundary separating the Colorado Plateau physiographic province to the east from the Basin and Range physiographic province to the west. The fault has formed nearly vertical cliffs about 1,000 to 1,400 feet high at the Virgin River. In the vicinity of the project the total stratigraphic displacement is about 5,000 feet, with the downthrown block on the west side. The LaVerkin Springs occur in the fault zone where it intersects with the Virgin River. These are the only known thermal springs associated with the fault.

Due to the magnitude of the Hurricane fault, and recent movements in the area, a zone 3 ground-motion classification was assumed for the studies in the LaVerkin Springs area. Zone 3 indicates areas of potential major damage and corresponds to VIII or more on the Modified Mercalli scale.

Minerals. - Gold, silver, lead, copper, coal, and iron have all been found within the county. During the early 1870's, several million dollars worth of silver were taken from the Silver Reef mining district. Due to a reduction in ore quality and the lack of adequate transportation, the business was abandoned.

A preliminary search has shown that there are no known mineral deposits near any of the features of the LaVerkin Springs Project.

Vegetation. - The vegetation is characteristic of much of the arid southwest and consists primarily of the desert brush type. Some of the plants commonly found are creosote bush, desert almond, blackbrush, rabbit-brush, juniper, and yucca. Willows, saltcedars, and cottonwood trees grow along streams and ditches (see figs. II-21 and II-22). A study of vegetal communities and their life support functions will be made for the project area. The data obtained will be included in the environmental statement for LaVerkin Springs.

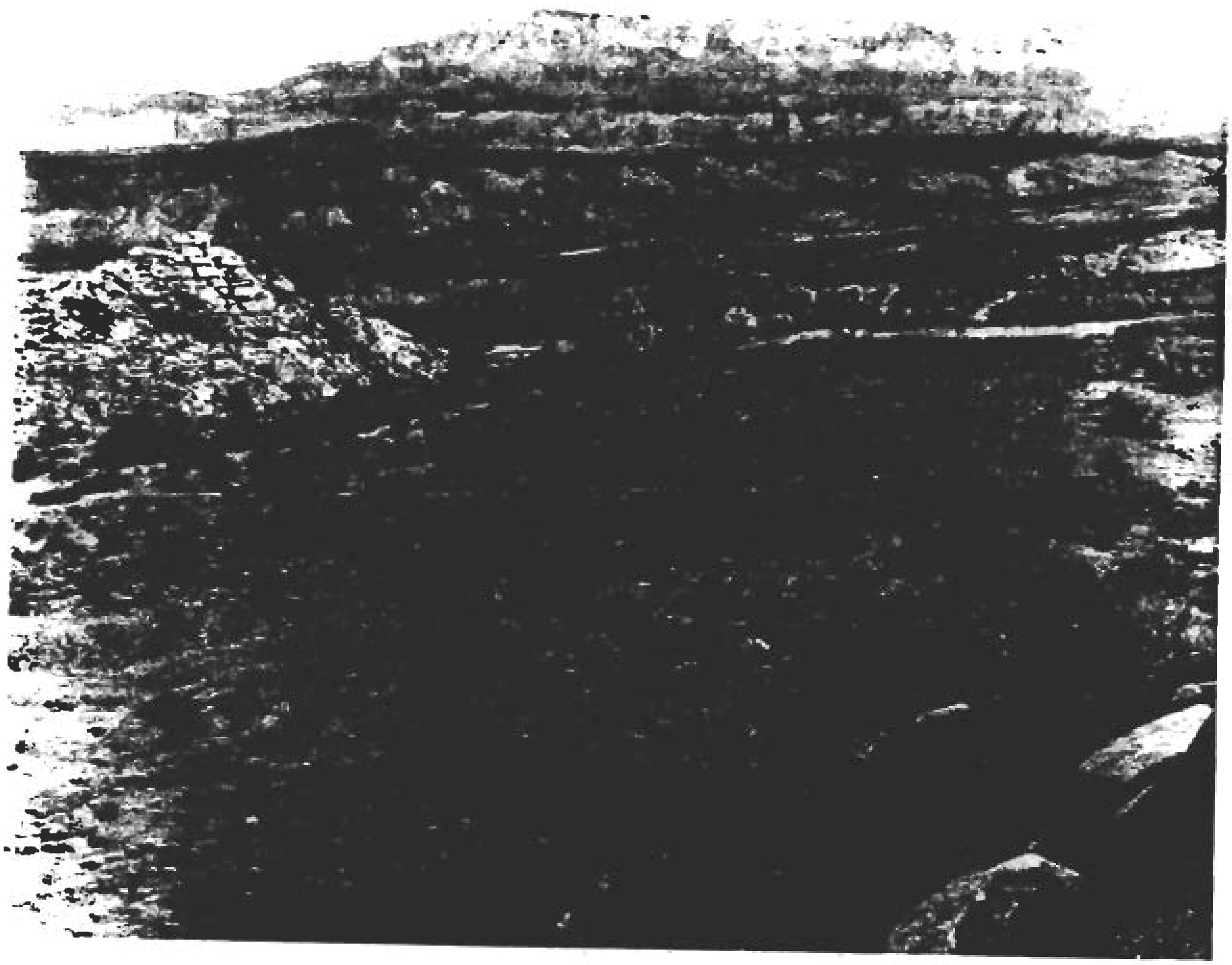
Fish and wildlife/recreation. -

Fish. - Sport fishing in the waters of the project area is of minor significance. The Virgin River is subject to extreme fluctuation and is often laden with silt. Within the area of the project the Virgin River does not support a viable fishery.

The Virgin River from LaVerkin Springs to Lake Mead is the only known habitat of the woundfin (*Plagopterus argentissimus*), an endangered species, with the most abundant population from LaVerkin Springs to Littlefield, Arizona. Other unique species include Virgin River spinedace (*Lepidomeda m. mollispinis*), Virgin River Bonytail (*Gila elegans*), the bluehead mountain sucker (*Pantosteus clarki delphenus*), and the flannelmouth sucker (*Catostomus latapinnis*). The effects of the project on the endangered woundfin are being determined by the U.S. Fish and Wildlife Service through a contract with the University of Nevada, Las Vegas.

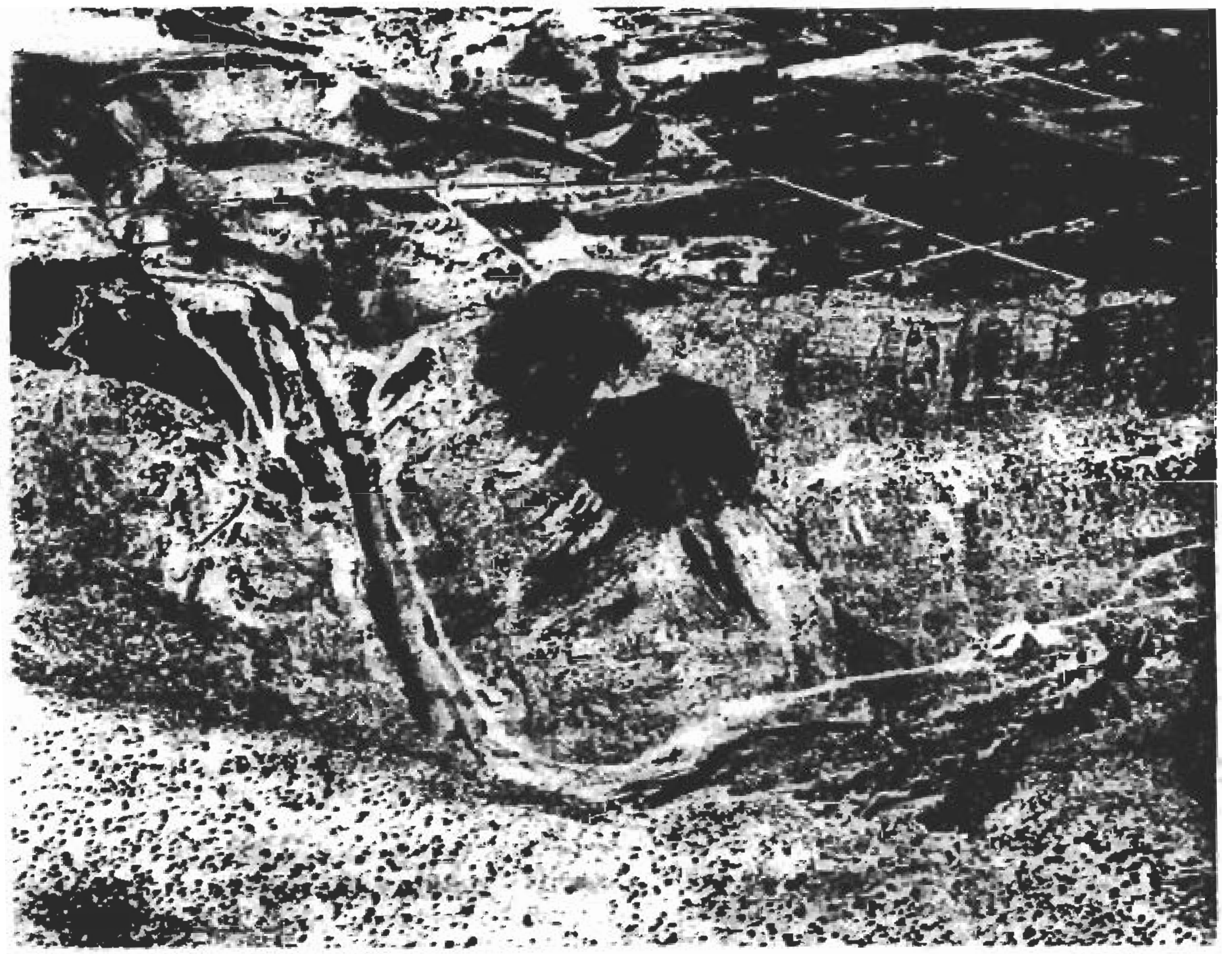
Wildlife. - The animal life of the area is characteristic of the desert Southwest and includes Gambel's quail, mourning doves, ringnecked pheasants, coyotes, rabbits, kangaroo rats, mice, and various species of snakes and lizards. Mule deer occur in the surrounding mountains. Canadian geese and several species of ducks inhabit the Virgin River area and utilize the agricultural lands as feeding grounds during the winter months. These waterfowl provide about 800 man-days of hunting annually. The hunting of upland game consisting of quail, mourning doves, cottontail rabbits, and pheasants amounts to about 5,300 man-days annually.[23] A study of wildlife will be made for the project area and the data included in the Unit Environmental Statement.

Recreation. - Recreational activities center in and around the National Parks, National Forests, areas of



Phreatophyte growth along the Virgin River below LaVerkin Springs

Figure II-22



View of LaVerkin Springs area.

Figure II-21

public domain, and State Parks in approximately that order of importance. Access roads into these areas join U.S. Highway No. 91 (Interstate Highway No. 15) within the Dixie area. Because of this, thousands of tourists, of necessity, travel through portions of the project area in making a circuit of Grand Canyon, Zion and Bryce Canyon National Parks, and Cedar Breaks National Monument. These scenic areas, together with Grand Canyon National Monument, Hoover Dam, Lake Mead National Recreation Area, and the Glen Canyon National Recreation Area, form a natural circuit for the touring public. The project is not expected to affect the recreation activities of the area.

Excellent deer hunting sites in National Forests and wooded areas of public domain to the north bring hundreds of deer hunters through the project area.

(2) Littlefield Springs Unit, Arizona. -

Introduction. - The Littlefield Springs Unit lies within the Virgin Valley of the Virgin River in northwestern Arizona. The springs are a group of thermal saline springs which rise in the desert area near Littlefield, Arizona, and discharge into the Virgin River.

From the mouth of "The Narrows," the Virgin River sluggishly flows in a wide bed of shifting sand, through the Virgin Valley and to Lake Mead near Overton, Nevada. The river valley varies in width from several hundred feet to more than a mile and is bounded abruptly on both sides by high mesa and benchlands lying several hundred feet above the river. Irrigation has been primarily restricted to the lower valley areas where water is more accessible. Arable lands are located on the mesa and bench areas in the vicinity of Mesquite and Littlefield.

Beaver Dam Wash, a tributary to the Virgin River, begins in Nevada and flows about 50 miles in a southerly course to its confluence with the Virgin River about 1 mile above Littlefield. The Wash is intermittent through most of its length, with certain reaches fed by perennial springs. Flows from Beaver Dam Wash and springs provide a good quality water supply for domestic and irrigation purposes. Most of the irrigated lands along the Wash lie upstream about 2 miles from the Virgin River. Several freshwater springs are found near the mouth of the Wash and across the river from the Littlefield Springs.

LaVerkin Springs are located about 62 river miles above the Littlefield Springs. The relationship, if any, between these springs is not known at the present time.

The principal communities in the vicinity are Littlefield, Arizona, and Mesquite and Bunkerville, Nevada. St. George, Utah, the largest community in the area, is located about 28 miles upstream from the Littlefield Springs.

Historical and archeological. - Settlement of the Virgin Valley followed the establishment of a wagon trail called the "Mormon Road." In 1847, Jefferson Hunt traveled through the Virgin Valley area on his way to Salt Lake City, Utah, after being discharged from the "Mormon" Battalion. In 1848 he journeyed to Calfornia by the same route and returned to Salt Lake City with a wagon loaded with seeds and plantings. This was, apparently, the beginning of the "Mormon Road."

Colonization of the Virgin Valley began in 1854 when the Mormon pioneers settled in small agricultural communities along the Virgin River near Santa Clara, Utah. Settlement in the Littlefield area first occurred in the fall of 1864 when Henry W. Miller led a small band of Mormons to the Beaver Dam Wash about 1 mile upstream from its confluence with the Virgin River. A large flash flood occurred at the close of 1867 which devastated the village and drove the settlers out. Settlement of the communities of Mesquite, Bunkerville, Riverside, Logandale, Overton, and St. Thomas, which were all located along the Virgin River or its tributary the Muddy River, occurred between 1865 and 1868. In 1878, John T. Graff, Christian Stucki, and Henry Frehner with their families settled at the present site of Littlefield. The history of the area is one of hardship, privation, and desperate struggles against floods and droughts. Development of these agriculture-oriented communities was possible only by intense cooperative community effort. Prior to 1920, the area was isolated from markets and large population centers by rough terrain and poor transportation facilities. The principal source of income was from livestock grazing on the open range. With improved highways and transportation facilities, the trend toward the growing of vegetables, nuts, fruits, and seeds has occurred; however, forage crops to support the livestock industry are still prominant.

Very little is known of the archeological resources in the Littlefield area or in the Virgin Valley. An archeological and historical assessment of the area will be made in coordination with the State historical preservation officer to assess National Register potential during the course of the investigations. In the event that cultural property is found and evaluated to be eligible for inclusion in the National Register of Historic Places, the Bureau of Reclamation will follow the procedure outlined in 36 CFR 800.

Economics. - Agriculture has, historically, provided the primary means of income. The modernization of farming has brought about a gradual change to fewer and larger farms. Employment opportunities are provided on the farms, various construction projects, schools, and the service industries required for community and tourist business.

The Virgin Valley area provides the only services available to tourists between the metropolitan center of Las Vegas, Nevada, about 85 miles to the southwest, and St. George, Utah, about 28 miles to the northeast. Consequently, services catering to the needs of tourists and other travelers contribute significantly to the economy of the area.

Land use aspects. - Land use is primarily governed by the agricultural industry of the area which includes range for livestock, dairying, and irrigated farming. The area has been significantly influenced by the deep, abiding religious faith of the founders and their determination to succeed despite obstacles and hardships. These characteristics have continued and as a result the area has had a continuous but modest growth in population and agriculture. Modern truck transportation and marketing practices have aided the communities and provided an outlet for their agricultural products.

The mild climate and rural atmosphere has proven attractive to many people, and in recent years there has been an increase in retired people living in the Virgin Valley area.

Population distribution. - The Virgin Valley is a productive farming area situated along the Virgin River in the northwesterly part of Mohave County, Arizona, and the northeasterly portion of Clark County, Nevada. The Valley provides a home for three small communities. The estimated 1970 populations of these unincorporated towns follow: Littlefield, Arizona, about 220; Mesquite, Nevada, about

750; and Bunkerville, Nevada, about 250. These communities lie along Interstate Highway No. 15.

Climate. - The arid climate of the Littlefield area is typical of the Mojave Desert. It is characterized by low humidity, high evaporation, abundant sunshine, mild winters, hot dry summer, and a wide fluctuation of daily and seasonal temperatures. In the summer and early fall, local thunderstorms and cloudbursts cause flash floods with rapid runoff and severe erosion. Strong winds reach the Valley from the southwest. The mean annual precipitation recorded at the National Weather Service station at Beaver Dam, Arizona, for the 7 years of record (1967-1973), was 6.45 inches, which occurs mostly as rainfall during the winter months. The mean annual temperature based on 5 years of record at the Beaver Dam temperature station is 65° F, with a January average of 43° F and a July average of 90° F. Summers are typically "desert" with maximum daily temperatures usually above 100° F, while winter temperatures sometimes fall to about 10° F. The frost-free period averages about 240 days.

Soils, topography, geology, and minerals. -

Soils. - The soils of the area have formed in alluvial deposits along the river flood plain, and are favorable for agricultural development. Suitable agricultural soils are also found along adjacent bench areas.

Topography. - The vertical-walled canyon known as "The Narrows" of the Virgin River forms the boundary between the Beaver Dam Mountains to the north and the Virgin River Mountains to the south. The river channel passes through "The Narrows" emerging from the canyon onto the low desert plains near Littlefield and thence follows a southwesterly course through the Virgin Valley in Nevada, finally discharging into Lake Mead.

South and east of the river in the vicinity of the Littlefield Springs the topography is formed by a piedmont slope extending out from the Virgin Mountains. The slope of the land is typically concave with steep slopes near the mountains, becoming flatter toward the river. In common with this type of terrain, the drainage pattern is poorly developed which is typical of this type of terrain. There are well-defined channels where canyons debouch on the piedmont, but these channels vanish a short distance downslope. The pervious sands and gravel forming the piedmont permit the rapid infiltration of all except the heaviest storms. When the infiltration rate is exceeded, runoff occurs as sheet flow down the slopes.

North of the river, the land is more broken with flat mesas and deeply incised drainage valleys. One of the main washes draining from the north is Beaver Dam Wash which enters the Virgin River just upstream from the Interstate Highway No. 15 bridge. This is an exceptionally large wash which heads in the Beaver Dam Mountains. Although the Wash is normally dry, it has a well-developed underflow that surfaces about one-half mile above its junction with the river. As a result, it is a perennial stream at its mouth.

Geology. - The Beaver Dam Mountains and the Virgin River Mountains are roughly alined north-south and southwest. They occur along the boundary between the Colorado Plateau and Basin and Range physiographic provinces. Both ranges are composed predominantly of faulted blocks of Paleozoic strata. The strata consist predominantly of limestone and the entire sequence ranges in age from Cambrian to Permian. Much of the limestone is cavernous. The Cambrian granite gneiss and schist are exposed in the Beaver Dam Mountains. The two mountain ranges are separated by the spectacular Virgin River Canyon. The faulted and cavernous strata are well exposed in the canyon floor and walls. In this reach, low flows of the river disappear beneath the course alluvial bed only to reappear near the mouth of the canyon.

Minerals. - There is some history of mining in the Virgin Mountains primarily involving beryllium, copper, and mica in the Cabin Canyon area, none of which has been commercially successful.

Vegetation. - The vegetation is characteristic of much of the arid southwest and consists primarily of the desert brush type. Some of the plants commonly found are creosote bush, desert almond, blackbrush, rabbitbrush, juniper, and yucca. Willows, saltcedar, and cottonwood trees grow along streams and ditches.

Fish and wildlife/recreation. - The animal life of the area is characteristic of the desert Southwest and includes

Gambel's quail, mourning doves, ringnecked pheasants, coyotes, rabbits, kangaroo rats, mice, and various species of snakes and lizards. Mule deer occur in the surrounding mountains. Canadian geese and several species of ducks inhabit the Virgin River area and utilize the agricultural lands as feeding grounds during the winter months. There are no data on the population densities of the various animals in the different areas of the proposed project. A wildlife inventory of the area will be made before commencement of the project.

Little information is available on the invertebrates (aquatic or terrestrial) and amphibians in the area. There are no known species of rare or endangered animals in the vicinity of the proposed project. However, the Virgin River from LaVerkin Springs to Lake Mead is the only known habitat of the woundfin (*Plagopterus argentissmus*), an endangered species of fish, with the most abundant population from LaVerkin Springs to Littlefield, Arizona. Other unique species include Virgin River spinedace (*Lepidomeda m. mollispinis*), Virgin River bonytail (*Gila elegans*), the bluehead mountain sucker (*Pantosteus clarki delphenus*), and the flannelmouth sucker (*Catostomus latapinnis*). The affects of the project on the endangered woundfin are being determined by the U.S. Fish and Wildlife Service.

No major recreation facilities exist in the area. The nearby desert provides some opportunity for off-road vehicles and horseback riding while the nearby mountains do offer some hiking opportunity.

(3) Glenwood-Dotsero Springs. -

Introduction. - The Glenwood and Dotsero Springs are a combination of thermal springs and ground-water inflows that discharge into the Colorado River between the mouths of the Roaring Fork and the Eagle Rivers in Garfield and Eagle Counties, Colorado. The locations of the springs are shown on the map in figure I-35. The springs are accessible from U.S. Highways No. 6 and 24 and Interstate Highway No. 70.

Some of the springs at Glenwood Springs have been developed commercially. The swimming pools shown in the center of the aerial photograph (fig. II-23) of Glenwood Springs are fed by thermal springs. The flows are collected for

Aerial view looking downstream along the Colorado River showing a portion of the town of Glenwood Springs. Hot saline springs are found intermittently along the edges of the river. The large swimming pool near the center of the photograph uses one of the springs for year-round recreation.

Figure II-23

distribution to swimming pools and the discharge piped into the river. The Dotsero Springs show less indication of manmade modifications although railroad and highway construction and small scale modification for bathing and recreation have affected these springs also. Springs issue on both sides of the river and within its bed. Some are inundated by the snowmelt spring flows of the Colorado River.

Historical and archeological sites. - A survey of historical and archeological resources associated with the Glenwood-Dotsero Springs Project features has not been conducted. Prior to the arrival of the white man, the Glenwood Springs were utilized by the Ute Indians. Both the hot springs at Glenwood Springs and those at Dotsero have been modified by man's activities. The Glenwood Springs have been developed commercially and disrupted by highway development. Those at Dotsero have been encroached on by the railroad and highway and several have been developed in the past, although they are not used to any known extent at this time.

Historic sites known to exist in the proposed project area include "Doc" Holiday's grave at Glenwood Springs; the Shoshone Dam (constructed in 1905 for hydroelectric power production) in Glenwood Canyon; and the Siloam Hot Springs (Dotsero) which were once developed for commercial purposes.

Economics. - The economy of the surrounding area is based on recreation, tourism and agriculture. Commercial recreational use of natural warm springs at Glenwood Springs has been an economic asset to the area for many years. The Dotsero Springs are little known and probably of little direct economic benefit.

Population. - Although Dotsero Springs is located in Eagle County, most project features and impacts will be located in Garfield County which includes the city of Glenwood Springs. Garfield County experienced a 23.3 percent growth between 1960 and 1970 and Glenwood Springs increased by 12.9 percent. The county (1970) population, 14,821[62] and Glenwood Springs (1970) population, 4,106 are still growing. This growth is taking place primarily along U.S. Highways No. 6, 24, and 70 to the west and State Highway No. 82 to the south of Glenwood Springs due to the limited space available within the city itself. Outmigration of post high school youth and immigration of retirement age individuals as a result of limited employment opportunities and recreational attractions seems to characterize the area.

With a labor force of 7,229 in the area in 1970, the importance of recreation-related employment seems to be a part of the two highest employment sectors. Services and miscellaneous account for 23.4 percent, while retail trade (19.1 percent) is second. Contract construction (11.8 percent) and agriculture (10.3 percent) are close third and fourth categories. Transportation utilities make up 7.2 percent employment while mining contributes to 5.1 percent.

The yearly average unemployment as of 1974 was 3.8 percent. This figure, however, is highly-seasonal.

Climate. - The elevation at Glenwood Springs of about 5700 feet and the latitude results in a cool climate and a moderate rate of winter snowfall and summer rain.

Topography, geology, and minerals. - Geologically, the spring area is located at the southeastern edge of the extensive White River uplift. The Glenwood and Dotsero Springs are situated at opposite ends of Glenwood Canyon which has been created by the Colorado River eroding through very resistant rocks of the uplift. Many faults have been mapped in the area and may be related to the springs in the subsurface. The topography of both Glenwood Springs and Dotsero is composed of rather narrow canyons.

The thermal springs generally issue through the gravel along the river, traveling to the surface through underlying bedrock. Generally, the springs seem to be found in areas where the cavernous Leadville Limestone outcrops, but other formations are also involved. It is also of significance that the Paradox Formation is found in the vicinity of both Dotsero and Glenwood Springs areas. Chemical analyses of the water from the springs show large amounts of both sodium chloride and calcium sulfate, and the Paradox Formation contains beds of these minerals in the form of halite and gypsum.

Evidence of volcanism, as recent as the Pleistocene age, occurs in the area and suggests the possibility that hot intrusive bodies may be present in the subsurface. An extinct cinder cone and lava flow are found about 5 miles east of the Dotsero Springs and other similar evidence exists.

In summary, only very generalized geologic data is available on the Glenwood and Dotsero Springs and an extensive exploration program would be necessary to delineate the geology and hydrology. It is possible to hypothesize that ground water in the area travels along faults or related fracture zones, dissolves out salts principally from the Paradox Formation, becomes heated by deep-lying intrusive bodies, and returns to the surface as warm, saline springs.

Vegetation. - The natural vegetation in the area consists principally of juniper, pinyon pine, and big sagebush around Glenwood Springs and on drier sites around the Dotsero Springs. Where moisture conditions are more favorable, serviceberry, Gamble oak, and Douglas fir are more important. Figure II-23 shows the general types of vegetation along the river.

Fish and wildlife/recreation. - Wildlife habitats in the Glenwood-Dotsero Springs area include cropland, riparian areas, aquatic habitats, and the mountain brush habitat. The photograph, Figure II-24 is an aerial view of the Dotsero Springs area along the Colorado River. The entrance to Glenwood Canyon can be seen in the upper right.

In addition to the developed springs and swimming pool at Glenwood other smaller springs have or are being used for recreation purposes. Other recreation activities in the area include skiing, fishing, camping, boating, hunting, and hiking. Glenwood Canyon between the Glenwood and Dotsero Springs area is famous for its scenery and is at present a controversial alternative route for a proposed section of Interstate Highway No. 70. The area is transversed by many winter and summer tourists and also serves as a major commercial highway and railroad corridor.

b. Irrigation sources control. -

(1) Palo Verde Irrigation District Unit, California. -

Historical and archeological. - Settlement and growth of the Palo Verde area has closely allied the obtaining of water rights under California Law. Development in the

Aerial view of the Dotsero Springs area along the Colorado River.

Figure II-24

area occurred as early as 1856, but was limited because of the shortage of available water. In 1877, California initiated its water right program. The first Notice of Appropriation was issued to Thomas Blythe, who had filed for 95,000 miner's inches (about 2,375 ft^3/s) to be used on an area of 186,150 acres in the Palo Verde Valley and on the Palo Verde Mesa. From 1877 to 1911, seven additional appropriations were made for the area. These appropriations were supplemental to the first notice that was dated July 17, 1877. The lands served by these water rights are within the boundaries of the present Palo Verde Irrigation District.

To consolidate the functions of the predecessor interests, the Palo Verde Irrigation District was organized under a Special Act of the California Legislature (Calfornia Stat. 1923, Ch. 452, p. 1067). By this Act, the management, assets, irrigation works, and water rights were transferred, purchased, and assigned to the new District by operation of the Law. Under California Law the Palo Verde Irrigation District is an agency of the State of California, formed and existing for Governmental purposes. (California Water Code 20570).

Prior to the Construction of Hoover Dam, development in the lower Colorado River Basin, particularly in California, was hampered by periodic floods and occasional periods of low flow in the river. It was apparent that further development would neccessitate the control and storage of these periodic floods. The seven Colorado River Basin States reached a decision to formulate an interstate compact. This proposal was authorized by Congress in 1921 (42 Stat. 171), and resulted in the 1922 (Santa Fe) Compact, which was signed November 24, 1922.

After the Compact was approved, several bills were introduced in Congress seeking the construction of a storage reservoir and an "All-American Canal." In December 1928, the Boulder Canyon Project Act was approved by Congress and signed on June 25, 1929, by President Hoover.

After the Project Act became effective, the Secretary of the Interior requested that the State of California, Division of Water Resources, make a recommendation to the Secreatry of the proper apportionments of the water of and from the Colorado River to which California may be entitled. Pursuant to said request on August 18, 1931, the California Seven Party Water Agreement was adopted.

Under this agreement, the Palo Verde Irrigation District agreed to limit the acreage under its 1877 through 1911 appropriations to a total of 120,500 acres. The District was then recognized as having the "first priority" in California for 104,500 acres in the Palo Verde Valley, and an equal share in the "third priority" for 16,000 acres in that area known as the "Lower Palo Verde Mesa," which is adjacent to the Palo Verde Irrigation District. Archeological resources of the area have either been recovered or destroyed with the expanding agriculture industry. Since the Palo Verde Unit will involve only those areas that are already developed, no additional archeological research will be made.

Economics. - The economy of the Palo Verde Valley is primarily centered around irrigated agriculture. In 1972, there were 91,400 acres of land being irrigated or prepared for crops, including the large parcels that are presently being leased to large agricultural firms. Of this total cultivated area, about 5,000 acres were located on the mesa to the west of the valley. The crops grown in the District include alfalfa, cotton, wheat, melons, and lettuce. The value of these crops in 1972 was $21,989,000. The industry of the area is also allied with the needs of agriculture consisting of sales and service industries, cattle feedlots, and an alfalfa dehydrature plant. In recent years, there has been an increase in water-oriented recreation activities such as boating, water-skiing, and fishing on the Palo Verde Drain. Services and facilities to provide for these recreational needs have also enhanced the economy of the area.

Land use aspects. - Palo Verde Irrigation District is a highly developed, intensively cultivated irrigated agricultural area. Crops are planted and harvested during every month of the year. Winter vegetables, melons, citrus, and field crops including alfalfa, small grains, and cotton are grown.

Landownership is held by both individuals and corporations. Ownerships of 40, 80, 160, and 320 acre tracts are common, but most agricultural operations are large consisting of 1,000- to 3,000-acre units managed by large agricultural corporations. Land is often rented or leased for a specific crop. Winter lettuce is frequently grown on land leased for a specified number of days. Each year thousands of sheep are transported from considerable distances to utilize winter pastures in the valley.

Population distribution. - The Palo Verde Irrigation District is located along the Colorado River primarily in Riverside and Imperial Counties, California. Blythe, the largest city within the District, has a 1970 population of 7,047. The remainder of the Palo Verde Valley has a 1970 population of about 5,203, which includes 1,252 in the community of East Blythe, but does not include the few inhabitants that live in Imperial County.

Climate. - The climate in the area is hot and dry, with precipitation averaging less than 4 inches annually. Most of the rainfall occurs in the form of summer thunderstorms. The maximum summer temperatures range between 115° and 125° F. The summers are long and the winters are short and very mild, with an almost complete absence of freezing temperatures.

Topography, geology, and minerals. - The Palo Verde area consists of roughly parallel mountains separated by an alluvial basin. Palo Verde Valley is comprised of sediments that were deposited in the flood plain of the Colorado River. The flood plain is only 3 miles wide at Palo Verde Dam and increases to about 9 miles in the Palo Verde Valley. The elevation of the flood plain at Blythe is 265 feet above sea level.

The mountains, although not very high, are rugged, and rise abruptly from the alluvial slopes. The highest summit in the area is more than 3,000 feet above the flood plain and about 3,350 feet above sea level. Most of the other mountain crests in the area are below 3,000 feet in elevation.

Between the flood plain and the mountains are dissected piedmont or alluvial slopes. In many places the piedmont slopes terminate in terraces bordering the flood plain. Although some prospecting has taken place in past years, there are no known producing mineral claims in the immediate area of the unit.

Vegetation. - The natural vegetation found within the area includes greasewood, mesquite, creosote bush, paloverde, saltcedar, and various species of cacti associated with the Sonoran Desert. These vegetation types remain in those areas that have not been used for the production of irrigated crops.

Arizona State University is currently typemapping the vegetation along the lower Colorado River from Davis Dam to the International Boundary.

Fish and wildlife/recreation. -

Fish. - Historically, there were only seven species of fish reported in the lower Colorado River. However, at the present time, there are about 55 species existing in the water of the Lower Colorado River below Davis Dam. The native Colorado squawfish (*Ptychocheilus lucius*), is on the Secretary of the Interior's list of endangered fauna, May 1974. It has not been found downstream from Hoover Dam in recent years. The humpback sucker (*Xyrauchen texanus*), has been reported in the vicinity of Lake Moovalya, above Headgate Rock Diversion Dam and in the vicinity of Walter's Camp. Other species of fish found within the Lake Moovalya area above Headgate Rock Dam include the largemouth bass, bluegill, redear sunfish, channel catfish, black crappie, yellow bullhead, threadfinshad, carp, fathead minnows, plains minnows, and golden shiners. These have all been introduced into the lake, mostly for sport or bait. It is assumed that some of these species have found their way downriver into the unit area.

Arizona State University, U.S. Fish and Wildlife Service, Arizona Game and Fish Department, and California Fish and Game Department are currently studying fish species density of lower Colorado River from Davis Dam to the International Boundary.

Wildlife. - The Lower Colorado River from Davis Dam to the Mexican Border provides some of the best and most varied wildlife habitat within the southwest. About 276 species of birds, 40 species of mammals, and 50 species of reptiles have been identified along the lower river below Davis Dam. The Lower Colorado River is a major factor in the viability of the Pacific Flyway, for it is used as a breeding, feeding, and a resting area for migratory waterfowl.

Many species of birds summer in the area, nesting and raising their young before migrating farther south during the winter. Others winter in the area and then migrate north during the summer. Other species that migrate to points farther north or south use the area as a stopover for resting and feeding.

The water fowl that are commonly found above Headgate Rock Diversion Dam, but are assumed to also be present in the Palo Verde area, include the mallard, pintail, shoveler, green-winged teal, cinnamon teal, gadwell, wigeon, goldeneye, ruddy duck, Canada goose, and American coot. These species of waterfowl are most numerous during the winter months following the hunting season.

Wading birds include the great blue heron, black-crowned night heron, snowy egret, and American egret. Also a number of shore, marsh, and pelagic birds have been observed and include white pelican, pied-billed grebe, double-breasted cormorant, common gallinule, Virginia rail, and Sonora rail, and the endangered Yuma Clapper rail. Songbirds, insectivorous birds, hawks, and swallows are also common.

Mammals occasionally sighted in the area include gray fox, kit fox, coyote, bobcat, ringtail cat, raccoon, blacktail jackrabbit, desert cottontail, muskrat, beaver, and infrequently, a mule deer. Small mammals include rodents such as rats, mice, and shrews.

A list of both fish and wildlife species present in both Parker and Palo Verde Valleys will be made when the Bureau of Reclamation completes a study presently being made to determine what species are found in the various reaches of the Colorado River below Headgate Rock Diversion Dam. The species study data will be presented in the unit detailed environmental statement which will follow this statement.

Recreation. - Recreation in the Palo Verde area consists of hunting game birds and aquatic activities on the lower reach of the Palo Verde Outfall Drain. Aquatic recreation, consisting mostly of waterskiing, boating, and boat racing attract numerous people from the metropolitan areas of southern California.

Arizona State University is currently inventorying all forms of recreational activity along the lower Colorado River from Davis Dam to the International Boundary.

(2) Colorado River Indian Reservation Unit, Arizona. -

Introduction. - The Colorado River Indian Reservation lies in a desert valley along the Colorado River in western Arizona and southeastern California. It is completely surrounded by sparsely vegetated mountains. The valley is composed of river bottom desert soils, which are among the most fertile in the country when fertilizer and water are applied.

The area is narrow, arrow-like shaped with the northern portion twisted to the northeast as it follows the bends of the Colorado River. It is about 46 miles long, beginning 2 miles north of Ehrenberg, Arizona, opposite Blythe California, and extending northeasterly to Monument Peak about 7 miles west of Parker Dam. The greatest width of the valley is about 13 miles.

The town of Parker, Arizona, is in the extreme northern portion of the Reservation and is the only major townsite in the area. It is completely surrounded by Reservation lands and is the headquarters for the Colorado River Agency and the Colorado River Indian Tribes.

The small settlement of Poston, the site of one of the Japanese relocation camps during World War II, is within the area.

Historical and archeological. - The Colorado River Indian Reservation was established by an Act of March 3, 1865 (13 Stat. 541,559) which set apart 75,000 acres in the territory of Arizona for an Indian Reservation. The boundaries were changed a number of times before the present Reservation was established by the Executive Order of 1915 and Public Law 88-302.

The 1867 Congress appropriated $50,000 for construction of the Grant-Dent irrigation canal diversion from the Colorado River. Water was turned into this canal in July 1870. The elevation of the canal headworks prevented diversions during low riverflow and, in 1874, appropriations were obtained to extend the canal upstream. Tunnels were constructed to reach a diversion point now known as Headgate Rock Dam. Cave-ins required excessive maintenance, and the tunnels were abandoned in 1876.

Diversions were then made just below the tunnels during the higher stages of riverflow. A pumping plant was installed by 1899 and gravity diversions were discontinued. This plant was enlarged in 1918 to its final capacity of 125 ft^3/s. The completion of Headgate Rock Dam in 1941 provided permanent diversion facilities and canal capacity to irrigate all of the irrigable lands by gravity. In 1942, there were about 10,500 acres of developed lands. In 1955, about 5,000 acres of these lands were out of production due to drainage problems. To alleviate this problem, an extensive drainage system was installed. With the improved drainage system, the irrigated lands have steadily increased to over 60,000 acres in 1972.

To encourage private investment, the Tribal Council has sought Federal authority to grant long-term leases. In 1962, authority to grant 99-year nonagricultural leases was obtained. In 1963, a 25-year agricultural leasing authority was granted, and in 1965 a 40-year leasing authority for citrus farming was granted.

Further incentive for the expansion of irrigated agriculture was provided by the adjudication of the right to divert from the Colorado River an annual quantity not to exceed 717,148 acre-feet of water for the irrigation of 107,588 acres of land on the Reservation. This decree was issued March 9, 1964, implementing the U.S. Supreme Court decision in the case of Arizona vs. California (June 1963).

Due to the history of Indian life along the lower Colorado River, archeological sites have been numerous. The joint Tribes of the Reservation have constructed a museum, and are actively pursuing the preservation of their past heritage. Activities related to the project will not affect any cultural resources.

Economics. - The Colorado River Indian Reservation has entered an accelerated phase of economic growth, with a large potential for further development. This economy is centered around the expansion of irrigated agriculture and water-oriented recreational development.

In 1972, about 60,000 acres of irrigated land produced a total crop value of about $22,616,000 and a tribal and personal income of $1,229,000. This included the parcels of land that are being leased to large agricultural firms. Major construction programs have been initiated, involving canals, laterals, and the rehabilitation of the drains. In addition, land clearing and leveling will be necessary to prepare for crop production. Crops grown on the Reservation include excellent yields of cotton, lettuce, corn, alfalfa, wheat, barley, maize, and melons.

Recreation and tourism are important sources of revenue, both on the Reservation and in the town of Parker, Arizona. In 1972, the tribal income from these sources was $51,500.

Industrial firms have indicated interest in the Reservation for several years, but development has been slow. Activity is presently limited to cotton gins and cattle feedlots. Commercial leases and mineral income produced $146,400 in 1972.

Land use/cultural factors. - The land in the Colorado River Indian Reservation is used primarily for irrigated agriculture and recreational-oriented activities. A progressive tribal government has developed an extensive leasing project which will eventually include 102,000 acres of land.

When the reservation was established in 1865, efforts were made to bring all Mohaves to the Colorado River Indian Reservation. Those who came formed the nucleus of the Colorado River Indian Tribes. The Tribes represented on the Colorado River Indian Reservation are the Mohave, the Chemehuevi, the Navajo, and the Hopi. In 1945, 16 Hopi families were relocated on the Reservation. During subsequent years, 114 Navajo families and 3 Havasupai families were colonized on irrigated lands on the Reservation, but this program was stopped in 1952.

All of the Navajo and Hopi Indians who remained on the Colorado River Indian Reservation after 1952 have officially been adopted as members of the Colorado River Indian Tribes.

The total membership living on or near the Reservation approximates 1,840 Indians. Approximately 500 members live off the Reservation and in distant cities.

The Mohave Indians have lived in this area since before the white man came to this country. They are classed by anthropologists in the Rancheria Tribes, their language being classified as Yuman. They lived along the Colorado River, subsisting by small-scale farming, gathering wild vegetable foods, hunting, and fishing. They used floodwaters to produce crops of corn, melons, and pumpkins, and later, beans, cantaloupes, and wheat were added to their crops.

The Chemehuevi Indians lived on the Chemehuevi Reservation below Needles, California, until their irrigable land was flooded by the construction of Parker Dam. At that time, they were moved to the Colorado River Indian

Reservation. They are classed by anthropologists in the Plateau Rancheria group with their language classified as Shoshonean. They were originally a California or southern Nevada desert tribe closely associated with the Paiute Indians whose means of subsistance was seasonal plant gathering and hunting in their area. Only limited tribal or religious ceremonies are practiced.

Navajo adopted members. - These people are classed as belonging to the widespread Athapascan linguistic family. The Navajos generally are nomadic and obtain their livelihood from the grazing of livestock. The adopted Navajo members living on the Colorado River Indian Reservation have adjusted well to becoming farmers and indicate their primary purpose in relocating on the Colorado River Indian Reservation was to take advantage of the opportunity afforded them to provide a better life for themselves and their children.

Hopi adopted members. - These people are classed as belonging to the Shoshonean linguistic family and are preeminently a religious people much of their time, especially in the winter, being devoted to ceremonies concerning the growth of crops. The Hopis have been farmers for centuries, so they adjusted very easily to their new life as members of the Colorado River Indian Tribes. Like the Navajo, they indicate their primary purpose in relocating on the Colorado River Indian Reservation was to take advantage of the opportunity afforded them to provide a better life for themselves and their children.

At the present time, the four Tribes make their livelihood by farming, some cattle raising, ranch work, and employment by the Government and private business in the surrounding community.

The Mohave, Chemehuevi, Navajo, and Hopi Indians enrolled as members of the Colorado River Indian Tribes and living on the Colorado River Indian Reservation together form a tribal group known as "The Colorado River Indian Tribes." They have accepted the Indian Reorganization Act of 1934, have adopted a constitution and bylaws, and have a Tribal Council of nine members who govern the Reservation. These council members are elected by popular vote of the adult members of the Tribes by secret ballot. They also have adopted a tribal law and order code and maintain tribal police and tribal court facilities.

Population distribution. - Parker, Arizona, is the largest town on the Reservation with a 1970 population of 1,948. It is estimated that another 2,000 people reside along the Colorado River north of town; an additional 2,000 people reside on the Reservation in Parker Valley. This population is expected to expand rapidly with the increasing recreational and agricultural development in the area.

Climate. - The climate is hot and dry, with precipitation averaging less than 5 inches annually. Most of the rainfall occurs in the form of summer thunderstorms. The average humidity is about 15 percent. The average mean temperature is 71° F. The average low temperature is 39° F. The maximum summer temperatures range between 115° and 125° F. The winters are short and very mild, with an almost complete absence of freezing temperatures.

Topography, geology, and minerals. - This area consists of roughly parallel mountains separated by an alluvial basin. Parker Valley is comprised of sediments that were deposited in the flood plain of the Colorado River. The flood plain is less than 1 mile wide near Parker and then increases to 9 miles in the Parker Valley. The elevation of the flood plain near Parker is about 360 feet above mean sea level.

The mountains, although not very high, are rugged, and rise abruptly from the alluvial slopes. The highest summit in the area is more than 3000 feet above the flood plain and about 3350 feet in elevation.

Between the flood plain and the mountains are dissected piedmont or alluvial slopes. In many places the piedmont slopes terminate in terraces bordering the flood plain. No major mineral resources are currently being produced from the area. Sand and gravel leases do, however, add several thousand dollars to the economy of the Reservation.

Vegetation. - The natural vegetation found within the area includes greasewood, mesquite, creosote bush, paloverde, saltcedar, and the saguaro and other species of cacti associated with the Sonoran Desert. These types of vegetation remain in many areas but irrigation has made it possible to convert some alluvial bottom lands into highly productive cropland.

Fish and wildlife. - The fish and wildlife on the Colorado River Indian Reservation and adjacent area is the same as described under item (1) Palo Verde Irrigation District Unit, California. These two areas occupy approximately the same range of latitude, with the Palo Verde area occupying most of the area west of the river, and the Indians the area east of the river. Some of the Indian lands are also located on the west side of the river. The effects of a decreased flow in Poston wasteway upon the fish and wildlife species associated with the wasteway will be studied.

Recreation. - The 3-mile-long reach of the Colorado River, immediately above Headgate Rock Dam, within the Colorado River Indian Reservation in California, has been developed or committed to development for recreational purposes. In the upper 1-1/2 miles, mobile home subdivisions have been established on all suitable riverbank areas along both banks. In the lower 1-1/2 miles of the reach, little development has taken place except for the Bluewater Marine Park constructed as a recreational park by the Tribe. This park consists of a 2,500-foot sandy beach, two large cabanas, a restaurant, boat service facilities, picnic areas, and mobile home and trailer parks.

The Tribe has also made several recreation-oriented leases, the largest being for 7,800 acres along 9 miles of river frontage in California. A golf course, country club, marinas, homes, schools, motels, boatels, shops, and community building are planned.

Permits to hunt and fish on the Reservation can be obtained from the Tribal administration. About 60 miles of Colorado River, associated backwaters and sloughs, and 250 miles of irrigation canals are open to fishermen.

Lake Moovalya is considered as one of the better waterskiing areas of the southwest. Many boat and ski clubs spend weekends on the Colorado River, and several nationally sanctioned boat and ski races are held each year. Many beaches are available for swimmers and sunbathers.

(3) Uinta Basin Unit, Utah. -

Introduction. - The Uinta Basin Unit area includes the Duchesne River drainage, Ashley Creek drainage, and Brush Creek drainage areas of the Green River Basin in northeastern Utah. The Uinta Basin lies between the

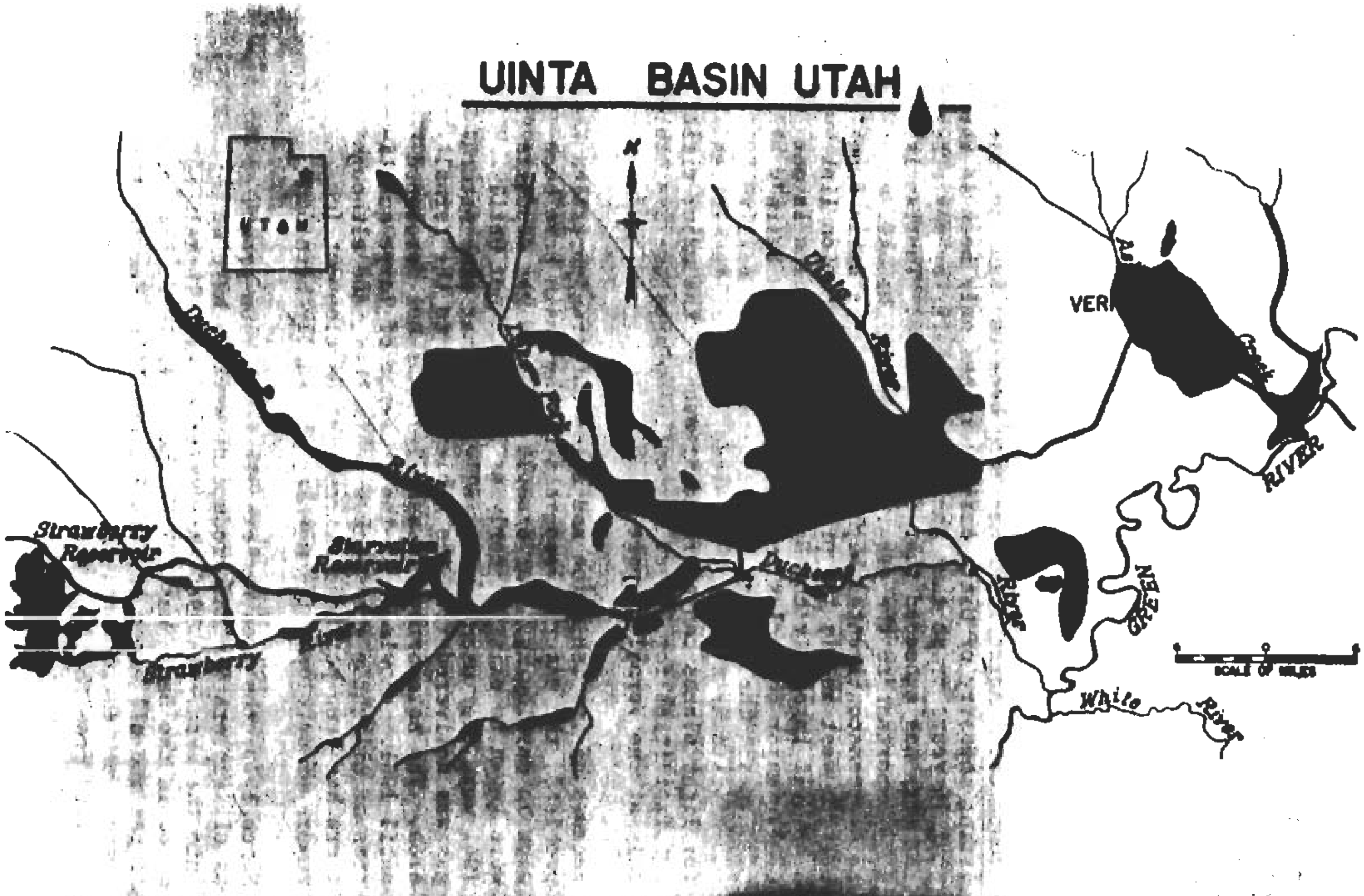
Uinta Mountains on the north and the Tavaputs Plateau on the south. U.S. Highway No. 40 and State roads provide access to the Uinta Basin. Principal cities include Duchesne, Roosevelt, and Vernal (fig. II-25).

History. - The heritage of the Uinta Basin is its indigenous population and mineral wealth. In 1860, the hydrocarbon mineral, gilsonite, was discovered and the great influx of miners and ranchers to the area prompted President Lincoln, in 1861, to proclaim the Uinta Basin as an Indian Reservation, to protect the rights of the Utes to their homeland. The early mining activities contributed considerably to the turmoil between the Indians and the whites and the scars of their struggle are evident, in that the Indians possess the badland regions of their former 1861 Reservation and the whites possess the fertile regions. The gilsonite mines are relics of the past that have been replaced by oil wells and prototype developments for the extraction of oil from oil shales. Yet the modern developments in the Basin today are the direct results of the labor of the mineral and agricultural industries of the whites.

Archeology. - The first known inhabitants of the Uinta Basin were members of the Desert Archaic culture. The oldest remains of this culture have been found in Thorne Cave, near Jensen, Utah. After the technology to produce corn was introduced to the Southwest from Mexico around 1,000 B.C., then the nomadic life of these people was abandoned by 500 A.D., thus the Desert Archaic culture was replaced by the Pueblo culture of the Southwest.

The Fremont culture was a branch of the Pueblo culture that occupied the Uinta Basin and remained in the area until about 1,250 A.D., when a drought of about 25-years' duration forced their migration to Arizona and New Mexico where they were assimilated by the Pueblo cultures of those areas. Archeologists state that the Uinta Basin was heavily occupied by prehistoric cultures. Over 400 archeological sites are recorded in Uinta and Duchesne Counties.

After the Uinta Basin was vacated by the Fremont culture, then the Shoshonean peoples of the Great Basin Desert culture, a branch of the older Desert Archaic culture (presently called the Southern Paiutes) reoccupied the



Uinta Basin - Location Map.

Figure II-25

Basin together with another branch of the old Desert Archaic culture that had acquired the horse and copied the Plains culture (presently called the Utes). Today the Basin is inhabited by descendants from the Southern Paiutes and the Utes.

Historic sites include: Old Fort Duchesne, the Uintah-Ouray Indian Reservation, Desolation Canyon, Sheep Creek Geological Area, Dinosaur National Monument, Indian Petroglyphs in Dry Fork Canyon, and Fort Robideaux. The Bureau will comply with the guidelines contained in Title 36, CFR Parts 60, 63, and 800.

Economics. - Agriculture has long been the base and stabilizing industry of Uinta Basin. It has only been in the past 10 years or so that the value of sales by any other industry has exceeded that of agriculture. Tourism is also important to the area. U.S. Highway No. 40, a major transcontinental highway, crosses the Basin from east to west and is the principal transportation link with Salt Lake City and Denver. Transportation is one of the major obstacles in development of the Basin's resources. The nearest railroad is located nearly 100 miles away at Craig, Colorado. Airport facilities for light planes can be found at each of the major cities but facilities for larger commercial planes are available only at the Vernal Airport.

Because of its isolation and attendent transportation problems, the natural resources of the Basin have been slow in developing. For example, oil and gas deposits were known to exist as early as 1925, but not until 1941 were they used commercially. At that time natural gas was delivered from the Ashley field to the Vernal area. The noteworthy Redwash field was not developed until 1951. Knowledge of the presence of large quantities of oil shale goes back even farther, and although there has been periodic attempts at development (or rumors of development), nothing has really been done.

Since 1970, the area has experienced a boom growth rate as oil exploration and production workers have moved into the area. In 1960, the value of all minerals produced in the Basin was $27,582,000. In 1973, the value of gas and oil alone totaled $72,060,000. People, businesses, new employment, and overall economic development resulted from this oil and gas exploration.

In 1962, the per capita income in the Uinta Basin was 80 percent of the per capita income for the State of Utah, and 73 percent of the United States per capita income. By 1972, however, because of the oil boom and an extremely low unemployment rate, the Basin per capita income was nearly 90 percent of the State and 75 percent of the national average.

Future growth and development of the Uinta Basin is directly proportional to the oil shale industry. Without oil shale development the Basin will grow, but at a rate much slower than it has in the past few years - probably at a rate equal to the 1930-1970 rate of just under 2 percent annually. With a viable oil shale industry, the growth could reach proportions ranging from a low estimate of 3 percent to over 5 percent annually. Other mining industries, while important, will have less effect on the overall growth rate.

Land use/cultural factors. - The first settlements by white men in the Uinta Basin were made by miners who were continuously at odds with the Indians. In 1905, when the Indian Reservation was opened to homesteaders, the farmers and ranchers settled most of the agricultural land. These three factions still exist in the Basin today, namely, the farmers and ranchers, the oil men, and the Indians.

Uinta Basin Unit area encompasses about 4,400 square miles. About 350 square miles of cropland are in the Basin. About 80 percent of the irrigated cropland (170,000 acres) and over 50 percent of the dry cropland (1,500 acres) produce feed for livestock. Over 5,000 acres are used for storage reservoirs and ponds for late season irrigation. Less than two-tenths of 1 percent of the land within the agricultural community is used by industry. Lands used miscellaneously consist of farmsteads, residential yards, stockyards and feedlots, urban, and abandoned farmsteads (total 6,540 acres). (All acreages were compiled from Utah Division of Water Resources, 1971, Staff Report No. 7.)

Population distribution. - The present population is centered around the cities of Vernal and Maeser in Uintah County, and Roosevelt and Duchesne in Duchesne County.

Indians from the Ute Tribe are primarily located in western Uintah County in the area of Ft. Duchesne. Only 9 percent of the population is classified as a minority.

The tabulation on the following page illustrates population trends in the counties and principal cities of the Uinta Basin since 1930 and the change, expressed in percent, that has occurred between reporting dates. In the Basin the population changed little between 1930 and 1970, with Duchesne County slowly losing population and Uintah County showing a very modest growth.

Climate. - The climate in the Uinta Basin is extremely variable. The summers are normally hot, with low humidity, and the winters are relatively severe. Extreme fluctuations in precipitation and temperature occur over the area.

The climate of the Uinta Basin varies from semiarid to wet, depending on the elevation. The approximate elevation ranges and climates (based on the standard [illegible] Index[24]) are as follows:[25]

Elevation	Climate
4500 to 6000	Semiarid
6000 to 7000	Subhumid
7000 to 10,000	Humid
10,000 to 13,500	Wet

The agricultural areas generally lie below 7,000 feet and are in the semiarid and subhumid types of climate.

Precipitation in the Uinta Basin area varies directly with topography. National Weather Service records from 1931 to 1960 indicate that the average annual precipitation ranges from less than 6 inches in the Ouray area (near the mouth of the Duchesne River) to more than 40 inches in the peak areas of the Uinta Mountains. The average annual precipitation in most valleys and agricultural areas varies from 6 to 16 inches a year.[25] The Southeast slope of the Uintas is the principal area of heavy thunderstorm activity in the State of Utah.

Temperature extremes have ranged from minus 43° F to 106° F in the agricultural areas. Average annual temperatures range from 20° F at elevations above 10,000 feet to about 47° F for the lower river valleys.

POPULATION TRENDS - UINTA BASIN 1930 TO 1973

Counties and principal cities	1930 (number)	1940		1950		1960		1970		1973		Percent change 1930 to 1973
		Number	Percent change	Number	Percent change	Number	Percent change	Number	Percent change	Number	Percent change	
Duchesne County	8,263	8,958	8.4	8,134	-9.2	7,179	-11.7	7,299	1.7	12,000	64.4	45.2
Duchesne City	590	907	53.7	804	-11.4	770	-4.2	1,094	42.1			
Myton City	395	437	10.6	435	-.5	329	-24.4	322	-2.1			
Roosevelt City	1,051	1,264	20.3	1,628	28.8	1,812	11.3	2,005	10.6			
Uintah County	9,035	9,898	9.6	10,300	4.1	11,582	12.4	12,684	9.5	15,200	18.8	68.2
Maeser City		428		643	50.2	929	44.5	1,248	34.3			
Vernal City		2,119		2,848	34.4	3,655	28.3	3,908	6.9			
Total Basin (3 Counties)	17,298	18,856	9.0	18,434	-2.2	18,761	1.8	19,983	6.5	27,200	36.1	57.2

Source: U.S. Department of Commerce - Bureau of the Census - 1930-1970
Utah Economic and Business Review, December, 1973

The frost-free period varies greatly with elevation. Freezing temperatures may occur anytime in the higher mountain areas. The average frost-free period ranges from 20 days or less at elevations above 10,000 feet to more than 130 days in the lower valleys. The average frost-free period in most valleys and agricultural areas ranges from about 80 to 120 days.

Soils, topography, geology, and minerals. -

Soils. - The soils of the Uinta Basin have developed in a semiarid continental climate. Parent materials are mainly shale and shale interbedded with sandstone and limestone. Most of the shale is gypsiferous and saline. Consequently, many of the soils are saline. They are also low in organic matter, nitrogen, and phosphates; however, the soil does contain large amounts of lime carbonate and salts of calcium, potassium, sodium, and magnesium.

The arable soils are the deep, medium, and moderately fine textured soils on alluvial fans and flood plains and the gravelly or shallow soils over hardpan on the benches and mesas. The cultivated soils are often in relatively small parcels surrounded by mesa escarpments and sandstone and shale hills.

Many of the soils are underlain at depths of 5 to 50 feet by impervious, saline shale. In most of the irrigated area, the shales dip moderately to the north into the Uinta Basin Synclinal Structure. This restricts the movement of water and causes the water table to stand close to the surface. Poorly drained soils that are strongly saline and alkali are thus widespread and intermingled with other soils.

Topography. - The Uinta Mountains provide rugged mountain peaks to over 13,000 feet and form an impressive backdrop for the developed areas of the Basin. These mountains, with their forests, valleys, lakes, and streams provide spectacular scenery in a wilderness atmosphere. The landforms of the lower elevations consist of rolling hills, benches, valleys, and semiarid flatlands that furnish a diversity of visual experiences.

The Uinta Basin forms the northern division of the Colorado Plateau, and its southern boundary is the

Book Cliffs, which also mark the northern limit of the Canyonlands division.

Geology. - During the late Mesozoic and early Cenozoic time, as the Uinta Mountains uplifted to form an eastward trending anticline, great volumes of sediment were produced by erosion and deposited into a subsiding synclinal Uinta Basin, which paralleled the southern flank of the Uinta Mountains. The Basin was occupied intermittently by large lakes that received sediment from these highland areas.

These deposits now constitute the three principal formations found in the Basin; (1) the Green River, (2) the Uinta, and (3) the Duchesne River.

Minerals. - The Green River Formation is the principal source for oil, natural gas, oil shale, coal, and gilsonite. In addition, a considerable amount of sand and gravel is produced from the Duchesne River Formation.

Vegetation. - The Utah State Division of Water Resources has subdivided this region into six life zones based upon the lands vegetative cover - these subdivisions and their approximate area of coverage are tabulated below:

Vegetative cover	Approximate area (square miles)
1. Conifer-aspen	2,400
2. Mountain brush	300
3. Herbs-shrubs	700
4. Grasses-sedges	500
5. River bottom (phreatophytes)	150
6. Cropland	370

(Adapted from Utah Division of Water Resources, 1971, Staff Report No. 7, Map No. 12.)

The prominent plant species in the Uinta Basin Unit area adjacent to the cultivated lands include Utah juniper and pinon pine at higher elevations, shadscale, greasewood, fourwing saltbush, galleta grass, sagebrush, and rabbitbrush at lower elevations, and willow, alders, box elder, Russian olive, and cottonwood trees along the rivers and their tributaries. The main crops grown in the area include alfalfa, pasture grasses, and small grains.

Fish and wildlife/recreation. -

Wildlife. - The Uinta Basin area contains a wide variety of wildlife habitat that supports an abundant and varied population of animals, birds, and fishes.

Cultivated lands generally support populations of pheasant, mourning dove, and California quail. Cottontail rabbits are abundant throughout the area. At higher elevations in the Basin are chukar partridge, sage grouse, forest grouse, and Hungarian partridge. Other bird species including numerous songbirds, golden eagles, and prairie falcons reside or migrate through the area. The Utah Division of Wildlife Resources has compiled the following upland game data for Duchesne and Uintah Counties for the 1965-1972 period.[26]

Upland game species	Percent of State hunters	Percent of State harvest
Pheasant	6.0	7.4
Mourning dove	2.5	2.2
Chukar partridge	4.1	4.9
Sage grouse	14.4	18.3
Forest grouse	3.8	3.7
Quail	6.6	4.9
Hungarian partridge	1.2	1.2
Cottontail rabbit	11.4	16.3

The Uinta Basin is an important resting area for waterfowl migrating through eastern Utah in the Pacific Flyway. In addition, the lakes, streams, marshes, bottomlands, and farmlands in the Basin afford some nesting habitat. Species that nest in the area include mallards, gadwall, pintail, cinnamon teal, shoveler, redhead duck, ruddy duck, and Canada goose. Duck and goose hunting in the Basin is considered good.

The main big game species in the Uinta Basin are mule deer, elk, and moose. Antelope, bighorn sheep, and mountain goat also inhabit the area, but in lesser numbers.

Nongame species inhabiting the Basin include black bear, mountain lion, and bobcat. Coyote, porcupine, beaver, muskrat, mink, marten, weasel, skunk, and badger are also found in the area. The Canada lynx is rare in Utah but is found in the Uinta Mountains.

Of the fur animals, the beaver is the most economically important. Good beaver and muskrat habitat is found along most of the streams in the Basin.

The highland areas of the Basin support a population of amphibian and reptile species including the clouded tiger salamander, mountain toad, western chorus frog, western leopard frog, sagebrush lizard, Great Basin skink, Rocky Mountain rubber boa, wandering garter snake, western smooth green snake, Great Basin gopher snake, Utah ringed snake and the Great Basin rattlesnake.

Fish. - The Uinta Basin streams support a wide variety of fishes including game and nongame species. Populations of brown, cutthroat, brook, and rainbow trout occur in the upper reaches of the streams. The North Fork of the Duchesne River contains rainbow, brook, cutthroat, and hybrid cutthroat-rainbow trout, sculpin, and mountain suckers. The West Fork contains cutthroat, brook, rainbow, and brown trout. The Duchesne River above Duchesne and below Rock Creek supports brown, brook, cutthroat and rainbow trout, mountain whitefish, sculpin, and a few mountain suckers. Strawberry River contains brook, rainbow, cutthroat and brown trout, speckled dace, sculpin, and very few flannelmouth suckers. Upper Ashley Creek supports rainbow, cutthroat, and hybrid rainbow-cutthroat trout, sculpin and very few whitefish. The upper reaches of Brush Creek support brown, native cutthroat, and rainbow trout along with some sculpin, mountain sucker, and speckled dace.

In the lower portions of the streams the fish populations are primarily of nongame species. The lower reaches of the Duchesne River contain sculpin, dace, flannelmouth sucker and a few chubs. Two endangered species, the Colorado squawfish and the Humpback chub, are known to occur in the Duchesne River. They probably migrate upstream from the Green River. Since endangered species are found in the general vicinity of the project, clearances may be obtained during the course of investigations. The lower reaches of Ashley Creek contain an abundance of carp, and a few smallmouth bass that were planted experimentally. In the lower Brush Creek, the fish population primarily includes sculpin, dace, flannelmouth suckers, and channel catfish.

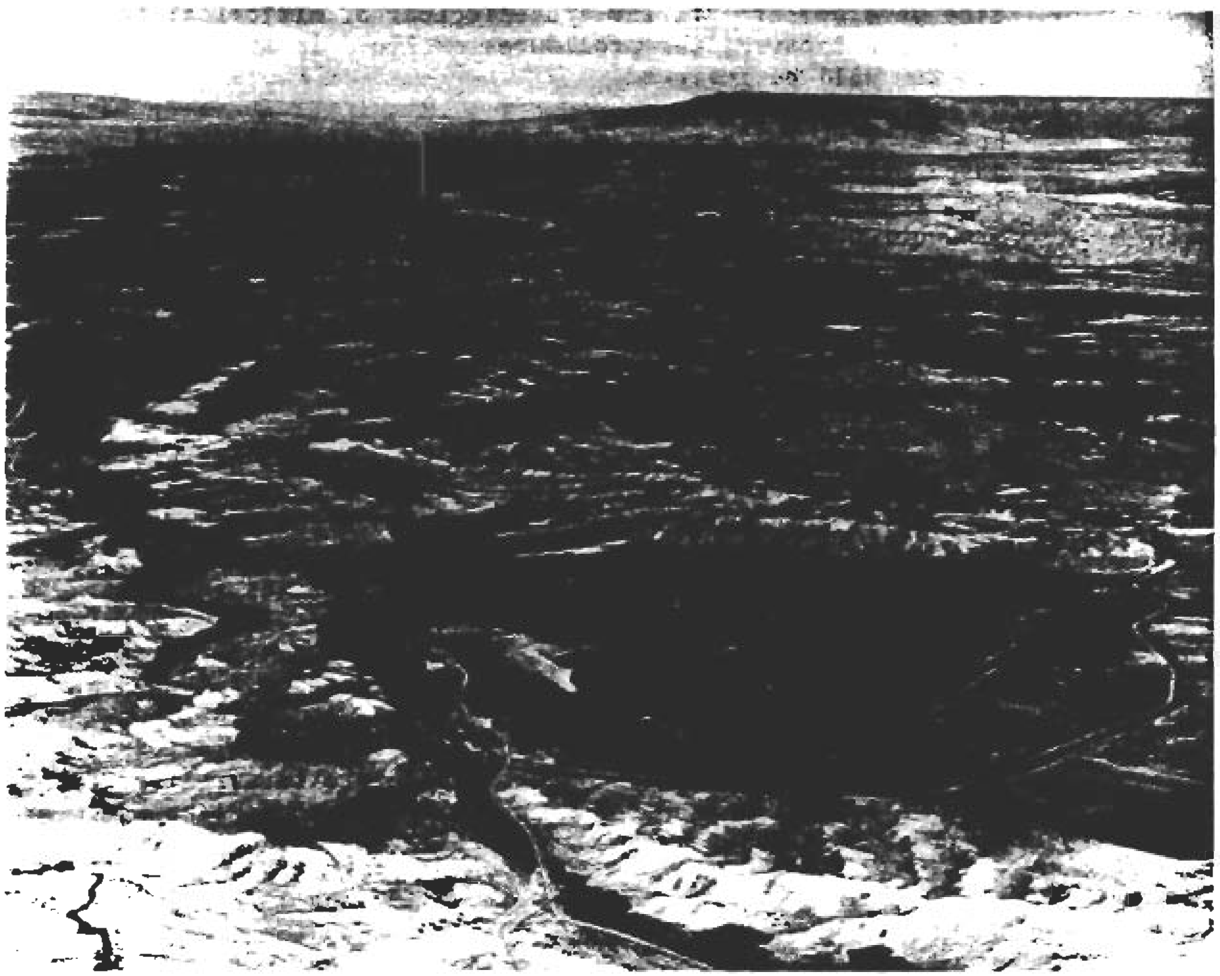
Recreation. - Established recreation areas located in the general vicinity of the Basin area are Dinosaur National Monument, Flaming Gorge National Recreation Area, Natural History State Park at Vernal, Steinaker Lake State Recreation Area, and Big Sand Wash Reservoir, and Steinaker Lake State Beaches. The National Forests are also used extensively for recreation including mainly camping, hiking, sightseeing, skiing and snowmobiling. Parts of Ashley, Uinta, and Wasatch National Forests are located in the Basin. The High Uintas Primitive Area (237,177 acres) received about 121,000 visitor-days of use in 1972.[27] Bottle Hollow Resort and the Green River also provide recreational opportunities.

The reservoirs in the area attract many visitors. In 1972, the estimated recreation utilization of Starvation and Strawberry Reservoirs was 645,000 visitor-days.[27] The use of Steinaker Reservoir was about 45,000 recreation-days per year during the 1971-73 period.[27]

(4) Lower Gunnison Basin Unit. -

Introduction. - The Lower Gunnison Basin Unit encompasses the Gunnison River drainage below the Black Canyon. The Unit includes portions of Delta, Montrose, and Ouray Counties in west-central Colorado. An aerial view of the project lands of the area is shown in figure II-26.

Historical and archeological. - The Spanish were the first Europeans to explore the area and Father Escalante's 1776 expedition crossed the Gunnison Basin. The Ute Indians used the area until 1881 when they relocated on the Uintah Reservation in Utah. In the late 1800's, many miners moved through the area and were subsequently followed by farmers, who by 1900, developed most of the readily available sources



Lower Gunnison Basin Unit project lands.

Figure II-26

of irrigation water. The Ute Memorial Site located 2 miles south of Montrose is listed in the National Register of Historic Places. There are archeological sites within the Unit's boundaries although in areas of existing development, they have largely been disturbed or destroyed. In areas of potential projects, such as the Fruitland Mesa Project, archeological field surveys will be completed prior to irrigation development. If any archeological or historical features are located, the procedures outlined in 36 CFR 60, 63, and 800 will be followed.

Economics. - The economy of the Lower Gunnison Basin is based primarily on agricultural enterprises. Fruit farming, together with general and cash crop farming and the production of forage and grain crop for livestock feed are the principal types of agricultural cropping. Nonirrigated lands are used principally for livestock grazing. Urban areas service the agricultural industry and some light industry has developed in the larger towns of Delta and Montrose.

Land use/cultural factors. - The Lower Gunnison has historically been an irrigated agricultural area. Towns were built to accommodate the farmowners, laborers, and to develop a business base for obtaining goods and services related to farming practices. The area has remained primarily rural with little urban or industrial growth.

Population distribution. - Population centers within the Lower Gunnison area include Delta (3,694 people in 1970) and Montrose (6,496 people in 1970). County populations and projections are shown below. These preliminary figures were furnished by the Colorado Division of Planning. Portions of these counties lie outside the boundary area.

	1970	1980	1990	2000
Delta County	15,286	18,621	40,000	60,000
Montrose County	18,366	21,500	24,000	30,000
Ouray County	1,546	2,500	3,500	5,000

The principal highway transportation route of the area is U.S. Highway No. 50, which extends through Grand Junction, Delta, Olathe, and Montrose. A branch of the Denver and Rio Grande Western Railroad serves Montrose, Delta, Hotchkiss, and Paonia. Montrose has a modern airport served by a commercial airline.

Climate. - Climate in the Lower Gunnison Basin varies with elevation but is generally considered semiarid with less than 10 inches of precipitation in the lower valleys. Greater precipitation rates are recorded in the higher elevation areas of the Basin, such as near Cedaredge, Colorado, which receives about 12 inches of precipitation annually.

Topography, geology, minerals, and soils. - The Lower Gunnison Basin has broad, moderately sloping valleys, bordered by low, rolling hills that break sharply into moderately or steeply sloping mesas which, in turn, are highly dissected by steep drainageways and canyons. Elevations range from 4900 feet near Delta to 7000 feet near Crawford.

The valleys in the Basin are generally eroded from the Mancos Shale which is a thick sequence of gray marine shale. The thickness of this salt-bearing formation ranges from 3,000 to 5,000 feet.

The Basin is bordered by the San Juan Mountains on the south, the Uncompahgre Plateau on the west, by Grand Mesa on the north, and by the West Elk Mountains on the east. The major rivers in the Basin are the Gunnison and the Uncompahgre, which join at Delta. The North Fork of the Gunnison joins the Gunnison about 12 miles east of Delta.

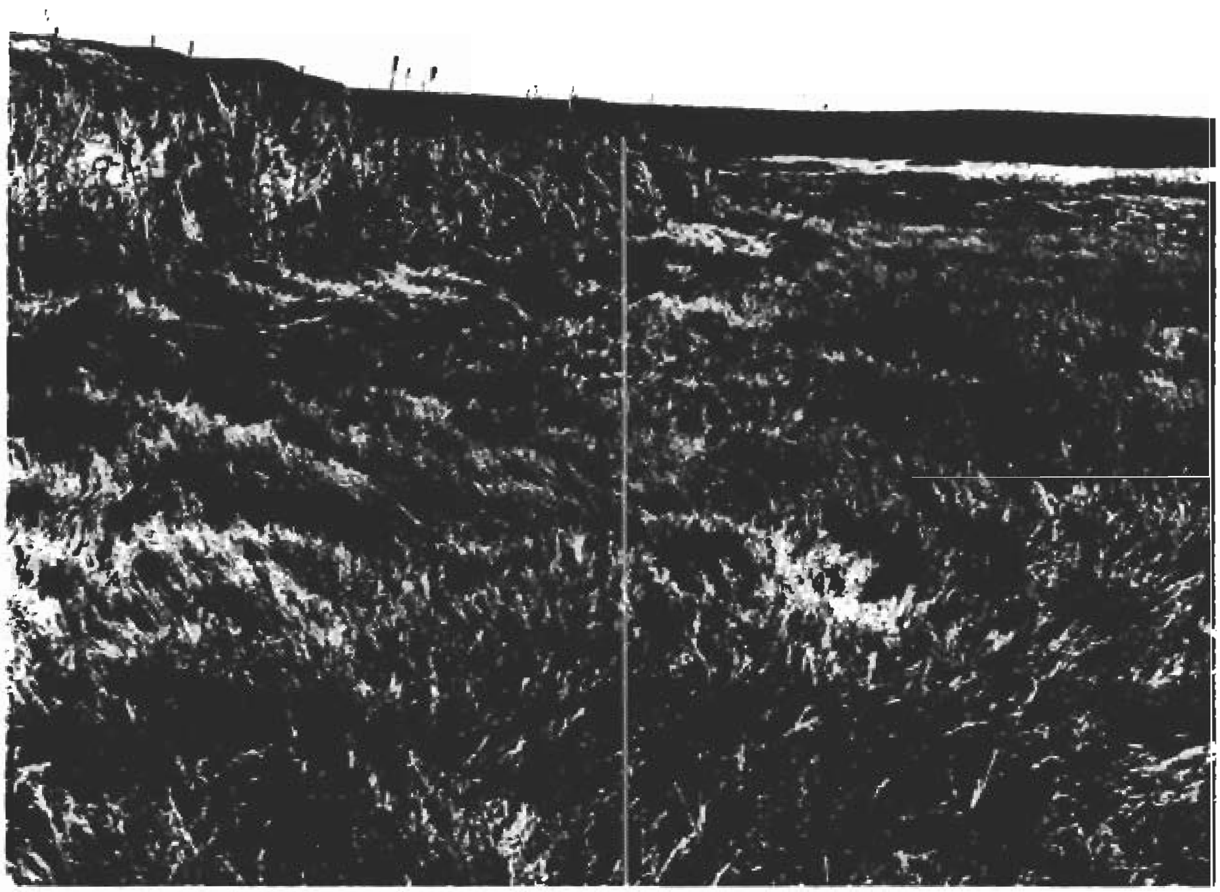
Coal is the most important mineral resource associated with the project area with fields located in the Paonia and Cedaredge areas. Most of the production is presently exported with some limited domestic use. Other minerals of importance include sand, gravel, and natural gas.

The soils found throughout most of the basin below 6000 feet have developed under low effective precipitation on flood plains and on shale hills, in alluvium and residuum from sandstone or shale. Soils generally found at elevations ranging from 6000 to 8000 feet have developed under higher effective precipitation on stream terraces, outwash fans and valley fills, sloping uplands, glacial till, in sandstone and shale alluvium and residuum.[28]

Vegetation. - The lower elevation irrigated lands in the Basin produce crops such as corn, sugarbeets, small grains, fruit, hay, and pasture. In areas that have not been irrigated, the common natural vegetation consists of the greasewood or saltbush community. Found in these communities are shadscale, mat saltbush, Gardner saltbush, rabbitbrush, winter fat, cactus, galleta, three awn, and squirreltail. The greasewood is found on heavy soils with a high saline or alkaline content, while the saltbush type occurs on drier and better drained soils that are less saline or alkaline. Streamside vegetation is often dense with cottonwood, willows, and associated species. Seepage areas, drains, washes, and some ditchbanks in the irrigated areas support willows, tamarix, cattails, greasewood, saltgrass, and other phreatophytes. Figure II-27 shows a marsh area that has developed due to irrigation east of Delta, Colorado. At elevations generally from 6000 to 8000 feet where the soils have developed, under higher precipitation the native vegetation commonly consists of sagebrush, juniper, pinyon pine, western wheatgrass, phlox, Indian ricegrass, needle-and-thread grass, and squirreltail. Irrigated lands on these soils grow orchard crops and livestock feed. Figure II-28 shows livestock grazing on irrigated pasture near Crawford, Colorado. Within the Lower Gunnison Basin, there are a number of private and Federal projects presently irrigating approximately 160,000 acres.

Fish and wildlife/recreation. - Habitat types in the area vary from the semidesert habitats associated with greasewood or saltbush near Delta and Montrose to those found in the mountain brush type at higher elevations. Wildlife habitats within the Unit's boundaries have been greatly altered by man's activities. Irrigation developments, for example, have altered the habitats that naturally developed in the project area. Important game species adapted to the new irrigation areas include pheasant, Gambel's quail, mourning dove, waterfowl, and rabbits.

Irrigated crops such as corn and small grains provide wildlife food, and interspersed areas of brush, trees, and grass resulting from irrigation return flows and seepage or developing on flood plains provide cover. For example, the Gambel's quail does best in brush areas where irrigated lands and creek bottoms or thickets are found in proper combination. Pheasant range, directly associated with the irrigated lands, is most extensive in the Uncompahgre Project area where there are approximately 90 square miles of pheasant range. Proper combinations of cover (thickets, cattails, fence rows, etc.), feeding areas, and nesting areas



Lower Gunnison Basin wildlife marsh.

Figure II-27

Lower Gunnison Basin irrigated pasture.

Figure II-28

provide the best habitat. Breeding waterfowl consist primarily of mallards, green-winged teal, and coots with river bottoms providing the most important nesting areas. Adjoining irrigated farms with canals, drains, and ponds provide areas for additional ducks. Large numbers of ducks winter in sections of the Gunnison and Uncompahgre Rivers and feed in corn and grain fields. Figure II-27 shows marsh area resulting from irrigation return flows. Such areas are important to wildlife.

Numerous other species of wildlife utilize the irrigated areas and associated areas of phreatophytes. During the winter months, phreatophyte areas provide almost all of the necessary cover for wildlife.

Big game species such as mule deer and elk are only important in the higher elevation areas of the Lower Gunnison Unit such as in the vicinity of the Grand Mesa and Fruitland Mesa projects.

Fishing in the area is limited primarily to the Gunnison, North Fork of the Gunnison, and Uncompahgre Rivers; several irrigation reservoirs, and some small streams. In the lower elevations, turbidity, siltation, and warm summer temperatures limit fish production, while low summer streamflows are a problem with the small streams at higher elevations. Game fish found include rainbow and brown trout.

Recreation activities within the Basin include hunting, fishing, and other outdoor activities. The higher elevation areas of the Gunnison River Basin are renowned for scenery, fishing, and hunting and attract many tourists. Although final destinations are usually outside the Unit's boundaries, many people travel through it. Crawford Reservoir, Paonia Reservoir, and Sweitzer Lake provide the largest areas of water-based recreation in the basin. Local community parks are also important recreation areas. In addition, the Curecanti National Recreation Area and the Black Canyon of the Gunnison National Monument provide potential recreational activities. A wildlife inventory will be undertaken during the course of the investigation.

The Lower Gunnison Basin Unit lies outside the Gunnison Wild and Scenic River study area which extends from the upstream (southern) boundary of the Black Canyon of the Gunnison National Monument to the confluence of the North Fork.

c. Diffuse source control. -

(1) Big Sandy River Unit, Wyoming. -

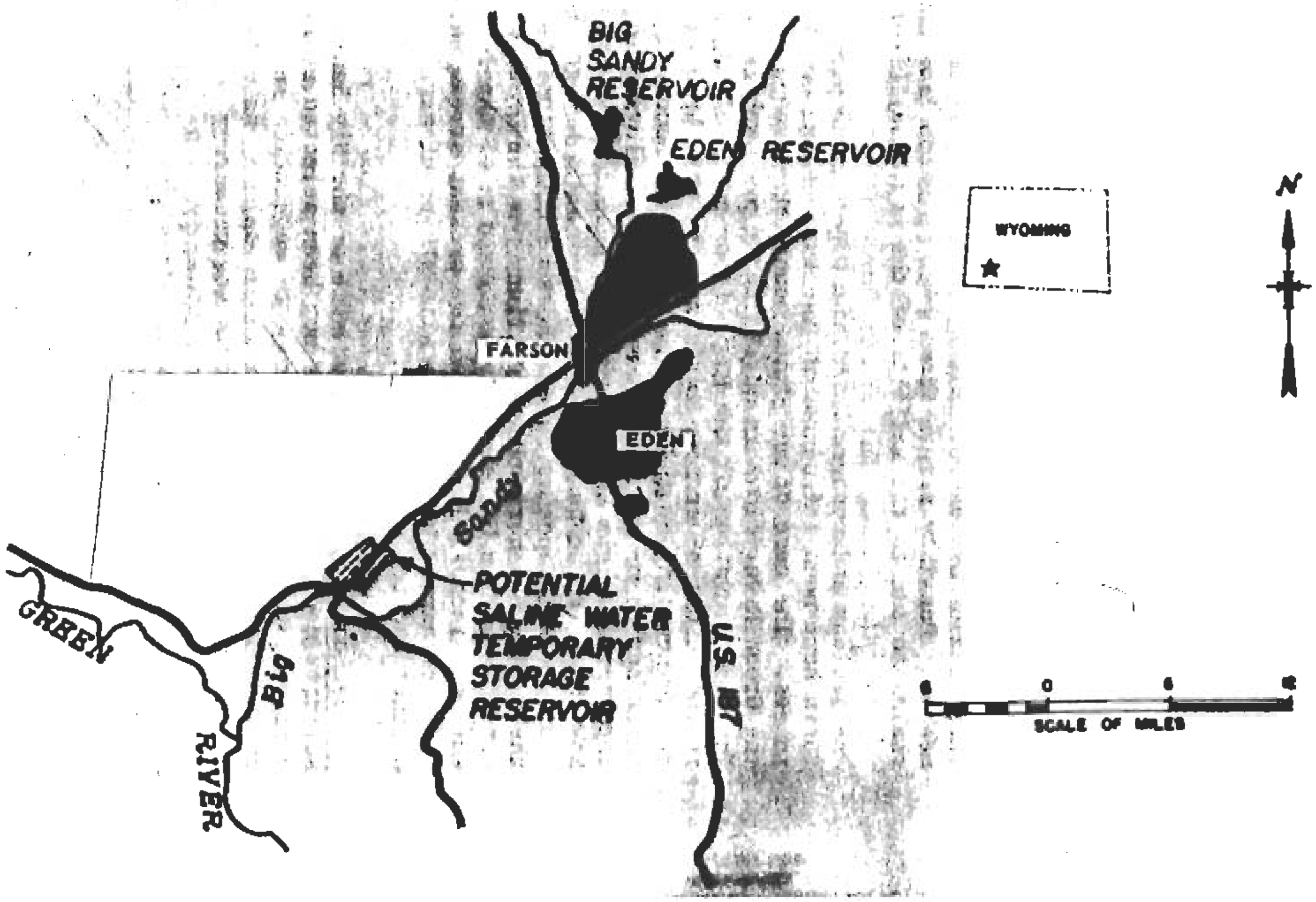
Introduction. - The Big Sandy River originates in the Wind River Mountains of southwestern Wyoming and flows southerly to the Big Sandy Reservoir and Dam where most of the flow is diverted to irrigate the Eden Project (fig. II-29). From Big Sandy Dam, it flows southwesterly to the Green River. Near the mountains, the water is of high quality containing less than 50 mg/l of dissolved solids. After flowing across several miles of desert, the dissolved solids increase from 70 to 120 mg/l at Big Sandy Reservoir. Below Big Sandy Dam, the river picks up the irrigation return flows from the Eden Project and many saline seeps along the river channel. No single point source along the river contributes a large amount of salt. The Big Sandy River annually discharges to the Green River approximately 180,000 tons of dissolved solids at concentrations ranging from 300 to 3,900 mg/l.

History. - Present irrigation development in the area was initiated in 1907. The Big Sandy Dam was constructed by the Bureau of Reclamation in 1952 to replace an earlier constructed Eden Dam. This new dam and reservoir opened up new lands to irrigation as well as supplying the areas already receiving water. Much of the return flows from the Eden Project contribute to the salinity of the lower Big Sandy River.

Economy and land use/cultural factors. - Coal mining, oil, and natural gas production, trona and phosphate mining, and power production are the main industries in the general locality. The areas adjacent to the Big Sandy River are used mostly for agriculture and grazing.

Population. - The 1970 population of the main cities and towns of the area were as follows: Rock Springs, 11,657; Green River, 4,196; Kemmerer, 2,292; Eden, 220; and Farson, 50. Some growth has occurred in the larger cities primarily due to the development of industries and the construction of the Flaming Gorge and Fontenelle Dams. For instance, Rock Springs, Green River,

BIG SANDY RIVER, WYOMING



Big Sandy River Unit - Location Map.

Figure II-29

and Kemmerer populations in 1950 were 10,856, 3,189, and 1,667, respectively.

Climate. - The climate is cold and dry in the winter with minimum temperatures often 40° F below zero. The average temperature for December is about 14° F, January about 9° F, and February, about 15° F. The summers are dry and mild with maximum temperatures only occasionally rising about 90° F.

Soils, topography, geology, and minerals. - Soils of the Farson area overlie the Eocene Bridger Shales. These shales are dense, saline, and relatively impermeable. Possibly return flows pick up salts from these shales to add to the salinity of the Big Sandy River.

The geology and topography of the Upper Green River Basin have been influenced by the surrounding mountain ranges. The core of the Uinta Mountains through which the Green River flows is quartzite of pre-Cambrian age. The high elevation of the Basin floor north of the Uintas is the result of erosion resistance by this hard material and downcutting by the river. During the Eocene age, a thick series of sedimentary materials of fluviatile and lacustrine origin was deposited in the Green River Basin. Now known as the Wasatch, Green River, and Bridger Formations, these deposits have remained fairly close to their original horizontal position. As the Green River cut through the Uinta Mountains, erosion of the level surfaces increased and formed the present stream patterns of narrow bottom lands with strips of parallel benches and terraces.

Vegetation. - Since the exact site of the Big Sandy salinity control project has not been selected it is difficult to determine the type of vegetation in the area. Where the water is extremely saline, below the irrigated area, vegetation consists primarily of greasewood and grasses while various other types of bushes are found along the streambanks. Upon final selection of a project site, a complete inventory will be made.

Fish and wildlife/recreation. - Fish in the Big Sandy River below Farson consists of suckers, carp and brown trout. This reach is a poor habitat and therefore it is not stocked and is rarely fished.

Wildlife in the area consists mostly of birds, antelope, deer, coyotes, rabbits, prairie dogs, and other rodents. An inventory of fish and wildlife will be made during the course of investigations.

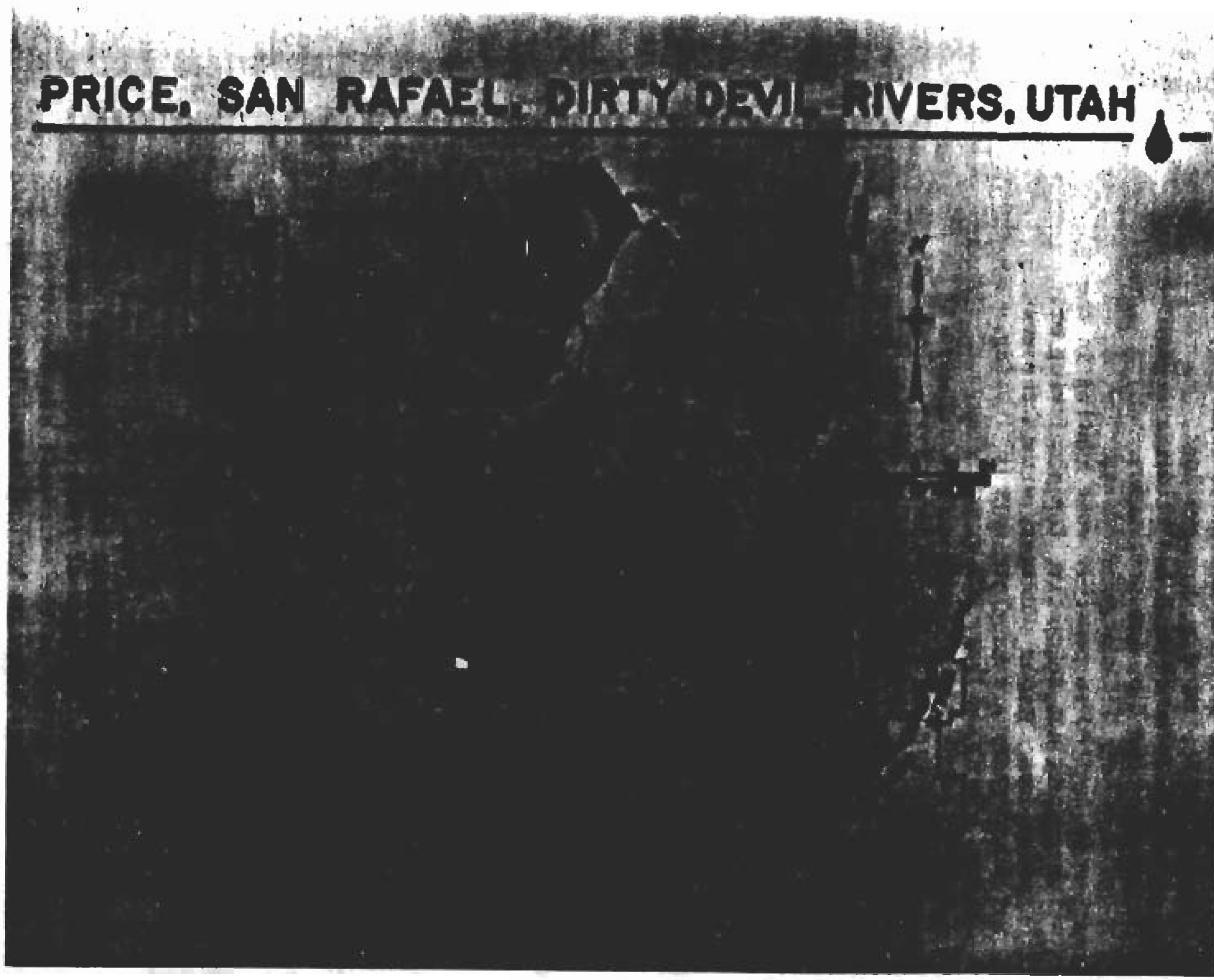
Recreation is limited to possibly some hunting in the area. The area is not attractive for picnicking or other types of recreation. However, within the general watershed there are many man-days of fishing, backpacking, hiking, riding, and sightseeing.

Hydrology. - The flow of the Big Sandy River below Eden 0.1 mile below Simpson Gulch averaged over a 19-year period was 32,170 acre-feet. The flow in water year 1973 was 46,690 acre-feet. A gage was installed in May of 1972 on the Big Sandy River near Gasson Bridge which is about 12 miles downstream from Simpson Gulch. The flow for water year 1973 at this station was 58,170 acre-feet. The diversions for irrigation are made upstream from these gages with the gages recording return flows seeps, spills, and bypassed water. The major part of the salt pickup occurs between these two gages.

(2) Price, San Rafael, and Dirty Devil River Units, Utah.

Introduction. - The Price, San Rafael, and Dirty Devil Rivers originate in the mountains of the Wasatch and Aquarius Plateaus and are tributary flows of the Green and Colorado Rivers in east-central Utah (fig. II-30). Elevations in these river basins range from about 4000 feet above sea level on the Colorado River to over 11,000 feet above sea level in the mountain ranges and high plateaus to the west. The drainage areas contain about 1,800 square miles for the Price River, 2,050 square miles for San Rafael River and 4,350 square miles for the Dirty Devil River. Interstate Highway No. 70, U.S. Highways No. 6 and 50 and State roads provide access to the area. The principal city in the area is Price.

History and archeology. - Early man, according to archeologists, has occupied the Canyon Lands Region of the Colorado Plateau for thousands of years. By 100 A.D., the Pueblo people living in the southwest had developed a distinctive culture based on agriculture. The culture that developed north of the Waterpocket Fold and west of the Colorado River was the Fremont and was based on farming and hunting as the chief occupations of the people. The Navajo's called these peoples the Anasazi,



Price, San Rafael, Dirty Devil Rivers, Utah - Location Map.

Figure II-30.

a word that means the ancient ones. The Anasazi reached their cultural climax in this area about 1300 A.D.; but a 25-year drought forced them to abandon their homes and migrate southward to Arizona and New Mexico, where they were assimilated by the Pueblo cultures of those areas.

In the watershed, drained by the Price, San Rafael, and Dirty Devil Rivers (the three basins area), the Anasazi farms were located mainly on the bluffs and in the canyon bottoms where the streams developed flood plains wide enough to farm. Some of the remains of their culture are occasionally found today in the three basins area, such as irrigation ditches along the bluffs, apartment-type cliff dwellings in the canyons, pictographs and petroglyphs in caves and on cliffs. Articles of jewelry, pottery, and basketry found in the immediate area of their dwellings depict their skills as craftsmen.

Briefly, the modern history of the area can be divided into three parts: (1) a period of exploration, by white men from about 1827 to 1877; (2) a period of settlement, from 1877 to 1906, which included the establishment of the first permanent settlements, opening of the first coal mines, establishment of the first irrigation diversions from master streams, and (3) a period of development, from 1906 to the present, when fluctuating national and local economies have controlled the local activities of the Region.

Economics. - Economic development in the area is directly proportional to the development of mineral resources, primarily coal. There are three Utah counties which are the principal contributors to this area; Carbon, through which the Price River runs; Emery, which contributes to all three rivers; and Wayne County, which provides major drainage for the Dirty Devil River and the Fremont River, a tributary of the Dirty Devil.

Total personal income has increased as has all the other economic indicators. Wayne County, which is more dependent upon agriculture than Carbon and Emery, has also shown growth and maintained a stable population for a rural agricultural county in these times of fewer but larger farms with more mechanization. The market value of all agricultural products sold in the three counties in 1969 is shown in the following tabulation:

County	Total value	Crops	Forest products	Livestock and their products
Carbon	$1,910,710	467,655	500	1,422,555
Emery	2,629,268	299,578	200	2,329,490
Wayne	1,463,384	120,542	-	1,342,842

As shown in the tabulation, agriculture is primarily devoted to livestock which can utilize thousands of acres of publicly owned grazing lands. Lack of sufficient irrigation water and short growing seasons limit crop production to hay and grain for livestock feeds.

The coal industry, easily the most significant economic factor for the area today, is experiencing a revival of interest not only locally and statewide, but nationwide as well. This interest is largely due to the increased demands for electric energy and steel production. Coal is a valuable commodity for both these industries. Utah coal production is centerd in Carbon and Emery Counties where about 95 percent is mined. The gross value of coal produced in the area is in excess of $30,000,000 annually.[29]

The Utah Power and Light Company has already completed their first unit of a four-unit, 435-megawatt steam-electric powerplant in Emery County, and the second unit is under construction. This plant when completed will have an installed capacity of nearly 2,000 megawatts and will consume approximately 5.6 million tons of coal annually.[30]

The Carbon Fuel Company through its parent company, McCullough Oil, recently signed a contract to deliver 140,000,000 tons of coal to a midwest power company over a 25-year period.

Transportation facilities are adequate. The area is served by a major railroad, Interstate I-70, and numerous other State and Federal highways. There is, however, no commercial air service to the area, although there are small county and city airports adequate for small aircraft use.

Land use/cultural factors. - The first permanent settlements in the area were established by Mormon pioneers, for the purpose of agriculture, along the eastern flank of the High Plateaus section of the Colorado Plateau.

It is within the High Plateaus that the headwaters of each of the three rivers originate. The drainage areas of the rivers can be subdivided into three sections and designated the Upper, Central, and Lower Basins. These subbasin designations can be used throughout the three rivers area, the Upper Basin section covering the High Plateaus portion, the Central Basin section covering the agricultural and most populated portions, and the Lower Basin covering the badlands portion. Cultural and physical features of these areas are described below:

> The upper section consists of high plateaus containing forest, lakes, and meadows. This section is used as a national forest and provides multiuse benefits such as recreation, timber, and livestock grazing.
>
> The central section includes irrigated cropland (93,785 acres); dry cropland (35 acres); farmsteads and abandoned farmsteads, urban and residential yards, and stockyards and feedlots (6,102 acres); industrial areas (350 acres); open water surfaces (1,416 acres); and phreatophytes (34,007 acres). Thus, water-related land use consists of about 212 square miles, or about 2.4 percent of the area. This section also supports most of the coal mining activity in the area, and in addition, contains well fields that produce a significant portion of Utah's natural gas.
>
> The lower section is dominated by the San Rafael desert and similar terrain. It has been explored for oil and gas although there are no commercially productive wells. This section is the site of many mineral prospects, chiefly carnotite and vanadium as a source for uranium production. In past years the area has contributed a significant part of the Nation's nuclear fuel reserves. The vast open areas also provide winter grazing for livestock.

Population distribution. - Communities near and within the project area include Price, Castle Gate, Dragerton, Helper, Hiawatha, and Sunnyside in Carbon County; Huntington, Castle Dale, and Ferron in Emery County; and Loa, Bicknell, Torrey, and Hanksville in Wayne County. Population trends for these cities for the period 1950 to 1970 and the percent change are shown in the following tabulation.[31]

POPULATION TRENDS 1950 TO 1973
PRICE, SAN RAFAEL, AND DIRTY DEVIL RIVER BASINS

	1950	1960	1970	Percent change 1950 to 1970	1973	Percent change 1970 to 1973
Carbon County	(24,901)	(21,135)	(15,647)	(-37)	(17,000)	(+9)
Castle Gate	701	321	205	-71		
Dagerton	3,453	2,959	1,614	-53		
Helper	2,850	2,459	1,964	-31		
Hiawatha	1,421	439	166	-88		
Price	6,010	6,802	6,218	+3		
Sunnyside	1,881	1,740	485	-74		
Emery County	(6,304)	(5,546)	(5,137)	(-19)	(6,800)	(+32)
Castle Dale	715	617	541	-24		
Cleveland	343	261	244	-29		
Emery	488	326	216	-56		
Ferron	478	386	663	+39		
Huntington	1,029	787	857	-17		
Orangeville	589	571	511	-13		
Wayne County	(2,205)	(1,728)	(1,483)	(-33)	(1,500)	(+1)
Bicknell	373	366	264	-29		
Hanksville	129	169	181	+40		
Loa	437	359	324	-26		
Torrey	241	128	84	-65		

Source: U.S. Bureau of the Census - 1950, 1960, 1970 and Utah Economic and Business Review, University of Utah, Vol. 33, Numbers 11 and 12, November and December, 1973.

County population totals for the three counties are also shown and are extended to 1973.[32] Population data for cities and towns are not available for 1973. Price is the largest city in the area and serves as the principal business center. The 9 percent increase in Carbon County and 32 percent increase in Emery County is due to the increased activity in coal mining and the construction of the Huntington Canyon Powerplant by Utah Power and Light Company.

Climate. - The climate in the Price, San Rafael, and Dirty Devil River Basins varies widely with elevation and location. The climate varies from arid in the lower valleys to humid in the upper mountains. The Unit study areas of these Basins includes principally the lower portions of each Basin. These areas are mainly desert, with an arid to semiarid climate. The summers are hot and dry and the winters are usually dry and cold.

Precipitation in the three basins area varies directly with topography. National Weather Service records (1931-1960) indicate that the average annual precipitation ranges from about 5 inches in low-lying areas near Green River and Hanksville to more than 40 inches in the peak areas of the Wasatch Plateau. The average annual precipitation in the lower areas ranges from 5 to about 8 or 9 inches.[33] Winter precipitation falls in the form of rain or snow while summer precipitation is characterized by extensive thunderstorm activity. These thunderstorms cause flash floods and are common over much of the area. They cause considerable damage and can be a serious hazard to travel in the deserts and canyon areas.

Temperatures vary widely in the three basins area because of seasonal effects and elevation. Temperature extremes have ranged from minus 35° to 112° F in the study area. Average annual temperatures range from below freezing at elevations above 10,000 feet to about 53° F for the lower river valleys.

The average frost-free period (above 32° F) ranges from about 20 days in the higher mountains to more than 180 in the lower valleys. The average frost-free period in the lower study areas ranges from about 120 to 160 days.

Soils, topography, geology, and minerals. -

Soils. - The soils in the agricultural areas of the watersheds of the Price, San Rafael, and Dirty Devil Rivers were derived from siltstones, mudstones, sandstones, and shales: with the exception of the upper Fremont River Valley - which is tributary to the Dirty Devil River - where the soils are also derived from limestone and volcanic rocks. Most of the soil profiles have developed on level to gently sloping benches, uplands, foothills, flood plains, and alluvial valleys. The Mancos Shale underlies most of the soils in the agricultural areas adjacent to the High Plateaus and Book Cliffs; the formation is a gray calcareous marine shale. Other formations upon which soils have formed, usually near streams, are the Moenkopi and Morrison Formations and Tertiary volcanics. The Moenkopi Formation is a dark brown siltstone, the volcanics usually weather to a grayish or whitish clay, and the Morrison Formation is a fluvial sandstone and mudstone that varies from a reddish-brown to light gray.

The soils are low in organic matter and nitrogen. Such soils have concentrations of calcium and magnesium carbonates that produce calcic horizons.

Topography and geology. - The three basins area lies in the east-central part of the State occupying the northern section of the High Plateaus and the northwest section of the Canyon Lands section of the Colorado Plateau. The three drainage basins are bounded on the north by the Book Cliffs; on the east by the Green River and Orange Cliffs; on the south by the Henry Mountains, the Circle Cliffs, and the Aquarius Plateau; and on the west by the Awapa, Fish Lake, and Wasatch Plateaus.

During the late Mesozoic and early Cenozoic time, Utah was affected by a geologic disturbance known as the Laramide Orogeny (a period of mountain building accomplished by folding, faulting, and uplifting of the earth's surface). The Colorado Plateau was uplifted during the orogeny by magma (mobile rock material generated within the earth) upwelling from below. Weak strata overlying the magma gave way to the underlying pressures, in some areas, to form dikes and laccolithic mountains; in other areas, such as the San Rafael Swell, pronounced unwarping produced tension cracks on the upper surface of the sedimentary formations making them highly susceptible to erosion. Thus, the mountains, plateaus, basins, canyons, and swells are a product of this orogeny.

Most of the Tertiary Formations have eroded from the three basins area (except for those located in the High Plateaus and Book Cliffs on the western and northern periphery of the basins), so that Mesozoic and some Paleozoic Formations are presently exposed. Many of the Mesozoic Formations were deposited under marine conditions; thus, the formations are interbedded with salts and clays that contribute to the mineralization of water moving over or through them enroute to the Colorado River.

Minerals. - Along the west flank of the San Rafael Swell, outcrops of gypsum ($CaSO_4 \cdot 2H_2O$) and anhydrite ($CaSO_4$) occurring in the Carmel and Summerville Formations contribute to the mineralization of water in the San Rafael and Dirty Devil River systems. The total resources of these minerals in both formations is estimated at 50 million tons. Sulfur and saline deposits, principally halite, also lie within the watershed of the three basins area.

Uranium and vanadium minerals have been found in the Chinle and Morrison Formations in quantities sufficient for mining, and a few oil and gas accumulations have been discovered in the Paleozoic Formations of Castle Valley. The chief coal-producing formations in the basins are in the Black Hawk and Ferron Sandstone.

Vegetation. - The vegetation in the three basins area varies with the elevation and location. The vegetation in the lower elevation desert-type portions of the area is limited to drought-resistant plants. The vegetative cover in the deserts is usually sparse, with few areas of verdant growth. As soil conditions are important in determining vegetative cover, the deep soil areas of the desert floor are usually covered by thin strands of native grasses. In the poor soil areas of the desert, shrubs and cacti seem to dominate. The vegetation along the rivers and small streams of the desert is verdant where soil conditions permit. The more common plants of the desert areas include cottonwood trees, greasewoods, sagebrush, shadscale, galleta grass, Indian ricegrass, cacti, and numerous forbs.

Vegetation in the lower foothills or intermediate elevations includes pinon, juniper, mountain mahogany, sparse stands of native grasses, and forbs. Stands of pinon and juniper are usually thin and stunted. Ground cover of native grasses and forbs is also thin to sparse. The more common varieties of plant life in the lower mountains include ponderosa pine, maple, pinyon, juniper, mountain ash, chokecherry, and other mountain brush. Vegetation in the mountain and higher elevation areas includes pines, hardwoods, mountain shrubs, and grass on the slopes. The stream channels are usually choked with live and dead vegetation.

Fish and wildlife/recreation. -

Fish. - Fish resources of the area reflect the general aridity of the climate. Stream fisheries are generally poor, except in the headwater portions. Among the better streams are upper Price River, and Huntington and Cottonwood Creeks, both tributary to the San Rafael River. The Fremont River (tributary to the Dirty Devil) also provides habitat for trout. Reservoir and lake fisheries also are mainly confined to the headwater areas. Good examples are Scofield Reservoir on Price River, Joes Valley Reservoir in the San Rafael River drainage (Cottonwood Creek), and Fish Lake in the Dirty Devil River drainage (Fremont River). Fish Lake, famous for its mackinaw Trout, is among the State's best trout waters.

The headwaters of the streams contain both game and nongame species of fish. Upper Price River supports brown, rainbow, and native cutthroat trout, sculpin, speckled dace, mountain sucker, Utah chub, carp, and redside shiner. Brown trout are the dominant game fish. The following species of fish are found in the upper portion of Huntington Creek: cutthroat, brown, rainbow and brook trout, speckled dace, mountain sucker, and mottled sculpin. The brown trout population is self-sustaining and the other trout are stocked periodically by the Utah Division of Wildlife Resources. Upper Cottonwood Creek has a similar population of fish. Ferron Creek also contains a small population of trout and some nongame fish. Fish which are believed to be bonytail chubs, but have not yet been positively identified, have been collected near the confluence of Ferron and Cottonwood Creek drainages in the San Rafael basin.[30]

The upper section of Muddy Creek (Dirty Devil River) supports a few trout and some nongame species but is not considered a good fishery. Dominant species include cutthroat trout, speckled dace, and mountain suckers. The Fremont River above Torry has several sections that are excellent trout fisheries.

In the lower reaches of the Price, San Rafael, and Dirty Devil Rivers, the fish populations are either nonexistent or primarily of nongame species. The lower Price River contains channel catfish, flannelmouth suckers, and carp. A little farther upstream, there are also sculpin and speckled dace. The lower San Rafael contains suckers, carp, and catfish. Both of these rivers are dry on occasion (several days in several different years). The lower Dirty Devil is dry during July or longer almost every year. When flowing, however, there are usually some nongame fish in it, such as carp and suckers.

Wildlife. - Many species of mammals, birds, and reptiles are present in the Price-Dirty Devil area. Mule deer, mountain lion, bobcat, bear, elk, badger, coyote, fox, mink, porcupine, turkey, grouse, partridge, and rabbit all occur at various locations in the high country. The semiarid and arid lowlands provide additional habitat for mountain lion, bobcat, coyote, buffalo, antelope, desert bighorn sheep, rabbit, quail, partridge, grouse, pheasant, and dove.

In addition to the birds listed above, the area also has waterfowl, numerous songbirds, vultures, falcons, hawks, pinon jay, desert thrush, and golden eagles. Common rodents include mice, rats, jackrabbits, cottontails, squirrels, chipmunks, and prairie dogs. Reptiles include lizards, toads, and snakes. The Utah prairie dog and peregrine falcon, both listed as endangered species, inhabit portions of this general area of Utah.

Recreation. - With its unique natural features and sparse population, the three-basins area has abundant resources for recreation, including sightseeing, photography, picnicking, exploring, rock hunting, hiking, backpacking, swimming, boating, waterskiing, fishing, and hunting. The forested higher elevation portion and the more arid lower elevation portion of the area each have features that are attractive to recreation seekers. Portions of Uinta, Manti-LaSal, Fishlake, and Dixie National Forests are located in the area. These forests also contain abundant wildlife and numerous streams and small lakes which support fish. The arid and semiarid lower elevation portion of the area is characterized by deep gorges and spectacular canyons caused by centuries of erosion by wind and water. Numerous strange and interesting rock formations exist throughout the area. The uniqueness of the scenery has resulted in the formation of two national parks and a national recreation area. Several State-developed facilities are also found in the area. The major attractions are listed in the following tabulation:

Recreational sites and scenic attractions in the vicinity of the Price-Dirty Devil area

Capitol Reef National Park
Canyonlands National Park
Glen Canyon National Recreation Area
Goblin Valley State Reserve
San Rafael Swell
Scofield Lake State Recreation Area
Price Canyon Recreation Area
Bamberger Monument
Huntington Lake State Beach
Wedge Overlook
Natural Arch
Sand Dunes
Petroglyphs and pictographs and Indian ruins
Cedar Mountain Recreation Area
Desert Lake Waterfowl Reserve
Cleveland - Lloyd Dinosaur Quarry
Henry Mountains
Starr Springs Recreation Area
Lonesome Beaver Recreation Area
Numerous rock hounding areas
Waterpocket Fold
Cathedral Valley
Joes Valley Reservoir
Fish Lake

(3) McElmo Creek Unit, Colorado. -

Historical and archeological. - The Bureau of Land Management has visually inventoried at least nine archeological sites on land they administer within and adjacent to the proposed evaporation pond. The artifacts found at these sites are from an ancient Pueblo Indian group that once lived in the area. Seven sites contain shard, or earthen vessel, and chip evidence scattered on the ground, indicating possible ruins. Two other sites contain the rubble of hillside pueblos. One has two kiva depressions, or ceremonial chambers. Such archeological sites are very common throughout the southwest. From those actually inventoried on public land, it is reasonable to assume that there are similar sites on the adjacent private lands. The Bureau will comply with the guidelines contained in Title 36 CFR Parts 60, 63, and 800.

Economics. - In 1970[59], Montezuma County had a population of 12,952 and a concentration of only 6.2 people per square mile. Initial growth of the population was directly related to mining. Agriculture became significant to the economy after 1890 when water for irrigation was first delivered to the Montezuma Valley. Until 1950, most of the population growth was a result of the expanding agricultural industry and growth was relatively uniform until the 1950-60 decade. At that time the annual growth rate increased to 3.25 percent due to a great deal of oil exploration within the area. Following 1960, the exploration dwindled and the population declined sharply. Between 1960 and 1970, the County lost 7.6 percent of its population. Current estimates of the population of the city of Cortez stand at 15,125. Unfortunately, the youth of the area continue to leave following high school to seek employment. They are more than replaced, however, by an in-migration of people predominantly in the retirement, college, and post-college age groups attracted by the lifestyle and scenery of the area.

Agriculture is the single largest industry, employing 22.3 percent of the population. Dry land beans, wheat, and irrigated hay are the present major crops, while orchard fruits are also produced. Government employment, including education, accounts for 19.5 percent of the employment. Retail trade and services account for 16.6 and 8.6 percent, respectively.

Manufacturing and mining make up 7.6 and 5.0 percent of the employment force, respectively.

Unemployment is especially a problem for the two minority groups present. Unemployment for the Indians was estimated at 35.1 percent in 1971[60] while the Spanish-American unemployment rate was 16.5 percent in 1970.[61]

Soils, topography, geology, and minerals. - Topographically, the area is characterized by gently rolling and sloping to gently rolling mesas incised by long, narrow, and steep gullies. The dominant feature is Ute Mountain to the southwest. The site of the evaporation pond is a relatively flat and gently sloping despression which gradually narrows toward the confluence of Mud Creek and McElmo Creek. The damsite is located in a shallow draw bordered by low bluffs (fig. II-31).

Mud Creek Evaporation Pond site is located approximately 5 miles southwest of Cortez, Colorado, and one-half mile west of the Montezuma County Airport. Several farms and about 5 miles of County roads lie within the area. The elevation is slightly under 6000 feet.

Geology. - The geology of the McElmo Creek Unit includes the steep, high-walled McElmo Canyon, the flood plain of Montezuma Valley, and the precipice of sedimentary rocks of Mesa Verde. This area is located in the northwestern portion of the Four Corners Platform geologic province. McElmo Canyon was created by the entrenchment of McElmo Creek through Dakota Sandstone and Morrison Formation of the Cretaceous and Jurassic periods, respectively. This entrenchment forms the main western drainageway for Montezuma Valley, and therefore receives material transported from the Valley itself and the adjacent cliffs of Mesa Verde to the southeast. The hard, erosion-resistant, buff-colored Dakota Sandstone and the varigated shales of the Morrison Formation are exposed in prominent outcrops along McElmo Canyon; however, it is the Cretaceous formation of Mancos Shale beyond the canyon which produces a pronounced effect upon this drainage system. Mancos Shale is extensively exposed on the sides of Mesa Verde, underlies the Montezuma Valley, and is the parent material from which the Valley's residual, clay soil is derived. This formation often has high concentrations of carbonate, sulfate, and associated minerals (calcite, gypsum, etc.) which are quite soluable, and therefore

Mud Creek evaporation pond site.

Figure II-31

are picked up as dissolved solids in water increasing the salinity of the McElmo Creek drainage. The soils extending from the rock formations of Mesa Verde across the Montezuma Valley are gray to grayish brown, lean to fat clays which also contain the soluable minerals present in the parent Mancos Shale. However, these relatively deep (sometimes over 20 to 30 feet deep), residual clays grade into a thin mantle of brown to reddish brown, lean clay and silt near the rim of McElmo Canyon. About 25 to 30 feet of grayish brown clay forms the channel fill of McElmo Canyon.

Land use. - McElmo Creek originates in Montezuma County in southwestern Colorado and flows into the San Juan River in the southeastern corner of Utah. The creek drains 350 square miles, including a large area in Colorado's Montezuma Valley which is irrigated with water diverted from the Dolores River.

Irrigation return flows from Montezuma Valley contribute a substantial amount of salt to McElmo Creek and Mud Creek, a tributary of McElmo Creek which drains the southern part of the Valley. The land is derived from and underlain by Mancos Shale, a brackish and impervious marine formation.

Vegetation. - Approximately half of the evaporation pond site is irrigated farmland. The native vegetative growth in the immediate area which is shown in figure II-31, is a desert sagebrush-grass community dominated by big sagebrush.

Other shrubs include greasewood, mountain mahogany, cliffrose, and Mormon tea. A few cottonwood trees grow along streambeds and irrigation ditches.

Several types of grasses are interspersed among the shrubs and the few trees. These generally provide a good quality of range for wildlife and livestock forage, but the sparse quantity limits the number of animals which the area can support.

Fish and wildlife. - There are several animal species in and near the pond area. Mule deer, the largest mammal, migrate into the area during the winter from Ute Mountain to the west. The habitat also supports Gunnison prairie dog, deer mouse, jackrabbit, and cottontail rabbit.

Due to limited nesting and feeding sites, the area does not support a large population of birds. There is no sustaining waterfowl habitat, but several species have been observed within the proposed evaporation pond site.

CHAPTER III

ENVIRONMENTAL IMPACTS OF PROPOSED ACTION

CHAPTER III - ENVIRONMENTAL IMPACTS OF PROPOSED ACTION

A. Cumulative Impacts in the Basin

The CRWQIP will have diverse impacts upon a number of different aspects of the environment, ranging from local site areas to the entire Colorado River Basin. By program design, the general social and economic aspects of the human environment will be enhanced while certain aspects of the natural environment will be enhanced and others impaired. The major beneficial impacts are presented in terms of reducing both natural and manmade sources of pollution subsequently resulting in general water quality improvement. Some adverse impacts have been determined while others, as yet, remain undetermined or unquantified.

The purpose of this section is to present a regional overview of the cumulative impacts of the total CRWQIP in the Colorado River Basin and adjacent geographic areas. This overview considers major impact trends as measured against a representative yardstick of key environmental factors. Later, in this chapter, a more detailed description of the specific impacts of the advance control units and other units of the program will be discussed.

The overall objective of the CRWQIP is to reduce the salinity of the Colorado River and maintain the quality of water at acceptable levels so that future, beneficial use of water is assured under conditions of continued water resource development. The CRWQIP is a comprehensive application of pollution control technology to minimize salinity contributions to the river and optimize the water quality benefits to Basin water users. As a result, the program is designed to yield cost-effective, salinity reductions in the river which can be measured directly by economic benefits to people. The adverse impacts, however, of water quality improvement extract a "cost" of other natural resources in terms of land, energy, water, and solid wastes.

In order to show the entire range of judgemental environmental factors and accompanying long-term trends expected with ultimate development of the various units under CRWQIP, a summary matrix is shown in table III-1. The matrix was derived from interdisciplinary team judgements based on available information. General trends such as gains, losses, no change, and unknown are indicated for each control unit and related areas of influence. For those impacts that can be quantified according to available planning data, the cumulative, estimated natural resource impacts of both the initial units for construction and other authorized units are summarized in table III-2. This table summarizes major impacts on land use, water depletions,

TABLE III-1. - Summary of Site Related Environmental Impact Trends

Environmental factor	Control units 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Air quality	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water quality	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Water quantity	-	-	-	+	-	-	-	+	+	+	+	-	-	-
Land use	-	-	-	+	-	-	-	+	+	+	+	-	-	-
Vegetation	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wetlands	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Recreation	+	+	0	-	-	0	0	0	0	-	-	0	-	-
Wildlife resources	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fisheries	0	0	+	0	+	+	+	+	+	0	0	+	0	0
Endangered species	0	0	*	*	-	-	*	*	*	0	0	0	0	0
Scenic resources	-	-	-	0	-	-	-	0	0	0	0	-	-	-
Agricultural production	0	-	+	+	+	+	0	+	+	+	+	0	0	-
Economic resources	+	+	+	+	+	+	+	+	+	+	+	+	+	*
Social aspects	+	0	+	+	+	+	+	0	+	+	+	0	0	-
M&I sector	+	0	+	+	+	+	+	0	0	+	+	0	+	0
Archeological/historical	-	0	*	0	-	-	*	0	0	0	0	-	*	
Energy resources	-	0	-	0	-	-	-	0	0	0	0	-	*	.
Minerals	-	0	-	0	-	-	0	0	0	0	0	0	*	*

Control unit key

1. Las Vegas Wash Unit
2. Crystal Geyser Unit
3. Paradox Valley Unit
4. Grand Valley Unit
5. LaVerkin Springs Unit
6. Littlefield Springs Unit
7. Glenwood-Dotsero Springs Unit
8. Palo Verde Irrigation District
9. Colorado River Indian Reservation
10. Unita Basin Unit
11. Lower Gunnison Basin Unit
12. Big Sandy River Unit
13. Price, San Rafael, and Dirty Devil Units
14. McElmo Creek Unit

Symbol key: + Some increase, gain or upward trends
- Some decrease, loss or downward trends
0 Little or no change
* Unknown

TABLE III-2. - Cumulative Estimated Impacts for Land, Water, Solid Wastes, and Energy

Control unit	Land directly affected (acres)	Water depletions (acre-ft/year)	Solid wastes removed (salt) (1,000 tons/year)	Change in salt concentration at Imperial Dam (mg/l)	Energy consumed 10^6 kwh/yr
Las Vegas Wash -					
First stage	725	3,600	46	-4	3.6
Second stage	735	1,450	76	-8	68.2
Crystal Geyser	160	150	3	-0.3	0
Paradox Valley	3,452	3,620	180	-16.3	18.8
Grand Valley	1,000	0	200	-19	0
Impacts of initial units authorized for construction	5,337-5,347	5,220-7,370	429-459	39.6-43.6	22.4-87
LaVerkin Springs	680	2,470	103	-11	30.3
Littlefield Springs	750	4,130	17	-2	1.5
Glenwood-Dotsero	1.700	4,200	200	-19	*
Palo Verde ID	*	0	23	-3	*
Colorado River IR	*	0	7	-1	*
Uinta Basin	*	0	100	-9	*
Lower Gunnison	*	0	300	-27	*
Big Sandy River Unit	*	2,000	80	-7	*
Price, San Rafael, Dirty Devil Rivers	*	15,000-90,000	260	-23	*
McElmo Creek	*	3,700-6,200	40	-4	*
Total program potential impacts for all units	8,477	36,720-116,370	1,589	-149.6	118.8

* Planning not far enough advanced to provide specific impact data

solid wastes, water quality, and energy consumed. The table does not necessarily show all water user impacts in the lower basin. It should be noted that some of these estimates are now being finalized for the initial units while other data is not yet available for the remaining units still in early planning stages. Hence, total cumulative impact analysis, in recognizing time and location limitations, can only be outlined at this point. The following discussions of the cumulative program impacts and related environmental factors are intended to give added dimensions to the tabular and matrix data presented.

1. Air Quality

The ultimate effect of CRWQIP on air quality of the Colorado River Basin will, on a long-term basis, as indicated in table III-1, be negligible. Some temporary deterioration of air quality can be expected during construction, primarily from blowing dust.

Blowing dust can normally be expected from construction activities requiring moving large volumes of earth, such as will be needed for dike and pond construction at the various units. However, due to the natural conditions of wind erosion, low humidity, and fine soils such localized, manmade excursions may be "masked" by natural events. Clearing of land will require removal and disposal of native vegetation. Open burning of vegetation will be restricted and only permitted when so allowed by local ordinance. Some temporary pollution can be expected from operation of mechanized vehicles at the construction site. No estimate of the amount of emissions to be released to the atmosphere is available. Construction related air pollution can be expected to result in insignificant proportions as measured against the vast, rural and remote air sheds of the Basin.

Observations of existing brine disposal ponds indicate that no adverse influence to air quality would result from the various proposed brine holding ponds. Blowing dust and salt spray during periods of high winds is expected to be nonexistent or minimal and local in its effect.

Some hydrogen sulfide gas has been encountered at the Paradox Valley Project Site and hence there is a potential, during project operations, for some of this gas to escape to the atmosphere. As will be explained in chapter IV, plans call for collection of the gas and disposal by oxidation. Consequently, the potential serious impact of H_2S being released to the atmosphere near the Paradox Valley Unit is considered highly remote.

2. Water Quality

The overall consideration of relating salinity control effects to cumulative salinity impacts of anticipated water resource development will require continuing intensive study. In fact, the Bureau of Reclamation will initiate a comprehensive environmental statement in 1977 to address the cumulative impacts of reclamation actions on the Colorado River. In order to provide some early perspective, however, for a preliminary overview of projected salt additions and reductions, a summary table and graph of cumulative salinity impacts is provided on the following page, and in figure III-1a.

There are three major criteria in predicting future salinity conditions in the Colorado River system; quantity of runoff, rate of development, and implementation of salinity control projects. Various entities have made these projections in the past and have arrived at differing salinity estimates dependent upon their input criteria. The Progress Report No. 8, Quality of Water - Colorado River Basin [67], uses the hydrologic records for the period 1941-1974, the only period having extensive concurrent runoff and quality data during which the mean annual virgin runoff at Lees Ferry was approximately 13.9 million acre-feet. The corresponding depletion level for the years 1990 and 2000 are projected to be 13.5 and 13.9 million acre-feet, respectively. Part of which are supplied by inflows below Lees Ferry. Any deviation from the projected depletion schedule and water yield will change the predicted salinity concentration at Imperial Dam.

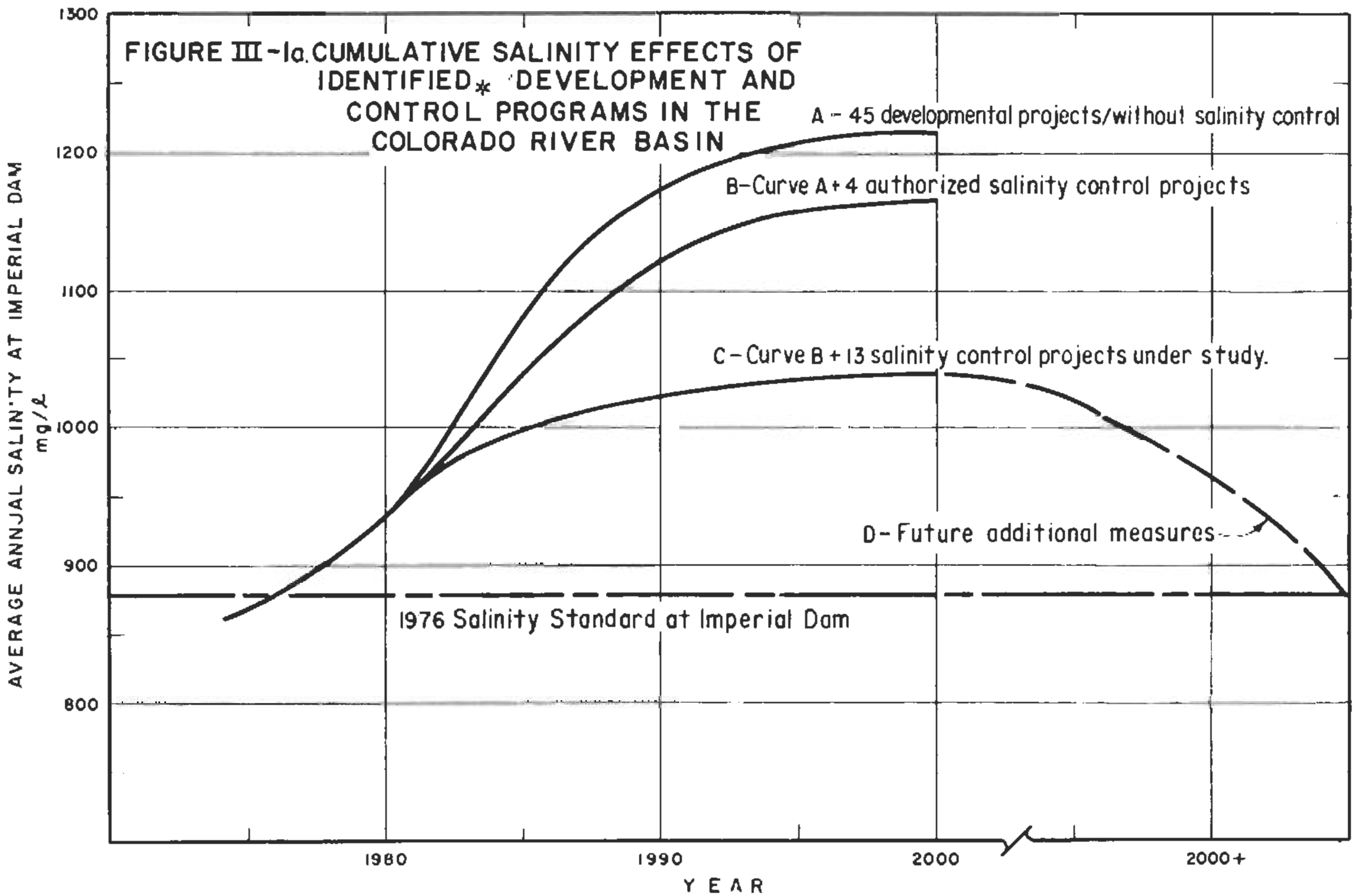
The graph displays the salinity projections on a time scale. Curve A shows the shape and magnitude of salinity effects of anticipated basin development without any salinity control programs. Curve A represents the effects of 45 projects including planned Federal developments which are dependent on authorization as well as state, local, and private development. Table VIII-1 lists the individual Upper Basin water resource development projects which are further discussed in the progress report. The Lower Basin water resources development projects included the Central Arizona Project; Southern Nevada Water Supply Project, Stage II; Colorado River Indian Reservation additions; Fort Mojave Indians; Chemhuevi Indians; City of Kingman, Arizona; Lake Havasu Irrigation and Drainage District; Mojave Steamplant; and Dixie Project alternative which were also taken into account in the progress report. Curve B shows salinity effects of the development shown by Curve A accompanied by timely construction of the authorized salinity control units under Public Law 93-320. Curve C shows the cumulative effects of incorporating salinity control units both authorized and under study, into the development curve. In order to attain the 1976 salinity standard, additional control, augmentation,

SUMMARY OF CUMULATIVE SALINITY IMPACTS AT YEAR 2000
(Average annual conditions)

Development level	Total depletions (1,000 acre-feet)	Salt added (1,000 tons)	Salinity conc. at Imperial Dam (mg/litre)	Salt removal to maintain 879 mg/litre (1,000 tons)
*Present modified (1974)	11,500	-	861	-
Identified projects[2]	13,900	88	1214	2900

Salinity control measures	Salt removed[1] (1,000 tons)	Concentration reduction at Imperial Dam (mg/litre)
Authorized (4 units)	429	48
Under investigation (13 units)	1,187	123
Total	1,616	171

* Present modified refers to historic conditions (1941-1974) modified to reflect all upstream existing projects for the full period.
1 From table III-2 + Meeker Dome Unit.
2 Existing and Projected.



* in the Quality of Water, Progress report No. 8, ref. (67)

Figure III-1a

or management steps will be necessary as shown by the dashed line of Curve D. Thus, weather modification, vegetation management, watershed improvement, additional desalting, and various nonstructural measures remain to be considered and studied in detail.

In estimating future salt loads, it has been assumed that all new irrigated land will contribute 2 tons per acre of additional salt loading, unless a return flow study has determined specific loading for the project. The "identified" water resource projects would contribute an additional 587,000 tons per year to the system by the year 2000. However, these new salt loading sources would be offset by salt removal from the system by other of the "identified" projects through transbasin diversion and "no-salt return" policies applied to industry. Consequently, the net additional salt loading would be only 88,000 tons per year which will have an impact of 10 mg/litre at Imperial Dam. This increase is only 3 percent of the total increase (353 mg/litre) expected by the year 2000 without salinity control. The remainder is due to increased water depletion. Reservoir depletions due to evaporation and other system consumption are already reflected in the present modified base conditions.

The physical objective of the salinity control program has been generally established as recommended by the 1972 EPA Enforcement Conference [4]. The conference recommended that, in general, salinity is to be kept at or below present levels, while the Upper Basin continues to develop its compact-apportioned water, recognizing that salinity levels may rise until control measures are made effective.

Later, the adoption of numeric salinity criteria as proposed by the Basin States under Public Law 92-500 requirements and EPA regulations provided even more specific program objectives. The Seven-State Colorado River Basin Salinity Control Forum proposed the following flow-weighted average annual numeric salinity criteria for three locations in the lower main stem of the river system as follows:

	Salinity in mg/litre
Below Hoover Dam	723
Below Parker Dam	747
Imperial Dam	879

EPA approval of the Basin States' proposed salinity criteria was announced in December 1976. As such, the salinity criteria at Imperial Dam (879 mg/litre) provides a new baseline or objective on which to compare future cumulative salt additions and reductions. Control of the point, diffuse, and irrigation sources under study would provide a reduction of about 1.6 million tons annually. As shown in the table, this level represents a concentration reduction of about 171 mg/litre at Imperial Dam in the year 2000 which only partially offsets the expected maximum total concentration of 1214 mg/litre.

The Colorado River Basin Salinity Control Forum analyzed an array of runoff and depletion levels in developing the salinity standards. The results of one of their analyses are plotted in figure III-1b. Curve a represents the salinity effects of the anticipated basin development without salinity control measures. Curve b represents the effect of adding the 4 authorized salinity control projects, 12 of the salinity control projects under investigation, and the adoption of a "no salt return" policy to industrial development. The Forum has concluded that the salinity standards can be maintained through 1990. However, recognizing the inherent difficulty in projecting cumulative future impacts in the basin, a key provision allows for reassessment and review of salinity criteria every 3 years.

The method of analysis used by the Forum and the Bureau of Reclamation are similar. The input assumptions, however, were different and the resulting projected 1990 salinity levels are different. The following is a comparison of the assumptions that went into each study:

	USBR	Forum
Virgin runoff (Lees Ferry)	13,900,000 acre-feet	15,000,000 acre-feet
Depletion level	13,500,000 acre-feet	12,600,000 acre-feet
Salinity control	Completion of 4 authorized and 13 projects under investigation. Assumed no salt return from large industrial developments.	Completion of 4 authorized and 12 investigated projects (Meeker Dome not included). Adoption of a "no salt return" policy to industrial development.

The decrease in salinity shown in figure III-1b for the period 1977-1979 is due to projected releases of excess flows from storage passing Imperial Dam. These releases would be required because an average inflow of 15.0 million acre-feet would occupy all available

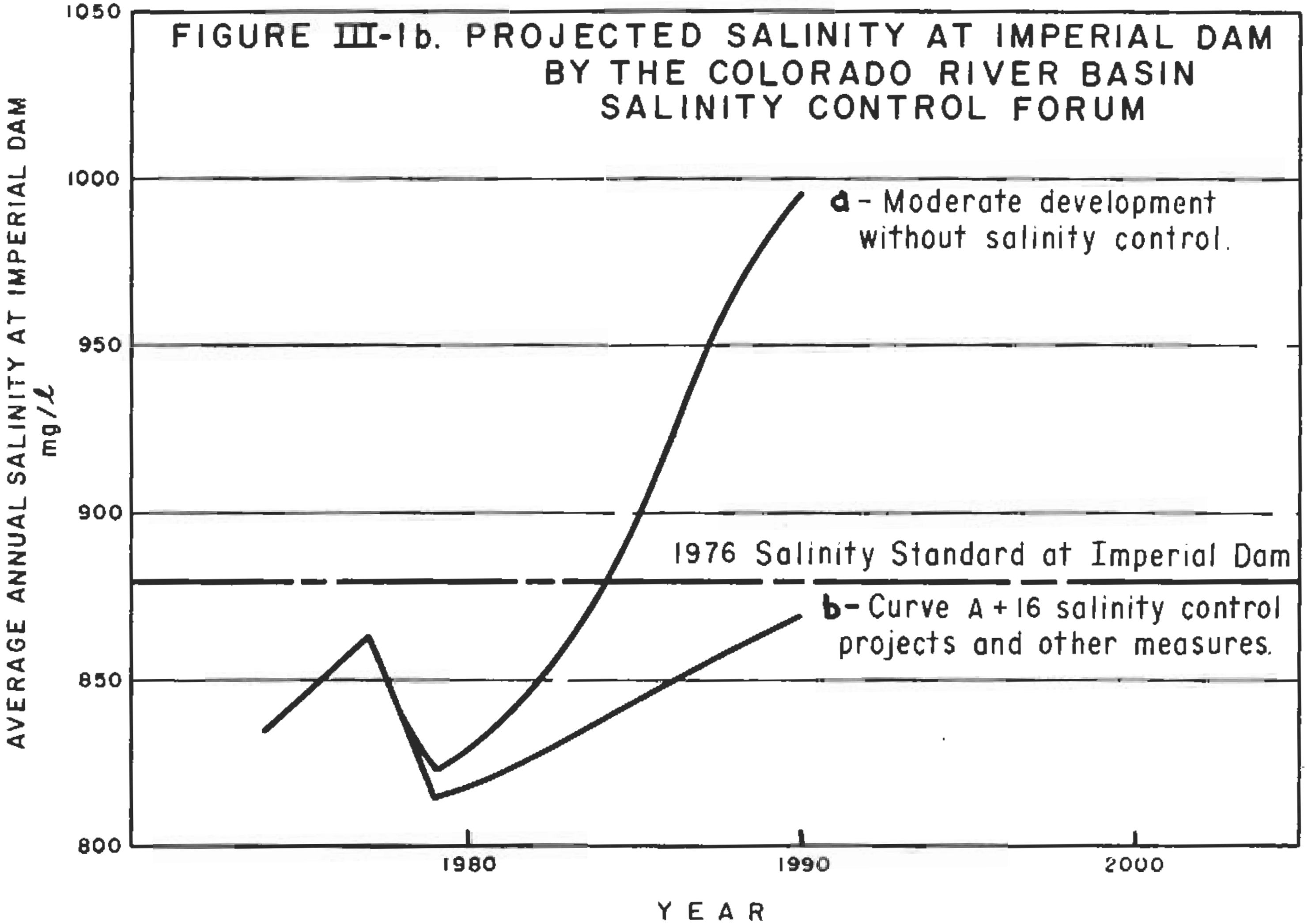


Figure III-1b

storage in the basin before the depletion rate reached a level capable of consuming the inflow. The Forum depletion projections include most of the same projects and developments as those of the Bureau of Reclamation, however, the anticipated date of completion for some of these is later and their projected total depletions by 1990 is less. The long-term runoff at Lees Ferry (1906-1974) is 14.9 million acre-feet and the Forum adopted a future water yield closer to that number in their assessment.

Because of the complexity of predicting future runoff and development in the basin, it is not at all surprising that the salinity predictions are not identical. The future use of mathematical models will provide new tools in projecting and analyzing the complex operation of the river as well as the effects of other future salinity control options. Improved cumulative impact analysis will depend on continuing, detailed computer-aided studies to keep pace with a rapidly changing river system.

Moreover, a salinity control program should be regarded as only one facet of a comprehensive plan for management of the total water resources of the Colorado River Basin. Total water management may offer the best way to plan and control the interrelated structures and the nonstructural measures to conserve and use limited basin water resources. Under such management, the effects of salinity would be controlled at levels suitable for the many uses to which the water is placed. A program to accomplish this objective would entail evaluation and selection of the salinity control measures that best fit within the total water management concept. The basic concept underlying total water management involves:

- Integrating water resources management, water quality, and land use planning,
- Planning and controlling of interrelated structures and physical features for improved system management,
- Examining and evaluating the existing systems, institutions, and legal requirements,
- Displaying alternative plans to examine interrelated quality and quantity impacts within a river basin, and
- Deriving efficient operational and management modes for the river system.

Under this approach, more planning effort will be placed on the evaluation of existing systems, institutions and legal frameworks to determine whether operations and facilities could or should be modified to achieve better management in light of new goals and values.

The primary, beneficial impact of water quality improvement is measured in economic terms for U.S. water users in the Colorado River Basin. Physically, the collective impact of the initial salinity control units will result in a decrease in salinity concentration in water delivered to municipal, industrial, and agricultural users downstream from the control points. On an annual basis, the estimated initial reduction amounts to over 400,000 tons of salt with concentration reduction of 40 mg/l at Imperial Dam. Overall program impact, as now envisioned, could remove about 1.6 million tons of salt per year from the river system with a concentration reduction of 150 mg/l at Imperial Dam. The beneficial impacts of salinity reduction will be reflected regionwide in stabilized water qualities delivered to over 3 million acres of irrigated farmland and over 17 million people. Moreover, salinity control will allow Upper Basin water resource development to proceed by offsetting projected salinity increases accompanying new water depletions. Based on recent Bureau of Reclamation estimates,[6] the total damages attributable to salinity levels of the Colorado River average $230,000 per mg/l increase in salinity at Imperial Dam.

The benefits of water quality improvement to agriculture arise from increased crop yields, improved diversity of crops, decreased leaching requirements, and decreased land management costs for the farmer. In the municipal and industrial sector, the benefits arise primarily from decreased water treatment costs, decreased pipe corrosion and appliance wear, decreased consumption rates of soap and detergents, and improved potability of drinking water. Direct effects of lower salinity or lower hardness in drinking water on human health remains in doubt as to related incidences of heart disease, life expectancy, and other health disorders.

In the long-term, water quality improvement will aid in stabilizing agricultural industry in the Basin and should extend existing land use and the agricultural industry segments of the economy.

Another beneficial effect of salinity reduction will be realized in the stabilized quality of river water used to recharge groundwater reservoirs in the water service areas of the Lower Basin. Hence, sources of water supplied from ground-water storage recharged with river water will have long-term availability to meet future demands in various service areas.

Under recent agreements, the quality of Colorado River water delivered to the Republic of Mexico is based on salinity levels at

Imperial Dam. Thus, salinity controls under the CRWQIP become very important to continued international goodwill and will also result in an acceptable water quality to water users in the Mexicali-San Luis Valley of Mexico where approximately 430,000 acres of irrigated agricultrual lands may be affected.

Adverse effects on water quality associated with the program results primarily from construction activities. Construction of facilities in or across existing flowing streams or rivers will cause some temporary increase in turbidity downstream from the construction area. The temporary turbidity will have no significant effect on sedimentation in impoundments. Fish species inhabiting these streams however may be temporarily affected by turbid conditions. Water quality could be reduced in the immediate area during periods of turbidity, and associated recreational activities, where allowed, may be temporarily impaired.

In the long term, however, construction of diffuse source control units will suppress natural erosion rates and reduce sediments carried into the tributaries of the Colorado River.

Evaporation ponds associated with several control units are expected to be lined or suitably treated to insure that brine or other waste materials do not contaminate nearby surface or ground-water systems. The ponds will be designed to accommodate floodflows and accumulated sediments.

3. Water Quantity

Aside from the benefits of water quality improvement, total water available in the river system for downstream users will be reduced by the point source and diffuse source control units of the Colorado River Water Quality Improvement Program. These water depletions will result primarily from evaporation to the atmosphere from brine impoundment. Total depletions for all control units range from 36,720 to 116,370 acre-feet per year as shown in table III-2. This level of water depletion due to salinity control may have some legal implications concerning loss allocations between the Basin States according to the present law of the river.

The 116,370 acre-feet maximum project depletion represents:

(1) About 1 percent of existing Colorado River Basin depletions for 1974, and will drop to less than 1 percent in year 2000;

(2) only 1 percent of the total hydroelectric energy generated on the Colorado River System annually;

(3) about 13.7 percent of M&I diversion* for 1980, 6.9 percent of M&I diversions for year 2000, and 4.2 percent of M&I diversions for year 2020.

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* Diversion requirements for the Lower Basin excluding diversions to southern California's Metropolitan Water District.

The water losses accrued to control point and diffuse sources may be somewhat offset by potential reductions in diversions expected from irrigation efficiency improvements. This assumes that some potential water remaining in the river by way of decreased irrigation diversion would be available for uses in other places. This would require all water rights within the basin area and downstream reaches to be fully recognized and necessary works constructed to deliver the water.

4. Land Use

The construction, operation and maintenance of the proposed units will require long-term use of land for the permanent and attendant facilities. Temporary use of the land will be needed during construction for borrow areas, equipment storage, service areas, and trailer camps.

Overall, more than 8,000 acres of land (table III-2) may be directly and adversely affected due to inundation from brine evaporation ponds and other structural features. The land-related impacts include the rights-of-way required for control unit purposes, involving private, State, and Federal lands. Much of the directly affected land use will result in arid, rangeland conversions to saline aquatic ecosystems. Secondary land-use changes are also expected to be associated with irrigation efficiency improvements which could bring marginal lands into production.

Brine impoundment. - Many of the structural modes of salinity control involve the removal of salts at the source by collection systems, impoundment, and evaporation. The primary land changes are associated with water impoundments or brine evaporation ponds replacing arid rangeland, grazing land and some agriculture land.

Impoundment reservoirs must be designed not only to accumulate and store the dissolved salts but would also provide storage space for sediment and floodflows.

The Bureau of Reclamation is continually researching for better quality liners or permanent sealing methods in efforts to prevent leakage. Texas Gulf Inc. in Moab as well as other sources has been investigated in this regard to obtain information gained either through actual experience or experiments. Design criteria for pond sealing, types of liners, permeability, and geology may vary at different sites and applicable criteria will be discussed in the individual EIS or assessment for each unit that features an evaporation pond.

The area of rangeland and agriculture lands inundated would vary due to periods of drought or high evaporation rates and some fluctuation in water depth should be expected. Evaporation would reduce the brine volume, leaving the sediment and salt in the impoundment area. The concentration of these salts as well as the volume of water impounded would gradually increase with time. Impoundment sites will be selected to provide a minimum evaporation pond life of 50 to 100 years. With the filling of the brine pond, the remaining salt, sediment, and debris will be reevaluated to assure that the solid waste materials do not reenter surface or ground-water systems.

With some exceptions, during the early stages of operation, the brine evaporation ponds could be inadvertently used as water supply for livestock or to nearby wildlife habitat. Table III-3 shows the maximum concentrations of dissolved solids that can be tolerated by domestic animals without danger of injury. However, the tolerance of animals varies considerably and is thought to depend upon many factors including health, salt content of the diet, and the nature of the salts involved. As a rule, no animal will by choice drink saline water when better water is available. Consequently, in general, brine ponds will be self-limiting to animals and wildlife use as concentrations increase.

An important natural phenomenon having an impact on the quality of impounded brine water is stratification. However, the development of stratification and accompanying anaerobic conditions are not expected to be a problem unless excessive quantities of nutrients or organic material find their way into the impoundments. Moreover, as the impoundments are relatively shallow, the prevailing wind conditions will induce a certain amount of

Table III-3

SAFE UPPER LIMITS OF DISSOLVED SOLIDS CONCENTRATIONS IN WATER FOR LIVESTOCK [66]

Animal	Threshold salinity concentration (mg/l)
Poultry	2,860
Pigs	4,290
Horses	6,435
Dairy cattle	7,150
Beef cattle	10,000
Sheep	12,900

mixing which will reduce any stratification of layers containing different densities of minerals in solution. Some nutritional pollution or eutrophication can be expected and will be characterized by excessive algae growth. However, the projected high dissolved solids concentrations in most of the impounded waters may limit the presence of most types of algae.

Wind erosion of brine impoundments would be confined to the beach and floor areas of the reservoir during periods when the pools are at very low levels or empty. The effects of wind erosion and blowing salt should be negligible because of the cementing action of the various precipitated salts from the brine.

Rapid and likely severe changes in the vegetation now rimming the impounding sites can be expected as the sediments and salts accumulate. A zone devoid of any native vegetation is expected to develop at least through the high watermark. Some halophytic vegetation can be expected to invade this zone in the initial pond use, but these too may fail with time. Brine ponds may contribute to the mosquito problem, at least in the initial stages. After the brines begin concentrating and pond vegetation is eliminated, conditions for maintaining vector habitat will change. In the long term, concentrated brines in the ponds will be hostile to mosquito production. The land surface thus affected will not only be sterile, but may be something less than esthetically pleasing to the eye.

Natural salt playas and dry lakebeds are scattered throughout the Colorado River Basin and give testimony as to future, long-term land and vegetative impacts of brine impoundment. In the short or mid-term, evaporation ponds will contain water and will give the appearance of either natural lakes or small man-made reservoirs. From the air such water would appear to have a distinctive blue cast resulting from the presence of the salts. In some aspects, the brine ponds envisioned may also resemble the artificial or industrial ponds sited near populated areas. In such cases, the siting of the ponds will be such as to not be in disharmony with the surrounding area.

It is not expected that any surface or ground-water contamination will take place due to brine impoundment, since the reservoirs will be confined to remote areas of relatively impermeable soil conditions and favorable geology. Impervious ponds or embankment linings will be used in specific areas where brine cannot be contained safely under known site condition.

Biological environmental impacts of brine impoundment ponds affecting wildlife can only be identified in general terms at the present time. Brine impoundments have been identified in the past with outbreaks of avian botulism and fowl cholera affecting only wildlife.

At present, commercial use for the stored salt in the brine ponds is not economically feasible. Future commercial use of accumulated salt is a possibility and will be considered.

Irrigation improvements. - Under the CRWQIP, the implementation of the Water Systems Improvement (WSI) program complemented by the Irrigation Management Services (IMS) program and the onfarm Irrigation Systems and Management Improvement Program should significantly reduce the salt loading of the Colorado River by irrigation in the Basin.

Under the new techniques of irrigation improvements, the primary cumulative environmental impacts of these programs will be in land and water use, and vegetation effects.

The land-related impacts of the irrigation source control units on soils would be to reduce the leaching of nutrients from the root zone. In addition, there would probably be a gradual increase in the salinity of the lower soil profile with time and some change in soil structures resulting from lowered water tables and reduced water movement through the soil profiles.

Improved irrigation efficiency will result in lower ground water levels and reduce the capillary use and precipitation of salts in the root zone.

The concrete lining of the canals and laterals would eliminate the erosion problems associated with present laterals and canals. Reduced surface runoff from fields due to more efficient irrigation practices could also reduce erosion from these fields. Reduced flows in drains and washes due to more efficient water use would reduce erosion along these waterways. The erosion reductions would result in a soils saving in the local irrigation areas plus a reduction in siltation and salt loading of the Colorado River.

Preliminary data indicate that through proper application of water and improved farm systems, a 60 to 70 percent onfarm irrigation efficiency could be reached, as measured against present levels of 30 to 40 percent. To reach the efficiency, full cooperation of the irrigators is necessary with strict adherence to the IMS and WSI programs. Some expected water diversion savings could be achieved if allowances were made to make the "saved" water available for other uses. Since the IMS program and the onfarm irrigation improvements program is now voluntary and water user organizations are under no contractual obligation to reduce salt loading of return flows, the overall impacts of widespread program application are difficult to predict.

Conditions conducive to the WSI program and returning a portion of idle land to production are: (1) lining of canals, (2) installing new, improved structures for better water control, (3) combining canals and laterals, (4) using enclosed pipe, (5) timely application of water in proper amounts and (6) onfarm irrigation improvements. Idle lands located in saline seep areas near canals and those located near the Colorado River should eventually become productive areas with a combination of proper water management, drainage, and onfarm improvements. These kinds of structural measures, (1) through (6), are subject to negotiation for cost-sharing arrangements with Federal Funds.

The acreage estimate of reclaimed would depend upon the desire and willingness of the individual landowners in these unproductive areas to attempt to reclaim these lands.

Agriculture lands. - About 1,100 acres of irrigated pasture, orchard, alfalfa and general field crops will be required for a desalting plant, evaporation pond and water rights to spring flow. In addition to the production loss of these lands to agriculture, a small amount of pheasant and other wildlife habitat will be lost. Also, about three families living on farms within the total Basin area will be displaced.

Borrow areas. - Project construction within unit areas containing inadequate or unsuitable earth materials will require excavation of adequate materials from borrow areas. The utilization of areas for borrow will be restricted and controlled.

Borrow areas required for construction will destroy existing vegetation and displace associated wildlife at the borrow site. The extent of the impact on esthetic values, natural vegetation, and wildlife habitat will be considered in choosing the location, size, and configuration of the borrow areas. Normally, no seeding or replanting of the borrow areas is required under the general construction specifications. Where construction will have a high impact, the areas will be restored to their original condition as much as possible. In areas where stripping, grubbing, or removal of topsoil will be required to provide access to the desired material, the replaced topsoil should contain adequate seed for revegetation.

Restoration of borrow areas will be accomplished by reshaping the pit to blend with surrounding terrain. The areas will be provided with gradual slopes and drainage features to prevent erosion and undesirable ponding of water. In some situations, the entire borrow areas may be covered with topsoil if feasible. The area will be scarified or ripped on the contour to create a rough surface capable of entrapping moisture, thereby enhancing natural and supplemental revegetation. Stagnation of pond water and possible mosquito breeding may also occur at times. Irrigation may also be considered to assist with the reestablishment of native vegetation in borrow areas when feasible.

Precipitation will generally control the recovery time necessary for vegetation and earth materials to reach a level of esthetic acceptance for each segment of the project. Limited restoration of native vegetation in borrow areas will be attempted when feasible.

Transmission lines. - Rights-of-way will be required for transmission lines to the desalting plants and to other project facilities. The amount of land required for this purpose has not been estimated. It is proposed to construct these lines along existing corridors and tapped into existing lines to the greatest extent possible. Substations will be located at the desalting complex. The power source for the desalting complexes is presently under study.

The principal impact of the installation will be visual by nature. The transmission lines will be constructed on single wood poles approximately 60 feet high and will follow existing corridors and rights-of-way to the greatest extent possible.

Construction access roads and camps. - Construction access roads will be necessary to facilitate the work and allow safe travel of construction personnel. Existing roads in the control unit areas will be used where possible for access to the construction area. Some new road construction or road improvement might be required for access to any alternative site selected. Some roads will need to be improved to handle the necessary increase in construction traffic. Existing roads in good condition and capable of handling the anticipated increase in traffic will need to be maintained in their present or improved condition. Indiscriminate creation of new trails will be controlled on Federal lands under provisions of Executive Order No. 11644.

Construction roads and onsite equipment storage areas necessary for orderly construction will be located within the project right-of-way whenever possible. Construction access roads will be closed to the general public. The closed roads should limit the contractor's liability, promote public safety, and prevent unnecessary disturbance of surrounding unspoiled desert areas. Upon completion of construction, all used or useless 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. Temporarily disturbed areas will be restored or returned as nearly as practicable to the original condition or to complement the natural surroundings.

With the exception of small temporary trailer camps, no new construction camps for personnel will be required. The only trailer camps anticipated are those associated with the construction field offices. This would include offices, maintenance facilities, and live-in security guard quarters. Water and sewage facilities in these areas of concern are nonexistent. Temporary water and sewage facilities meeting the requirements of Federal and State health laws will be established.

Temporary trailer camps will be provided with portable chemical facilities when other appropriate methods of sewage disposal are not available.

Existing towns in the general area of construction will provide temporary housing, material storage and construction field office sites. The sanitation facilities in some small towns may have to be supplemented to meet the increase in temporary population and construction office locations. These problems will need to be resolved by the local community in compliance with the applicable regulations of the concerned State Health Departments and the Environmental Protection Agency. One area of concern may be the occasional construction worker who would use a camp trailer or pickup-type camper temporarily within the construction vicinity. Responsibility for limiting this type of housing would rest primarily with the landowner. Contractor's employees may be discouraged from this practice by the contractor's work schedule, contractual relationships, and the establishment of adequate facilities within the right-of-way boundaries or nearby communities or on private lands.

Environmental impact of these construction facilities will be temporary in nature. The removal of buildings and facilities will eventually return the area to the basic original condition. The temporary disturbance of vegetation, wildlife, and esthetic values will be eliminated soon after construction is completed.

Waste material disposal. - 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 any negative aspects. The disposal of excavated waste material will cause a temporary loss of existing vegetation and esthetic values in and around the deposit area. Wildlife in the immediate vicinity may be disrupted by the construction activity. Waste material will be placed in low profile areas and shaped to conform to natural lines and existing terrain.

Some topsoil containing vegetation, seeds, and material unsuitable for construction purposes will necessarily be moved. The material will be deposited in such a manner that the upper layer will support native vegetation. Planting of native vegetation will be accomplished whenever feasible.

Land-related impacts on the human environment. - These impacts are those related to population growth and location. Demographic projections for the Colorado River Basin indicate an increase in population and concomitant land use. These projections are not dependent upon construction of the salinity control units nor upon importation of augmentation water. Indications are that the population will continue to grow in water-short areas in spite of the existing water shortages.

5. Vegetation

The overall impacts of the construction of project units upon the plant communities would be the loss of approximately 8,000 acres of vegetation. This would involve the loss of vegetation through clearing and construction activities along canals and construction of desalting plants and evaporation ponds.

The long-term effect of the project on vegetative growth would be directly related to the changes in the surface and ground water. Lowering of water tables, reduced flows in drains and washes, and the drying up of seep areas would affect the native plants. Some changes would occur rapidly, for example the drying up of a seep area below a leaking canal. Other changes would be gradual, as several years would pass before a new equilibrium between surface and ground waters becomes established.

Impervious concrete canals would cause seep areas to dry up and become unsuitable for phreatophytes and hydrophytes. However, some lined canal leakage can be expected through cracks and expansion joints. These probable reductions in phreatophytic growth are difficult to quantify at this time, but could be substantial. With the decline of vegetation in these areas, however, corresponding reductions in vector populations could be expected with the reduction of seep areas and marsh habitat.

In general, as depth to ground water increased, some plant groupings could become less vigorous and more scattered. One species might replace another; for example, deep-rooted greasewood plants might replace the relatively shallow-rooted willow in local areas, or willow might replace cattails in others. In the riparian habitats along the Colorado River and its tributaries, major changes would not be expected because the river would maintain water levels along the flood plains.

It is possible that windblown salt from evaporation ponds could affect native vegetation in the immediate surrounding land, but the extent of this impact is not known. Algae growth within the evaporation ponds is expected to occur on a short-term basis but would subside as salinity concentrations reach intolerable level.

The revegetation process would be slow and would be accomplished by seeding and transplanting along canals and other areas following construction. Considerable natural revegetation would be expected to occur especially in riparian areas presently denuded or where vegetation is inhibited due to saline flows.

6. Wetlands

Small areas of hydrophytes occur throughout the Basin. Onfarm Irrigation Systems and Management Improvement, Irrigation Management Services, and Water Systems Improvement may affect such land areas.

When site specific improvements are proposed, there will be an evaluation of site specific impacts on wildlife habitat that will include determining wetland type (USFWS Circular 39, Wetlands of the U.S.) and quantity.

It is expected that ground-water levels will be lowered somehwhat with improvement in irrigation efficiencies and reductions in drainage return flows. Consequently, a change is anticipated in the patterns and density of vegetation dependent on ground water. Drainage will continue to be provided in irrigated areas. A lower water table would eliminate some seep areas, thus reducing vector (mosquitoes) habitat, thereby reducing their population and public health hazards.

7. Recreation

The overall program will generally have an adverse effect on recreation. Large tracts of open space will be needed for the various brine evaporation ponds. The areas for the ponds are mostly desert land and the major form of recreation effected will be off-road vehicle (ORV) use. It is expected, however, that construction of the various facilities and access roads could open up other adjacent lands to ORV use. The cumulative losses of water due to salinity control units will not adversely affect the main streamflows and related recreation potential of rivers adjacent to unit areas.

As mentioned under the discussion of Vegetation Impacts, the reduction of vegetation as a result of the IMS and WSI programs will lead to reduction of wildlife using this habitat. This will in turn result in a reduction in hunter use of small game and birds that use this habitat.

Sharp local reductions in salinity of waters entering the Colorado River may have a beneficial effect on fish life in those areas, i.e., Poston wasteway and Palo Verde drain. If fish life were to improve in these areas then there could be a corresponding increase in fisherman use of the same area.

Construction of the brine evaporation ponds could provide a surface water source that could be utilized for limited recreational purposes in various water contact recreation forms.

Las Vegas Wash is presently a green belt in the Las Vegas Valley that supports various types of uncontrolled recreation. The Las Vegas Wash Development Committee is formulating a master plan for the recreational use of this Wash. The Las Vegas Wash Unit of CRWQIP will have some impact on recreation in that about 400 acres of land will be set aside for project facilities precluding recreational use. Chapter IV will discuss in more detail how Reclamation is working with the Committee to minimize recreational impacts to the public.

Crystal Geyser has, over the years, become a tourist attraction. Access to the site is over a rugged road precluding travel by a large segment of the public. A feature of the Crystal Geyser unit is the construction of a roadway to the Geyser which will also improve access to the site by visitors wishing to see the periodic eruptions.

Since many of the units are still undergoing study, a total estimate of recreational user-days either lost or gained through the CRWQIP is not available. Information on specific units, to the extent it is available, is presented in other portions of this chapter or will be discussed in future environmental statements or assessments.

8. Wildlife Resources

The cumulative impacts of the construction of project units would have overall adverse effects and would result in the loss of 8,000 acres (previously mentioned under vegetation) of wildlife habitat (includes habitats of amphibians, reptiles, birds, and mammals). Wildlife densities as a whole are low in the project unit areas. The drying up of seeps along canals would lead to a reduction in the phreatophytes which in turn would lead to a reduction in the total wildlife populations. Valuable nesting and cover areas would be lost for many songbirds, game birds, and small mammals. Various species of amphibians and reptiles would also experience a reduction in habitat.

Small game hunting and trapping opportunities would be reduced according to the loss of habitat in the project unit areas.

Mosquito-breeding areas will be eliminated as seep areas dry up. However, evaporation ponds will provide new mosquito-breeding sites on a short-term basis, but as the buildup of salt levels occur in the ponds, insect reproduction should be inhibited.

The possibility exists for the development of anaerobiasis (conditions void of air) in the mudflats of evaporation ponds and could lead to the propagation of avian botulism. Since these ponds would provide an area usable by migratory waterfowl as resting areas and possibly some feeding, chances exist for an outbreak of avian botulism. Also, another avian disease, fowl cholera has been traced to brackish and fresh waters and has been reported in the literature to occur in the waterfowl populations.

This analysis should not assume that outbreaks of either of these avian diseases will occur due to the implementation of the proposed control units, but the conditions that may lead to an outbreak will nonetheless be present. There is a possibility that shorebirds and waterfowl which inadvertently utilize the brine ponds for nesting areas may become covered with salt. This could result in bird mortalities due to hypothermia and salt accumulation on feathers restricting mobility.

9. Fisheries Resources

The overall impacts from the construction of project units would be beneficial to fish populations. Some local area changes would be expected to occur including a reduction of sediments and turbidity and increased water quality. Some movement of fish populations to higher flow and better water quality areas would be expected to occur as streamflows are reduced at unit sites.

Some species of fishes have become adapted to living in more saline waters, and a few freshwater species have been reported to occur in natural waters with a salt concentration of 15,000 to 20,000 mg/l.[64] Fish can become acclimatized slowly to higher salinities than those to which they are accustomed. In tributaries now devoid of fish populations, some fish species (for example, cyprinids, suckers, catfishes, and salmonids) may become acclimatized and established following reductions in total dissolved solids.

Because dissolved solids may influence the toxicity of heavy metals and organic compounds to fish and other aquatic life in an antagonistic manner, chemical and physical data alone may be insufficient to predict the overall results of the salinity control units. As individual unit biological field studies are completed for the respective environmental statements, the data should permit additional predictions and conclusions concerning fishery habitats and standing crops.

The water quality improvement program is expected to have a decreasing effect on sediments and turbidity which in turn could result in increased sight feeding of fishes and reduced clogging of gills. Egg survival would also increase in areas of reduced sediments. Increased water quality could result in increases in standing crop and egg survival, and expanded distribution of various fish populations.

Some unforeseen effects may occur as the salinity control units are constructed. It's possible that some fish species which depend upon turbid aquatic conditions will be affected adversely. For example, the endangered woundfin in the Virgin River drainage could be subjected to higher predation as sight feeding increases in other fish species following reduced turbidity and sediments.

10. Endangered Species

Endangered species investigations have not yet been completed but are currently underway. It is known that some endangered species exist in various areas of the Colorado River Basin but with exception of some possible local areas it appears that the effect will be minimal.

A study is presently underway, funded by the Fish and Wildlife Service and Bureau of Reclamation on the Virgin River to determine what the effect of the LaVerkin Springs and Littlefield Springs Projects would have on the woundfin fish. Indications are that the decrease in salinity may have an adverse affect, but this will not be known until the study is completed.

A number of endangered plant species may exist in the Colorado River Basin. The projects effects upon these however, are not known at the present time. A list of endangered species of plants has been made but has not yet been approved by the Department of the Interior. The list has been included in appendix A for information. Further investigations will be made when the list becomes official.

11. Scenic Resources

The overall effect of the CRWQIP on the scenic resources of the Colorado River Basin will be adverse. Construction activities will leave scars on the landscape that will be slow in restoring themselves, particularly in desert regions. Most Program features are located in remote areas and the placement of manmade features such as pipelines, structures, transmission lines and roads will have a displeasing effect for the majority of people seeing them. The remoteness of the locations, however, will tend to lessen that impact.

Brine holding and evaporation ponds will place displeasing white scars on the landscape that will be visible to varying degrees at the individual features. Mud flats at the outer edges of the evaporation ponds may also form. These impacts will be felt in varying degrees by people using adjacent highways and flying overhead in commercial and noncommercial aircraft.

None of the Program features are being constructed near natural scenic areas or National Parks and should not have significant esthetic impact on recreationists traveling through the areas.

12. Agricultural Production

The implementation of the units proposed in the Program would leave little effect on present or future agricultural production in the Upper Basin. However, downstream effects in the lower basin would be significant. A complex relationship is involved in relating salinity of irrigation water to crop yield. Factors involved are soil condition, crop type and variety, drainage, climate, and irrigation practices. Generally, high-valued crops are grown with Colorado River water. In most cases such crops have a low salt tolerance, therefore, yield is repressed by the salinity. Increased crop yields and improved crop quality are expected through improved water quality, timely irrigation applications, and proper amounts. These practices, along with improved distribution systems, will greatly enhance irrigation efficiencies.

Grazing and some irrigated agriculture would be eliminated as a result of the construction of evaporation ponds and other permanent structures. Agriculture production lost due to these activities would be relatively small, less than 1,100 acres.

The improvement in water quality combined with the WSI, IMS, and Onfarm Irrigation Systems and Management Improvement Programs will reduce the operations and maintenance costs to the irrigated agriculture water user's on about 1 million acres of agricultural land in the downstream area. Improvement such as use of lined canals and buried pipe will reduce conveyance losses and subsequently, return flows. The water saved through improved irrigation and drainage systems will permit the farmers to return idle land to agriculture production. Expected benefits include increased crop yields and reduced water deliveries, leach and labor requirements, fertilizer costs, and drainage requirements.

13. Economic Resources

The development of the CRWQIP units will have a positive impact in terms of local employment and incomes, and goods and services on small nearby communities in support of unit construction and operation. Implementation of the units could also have negative impacts on local education, recreation, housing, sanitation, and health facilities. Federal ownership of the units will have a minor impact on the tax base by removing lands from the tax rolls.

The primary, beneficial impact of salinity control is measured in economic terms for the water users in the Colorado River Basin. Physically, the collective impact of the initial salinity control units will result in a decrease in salinity concentration in water delivered to municipal, industrial, and agricultural users downstream from the control points. Based on recent Bureau of Reclamation estimates,[6] the total direct and indirect damages attributable to salinity levels of the Colorado River average $230,000 per mg/l increase in salinity at Imperial Dam. Assuming continued Basin development of water and this rate of salinity damage, the initial salinity control units are estimated to show total economic benefits of about $10 million per year. Total program impact for all control units under the CRWQIP could reach over $34 million per year.

Construction and operation of the units provided for in the Colorado River Basin Salinity Control Act, can be expected to have impacts of national significance. These impacts concern aspects of pollution control, nationwide productivity, the cost of the project to taxpayers, and the use of data and desalting technology for similar project planning. There will be a measurable increase in the productivity of the Colorado River Basin because of the increased water quality available to sustain agricultural and related commerce and service industry production. As related to the national economy, the impact of the program will probably be small compared to changes in production of other agriculturally rich areas of the Nation. However, the program will sustain the long-term productivity of irrigated cropland in the Basin, and thus in-turn will help to assure the Nation of abundant food and fiber. The financing of conveyance improvements in Grand Valley will be on a cost-sharing basis, 75 percent nonreimbursable to the Federal Treasury and 25 percent from Basin Power revenues. It represents a significant Federal commitment to manage water resources on an advanced long-range planning level. Such an investment will produce intangible benefits of pollution control, improved quality of life, and general environmental enhancement.

14. Social Aspects

To comprehend the full significance of overall Program social impacts, three aspects are utilized; (1) the quality of life; (2) social well being; and (3) relative social relationships. These aspects do not lend themselves readily to quantitative analysis of impacts or effects. However, the inability to make quantitative comparisons does not mean that such aspects cannot be used on the basis of qualitative considerations which have their own values, many of which are discussed elsewhere in this section. It may not be possible to measure the percentage improvement in the quality of life of the 17 million people who rely in some way on the waters of the Colorado River, but it is still useful to know that there will be an improvement and that this improvement can be important in the overall determination of the quality of life in a community.

Construction of the salinity control units are not expected to have any significant affect on the growth patterns of the Basin. Therefore, an analysis of growth as it relates to the above aspects is not addressed in this statement. Demographic projections for the Colorado River basin indicate an increase in population regardless of salinity control projects. In fact, indications are that growth will occur in spite of existing water shortages.

Quality of Life

The concern for quality of life is related to the individual and family, and encompasses the social desires which have personal meaning for most people. These have of necessity been generalized into such categories as good health, reasonable standard of living, proper development of children (education and health), happy family life, decent home and neighborhood, peace of mind, recreation, and a confidence in the stability of the community.

Several project functions will have some bearing on these considerations as they apply to the quality of life.

In the short term there will be both positive and negative impacts relative to construction operations. Dust, noise, traffic, and the influx of construction workers will probably be annoying, an inconvenience, and may place a strain on locally available services. The degree to which these impacts accrue will depend on the location of the activity relative to the location of the residents. On the positive side, there would be an increase in the sale of local goods and services which would enhance local economies. There may also be an increase in local employment opportunities as a result of project construction. Although these effects are temporary, they could have a long-term influence on ones quality of life, i.e., additional income even though temporary could enable an individual or family to procure an amenity which to them would increase their standard of living, add to their feeling of personal or family security, recreation or even assist with the families concept of child development.

Some agricultural and private land will be required for project facilities. Such land would probably be obtained by fee title. However, it would still pose a major social adjustment for the property owner. Such activities are generally very disturbing to most people. In general such land acquisition will be small. It is significant that attendant with land acquisitions only three families in the entire Colorado River Basin are expected to be displaced. For these three families, however, there will be a serious social adjustment. The degree of this effect will be determined to a large extent by the family's ability to cope with change.

The lining of canals with concrete and the construction of evaporation ponds will pose an added security hazard. The impact of this hazard would be primarily related to the young who frequently view any body of water as a recreation opportunity. The degree of this hazard will be related to the accessibility of the facility to those who would be attracted to it.

To the extent that lined canals and evaporation ponds are accessible, they may constitute a source of worry and loss of peace of mind for some parents, particularly those with young children.

Several of the proposed units will directly affect Indian lands. These impacts would primarily be associated with overall improved agricultural conditions. These improvements will enhance the productivity of the land which in turn increases not only the monetary status of the Indian but possibly their pride also as they achieve greater success.

Operation and maintenance of most of the salinity control units will provide employment opportunities either directly or indirectly through the sustaining influence of the increased water quality on agriculture, municipalities and industry. This overall economic gain is expected to enhance the quality of life of many Basin residents.

Social Well-being

Social well-being is defined herein as an expression of social values at the community level. It is concerned with the stability of organizations, including private, business, and government. It includes various levels and types of activities, e.g., education, hospitals, nonprofit groups, and those organized for social or economic purposes.

The significance of the salinity control effort itself combined with some of the unique approaches to controlling it, e.g., desalting plants, well fields, and other specially engineered efforts designed not only to accomplish the specified objective but also to harmonize with the environment, provide a study worthy of note. As such, certain facilities will undoubtedly become objects of educational interest. The main thrust of this interest would probably stem from higher educational institutions.

Some governmental entities would be impacted from project construction and operation. Most notably would be irrigation districts who are directly involved with salinity control of irrigation return flows. The success of such organizations would assist to enhance their solidarity and viability as community leaders. As individuals and families view the success of this example, they may tend to extend their expectations and confidences into other sectors, some of which perhaps will be far removed from water problems. This sense of confidence and community pride could enhance both the stability and viability of many social organizations within the community.

Relative Social Relationships

Relative social relationships refers to the status of various social groups from different financial or social backgrounds.

This includes such broad categories as the wealthy, the disadvantaged, the middle class, races, aged, creeds, or other groups whose common circumstances have led to specific identification.

The salinity control projects discussed in this document are not expected to have any significant impact on relative social relationships with two notable exceptions discussed below.

Indians. - As previously mentioned some of the units will affect irrigated agriculture on Indian lands. The success of these programs will enhance the economic position of those Indians affected. Attendant with an increase in economic capability is the potential for an increase in standard of living which in turn sometimes tends to increase ones social standing in the community.

Upstream water users versus downstream users. - To a large extent salinity control measures implemented in the Upper Basin will not benefit those water users in proportion to the cost of salinity control. The greatest benefit will be felt by water users in the Lower Basin and Northern Mexico where the effect of individual control units become cumulative. The greatest economic advantage, health influence, and subsequent social relationships will be in proportion to the improved water quality in areas where the quality is becoming critical, i.e., downstream users.

15. Municipal and Industrial Sector

One of the most important cumulative impacts of water quality improvement will be found in the many municipalities served by the lower Colorado River. As indicated in the earlier discussions of water quality impacts in this chapter, the direct and indirect economic benefits for both the Municipal and Industrial sector and Agricultural sector have been identified and quantified. Most of the economic benefits of decreased salinity accrue to the Municipal sector in the form of less scaling in plumbing, corrosion of appliances, reduced water softening, less demand for bottled water, and decreased soap use. Cities such as Los Angeles, San Diego, Phoenix, Tucson, and Las Vegas will, or are expected to, experience improved water quality in municipal water supply.

On a regional basis, improvement of water supplies or reuse of agricultural returns flows could support industrial expansion in the Basin. The availability of additional water supplies may be critical to the full development of the coal, oil shale, and other energy resources found in the basin.

In the various control unit localities, other impacts will occur in the smaller communities due to influx of construction and operations and maintenance personnel. Thus, both temporary and long-term impacts will affect local housing, sewage facilities, water supply, utilities, hospitals, schools, and other municipal services.

16. Archeological, Historical and Cultural Resources

Archeological and historical studies have been performed on some of the proposed features and work is planned on others. All Program features will be surveyed as to their cultural resources.

To date, no major cultural resources have been located that would be damaged or effected by construction of the features although minor archeological sites have been discovered. A continuing program is underway, on a case by case basis, to evaluate each site discovered. Chapter IV describes the procedures Reclamation will use in the protection of discovered cultural resources.

There are no known sites listed on the National Register of Historic Places that will be affected by Program features.

There should be no effect on the cultural resources of the Colorado River Basin as a result of construction and operation of the Program.

17. Energy Consumption

Construction and operation of the CRWQIP will require consumption of electrical power and other forms of energy.

Gasoline, oil, and diesel fuel will be consumed during the construction process by various types of vehicles. No estimates are available as to the quantity of fuels that will be consumed for the individual units. The impact of fuel consumption is not considered substantial as it is dependent on the availability of the product in an open market, free enterprise system and represents the basis for which the fuels were originally produced.

Electrical energy will be required to operate desalting plants and pumping plants to be constructed under the various features. Power to operate units constructed in the Upper Colorado River Basin will be taken from Reclamation's Colorado River Storage Project (CRSP) whereas power for lower basin features will be purchased from public utility companies in the respective feature areas. Utilization of CRSP power for upper basin units will not result in curtailed deliveries to existing customers within the CRSP system.

The total cumulative energy consumption of planned units under the CRWQIP is in excess of 100 million kWh/yr. This rate of energy consumption would require a powerplant operating at a firm capacity of 14 megawatts. In perspective, the level of energy resources required for salinity control will be very insignificant when compared to other electrical power requirements in the West; e.g., recent data published by the Western Systems Coordinating Council (WSCC) show that the installed electrical generating capacity for the 11 western states as of December 31, 1974, is nearly 82,000 megawatts.[35] The projected generation capability necessary to serve these states during the next 20 years is shown in the following tabulation:

Calendar year	Peak-load* MW	Generating capability** MW
1984	108,000	144,000
1985	116,000	154,000
1986	122,000	162,000
1987	129,000	169,000
1988	136,000	176,000
1989	143,000	183,000
1990	151,000	190,000
1991	159,000	202,000
1992	167,000	211,000
1993	176,000	222,000
1994	185,000	233,000

* Net firm December peakload less any firm transfers into WSCC from areas outside of WSCC.

** December generating capability (not reduced for scheduled maintenance).

Operation of the CRWQIP will cause a maximum of 116,370 acre-feet of water to be removed from the Colorado River System annually principally through evaporation. Removal of this water represents a theoretical loss of approximately 110 million kWh per year of potential hydroelectric generation if this water had passed through the river's system of dams. The average amount of hydroelectric energy generated in the river system has approximated 10.6 billion kWh per year. Hence, the anticipated maximum loss of hydro potential energy due to CRWQIP represents about 1 percent of the capability of the system.

18. Minerals

At the present time it has been found uneconomical to recover the salts which would be collected in the project evaporation ponds. A possible future potential may exist in the recovery of some minerals from the salts deposited in these ponds. Limited commercial use is now made of salts extracted from the Paradox Valley. Brine is used in the Union Carbide Company's uranium processing plant at Nucla, Colorado and as a drilling fluid for oil exploration in the vicinity of the project. Although not within the Colorado River Basin, minerals have for some time been recovered for commercial use from the Great Salt Lake, in Utah. It is unknown at present, the extent of mineral recovery that could economically be made or when this would occur.

Some chemicals will be needed for the pretreatment processes in the desalting plants, principally lime and soda ash. The use of these and other chemicals will result in the depletion of minerals required for development of the chemicals, but on the other hand will increase the activity of industries to produce them.

The creation of evaporation ponds would prevent the mining of minerals from the area covered by the brine. At the present time there are no known potentials for mineral excavation from the evaporation pond areas with the possible exception of sand and gravel and possibly some carnotite or uranium ore in the Paradox Valley area. A few active mines are located on the mesas around the periphery of Paradox Valley and a few undeveloped claims have been found in Dry Creek Basin near the proposed site of the evaporation pond.

19. Noise

Construction and operation of the CRWQIP will contribute significantly to any potential noise pollution of areas of the Colorado River Basin.

Temporary noise pollution will occur throughout the construction period of each unit. Construction noise will be a factor in the displacement of wildlife that may occur at individual units.

After construction, those features that have desalting facilities or pumping facilities will experience some local noise, generally as a low hum. This noise will only be experienced with a maximum of 200 feet of the feature.

At no time during construction or operation of the project are noise levels expected to be high enough so as to be uncomfortable to human beings.

B. Impacts of Authorized Features

1. Initial Control Units for Construction

a. Las Vegas Wash Unit. - The impacts described herein will have their greatest affect on Las Vegas Valley in Clark County Nevada. The following discussion is intended to describe local impacts of both construction and operation of the Las Vegas Wash Unit.

(1) Local economic resources[57]. - The project will directly impact Las Vegas Valley employment and incomes through local labor and products and services purchased for project construction and operation. Up to about 50 construction jobs could be potentially developed during any one year of the 5-year construction period. Local payrolls for the same time period have been estimated at 8 to 10 million dollars. About two new permanent jobs would be created following completion of the project. In the Las Vegas Valley area, there exists a multiplier effect of basic industry jobs. This is reflected in the requirement of 1.54 support jobs for each basic job created. Therefore, the actual effect of project completion and operation could be about five permanent jobs created. However, these jobs and the construction and operation purchases would be minor relative to the overall economic activity in the area. Regardless of whether or not a salinity control project is constructed in Las Vegas Wash, the economic growth in Clark County is estimated to proceed at least through 1990 with per capita income remaining higher than the national average.

Construction of a second-stage desalting plant after the turn of the century would probably create an opportunity for construction employment similar in magnitude to that of the first stage. Completion and subsequent operation of a desalting plant could create up to 44 new permanent jobs with an annual present worth of $632,000 in salaries. Adding the areas current 1.54 multiplier would result in about 68 new jobs. The overall effect of these jobs in addition to local purchases and salaries during construction would probably be less significant in year 2000 than the first stage will be currently due to the magnitude of expected economic activity and growth projected for the Las Vegas area.

Construction of the proposed project would remove over 800 acres of private land from the county's taxable property base. The land is currently undeveloped and remote in relation to other developed areas and, therefore, does not constitute a significant source of income for the county.

It has been determined that there is a 24 percent probability that the land use for brine disposal would be fully developed by year 2000 if it were not to be used for brine water evaporation and a 76 percent chance that no development at all would occur at the site even if it were available for development. Alternatively, there is a 48 percent probability that half of the site would be developed by year 2000 and a 52 percent probability of no development at all. The corresponding probabilities of full development by 1980 and 1990 are 5 percent and 11 percent, respectively, based on expected demands for use of the site by those years. It has also been determined that even with the maximum population projections the impact of the project on these lands would cause less than an 8 percent reduction in the population growth of the city of Henderson.

Under the projects first stage operation, the composition of precipitated salts in the brine evaporation ponds would probably be similar to the current distribution of salt in water collected at Pabco Road. The average percent by weight distribution of salt in samples taken from May through July 1975 are as follows: Sodium, 24 percent; potassium, 1 percent; calcium, 15.5 percent; magnesium, 9.6 percent; bicarbonate, 9.1 percent; chloride, 17.6 percent; and sulphate, 23.2 percent. Principal compounds would be calcium and magnesium sulphates and sodium chloride salts. It is doubtful whether any economic importance could be attached to these substances at the present time.

(2) Land use. - The impacts on land use of the Las Vegas Wash Unit will be primarily related to excavation, access roads, materials storage, equipment movement and service areas. In addition there will be a permanent commitment of over 700 acres to project features. These impacts are itemized below.

Borrow Areas

Project construction within areas containing inadequate or unsuitable earth materials for backfill or roadbed purposes will require excavation of adequate materials from borrow areas. Borrow materials are available from existing commercial facilities or from sites previously used during the construction of the first stage of the Southern Nevada Water Project. Borrow from impervious backfill could be obtained from a site described in chapter II. The area is near existing source material excavation in a sparsely vegetated creosote community. Fine surface silt contributes to blowing dust. Excavation of clay materials would not significantly increase blowing dust, however, the excavated pits would be subject to filling with seep water that could present a potential health hazard if mitigation measures were not implemented. Such measures are discussed in chapter IV.

Access Roads and Construction Camps

Access roads will be necessary to facilitate construction work and to allow safe travel of construction personnel. Existing roads in the project area will provide general access for most activity areas. Approximately 10 miles of new road would be required during the construction period. These roads along with the pipeline rights-of-way will utilize about 61 acres of desert habitat (primarily creosote bush community) and about 7 acres of desert riparian habitat. The effects of this activity will change the use of this land from wildlife supportive to unsupportive and barren until vegetation is able to naturally reestablish itself.

Due to the close proximity of Las Vegas, Henderson, and Boulder City with their attendant services, no construction camp will be established. A temporary, small field office may be required for field headquarters, maintenance and live-in security guard quarters. Such an office, if required, would use an estimated 1 to 2 acres for about 2 years.

Waste Material Disposal

Excavated material in the evaporation pond site would be used for embankment with no disposal required. Material excavated during construction of the pipelines would be reused as compacted backfill. Any excess not used for backfill or for road construction would be evenly distributed over the 53-acre right-of-way area. The principal type of land affected would be that currently supporting the desert creosote bush community. Material excavated from the cutoff trench would be largely reused as both pervious and impervious compacted backfill as described in chapter I, or as fill and topsoil for the desalting plant site. Any remaining waste material could be spread over the 8-acre area used for temporary storage as described below. The placement of all disposal material will be in accordance with Reclamation policy and local regulations with any adverse impacts mitigated as described in chapter IV.

Storage of Materials

An 8-acre site of primarily salt bush community immediately downstream of the proposed interception facility and south of the current channel could be used for temporary storage of material excavated from the cutoff trench. Use of the area would destroy existing vegetation and displace wildlife from the area. The 8 acres represent 2 percent of this type of habitat in the wash study area as shown in chapter II (fig. II-5).

Equipment Storage and Service Areas

The storage and servicing of construction equipment and related temporary buildings will probably be established in the field office area. Some equipment maintenance may be performed in other areas as well. These areas will generally be located near or within project rights-of-way. Service areas will disrupt the environment with continual activity, noise, and problems associated with repair and maintenance of heavy-duty equipment. Although the contractor will be required to control spills and dispose of waste products in accordance to Bureau, State, local and other applicable regulations, the nature of maintenance activities are such that oil, diesel fuel, grease, and solvents may be spilled on the ground. The land area affected by these waste products would be small, but the adverse influence they would have on the reestablishment of vegetation would last considerably longer than the 2-1/2-year duration of the service areas themselves.

Service areas are esthetically displeasing. This visual impact would exist for the duration of the construction period. However, normal traffic along Lake Mead Drive would only be in visual contact with the interception facility site for about 1 minute at the speeds normally used on this road. The same area is traversed by a 500-kV transmission line, and is flanked by former mining operations of the Three Kids Mine which would tend to lessen the specific esthetic impact of project construction.

Service areas for construction of the evaporation ponds will either not be visible from existing highways or will be incorporated near existing service areas in the vicinity.

Erosion of Disturbed Areas

The project area and surrounding region are replete with evidence of the processes of erosion. Land forms in this area are particularly susceptible to the influences of water and wind. Desert winds and summer thunderstorms are often intense, and flash floods of various magnitude are common. Because of this natural phenomena, any disturbance to soil structure, such as might be caused by heavy equipment movement or excavation magnifies the erosion potential.

Permanent Project Features

Following completion of the construction period the nearly 53 acres of land required for pipelines will be allowed to return to a natural state except for about 12 acres that would be used as an operating road for occasional inspections. The amount of time required for these areas to revegetate is unknown.

Although much of the 20 acres of riparian and 8 acres of salt bush and their associated habitats will be removed during excavation of the interception facility it is anticipated that this major construction impact will be temporary. The surface of the compacted backfill will require protection from floodflows as described in chapter I. This is to be accomplished by covering the surface with riprap. Since this protective surface will be at ground level, the voids of the riprap will be saturated and will, with time, fill in with sediment. Phreatophytes and hydrophytes will find this area a suitable growth medium and it is expected that vegetal encroachment will begin almost immediately following construction completion. Eventually, the construction scar would be nearly obscured with vegetal growth. The time required for this growth to occur will depend on flow and nutrient conditions.

The 21 acres required for the access road to the interception facilities, the transmission line, and the desalting complex will be permanently committed to new use.

Approximately 625 acres will be committed to the evaporation pond. This use would preclude the use of the land for other purposes. Desert creosote brush habitat would be lost.

Minerals

Alluvial fan deposits are the primary source of sand and gravel in Las Vegas Valley. These areas total about 327,500 acres in the Valley not counting those areas that have been developed for M&I purposes. Although there are no plans to develop this type of resource in the proposed evaporation pond area, construction of the ponds would remove 0.18 percent of the potential source of sand and gravel in the Valley.

(3) Social aspects[57]. - The impacts of the Las Vegas Wash Unit on the cultural and social fiber of the Las Vegas Valley area are presented in three general categories: (a) social functions, (b) social sectors, and (c) social aggregations. Definitions of these categories are presented under their separate headings.

(a) Impacts on social functions. - Water projects are designed to fulfill certain goals or functions which directly relate to the social aspects of man's culture. A brief analysis of the impacts of the Las Vegas Wash Unit on some of these functions is described below.

Transportation. - State Highway No. 41 is one of three roads providing access from the Las Vegas-Henderson area to the Lake Mead National Recreation Area. As such, it carries a heavy traffic load that is particularly pronounced on weekends and holidays. Movement of construction vehicles along, on-off, and in the vicinity of a major thoroughfare can disrupt, distract, and impede the normal flow of traffic. Such a disturbance greatly increases the potential traffic hazard.

Life Support. - The major impact of the project on this function lies with the projects capability to provide potable water for Las Vegas Valley. At the present time, surfacing ground water, while providing for the natural enhancement of the Wash "green belt," does not serve to increase the potential beneficial water supply of Las Vegas Valley, since return credit from Nevada's average annual allocation of water from Lake Mead is not presently granted. This credit for return flows will become critical in the future as Nevada's use of Colorado River water begins to approach it's annual entitlement of 300,000 acre-feet. The quality of the 16,200 acre-feet of product water from the desalting plant may have some added value as a potential beneficial source of water.

Security. - The existence of a 625-acre evaporation pond would pose some danger to pond visitors in terms of the potential of drowning accidents, which would still exist even though the ponds would be fenced. The proximity of the city of Henderson to the ponds makes them fairly accessible to youngsters on bicycles.

Production in agriculture. - Since agriculture is not considered a major aspect of the Valley's commercial output, either presently or in the near future, desalinization impacts are considered insignificant.

Downstream effects of salinity control would appear to be significant. A very complex relationship is involved in relating salinity of irrigation water to crop yield. Major factors involved are soil conditions, crop type and variety, drainage, climate and irrigation practices. Many high-valued crops are grown with Colorado River water. Generally such crops have a low salt tolerance, thus yield is repressed by the salinity. The improved salinity of downstream waters resulting from project operation would enhance the production of these crops.

(b) Impacts on social sectors. - While the foregoing evaluates the impacts of the Las Vegas Wash Unit on various functions typically served by water projects, this section pursues a different perspective, that of the social sectors which comprise a community and which serve as separate foci of public interest and concern.

While it is obvious that the Las Vegas Wash Unit may only remotely affect some social sectors, most social sectors of importance are presented, both to confirm the presence, lack of, or insignificance of possible impacts and to take note of these impacts which, while relatively small and perhaps also quite indirect, join with other such impacts to be important in the aggregate.

Education. - Because of the size of the education sector alone, if not for other reasons, any water project which significantly affects the community or community attitudes in almost any form can be expected to affect education. The proposed project with its relevance to pollution, conservation, and natural resources, will probably be discussed at many levels of education. When completed, the second-stage desalting plant can be expected to be visited by student groups, and its functioning and impacts can be expected to be the subject of study and research by students at the higher levels of education.

Economic base, employment, and income. - The project will directly impact Las Vegas employment and incomes through local labor and products purchased for project construction and operation. Such purchases will be minor relative to the overall economic activity in the area as noted under "(1) Local Economic Resources" discussed previously.

Housing and neighborhoods. - The evaporation ponds of the project will remove land near Henderson from potential development. The land areas involved could accommodate approximately 4,000 persons at the 0.151 acres per person land use ratio employed by the Clark County Regional Planning Council in its land use projections, net of rural and suburban land uses. As established in the section on "Land use" however, there is only a 24 percent probability that this land would be fully developed by year 2000 even if it were available.

Housing that might have been constructed at the evaporation ponds will be shifted to other parts of Henderson and elsewhere in the valley. This impact would not involve more than 8 percent of the projected population of Henderson.

The social sectors of health, law and justice, communications, and social services will not be impacted significantly.

(c) Social aggregations. - To comprehend the full significance of socioeconomic impacts of such general nature as that in regard to pollution, conservation and related attitudes people have concerning themselves, their community and frequently also their position in the community, it is necessary to provide a basis for aggregation. These are: (1) the quality of life; (2) social well being; and (3) relative social position. These logical aspects do not lend themselves readily to quantitative analysis of impacts or effects. The inability to make quantitative analyses does not mean that such aspects cannot be used on the basis of qualitative considerations which have their own values. For example, it may not be possible to measure the impact of the project in terms of a percentage improvement in the quality of life of impact area residents, but it is still useful to know that there will be an improvement and that this improvement can be important in the overall determination of the quality of life in a community.

Quality of Life

As used here, the quality of life is oriented toward the individual and family. It embraces those social goals which have personal meaning for most people, such as good health, a reasonable standard of living, healthy development of children, a happy family life, a decent home and neighborhood, peace of mind, recreation and, perhaps above all, a confidence in community stability as it impacts on individuals and families.

When aggregated into effects on the quality of life, the relatively small positive effects of the project plan on several social functions and sectors make a significant contribution on community stability as it impacts on individuals and families.

Social Well-being

While the quality of life is an aspect expressing the degree to which individuals and families can enjoy their lives on a personal basis, social well-being is evaluated at a step higher in the level of aggregation. It is the expression of social values at the level of the community and its constituent groups. Social well-being therefore is concerned with the viability and stability of organizations and institutions in the community, including both private groups such as business organizations, governmental entities to include those at all levels and in all types of activities including education, nonprofit organizations, hospitals and all other examples of human organization in social or economic purpose.

Aggregation to the organizational level, i.e., the level of social well-being, brings into focus the melded impacts, positive or negative, of the project. Institutions are generally strengthened by successful community action and particularly by realization of community objectives which have widespread public acceptance. To the extent that the project is successful, it would serve as a builder of the strength and continued viability of social organizations and social well-being.

Relative Social Relationships

Evaluation of project impacts can be completed with a view from the perspectives of social groups in different financial and social status, i.e., the wealthy; the middle class; the disadvantaged by race, age, educational disadvantage or other cause; and other groups whose common circumstances have led to their identification as groups in different social relationships and position than the majority of those in a community.

The project is not expected to have any significant impact on relative social relationships.

(4) Archeological, historical, and cultural. - The archeological survey which was conducted by the Nevada Archeological Survey, Southern Branch, located a total of 4 historic and 40 archeological sites within the overall project area.

The historic sites include two recent dumps, one associated with a mining complex, and the other recently used by the city of Henderson, Nevada. The remaining two historic sites include a house foundation and the remains of a stone walled structure of unknown age and function. The latter site (26 CK-1277) will be affected by construction of the subsurface interception facility. The recent city dump 26 CK-1279 will be affected by the brine pipeline from the desalting plant.

The other dump will not be affected. The historic house foundation is near the interception facility and desalting plant.

Of the 40 archeological sites, 27 are considered to be fragile as they consist of surface remains such as stone sleeping circle rings, and are very susceptible to damage or disturbance. The remaining 13 archeological sites contain features such as rock shelters, artifact concentrations and rock alinements.

A total of seven archeological sites will be affected by the project. The brine pipeline from the desalting plant will pass through a portion of sites 26 CK-1120 and 26 CK-1140. The interception facility and pipelines to the desalting plant will affect portions of sites 26 CK-1282, 26 CK-1138, 26 CK-1120, 26 CK-1126, and 26 CK-1139.

The final report of the archeological survey outlines suitable mitigation measures to be carried out for any significant sites which will be affected by the project. It also provides data for evaluating the significance of the cultural resources in terms of eligibility for nomination to the National Register of Historic Places in accordance with 36 CFR 800.

Since Nevada's State Historic Preservation Officer does not have authority to evaluate cultural material for nomination, the entire final report of the survey has been sent to the National Park Service in Washington, D.C., for proper evaluation of the resource.

(5) Air, noise, and visual impacts. - During construction of the project some increase in local air pollution levels will be noticed, particularly during periods of high winds. Blowing dust is inherent in construction activities that require moving substantial volumes of earth, such as that required for constructing the evaporation ponds. The volume of particulates to be introduced into the local atmosphere will be a function of the wind velocity occurring at any given time. During periods of high wind (20 to 30 mph) localized blowing dust could be substantial. The localized increase in oxidents and other products of combustion from construction equipment are expected to be minimal and insignificant relative to prevailing conditions. Chapter IV will discuss methods and procedures construction contractors will have to follow to avoid excessive dust problems.

However, relative to existing conditions during high winds, construction activities are not expected to be too significant. Since the Wash is the air drainage corridor from Las Vegas Valley, most particulates would be dissipated in remote areas away from municipal development.

During construction operations, noise levels will increase substantially over what they presently are. The local area presently has no development and noise is not considered a problem. The use of heavy construction equipment and other activities by workers will increase noise levels in the area and will contribute to the temporary displacement of local wildlife. Impacts from noise will be temporary and will discontinue after construction is completed. Noise levels will not reach a point that would be harmful to people working in the project area.

Noise levels in the project area after construction will be higher in the vicinity of the pumping plant. The noise level to be expected will be on the order of a low hum which may prove objectionable to some wildlife reoccupying the area. Noise levels from project operations will not be harmful to humans. The buildings are expected to make pump noise unnoticeable 200 feet away, adding only slightly to the ambient noise level.[63]

Construction of the project will require clearing of over 700 acres of land for project facilities. This clearing will cause an esthetically displeasing appearance initially. Those lands cleared in the wash area will revegetate in a few years but construction scars made through desert lands will be long term and revegetation will be slow. The very existence of physical structures and necessary peripheral construction in or near that which is now considered a greenbelt area, could be considered detrimental to the Wash as both a natural and potential recreational area in that man-made structures are not always viewed as complimentary.

The complex will not be readily visible from local highways and visual impacts will not be felt by many people.

An exception to this would be one family residing adjacent to Lake Mead Drive about 1-1/2 miles south of the project facilities. Their location would be just west of the proposed access road and they are visually located to observe the activities of both construction and operation. All impacts relative to noise, dust, and visual esthetics would be more keenly felt by this family due to their location.

The evaporation ponds to be constructed may have a visual impact, particularly for those traveling by air overhead. As the waste brine evaporates it may leave a white stain around the edge of the water surface of the pond as the water level fluctuates. The ponds will not be readily visible from ground level as they will be surrounded by earthern berms, but they will be visible from the air. Commercial aircraft using McCarran International Airport to service Las Vegas often make their approach over Las Vegas Wash and the evaporation ponds would be visible to them.

(6) Vegetation. - The structural features of the Las Vegas Wash Unit are to be constructed through a number of vegetal communities existing in and adjacent to the wash. A total of 700 acres of land will be subjugated for project features affecting principally portions of the creosote bush, saltbush, barren, and marsh communities. The interception facility and collection system which includes the intake pumping plant will require clearing 20 acres of land for construction affecting principally the saltbush and marsh communities. Impacts from this clearing will be temporary as the area involved should revegetate within a few years.

An access road to the complex from State Highway No. 41 will require about 15 acres, principally in the saltbush community, but will generally follow an existing, well-traveled dirt road. Permanent operating features will preclude vegetation reestablishing itself.

Construction of the evaporation ponds will require 625 acres of land in primarily creosote-brush community. Based on the experience of the existing evaporation ponds located to the south of the proposed new ponds, some vegetation, probably representative of the saltbush community, will establish itself on the periphery of the ponds but 90 to 95 percent of the area subjugated will remain void of vegetation during project operations. Approximately 53 acres of land will be required for the bypass, brine and intake water pipelines traversing saltbush, creosote bush, and transitional riparian communities. The pipelines will be covered with the area allowed to reestablish itself naturally with the exception of an operating road. The vegetation in the saltbush community is expected to reestablish itself within a few years whereas the other communities may take many years to return to their former state.

Emergent vegetation along the periphery of the ponds may temporarily contribute to mosquito breeding, although the effect would be minor compared to the potential within the Wash itself.

Throughout the planning process and public involvement program for the Las Vegas Wash Unit and the county's attendant proposal to treat domestic wastes at the advanced wastewater treatment plant, the public has expressed a fear that the emergent greenbelt of the Las Vegas Wash would be lost as its water supply was removed. It is anticipated that the county will release advanced wastewater treatment plant effluent into the upper reach of the wash for maintenance of the wildlife habitat and recreational and educational values. A recommendation for the sustaining of the upper wash area was made to the Clark County Board of Commissioners by the Las Vegas Wash Development Committee on April 5, 1974, and again on January 21, 1975. All advanced wastewater treatment plant flows not required for maintenance of the wash would be bypassed around the ground-water interception system and would be used to maintain the lower reach of the wash.

(7) Fish and wildlife. -

(a) Fish. - A biological inventory of Las Vegas Wash indicated that four species of fish may be found in

Las Vegas Wash. They included the goldfish, carp, mosquitofish, and bluegill. In each case it was indicated their occurrence was rare. Construction and operation of the project in conjunction with operations of Clark County's proposed advanced wastewater treatment plant will reduce the volume of water passing through the wash. However, this reduced volume in the upper wash will not adversely affect fish habitat; this is already very poor. The unit is not expected to have any significant effect on the aquatic habitat of Las Vegas Bay of Lake Mead. The improved quality of water in the wash downstream from the project features may result in the establishment of a greater variety of fish species in this reach.

(b) Wildlife. - During project construction, any habitat destruction will affect wildlife. Behavioral patterns of wildlife that utilized the area near the main complex will be the most affected. During construction, wildlife will tend to avoid areas of human activity.

Some amphibians will be disturbed during construction of the interception facility but these impacts should be temporary as the area will rapidly restore itself after completion.

Construction of the main complex, the brine and bypass pipelines, and the evaporation ponds will affect the habitat of some of the reptiles in the project area identified in chapter II. Habitat loss for the complex and evaporation ponds will be permanent while restoration of habitat over the buried pipelines will take many years to occur naturally.

A total of 252 species of birds are known to utilize the wash on either a seasonal or year-round basis. The type of use, i.e., nesting, cover, feeding, is noted in appendixes. Construction activities will alter use patterns of birds in the area of the facilities but the disturbances should be temporary. Subjugation of 700 acres for project facilities will eliminate that much habitat, which may not be significant when compared to the 13,960 acres of habitat available in the study area of the wash.

There is a possibility that shore birds and waterfowl which inadvertently utilize the brine ponds for nesting areas may be covered with salt. This could result in bird mortalities as salt accumulates on feathers and restricts mobility.

(c) Endangered species. - The biological inventory conducted by the Department of Biological Sciences, University of Nevada at Las Vegas, identified the endangered brown pelican, Southern bald eagle, and peregrine falcon as possibly utilizing the wash on a migratory basis. Construction and operation of the project should not curtail or impair use of the wash by these species.

(8) Recreation. - As indicated in chapter II, recreational use of the wash is multifaceted and principally unregulated. Construction and operation of the project will curtail recreation use in the area of the project features. No estimate of man-days of recreation lost is available.

Concern over recreational use of the wash has been expressed by the general public for sometime. The various types of use have in the past come into conflict with each other because of incompatibility, i.e., hunting versus picnicking, hiking or off-road vehicle use. Chapter IV gives an expanded discussion of some of the recreational concerns of the general public and how they might interface with this project.

As a summary of the forgoing impacts, the following tabulation indicates the principal ecological impacts of the project.

Tabulated Ecological Impacts
Las Vegas Wash, Unit

Habitat type	Acres disturbed*	Percent of habitat**	Principal type of permanent wildlife affected***
Creosote	43-T	0.4	Reptiles, birds, mice, squirrel, badger, rabbit, bat
	186-P	1.9	
Saltbush	8-T	1.9	Bird, mice, squirrels
Desert riparian	4-T	0.8	Reptiles, birds, mice, rabbit squirrels, badger, coyote
	7-P	1.5	
Riparian cliff	N/A	N/A	- - - - - -
Transitional riparian	9-T	0.5	Bats, mice, skunk, reptiles (particularly the Yucca night lizzard, red racer, gopher snake, and sidewinder)
	535-P	30.0	
Barren	3-T	0.7	Reptiles (particularly chuckawalla lizzard), mice
Urban	N/A	N/A	- - - - - - - -
Marsh	7-T	0.6	Frogs, toads, water birds, mice, skink, bats
Open water	Temporary turbidity downstream may have a temporary effect on few fish and water birds.		
	625-P	0.0	Create ponds that may serve as resting and escape areas for migrating waterfowl for up to 5 to 10 years.

* T-Temporary, P-Permanent
** Percent of Study Area
*** Those specifically mentioned are common to abundant in specified communities. See appendixes B-3 (Amphibians), B-5 (Reptiles), B-7 (Birds), B-9 (Mammals).

(9) <u>Water supply and quality</u>. - The Las Vegas Wash Unit is designed to reduce the salt contribution of the Las Vegas Wash to Lake Mead and the Colorado River resulting in an eventual improvement in the water quality of the river system. During construction there will be some increase in turbidity and sediment transport due to excavation activities in the wash. This increase will extend throughout the construction period of the interception facility. There will not be any permanent adverse effects.

The removal of salts from wash flows is not expected to have a material influence on algal blooms in Las Vegas Bay of Lake Mead. The algae problem that has occurred rather frequently in the lake is more closely related to the nutrients in sewage effluent. Construction of the Clark County AWT Plant would reduce the amount of phosphorous and other nutrients that contribute to the algae problem.[58]

Depletions to the Colorado River will amount to 3,600 acre-feet for the first stage and will decrease to about 1,450 acre-feet under the future second stage. These annual depletions and other developments in Las Vegas Valley were analyzed by the simulation model discussed in chapter II. When these results were evaluated in accordance with the probable future upstream developments as set forth in the Department of Interior's biennial publication "Quality of Water, Colorado River Basin - Progress Report No. 7" dated January 1975, the following results were noted:

Future Water Quality Effects of Las Vegas Valley Development (mg/l)	1980		1990		2000	
	H	I	H	I	H	I
First-Stage SNWP	5	8	7	11	10	16
Second-Stage SNWP	0	0	5	8	13	20
Total SNWP (First and Second Stages)	5	8	12	19	23	36
NPDES Permits	0	0	-6	-7	-4	-7
First-Stage Las Vegas Wash - CRBSCP	0	0	-4	-4	0	0
Second-Stage Las Vegas Wash - CRBSCP	0	0	0	0	-8	-8

Note: SNWP = Southern Nevada Water Project
H = Hoover Dam
I = Imperial Dam

(10) Energy consumption. - Operating facilities for the Las Vegas Wash Unit will be by electric power. The first stage will require an estimated 3,575,000 kWh per year. After the addition of the second stage, the energy requirement will be 68,155,000 kWh per year.

The relationship of this energy use is best described in comparison to the peak demand for electric energy provided by the Nevada Power Company, the principal supplier in the southern Nevada area. This company will also supply the energy for the desalting plant. During 1975 the peak demand was 1,007 megawatts. The energy required for the first stage of the Las Vegas Wash Unit would amount to .04 percent of this total demand. Projecting to year 2000, this percentage would increase to about .28 percent of the companies expected demand.

b. Crystal Geyser Unit, Utah.

(1) Local economy/resources. - The impact on the local economy from development of the Crystal Geyser project would be minimal. No formal attempt would be made to enhance the facility as a tourist attraction, which is the only way the project could significantly affect the economy. Some increase in tourism, however, might result, as a side benefit, from the proposed road improvement which would provide tourists easier access to the geyser. The dike around the geyser would be formed by a compacted earth embankment, and the pond lined with a plastic membrane to prevent seepage.

Other temporary economic impacts would result during construction. Construction manpower would purchase materials, housing, and other goods and services in Green River, Utah or nearby areas. Some employment opportunities would also be created. In addition to construction materials, fuel and lubricants would be used in the operation of equipment and travel to and from the project.

(2) Land use/cultural factors. - About 160 acres of land will be affected by construction of the evaporation pond while about 2 acres will be affected during construction around the geyser. The evaporation pond is located about 3 miles from the geyser. Except for limited cultivation, none of the land in the area affected by the project is presently used. Wildlife inhabiting the area is sparse and therefore wildlife losses would be negligible. The

project will have no significant effect in the cultural patterns of the area.

(3) Social aspects. - The impact on humans would be significant only during construction of the project when some employment opportunities could be available to local residents, and some demands created for local goods and services. Following construction, the impact on local residents would be reduced to occasional visits from tourists or operation and maintenance forces passing through the area.

(4) Archeological and historical. - Construction of the evaporation ponds will affect three archeological sites. These sites were discovered within the boundaries of the proposed evaporation ponds in a preliminary survey made by the Utah State Historic Preservation Office. The State office had been contacted to make the survey upon referral by the National Park Service. These sites are probably archaic in cultural affiliation based on the presence of an Elko Side-notched point, several large point fragments and the total absence of pottery. Based on the data available none of the sites appear to be of National Register quality. Prior to construction, the Bureau of Reclamation will follow the procedures in 36 CFR Part 60, 63, and 800.

(5) Air, noise, visual impacts. - After completion of construction work, no additional impacts will result to the air quality or noise.

The evaporating ponds with salt encrustations or deposits might be unsightly at certain times of the year.

(6) Vegetation. - Some sparse vegetation in the geyser area will be destroyed by the dike and by earthmoving equipment used for construction. Up to 105 acres of sparse vegetation in the evaporating pond area will also be destroyed by the brine and pond dike. A 1.3-mile reach of pipeline, that will convey water from the geyser to the lined evaporation pond, will be buried under the unsurfaced country road. The area overlying this portion of the pipeline trench, therefore, will not require revegetation. The remaining 1.7 miles of pipeline with a 32-inch-wide backfilled trench would create limited landscape disturbance. The arid nature of the area greatly restricts vegetative growth to the extent that this narrow band of landscape

disturbance would hardly be seen. Any attempt to revegetate by transplanting and possibly sprinkler irrigation would create an unnatural green strip. With the elimination of the saline flow to the Green River, some willows and other vegetation may grow along the banks where they are presently denuded. Otherwise, there will be no effect on vegetation.

(7) Fish and wildlife/recreation. - Several species of minnows, suckers, and catfish occur in the Crystal Geyser area. The endangered Colorado squawfish and humpback chub were reported in the literature to occur within the Green River in the Crystal Geyser area. The decrease in salt from the Crystal Geyser may have a small immediate beneficial effect to fish life where the discharge is now entering the Green River. Otherwise, effects to fish life will be negligible because of the small amount of salt and water involved when compared to the total in the Green River. The salt load from the geyser amounts to only 0.12 percent of that in the Green River at Green River, Utah, and the flow is only about 0.004 percent of the flow of the Green River.

From the biological investigations conducted by Brigham Young University, it was determined that the effluent of the Crystal Geyser has little or no detrimental effect on the macroinvertebrate populations of the region of Green River below the point where the mineral-laden waters of the geyser enter. This is due to the infrequency of eruptions and the rapid dilution of the effluent in the Green River. There will be negligible change with control of the discharge from the geyser.

The American peregrine falcon is the only endangered wildlife species reported in the literature to occur in the proposed project area. No nesting sites exist in the vicinity of the project. The overall impacts of the project upon the various species of wildlife (includes amphibians, reptiles, birds, and mammals) is expected to be negligible.

Recreation might increase with development of the site as a tourist attraction due to the access road improvement as described previously under "Local economy/resources."

(8) Water supply and quality. - The present geyser discharges are so widely separated and small compared to the

Green River itself that the flow difference in the river between the present conditions and those with the geyser controlled would be extremely small. The geyser flow is about 150 to 200 acre-feet per year as compared to about 4,000,000 acre-feet per year in the Green River at Green River, Utah.

The removal of about 3,000 tons of salt from the Green River would reduce the total dissolved solids concentration of the Colorado River at Imperial Dam by about 0.3 mg/l.

An adverse effect would be the loss from evaporation of about 150 to 200 acre-feet of water annually. Present Utah water laws require evidence of beneficial use to establish water rights. An interpretation of whether or not this water use is beneficial should be determined by the State of Utah.

2. Other Control Units for Construction

a. Paradox Valley Unit, Colorado. -

(1) Local economic resources. - The construction of the project would temporarily increase economic activity in and adjacent to the project area. The total cost of construction can be categorized into materials, equipment, freight, labor and miscellaneous items. Approximately $5,000,000 would be spent for materials and equipment used in construction. It is estimated that 40 percent, or $2,000,000, would be spent in Colorado.

Salaries paid to contract labor will result in a payroll estimated to be about $3,220,000. Assuming a 3-year construction period, annual take-home pay would average $539,000. This would temporarily increase employment opportunities and the standard of living within the trade area of Paradox Valley.

Sales tax revenues (that portion of the total tax collected by the State and returned to the local area) would increase. The assessed values of personal properties would increase as a result of new families living in the area. Assessed values of commercial and industrial machinery used by the contractor and subcontractor would also be added to the tax rolls.

Miscellaneous cost would be approximately $3,000,000, consisting of land and rights-of-way and other expenses. Much of this would be spent in the local area.

Project operation would not have a significant effect on the local economy. The evaporation pond would gradually remove about 3,375 acres of land now used for the late winter and early spring grazing in Dry Creek Basin.

The Bureau of Land Management's estimated carrying capacity is .05 Animal Unit Months per acre in the evaporation pond area. Based on the 3,375 acres to be removed from grazing this would amount to about a 170 AUM loss in grazing which is minor with respect to the total rangeland in the area. Some of the high grazing land in Dry Creek Basin has a carrying capacity of 0.2 AUM's per acre, somewhat better grazing when put in perspective with the lower part of the Basin.

The project will not adversely affect the present status of economically valuable resources such as uranium now found in the area. Mineral extraction and processing would not be altered, nor would irrigated agricultural land. Some rangeland would be lost as a result of permanent structures, but grazing along the river would probably improve with the disappearance of the salt flats.

(2) Land use. - An estimated 6,000 acres of rights-of-way would be acquired for access, work areas, and permanent structural sites. The majority of this land is privately owned, and the remainder is administered by the Bureau of Land Management. Grazing would be eliminated during construction activities, but should be possible on much of the land after natural revegetation has occurred. The acreage occupied by physical surface structures would be permanently lost to nonproject uses.

Surveillance would be maintained by project operation personnel at all times to see that any breaks or leaks in the pipeline, pumping plants, dikes, or malfunctions of the hydrogen sulfide stripping plant would be repaired immediately to prevent excessive brine spills or releases of any hydrogen sulfide gas that may cause damage to the environment. In the event of a major leak in the pipeline or a failure in the hydrogen sulfide stripping plant, pumping would be closed down automatically to minimize the spills.

(3) Social aspects. - The impacts resulting from the influx of construction workers to the Paradox Valley area would be temporary. Employment during the 3-year construction period would peak at approximately 100 workers in the second year. The city of Naturita (population 820) is the most likely settlement location. Although Montrose County (population 11,353) experienced a high growth rate of 20.5 percent between 1960 and 1970, the western half of the county (population of about 4,000), which contains the project area suffered a high population decline of 27.7 percent. New demands for additional housing, sewage disposal, municipal water, schools, and medical facilities will be created. Some of these demands could be met by workers commuting from communities with existing available facilities. Since there are essentially no rental units available in the valley, arrangements by new residents would have to be made for new housing construction, mobile homes, or relocatable units. Present school facilities would need to be expanded as would municipal water, sewage treatment, and possibly medical facilities. Unfortunately, these demands tend to impact prior to provision of expanded facilities. A portion of the new jobs would be taken by permanent local residents (4.6 percent unemployed in 1973), and part by young people currently migrating out for opportunities elsewhere.

Only five long-term jobs for operation and maintenance will be created. The most significant long-term impacts to people will result from the use of improved quality of water by downstream water users.

(4) Archeological and historical impacts. - The area will be evaluated by an archeologist or other appropriate professional who will make a determination in consultation with the State Historic Preservation Officer. Their work will be an evaluation of cultural resources which would be affected by the proposed action and eligibility for inclusion in the National Register of Historic Places. Should such resources be found, the Bureau of Reclamation would mitigate the impact of the undertaking on any cultural resources found during construction and would follow the procedures outlined in 36 CFR 800.

(5) Air, noise, odor, and visual impacts. - The project would not alter the quality of air on a permanent basis. The electric power required for the pumps would amount to about 2,230 kilowatts, with 18.8 million kilowatt-hours

of energy which would be obtained from the Colorado River Storage Project; and, therefore, will not result in air pollution or additional noise, odor, or visual impacts. A salt flat would eventually develop around the evaporation pond during summer months. Wind-driven salt spray and loose salt crystals could degrade air quality in the immediate area. This, however, would occur only occasionally. The hydrogen sulfide stripping plant and facilities would be under constant surveillance to insure no escape of hydrogen sulfide gas if a malfunction or breakdown occurred. Failure in the hydrogen sulfide stripping plant could create an obnoxious stench which would require closing down the plant for repairs.

Local visual qualities would be impaired by the structural facilities of the project. Wellhead housings, transmission lines, and access roads would be visible in the riparian vegetation along the Dolores River. Since the brine pipeline to the evaporation pond would be buried, these visual impacts would gradually disappear as revegetation occurred. The transmission line along the pipeline from State Highway No. 90 to the last pumping station, figure I-6, would alter the scenery, although much of it would be obscured by the trees in the higher elevations. The selected evaporation pond would affect the natural, open range scenery of Dry Creek Basin.

(6) <u>Vegetation</u>. - Approximately 11 acres of riparian habitat and 4 acres of sparse desert vegetation would be permanently lost along the Dolores River as a result of the well field, collection system, access roads, and appurtenant facilities. An additional 12 acres of riparian vegetation would be disturbed during construction, but would return to its present condition after the completion of work. Since the wells would be drilled in successive stages, with intervening testing programs, the impacts would occur gradually. Figure III-1 shows the riparian habitat typical of the well sites on the west bank of the Dolores River.

The construction of the brine pipeline would remove about 52 acres of sparse grasses and sagebrush at lower elevations (fig. III-2) and about 10 acres of Pinyon pine and juniper woodland on the mesas between Paradox Valley and Dry Creek Basin. Since the pipeline would be buried, the vegetation would be naturally or artifically reestablished along the alinement. However, regrowth would be quite slow

West Bank habitat of the well site.

Figure III-2

Upper slopes of proposed evaporation pond site Dry Creek Basin.

Figure III-3

as a result of the semiarid climatic conditions. Very little habitat would be removed for the transmission line rights-of-way.

The evaporation pond would gradually inundate up to 3,375 acres of sparse sagebrush and grass (fig. III-3) during the life of the project. No vegetation would grow on the deposited salts and the loss would be permanent. It is possible that windblown salt could affect native vegetation in the immediate surrounding land, but the extent of this impact is not known.

Riparian vegetation along the Dolores River downstream from the project could be enhanced by the improvement in water quality. Under existing conditions, salt encrustations frequently build up along the stream channel and the adjacent lowlands, possibly inhibiting vegetative growth.

(7) <u>Fish and wildlife/recreation</u>. - The Dolores River is diverted above Paradox Valley mainly for irrigation which depletes the streamflows in the late summer months to almost a no-flow condition.

The main fish species that live in the Paradox Valley portion of the Dolores River are the red shiner, roundtail chub, speckled dace, and the flannelmouth sucker. These species have adapted to the erratic nature of the streamflows - high spring runoff, and very low flows during the summer months.

The flow pattern will remain essentially unaltered by the project. The reduction in salinity of the Dolores River may provide an improved habitat for the native species. The low-flow conditions will be essentially unchanged in the summer months and this aspect may be more significant to the population levels than salinity. It is therefore expected that the fishlife in the Dolores River will remain essentially unchanged by the project activity with a chance for slight improvement as a result of the lower annual salinity level. This improvement may be offset by the depletion of approximately 5 cubic feet per second due to the evaporation of saline ground water.

The well field, collection system access roads, and appurtenant facilities will utilize 11 acres of riparian vegetation and 4 acres of sparse desert vegetation. The evaporation pond would gradually remove 3,375 acres of sagebrush

Proposed site of the evaporation pond in Dry Creek Basin.

Figure III-4

and grass. The brine pipeline will remove about 52 acres of sparse grasses and sagebrush and about 10 acres of pinon juniper woodland.

The loss of 11 acres of riparian habitat (saltcedar, cottonwood, and willow) will have an effect on birds and other animal life that frequent the riverine environment. The ringneck pheasant is found primarily on irrigated lands in the western portion of Paradox Valley and in the dense habitat adjacent to the Dolores River. Since the 11 acres will be used for permanent facilities, this small loss of riparian habitat will be long term.

Other game birds such as dove, as well as raptors, also utilize riparian habitat for part of their life cycle. Again this small amount of habitat will be permanently lost and will be unavailable for nesting, roosting, and feeding areas. Riparian habitat also provides an important niche for a number of nongame birds and other animal life.

The upland habitat that will be disturbed by the pipeline and covered by the evaporation pond will reduce lands available to sage grouse, mule deer, coyote, and other forms of animal life. While the evaporation pond area is large, wildlife densities are low and the removal of this acreage for project features is not expected to be noticeable on population numbers. The pipeline will be buried, therefore, the habitat disturbance will be short term and the pipeline will not present a surface barrier to animal movement.

The evaporation pond will gradually fill with brine and will cover about 2,200 acres after 10 years.

The brine in the pond will be so salty (estimated at 312,000 mg/l after 13 years) that it will not be utilized by wildlife as a source of water.

The operation of the pumps will cause minor disturbance to wildlife species in the immediate area of the pumps. Routine operation and maintenance activity will also cause only a minor disturbance since the area where the pumps and roads will be installed is undeveloped.

Waterfowl may be attracted by the brinepond. Most of the present waterfowl use is located southwest of the project features in small ponds and in the agricultural lands. Studies are now being conducted to determine if accumulation of salt on the bodies on certain species of waterfowl together with temperature effects may result in restriction of flying ability and possible mortality.

With the reduction in salinity of the Dolores River, aquatic or emergent plant life should gradually increase in areas where high salinity levels have kept growth to a minimum.

The project area is not a major recreation area and most of the current recreation activity is by local residents. Such uses as hunting, hiking, horseback riding, and camping will be essentially unchanged by the well field and evaporation pond.

Hunting for pheasants, sage grouse, and deer will be temporarily impaired while construction activity is taking place on the wells and evaporation ponds.

If a portion of the Dolores River is included in the National Wild and Scenic River system, the designation alone would have a tendency to attract additional visitation use. It is doubtful if the inclusion of any reaches of the river would alter existing recreational opportunities in the area influenced by the project wells because of the very erratic nature of the streamflows and the agricultural development in the valley.

(8) Water supply and quality. - The quality of water in the Dolores River downstream from Paradox Valley would be substantially improved. The average annual salt concentration in the river would be reduced by about 502 mg/l immediately below the project whereas the average daily concentration would be reduced by about 9,430 mg/l. The average salinity of the Colorado River would be decreased by about 16.3 mg/l at Imperial Dam. This salt concentration reduction would result in an overall improvement of water quality which would have long-term benefits to downstream water users. Some of these benefits would be: (1) increased crop yields, (2) reduction of operation, maintenance, and replacement costs, (3) return to production of unproductive acres, (4) water and fertilizer savings due to reduced leaching, (5) reduced use of soap and detergents, and (6) reduced scaling in plumbing and reduced water softening needs.

The flow of the Dolores River would be depleted by approximately 5 cubic feet per second, or 3,620 acre-feet per year, due to the evaporation of saline ground water.

b. Grand Valley unit, Colorado

(1) Local economic resources. - Economic impacts would occur if the Grand Valley WSI program is built and the IMS program

now underway becomes a permanent program. Investigations are still in the early stages and firm data are not available at the present time. Indications, however, point to three significant local impacts: Reduced applications of irrigation water, increased crop yields, and economic effects due to construction and operation of the project.

Concrete lining of existing canals and laterals and construction of better and more permanent structures would not materially change the water distribution system in the Grand Valley. A few laterals would be combined which would mean that some open ditches would be filled in and leveled. After irrigation scheduling is in effect, there would be a change in the amount of water applied per acre.

Irrigators in the Grand Valley are now achieving about 33 percent efficiency in water use. Preliminary data indicate that with improved onfarm irrigation system and proper irrigation management a 60 percent onfarm efficiency could be reached. Based on a present diversion of between 7 to 8 acre-feet per acre applied to 57,000 acres, an annual reduction in diversions of approximately 128,000 acre-feet might be achieved.

There are 8,600 acres of idle farmland in the project area. Some of this might be supplied with water saved through elimination of nonbeneficial uses such as consumption by hydrophytes and phreatophytes. In order to accomplish this, present water rights including direct flow, storage or exchange agreements may have to be modified or new rights established and some additional construction work done.

The IMS program in the Grand Valley has not been in operation long enough to determine the impact on crop yields. One variable that will influence the effect on crop yield is the willingness of the irrigators to follow the recommendations of the Program. In January of 1974, the Bureau of Reclamation published the Annual Report of the Minidoka Project Irrigation Management Services Program, for its fourth year of operation. It is recognized that results achieved in Idaho may not necessarily be the same as those in Grand Valley but are presented as an example until the data on Grand Valley are available. The Minidoka Project report based on 67,570 acres reported an increase of $28.46 per acre due to increased crop yields. This represents a 13 percent increase. If this same increase were applied to the Grand Valley Project an additional positive impact of $1,600,000 per year would be realized by the farmers of the Grand Valley.

As a result of constructing the project, it has been estimated that about $15,000,000 would be contributed to local payrolls over a 5- to 10-year period. This would be basic or new income and would have a multiplying effect on the economy. Virtually all this payroll would be spent locally, and a secondary impact would produce new payrolls and profits for persons in the service industries.

Increased demands for goods and services will impact prior to the development of facilities to meet these demands. Facilities developed to meet the short-term increased demands for goods and services during the construction phase of the project may be in surplus as these demands decline.

The present cost of $7.50 per acre for operation, maintenance, and replacement of irrigation systems would be reduced to $5. This would create an annual savings of about $142,000 per year. The annual cost of operating and maintaining the project would be $285,000. About $170,000 of this amount would be for labor and the remainder for equipment, supplies, and materials, most of which would be purchased locally. The IMS program would provide the equivalent of about 10 full-time jobs if it were universally adopted as a permanent program in the valley. It is assumed that the program would be funded by the irrigators in the valley.

Realization of the proposed salinity control program would result in very minor effects on topography, geology, or minerals. Small changes in topography would result where any construction materials were borrowed such as sand, gravel, or embankment materials. It is anticipated that clay soils for compacted embankment would be obtained mostly from the undeveloped area above the Government Highline Canal and that sand and gravel for concrete structures and lining would be obtained adjacent to the channel of the Colorado or Gunnison River. Excavation of sand and gravel adjacent to the river could conceivably result in local changes in the river channel. Changes in topography could also result if two or more laterals are combined into one lateral. In these instances the abandoned channel would be refilled to the natural ground level. The only impact on minerals would be the use of sand and gravel for construction purposes, which would result in a very minor reduction in the volume of that resource available within the valley.

The primary impact of the project on soils would be the changes in salinity in those soils overlying present water tables which would be lowered or eliminated by implementation of the salinity control programs. Irrigated soils in such a position might be expected to show a gradual reduction in the salinity of the upper soil profile with the passage of time. Because of the low precipitation in the area, nonirrigated lands would probably continue to gain salt in the surface soils but at a slower rate than at present due to the reduction of capillary movement of water.

The concrete lining of the valley canals and laterals would eliminate the erosion problems associated with present laterals and, in some instances, canals. Reduced surface runoff from fields resulting from more efficient irrigation practices under the IMS program could also reduce erosion from these fields. Reduced flows in drains and washes due to more efficient water use in the valley would reduce erosion along these waterways. The erosion reductions cited above would result in a soils saving in the Grand Valley plus a reduction in siltation in the Colorado River. In addition, other pollutants such as fertilizers, pesticides and organic matter would be reduced in the return flows.

(2) Land use. - Land use trends with regard to urbanization and industrialization would not be expected to change as a result of proposed construction. The acreage devoted to canals and rights-of-way would also remain about the same. The most significant impact would be upon the present idle and marginal production lands.

As previously indicated, there are 8,600 acres of idle farmland. A small portion of this land is idle by choice of the owners, but much of it is idle because of high water tables and salinity problems. Both the WSI, IMS, and onfarm Irrigation Systems and Management Improvement programs could appreciably affect this total. Idle land could be brought back into production by: (1) lining canals, (2) installing new, improved structures for better water control, (3) combining canals and laterals, (4) using enclosed pipe, (5) uniform irrigation with timely application of water in proper amounts, (6) improving drainage systems, and (7) onfarm irrigation improvements.

Idle lands located in seep areas near canals should once again maintain maximum production. Other idle lands, especially those located near the Colorado River, should eventually become productive areas with a combination of proper water management and onfarm improvements.

(3) Social aspects. - The population and its distribution within this area would not be greatly affected by the salinity control program. Any construction personnel not presently located in the area would need housing during construction periods. More Government personnel would be needed prior to and during construction. Little change would be expected to occur in long-term manpower needs of the irrigation companies found in the area. No great permanent influx of people would be expected from the proposed construction.

It is anticipated that some new drains will be required and that some existing open drains would be either tilled or eliminated. Eliminating open type drains would reduce safety hazards as well as improve the esthetic appearance of the area.

Open concrete-lined canals and laterals are inherently more dangerous than open earth canals and laterals due to the difficulty in escaping from them. The Bureau of Reclamation is aware of the safety hazards associated with open waterways, and incorporates protective features for the protection of the public. The features are outlined in the section on mitigation, chapter IV.

The construction of safety features on inlets to siphons, chutes, bench flumes, drops, and check structures will lessen safety hazards at these structures. Replacing some smaller open lateral sections with pipe would also reduce the hazards in these areas.

(4) Historical and archeological sites. - The project will not affect any known sites of historical interest. Also, the project would not be expected to affect any archeological sites because construction will be limited to presently irrigated lands or sites of existing canals and laterals.

(5) Air, noise, visual impacts. - Impacts to air quality plus additional created noise would primarily result from seasonal construction activities over a 10-year period and, therefore, would be of temporary but reoccurring nature. Dust and noise created during construction would be confined to the area of construction and will have only minor, intermittent effects on nearby wildlife or humans. After construction, the area would revert back to its preconstruction conditions.

Visual impacts would be affected by the elimination of weeds, water plants, and other vegetation along canal banks and open drains. Small open earth laterals and open drains would in some cases be replaced with buried pipe laterals and closed drains. This would add to the esthetic appearance of the landscape. Some presently seeped areas with greasewood and salt grass will be reclaimed and planted with crops, which will result in an esthetic change.

(6) Vegetation. - A flora and fauna field study of the Grand Valley Salinity Control Unit is presently being conducted. Data from this study will be available for a separate, draft environmental statement in June 1976. This study will present details of impacts and effects from the project upon vegetation and animal communities and recommended mitigation measures. Information presented herein will serve as an introduction to the impacts of the environmental impact statement to follow.

The immediate effect of the WSI program would result from the clearing of about 1,000 acres of vegetation from the necessary portions of construction rights-of-way. This would involve primarily cattails, bulrushes, sedges, annual weeds, and various grasses from along laterals and canals. Total revegetation of disturbed areas will be slow due to the xeric conditions.

The long-term effect of the project on vegetation growth would be directly related to the changes in the surface and ground water in the valley. Lowering of water tables, reduced flows in drains, and the drying up of seep areas would affect the native plants in the valley. As water availability was reduced, some plant groupings could become less vigorous and more scattered. One species might replace another; for example, deep-rooted greasewood plants might replace the relatively shallow-rooted willow in local areas, or willows might replace cattails in others. Lining of smaller laterals within the valley will impact ditchbank vegetation not only by limiting moisture availability but also by facilitating clean cropping practices.

The vegetation types described in chapter II will be impacted in differing ways. The greasewood vegetation type is projected to decline in the valley because of the lowering water table and the less rapid salt buildup. The sagebrush-saltbush type and the pinon-juniper type are not expected to significantly change as a result of the project. A marked decrease in the marsh-type vegetation is projected because of the number and extent of marshes found adjacent to unlined canals. In the cottonwood type, an increased loss in acreage is projected because of the demands for sand and gravel by the project. The tamarisk vegetation type is projected to show a slight increase in area based on the assumption that water saved from seeping out of the canals will be administratively wasted down washes and may benefit this type.

(7) Fish and wildlife/recreation. - Fishing is limited in the project area. The Colorado and Gunnison Rivers have sport fishing potential but are not used extensively. Fishery habitat in the two rivers is transitional between warm and cold water. Fish species include the brown trout, carp, channel catfish, green sunfish, bluegill, largemouth bass, Colorado squawfish, humpback chub, speckled dace, and several species of suckers, including the humpback sucker.

Significant impacts from project construction upon fish populations have not yet been identified. The reduction in salinity and sediment may provide an improved habitat for the fisheries below the project area as well as for the fish species that utilize the washes flowing into the Colorado River in the project area.

Construction and operation of the project would impact wildlife species because of habitat changes related to vegetation changes. Species that utilize the desert shrub or the pinon-juniper habitats would not be significantly impacted by the project. Projected impacts include an increase in agricultural habitat and a decrease in phreatophytic shrub, marsh, and river woodlands habitat. Concrete lining of canals will greatly reduce canal bank vegetation and bottom fauna and therefore reduce the use of canals by muskrats, beaver, raccoons, skunks, and possibly other species. The faster moving water and steep sides of lined canals would create a hazard to small mammals. Ducks would be affected to some extent due to reduction of warm-water seeps along drains which are utilized by these water birds in periods of extreme cold.

The recently completed flora and fauna study of the Grand Valley Unit projected that agricultural habitat would increase 10 to 15 percent over the area occupied without the project over a 100-year period. This primarily represents land that without the project would have been phreatophytic shrub habitat primarily consisting of greasewood. Overall, however, the quality of the agricultural habitat will decline because the extent and quality of associated edge habitat presently within the valley in the form of fencerows, canal banks, waste areas, and other undisturbed areas would be reduced in number with the project. Representative species that would be adversely impacted include the cottontail rabbit, deer mouse, ring-necked pheasant, Gambel's quail, mourning dove, black-billed magpie, American robin, western meadowlark, Brewer's blackbird, and Brewer's sparrow. Waterfowl, principally mallards and Canada Geese, would benefit from the increased acreage of cropland.

A direct conversion of over 200 acres of marsh habitat to croplands or to phreatophytic shrubs is projected and this will reduce species that utilize this habitat type. Representative species that will be adversely impacted include the deer mouse, long-tailed vole, western harvest mouse, marsh hawk, western meadowlark, red-winged blackbird, brown-headed cowbird, Savannah sparrow, and leopard frog.

Any reduction in the river woodland (cottonwood) habitat due to project-related gravel operations would represent a long-term loss of this type and would adversely impact species such as the gray fox, beaver, raccoon, American kestrel, ash-throated flycatcher, black-billed magpie, Bewicks wren, American robin, starling, and northern oriole.

In summary, most wildlife species would be adversely impacted due to habitat changes related to the project. Small game hunting and trapping opportunities would be reduced proportionately to the loss of habitat in the project area. The project would not have a significant impact on any developed recreational areas in or near the project area.

(8) Water supply and quality. - Impacts on surface and ground water due to the implementation of salinity control measures would be quite significant. Primary effects would be: reduced outflows in washes and drains, reduced salt load to the Colorado River, disappearance of many seep areas and lowered water tables. Few, if any, changes would occur in the inflows to the valley. Some changes might occur in the irrigation delivery systems; for example, water might be delivered at different points due to minor changes in canal and lateral alinements. It is also expected that actual water deliveries could be reduced due to the reduction of seepage losses and improved irrigation efficiencies.

Agricultural-related consumptive use could vary with a change in cropping patterns due to the project. Any lowering of water tables and reduction of seep areas would also cause reduction in the consumptive use of water by phreatophytes.

Outflows in the washes and drains would be expected to decrease significantly as irrigation efficiencies improve and seepage losses minimize in the canals and laterals. Increased efficiencies would result in less surface runoff and less deep percolation from irrigated fields. Surface runoff is usually collected in waste ditches which empty into a drain or wash. Deep percolation contributes to the ground-water reservoir which in turn provides input to the drains and washes. Other inflows to the drains and washes include administrative waste from the canals. At present, quantitative data on the potential effects are not available.

Since the return flows to the Colorado River from the valley would be expected to decrease, the tonnage of dissolved solids would decrease as well. It is estimated that with the implementation of canal and lateral lining and irrigation management, the salt loading to the river would be reduced by an estimated 200,000 tons per year. This would be a potential reduction of about 19 mg/l at Imperial Dam.

The changes in quantity and quality of the surface and ground-water outflows are not expected to occur instantaneously. Changes in surface runoff would be most readily apparent. Because of low permeabilities of the soil materials, however, several years would be required for a new equilibrium to be established between the surface and ground-water system. This equilibrium would involve quality as well as inflow-outflow quantities.

C. Summary of Potential Impacts of Units Under Study

As indicated in chapter I, Title II of the Colorado River Basin Salinity Control Act directed the Secretary to expedite completion of planning reports for other units of the Colorado River Water Quality Improvement program. Environmental studies have been continuing on these other units to varying degrees. At this point in time, sufficient information is not available to analyze in depth what the environmental impacts of construction of the units will be. Potential impacts have been identified for each unit and are presented below. Studies are ongoing for these units and impacts will be identified and quantified as they become known. These impacts will be presented in individual environmental statements or assessments to be prepared as explained in chapter I. The following is presented as an overview.

1. LaVerkin Springs Unit, Utah

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Bypass System - small concrete diversion dam, bypass pipeline around springs.	-Temporary increases in turbidity, construction of dam, road improvement
b. Collection System - small inflatable control dam, pumping plant and pipeline - 14 acres used.	-Temporary increase in turbidity, disturbance to local area, 6-acre pond created, short-term impacts to agricultural activity on 2 acres, low-intensity sound from pumps, powerline above ground
c. Desalting Complex-RO plant - 8 acres of land, operated 24 hours per day, brine and product pipeline, transmission lines.	-Physical existence if large structure, agricultural land impacted, upland game habitat lost, energy consumption, low-intensity sound emitted, O&M personnel will be on duty all of the time, powerlines above ground, economic gain to community from construction and O&M personnel salaries
d. Brine evaporation pond - 650 acres of land required, lining material, fencing.	-Desert grazing land lost, upland game habitat lost, fencing will limit range cattle movement
e. Product discharge.	-Lower salinity at Imperial Dam by 11 mg/l, lower salinity in Virgin River downstream from project by about 469 mg/l when compared to 1941-70 flow-weighted average at Littlefield gage,

Proposed Project Feature	Potential Impacts
	enhance habitat of native fish in Virgin River including endangered woundfin, net estimated depletion to the Virgin River of 3.5 ft^3/s on an average annual basis -Reduced farm labor on lands served by diversions below springs to reduced need for off-season leaching of accumulated salts

2. Littlefield Springs Unit, Arizona

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Collection System.	-Clearing of native vegetation and disturbance to small animal life
b. Delivering Tank.	-Clearing of native vegetation and disturbance to small animal life
c. Evaporation ponds - lined 680 acres - flood interceptors.	-Small animal habitat eliminated, esthetic impact
d. Construction and operation of unit.	-Deplete flow of Virgin River by 4,100 acre-feet per year, reduce salinity at Imperial Dam by 2 mg/l, unknown impacts on native fish in Virgin River, including endangered woundfin, archeological impacts unknown at this time, improve salinity of lower Virgin River by about 50 mg/l when compared to 1941-70 flow-weighted average at the Littlefield gage.

3. Glenwood-Dotsero Springs Unit, Colorado

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Collection facilities - collected from commercial bathing establishment discharge pipes and springs, requires between 51-53 acres land.	-Reduce flow into Colorado River, eliminate vegetation and some aquatic invertebrates -Esthetic impacts - scars to landscape
b. Desalting plant(s) combined plant - 16 acres.	-Energy use -Gaseous emissions to air -Chemical use -Eliminate vegetation -Brine discharge -Product water thermal pollution to river -Noise pollution -Esthetic impacts - scars to landscape
c. Brine evaporation pond(s) for desalination plant discharge (lined) combined plant 1,700 acres.	-Eliminate vegetation -Eliminate small game and other animal habitat -Salt disposal -Esthetic impacts
d. Brine evaporation pond(s) as alternative to desalting plant resulting in a much larger pond size.	-Loss of 5,300 acres of irrigated farm land -Large pond with highly saline water - salt residue could pollute surrounding area -Esthetic impacts
e. Concrete pipeline - 87 acres; combined desalination plant - 16 acres; individual plants - 41 acres.	-Eliminate vegetation and disturb animal life -Esthetic impacts - landscape scars

Proposed Project Feature	Potential Impacts
f. Construction and operation.	-Reduce salinity in all downstream reaches and at Imperial Dam a total of 19 mg/l -Improved downstream aquatic habitat for invertebrates, fish and flora -Reduce riverflow by 4,200 acre-feet with desalting plant(s) -Reduce riverflow by 11,000 acre-feet if evaportaion method alone is used -Temporary increased employment and sales within the area as well as increased demands for housing, sewage disposal, water supplies, schools and medical facilities

4. Palo Verde Irrigation District, California

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Installation of measuring flumes and weirs for regulating the amount of water used in relationship to crop needs.	-Disturbance to existing canals and ditches
b. Lining canals and buried pipeline to reduce conveyance losses and return flows.	-Disturbance to existing canals and lowering of ground water adjacent to canals -Loss of native brush habitat on periphery of canal

Proposed Project Feature	Potential Impacts
c. Return flow utilization under study is utilization of return flow for powerplants as cooling water plus exchange agreement.	-Reduce salinity at Imperial Dam by 4 mg/l or 19 mg/l depending upon alternative selected. Impact associated with powerplants
d. Program implementation.	-Increase crop yields -Irrigation efficiency increase -Decrease water use -Reduce salinity at Imperial Dam by 3 mg/l

5. Colorado River Indian Reservation, Arizona

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Installing measuring flumes and weirs for regulating the amount of water used in relationship to crop needs.	-Disturbance to existing canals and ditches
b. Lining canals and buried pipelines to reduce conveyance losses and return flows.	-Disturbance to existing canals and lowering of ground water adjacent to canals -Loss of brush habitat on periphery of canal
c. Program implementation.	-Increase crop yields -Irrigation efficiency increase -Decrease water use -Reduce salinity at Imperial Dam by 1 mg/l

6. Uinta Basin Unit, Utah

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Lining canals and laterals and burying of pipelines; consolidation or realinement of some irrigation ditches.	-Eliminate or reduce seeps -Lowering of water tables stressing certain plant species and animal habitats -Loss of various plant communities and wildlife habitat; changes in plant and animal distribution -Esthetic impacts - landscape scars -Temporary increased turbidity and sedimentation affecting aquatic life -Temporary increased employment, sales, and demand for housing, schools, services, etc. -Decreased consumptive use by phreatophytes and weeds along canal banks -Reduced mosquito-breeding areas -Possible loss of some waterfowl and game bird hunting
b. Program implementation.	-Increased crop yields -Irrigation efficiency increased -Decreased water use -Reduced salinity in all reaches below project with a 9 mg/l reduction at Imperial Dam

Proposed Project Feature	Potential Impacts
c. Possible installation of fences, escape devices, and bridges along canals.	-Prevention of drownings and accidents of humans, wildlife, and domestic cattle -Bridges would permit migration of big game along established routes -Esthetic impacts

7. Lower Gunnison Basin Unit, Colorado

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Lining canals and laterals and burying of pipelines; consolidation or realinement of some irrigation ditches.	-Eliminate or reduce seeps -Lowering of water tables stressing certain plant species and animal habitats -Loss of various plant communities and wildlife habitat; changes in plant and animal distributions -Temporary increased turbidity and sedimentation affecting aquatic life -Temporary increased employment, sales, and demand for housing, schools, services, etc. -Decreased consumptive use by phreatophytes and weeds along canal banks -Reduced mosquito-breeding areas

Proposed Project Feature	Potential Impacts
b. Program implementation.	-Increased crop yields -Irrigation efficiency increased -Decreased water use -Reduced salinity in all reaches below project with a reduction of 27 mg/l at Imperial Dam
c. Possible installation of fences, escape devices, and bridges along canals.	-Prevention of drownings and accidents of humans, wildlife, and domestic cattle -Bridges would permit migration of big game along established routes -Esthetic impacts

8. Big Sandy River Unit, Wyoming

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Power controls, pumps, spray nozzle. To pump river water onto adjacent land which will freeze and make a field of ice.	-Land disturbance, energy required, pumps in river may displace aquatic life to storage pond
b. Off-stream storage pond to be used as pumping site.	-Vegetation removed or inundated by pond, animal life displaced
c. Ice field - acreage dedicated to the icefield.	-Land dedicated to this use eliminates other use during winter months
d. Brine evaporation pond to evaporate the brine that flows from icefield.	-Land dedicated to this use will result in loss of vegetation and animal life in this area

Proposed Project Feature	Potential Impacts
e. Project water supply water that melts off the icefield during warm weather; construction and operation.	-Reduction of salinity in all reaches below project and reduction at Imperial Dam of 7 mg/l. Big Sandy, Green, and Colorado Rivers will have a decrease of 80,000 tons of dissolved solids -Depletion of 2,000 acre-feet due to evaporation at brine pond -Improve downstream aquatic habitat -Temporary job opportunities and economic activity during construction

9. Price River, San Rafael River, and Dirty Devil River Units, Utah

Impacts of proposed action

Proposed Project Feature	Potential Impacts
a. Collection facilities.	-Reduce flow of Colorado River -Eliminate some vegetation and wildlife -Esthetic impacts - scars to the landscape
b. Desalting plant(s).	-Energy use -Chemical use -Eliminate vegetation -Brine discharge -Product water -Thermal pollution to river -Noise pollution -Esthetic impacts - scars to the landscape and presence of desalting plant

Proposed Project Feature	Potential Impacts
c. Brine evaporation pond(s) for desalination plant discharge (lined) combined plan.	-Eliminate vegetation -Eliminate small game and other animal habitat -Salt disposal -Esthetic impacts
d. Brine evaporation pond(s) as alternative to desalting plant resulting in much larger pond size.	-Large pond with highly saline water - salt residue could pollute surrounding area as well as pond area itself, eliminating vegetation and animal habitat -Esthetic impacts
e. Construction and operation.	-Reduce salinity in all downstream reaches and at Imperial Dam a total of 23 mg/l -Depletion of 15,000-90,000 acre-feet of water annually from Colorado River -Improve downstream aquatic habitat for invertebrates, fish, and flora -Temporary increased employment and sales within the area as well as increased demands for housing, sewage disposal, water supplies, schools, and medical facilities

10. McElmo Creek Unit, Colorado

Impacts of proposed action

Proposed Project Features	Potential Impacts
a. Brine evaporation pond.	-Loss of about 1,000 acres of desert vegetation and small mammal and bird habitat -Loss of about 1,000 acres of irrigated farm land and three home sites -Salt disposal -Esthetic (visual) impacts and landscape scars -Inundation of archeological and historical sites by brine pond
b. Desalting plant.	-Energy use -Chemical use -Eliminate vegetation -Brine discharge to evaporation pond -Product water - could be used for municipal or industrial purposes -Thermal pollution if discharged to river -Noise pollution -Esthetic impacts - scars to landscape -Elimination of irrigated land for evaporation pond -Wind erosion of salts
c. Construction and operation.	-Depletion of about 6,200 acre-feet/yr. from McElmo Creek and the Colorado River system with evaporation-pond method -Depletion of about 3,700 acre-feet/yr.

Proposed Project Feature	Potential Impacts
	from McElmo Creek and the Colorado River system by the desalting-plant method -Treatment of the McElmo Creek Unit will remove a maximum of about 9 ft^3/s from the system on an average annual basis. The average annual flow of the San Juan River at the nearest gaging station averages in excess of 2,000 ft^3/s. Hence, the losses will not adversely affect the recreation potential of the downstream river areas. -Create new employment and sales opportunities due to construction and operation as well as increased demands for housing, sewage disposals, water supplies, schools, and medical facilities. -Removal of 40,000 tons of salt/yr. reducing salinity in all reaches below the project and reducing it at Imperial Dam by 4 mg/l.

CHAPTER IV

MITIGATION AND ENHANCEMENT MEASURES

CHAPTER IV - MITIGATION AND ENHANCEMENT MEASURES

A. Overall Mitigation and Enhancement Posture of the Program

Introduction

Salinity control due to the CRWQIP will allow Upper Basin Water resource development to proceed by offsetting projected salinity increases accompanying new water depletions. Physically, the salinity control program will enhance the quality of Colorado river water delivered to water users in the United States and Republic of Mexico. Overall salinity reduction will be reflected regionwide in improved water qualities delivered to over 3 million acres of irrigated farmland and over 17 million people.

Enhancement of the Region's economy is expected to occur with direct, measurable benefits in the Agricultural, Municipal and Industrial sectors. Assuming continued Basin development of water resources and current rates of salinity damage, the initial four salinity control units are estimated to show total economic benefits of about $10 million per year. Total program impact for all control units under the CRWQIP could provide total benefits of over $34 million per year.

Agricultural productivity can be enhanced primarily as a result of the application of improved water quality to sustain or increase crop yields and reduce those operating costs presently incurred to combat salinity increases. Other program efforts to improve irrigation efficiency will enhance general water use, reduce leaching and labor requirements, fertilizer costs, and drainage requirements.

The general policy of the Bureau of Reclamation for the preservation and enhancement of environmental quality is explained in Part 376 of the Reclamation Instructions.[36] In chapter 5, appendix A-5, mitigation is defined as follows: "Measures that are proposed and/or required to be undertaken to enhance, protect, or mitigate impacts upon the environment by the proposed actions, including any associated research or monitoring."

This chapter describes the measures which will be taken to mitigate the overall impacts described in chapter III. These factors are classified under two broad categories: (1) standard criteria for design and construction and (2) mitigating measures for which funding authorization was not provided and may be sought in the future.

Standard criteria for improving the appearance of all structures and preserving the landscape at all installations will be implemented. These are applicable in the planning, design, and construction of all facilities in order to minimize adverse environmental impacts.

Additional measures are included to mitigate the impacts of a specific feature in a particular area. Such features may be designed either to mitigate an anticipated adverse effect or to enhance the environmental quality of an area, including vegetative habitat, fish and wildlife, recreation, esthetic values and other factors. Basically, there are two methods of alleviating the environmental ramifications of a proposed action. Wherever possible, measures will be taken to minimize the extent of an impact at a particular site. In addition to this, features will be included as substitutions for losses, thus mitigating the overall impact of the program and preserving environmental quality in the general area. Mitigating measures will be undertaken in coordination with appropriate agencies.

Fish and Wildlife

Due to the necessity of arriving at a prompt solution to the international salinity problem and expeditiously presenting the proposal to Congress for authorization and funding, a fish and wildlife plan or other detailed consideration for environmental mitigation was not included in the legislation.

In order to comply with the Fish and Wildlife Coordination Act of 1958, the following steps will be taken to develop any specific environmental mitigation plans considered necessary on a control unit basis:

a. Organization of Ad Hoc Committees for Fish and Wildlife.

b. Completion of control unit environmental studies identifying existing resources.

c. Analysis of the unit to determine losses of resources to be incurred.

d. Formulation and recommendations of mitigation concepts to replace those losses.

e. Specific mitigation measures required for individual control units will be refined and authorization for funding and implementation will be sought as necessary. Mitigation in SCS programs is part of the overall cost of the measure and does not require additional funding by special authorization.

Esthetics

It is expected that the preconstruction planning phase would play a critical role in preserving esthetic quality by exposing many problems to be avoided. It is at this stage that input from other concerned agencies would be crucial and welcome. The Bureau of Reclamation has learned a great deal about restoration problems from experience and consultation with cooperating agencies. From this experience the Bureau expects to demonstrate greater competence in this aspect of construction.

Because much of the interpretation of esthetics is intangible and depends to a large extent upon the personal tastes and judgement of observers, it is difficult to present an objective discussion on this subject. The Bureau of Reclamation recognizes that lined canals, pipelines, evaporation ponds, desalting plants, and roads would not be constructed without having some major long-term adverse effects upon the esthetics. The objectives of the Bureau would be to minimize adverse impacts through a process of planning, consultation, careful construction, and restoration.

Past experience and recent increases in environmental sensitivity have given the Bureau an insight into esthetic problems that can develop. It is apparent that the various units would cause some significant adverse esthetic impacts; it is also reasonable to deduce that they would produce some impacts that, although foreign to the natural situation, would be esthetically attractive.

There are problems associated with discussing the mitigation of adverse esthetic impacts in this environmental statement. These problems are:

a. Even with careful preconstruction planning, the exact amount and degree of restoration required cannot be fully determined at this time until construction is nearly completed. Thus, in this regard, restoration procedures would be flexible as well as comprehensive.

b. The fact that sound construction techniques are to be applied to disturbed areas does not guarantee successful results. The semiarid and arid lands involved pose special problems because of severe climatic conditions including limited rainfall. In difficult situations experimentation would be warranted.

c. At the present time, all the design and location planning has not been completed. Existing plans are subject to environmental improvement through modification.

d. Through experience and improvement developed in restoration methodology, existing restoration procedures may require alteration to achieve better results.

Reevaluation of Proposed Plans

The need for specific advance planning designed to reduce and minimize permanent environmental disruption and to provide effective restoration and rehabilitation of disturbed areas is recognized by the Bureau of Reclamation. In this regard the Bureau will modify features to achieve environmental benefits when feasible.

Cultural Resources

Any area to be affected by a project unit will be evaluated by an archeologist or other appropriate professional who will make a determination in consultation with the appropriate State Historic Preservation Officer regarding the property's eligibility for inclusion in the National Register of Historic Places. Should the property be determined eligible for inclusion in the National Register of Historic Places, the Bureau of Reclamation will follow the procedures outlined in 36 CFR 60, 63 or 800, as applicable.

B. Program Monitoring Plan to Demonstrate Program Results

The salinity control units under the CRWQIP represent a long-term, coordinated, basinwide effort to mitigate future salinity impacts in the lower main stem of the Colorado River.

As such, considerable attention has been directed to both a Program Monitoring Plan and individual unit monitoring efforts to determine program effectiveness.

Intensified salinity monitoring on the Colorado River coupled with numeric criteria at selected stations is expected to be established shortly to meet recent Environmental Protection Agency (EPA) regulations. Those regulations required by P.L. 92-500, the Federal Water

Pollution Control Act, essentially established salinity control policy and procedure to achieve compliance with adopted standards by July 1, 1983.

Consistent with this recent EPA policy, select salinity monitoring stations are also expected to yield the annual impact of all salinity control projects and programs. It can be reasonably assumed that the average salinity reductions from CRWQIP are equal to the sum of the individual control units as measured on the lower main stem.

This assumption that "lumps" salinity control effects together for monitoring and criteria purposes, must be tempered by considering the following heterogeneous characteristics of the river system:

1. Upper basin salinity reductions will be "damped" or considerably "smoothed" out by the large storage reservoirs.

2. A 3-year travel time is expected to transmit Upper Basin salinity reductions to the lower main stem.

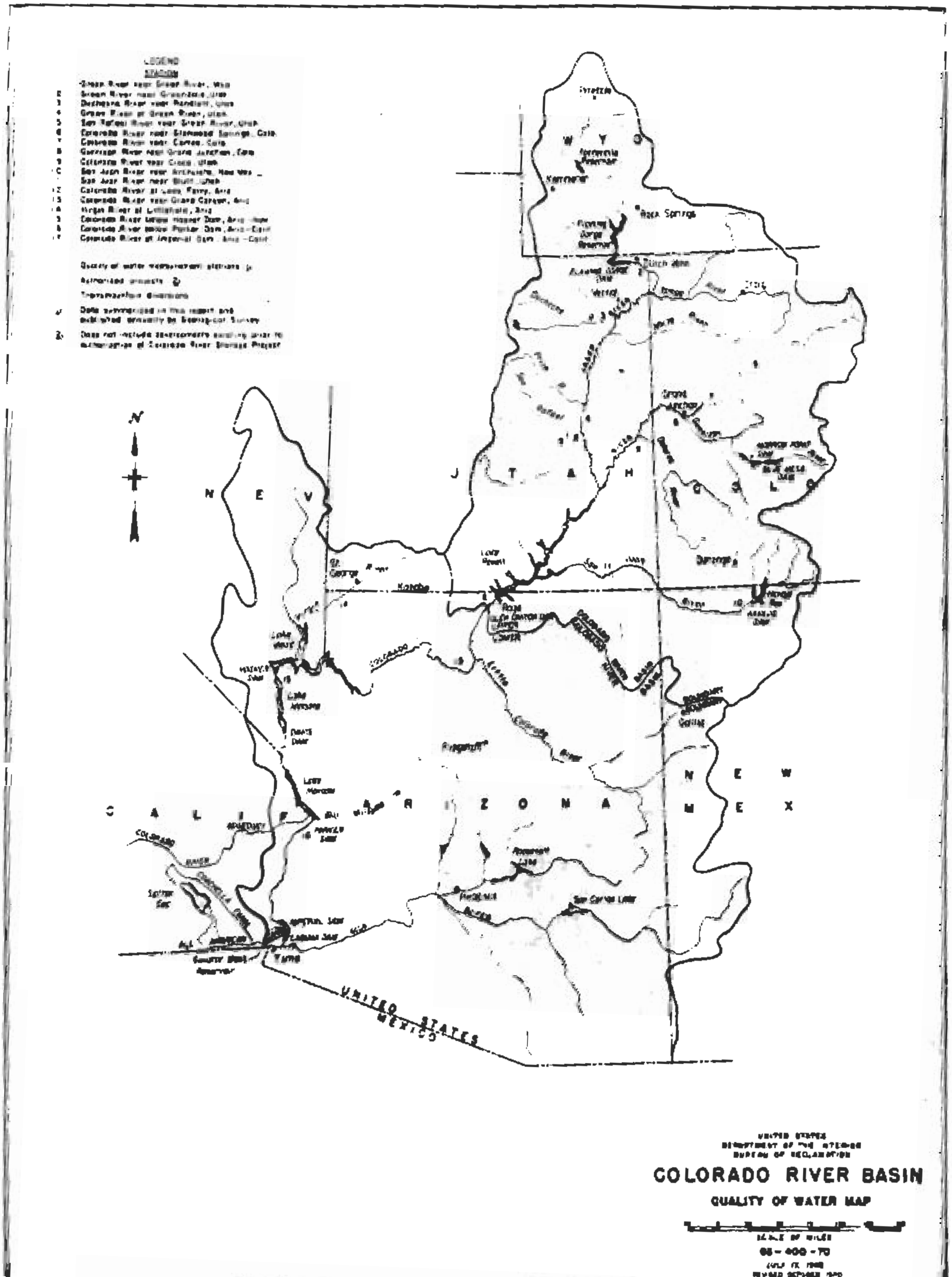
3. The cause and effect of salinity concentrations in the river system display nonlinear properties due to mixing, precipitation, and chemical phenomena in reservoirs.

Initially, existing monitoring stations such as those shown in figure IV-1 will provide a measure of the composite effectiveness of salinity control units. It may be necessary to augment this 17 monitoring point network in the Basin to measure the effectiveness of individual control units or tributary programs. Specific monitoring points will be selected for each control unit to isolate and evaluate individual contributions.

Much work remains for Federal and State agencies to assess the relative effectiveness of the various control units and other control efforts. More accurate determinations must be made of "background" salinity levels so that natural variations will not mask man-induced reductions.

C. Mitigation of Construction Impacts

In 1974 the Bureau of Reclamation published an Environmental Guidebook for Construction.[37] This 61-page pocket-sized book gives construction people ideas and suggestions about specific aspects of environmental control in everyday "on-the-job" situations. Specifications issued for construction will express the intent of the Bureau in maintaining environmental quality.



Colorado River Basin, water quality station map.

Figure IV-1

The types of actions in this discussion include:

a. Those incorporated into the design of features,

b. Those incorporated into the construction of features,

c. Those incorporated into the operation of features,

d. Those designed to lessen adverse impacts,

e. Those designed to restore undesirable impacts, and

f. Those designed to allow investigation of and better understanding of the existing environment and of unit impacts so that adverse effects would be lessened or avoided.

1. Special Considerations for Design and Construction

Specific requirements which are included in the Reclamation Instructions and which apply to this project are as follows:

a. Required structures would be located to take advantage of the natural topography.

b. The structures would be designed to be compatible with the surrounding area.

c. The external appearances of the structures would be incorporated into the design program so as to be environmentally compatible with the surroundings.

d. Cut-and-fill slopes would be minimized and blended into the natural terrain.

e. Borrow areas would be located within reservoir basins whenever practicable. If any pits are required outside the pond sites, they would be reshaped to blend with the surrounding terrain, and gradual slopes and drainage features would be used to prevent erosion and any undesirable ponding of water.

f. Required access roads would follow the natural contour of the land and, where possible, would be relocated along alinements of roads required for project operation and maintenance. Existing roads would be used wherever possible to minimize new construction. Access roads would be closed to the general public, which should limit the contractor's liability, promote public safety, and prevent unnecessary disturbances of undeveloped surrounding areas. Upon the completion of construction, temporarily disturbed areas would be restored as nearly as practicable to their original condition to complement the natural surroundings.

g. Only the necessary amounts of vegetation would be cleared within the project right-of-way.

h. Features would be designed to withstand reasonable expected stresses resulting from seismic activity.

i. The final design and location of power transmission facilities required for unit features have not been completed. Transmission facilities would be in accordance with the Environmental Criteria for Electric Transmission Systems.[38] These criteria encourage use of low profile concepts to enhance overall appearance of switchyards and substations. Right-of-way clearing would be restricted so that long straight corridors would not result.

j. Adequate lighting facilities would be provided to accommodate safe working conditions.

k. Pumping plants would be designed to prevent harmful and bothersome noise levels.

Safety features would be constructed on canals and laterals under the WSI program. Fencing would be provided for both sides of open concrete-lined canals and laterals where capacities exceed 25 ft^3/s or where the height of concrete lining is more than 30 inches. Some fencing would also be provided along smaller capacity laterals in urban areas where it is determined that a specific hazard exists. Safety nets and cables would be placed immediately upstream from siphons, checks, drops, and chutes where the canal water depth is 3 feet or greater, and safety cables would be provided for water depths less than 3 feet and pipe diameters less than 30 inches. Safety ladders would be installed immediately upstream from siphons, checks, drops, and chutes where the lining height is greater than 30 inches or pipe diameters greater than 30 inches. Also, ladders would be installed on both sides of the canals and laterals every 750 feet when the height of lining is greater than 30 inches.

2. Protective Action During Construction

Construction contractors would be required by specifications provisions to reduce or avoid adverse impacts by the following methods:

a. The contractor would abide by all local, State, and Federal laws concerning the prevention and control of air and water pollution.

b. The contractor's construction activities would include methods which would prevent the entrance, or accidental spillage, of solid matter contaminants, debris, and other objectionable pollutants and wastes into streams, flowing or dry watercourses, lakes, or underground water sources. Such pollutants and wastes would include, but would not be restricted to, refuse, garbage, cement, sewage effluent, industrial waste, radioactive substances, oil and other petroleum products, aggregate processing tailings, mineral salts, and thermal pollution.

c. Sanitary wastes would be disposed of on land by burial at approved sites or by other approved methods.

d. Waste waters from aggregate processing, concrete batching, or other construction operations would not be allowed to enter streams, watercourses, or other surface waters without the use of such turbidity control methods as settling ponds, gravel-filter entrapment dikes, approved flocculating processes that are not harmful to fish, recirculation systems for washing aggregates, or other approved methods. Any such waste waters discharged into surface waters would be essentially free of sediment. Approved permits to discharge into navigable waters will be obtained from the various State agencies, the Environmental Protection Agency or the Department of the Army for protection against uncontrolled waste discharges.

e. The emission of dust into the atmosphere would not be permitted during the manufacturing, handling, and storing of concrete aggregates; and the contractor would use such methods and equipment as would be necessary for the collection and disposal, or prevention, of dust during these operations. The contractor's methods of storing and handling cement and pozzolans or earth materials would also include means of minimizing atmospheric discharges of dust.

f. The burning of cleared trees and brush, combustible construction materials, and rubbish would be permitted only when atmospheric conditions were considered favorable by appropriate State or local air pollution or fire authorities. In lieu of burning, such combustible materials would be removed from the site, chipped, shredded, or buried.

g. The contractor would exercise care to preserve the natural landscape and would conduct his construction operations so as to prevent any unnecesary destruction, scarring, or defacing of the natural surroundings in the vicinity of the work. Except where clearing was required for permanent works, for approved construction roads, and for excavation operations, all trees, native shrubbery, and vegetation would be preserved and protected from damage which could be caused by the contractor's construction operations and equipment. Movement of crews and equipment within the right-of-way and over routes provided for access to the work would be performed in a manner to prevent damage to grazing land, crops, or property.

h. The contractor's camp, shop, office, and yard areas would be located and arranged in a manner to preserve trees and vegetation to the maximum practicable extent. Following the completion of constructing all camp, storage, and construction buildings, including concrete footings and slabs, all construction materials and debris would be removed from the site. The camp area would be left in a neat and natural condition.

i. Borrow pits and quarry sites would be so excavated that water would not collect and stand. Before being abandoned, the sides of borrow pits and quarry sites would be brought to stable slopes, with slope intersections rounded and shaped to provide a natural appearance. All rubbish, contractor's equipment, and structures would be removed from the site. Waste piles would be leveled and trimmed to regular lines and shaped to provide a neat appearance.

j. The contractor would limit his hauling and other construction operations over the lands and property of others where the Government has right-of-way easements, including access routes approved by the contracting officer, so as to minimize damage to crops or property and to avoid marring the land. Ruts and scars would be obliterated; damage to ditches, roads, and other features of the land would be corrected; and the lands would be restored as nearly as practicable to their original condition before final acceptance of the work.

Soil which had been excavated during construction and not used would be evenly backfilled onto the cleared area or removed from the construction site. The soil would be graded to conform with the terrain and the adjacent land, and topsoil would be replaced. Terraces and other erosion control devices would be constructed as necessary to prevent soil erosion along and in the vicinity of the proposed construction. The crests of spoil piles in arid locations would be shaped in a contoured manner to retain moisture. Steep slopes on these spoil piles would be avoided to prevent erosion and to enhance the natural growth of vegetation.

In the event of a significant discovery of artifacts or fossils during archeological and historical surveys or during construction, the State Historic Preservation Officer would be notified so that the proper action with respect to protection or removal could be implemented. This would be accomplished by appropriate professionals following the procedures outlined in 36 CFR 800.

3. Restoration of Construction Disturbances

The proposed plan provides that considerable attention would be given to carrying out construction activities so that the adverse esthetic impact would be minimal. By using the most advanced methodology available, areas disturbed by construction activities would be rehabilitated and restored. It is recognized that esthetically satisfactory results would often be difficult or even impossible to obtain and that some permanent unattractive landscape scars would occur.

It is also acknowledged that measures other than seeding would sometimes be required to provide soil stability and revegetation. This may include such techniques as wattling, mulching, use of jute netting, contouring of slopes and spoil piles, placement of topsoil, drilling of seed, and placement of grass sod. The restoration measures would also include fertilization of soil, careful selection of plants adapted to local conditions, and initial irrigation watering of plants where required.

Each construction situation would pose a unique set of restoration problems requiring application of specific measures. The objectives of the restoration measures would be to achieve both soil stability and reasonable esthetic quality in the disturbed areas.

4. General Plan of Landscape Restororation

At present, it is not possible to specify and quantify the exact restoration measures that would be required and applied to each feature to achieve reasonably successful results. However, in general, the following criteria would be applied:

a. Restoration and/or enhancement measures would be included in the preconstruction planning.

b. Input would be solicited from concerned agencies having jurisdiction in the unit area.

c. Feature design and location would emphasize minimization of landscape disturbance.

d. The extent of land clearing for road cuts and fills and borrow areas would be kept to a feasible minimum. Wherever possible, contractors would be restricted to work within specific boundaries.

e. The degree of slope on side hills would be made as flat as practicable.

f. Where steep slopes were unavoidable, contouring into benches or terraces would be employed to improve moisture retention and the chances of successful stabilization of soil and growth of vegetation.

g. Wherever feasible, topsoil from the area to be disturbed would be stripped away and stockpiled for later redistribution and seeding after excavation of material or deposition of spoil had been carried out. This item would be written into contract specifications.

h. Preconstruction planning would include an analysis of existing vegetation, soil, and climatic conditions to determine which restoration plans would be best suited for the particular area.

i. Seeding and planting of shrubs would be completed as soon as possible after final contouring had been carried out. Emphasis would be placed upon planting during the proper season of the year and steps would be taken (fertilization, watering, etc.) to insure that growth became well established.

j. Permanent spoil piles would be leveled and contoured as much as required to achieve adequate stability. Waste piles near water would be sprayed with clear, biodegradable stabilizing material. Establishment of vegetation would be attempted. Whenever feasible, spoil piles would be kept away from stream courses.

k. Restoration treatments would be monitored until a stable situation develops. Additional treatment would be carried out when justified.

l. Maintenance operations would be designed to allow stabilization of cut slopes and establishment of vegetal cover.

5. Protective Utilization During Operation and Maintenance

Permanent access and operating roads will be paved to eliminate the dust problem during operation of the project. Pumps and motors will be housed within buildings so that the sound emitted will be limited to the immediate vicinity of the pumping plants.

Noise and light will be buffered by using shielding and screening consisting of baffling, vegetation, walls, and other means. The low-intensity sound and light levels at night will not have a significant impact on wildlife or human activity in the area. Proper surveillance will be maintained to assure that all safety measures such as escape ladders, cables, nets, and fencing on the canals are in proper condition. Diversion works, canals, drains, and operating roads will be properly maintained. Weeds, trash, and moss removal will be made when necessary for improved efficiency, appearance, and safety.

Operating and maintenance crews will keep a continued surveillance of the project features to repair immediately any damage resulting from storms or accidental causes which would allow breaks in canals or other failures that cause adverse impacts.

Brine ponds will be routinely investigated for emergent vegetation development. An accepted procedure for removal of emergents will be initiated in instances where emergents are creating recognizable mosquito habitat.

D. International Effects

The United States and Mexico have agreed in Minute No. 242 of the International Boundary and Water Commission to a permanent and definitive solution of the international problem of salinity of the

Colorado River. Accordingly, the United States will implement measures now established under Title I of P.L. 93-320 to assure that the approximately 1,360,000 acre-feet of water normally delivered to Mexico above Morales Dam has an annual average salinity of no more than 115 mg/l plus or minus 30 mg/l over the average annual salinity of water arriving at Imperial Dam.

Title II salinity control measures authorized for construction or study by the Act will collectively reduce the average salinity at Imperial Dam from 43 mg/l with the initial projects and by 150 mg/l with full implementation of all units. Since the salinity of water delivered to Mexico is influenced by the salinity at Imperial Dam, any salinity reductions resulting from Upper Basin controls will prove beneficial to Mexican users as well as United States users.

E. Mitigation Measures for Initial Control Units for Construction

1. Las Vegas Wash Unit, Nevada

a. Special considerations for mitigation or enhancement. - Aside from the general mitigation program previously outlined for construction impacts, no significant impacts are expected as a result of implementation of the Las Vegas Wash Unit.

(1) Monitoring of water quality. - A monitoring program is being established to sample and analyze both ground water and surface flows coming into the wash and the flows below the project facilities. These data will be used to monitor the effectiveness of the unit operation and to insure that downstream flows will conform to established standards.

(2) Archeological and historical resources. - A cultural resources inventory was performed by the Nevada Archeological Survey in the project area of the Las Vegas Wash Unit. As discussed in chapter III, several historic and archeological sites were encountered. To the extent possible, project facilities have been located and designed to avoid disturbance of these sites. However, it appears that two historical sites and seven archeological sites will still be disturbed to some degree by project activities, as presently planned.

The final report on the cultural resource inventory provides data for evaluating the significance of the sites encountered. The cultural resources identified are currently being evaluated in accordance with the procedures established by the Advisory Council on Historic Preservation and embodied in 36 CFR 800 of the Code of Federal Regulations. Individual sites are being studied to determine their eligibility for inclusion on the National Register of Historic Places. A determination of effect will be made for each site as a result of construction and operation activities and, if the effect is determined to be adverse, a mitigation plan will be developed for the site. Reclamation will perform these functions in consultation and coordination with the Nevada State Historic Preservation Officer and the Advisory Council on Historic Preservation.

(3) Air quality. - As indicated in chapter III, some temporary adverse impacts on local air quality can be expected from construction activities. Appropriate measures will be taken to lessen the impact of blowing dust during construction activities. These measures include wetting of ground surface and suspension of work if blowing dust creates a hazardous situation.

(4) Recreation. - The Las Vegas Wash has, over time, established itself as an extensive greenbelt in the southeast corner of the Las Vegas Valley. Consequently, it has been used by a number of local residents for varying recreational pursuits. Recreation in the Wash is uncontrolled and often different types of recreation are in conflict, i.e. hunting versus hiking, picnicking or bird watching. The Las Vegas Wash Development Committee was established by Clark County to study the problems of the Wash and develop recommendations for solutions. A conceptual plan of recreational development has been put forth by the Committee. Contact has been closely maintained between Reclamation and the Committee to discuss the conceptual plan and to see how it might interfere with the Las Vegas Wash Unit of the CRWQIP. Public Law 93-320 did not contain provisions for recreational development and hence no funding is available directly for recreational facilities.

(5) Fish and wildlife resources. - Much concern has been expressed by the general public that implementation of the Las Vegas Wash Unit in conjunction with Clark County's proposed Advanced Waste-Water Treatment plant (AWT) would destroy the natural greenbelt that has evolved over the years causing extremely adverse impacts on wildlife that has established residency there. Coordinated planning

between Reclamation, the County, the State of Nevada, and other interested segments of the Public has led to a plan whereby there should be no major adverse impacts on vegetation and wildlife existing in the wash. Through periodic inspections of the facilities, birdlife will be observed in and around the brine ponds. Although at present there are no plans to set up bird salvage operations, if it appears to be necessary the appropriate fish and game agencies will be contacted and a plan for salvage will be formulated and executed. A major portion of the treated effluent from the AWT plan will be carried by pipeline to a point just downstream from Reclamation's proposed cutoff trench where it will be released back to the natural channel of the wash. This should maintain the greenbelt below the cutoff trench to Las Vegas Bay of Lake Mead. Similarly a smaller portion of the AWT effluent will be released at the plant site to the natural channel which should maintain the greenbelt between the AWT and the cutoff trench. Vegetation and wildlife losses should only be nominal as a result of this plan.

Routine inspection activities will identify any potential problem with waterfowl becoming salt-encrusted on the ponds or of emergent vegetation contributing to mosquito breeding. In the case of waterfowl, a salvage program will be adopted in coordination with the Nevada State Fish and Game if the ponds pose a threat. In the case of emergent vegetation, eradication programs would be adopted. These would most likely consist of chemical treatment.

(6) Land Use. - Specific mitigation measures may be required for two primary areas of concern (1) the impervious material source 9 miles west of the interception facility site, and (2) the 8-acre temporary storage area adjacent to the interception site.

Impervious Material Source Area

Mitigation in the form of fill, blending, and shaping of the area may be required after excavation to prevent seep water from collecting in open pits. The area is currently privately owned, and any mitigation measures would have to be in harmony with the owners land use plans.

Temporary Storage Site

The material to be stored is rich in organic material and nutrients. Its composition is such as to make it excellent for use as top soil. Any residual material left or disposed at this site would provide excellent media for regrowth. To facilitate this growth it may be desirable to reseed the area following project completion.

Other mitigation measures as pertain to general construction activities have been previously outlined.

(7) Safety. - To minimize the potential drowning hazard due to the accessibility of the evaporation ponds, security fencing will be installed and regularly inspected.

(8) Accommodations to conform with other local, State, or Federal plans. - The projects in the area which have required a specific effort to accommodate or harmonize with are the proposed park development in Las Vegas Wash and the County's AWT plant. Preplanning efforts were discussed with the Las Vegas Wash Development Committee and resulted in the current proposed plan which has been accepted as being compatible with the park development.[50]

2. Crystal Geyser Unit, Utah

a. Special consideration for mitigation or enhancement. - The Crystal Geyser Unit is relatively simple in both design and operation. No specific problems requiring special mitigation measures are known. The project will, as previously described, potentially enhance the visual impact and tourist attraction of the geyser.

Water quality monitoring plan. - Water quality and quantity will be monitored from the outflow of the geyser as necessary to determine the effectiveness of the project.

Plans are not yet definite enough to establish the location of monitoring stations. Monitoring may be required on only a short-term basis if the flow and concentration remain constant and the project operates as planned. In addition, monitoring of ground water near the brine ponds may be required.

F. Mitigating Measures for Other Control Units for Construction

1. Paradox Valley Unit, Colorado

a. Special considerations for mitigation or enhancement. - The construction and operation of the Paradox Valley Unit will not entail any unusually hazardous facilities or operations that would require specific mitigation. General efforts for the minimizing of construction impacts and normal operating practices have been previously covered in the introductory sections of this chapter. A concern of the Unit is to monitor its effectiveness to assure the utmost benefits of salinity improvement and to ensure the integrity of the ground-water system.

The Bureau of Reclamation proposes to mitigate wildlife losses and impacts of the undertakings on any archeological or historical property. The area will be evaluated by an archeologist or other appropriate professional who will make a determination in consultation with the appropriate State Historic Preservation Officer regarding the property's eligibility for inclusion in the National Register of Historic Places. Should any historic or archeological resources be determined eligible for inclusion in the natural register, the procedures in 36 CFR 800 will be followed.

Water quality monitoring plan. - Water quality and flows are presently being monitored above and below the Paradox Valley. During construction and operation of the project, the water quality monitoring will be further implemented to determine the effectiveness of the project, obtain information on the well field, and protect the shallow fresh ground-water body west of the river.

Prior to the initiation of construction, additional monitoring equipment as needed will be installed on the Dolores River immediately downstream from Paradox Valley. This will record the quality of the river and enable pumping rates to be adjusted to achieve the most desirable salinity reduction.

The piezometer grid will also be monitored during the construction and operation of the project. The data would indicate any changes in the ground-water system and would identify specific areas where the pumping is either too great or too small. This will allow the adjustment of individual pumping rates for the greatest overall efficiency.

The quality of the brine pumping from the valley will also be continuously monitored. Changes in the salinity could indicate that excessive pumping from one or more wells was drawing fresh ground water into the salt zone.

In addition, periodic sampling or monitoring may be required to determine whether leakage from the brine ponds occurs. Should the leakage warrant control, provisions will be made for recycling.

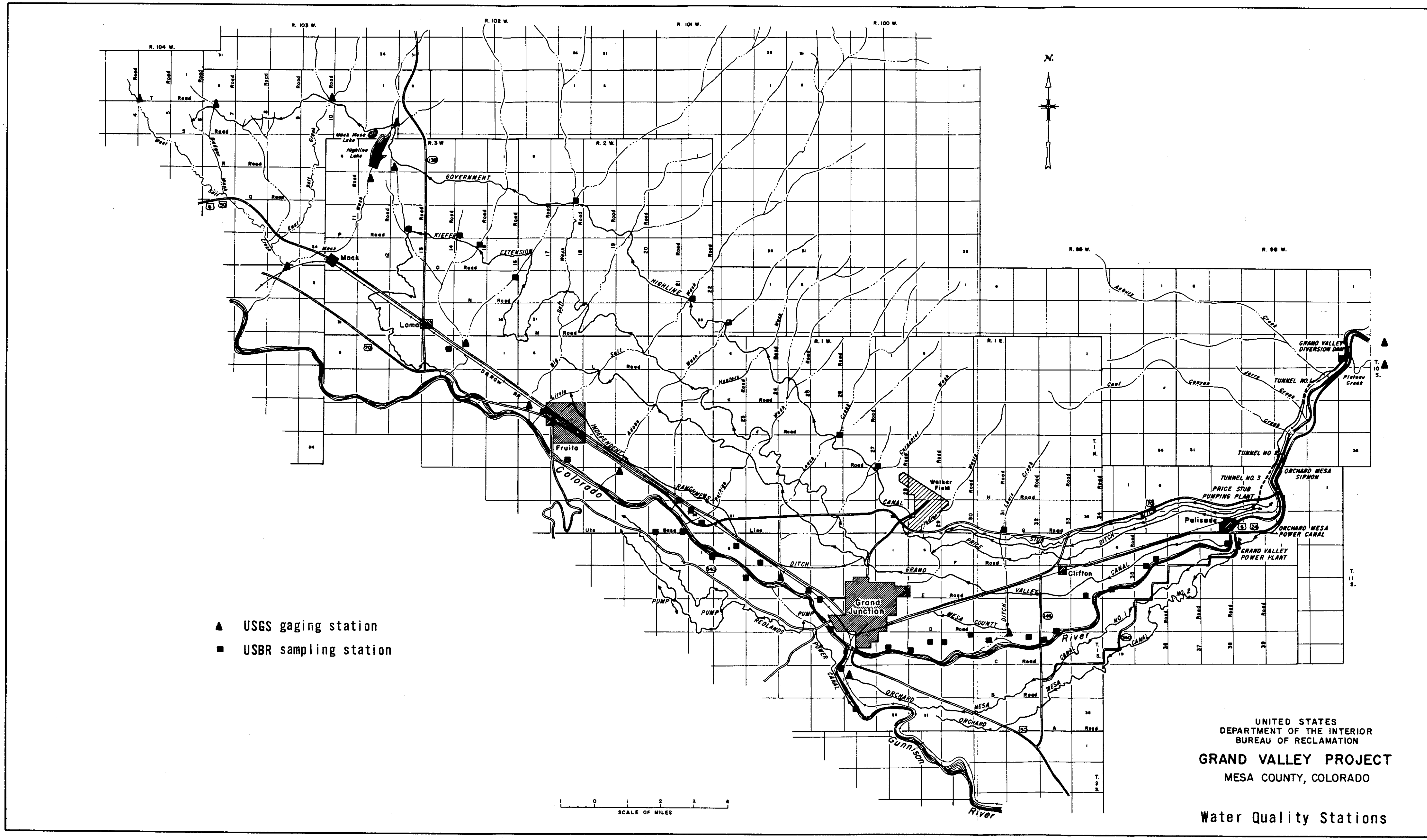
2. Grand Valley Unit, Colorado

Specific mitigation measures for the Grand Valley will be further developed in the advanced planning studies now underway. Those areas that require additional study include wildlife mitigation plans, revegetation requirements, and protection of water rights.

a. Special considerations for mitigation or enhancement. - Aside from those areas specified above, specific mitigation efforts will concentrate on safety and water quality monitoring. Those efforts concerned with canal safety will follow those outlined in the introductory sections of this chapter.

The Bureau of Reclamation proposes to mitigate the impact of the undertaking on any archeological or historical property found during construction. The area will be evaluated by an archeologist or other appropriate professional who will make a determination in consultation with the appropriate State Historic Preservation Officer regarding the property's eligibility for inclusion in the National Register of Historic Places. Should any historic or archeological resource be determined eligible for inclusion in the National Register, the procedures in 36 CFR 800 will be followed.

Water quality monitoring plan. - Water samples and flow measurements are currently being taken at 62 stations in the Grand Valley (fig. IV-2). The sampling points include river inflows, outflows from the major washes and drains, and major inflows from the surrounding highlands. Sixteen of these sampling points have an established Geological Survey gage. Monitoring of all sampling points for quality and quantity is planned at



Grand Valley Project.

Figure IV-2

least through fiscal year 1978. The data will be used in researching the salinity problem.

Twenty-nine observation wells have been placed on various farms throughout the valley (fig. IV-3). The wells were primarily installed to obtain water table information for the IMS program. The wells also provide a means of collecting ground-water samples for quality analyses. More wells are expected to be installed as the IMS program expands. The Bureau of Reclamation is initiating a study area in the western end of the valley near Loma, Colo. The area is divided into two subareas: The Reed Wash-Peck and Beede Wash drainage area, and the East Branch of Reed Wash drainage area (fig. IV-4). An intensified effort to evaluate WSI effectiveness as a salinity control measure will be conducted in the Reed Wash-Peck and Beede Wash area. The adjacent East Branch of Reed Wash area will be monitored to obtain control data indicative of conditions without salinity control. Both areas will be extensively instrumented with observation wells, piezometers, and surface flow measuring devices. The data will be used for calculation of water and salt budgets on a periodic basis. It is anticipated that monitoring will continue for several years.

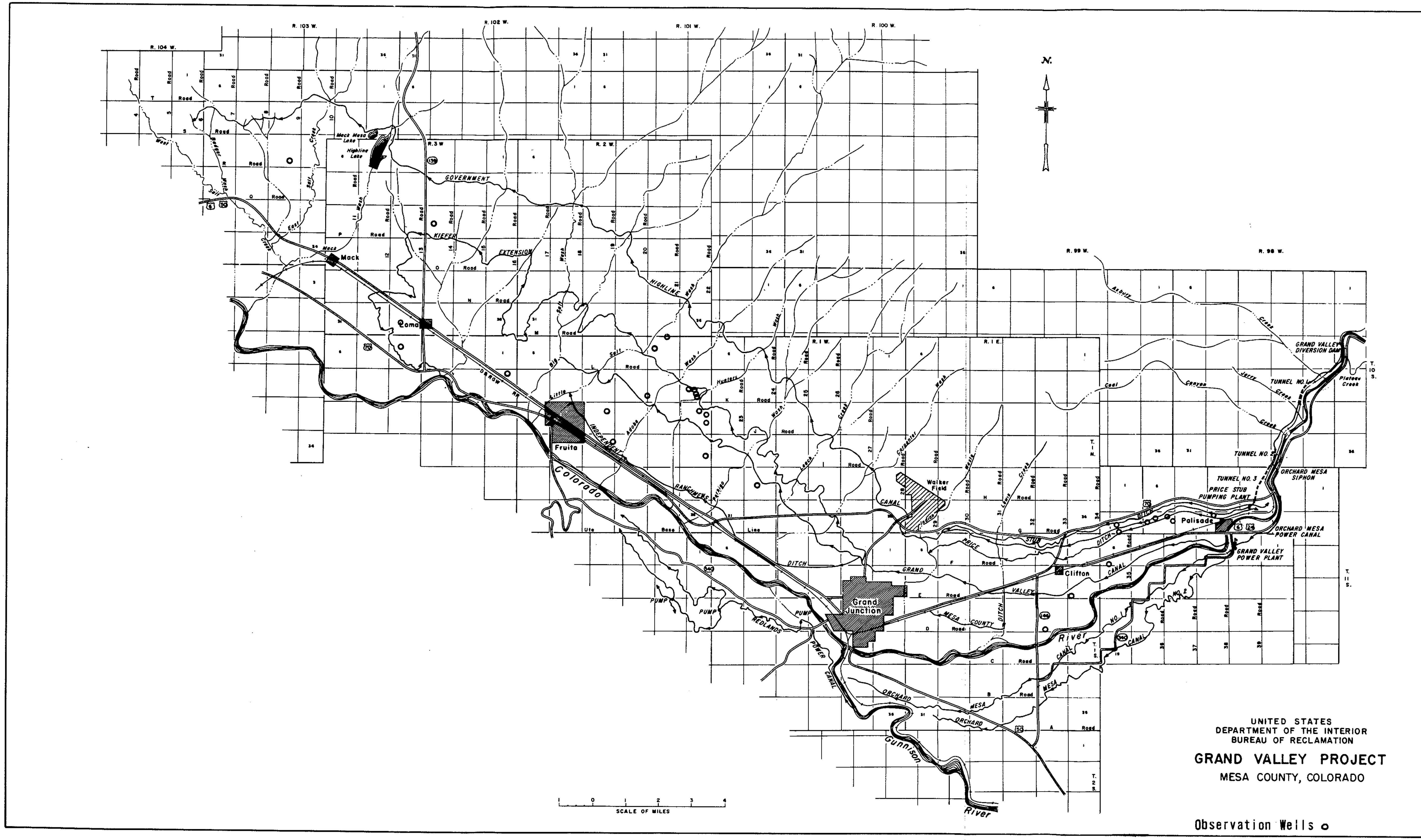
G. Mitigation Measures for Authorized Feasibility Studies

1. LaVerkin Springs Unit, Utah

Due to the presence of radioactive material in the springs water, and the presence of an endangered fish species downstream from the springs, special mitigation efforts will be required. These efforts, along with a particularly local enhancement that will result from the project, are described below:

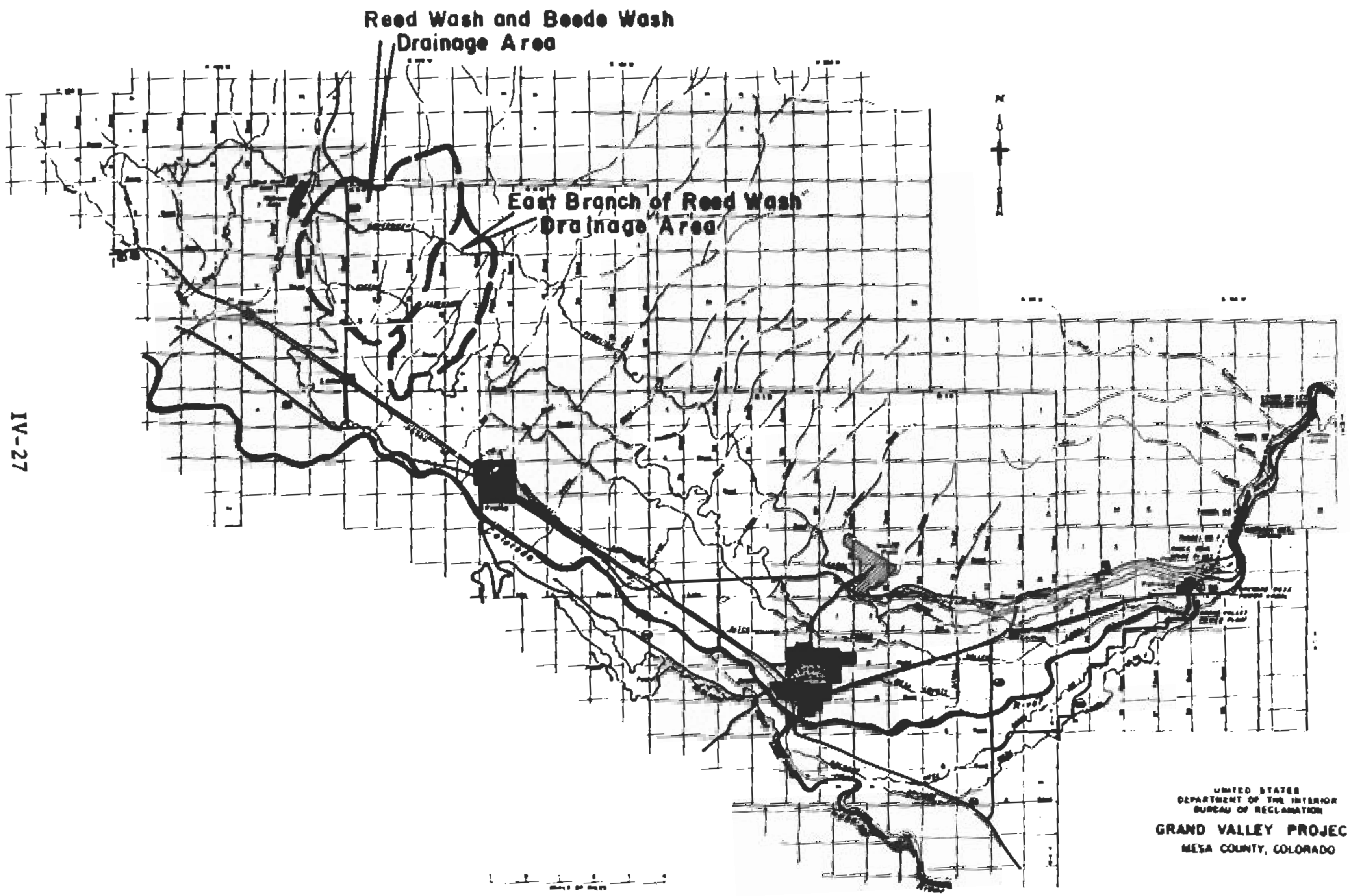
a. The design and operation of the dams on the Virgin River is such that the lower control dam will be deflated during floodflows, thus allowing the water to pass without rising beyond normal limits. This action will also keep the pond area clear of sediment and debris.

b. Determinations indicate that water from the LaVerkin Springs contains an average of 37 picocuries per liter of radioactive radium-226; the desalting plant will concentrate this to about 0.36 gram per year. The Environmental Protection Agency has determined that this quantity would not be harmful unless ingested. Continued use of the water for



Well sites, Grand Valley Project.

Figure IV-3



Proposed study areas, Grand Valley Project.

Figure IV-4

drinking, either by man or wildlife, could result in a dangerous accumulation of radioactive salts. However, since the brine wastes will have a salt content slightly higher than seawater, this should not be a problem. As a precaution, the desalting plant and the evaporation pond will be fenced. For the safety of the public, employees, and wildlife, a radioactive monitoring program will be included in the operation of the facilities to provide the necessary data to determine whether the radioactive levels in the pond will result as predicted.

c. In June 1973, the Bureau of Reclamation and the Fish and Wildlife Service initiated joint funding for research studies on the woundfin *(Plagopterus argentissimus)* which is listed as an endangered species. The Fish and Wildlife Service has contracted with the Environmental Consultants, Inc., of Las Vegas, Nevada, with Drs. James E. Deacon and W. L. Minckley as Co-Project Directors. The contractor is conducting studies and investigations of the woundfin for the purpose of reviewing existing literature, assessing the success of transplants of the woundfin into Paria River in Arizona and Utah, Hassayampa River in Arizona, adequate and practical information regarding physiological, behavorial, and reproductive responses to saline water; and developing a research design specifically geared to answer questions essential to the survival of the species. The Fish and Wildlife Service proposed to combine this work with studies on the ecological life history and other work on the fishes of the Virgin River. This will provide data necessary for an objective evaluation of the probable results of the proposed environmental manipulation and its effect on the woundfin and the other fishes in the Virgin River System.

2. Littlefield Springs Unit, Arizona

Although no serious effects are expected as a result of this project, the Bureau of Reclamation, in keeping with its policy of preservation and enhancement of the environment, initiated joint funding with the Fish and Wildlife Service in June 1973 for research studies on the endangered woundfin fish *(Plagopterous argentissimus)*, which is known to inhabit this reach of the Virgin River. A description of this study and objectives are given in the preceding discussion of the LaVerkin Springs Unit.

3. Glenwood-Dotsero Springs Unit, Colorado

Specific mitigation measures will be developed during feasibility studies on the Glenwood-Dotsero Unit when plans become firm. However, should construction activities be required in the scenic Glenwood Canyon, adverse impacts might be mitigated by combining the pipeline construction with the proposed construction of Interstate Highway No. I-70 through the canyon. The Bureau of Reclamation would in any case, follow its standard policy of providing improved appearances of all structures and preserving the landscape by requiring the contractor to adhere to the rigid environmental specifications.

4. Palo Verde Irrigation District Unit, California

The major impact that may require mitigation is the adverse effect that the reduction in return flows would have on water-oriented recreation on the Palo Verde Drain in the vicinity of the community of Palo Verde. This could be mitigated by diverting water from the Colorado River to the drain above Palo Verde, which would require construction of a small, low-head pumping plant on the river and a feeder canal from the river to the drain. Dredging of sandbar areas in the drain might also mitigate some of the impact caused by a reduced drain flow. Diversion of Colorado River water directly to the drain for recreation would decrease the salt concentrations in the drain below the point of introduction.

5. Colorado River Indian Reservation Unit, Arizona

It is not expected that any action taken under the proposed unit would require special mitigation measures.

6. Uinta Basin Unit, Utah

Wildlife habitat would be eliminated from canals and marshy areas affected by the IMS and WSI programs. The impact of these programs on wildlife is yet to be determined.

A water sampling program has been initiated as part of the IMS and WSI investigations. Sampling will continue throughout the construction and operation phases to determine the effects of these programs on the water quality in the Uinta Basin and of inflow to the Colorado River.

7. Lower Gunnison Basin Unit, Colorado

Since plans are not formulated, mitigation measures have not been developed for the Lower Gunnison Unit. The general measures anticipated for the Grand Valley Unit, however, probably would be appropriate. Specific mitigation measures, if needed, will be determined when plans become more firm.

8. Big Sandy River Unit, Wyoming

A program of sampling has been established on the Big Sandy River and will be used in identifying the source of salts. This will assist in formalizing a definite plan.

Special consideration in design of the evaporating pond will be required to prevent concentrated dissolved salts from spilling back into the stream system.

The area will be evaluated by an archeologist or other appropriate professional who will make a determination in consultation with the appropriate State Historic Preservation Officer regarding the property's eligibility for inclusion in the National Register of Historic Places. Should the property be determined eligible for inclusion in the National Register of Historic Places, the Bureau of Reclamation will follow the procedures outlined in 36 CFR 800.

9. Price River, San Rafael River, and Dirty Devil River Units, Utah

Definite plans are not yet formulated, however, a water sampling program has been initiated within each river basin in an attempt to identify the primary sources of salts. This sampling program will continue to be expanded during the construction and operation phases to determine the effectiveness of the unit in reducing salt loading of the Colorado River.

As a plan of control is developed, specific mitigation measures will be determined and cooperating agencies will be consulted to ensure that environmental requirements are met.

10. McElmo Creek Unit, Colorado

Mitigating measures particular to the McElmo Creek Unit have not been determined, since a specific plan of development has not been formulated.

CHAPTER V

UNAVOIDABLE ADVERSE EFFECTS OF THE PROGRAM

CHAPTER V - UNAVOIDABLE ADVERSE EFFECTS OF THE PROGRAM

A. Introduction

This chapter discusses all the adverse effects of environmental impacts that are considered to be unavoidable within the context of the present development plan. Any impacts which are known to be avoidable with reference to the plan would be avoided and have not been included in the discussion.

Measures which will enhance the project or reduce the extent of the unavoidable impacts have been presented in chapter IV. The following discussion summarizes the most important adverse effects which, under the proposed plan of development, cannot be avoided or fully mitigated.

B. Cumulative Adverse Effects of the Program

Table III-1 reveals at a glance those environmental factors, related to specific units, that have generally cumulative adverse trends. Overall, the following factors were judged to result in cumulative adverse effects and are discussed in further detail in this section: Water Quantity, Land Use, Vegetation, Wildlife Resources, Endangered Species, Scenic Resources, Archeological and Historical Resources, and Energy Resources.

1. Water Quantity

Total water available in the river system for downstream users will be reduced by several units of the CRWQIP. Water depletions or losses will result primarily from brine impoundment, losses, and evaporation to the atmosphere. The cumulative water losses for all control units range from 37,000 to 116,000 acre-feet per year as shown in table III-2.

This level of water depletion due to cumulative salinity controls may have some legal implications concerning loss allocations between the Basin States according to the present law of the river. It is beyond the scope of this statement to consider all the ramifications of water losses to a water system already faced with predictable, future shortages.

2. Land Use

The construction, operation and maintenance of the various control units in the basin will result in both short- and long-term adverse effects on lands in, or adjacent to, project areas.

The temporary adverse effects are related to construction borrow areas, construction camps, access roads, transmission lines, equipment storage, waste material disposal, and other right-of-way requirements.

In the long term, a cumulative total of more than 8,000 acres of land (table III-2) may be directly and adversely affected due to inundation from brine evaporation ponds and other structural features. This commitment of land for all program features represents a very small percentage of land in relation to the 254,000 square miles of surrounding, mostly undeveloped, lands in the basin. Much of the directly affected land use will result in arid rangeland conversions to saline aquatic ecosystems. About 1,100 acres of irrigated pasture, orchard, alfalfa, and general field crops will be required for desalting plants, evaporation ponds, and water rights to spring flow. The area of rangeland and grazing land inundated would vary due to periods of drought on high evaporation rates and some fluctuation in water depth should be expected. Evaporation would reduce the brine volume, leaving the sediment and salt in the impoundment area.

The concentration of these salts as well as the volume of brine water impounded would gradually increase with time. Impoundment sites will be selected to provide a minimum evaporation pond life of 50 to 100 years.

Natural salt playas and dry lakebeds are scattered throughout the Colorado River Basin and give mute testimony as to the future, long-term land impacts of brine impoundment. In some areas, structured ponds may resemble those similar to ponds used by various industrial processes.

3. Vegetation

The adverse impacts of the program upon plant communities would be the loss of approximately 8,000 acres of native vegetation. Vegetation would be both temporarily and permanently destroyed due to clearing and construction activities along canals as well as the operation of desalting plants and evaporation ponds.

The long-term effect of the irrigation improvement control units on vegetative growth would be directly related to the changes in the surface and ground water. Lowering of water tables, reduced flows in drains and washes, and drying up of seep areas would affect local, native plants. Some changes would occur rapidly, for example, the drying-up of a seep area below a leaking canal. Other changes would be gradual with several years required in establishing new equilibrium between surface and ground water.

In general, as depth to ground water increases, some plant groupings could become less vigorous and more scattered with some species replaced by others. In the riparian habitats along the Colorado River and its tributaries, major changes would not be expected because the river would maintain water levels along the flood plains.

It is possible that wind-blown salt from evaporation ponds could affect native vegetation in the immediate surrounding land, but the range of this local effect is not known.

In general, the revegetation process would be slow and would be accomplished in those agricultural areas affected by seeding and transplanting.

4. Wildlife Resources

The cumulative impacts of the program units would have overall adverse effects and would result in the loss of over 8,000 acres of various types of wildlife habitat (including amphibians, reptiles, birds, and small mammals). Wildlife densities as a whole are low in the project unit areas. The drying up of seeps along canals would lead to a reduction in phreatophytes which, in turn, would lead to a reduction in the total wildlife populations in agricultural areas. Valuable nesting and cover areas would be lost for many song birds, game birds, and small mammals as well as various species of amphibians and reptiles.

The displacement and redistribution of wildlife would be expected with the installation and long-term operation of evaporation ponds. In most instances, reestablishment of wildlife habitat will occur in the vicinity of the ponds following revegetation, but with reduced populations.

5. Endangered Species

The overall impact of the program on endangered species within the control unit areas or the basin itself is generally unknown. Investigations in this regard have not yet been completed. It is known that some endangered species reside in some of the unit areas or nearby vicinities but preliminary indications are that the effects will be minimal.

One study, now underway, will determine the effects of control units on the Virgin River (LaVerkin Springs and Littlefield Springs) and the endangered woundfin. Here, indications are such that the decrease in river salinity may have an adverse effect but this will not be confirmed until the study is completed.

6. Scenic Resources

The overall effect of program features on the scenic resources of the Colorado River Basin will be adverse. Construction activities will leave scars on the landscape that will be slow in restoring themselves, particularly in desert regions. Most program features are located in remote areas and the placement of manmade features such as desalting plants, pipelines, structures, transmission lines, roads, and evaporation ponds will have a disturbing, if not displeasing effect for the majority of viewers. Any manmade features in these remote areas will provide stark contrast to the barren, natural beauty of the area.

7. Archeological and Historical Resources

To date, no major archeological resources have been located that would be damaged or affected by construction of any control unit features. However, some minor Indian-related archeological sites have been discovered in some unit areas and continuing studies are evaluating the extent and importance of each site on a case by case basis. There are no known historic sites listed on the National Register of Historic Places that will be affected by any program features.

8. Energy Resources

Operation of the program will require withdrawing as much as 116,000 acre-feet of water per year from the Colorado River system. This withdrawal represents a loss of potential hydroelectric energy if it were left in the system and allowed to pass through the various dams on the river. It is estimated that the loss of potential electric energy from withdrawal will be over 100 million kWh per year. This figure compares to a total average of 10.6 billion kWh that have been generated yearly in recent times. The annual loss estimated will only occur after all waters of the Colorado River are actually being diverted for their intended use and will vary from year to year, depending on reservoir operation, hydrologic conditions, energy demand, and water depletion schedules.

Direct consumption of electrical energy will be required to operate unit desalting plants and pumping plants associated with program features. The total cumulative energy consumption of planned units under the CRWQIP (table III-2) is in excess of 100 million kWh/yr.

C. Unavoidable Adverse Effects of Initial Control Units for Construction

1. Las Vegas Wash Unit

Construction of the Las Vegas Wash Unit will cause some adverse impacts on the environment that cannot be avoided.

Approximately 700 acres of land will be needed for project facilities that will preclude its use for other purposes. Approximately 625 acres will be required for evaporation ponds. In time, these ponds will develop a white stain that will be visible from local highways and from the air. The new ponds represent a 44 percent increase in the quantity of land already used for this purpose in this location.

Construction of project facilities will require placing manmade structures in areas where none presently exist. Such an action will prove to be adverse to that segment of society which is offended by disturbance of natural areas. Similarly, construction of some pipelines will be across desert lands which will result in scars on the landscape that will take many years to heal.

Project operations will result in the depletion of 3,600 acre-feet of water from the Colorado River System annually for the first stage, and 1,450 acre-feet for the second stage.

2. Crystal Geyser Unit, Utah

Some landscape changes around the geyser would be created by construction of the dike. Additional land disturbances would occur in the construction of 3 miles of buried pipeline. During construction there would be a temporary increase in dust and noise level. The disturbance to wildlife however would be minimal. The evaporation pond and dikes covering 105 acres may create an unnatural white salt flat which could be observed from nearby roads. The evaporation site would not be visible from the river below the area due to the approximate 15-foot difference in elevation between the ground at the evaporation pond site and the river water surface. The loss of 150 to 200 acre-feet of water evaporated annually from the Colorado River System cannot be avoided.

D. Unavoidable Adverse Effects of Other Control Units for Construction

1. Paradox Valley Unit, Colorado

The 3-year construction period for the proposed unit would include building of new roads, some of which would be located on undeveloped land and would disturb existing wildlife and vegetative patterns. There would also be impacts related to the frequency and type of use of the new access routes. Roads used only during construction would be scarified and allowed to return to a natural condition when no longer required, and would have only a temporary adverse effect.

Impacts would also result from the construction of the electric transmission lines. These impacts would primarily be visual, but would, nevertheless, be unavoidable. The pipeline would be buried, and the backfill would be contoured to harmonize with the surrounding topography and the area allowed to return to its original use. These impacts would thus be primarily temporary.

Borrow and waste disposal areas could be required for project construction, resulting in a removal of vegetative cover and a change in existing topography. This action would be mitigated through methods as described in chapter IV.

The project would permanently alter land use patterns in Paradox Valley and Dry Creek Basin. Land occupied by surface structures, with the exception of the transmission lines, would be excluded from any other use during the life of the project.

Native vegetation would be permanently reduced, which could reduce the overall carrying capacity of wildlife habitat in the area. It is possible that a slight reduction in some animal populations could result from the reduced habitat. Although these impacts would be small with respect to the vegetation and wildlife in the general area, they would be permanent.

2. Grand Valley Unit, Colorado

As irrigation systems become more efficient and less water is wasted, wildlife habitat associated with seepage, high water tables, and excess waterflows would be reduced or eliminated. Small game hunting and trapping opportunities would be reduced as wildlife habitat would be reduced. This would be an unavoidable adverse effect.

Unavoidable impacts during construction would occur which could temporarily have an adverse affect on fauna in the area.

E. Summary of Potential Unavoidable Adverse Effects of Units Under Feasibility Study

1. LaVerkin Springs Unit, Utah

Providing electric power to the desalting complex may involve environmental impacts of regional scope. Even if existing local generating capacity is used to supply the required load, the result will be a general increase in the power needs (30 x 10^6 kWh/yr) in the area.

The Toquerville Evaporation Pond will require permanent removal of 650 acres of desert grazing land. The extent of additional adverse effect to native vegetation and wildlife as a result of wind-drifted salt spray and dust has not been evaluated. There will be a permanent loss of 8 acres of irrigated pasture and orchard as a result of construction of the desalting plant.

The combined flow of the Virgin River and LaVerkin Springs is considered in allocating the amount of water to be diverted at the Hurricane, Laverkin, and St. George-Washington Diversion Dams. This water is divided under existing water rights. Depletion of the Virgin River by the project will reduce the water supply available for these water rights by 2,470 acre-feet per year. However, there should not be any discernible depletion to uses below the St. George-Washington Diversion Dam. During most of the irrigation season, the St. George-Washington Diversion Dam diverts the entire flow of the river, and downstream users depend entirely on return flows and tributary inflow for their water needs. The change in the quality of the river below the springs may have some influence on the fish. The impacts resulting from the action will be permanent.

The river itself is not classed as a fishery, but it is the habitat of the endangered woundfin. As previously discussed in chapter IV, the Bureau of Reclamation and the Fish and Wildlife Service jointly funded research studies which have determined that the influence of the project on this fish species will not be adverse.

2. <u>Littlefield Springs Unit, Arizona</u>

Construction of the collection system will alter the natural flow of the Littlefield Springs and result in a minor depletion of the Virgin River due to the exportation of the spring flow to evaporating ponds. The impacts resulting from this action will be permanent. There may be an adverse impact to the endangered woundfin. The extent of the effect of the project on this and other aquatic species is currently under study as mentioned in chapter IV.

The construction of the evaporation pond will require right-of-way for the pond, for the area required to retain flash floods, and for a buffer zone to provide for operation and maintenance purposes. The land and vegetation will be permanently lost if this action is taken.

The wildlife inhabiting the evaporation pond site will be displaced, and some may fail to survive. The pond will have an adverse impact on esthetic quality in the area, particularly because of the salt bed that will be formed as a result of evaporating the spring water.

The construction and operation of the unit will require commitments of energy resources.

3. <u>Glenwood Springs-Dotsero Springs Unit, Colorado</u>

The unavoidable adverse effects of the Glenwood-Dotsero Springs Unit cannot be definitely determined until further studies are made. Some impacts, however, appear evident. Esthetic impacts would occur in the vicinity of project features and brine evaporation pond(s) would replace present land uses. Some water loss would also occur to the Colorado River system.

4. <u>Palo Verde Irrigation District Unit, California</u>

The adverse effects would be minimal because the project is primarily limited to changes in irrigation practices and the rehabilitation of the existing distribution system. Implementation of the unit will result in reducing the flows in the Palo Verde Drain and could cause some change in habitat along the canals and drains.

Future utilization of return flows as discussed earlier would greatly deplete the flows in the lower reach of Palo Verde outfall drain, which without mitigation would greatly affect wildlife and recreation.

5. <u>Colorado River Indian Reservation Unit, Arizona</u>

The adverse effects of this program would be small since the action will be limited to changes in irrigation practices through management and the rehabilitation of the existing distribution system. Implementation of the unit will result in reducing the return flows in the drain and may cause some changes in the habitat along the canals and drains. If a viable plan is developed to utilize the return flows, the resulting loss of water could have a major impact on wildlife habitat.

6. <u>Unita Basin Unit, Utah</u>

Wildlife habitat will be eliminated from canals and marshy areas affected by the implementation of the proposed WSI and IMS programs. The amount of habitat affected cannot be determined until the investigation phase of these programs is completed.

7. <u>Lower Gunnison Basin Unit, Colorado</u>

As studies have only recently been initiated, an objective evaluation of adverse impacts cannot be made. However, due to the similarities between this Unit and the Grand Valley Unit, it is anticipated that the implementation of the proposed program would have similar adverse impacts. These consist primarily of reduced flows and loss of wildlife habitat.

8. <u>Big Sandy River Unit, Wyoming</u>

The primary adverse effect of the unit under the present plan is one of land use. There may be others associated with the diversion of low flows during the winter. Current and projected studies will evaluate and quantify the adverse impacts of the proposed action.

9. <u>Price River, San Rafael River, and Dirty Devil River Units, Utah</u>

Habitat will be eliminated for wildlife in areas used for evaporation ponds or desalting plants as the soils become sterile with salt accumulation. The amount and locations of the habitat effected cannot be determined at this time. If diversion dams and feeder canals to the ponds are used, wildlife habitat including established trails could be disrupted possibly making conditions hazardous to certain wildlife. Salts could also be scattered by winds, adversely affecting areas adjacent to the ponds.

Landscape disturbances caused by excavation for structures and dikes, and construction of access roads would be permanent except where restoration is possible. Some degradation of natural scenery would result from construction of diversion dams and evaporating ponds or desalting plants.

If the evaporation method is chosen the estimated annual loss of water from the Price, San Rafael, and Dirty Devil Rivers would be about 30,000 acre-feet each. If the desalting method is chosen, the estimated annual loss would be 5,000 acre-feet each.

10. McElmo Creek Unit, Colorado

The project would permanently alter land use patterns, since the 1,500 acres in the evaporation pond site would be excluded from any other type of use. The salt deposited in the area would ultimately prohibit any vegetative growth and permanently displace the wildlife inhabiting the site. Three farm families residing within the site would also be permanently displaced. Highly saline water would be depleted from the Colorado River system.

CHAPTER VI

THE RELATIONSHIP BETWEEN LOCAL, SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

CHAPTER VI - THE RELATIONSHIP BETWEEN LOCAL, SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

Short-term disturbances of the environment will occur during the construction of unit control facilities, as discussed in Chapter III. Changing the appearance of the natural setting by construction of the units will have long-term effects on esthetic values. Adverse effects will be minimized by clearing only those areas necessary for construction and taking only the minimum irrigated acreage necessary for unit facilities. All new facilities will be designed with low profiles to blend with the natural setting.

A. Water Resources and Quality

In the short-term period of 10 to 20 years, the net program effect will be gradually improved water quality at the expense of some water loss (up to 116,000 acre-feet per year) from the river system. Downstream reductions in salinity and hardness will result in savings in the costs of cleaning compounds, water softening, appliances, plumbing fixtures, boilers, food processing, and a host of other municipal and industrial applications that require good quality water. Long-term agricultural benefits of water quality improvement will accrue to irrigation by increased crop production and lower costs of food production to the United States and Mexico.

In the long term, additional water quality improvement must consider the augmentation of water supply to the basin to also increase the availability of water.

B. Economy of Basin

The long-term productivity of agriculture in the Imperial, Coachella, Gila, and Yuma Valleys and areas such as Palo Verde and Indian lands adjacent to the Lower Colorado River in the United States and irrigated lands in Mexico are at stake in the total water quality improvement program. A better quality of water would be diverted to the Metropolitan Water District of Southern California and the Las Vegas Valley Water District due to the removal of about 1.6 million tons of salt from the Colorado River System. If no control facilities were constructed, economic losses would continue to occur to a large block of municipal water users in the areas served by these entities. Upon completion of the Central Arizona Project, water users in the Phoenix and Tucson areas would be similarly affected.

Long-term electrical energy requirements for the control unit desalting plants and pumping facilities will amount to about 100 million kWh annually, thus requiring an annual energy source equivalent of about 47,082 tons of coal or about 178,571 barrels of oil. In addition, the long-term loss of water from the river system due to salinity control represents a theoretical loss of about 110 million kWh of potential hydroelectric generation. On the other hand, the collection and potential use of wastewater due to control facilities could enhance the development of the vast energy resources of the basin. Reclaimed water could be used for powerplant cooling, in various energy conversion processes, and in land reclamation.

Finally, in the short term, with the construction of the four authorized control units, the total present economic benefit to the Region would amount to about $10 million per year based on the $230,000 per mg/l increment for total salinity detriments.

In the long term, based on the same assumptions, the economic benefits attributable to the accumulative effects of the entire program would result in about $34 million per year.

C. Land Use and Wildlife Resources

Long-term commitments of over 8,000 acres of rangeland, grazing land, and agricultural land for salinity control facilities will essentially exclude these lands from other use. Some presently unused agricultural lands affected by seepage and high water table will be reclaimed for crop use. Terrestrial wildlife species in the affected areas used for brine ponds and related facilities will experience long-term population reductions. Some long-term losses of aquatic or semiaquatic wildlife populations will be experienced with improvements of irrigation water delivery systems.

D. Recreation Potential

With the introduction of large ponds of saline water into areas of existing arid rangeland, the accumulated water is expected to attract human interest. The stark contrast of any aquatic environment in any water-short area makes potential recreational use a speculative venture. However, present recreational use of the Salton Sea, Great Salt Lake, Walker Lake, and other saline waters might suggest some future though tenuous use of the evaporation ponds.

The reduced salinity of the Lower Colorado River may result in long-term fishery benefits. A continued monitoring of these aspects will be needed to determine whether any long-term benefit is actually derived.

E. Initial Control Units for Construction

1. Las Vegas Wash Unit, Nevada

Short-term disturbance of the environment will occur during the construction of the project features. Some minor changes on the natural appearance of the landscape will have a long-term effect on esthetic values. The long-range effect on the productivity of native vegetation will be minor.

Construction and operation of the project will have a long-range effect on the contribution of salts by Las Vegas Wash to Lake Mead and the Colorado River System. For the first stage, there will be a reduction of 46,000 tons per year of salt load to the river. This will provide long-term benefits by reducing the salinity of the Lower Colorado River by about 4 mg/l at Imperial Dam. The second stage will remove over 76,000 tons of salt and reduce salinity at Imperial Dam by 8 mg/l.

The long-term adverse effect of depleting the available water supply through brine evaporation will amount to 3,600 acre-feet for the first stage and 1,450 acre-feet for the second stage.

The project will be consistent with the long-term human environmental and economical needs, since the reduction in salinity in the Colorado River will be beneficial to municipal and industrial uses.

2. Crystal Geyser Unit, Utah

The 105 acres of partially used land at the evaporation pond site would be committed to a long-term use for evaporating geyser water. Long-term recreational changes could be expected if the geyser develops into a tourist attraction. As previously mentioned, long-term reduction in salts will occur in the lower Colorado River Basin causing a corresponding increase in productivity.

F. Other Control Units for Construction

1. Paradox Valley, Colorado

Short-term commitments of environmental resources, particularly land and vegetation, would result during the construction of the project facilities. These would generally be slow in disappearing, even after regrading and revegetation, since the arid climate would inhibit vegetative growth. The economy would be stimulated by construction.

The project would entail a long-term commitment of the land occupied by surface facilities (3,375 acres), electric power used (18.8×10^6 kWh/yr), materials, monetary resources, and the water component of the brine (3,620 acre-feet per year). There could also be a long-term influence on the small wildlife populations in the area as a result of the reduced habitat on the project land. These commitments should not restrict the long-term use of other lands in and adjacent to the project area.

The quality of water in the Dolores River downstream from the project and in the lower Colorado River would be improved on a long-term basis. Freshwater flora and fauna would encounter improved conditions for development.

2. Grand Valley Unit, Colorado

Short- and long-term environmental uses associated with the Grand Valley Project include the following. Short-term environmental uses would occur generally during construction activities. Adverse construction effects such as dust and noise would be temporary as would the stimulation of the local economy.

The present trend of impairment of agricultural productivity in the Grand Valley by salt buildup, high water tables, and seepage areas would be arrested and perhaps reversed, increasing the long-term agricultural productivity and economic base in the valley.

Erosion of unlined canals and laterals would be reduced along with reduced erosion in drains and washes. Downstream, sedimentation would also be reduced.

Long-term changes in vegetation, primarily a reduction in phreatophytes, would be accompanied by a reduction in wildlife that utilizes this type of vegetation.

A long-term decrease in salinity would occur in all reaches downstream from the project and at Imperial Dam this would amount to about 19 mg/l.

G. Units Under Feasibility Study

1. LaVerkin Springs Unit, Utah

Short-term impacts would be those associated with temporary construction activities. The increase in noise, dust, vehicular traffic, clearing of vegatation, and excavations are all temporary. There will be no major permanent defacing of the land with the exception of the evaporation pond. The pond will have a long-term impact. The accumulations of salt and mild radioactive materials will render this 650-acre brine disposal site useless for any useful purpose. The 6-acre collection pond formed by the lower control dam will be unavoidable but is not considered adverse.

Construction and operation of the desalting complex will have the long-range effect of providing 5,690 acre-feet of 500 mg/l of water to the Virgin River in lieu of 8,160 acre-feet of 9,650 mg/l of water. This action will reduce the salt load of the Colorado River by removing 103,000 tons per year which have historically entered the Lower Colorado River. This will provide long-term benefits by reducing the salinity of the Lower Colorado River by about 11 mg/l at Imperial Dam.

Construction of the unit will produce a short-term economic impact on the local area. Increased employment with a related increase in the need for services and materials will be of definite short-term value. There will be some immediate and long-term adverse effects from the reduced flow in the Virgin River downstream from LaVerkin Springs, but this may be more than offset by the immediate and long-term benefits to downstream users as a result of the reduced salinity. The constructed unit will be consistent, however, with the long-term human environmental and economical needs, since the reduction in salinity in the Colorado River will be beneficial to municipal and industrial uses. A few long-term jobs will be provided by the operation and maintenance of the desalting plant. The long-term energy requirements will amount to 30 million kilowatt-hours of power annually.

2. Littlefield Springs Unit, Arizona

Short-term disturbances of the environment will occur during the construction of the unit facilities. Changing the appearance of the natural setting will have a long-term effect on esthetic values. The long-range effect of the unit on the productivity of native vegetation for wildlife habitat will be minor. The construction of the collection system will have a long-term effect on the natural flows of the Littlefield Springs and the Virgin River by diverting the spring flows to an evaporation pond.

Construction and operation of the unit will have a long-range effect on the Colorado River by removing 16,700 tons of salt per year which have historically entered the lower Colorado River. This will provide long-term benefits by reducing the salinity at Imperial Dam by about 2 mg/l.

Unit operations will have a long-term adverse effect of depleting the combined average discharge of the springs by about 5.7 ft^3/s or about 4,100 acre-feet per year.

3. Glenwood Springs-Dotsero Springs Unit, Colorado

Existing commercial and recreational uses of the Glenwood Springs discharge would not be interfered with. Land and energy would be long-term uses of the environment in the desalination plans. Evaporation ponds for either the total flow or the brine from the desalination plant(s) would become devoid of aquatic life as the brine solution became more concentrated. The salt load in the Colorado River would be reduced below the springs to the benefit of Colorado water users as well as users along the lower Colorado River.

Short-term uses of the environment would relate mostly to construction activities. The construction work would stimulate the economy of the area while causing temporary effects such as noise, dust, or adverse aesthetic conditions.

4. Palo Verde Irrigation District Unit, California

The program will result in reduced return flows in the Palo Verde Drain. The Palo Verde Drain provides a habitat for fish and waterfowl. The extent of the flow reduction is problematical; however, any reduction will reduce the habitat and may degrade the remaining environment. This is considered as a long-term impact. Included in this category would be depletions associated with the utilization of return flows which would not only affect wildlife but boating recreation on the lower portion of the Outfall Drain.

Under the proposed use of Palo Verde's return flow, there would be short-term uses only of those resources required for and during the construction of the power generating facilities. There would be long-term uses of land, water, and energy resources, along with the required services and personnel associated with the operation and maintenance of the generating facility.

5. Colorado River Indian Reservation Unit, Arizona

Implementation of this program will result in a long-term effect in the reduction of the total amount of soluble salts returned to the Colorado River per unit of agricultural land irrigated. Water will be more readily available for development of the remaining irrigable acres of Indian land in Arizona. Increased crop yields will occur using manpower and fertilizer more efficiently.

The distribution and drainage system provides habitat for fish and wildlife. The reduction in flow in the drain could have a long-term undesirable effect on the habitat in the area.

Long-term employment involving 10 positions will be provided in the operation and maintenance of the IMS and WSI programs.

Short-term disturbances of the environment will occur during the construction activities in connection with the rehabilitation of the irrigation distribution system.

Should utilization of the return flows become viable at some future date, it is expected that the short- and long-term uses would be similar to those for the Palo Verde Unit.

6. Uinta Basin Unit, Utah

Short-term economic benefits would result to those involved with the construction activities and to communities supporting the construction forces. Longer term economic benefits to local communities could result from increased income due to improved crop yields and efficiency of operation.

Long-term water supply for irrigated lands may be increased by reduction of seepage losses and more efficient use of water. Quality of water used for irrigation may be improved under the WSI program. Water quality in the lower reaches of the Duchesne River may improve due to reduced salts, pesticides, phosphates, and nitrates.

The full implementation of the IMS and WSI programs will remove an estimated 100,000 tons of salt annually. The removal of this amount of salt from the Colorado River would decrease the salinity concentration at Imperial Dam by an estimated 9 mg/l.

7. Lower Gunnison Basin Unit, Colorado

Short- and long-term environmental uses associated with the Lower Gunnison Project include the following. Short-term uses of land would be mostly related to construction activities which are temporary. Agricultural productivity would be enhanced; and salt buildup, high water tables, and seepage areas would be reduced. Erosion and associated sedimentation would be reduced by concrete lining. Long-term changes in vegetation, primarily a reduction in phreatophytes and hydrophytes, would be accompanied by a reduction in wildlife that utilize this vegetation.

8. Big Sandy River Unit, Wyoming

The effect of this project would result in a long-term salt reduction to any downstream reaches on the Green and Colorado Rivers as well as to the lower portion of the Big Sandy River where freshwater aquatic life could be provided more favorable habitat in the river. The brine pond would be committed to a long-term use for evaporation purposes. Short-term uses would be mostly related to temporary construction activities.

9. Price River, San Rafael River, and Dirty Devil River Units, Utah

Some long-term changes will occur in wildlife due to the changes in environment caused by saline ponds.

The areas designated for evaporation ponds or desalting plants with brine disposal ponds would be committed to long-term use.

The effect of the construction activities on wildlife would be temporary; however, the loss of habitat and the disruption of wildlife trails would be long term. Additional studies must be conducted as investigations progress to determine the effect on wildlife.

If ponds are located where sediment can be trapped, the downstream sediment loads will be reduced. The ponds might retard erosion in certain areas.

The long-term effect of this program on downstream water quality would be a reduction of an estimated 260,000 tons of salt annually from the Colorado River, which would reduce salinity concentration at Imperial Dam by an estimated 23 mg/l. A loss of an estimated 5,000 to 30,000 acre-feet due to evaporation would occur in each of the three river basins. The amount of water loss would depend on the control method used.

10. McElmo Creek Unit, Colorado

Short-term commitments of land and vegetation, would be produced during the construction of the project facilities. These would generally be slow in reappearing, even after regrading and revegetation, since the arid climate would inhibit vegetative growth.

The project would entail a long-term commitment of the land occupied by surface facilities, materials, monetary resources, and the water component of the brine. There could also be a long-term influence on the small wildlife populations in the area as a result of the loss of habitat. These commitments should not restrict the long-term use of other lands in and adjacent to the project area.

There would be both long- and short-term impacts to the farm families that would be displaced. These could involve monetary, cultural, and social changes.

CHAPTER VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

CHAPTER VII - IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

A. Introduction

A number of resources would be affected by plant or unit construction and operation; the irreversible or irretrievable nature of the use of each is described for each major resource category.

B. Cumulative Effects

1. Water Resources

The water lost through pond evaporation and disposal will be irreversibly lost to the Colorado River Basin. A total amount of 37,000 to 116,000 acre-feet of degraded quality water will be essentially isolated and removed from the surface- and groundwater system.

The long-term commitment of this volume of water will essentially advance the timing and scale of eventual augmentation of the Colorado River. Recent Bureau of Reclamation estimates[15] show that the Basin water supply will be, both legally and physically, fully committed before the year 2000.

2. Land, Mineral, and Vegetative Resources

Total land area committed to full program development includes about 7,000 acres of rangeland and about 1,100 acres of agricultural lands which will be inundated with either brine or precipitated mineral salts, or other permanent project features. Most of these lands cannot be returned to former use. Total mineral wastes to be disposed of will be about 1.6 million tons per year. At present, the reclamation or recycling of salts or chemicals from this waste material appears uneconomical.

Impoundment sites will be selected to provide a minimum evaporation pond life of 50 to 100 years. In terms of this typical expected project life, the lands required will remain limited in use and will represent irreversible commitments of a natural resource. The creation of evaporation ponds would prevent the potential mining of any minerals from the immediate area affected by the brine and precipitated salts. However, there are no known mineral deposits in the prospective pond areas with the possible exception of sand and gravel and a few uranium claims located on the periphery of the Paradox Valley Unit.

Right-of-way for project construction and operation will affect up to 8,000 acres of natural vegetation and agricultural crops now growing on the proposed sites and along right-of-way alinements. Included in this total are more than 1,000 acres of seep-supported vegetation that would be lost or converted to cropland.

3. Energy Resources

The energy resources committed to construction and operation of the total program will be irretrievably lost. This includes electric generating capacity and maximum energy requirements of approximately 14 MW and over 100,000,000 kWh per year for the pumping, processing, treatment, and disposal of saline flows. Regardless of the source of supply, ultimately there will be irreversible or irretrievable commitments of about 47,000 tons of coal or about 179,000 barrels of oil per year. Other equal energy sources may be used such as fossil fuels, nuclear fuel, or geothermal energy.

Additional commitment of water resources, lost principally through evaporation at unit facilities, will result in a maximum theoretical loss of about 110 million kWh per year of potential hydroelectric generation. This potential energy loss assumes that the water would have passed through the major dams on the river system. This same tradeoff occurs in any consumptive depletion of water in the Upper Basin for agricultural purposes or M&I use. Actual potential energy losses will be dependent on reservoir operation, hydrologic conditions, depletion rates, and energy demand.

4. Wildlife, Recreation, and Esthetic Values

Wildlife will be lost or displaced in proportion to the loss of vegetation and aquatic habitat resulting from control unit operations. Terrestrial wildlife species in the affected areas used for brine ponds and related facilities will experience unknown population reductions. In addition, some long-term losses of aquatic or semiaquatic wildlife populations will be experienced with improvements of irrigation water delivery systems. The detailed environmental statements being prepared for each control unit will quantify these losses.

The major, irretrievable recreation commitment of resources will result in the removal of large tracts of open-space (up to 8,000 acres) for the various control units. Brine ponds, structures, and other rights-of-way may hamper recreational access to open-space areas or new hunting areas. Since many of the units are still under study, a total estimate of recreational user days lost is not yet available.

Manmade intrusions of transmission lines, pipelines, desalting plants, evaporation ponds, etc. will permanently change the esthetic value of the remote lands under consideration for unit sites. These visual impacts are not found near any designated natural scenic areas or National Parks but would be experienced by people using adjacent trails, roads, and highways or flying overhead in aircraft.

5. Economic Resources

Construction and operation of the proposed program features will require a commitment of economic resources in the form of Federal expenditures and Basin power revenues. Installation costs for the entire program are estimated to be about $125 million. Some of the direct expenditures will be recovered in the annual economic benefits attributed to lower basin water users. Other indirect economic benefits will result in the full utilization of available basin water supply and the short-term stimulus of public works funds into the regional economy.

C. Resource Commitments for Initial Control Units for Construction

1. Las Vegas Wash Unit, Nevada

The lands required by the project will represent irreversible commitments of a natural resource. This will amount to about 800 acres. The portion of these lands actually used for structures will be cleared of vegetation and, in some cases, topographically modified to accommodate the features.

Operation of the project will result in the removal of about 3,600 acre-feet per year of water from the system. This depletion of the flows will be an irretrievable commitment of the water resource. This commitment will be reduced to 1,450 acre-feet per year upon completion of the second stage.

Construction and operation of the proposed features will require irreversible and irretrievable commitments of construction materials, operations materials, and public funds. The requirement for energy resources will result in the commitment of natural resources such as natural gas, coal, oil, or nuclear fuels.

2. Crystal Geyser Unit, Utah

Crystal Geyser evaporation ponds and dikes would cover 105 acres of land including both cultivated farmland and native vegetation and eventually, the land would be covered with a layer of salt. This land would be irreversibly lost to other uses because of the conversion to evaporation pond use.

The evaporated water (about 150 acre-feet per year) would be irreversibly lost to other uses in the Colorado River Basin. Construction material used on the project would be irretrievable after its expended life.

D. Resource Commitments for Other Control Units Set for Construction

1. Paradox Valley Unit, Colorado

The well field, hydrogen sulfide treatment plant, brine pipeline, evaporation pond, and appurtenant facilities would be permanent commitments with respect to the 100-year life of the project. Some vegetative patterns, wildlife populations, and other natural resources would also be committed for the duration of project operations. Beyond this, some of the project area would not be irreversibly or irretrievably modified, since the facilities could be removed and the land restored to its present condition. The salt in the evaporation pond, however, would probably render that area biologically sterile.

The commitments of raw materials, electrical power, and labor would be irretrievable. Similarly, up to 5 cubic feet per second of brine will be conveyed to the evaporation pond. Water contained in the brine would be lost during the life of the project and would not be available for other uses in the Colorado River Basin.

The pumps used for the well field would require a total of about 18.8 million kilowatt-hours of electrical power each year and would have a power demand of about 2,230 kilowatts. Power would be obtained from the Colorado River Storage Project. This use would make it unavailable to other users. Fuel would be consumed during construction of the project.

2. Grand Valley Unit, Colorado

Construction materials, such as cement, sand, gravel, pipe, fencing material, and structural material plus energy used during construction would be committed to the project. Areas of native vegetation and wildlife habitat would be altered by hydrologic changes during the life of the project, and the agricultural productivity of the land would be increased.

E. Resource Commitments for Units under Feasibility Study

1. LaVerkin Springs Unit, Utah

The LaVerkin Springs Unit would require a commitment of resources that would be considered permanent throughout the life of the project. The present water laws of the State of Utah do not recognize a right for incidental consumptive use such as would be required in a desalting plant. Utah water laws require evidence of beneficial use to establish a valid right. Salinity reduction certainly benefits other water users, but an interpretation to that effect has never been made by the Utah State Supreme Court who is the official interpreter of State laws. In addition, Utah law specifies priorities in water use which would be in direct conflict with the operation of the project. This may require legislative action or court interpretation to validate the water right required for the project's operation.

A commitment of incidental consumptive use of water resources for project operation would amount to an average of about 3.5 ft^3/s or 2,470 acre-feet per year. This estimate is assuming full plant capacity operating 98 percent of the time. In actual practice, the plant would not be operated during floodflows which would dilute the springs and make desalting impractical. This is expected to occur about 2 percent of the time.

At the present time, Utah water law restricts water rights to a given rate of flow rather than an average volume. To adequately secure a right for the project's needs, a rate equal to the maximum consumptive use would have to be obtained. This maximum rate of use is about 3.67 ft^3/s.

The lands required by surface structures and for rights-of-way represent irreversible commitments of a natural source. This will pertain to a total of about 680 acres; including 12 acres for the collection system, 2 acres for the feeder pipeline to the desalting plant, 17 acres for the desalting plant, product water pipeline, and brine pipeline, and 650 acres for the brine evaporation pond. The portion of these lands actually used for construction will be cleared of vegetation and, in some cases, topographically modified to accommodate the physical structures. After construction, some of the lands used for rights-of-way would be available for continued agricultural or other uses.

There are several ways of acquiring water rights, one of which is to purchase irrigated land. If this alternative were followed, there would be a definite change in the use of those lands acquired. This impact would be considered irretrievable unless another source of irrigation water became available or the land became valuable for some other use.

There would be an irretrievable commitment of resources such as earthfill, riprap, cement, aggregates, and fuel consumed during construction. There will also be a commitment of fossil fuel used by electric companies who will supply the energy requirements of about 30 million kilowatt-hours for project operation.

The environment in which the unique fish and other aquatic population live in the 134 miles of the Virgin River below the springs will be changed as a result of the construction and operation of the unit. The effect that this action may have on the woundfin, an endangered species, and other unique fish that inhabit the river system could be considered as irretrievable.

Construction and operation of the features of the proposed unit will require irreversible and irretrievable commitments of construction materials, chemicals, and public funds.

2. Littlefield Springs Unit, Arizona

The lands required for the project structures will represent an irreversible commitment of natural resource. This commitment will amount to about 750 acres for the construction and operation of the evaporation ponds, access roads, and headquarters areas. The construction of the surface structures will have a minimal effect on the scenic value of the area.

Construction and operation of the unit will require irreversible and irretrievable commitments of construction materials and public funds. The energy committed to the construction and operation of the unit will be irretrievably lost. Although the objective of evaporating the springflows will be achieved by using solar energy, the unit will still require the use of about 1.5 million kilowatt-hours of electric energy for pumping the collected water to the evaporation ponds. The depletion of the flows of the lower Virgin and Colorado Rivers by about 4,100 acre-feet of water per year will be an irretrievable commitment of the water resource throughout the life of the unit.

3. Glenwood Springs-Dotsero Springs Unit, Colorado

Lands required for project features and brine evaporation pond(s) would be committed to project use during the project's lifetime. The flow of Dotsero Springs would be interrupted throughout the life of the project. Construction materials would be committed to long-term project use. Salinity concentrations downstream would be decreased and the evaporated water would be lost from present downstream uses.

4. Palo Verde Irrigation District Unit, California

This program does not result in an irreversible situation. If the program is terminated, the preexisting conditions would probably evolve rapidly. Man-hours and supporting equipment and supplies are the only irretrievable resources committed to this program.

Due to increased need for generating capacity to supply the needs of the people of the United States, any power structure or facility designed and constructed for this purpose will become a permanent feature. Thus, if the utilization of return flows materialize, the resources mentioned in chapter VI, that is, land, water, nuclear, services, and personnel associated with this development will be irreversibly and irretrievably committed.

5. Colorado River Indian Reservation Unit, Arizona

This program does not result in an irreversible situation. If the program is terminated, the preexisting conditions would probably evolve rapidly. Man-hours and supporting equipment and supplies are irretrievable resources committed to this program.

6. Uinta Basin Unit, Utah

Removal of vegetation from canals and some construction scars would be, for the most part, irreversible during the life of the project. Wildlife habitat eliminated from the canals and seepage areas could not be reestablished during the life of the project.

Resources including energy committed for construction of lined canals or pipelines and other structures would be irretrievable. When a construction program is selected, economic resources will be committed toward the completion of the programs.

7. Lower Gunnison Basin Unit, Colorado

Construction materials such as cement, sand, gravel, pipe, fencing material, and structural material would be committed to the project. Areas of native vegetation and wildlife habitat would be altered by hydrologic change during the life of the project.

8. Big Sandy River Unit, Wyoming

The brine evaporating pond area would become irreversible to present or other uses because of the heavy layer of salt that would be accumulated. The evaporated water would be irretrievable or lost to other uses. Energy for pumping would be unavailable to other users. The other parts of the project would be reversible, if so desired, by dismantling the equipment and allowing the natural vegetation to reestablish in the area. The equipment used in construction or used and depreciated on the project would be irretrievable.

9. Price River, San Rafael River, and Dirty Devil River Units, Utah

The most important irretrievable commitment of resources is the land used for evaporation or brine ponds. A deposit of salt will accumulate within the impoundment which will permanently alter the condition of the soil and plant community. Water evaporated from these ponds would be lost to other uses.

Construction scars and removal of vegetation would be for the most part irreversible during the life of the project.

Archeological or historical sites may be lost if located within the pond areas. A field survey of archeological and historical sites will be made after project feature locations are determined.

Resources committed for construction of the majority of project features will be irretrievable. When a construction program is selected, economic resources will be committed toward the completion of the project.

10. McElmo Creek Unit, Colorado

The evaporation pond and appurtenant facilities would be permanent commitments with respect to the 100-year life of the project. Native vegetation, irrigated farmland, wildlife population, and esthetic resources would also be irreversibly committed by project operations. The eventual concentration of salt in the evaporation pond would render that area biologically sterile. The commitments of raw materials, nonrenewable fuels, energy during construction and operation, and monetary resources would be irretrievable. Similarly, the water conveyed to the evaporation pond would be lost for future use. The social and economic impacts resulting from the displacement of three farm families would be irreversable and irretrievable.

CHAPTER VIII

ALTERNATIVES TO THE PROGRAM AND RELATED IMPACTS

CHAPTER VIII - ALTERNATIVES TO THE PROGRAM AND RELATED IMPACTS

A. Major Alternatives to the Program

The major alternatives to the CRWQIP as outlined in this statement include:

1. Moratorium on future water resources development in the Basin

2. Retirement or restriction of irrigated agriculture

3. No action for salinity control above Imperial Dam

4. Alternative modes of river augmentation

It should be noted that these alternatives are only to be considered entirely in lieu of the CRWQIP. However, they could also reinforce or supplement necessary control action to achieve recommended levels of salinity control in the Basin. In general, alternatives 1 and 2 have serious legal and institutional constraints involved, while alternative 4 is highly dependent upon successful technological application of new techniques. Under the general modes of river augmentation (4), considered in this statement are:

a. Geothermal resources

b. Seawater desalting

c. Weather modification

d. Watershed management

e. Importation and exchange

f. Conservation and reclamation

Augmentation of the Colorado River Basin includes the question of need from both a salinity control standpoint and water demand, as well as consideration of when additional water will be required.

The major alternative solutions to the Colorado River salinity problem are of a longer range character, substantially larger in scope, and less demonstrable than some of those measures already described. Implementation of one or more of these measures would not necessarily be incompatible with the CRWQIP, but may well go beyond political credibility and legal limits.

1. Moratorium of Future Water Resources Development in the Colorado River Basin

This measure would involve the postponement of all or most future Federal action that involves water development within the Basin. Proposed irrigation projects, transmountain diversions, powerplants and other energy development might be some of the kinds of activities that would be adversely affected. Limitations also might be placed on already authorized developments. As a consequence of this moratorium, salinity levels would not necessarily be reduced, but projected increases would be curtailed. Most of the future proposed development and depletions are in the Upper Basin. Table VIII-1 shows a listing by State of projected water supply and depletion as of August 1976 in the Upper Colorado Region.

Projected depletions are estimated for potential Reclamation projects as well as water requirements for energy-related industries.

The most significant constraint on the scope of such a measure as a moratorium is that such an action would apply to Federal development only and would not directly prohibit non-Federal or private development. Consequently, such a measure would have to preclude all direct and indirect Federal assistance which in any form would contribute to further development. This would include any program by State or non-Federal entities to develop or utilize Colorado River water within the Basin.

Obviously, the impacts of such a sweeping measure would depend upon the legality of separate actions, lengthy litigation, and successful imposition of any court-sustained provisions over time. Assuming a successful moratorium on Federal development as assumed above, it would be reasonable to expect a reduced rate of adverse environmental effects including salinity increases stemming from development that might otherwise occur. However, it is by no means certain that in the long term, adverse environmental effects would be reduced under non-Federal or private development. For example, if federally sponsored development were effectively foreclosed, many of the water rights now held for anticipated water development would likely become available for private industrial use both in and out of the Basin. Thus, water development would be only shifted in priority since most Basin State water rights laws recognize industrial water use as third in priority following domestic and agricultural water use.

Table VIII-1

UPPER COLORADO REGION
PROJECTED WATER SUPPLY AND DEPLETIONS

(Unit - 1,000 acre-feet)

	1976	1980	1990	2000
Arizona				
Present (1974)	13	13	13	13
Navajo Powerplant	12	34	34	34
Other M&I		3	3	3
Total, Arizona only	25	50	50	50
Compact apportionment	50	50	50	50
Colorado				
Present (1974)	1,828	1,828	1,828	1,828
Fryingpan-Arkansas		33	33	33
Ruedi Reservoir M&I				24
Fruitland Mesa			20	21
Savery-Pot Hook			11	13
Animas-La Plata			119	119
Dolores			79	81
Dallas Creek		10	13	17
West Divide			33	40
San Miguel			53	67
Denver expansion		40	90	150
Colorado Springs expansion		6	6	6
Homestake		10	49	49
Pueblo (Eagle River)		3	3	3
Green Mountain M&I			45	45
Hayden-Craig steamplants		14	20	20
Independence Pass expansion		7	7	7
Englewood		10	10	10
C-a oil shale prototype development			60	60
C-b oil shale prototype development			18	18
Total depletion	1,828	1,961	2,497	2,611
Evaporation storage units	269	269	269	269
Total	2,097	2,230	2,766	2,880
State share of 5.8 MAF level	2,976	2,976	2,976	2,976
Remaining water available	879	746	210	96

Table VIII-1 - Continued

	1976	1980	1990	2000
New Mexico				
Present (1976)	110	110	110	110
San Juan-Chama	90	110	110	110
Animas-La Plata			27	34
Navajo Reservoir evaporation	26	26	26	26
Hogback expansion	2	5	10	10
Utah International, Inc.	20	25	39	39
Farmington M&I			5	5
Navajo Indian Irrigation[1]	21	89	254	254
Navajo M&I contracts	5	16	100	100
San Juan (NMPSC)[2]	(5)	(16)	(16)	(16)
Utah International, Inc. (WESCO)[3]		(8)	(35)	(35)
El Paso Nat. Gas Co.[4]		(14)	(28)	(28)
Other			(21)	(21)
Total depletion	274	381	681	688
Evaporation storage units	58	58	58	58
Total	332	439	739	746
State share at 5.8 MAF level	647	647	647	647
Remaining water available	315	208	-92	-99

Table VIII-1 - Continued

	1976	1980	1990	2000
Utah				
Present (1976)	678	678	678	678
Bonneville Unit	37	76	166	166
Upalco Unit			10	10
Jensen Unit		8	15	15
Uintah Unit			30	30
Emery County-Huntington Canyon		6	6	6
Deferred Indian lands			40	50
Kaiparowits			30	30
Huntington Canyon Powerplant		6	15	15
Ua-Ub oil shale prototype development			24	24
Total depletion	715	774	1,014	1,024
Evaporation storage units	120	120	120	120
Total	835	894	1,134	1,144
State share of 5.8 MAF level	1,322	1,322	1,322	1,322
Remaining water available	487	428	188	178

Table VIII-1 - Continued

	1976	1980	1990	2000
Wyoming				
Present (1976)	313	313	313	313
Cheyenne-Laramie	7	10	16	31
Lyman	6	10	10	10
Savery-Pot Hook			9	11
Seedskadee	10	30	100	278
Private industrial rights			50	57
Total depletion	336	363	498	700
Evaporation storage units	73	73	73	73
Total	409	436	571	773
State share of 5.8 MAF level	805	805	805	805
Remaining water available	396	396	234	32

Table VIII-1 - Continued

	1976	1980	1990	2000
Upper Colorado River Basin Totals				
Depletions	3,178	3,529	4,740	5,073
Evaporation storage units	520	520	520	520
Total depletions	3,698	4,049	5,260	5,593
5.8 MAF level	5,800	5,800	5,800	5,800
Remaining water available	2,102	1,751	540	207

[1] Solicitor's opinion (May 17, 1974) indicates probable depletion of water by Navajo Indians totaling 254,000 acre-feet even though NIIP sprinkler plan identifies only 226,000 acre-feet depletion.

[2] Revised maximum consumption value (FES 76-2, Bureau of Reclamation, p. 1-20).

[3] This water is furnished to Utah International Inc. from the Navajo Reservoir through an existing water service contract with the Bureau of Reclamation. UII has assigned this water to Western Gasification Company. The contract provides for a revised maximum consumptive use of 35,000 acre-feet of water per year through the year 2005. However, actual water consumption for gasifying the coal, cooling, mine operations and reclamation irrigation is expected to be 31,940 acre-feet per year for the entire four proposed plants, or 7,985 acre-feet per year for each plant. (FES 76-2, Bureau of Reclamation, p. 1-3.)

[4] No contracts have been completed to furnish this water nor are there assurances that the water will be made available.

The ultimate cost of a moratorium in terms of the lost investment in facilities already constructed would amount to hundreds of millions of dollars. In addition to the loss of Federal investment, there would be immeasurable loss of economic benefits to the Basin States associated with the inability to support future growth. As an example of a possible serious adverse effect on the diverse human environment, a moratorium would adversely affect the economy and cultural heritage of several Indian tribes within the Basin area.

Another serious implication of the moratorium measure would affect energy development, such as powerplants, coal gasification, and oil shale conversion, which depends on storage facilties and availability of water rights from the agricultural sector, Indian lands, and other private entities.

A Federal moratorium on water resources development would directly restrict all development on Indian land and other Federal lands supporting fish, wildlife, etc. Finally, with regard to the practicability of such a moratorium measure, there can only be speculation about the legal action and counteraction by all affected parties. Congressional action and extensive litigation on Federal and State levels would quickly follow any legal or institutional rearrangement of operative laws and compacts within the Basin.

2. Retirement or Restriction of Irrigated Agriculture in the Basin

Irrigated agriculture represents the largest single consumptive use of water in the Colorado River Basin. It is also the largest man-induced contributor of salinity (37 percent basinwide) to the river by direct salt loading and indirectly through salt concentrating effects. Thus, the elimination of irrigated agriculture by retirement of existing lands or restrictions on new lands coming into production is considered a theoretical alternative measure to irrigation improvements envisioned under the CRWQIP.

The question of retirement or restriction of irrigated agriculture in the Colorado River Basin cannot be treated as an isolated policy matter in itself.

Past Federal policies toward irrigation development were based on the need to promote settlement of the West. Presently, irrigated agriculture is one of the key factors underlying the present economy of the Western States.

In recent years, several factors have combined to question the need for continued irrigation development. These factors include conflicts with other Federal programs to control supply and reduce crop surpluses, increases in the amount of Federal assistance required, the maturing of Western States' economics, and environmental concerns over desirability of constructing major facilities. Restrictions on irrigated agriculture for salinity control must consider the larger impact of irrigation development to meet future food and fiber needs and changing national goals.

Data from the census of agriculture[39] indicate that of 30.9 million acres irrigated in the 11 Western States in 1970, only 10 million were under Federal projects. There is little doubt that the prominence of non-Federal irrigation is increasing. Consequently, Federal control restricting or retiring irrigated lands on Federal projects would not be effective since non-Federal irrigation development would not be directly controlled. P.L. 92-500, The Federal Water Pollution Control Act as amended, may provide salinity controls on non-Federal installations indirectly through discharge permits on irrigation return flows.

Irrigation's contribution to agricultural production is more significant than acreage data indicate because of relatively greater yield and type of crop growth, particularly in the West. As an example, of the Nation's total annual domestic consumption, 25 percent of citrus fruit, 60 percent of noncitrus fruit, 75 percent of dry beans and peas, 50 percent of fresh vegetables, and 50 percent of potatoes are produced in the 11 Western States[40]. Virtually all these crops are produced under irrigation because of the natural arid conditions that prevail such as in the Colorado River Basin.

According to recent Bureau estimates, irrigated land (Federal and private) dependent upon Colorado River water is about 3.4 million acres, producing a gross crop value of approximately $1 billion per year.[41]

The impact of irrigated land retirement or restrictions must be weighed against present data. The total National cropland base included an estimated 60 million acres of land that was considered surplus as recently as 2 years ago. Projections developed for the Water Resources Council, OBERS[42] assumed that this amount would be gradually absorbed as needed through the future projected period. To meet agricultural shortages, it was estimated that all but about 12 million acres of the 60 million acres in long-term retirement and set-aside programs was placed into production by 1972 with the remaining surplus lands reduced to zero in 1974.

Since 1971, the export market for American agricultural products has changed dramatically. The value of agricultural exports has risen from $5.7 billion in FY 1969 to $12.9 billion in FY 1973, an increase of more than 100 percent.

In total, the impact of this measure as an alternative to salinity control may have National as well as international effects. Recent worldwide food and fiber shortages, droughts, and the dynamic international trade situation emphasize the importance of strategic food reserves and focus new attention on the advantage of stablized food production and the contributions of irrigated agriculture.

Specific impacts of this retirement measure applied to the Colorado River Basin have been examined in relation to alternatives described in the Environmental Statement for the Colorado River Basin Salinity Control Projects, Title I.[43]

One alternative considered total shutdown of the Wellton-Mohawk Irrigation District near Yuma, Arizona. This theoretical proposal would involve the Federal purchase of all lands, buildings, equipment, utilities, and other capital improvements. Payment would be made for investments, interests, damages assessed, and the Federal investment in the area would be written off. Under Federal ownership, regulations would restrict land use to a natural environment of desert and riparian habitats. As a consequence, Wellton-Mohawk drainage flows would be eliminated and the salinity of Colorado River water would be reduced to meet the requirements of Minute No. 242 with Mexico. The resulting salinity impact would provide Mexico with a water quality not exceeding 115 mg/l plus or minus 30 mg/l over the salinity of water as measured at Imperial Dam. The direct costs to achieve the desired salinity differential are estimated to be between $125 and $150 million.

With the theoretical shutdown of Wellton-Mohawk return flows, representative environmental impacts can be described as follows:

a. All cultivated crops and riparian vegetation would be eliminated.

b. Cropland and land occupied by communities would return to the desert environment.

c. An existing fishery in the drain would be eliminated along with water-dependent game species.

d. Adverse social and economic impacts would be extensive, affecting the entire economy of the area, including the city of Yuma, Yuma County, and the State of Arizona. Indirect economic losses are estimated to be double those of direct losses.

It is not difficult to translate these impacts to other irrigated areas of the Colorado River Basin if either land retirement or irrigation restrictions were instituted for salinity control.

3. The Alternative of No Salinity Control Action above Imperial Dam

The alternative of no action has been considered. Such action would avoid construction of any facilities or their alternatives described in this statement. As such, structural facilities would not cause the impacts described in terms of land use, fish and wildlife, water loss, or energy consumption. If none of the four authorized control units or units under study are constructed, salinity increases will continue unabated as projected in table I-1, with the continued development of available water supplies in the Basin. Water users in the United States would continue to suffer the economic detriments described in chapter I at the unit rate of $230,000 per mg/l per year. Although the Republic of Mexico is guaranteed salinity levels relative to Imperial Dam quality, that country would also be affected by higher total river salinity if Upper Basin controls are not constructed.

As river salinity increases, it is likely that non-Federal action would be required to protect individual water supplies from further deterioration. Reversion to a fragmented, self-interest, uncoordinated approach to the salinity problem would result, with resources wasted due to the lack of shared facilities or economies of scale. Moreover, this action would most likely involve control measures at water delivery points in the river system in contrast to control at point, diffuse, or irrigation sources with basinwide benefits.

Without salinity control, there would be a heavy impact on the economic factors of both agriculture and industry. In the argricultural sector of water use, some irrigated cropland would eventually be abandoned from production due to salinity damage. In most cases, sparse desert vegetation would be reestablished on abandoned agricultural lands over several years. Dust, erosion, and other associated problems would increase as a result of abandoned agricultural lands.

It should be emphasized that the alternative of no control action will not necessarily affect the imposition of water quality control criteria on the Colorado River under the provisions of P.L. 92-500, The Federal Water Pollution Control Act, as amended. In effect, the establishment of salinity standards will contribute to the long-term solution of the Colorado River salinity problem and reinforce other options for control.

In view of the physical and legal consequences described below, some form of control will ultimately be required.

Increasing the salt loading of the river has essentially a linear effect, while decreasing water volume has practically an exponential increasing effect on river salinity. Continued water development without salinity control causes both effects to occur simultaneously. However, as full development of the river water supply is approached, flow depletions greatly magnify the impact on water quality. Thus, while approaching full development, small increases in consumptive use, exports from the Basin, or increased evaporation due to additional storage would lend to disproportionately large downstream increases in salinity concentrations. Under such conditions, it is clearly necessary that salinity control units be moved rapidly to completion.

Another important, physical-legal aspect is related to storage on the river. The Colorado River is highly regulated, and storage has a significant effect on mineral quality of waters delivered from the larger reservoirs. A relatively large volume of water might enter a reservoir in a single month during spring runoff, while it would take several months for the same amount of water to enter the same reservoir in the low-flow season. Thus, a single water quality reading during the spring would be as important as several readings during the fall so far as future downstream quality is concerned. In water quality studies, flow-weighted mean salinity values are used to account for this factor. Since storage in the river system exceeds the annual flow (four to five times), water quality in the lower river is related to the average of such flow-weighted data from several preceding years. Due to these damping effects of upstream storage, water quality effects downstream are spread over several years and generally are mixed with one another. In effect, standards violations in the lower river would be difficult to trace to a specific upstream cause in a quantifiable way. In other words, standards violations attributed to upstream activity would be difficult to control through legal action if stream quality criteria alone were used as the basis for such action. Thus, it is essential that the benefits of completion of units under the CRWQIP be added to controls now being exercised by the States.

Finally, the environmental effects in the Colorado River Basin related to the abscence of salinity control is discussed in chapter II, Future Basin Environment Without the Program.

4. Alternative Modes of River Augmentation

In considering the following alternatives for augmenting the flow of the Colorado River, it must be remembered that in accordance with provisions of the 1968 Colorado River Project Act, new water supplies developed through augmentation will first go to meet the Mexican Water Treaty obligation. Only after this commitment has been met would water from these sources be available for use to the Colorado River Basin States.

a. Geothermal resources. - Geothermal water is an attractive source of irrigation, municipal, and industrial water that could be used to augment the Colorado River. Development of a supply of demineralized water would improve the water quality of the lower Colorado River.

The Imperial Valley has proved to be one of the several known geothermal resource areas throughout the world. The University of California at Riverside began geothermal studies in Imperial Valley in 1964. Beginning in June of 1968, the Bureau of Reclamation provided financial assistance to the University. These studies led to the identification of several geothermal anomalies in the Imperial Valley area. Subsequent test holes have indicated the presence of a geothermal resource that would support the economic production of geothermal water. The Geological Survey has estimated that the recoverable reserves of geothermal water in the Imperial Valley is about 1 billion acre-feet.

Large-scale development could augment the Colorado River by delivering as much as 2.5 million acre-feet of desalted water annually. This large volume of output would require importation of water from the Pacific Ocean or Gulf of California to replace geothermal brines withdrawn from Imperial Valley. These replacement fluids would be used for cooling and would then be injected for geothermal ground-water maintenance and surface stabilization.

The power potential associated with the production of 2.5 million acre-feet of desalted water is estimated to be 10,500 megawatts. When produced concurrently with the distillation process of desalting water the operation is essentially pollution free. Up to one-fourth of the power produced would be needed for internal processing and pumping for the conveyance of import and product water.

Disposal of residual brines is an important aspect of geothermal development. Residual brine disposal could present a major problem to inland geothermal development, but it is anticipated that the proposed reinjection would be a workable solution.

Water quality improvement would be an important function of augmentation from geothermal reserves. It is estimated that the addition of 2.5 million acre-feet of desalted water containing only 20 mg/l of salts to the Colorado River at Parker Dam would lower the average annual salt concentration from 1,150 mg/l to 850 mg/l under future conditions without other methods of salinity control. The actual reduction, of course, would depend upon the salinity of the river at the time of augmentation. It may be necessary to cool the water to avoid adverse environmental impacts.

Several potential delivery points of desalted water from Imperial Valley would provide varying degrees of improvement in quality. Delivery as far upstream on the Colorado River as Lake Havasu or Lake Mead would provide the greatest benefits that would apply to the entire Basin, and would include the improvement of Colorado River quality as a major function.

The very magnitude of the conceptual development program and the additional research that must be accomplished before specific data will be available makes all assessments of environmental impact conjectural. The impacts as presently envisioned are as follows:

> Developing geothermal resources in the Imperial Valley of California would, in many respects, raise the same environmental issues as would other water development projects. There would be access roads, pipelines, visible facilities, and the usual construction activities. However, several aspects unique to this type of program would be encountered.
>
> Geothermal development for the production of water and power would involve the extraction of hot mineralized geothermal fluids, which could be expected to create a problem with land subsidence, unless preventive measures were undertaken. Since the Imperial Valley has a highly developed irrigation system, any appreciable subsidence would have serious consequences. The Bureau of Reclamation's plan of development, if such an option were pursued, would be to inject fluids into the underground system and replace quantities removed to reduce the possibility of surface settlement.
>
> To determine any change in seismic activity arising from geothermal development, the Geological Survey has established a seismic monitoring system in the Imperial Valley.

The Bureau of Reclamation has installed a microseismic net covering the Mesa anomaly, which will be integrated into the Survey's overall grid.

Under this option, in the process of extracting and desalting geothermal fluids, it would be essential that both the initial fluid and the residual brine be isolated from the shallow ground-water system in the area to prevent any contamination. Consequently, all pipelines would be above ground, permitting a rapid detection of problems, and would be designed for quick shutoffs in the event of leaks. During well testing and desalting operations it is postulated that the concentrated brine would be either discharged to a lined evaporation pond or reinjected into the geothermal reservoir. Reinjection would be a means of preventing subsidence as well as an effective method of disposal.

Noncondensable gases, which include carbon dioxide, hydrogen sulfide, ammonia, and trace elements of carbon monoxide and other hydrocarbons, could be compressed and reinjected with the brine, while noxious gases could be disposed of by chemical treatment. Solid wastes would be dissolved and reinjected, when possible, or transported to suitable disposal areas where they could be isolated from the ground-water system.

Since the East Mesa of Imperial Valley is sparsely vegetated, most of the geothermal facilities would be visible for some distance, and appropriate architectural and landscaping techniques would have to be used to minimize the visual impact. The steam continually released from the power facilities would also be visible for a distance. However, since most of the activity would occur on remote Federal lands, this aspect should be insignificant with respect to the number of people affected.

Noise from steam wells has been an inherent trait in geothermal developments. The noise associated with powerplants and desalting plants could be effectively muffled through the use of acoustical building materials.

With an extensive development of such a geothermal resource, importing large quantities of cooling and injection water from distance sources would be required. This would entail long pipelines crossing a variety of environmental areas and would necessitate acquiring considerable rights-of-way. It would be important to minimize the possibility of import water leaking into local ground-water systems from the pipeline.

Augmenting the Colorado River with large amounts of desalting water would significantly improve the quality of the riverflows. Prior to delivery, the water would be cooled to prevent any adverse ecological problems in the river system. It would also be dispersed at the delivery point to eliminate temperature stratification in the river.

Delivery could be made to any one of a number of points on the river, such as Lake Mead, Lake Mohave, Lake Havasu, or near Imperial Dam, or to the All-American Canal System. The improved quality would permit the direct use of diversions in municipal systems with lower pretreatment costs, and would improve the crop yields of lands irrigated from the river. Such an augmentation of the river would also enhance fishery and recreational values. Two main difficulties of the scheme, however, are that it is in experimental stage, and like some of the other more capital intensive efforts, would be relatively costly.

A more detailed discussion of the potential adverse impacts and of measures to avoid them is contained in three environmental statements already written, and in a recent status report on the geothermal desalting program.[44, 45, 46]

Other specific, quantifiable impacts include:

(1) As many as 5,000 workers could be employed during construction, with as many as 1,000 permanent employees required to operate and maintain the facilities.

(2) About 2,000 to 5,000 acres of Federal withdrawn lands would be required for production facilities. Vegetation and wildlife would be permanently displaced. Additional land and rights-of-way would be required for conveyance facilities.

(3) Based on January 1972 prices, the cost of this development would range from about $100 to about $150 per acre-foot of product water delivered, depending upon the alternatives selected. Aside from the benefits derived from the augmented flow and power production, the benefits attributed to reduced salinity at Imperial Dam under future conditions are estimated to be $69,000,000.

b. <u>Seawater desalting</u>. - Since 1952, Federal support for research and development of desalting technology has produced many advances in desalting processes such as distillation, reverse osmosis, and electrodialysis. Most of these processes are now considered commercially available for select applications. However, due to relatively high cost, lack of experience, and present availability of other water supply sources, United States desalting applications have been slow compared to current worldwide experience.

California's seacoast has been under recent intensive study to site large-scale seawater desalting plants. Recent reconnaissance studies have evaluated desalting plants at Diablo Canyon (40 Mgal/d), Encino-San Diego (40 Mgal/d), and San Diego Refuse Incinerator Project (32 Mgal/d). The Orange County Water Factory 21 (3 Mgal/d), is now in operation. Ultimately, large-scale, dual-purpose, coastal desalting plants could not only augment local municipal and industrial demands, but also export or exchange water to meet inland demands such as augmentation of the Colorado River.

In providing new water in large quantities for augmentation purposes, seawater desalting is viewed only as a distant future possibility, as long as relatively low-cost conventional water supplies are available. Under the present economics of water supply and increasing energy costs, any large-scale desalting plant should be integrated into a dual-purpose or multipurpose system.

Typical product water costs for large-scale, dual-purpose desalting plants are shown below. All costs shown are at-site costs based on a 1972-73 nonescalated cost basis:

Project	Desalting capacity (Mgal/d)	Total product water cost	
		Cents per 1,000 gallons	Dollars per acre-foot
Diablo Canyon	40	92	300
San Diego refuse Incinerator	32	45-50*	147-163*

*Costs are dependent upon the credit allowed for disposal of waste refuse.

A research and development prototype plant for seawater desalting is still needed to demonstrate the economics of large-scale (100 Mgal/d or greater) dual-purpose operation. Future development with refuse or nuclear powerplants could amalgamate new technologies in an economic manner to minimize environmental impact and meet water augmentation requirements.

(1) Environmental impact for a representative, coastal desalting plant. - Marine processes most likely to be affected in the area of brine discharges from distillation plants of this character are ecosystems involving benthic (bottom) organisms. The brine effluent (brine blowdown plus cooling water) is discharged from distillation plants (multistage flash, vertical tube evaporator, or a combination thereof) at temperatures, salinities, and concentrations of heavy metals exceeding those of the marine environment.

Brine effluent disposal in the immediate vicinity of the outfall has the following impacts: Heavy metals - benthic organisms as well as shellfish can be affected by copper concentrations as low as 0.02 mg/l. Titanium could be used for tubing to minimize the effects of copper; Temperature - elevated brine discharge temperatures have an adverse effect on most larval forms of marine organisms; Salinity - salinities in excess of ambient exert an osmotic effect on benthic organisms.

Under this option, temperature and salinity could destroy elements in the food chains, resulting in some disappearance of higher forms of marine life.

(a) Fish losses at intake structure. - Some fish losses would occur at intake structures as a result of impingement.

(b) Construction. - Construction activities would remove vegetation from the construction site and displace some wildlife. Approximately 35 acres would be required for a 300-Mgal/d desalting plant.

(c) Air pollution. - Operation of a coastal desalting plant would not cause air pollution since the plant probably would use steam from a nearby nuclear powerplant.

(d) Noise. - During plant operation, noise would not exceed acceptable legal industrial levels. Commercial noise-muffling devices would be used where necessary.

(e) Earthquake hazard. - Any proposed desalting plant located on the coast of California falls within a broad area of major seismic risk corresponding to intensity VIII on the Modified Mercalli scale. A major problem that would have to be faced is that of safely designing and constructing such a facility, including its nuclear component, to withstand the effects of any major tremors that might ultimately occur at the selected site.

(f) Visual. - A coastal site structure would be visible for some distance.

(g) Social. - The main social impact would be in the area of employment. About 200 people would be expected to be employed at the time of peak construction, and about 50 people probably would be needed after construction for plant operation.

(h) Archeological and historical values. - Since no site has been selected, it is not possible to determine what archeological or historical values would be affected if this option were selected. However, during any feasibility and preliminary design phases, these values would be considered so that any adverse effects could be avoided.

(2) Environmental impact - nuclear powerplant. - The nuclear powerplant that would provide heat energy for a seawater desalting plant would probably use light water reactor technology, and because of the construction lead time, a powerplant of this type would not be available for operation until the mid-1980's.

The environmental impacts from this postulated nuclear plant should be generally similar to those listed in the Final Environmental Statement for the San Onofre Nuclear Generating Station, Units 2 and 3, Dockets No. 50-361 and 50-362, dated March 1973. Some of the impacts described in the above-mentioned statement that would be generally applicable are as follows: (It should be noted that the quantitative data given will vary depending on the size of the facility.)

(a) Cooling water heated to about 20° F above inlet temperature would be discharged from each unit to the Pacific Ocean at a rate of 830,000 gal/min. The heated water would result in changes in the species composition in the vicinity of the outfall, but no general ecological changes would be expected.

(b) An impact on aquatic resources may occur in the cooling water intake structure through entrapment of plankton and fish. Fish losses may range from 39,000 to 85,000 lbs/yr. This would not, however, be expected to have a significant impact on the overall fish population in the area.

(c) Chemical effluents from Units 2 and 3 should cause only minimal impact on the Pacific Ocean. The total residual chlorine concentration would be less than 0.1 mg/l in the immediate vicinity of each of the discharges, and no significant impact on the aquatic biota in the Pacific Ocean is expected.

(d) The program for construction and maintenance of transmission lines would be designed to reduce environmental impact. Existing transmission lines and towers would be used where possible. New towers, access roads, and switchyards would occupy about 10 acres.

(e) About 85 acres of the sea floor would be temporarily disturbed by installation of buried pipes which transport seawater to and from the plant. This would destroy or temporarily displace bottom-dwelling organisms, but a rapid resettlement by biota could be expected.

(f) Units 2 and 3 would occupy about 33 acres of coastal land which could otherwise be used primarily for recreation or maintained as wildlife habitat. The beach at and near the site would be improved by adding the sand excavated during construction.

(g) No significant environmental impacts would be anticipated from normal operational releases of radioactive materials within 50 miles of the plant. The estimated dose from operation of the plant to the population within 50 miles would be 2.5 man-rem/yr (Roentgen equivalent, mammal); significantly less than normal fluctuations in the 685,000 man-rem/yr background dose that this population would receive.

(h) The risk associated with accidental radiation exposure remains to be evaluated.

c. Weather modification. - The subject of weather modification including precipitation management has been under intensive investigation for about 25 years. Since 1966, most of the precipitation management research has been conducted or sponsored by the Bureau of Reclamation. This program, known as Project Skywater, is a coordinated multidisciplinary research effort with the goal of perfecting the necessary technology of cloud seeding so a predictable amount of snow or precipitation can be produced in an efficient, economic, environmental and socially acceptable manner.

This measure which would be long-term in character and would be contingent on further research and experimentation; would use cloud seeding techniques in an effort to increase winter snowfall in high mountainous areas an estimated average of 15 percent. If the cloud seeding techniques are successful, up to an additional 2.0 million acre-feet of streamflow in the Upper Colorado River Region could be produced. This would help to reverse the general downward trend of Colorado River virgin flows at Lee Ferry, Arizona. Average annual direct cost for such a measure is estimated at about $5.4 million.

During winter months, supercooled clouds form over the higher elevations as moist air is forced aloft by strong winds over the major mountain ranges in the Upper Colorado River Basin. Under certain favorable conditions, the precipitation from these clouds can be increased by seeding with silver iodide.

A winter orographic cloud seeding experiment in the U.S., the Colorado River Basin Pilot Project, has been conducted by the Bureau in the San Juan Mountains of southwest Colorado. The pilot project has been coordinated through the fifth and final year ending May 15, 1975. An independent private contractor, Aerometric Research, Inc., will prepare a final evaluation of project results by June 1976. A description of this study, Colorado River Basin Pilot Project was discussed in a final environmental statement (INTFES 71-6) which was filed with the Council on Environmental Quality on July 16, 1971.

A programmatic draft environmental statement on authorized "Project Skywater," Atmospheric Water Resources Project has been prepared by the Bureau of Reclamation (INT DES 76-10) which will further describe this project and the findings of related environmental studies.

In brief, the Colorado River Basin Pilot Project is a 5-year weather modification experiment in southwestern Colorado for augmenting water supplies. Winter snowfall is expected to be increased an average of about 15 percent by cloud seeding. This relatively slight increase will be imposed upon the already highly variable extremes of seasonable snowfall. About 250 kilograms of silver iodide will be burned during a typical winter season to affect a 1,300-square-mile target area.

Evaluation of seeding results and related costs of the Pilot Project is being carried out by a private contractor independent of other project operations. Although final evaluation is not scheduled to be completed until 1976, preliminary results indicate that the pilot project is producing significant increases in precipitation in the target area. Current estimates are that the water supply within the Colorado River Basin could be increased up to 1.3 million acre-feet per year by selectively seeding the warmer winter storms over the basin.[47]

The cost of the water produced would be about $5.50 per acre-foot which includes substantial monitoring and additional research costs as well as the production costs. The revenue from the additional power that this added water would generate in the main-stem powerplants of the Colorado River alone would be about $5 million or enough to offset the entire cost of the project. In addition, water quality downstream would be enhanced, there could well be favorable impacts on the activities being carried out by the United States pursuant to Minute No. 242 to the Mexican Water Treaty recently negotiated by Mexico and the United States, and there would be some insurance against a potentially future adverse runoff cycle.

The project studies are not yet concluded, but the present evidence does not suggest any dramatic direct ecological consequences from such a program. At this time, changes cannot be predicted which would result from the interaction and propagation through the ecological system of many minor indirect effects. The relationship of some of these changes to human activities and values is not fully understood. Environmental monitoring studies are therefore an important part of the current investigative program, and should be continued as part of any new program. Seeding will be suspended in seasons of heavy snowfall, or during periods of avalanche danger. Avalanche research is being conducted to determine effects of increased snow on avalanches and to improve avalanche forecasting techniques.

A large-scale demonstration operational cloud seeding program is proposed in the Colorado River Basin for the production of new water to meet the essential national needs and to sufficiently firm-up state supplies. A range of design alternatives with staggered starting dates for the separate proposed areas is possible. With authorization and funding in FY 1977 seeding can be started in the fall of 1978.

There are six main potential cloud seeding areas in the Colorado River Basin Region. The potential flow available to the Colorado River from the demonstration operational cloud seeding program is estimated by the USBR to be 700,000 acre-feet annually. The demonstration program would exercise constraints on the operation when increased snowpack levels would result in hazards such as avalanches or floods.

The implementation of the demonstration program may be affected by a number of external factors. Cloud seeding in wilderness and primitive areas has not been generally accepted with the Forest Service or the National Park Service. Either a clear administrative definition or separate legislation is required. Ongoing and future large-scale seeding operations such as those in Utah will require a high degree of coordination and cooperation. Recognition of claims for real or alleged disbenefits from persons in the project or adjacent areas and in the area receiving increased runoff must be reconciled for a successful program. A balanced policy and legal precedent will need to be formed and implemented.

It is axiomatic that if the flow of the Colorado River is increased through weather modification, there will result an increase in the tonnage of salt that must be carried by the river. So long as all or a substantial part of the augmented supply is allowed to flow directly down the river system to increase the supply to the Lower Basin, the water quality in the Lower Basin will be improved. On the other hand, when and if the augmented supply is consumptively used by projects having return flow in the Upper Basin, the quality to the Lower Basin will be degraded.

A theoretical increase of the virgin flow of the Colorado River by about 2 million acre-feet per year could add about 700,000 tons of dissolved minerals and 12.5 million tons of sediment to the river annually. However, the net diluting effect of this increase would be to reduce the salinity at Imperial Dam by about 70 mg/l. A more significant impact on water quality may result from the uses to which the new water increment is applied. The salinity problem could be aggravated if the new water were used to place additional lands under irrigation or energy development.[47]

Without control measures, the probabilities of avalanches and floods would increase. With well-managed control programs, present avalanche hazards could be lessened. By incorporating a weather and snow forecasting program, the losses from flood effects could also be reduced below the present level.

Heavy runoff or floods are primarily a function of the water content of the snowpack, temperature, and precipitation. Thus, these hydrologic events are an occurrence in compound probability. Surveyed snow courses established in the mountains provide data on the water content of the snowpack. These data along with recorded and forecasted climatological data are used to analyze the probable runoff from any storm event or seasonal period. Historical records of such recorded and forecasted events are used to determine flood control parameters that form a part of the design criteria used for all regulating structures on the Colorado River.

Most of the storage reservoirs in the Colorado River Basin have flood control space (vacant storage) allocated as part of their original authorization. These reservoirs are normally operated for flood control on a seasonal volume forecast basis. Some reservoirs have inviolate flood control space that can only be used to control floods. These reservoirs are normally operated on a rule-curve which defines the maximum storage to be allocated for each month.

Cloud seeding would necessarily be suspended in any season of heavy snowfall or whenever the forecasted volume of runoff caused the required flood control space to equal the actual flood control space.

Plants and animals respond slowly to environmental changes. Increased snowpack would have a direct effect on aquatic life, wildlife and its habitat, and insect life. If the snowpack is of sufficient depth, there could be some loss of fishlife in high mountain lakes. A longer snow season would force deer, elk, and livestock to remain on winter ranges longer.

The changes in vegetation resulting from snowpack increases would be subtle. Any increase or decrease in vegetation types would have some effect on species of mammals, birds, and insects. In some instances, populations might decline; in other instances, increase.

There might be some indirect effects on downstream aquatic environments if the program increased the snowpack and the resulting snowmelt decreased the downstream temperature of the river or stream. A few degrees of change could alter the distribution of aquatic organisms and change the timing of breeding seasons, life cycles, and growth.

There would also be effects on the manmade environment in the target area. Work activities such as mining and timber cutting could be made somewhat more difficult if there were an increased snowpack. The normal activities of man in a mountain community also could be made somewhat more difficult; for example, driving, working out-of-doors, snow removal, and winter recreation activities would all be affected.

In the alpine tundra, some plants show no response to variations of snow depth while others indicate retarded growth or later onset of flowering. Increased snow appears to shorten the period of pollinator insect activity, but seems to have little or no effect on quantities of seed set.

A long-continued cloud seeding program in a given locality would result in present plant communities changing their preference to a more hydric environment. Several aspects of small mammal population changes below timberline might be related to snow variability. Erosion would probably increase slightly. The magnitude of the increase would depend upon several factors, such as slope, vegetative cover, preciptiation intensity, rate of snowmelt, and burrowing activities of rodents.

In terms of Basin hydrology, the expected increase in flows in the Colorado River Basin would not cause total flows in the river to exceed the long-term average of the 1896-1921 period; therefore, the effect would be to gradually increase the present yearly flow totals to approaching the higher long-term average. No problems of damaging floods are anticipated because adequate flood control measures have been incorporated in the operation of the reservoir systems of the Colorado River Basin.

Technically, weather modification is a reversible system; it can be turned on and off at will, and causes only minimal disturbance to the physical surroundings.

d. <u>Importation</u>. - The concept of augmentation by importation can be generally considered as interbasin transfer of water supply to the Colorado River Basin.

Sources of import water include basins with surplus surface water and/or mining of ground water from adjacent basins, or possibly icebergs towed to coastal areas from the antarctic regions of the world. Importation configurations tapping these sources of water involve pumped-storage schemes, open and closed conduits, offshore pipelines, tunnels, and other conventional overland systems.

Transfer of water from areas of surplus, such as Alaska or the Pacific Northwest, has been contemplated but legislative constraints have been imposed prohibiting current study of this potential. P.L. 90-537, Section 201, provides that "* * * for a period of 10 years from the date of this Act, (1968), the Secretary shall not undertake reconnaissance studies of any plan for the importation of water into the Colorado River Basin from any other natural river drainage basin lying outside the States of California, Arizona, Colorado, New Mexico, and those portions of Nevada, Utah, and Wyoming which are in the natural drainage basin of the Colorado River."

Since these studies have not and cannot be initiated for some time, interbasin transfer of water as an alternative source for salinity control in lieu of the CRWQIP is not presently feasible. In addition, the normal lead time from the start of planning through authorization and construction for interbasin transfer of water could require 20 to 30 years or more. Environmental impacts from any conventional, interbasin transfer system would be similar to those experienced from storage reservoirs, canals, pipelines, etc. Moreover, additional impacts on the environment would be experienced outside the currently anticipated project area.

e. Conservation and Reclamation. - The remaining alternative sources of water supply for the Colorado River originate within the Basin and are generally aimed at conserving present supplies. These alternatives include Vegetative Management, Water Reclamation, and Watershed Management.

(1) Vegetative management. - An estimated 22,000 acres of vegetation on Reclamation withdrawn lands along the Lower Colorado River are available for a vegetative management program. Capital costs of such a measure are estimated at about $2,900,000.

Nearly half the 22,000 acres are identified in the Lower Colorado River Land Use Plan (1964) as potential parks, recreation areas, or wildlife lands. Therefore, any vegetative management program would require coordination with these proposed uses, or the proposed uses deferred or altered.

water now being lost to evaporation and transpiration might be salvaged using this concept. Estimated salvage would be 60,000 acre-feet if 2.7 acre-feet were considered the consumptive use differential between that used by phreatophytes currently in the area and replacement vegetation following program implementation. An annual maintenance program would be required to control regrowth unless a replacement vegetation were found that need not be controlled. Theoretically, this measure would reduce the salinity at Imperial Dam by 15 mg/l.

However, considerable speculation exists today as to whether removing phreatophytic vegetation would actually improve water quality in relation to salt concentration. The Pacific Southwest Inter-Agency Committee, who for the past 24 years has been studying the feasibility of removing phreatophytes to improve water quality, has been unable to reach a unanimous opinion. Research into manipulation of phreatophytic vegetation to salvage water has not been undertaken along the Lower Colorado River.

This measure would also affect some of the remaining wildlife habitat along the Lower Colorado River. These effects might not all be adverse since part of the replacement vegetation might use less water and might also provide equivalent wildlife values. There would be a short-term impact on wildlife during program implementation and a long-term impact if suitable replacement vegetation failed to grow. There would be adverse effects on esthetic values during implementation. Several years are required to regrow vegetation along the Colorado River; dust problems would increase during the interim.

The value of vegetative management has been debated, since habitat is destroyed during vegetative removal. The vegetative management program would be aimed toward providing replacement vegetation having wildlife values, which would be taken into account in the planning phase. Some areas would remain intact; other areas would be selectively cleared, allowing desirable plant species to remain. Still other areas would be completely cleared and replanted to more desirable native plants. Vegetation management would also affect the insect life in the area. Since dense vegetation provides a source of honey, and with the spraying of farmland areas, many beekeepers move their bees to the dense vegetative areas along the Lower Colorado River to protect the bees from lethal sprays. All these aspects are currently proposed for study by the Lower Colorado Region of the Bureau of Reclamation in connection with its Colorado River management responsibilities.

(2) Water reclamation. - Reclamation of municipal and industrial wastewater in the Basin offers some promise for recycling of present supplies. Since wastewater must be extensively treated to meet pollution discharge requirements under P.L. 92-500, reuse of this water becomes more practicable.

Some specific benefits that can be derived from development of wastewater are: (1) additional use through recycling, (2) environmental enhancement, (3) improved water quality, and (4) possible economic benefits if the alternative source of water is more expensive.

Wastewater management plans are necessary for urban areas throughout the Colorado River Basin. These plans are intended to implement the goals of the Federal Water pollution Control Act (P.L. 92-500), i.e.:

(a) That the discharge of pollutants into the navigable water be eliminated by 1985; and

(b) That, where attainable, an interim goal of water quality which provides for the protection of fish, shellfish, and wildlife, and provides for recreation in and on the water, be achieved by July 1, 1983.

Section 208 of P.L. 92-500 directs Governors of the States to identify areas which, as a result of urban-industrial concentration or other factors, have substantial water quality control problems. The Governors must designate (a) boundaries of each such area, and (b) a single representative organization, including elected officials from local governments or their designees, capable of developing effective areawide waste treatment management plans for such areas.

To identify the magnitude of water quality degradation and to design systems to solve this problem, constituents and physical characteristics such as heat and water volume must be accounted for by source; for example: (a) point sources of pollution, including municipal sewage and storm sewer outfalls, and industrial outfalls, including thermal discharges; (b) nonpoint sources including urban and rural runoff, acid and other mine drainage, construction runoff, and salt water intrusion; and (3) inplace or accumulated pollution sources.

Unless the problems associated with constituents from these sources are understood, it is unlikely that the impacts generated by a wastewater system will be foreseen and properly assessed. Identifying the constituent loads by source also will allow establishment of priorities for planning, and is necessary to assure that wastewater management systems designed for sources of immediate concern are compatible with future systems design to handle other sources.

Recycled wastewater has been used for many purposes, of which irrigation of crops, development of recreational areas, and cooling water are the more common. More research is needed on the use of recycled water for irrigation in relation to the long-term effects upon soils, crops, and ground water. Because of the uncertainty of whether present treatment methods can eliminate pathogenic organisms from wastewaters, and the inability to identify and propagate them in the laboratory, wastewater should not be directly reused for drinking. Further research in this area is required to assure that public health is not endangered. Current understanding of ecological processes indicates that the high quality of watercourses can be assured by reducing the levels of wastewater impurities so as to preclude significant adverse environmental affects or social-hygienic impact.

Reclamation of wastewater will play an important part in water quality improvement. The Federal Water Pollution Control Act Amendments of 1972 will have a considerable effect on future wastewater supplies and recycling. It could result in water users recycling more of their wastes for their own use rather than treating them sufficiently for return to streams. This would result in a reduction of wastewater discharges and less demand on available freshwater supplies.

Under current plans, all wastes are treated to an equivalent secondary level, after which the treated effluent is applied to the land for removal of additional impurities by infiltration through the soil. Water is thus made available by ground-water recharge and is available for unrestricted irrigation and recreation uses. In addition, mining and other industrial uses are being studied. Potential health hazards and other possible adverse environmental consequences resulting from utilizing soil for impurity removal by filtration have not been fully evaluated. Further studies of pathogen and/or other bacterial response, the effects on the soil fertility, percolation rates, and long-term ground-water recharge will be required before total health and other environmental effects can be predicted in the service area.

Based on present volumes, reuse, and other factors, there appears to be little potential for augmenting the water supply of the Colorado River Basin through wastewater management. Most of the present sources are being utilized either incidentally or through constructed facilities. Nonutilization is due to limited quantities at specific locations, poor quality, excessive treatment costs, lack of technical processes for reclaiming, no immediate need for the reclaimed water, legal complications, and other reasons. Much of the municipal effluent produced in the Basin is being discharged into streams or is returned to the ground water, where it often becomes part of the water supply available to meet area demands or downstream commitments.

The largest municipal effluent in the Colorado River Basin is produced by the Phoenix metropolitan area. Estimations are that in 1970, about 77,750 acre-feet of effluent was produced; by 1980, 146,000 acre-feet; and by 2000, 271,000 acre-feet.[40] Another large wastewater producer in Arizona is the Tucson metropolitan area. Presently, the effluent produced is about 40,000 acre-feet and is predicted to reach 88,000 acre-feet by the year 2000. This resource is either being used for irrigation or is returned to the Santa Cruz River where it disappears into the valley alluvium and eventually reaches the ground water. Other significant sources of municipal effluent and their discharge points in the Colorado Basin are: Yuma, Colorado River; Flagstaff, Rio de Flag Wash; Nogales, Santa Cruz River or for irrigation; Durango, Animas River; Grand Junction, Colorado River; Las Vegas, Las Vegas Wash; Henderson, land; and Farmington, San Juan River. In most instances, the wastewater is returned to streams or the ground water, where it becomes available for reuse. Many of the smaller wastewater resources are being lost for reuse but their reclamation is usually not economically feasible.

Although augmentation of water supplies in the Colorado Basin through wastewater management appears very limited at present, future increases in use of recycled wastewater could help meet water needs. Where Basin water supplies are increased through reduction of exports, by weather modification, or other means, wastewater supplies should increase proportionally. For example, the wastewater from the Phoenix area is expected to increase by about 200,000 acre-feet annually by the year 2000. It is not unreasonable to expect that at least half of this increase, or 100,000 acre-feet, could be economically reclaimed and put to some beneficial use either through planned developments or through incidental use.

Other opportunities exist for augmenting the water supply through wastewater management in the Basin. One possibility is the substitution of reclaimed water for water exported from the Colorado River. If a portion of the large quantities of water discharged to the ocean in Southern California were reclaimed, some could be exchanged for water received from the Colorado. California now generates about 2.4 million acre-feet of wastewater, of which 1.4 million acre-feet are suitable for reclamation. Colorado River water previously exported could be used to augment inbasin supplies. However, many legal obstacles would need to be overcome to obtain rights to the wastewater and to negotiate the exchange. An exchange of reclaimed water for freshwater would be difficult and unlikely. In Colorado, plans are already underway for recycling much of the wastes resulting from use of water diverted to the East Slope.

Future projected water requirements in the Colorado River Basin greatly exceed the quantity of wastewater potentially for reuse. Thus, recycling is not a practical or viable alternative, but may be a necessary supplement to augment the Colorado River.

(3) Watershed management. - Watershed management is directed toward the use of land to improve quantity and quality of water, to reduce erosion and sediment yield, and to maintain and enhance a productive watershed. Proper management must consider many factors, including past use of the land, ownership patterns, vegetative types, climate, and physiography. Any well-balanced watershed management program must consider the use and development of such resources as timber, forage, and wildlife, and such social values as recreation, esthetics, and population dispersal.

Studies in Arizona and watershed research in Colorado, and other intermountain states, the Pacific Northwest, and California are providing valuable information for land managers. At this time, however, further study is needed before the effects of various watershed management programs can be reliably determined, certain conclusions can be drawn, and basic assumptions can be made from existing research. Generally, larger increases in yield are associated with high precipitation, and smaller increases occur when precipitation is low. The possibilities for increasing water yields in the west appear to be most favorable in areas of high elevation and precipitation. Research has shown that partial cutting in some types of forests can provide opportunities for increasing water yield through redistribution of the heavy snowfall and reduced evapotranspiration. Replacement of native vegetation with grasses in some areas has yielded inconclusive results.

Most of the present investigations involve modifying harvesting practices on conifer-covered lands and conversion of chaparral and mountain bush to shallow-rooted grasses and forbs. One of the major environmental considerations associated with this alternative is the conversion of large numbers of acres of native vegetation to that of grasses and forbs. Complete conversion of native vegetation to grasses and forbs could not be accomplished without almost total alteration of the associated fauna. The displacement and alteration of existing species may be followed by establishment of species adaptable to a grassland habitat or by creation of empty niches. The impact of such displacement and alteration is not fully known, and would vary from place to place depending upon the area being managed.

The net loss of water through evaporation and transpiration from the vegetative cover on a watershed varies with the amount and kind of vegetation present, and in forested areas with the forest cutting practices employed. Harvesting timber tends to increase runoff. Experiments with total forest cover removal have resulted in first-year increases in runoff ranging from 1.3 to 18.0 inches. Partial removal of vegetative cover produces smaller increases and, in some cases, no increase at all. Generally, forest management which involves harvesting all of the trees in selected areas tends to produce greater increases in runoff than are produced by comparable reductions in vegetative cover by harvesting timber on an individual tree selection basis. In the West most of the increased water yield occurs during the winter and spring. Data indicate a steady decline in increased annual water yield after the first year of vegetative cover removal. The rate of decline depends upon the rate of revegetation.

Conversion of one type of vegetal cover to another in forests and brushlands has produced mixed results. In the Southwest, conversion from trees to grass on moist sites has significantly increased runoff. Similarly, in the West, substituting grasses for chaparral has been found to increase water runoff.

It is possible to manage forest areas to increase snow accumulation or delay or advance melt for the purpose of regulating the amount of water yield and the timing of delivery. In many cases, manmade barriers can affect the distribution of snow.

At least in some areas, it appears that land management to attain small increases in water supply can be accomplished without lowering water quality, degrading the watershed, or deteriorating the forest environment. But in planning the use of land management techniques to increase water supplies, tradeoffs must be struck. Increases in water yield will likely reduce maximum timber yields, resulting in modified economic and social impacts on the local and regional population. Recreation and wildlife habitat will also be affected, and some of these effects may be adverse, particularly during the time of cutting or removal. Although the concept has been studied for decades, increased water production has been insignificant because of seeking these tradeoffs. Significant changes in salinity due to watershed and vegetative cover management are not expected by 1990. Present information indicates that water increases developed from watershed management programs would not produce sufficient quantity to be considered as a suitable alternative for large-scale augmentation.

B. Alternatives for Initial Control Units for Construction

Since most of the control units discussed in previous chapters are still in an investigative stage, the alternatives presented in this chapter should not be construed as the only alternatives available. Other alternatives may present themselves during the course of ensuing investigations which will be presented in succeeding project and environmental reports.

1. Las Vegas Wash Unit, Nevada

There are four alternatives to the proposed plan discussed in chapter I. These consist of (1) total evaporation of all collected flows at a site located outside the general project area, (2) total evaporation within Valley, (3) surface dam and reservoirs, and (4) no action.

Virtually all alternatives, with the exception of "no action" must interface with the municipal sewage treatment plants. This interface consists of bypassing AWT effluent around the Las Vegas Wash and the unit's proposed interception facilities.

a. Alternative No. 1. Total evaporation of collected flows outside the Unit area. - Three separate sites have been investigated for their potential as disposal areas for waste water.[58] These sites are closed basins or subbasins and are typically occupied by a playa or dry lake. The lakebeds are valley fill deposits consisting of stratified clay and silt with scattered lenses of sand and gravel. These beds may contain large amounts of soluble salts. The basin may be covered with water at irregular intervals to form a temporary lake. The surface is usually flat and devoid of vegetation.

The dry lakes that were considered for total evaporation of collected saline ground water exist in Eldorado Valley, about 16 miles from Las Vegas Wash; near Jean, Nevada, about 27 miles from Las Vegas Wash; and near Apex, Nevada, about 26 miles from Las Vegas Wash. Impact associated with using any of these locations would be similar as they are all located away from populated areas in barren desert lands. Impacts of using locations that are further from the Wash would be increased by the additional length of export pipeline needed (hence more land for rights-of-way required) and increased energy required for pumping the same amount of water over the longer distance.

Investigations of the surface soils and shallow geology of both the Eldorado Valley and Jean Lake sites indicate that it may not be possible to avoid pollution of the regional ground waters without extensive evaporation pond lining.[58] Consideration in this statement is given only to the Dry Lake site, as this location was determined to offer the greatest security against any potential degradation of regional ground waters due to the subsurface leakage of saline fluids.

(1) Description of the alternative. - This alternative involves a bypass pipeline for AWT effluent, a subsurface

interception facility, an intake pumping plant, an export pipeline, and three small regulating reservoirs or forebays with a capacity of about 25 acre-feet in conjunction with three pumping plants.

In operation, this alternative would export all collected Wash flows through a system of three pumping stations and holding reservoirs approximately 26 miles to dry lake near Apex, Nevada. Physical data and rights-of-way are shown in the following tabulation. Figure VIII-1 shows the relationship of Dry Lake to other project features and one conceptual alinement for an export pipeline.

Features	Description	Rights-of-way (acres)
Bypass pipeline	60-inch-diameter concrete, 5 miles long	29
Interception facility	Subsurface impervious barrier and collection system	20
Three export pumping plants and three holding reservoirs or forebays of 25-acre-feet capacity (6 acres required for each)	20 ft^3/s	18
Export pipeline	30-inch-diameter reinforced concrete, 26 miles long	150
Evaporation facility	.	2,300

(2) Description of the environment. - The environment of the project facilities located in Las Vegas Wash would be the same as described in chapter II of this environmental statement.

The dry lake near Apex, Nevada, lies in a closed basin outside of the Las Vegas Valley approximately 18 miles northeast of Las Vegas, Nevada. The area required for evaporation covers approximately 2,300 acres adjacent to and northwest of Interstate No. 15, between the highway and the Arrow Canyon Range of mountains.

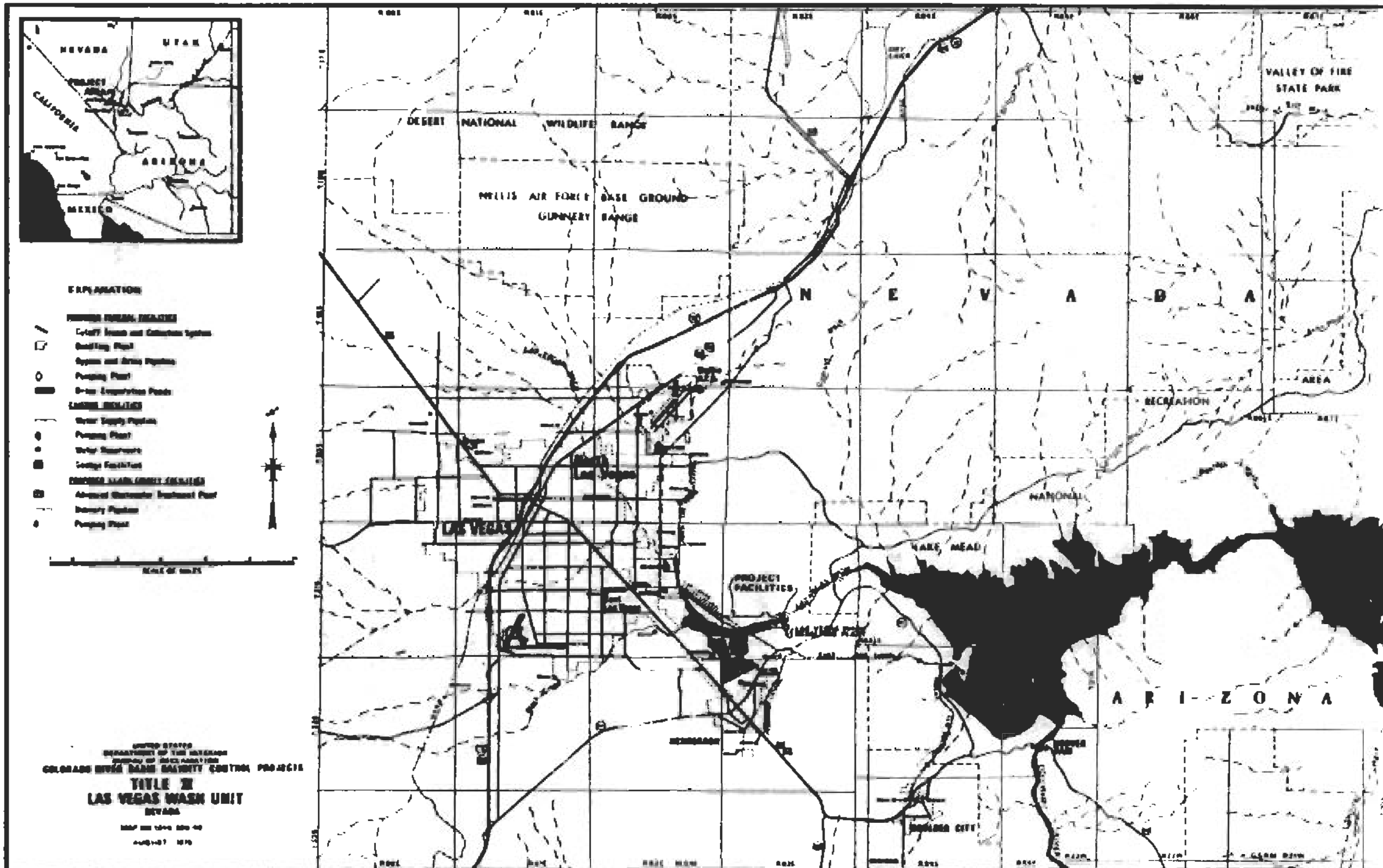


Figure VIII-1

The dry lakebed is a barren expanse of hardened clay, sand, and silt covering approximately 4 square miles and surrounded by sparse desert shrub mostly of the creosote bush family. The lakebed area and periphery support little or no wildlife on a continuing basis other than lizards, invertebrates, and desert rodents. It is possible that some mammalian life uses the lakebed area for drinking purposes after infrequent rainstorms.

No studies have been made on the archeological or historical resources of the area.

(3) Environmental impacts. - Impacts in the Las Vegas Wash area described in chapter III for construction and operation of the proposed plan would remain the same for alternative no. 1 with the following exceptions:

(a) Six hundred acres of lands for evaporation ponds would not be required and the habitat previously lost to that feature would remain as is. However, 150 acres of land would be required for the export pipeline, and 2,300 acres in dry lake for the evaporation facilities.

(b) About 6 acres of land required for a second stage desalting plant would no longer be subjugated, but 18 acres of land for regulating reservoirs and pumping plants would be needed.

(c) Approximately 27 million kWh of electrical energy would be needed annually to operate this alternate versus 31-68 million kWh/year for the proposed plan.

(d) Operation of the alternate would provide 6 additional jobs whereas the proposed plan ultimately provides for 44 additional basic industry jobs.

(e) Noise problems associated with operation of the desalting plant would be eliminated although some additional noise could be expected from increased pumping operations.

There would be impacts associated with the dry lake area with this alternative that would not be associated with the proposed plan. There would always be a water supply in the lake area that is presently dry. In the early stages that water would approximate the salinity of Las Vegas Wash natural ground water but after evaporation commenced the salinity would increase. Maximum depth of water would probably be no more than about 5 feet and would fluctuate in response to varying evaporative climatic conditions which would preclude any water-oriented recreation.

The quality of water will degrade over time to preclude it from being used by either fish or wildlife for life sustaining processes. A population of shrimp or other variety of crustaceans may develop in the lake area.

Over time the water levels of the lake will rise and fall in relationship to varying evaporation rates. As evaporation takes place, white chalk-like stains will develop on the periphery of the lake that will be clearly visible from Interstate No. 15. Such an effect is usually esthetically objectionable to travelers who witness it. No other significant socioeconomic impacts have been identified.[57]

Implementation of this alternative would be somewhat contrary to the State of Nevada's principles for development and use of water. These principles are based on conservation and beneficial use. Total evaporation schemes, While economically feasible, are not in harmony with current interpretations of beneficial use. In addition, a total evaporation scheme would deplete the Colorado River of up to 14,480 acre-feet per year of available water. This effect would be felt the most by the citizens of southern Nevada who would lose this potential credit for return flows further restricting the supply of an already limited resource.

A variation of this concept called the "AWT" plan would involve a potential pipeline to convey AWT water to a proposed powerplant near the Dry Lake area. The plant would use AWT wastewater for cooling purposes. Joint use of this pipeline could provide a means to convey saline flows from Las Vegas Wash to Dry Lake for evaporation. The most serious concern of this plan is the uncertain scheduling of the proposed powerplant and the lack of water conservation.

b. <u>Alternative No. 2. Total evaporation of collected flows within Valley</u>. -

(1) <u>Description of the proposal</u>. - This alternative involves the same features and alinements as the proposed plan in chapter I without a second stage desalting

facility. The intake pumping plant would have the same capacity but the brine disposal pipeline would be 30 inches in diameter instead of 18 inches. Approximately 2,300 acres of land would eventually be required for evaporation ponds. Some of this land would probably be available from the BMI complex in Henderson, and would require the rehabilitation of existing pond area and membrane lining to prevent seepage. Some land might also be required from the existing commercial sand and gravel operation east of the BMI ponds. Figfure VIII-2 is a view of the existing ponds. The energy requirement for this alternative would amount to about 8 kWh. The following tabulation shows the physical and rights-of-way requirements:

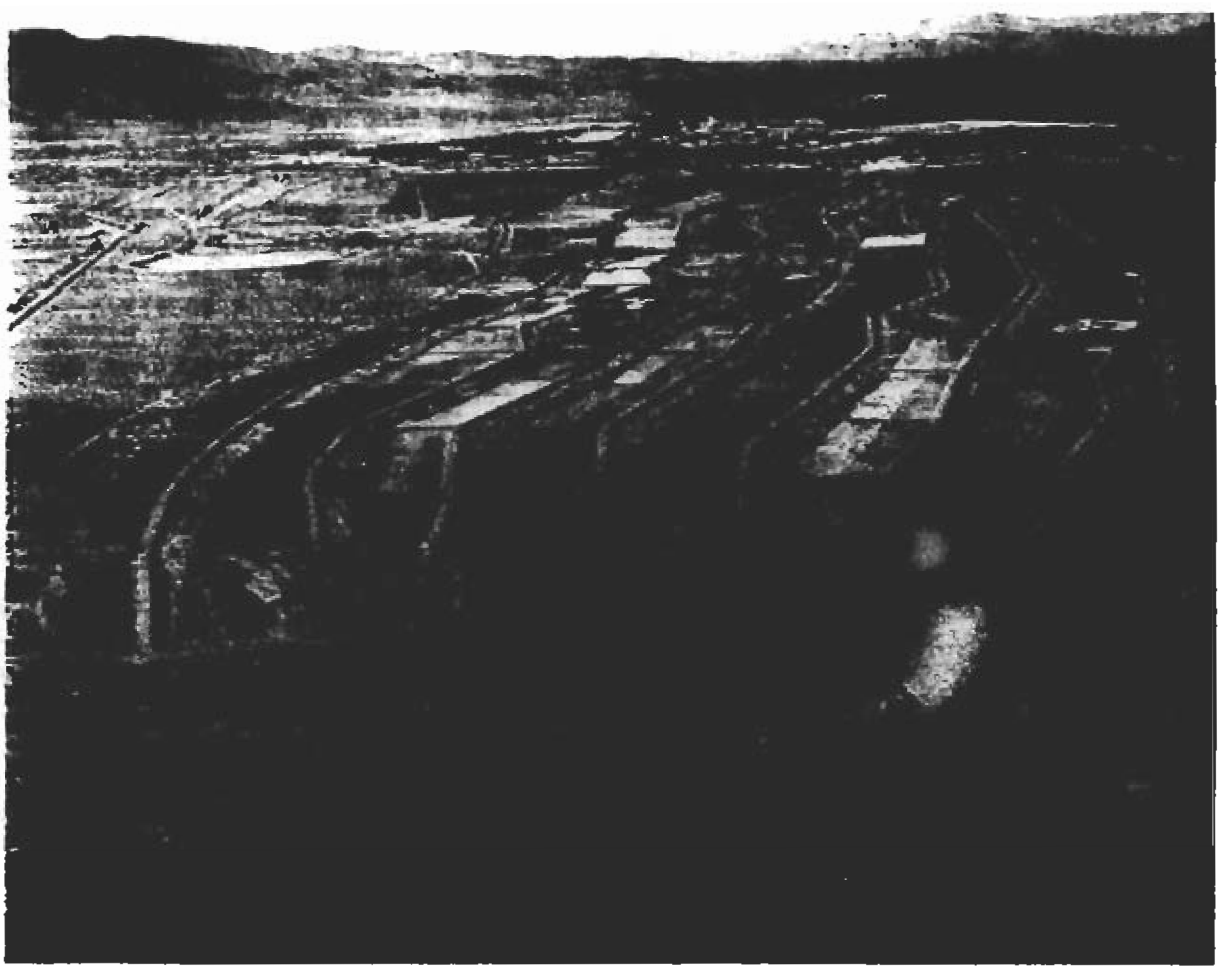
Feature	Description	Rights-of-way (acres)
Bypass pipeline	60-inch-diameter concrete, 5 miles long	29
Interception Facility	Subsurface impervious barrier and collection system	20
Intake pumping plant	20 ft^3/s 300-ft hd.	2
Disposal pipeline	30-inch diameter, 3 miles long	17
Evaporation pond	Membrane lined	2,300

(2) Description of the environment. - The environment of this alternative would be similar to that of the proposed plan which is described in chapter II of this statement.

(3) Impact of the proposed alternative. - The impacts of construction and operation of this proposed alternative would be similar to those of the proposed plan with the following exceptions:

Construction of a second-stage desalting plant would not be required and 6 acres of wildlife habitat would not be subjugated to this use.

Up to 1,700 acres of existing ponds would have to be rehabilitated for use. These lands are presently void of natural vegetation but do support thick stands of vegetation of the saltcedar community on the periphery



View of Basic Management Incorporated disposal pond area.

Figure VIII-2

of the ponds. This vegetation would probably not reestablish itself.

The evaporation ponds will in a few years develop a white stain through salt deposits after evaporation of salt water, and may create an adverse esthetic impact.

The ponds, even though fenced, would pose a security hazard for those who would view area as a recreation potential (primarily the young).

Use of the ponds would preclude other forms of development. As discussed in chapter III there is a 24 percent probability of this land being used for housing development in year 2000. If this much land were available for development, it could accommodate up to 15,000 people at the 0.151 density rate per acre described in chapter III.[57]

Operation of the project will require 8 million kWh of energy annually.

As explained in alternate No. 1 the concept of total evaporation is contrary to the State's principle for development and use of water and would result in a depletion of 14,480 acre-feet of water per year from the Colorado River system. This alternative would also remove about 35,000 tons of salt per year from the Colorado River system and result in salinity improvement at Imperial Dam equal to about 2 mg/l.

c. Alternative No. 3. Surface dam and reservoir. -

(1) Description of the proposal. - The proposed project and alternatives No. 1 and 2 involve the use of a subsurface interception facility to collect saline ground-water flows. An alternative to this feature that was initially considered would consist of an earth dam which would rise 45 feet above the existing stream elevation. Advantages of this alternative would be an open body of water in the Wash with a surface area of about 100 acres. This open water would be of great benefit to waterfowl and possibly some species of fish. An open reservoir would also decrease or terminate the erosional headcutting that currently threatens a portion of the Wash. A disadvantage is the short life of the storage aspects of the facility due to sediment deposition and phreatophytic growth. Fine sand

and silt could essentially fill the reservoir area during a major flood, thus limiting the flexibility of this alternative to accommodate future trends.

d. Alternative No. 4. No action. - The alternative of no action would result in increasing contributions of salt loads to the Colorado River system by Las Vegas Wash. Construction by Clark County of their proposed AWT plant would reduce the nutrient contributions to Lake Mead and would remove a minor amount of TDS. However, the overall increase in saline return flows would continue to prove a detriment to downstream water users. By the year 2000, Las Vegas Wash would contribute over 311,000 tons of salt per year to the Colorado River system.

e. Spray evaporation. - A third alternative to the proposed evaporation schemes would be spray evaporation. Such a system would consist of elevated spray nozzles which would discharge the brine in a fine mist over the evaporation ponds. This allows for greater exposure of the brine water and thereby increases the evaporation process. The additional cost of the spray system could be offset by a decrease in pond area size. Spray systems are still in the development stage and many problems associated with them have not been solved. Because of these problems this system has not been recommended but is still under study.

f. Desalting method alternatives. -

(1) Pretreatment. - As an alternative to the lime-soda ash pretreatment process, lime-ion exchange softening could be employed. The lime-ion exchange softening process is similar to the lime-soda ash process except strongly acidic cation exchange resin beds would be used rather than soda ash for the removal of calcium. It has been estimated that it would take approximately 2 years to concentrate the brine in the evaporation ponds to adequate strength for a source of supply for the ion exchange method. The lime-ion exchange process can be used in conjunction with either reverse osmosis or electrodialysis desalting methods.

(2) Desalting. - The electrodialysis process could be used as a desalting process in the Las Vegas Wash. The process would operate at 90 percent recovery and could be operated with either pretreatment process.

g. Other evaporation pond sites. - In addition to those sites already discussed, consideration was given to locating the ponds in dry wash areas on the north side of Las Vegas Wash.

These locations were in fairly impermeable muddy creek formation materials. Surveying revealed slopes too steep for normal pond construction. Estimated costs for this area were found prohibitive.

The following tabulations summarize the costs and impacts of the alternatives. For convenience of comparison, the project plan described in chapter I is included.

2. Crystal Geyser Unit, Utah

Due to the position of the geyser well with respect to the Little Grand Wash Fault, plugging was considered to be only a temporary solution. The reasoning was that with plugging of the well, water under high pressure would be forced to seek release through natural openings on the north, east, and west sides of the geyser cone and continue to add salt to the river as it had before the well was drilled. Other alternatives are described below:

a. Deep-well injection. - The only formation at the geyser that would possibly accept injection water is the Navajo sandstone some 700 feet below the surface. Injection of water into this formation south of the fault would result in its being carried downstream and reappearing about 20 miles south where outcropping of the formation exist. Another hazard accompanying deep-well injection may be an increased risk of earthquake activity.

b. Desalinization of discharge. - Several methods of accomplishing desalination have been developed, such as two commonly used membrane processes (reverse osmosis and electrodialysis) and various forms of distillation. All these methods are becoming relatively less expensive as technological knowledge increases and the value of water increases.

The reverse osmosis and electrodialysis processes best apply to Crystal Geyser, except present membrane technology limits their use to water with total dissolved solids of less than 10,000 and 5,000 mg/l, respectively. Crystal Geyser water with total dissolved solids of 11,000 to 14,000 mg/l is beyond the capability of present membrane methods. Should membranes be developed in the near future capable of handling water with 14,000 mg/l total dissolved solids, these methods would be more competitive with the recommended plan of using evaporation ponds.

ALTERNATIVE PROJECT COST SUMMARY
Las Vegas Wash Unit, Nevada

	Project plan	Dam and reservoir	In-valley total evaporation	Export total evaporation to Dry Lake (AWT)*	Export total evaporation to Dry Lake (USBR)
First stage					
Collection system	2,640,000	6,022,000	2,640,000	2,640,000	2,640,000
Disposal pipeline system	2,416,000	2,416,000	2,416,000	11,324,000	18,635,000
Evaporation ponds	15,850,000	15,850,000	15,850,000	31,014,000	31,014,000
Bypass pipeline	3,711,000	3,711,000	3,711,000	3,711,000	3,711,000
Second stage					
Desalting plant	18,678,000	18,678,000	-	-	-
Additional disposal pipeline system	150,000	150,000	936,000	70,000	66,000
Additional evaporation ponds	-	-	44,498,000	31,014,000	31,014,000
Field costs	43,455,000	46,827,000	70,051,000	79,773,000	87,080,000
Other costs	13,111,000	14,123,000	21,090,000	24,007,000	26,199,000
Project costs	56,566,000	60,950,000	91,141,000	103,780,000	113,279,000

* Joint use of pipeline to supply cooling water to a proposed powerplant.

PROJECT COSTS WITH VARIOUS DESALTING PROCESS ALTERNATIVES
Las Vegas Wash Unit, Nevada

	First stage[1]	Second stage	Total
Reverse osmosis with lime-soda ash pretreatment (project plan)	$32,047,000	$24,509,000	$56,556,000
Reverse osmosis with lime-ion exchange pretreatment	32,047,000	26,237,000	58,284,000
Electrodialysis with lime-soda ash pretreatment	32,047,000	36,789,000	68,836,000
Electrodialysis with lime-ion exchange pretreatment	32,047,000	38,648,000	70,695,000

[1] No desalting plant scheduled for first stage.

AGGREGATION PERSPECTIVES - LAS VEGAS WASH UNIT ALTERNATIVES
Las Vegas Wash Unit, Nevada

Perspective	Alternatives				
	Recommended plan*	Dam and reservoir*	In-valley total evap.	Export Evaporation AWT	Export Evaporation USBR
Park compatibility	+	++	+	-	-
Land use consistency	+	+	o	-	-
Water conservation	-+	-+	--	--	--
Energy conservation	+o	+o	+	o	o
Cultural sensitivity	o	o	-	o	o
Economics	(See alternative cost summary)				
Social perspective	+	+	-	-	-
Fish and wildlife	+	++	-	-	-
Quality standards	+	+	+	+	+

* First figure refers to the first stage, second figure to second stage.

Note: ++ and + positive benefit
-- and - negative benefit
o neutral or relatively insignificant

Distillation processes are presently being used to desalt large quantities of water for municipal and industrial uses. The cost of equipment to desalt such small quantities as that from Crystal Geyser would be prohibitive. Therefore, desalination is not considered a reasonable alternative to the recommended plan.

c. Release of carbon dioxide gas. - Preliminary studies of the logs of the Crystal Geyser oil well hole indicate water occurs at the 270- to 290-foot depth, and gas at a lower depth. One possible solution would be to install a plug in the well casing below the water level and insert a smaller diameter pipe through the plug to release only the gas from below. An alternative plan would be to drill a 5-inch hole near the geyser into the Navajo Sandstone and below the water level and tap the gas.

In either plan the water will probably continue to be ejected with the carbon dioxide gas or flow out the other springs or fractures. Under existing conditions, the north spring starts to flow up to 2 hours before eruption of the geyser while the east spring rises to near the surface of the opening prior to the eruption. In either of the springs there is no bubbling or other evidence of gas causing the water to rise, indicating the flow to be caused instead by a hydraulic head. This hydraulic head would probably force water out regardless of the gas release. Both north and east springs erupt slightly when eruption of the main geyser occurs suggesting gas escape to these springs at the time of eruption.

d. No action. - The 1968 flow measurements compared with the 1972 measurements indicate the discharge from the geyser is decreasing with time. Yearly discharge in 1968 was approximately 200 acre-feet; whereas, based on 1972 measurements, the yearly discharge was 150 acre-feet. This indicates the rate at which the geyser flow is diminishing assuming no variation in geyser discharge with the different seasons of the year. In time the natural flow of the geyser may become small. To be more certain of the rate of decrease of geyser flow, more measurements would be required over the next 10 to 15 years. Meanwhile a large amount of dissolved salts would have been discharged into the Colorado River. There is also no complete assurance that the discharges will continue to decrease. This is indicated by the long geologic history of the saltwater discharge to the river. Therefore, it can only be assumed that a plan of no action would result in a continuance of quality degradation to the Colorado River System.

C. Alternatives for other Central Units for Construction

1. Paradox Valley Unit, Colorado

The Bureau has investigated several different measures for reducing the salt contributions in Paradox Valley, as well as alternatives to specific features within the pumping plan previously described in chapter I. Many of these have proved to be prohibitively expensive and have been eliminated from further study. Those which warrant additional study will be included in future investigations. The final selection of a project plan will be based upon a variety of economic, technical, and environmental criteria.

a. Freshwater injection of aquifer. - An alternate solution to brine pumpage and evaporation has been proposed for the Paradox Valley Unit. The technique involves pumping low salinity water from shallow wells in the western and eastern parts of the valley or utilizing freshwater from other sources and injecting it into the aquifer in the vicinity of the brine springs. This would create or maintain a freshwater lens and effectively exclude the discharge of brine by separating the fresh and saline portions of the aquifer. Discharge would continue into the river but would be at a quality similar to the injected water. The technique poses some risk of creating seepages elsewhere but will be studied further.

The injection well field would consist of a series of shallow wells surrounding and within the existing brine seep areas. Environmental impacts within the Paradox area would be minimal. Only small amounts of vegetation will be removed at the well sites to facilitate drilling operations. Temporary esthetic impacts will also result from the drilling operations. The electric pumps of the project will produce only a low level of noise, which will not reach or disturb any humans residing in the area. Wildlife would be displaced in small numbers by the removal of vegetative habitat and by construction activities. The project would not be expected to reduce wildlife numbers or change general distribution patterns. The land disturbed during construction will be available to wildlife as natural revegetation occurs. Fish losses are not anticipated as a result of discharging water into the river and the fishery habitat downstream from the brine wells to the confluence of the San Miguel River may be improved.

b. Dolores River flood channel bypass. - This alternative is based upon the concept of routing the Dolores River across the valley in an impervious channel and allowing the saline ground water to surface and evaporate in the natural flood plain of the stream. A diversion structure and cutoff wall would be installed at the entrance to the valley, forcing the streamflows and any ground-water recharge from the river into a compacted earth-lined channel. The flows would be released into the riverbed on the other side of the valley, downstream from a second cutoff wall. This wall would impound ground water surfacing along the flood plain and prevent it from entering the river. The freshwater of West Paradox Creek would also be routed into the lined channel.

The bypass channel, located west of the present riverbed, would be about 26,400 feet long and would be designed to prevent a maximum design flood of 70,000 ft^3/s from spilling into the brine area to the east. This would require an eastern bank 52 feet above the bottom grade of the natural streambed. The western bank would be 22 feet high, large enough to contain a 25-year flood of 15,200 ft^3/s. Flows in excess of this amount would spill over the western bank and form a temporary pond covering about 900 acres. This water would be drained out as the floodflows receded. Compacted earth lining would be placed in the channel to handle flows of 3,000 ft^3/s or less, which should occur about 95 percent of the time.

The pond east of the channel would have a maximum capacity of 58,200 acre-feet with a surface area of 2,630 acres. This would be sufficient for a project life of at least 200 years. The inflow would be comprised of both fresh and saline ground water and precipitation. The quality of the water should not prohibit riparian vegetation, and the area could develop into a waterfowl habitat.

By removing at least 180,000 tons of salt per year, this alternative would reduce the salinity at Imperial Dam by a minimum of 16.3 mg/l. The associated benefits would amount to $3,749,000 annually.

The cutoff walls and bypass channel in this alternative would greatly alter the present landscape of Paradox Valley near the Dolores River. The 52-foot-high dike would be visible for a long distance in the valley. There would also be a safety hazard involved in the facilities because of the danger of humans and animals drowning in the channel.

The inflow to the pond, consisting of fresh and saline ground water and precipitation, would encourage riparian growth around the periphery to replace the vegetation which would be inundated, and the area could develop into a waterfowl habitat. However, the salinity of the water would gradually increase as a result of evaporation, inhibiting vegetation in the later years of project operations. A salt flat would eventually form, and the net effect would be the loss of a considerable amount of riparian vegetation now found along the river and the wildlife dependent upon the habitat.

c. Regulated Dolores River Bypass. - This plan would involve the construction of a dam to form a regulatory reservoir on the Dolores River immediately upstream from Paradox Valley. Controlled releases would then be conveyed across the valley in a concrete-lined canal and discharged into the natural streambed just below a second dam. The lower dam would impound ground water surfacing along the flood plain, where it would be evaporated.

Bedrock Dam would be located in the narrow canyon of the Dolores River and would form a reservoir with a capacity of 48,000 acre-feet. Constructed of earth, sand, gravel, and cobble fill, the structure would be 135 feet high and 1,300 feet long at the crest. The design capacity and outlet works would provide control for a 100-year flood. Controlled releases would be made to a 5.7-mile-long, 1,500-ft^3/s canal extending across the valley along the eastern side of the natural river plain. The flows of West Paradox Creek would be conveyed along the western edge of the river plain in a 100-ft^3/s unlined canal and released into the Dolores River bed below the valley.

Paradox Dam, constructed across the river channel near the outlet from Paradox Valley, would be about 45 feet high and 600 feet long. This facility would impound both fresh and saline ground water and precipitation. The combined inflow could be sufficiently fresh to support riparian vegetation and could develop into a waterfowl habitat.

The alternative would remove at least 180,000 tons of salt per year from the Colorado River System, reducing salinity at Imperial Dam by a minimum of 16.3 mg/l.

The environmental effects would generally be similar to those of the alternative previously discussed. A concrete-lined canal would present a greater safety hazard than an earth-lined channel, since escape would be more difficult. The construction of a dam in the Dolores River Canyon upstream from Paradox Valley would have considerable impacts on native vegetation, fish, and wildlife by regulating a free-flowing and scenic stretch of the river.

d. No action. - The environmental quality of Paradox Valley and Dry Creek Basin would probably remain the same without the project. With the exception of the fluctuating mining conditions, which should not be affected with or without the project, the status of development in the area has not changed much in the past and would probably not do so in the foreseeable future.

The influx of salt in Paradox Valley would continue to affect the quality of water in the Dolores and Colorado Rivers. Increasing salinity levels in the Lower Colorado River Basin could cause increased economic damages as the Upper Basin States develop their compact-apportioned water supplies.

e. Other alternatives. - The Bureau has considered other alternative measures which have not been definitely eliminated. At the present time, however, these do not appear to warrant detailed studies.

It would be possible to modify the plan of development by conveying brine from the well field to one or more sites for deep-well injection. This would eliminate the adverse impacts associated with a large evaporation pond. It is doubtful, however, that any suitable locations could be found in the vicinity of the project area. Transporting the brine any great distance for this method of disposal at present does not appear to be economical.

If future studies indicate that the salt contribution of Paradox Valley could be effectively reduced by pumping 0.75 ft^3/s or less from a well field, the brine could be disposed of by small evaporation ponds located near the wells. Crystalline salt would then be periodically removed from the ponds and stockpiled. This would require five wells each approximately 250 feet deep and 200 feet apart along the west side of the Dolores River. Four ponds having a total area of 200 acres would provide a sufficient area for solar evaporation. These would also be located on the west bank of the river.

The Bureau is also studying alternatives to the specific features in the plan of development. One of these is a different pipeline route from the well field to the evaporation pond. The alinement would extend southeast along the axis of Paradox Valley, then turn south up Dry Creek Canyon to the pond. Although the pipe length would be increased, the number of relift pumping plants would be reduced from eight to five. This plan would also have lower operations costs, since the amount of power required would be reduced. Additional field studies will be required to confirm the practicality of this alinement.

2. Grand Valley Unit, Colorado

The WSI, IMS, and return flow programs presented in chapter I ideally operate in conjunction with one another. Alternatives to these individual programs may not be as functional. Various alternatives are as follows:

a. Water Systems Improvement (WSI). - The alternative method of delivery of water through an underground pipe system instead of open concrete lateral was studied for an area comprising about 6,700 acres in the lower Grand Valley. This study showed that the cost of this type system would be much greater than for a concrete-lined lateral system. Should further study indicate that an underground pressure system would be more beneficial to areas of the valley, then consideration would be given to use of pipe.

Impacts associated with this alternative would be related to reduced seepage losses. This savings does not appear to affect the increase in construction costs. Vegetation now growing along canals, laterals, and seep areas would be depleted, thus affecting the feed and cover currently used by wildlife in the area.

A control method not totally investigated would be that of partial system improvements. Areas of most severe canal seepage could be improved with the initial result of salt load reduction. A possible resultant effect of this alternative could be the aggravation of other seepage areas not now present.

b. Irrigation Management Services (IMS). - Some alternatives to the IMS program have been recognized. These alternative methods might include restrictions on water usage and stringent standards imposed on effluents. A system of water supply allotments could be used for agricultural, municipal, and industrial uses. A continual monitoring system in the Grand Valley could be initiated to control effluent quality. These alternatives would be expensive and also restrictive to any future development of the valley.

A structural alternative to the IMS program would be the interception and collection of all surface and subsurface drainage. This drainage water contains an average of 2,800 mg/l. Water of this quality has little value and would either have to be conveyed to evaporation ponds for disposal or processed through a desalting facility.

The alternative of no action would result in continued irrigation problems such as low efficiencies, high water tables, and soil salinity. There would be a continual annual discharge of 600,000 tons of salt to the Colorado River, and other control features in the Colorado River Basin would be required to lower salinity levels in the river.

D. Alternatives for Units Under Feasibility Study

1. Point Source Control

a. LaVerkin Springs Unit, Utah. - Several possible alternatives have been considered for removing the dissolved salts from the LaVerkin Springs. The recommended plan involves a collector system, a desalting complex, and a brine evaporation pond, as described in chapter I. Other alternative methods to remove the dissolved salts from the LaVerkin Springs have been considered and are presented in this chapter. They are:

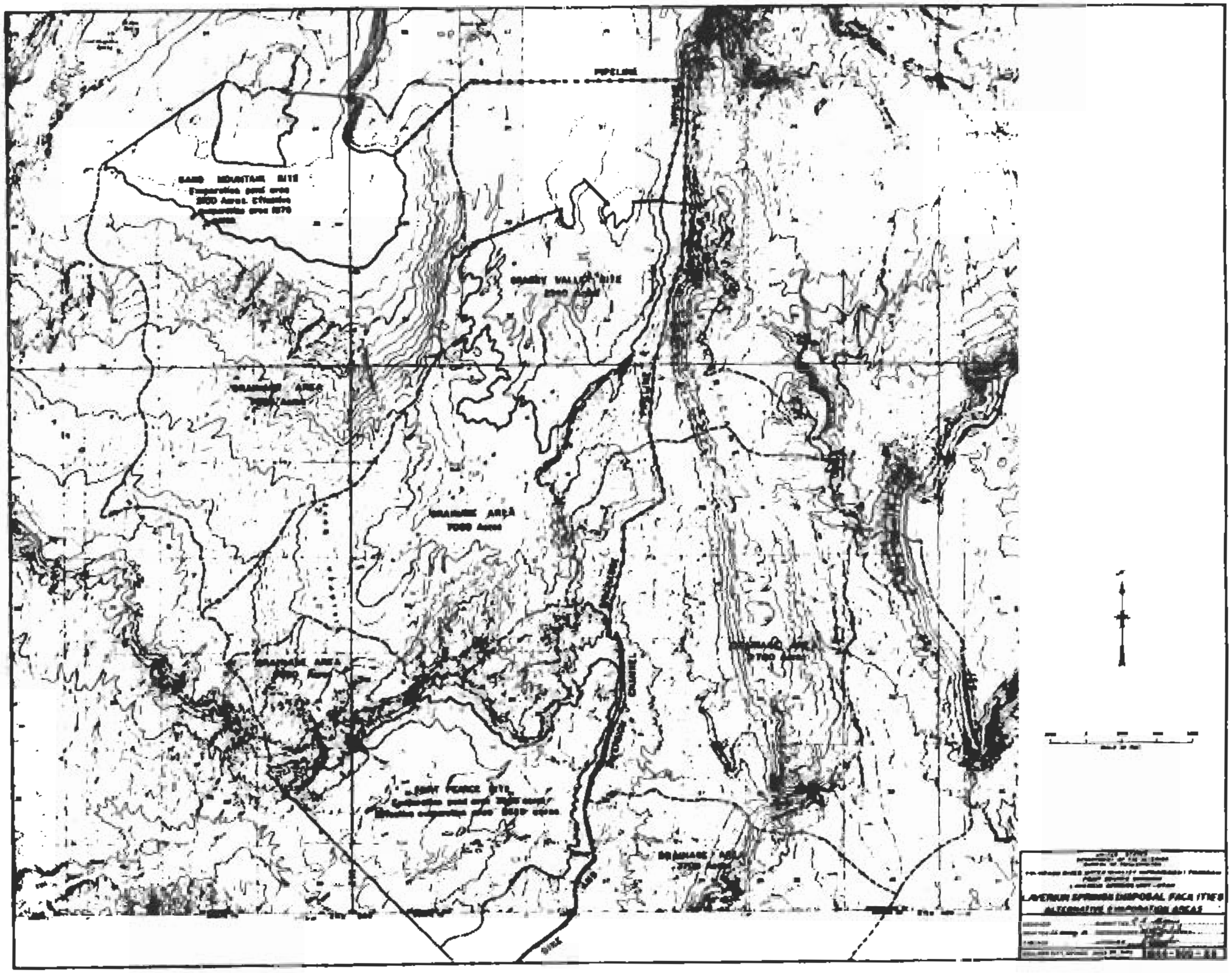
(1) Well field pumping system. - The plan of development under this alternative would provide for the collecting of discharge from the springs by constructing a series of wells drilled into the aquifer formations to intercept the spring flows. These flows would be desalted and the product water would be returned to the river, and brine discharges would be ponded and evaporated. Two test wells were drilled in the vicinity of the springs to test this theory. From the results of these test wells, it is estimated that at least 10 wells with a capacity of 2 ft^3/s, including standbys, would be required to intercept enough of the spring flows to eliminate the salt problem in the river caused by the springs. Collection piping and a receiving tank would also be required. According to available geologic information, the entire area is badly fractured, particularly in the vicinity of the springs. It is probable that the wells would soon be pumping riverflow, which would result in increasing the number of wells and the capacity of the treatment system. It is possible that a large portion of the riverflow would eventually seep into the aquifer

formation, which would require abandoning the well collection system. The environmental impact of this alternative would be essentially the same as that presented for the recommended project plan.

(2) Total evaporation of spring discharges. - Under this alternative, the collection system would be the same as that in the recommended plan. The spring flows would be pumped to an evaporation pond, which would be large enough to hold the entire discharge from the springs. Pond sites of this magnitude are limited and only two sites were identified in the feasibility investigations that would be adequate for this purpose. These sites are designated as the Fort Pierce Wash area and the Sand Mountain and Grassy Valley areas. Under this plan two pumping plants would be required to lift the water to the evaporation sites. These sites as shown on figure VIII-3 would have to be so constructed as to accommodate storm inflow as well as the spring inflow. Construction of approximately 70,000 feet of 21-inch-diameter pipe, two 12-ft^3/s pumping plants, two substations and associated transmission lines would be required.

There are no historical sites listed for the area in the National Register of Historic Places. However, the old wagon road (Temple Trail) which the Mormons used to haul logs from Mt. Trumbull in Arizona to St. George, Utah, is still partly visible in Ft. Pierce Wash and is being considered by the BLM for nomination to the National Register. The logs were used in the construction of the St. George Temple. The part that this old road played in that historic event has recently been marked as a historic place in southern Utah. Today, the scar left by this wagon road is nearly obliterated. Other environmental impacts of this action would be similar to that of the recommended plan, with the exception that there would be an irreversible and irretrievable loss of irrigation water.

(3) Deep-well brine injection. - This alternative would include the same features as those described in the recommended plan, except that a deep injection well would be used in place of an evaporation pond for brine disposal. Although this method of disposal has some advantages over the evaporation method, it would also present the problem of assuring that the receiving formation would not leak. Should the injected brine find its way into the surface or ground water, it would present a serious problem. No suitable formation has been identified in the area, and extensive



Alternative Sites for LaVerkin Springs Disposal Facilities

Figure VIII-3

geological investigations would be required to determine the existence of a suitable site if this alternative were to be developed.

The environmental impact for this proposal would be the same as described in the recommended plan, chapter III, except that the brine would be disposed of in a deep injection well rather than by evaporation in surface ponds. The adverse impact of the injection wells would be less than the evaporation ponds since the land use would be less and no salt beds would be formed. However, the potential of contaminating the ground water is far greater with the injection wells.

Although no estimates have been made, it is assumed that the injection wells would cost considerably more to construct and operate than the evaporation ponds. In addition, the risk of successful operation of the wells would be high.

(4) Alternative desalting methods. - Appraisal studies of various methods for desalting the spring water were made by the Bureau of Reclamation's Engineering and Research Center in Denver, Colorado. These included reverse osmosis, electrodialysis, freezing, crystallization, and multistage flash. The reverse osmosis process has the lowest total capital cost and the lowest cost per ton of salt removed. In general, the environmental impact of the reverse osmosis process would be less than the other methods considered.

(5) Alternative utilization of product water. - It would be possible to store product water during periods of high riverflow or low demand. Feasibility investigations considered two alternatives. The selection of the most appropriate plan during final design studies would be based on water demand, downstream water rights, the value of the product water, and other considerations.

(a) Storage for release during the irrigation season. - Product water would be pumped to a 4,600-acre-foot reservoir during the off season and during high flows of the Virgin River. Releases would then be made during the peak irrigation season. This would relieve the project of the costs of acquiring water rights or of indemnifying water users for ensuing damages. Construction costs of pumping facilities, pipe, and reservoir would exceed $1,000 per acre-foot of storage area.

Environmentally, this alternative would require additional land use for a reservoir, a pumping plant, transmission lines, and a pipeline. There would be an increase in the use of electrical energy. This alternative would also require a greater commitment of Federal funds.

(b) Delivery and storage for M&I uses. - Facilities would be provided for delivering water produced in the off season to a storage area near St. George for municipal and industrial use during the summer peaking season. Construction costs would exceed $1,500 per acre-foot of storage area.

Environmental impacts would include additional use of land and water resources, depletion of the Virgin and lower Colorado Rivers, and higher consumption of electric energy.

(6) No action. - The alternative of no action would result in no reduction in salinity of the Virgin River and it would continue to contribute about 109,000 tons of salt annually to the Colorado River. The quality of the water used by downstream irrigation would be unchanged and the habitat of the endangered woundfin fish would remain unaltered.

b. Littlefield Springs Unit. -

(1) Pumped wells and desalting plant. - An alternative to collecting and disposing of the spring discharges would be to use wells to intercept a portion of the underground flow near the mouth of the canyon. The intercepted flow would be delivered to a desalting plant. The good quality product water from the plant would be returned to the river through a short, buried pipeline. The reject brine fluids from the desalting plant would be conveyed to evaporation ponds. For the purpose of this alternative, it is assumed that 20 ft^3/s of the underflow could be intercepted.

This alternative would consist of a collection system, delivery system, desalting plant, product return pipeline, brine pipeline, and brine evaporation ponds. The collection facilities would consist of a well field with 15 to 20 wells depending on the capacity that can be developed for each well. The well field would be located along both sides of the river near the mouth of the canyon. The discharge from the wells would be delivered to pumping plants, one on each side of the river.

The delivery system would consist of the pumping plants and pipelines to deliver the well discharge to the desalting plant. All pipelines would be buried. One of the lines would have to cross the river to reach the desalting plant. The desalting plant could be located on the east side of the river, and would consist of pretreatment facilities and a desalting complex. Present studies indicate that a reverse osmosis (RO) modular desalting system would be the most practicable method of desalting the springs. However, future studies will consider other desalting methods.

In an RO plant, there would be pretreatment facilities including calcium reduction and filtration. With a feed water rate of 20 ft^3/s and 90 percent plant operation, about 13,000 acre-feet per year could be processed The plant could be designed to recover about 90 percent of this feed water, resulting in 11,700 acre-feet of product water having a residual salt load of about 500 mg/l.

Although operation of the unit facilities would deplete the natural flows of both the springs and the Virgin River, the effect of returning the product water to the river will reduce the net depletion to an amount equal to the brine waste of the desalting plant, or about 1,300 acre-feet per year. This alternative would remove about 44,700 tons of salt per year from the lower Virgin and Colorado Rivers, and reduce the salinity at Imperial Dam by about 5 mg/l.

The evaporation ponds would be located adjacent to the desalting plant and would consist of a series of lined basins constructed with a water depth of about 5 feet to compensate for seasonal variation in evaporation and to provide for about 30 years of storage for the salts introduced with the brine.

Access to the plant area would require the construction of about 2 miles of road to connect with old Highway No. 91. For most of the way, the road will follow existing trails. Access to the well field on the south side of the river would be from Interstate Highway No. 15.

The well field and desalting plant would be operated on a 24-hour basis. Operation and maintenance personnel would be required on a round-the-clock basis.

Concrete aggregate could be obtained near the site by reopening gravel pits used during the recent construction of the adjacent stretch of Interstate No. 15.

This alternative would require about 300 acres of sparsely vegetated desert environment. The vegetation in the construction area would be removed. The wells would be located on undeveloped land on the bench above the Virgin River. Construction of the well field would have minimal effect on the vegetation of the area. Vegetation in the evaporation pond area would be completely removed and permanently lost.

The impact that construction and operation of this alternative would have on air and noise quality is expected to be small. There would be a constant low-intensity sound emitted from the pumping plant facilities and transformers during operation of the wells. The visual impact of this alternative would be minor. Some esthetic value would be lost because of the salt bed that would be formed in the evaporation pond and some wildlife would be displaced from the pond area. This wildlife would consist of small mammals and reptiles. The well field skyline would be changed by the receiving tank, transmission lines, pumping plants, and the desalting plant. The alternative would require a considerable commitment of electric power and fossil fuels both during construction and during the operating life of the well field and desalting complex.

(2) Alternative of no action. - The alternative of no action on the Littlefield Springs would result in the following:

(a) No reduction of flow in the lower Virgin and Colorado Rivers.

(b) No reduction in salts contributed to the lower Colorado River. The quality of water would not be improved and the added burden of reducing salt concentrations at Imperial Dam would need to be absorbed elsewhere.

(c) No action would not guarantee the survival of the woundfin fish which has already become an endangered species, but neither would it compound the hazards that endanger the species. The Bureau would be relieved of any mitigating action that might result from construction of the unit.

c. Glenwood Springs-Dotsero Springs Unit, Colorado. -

(1) Evaporation ponds. - Brief consideration was given to collecting the flows of each spring and conveying the water to evaporative ponds; however, there are several factors that would seem to eliminate this possibility. Because

rather large flows are involved, ponds with a large surface area would be necessary. This would also result in considerably more water loss than with a desalting plant. The topography at both Glenwood Springs and Dotsero is a rather narrow canyon; therefore it might be necessary to convey the saline water downstream 30 miles or more, possibly to the Rifle, Colorado area, to obtain a suitable site. Moreover, the elevation of about 5700 feet at Glenwood Springs and the latitude result in a cool climate and moderate winter snowfall which would further restrict the effectiveness of evaporative ponds.

(2) Deep-well injection. - Deep-well injection has been used in various circumstances to dispose of industrial wastes and has been studied by different agencies as a technique for disposal of brine solutions. After a brief review of the geologic conditions at the Glenwood and Dotsero Springs areas, it seems very unlikely that a subsurface formation exists into which the saline water could be injected due to the existence of faults and well-developed joint systems in the vicinity. It might be practical to convey the concentrated brine effluent from a desalting plant several miles downstream for evaporation or deep injection if satisfactory geologic conditions can be found and if any earthquake risk can be minimized.

(3) Plugging, grouting, ground-water pumping. - Serious consideration was not given to plugging, grouting, or groundwater pumping off the springs, since the mode of their occurrence and the complex geology seem to preclude the practicality of these alternatives. Also, the Glenwood Springs are commercially developed for recreation and those springs that supply the resort areas could not be plugged off or pumped without adverse social and economic impacts.

(4) Other desalting methods. - Several types of desalination treatment plants are available; preliminary studies indicate that the multistage flash distillation process is the most thoroughly proven method of treating water similar to the Glenwood-Dotsero Springs discharges. It is possible that the thermal nature of the springs is the result of ground water moving along faults and related fracture zones, becoming heated by deep-lying intrusive bodies, and returning to the surface. Geophysical studies are planned that should identify any thermal anomaly present. Geothermal heat if present, could provide the source of desalting energy.

(5) No action. - The alternative of no action would have no effect on the project area. No construction would be necessary. Current studies could be suspended and investigative funds applied to some other project.

However, the springs would also continue as the largest contributor of salt to the Colorado River in the Upper Basin area. The salinity of the river at Imperial Dam would not be reduced as a result of the project, and the annual sum of $4,370,000 would be lost by water users downstream from the proposed project.

2. Irrigation Source Control

a. Palo Verde collector system, California. - The alternative of constructing a desalting plant using a reverse osmosis or other methods to desalt the entire flow of the Palo Verde Outfall Drain and remove about 1,033,700 tons of salt annually from the return flows will be considered during the course of the investigations.

This proposal would reduce the salinity of the Colorado River water at Imperial Dam by about 145 mg/l. The presence of a large-scale desalting plant at the lower end of the Palo Verde Irrigation District would affect the human environment by contributing to the employment, industry, and economy of the Blythe Region. As in the case of some other options, however, desert vegetation would be destroyed through construction of the plant and disposal of the brine.

Other alternatives such as combined power generation and desalting will be considered as the investigations continue.

The alternative of no action would result in no change to the current socio/economic/recreation relationships of the Palo Verde area. There would be no reduction in salinity to the Colorado River that would otherwise have resulted from use of the drain water.

As a consequence, if the saline drain water is not used for powerplant cooling, other sites with cooling water sources will be necessary. Thus, locating required powerplants in environmentally sensitive locations along the coast of California or inland locations tapping limited freshwater supplies will result in additional adverse impacts on land and water.

b. Colorado River Indian collector system, Arizona. - The alternatives for reducting the salt contribution to the Colorado River from this source would be to either evaporate the drain flow or desalt it. Evaporation at the present time would cause a serious depletion in Colorado River flows. Desalting would require a commitment of land, water, and power resources, but would greatly improve the quality of water at Imperial Dam. These and other alternatives will be further evaluated in the continuing investigations.

c. Unita Basin Unit, Utah. -

(1) No action. - The alternative of no action would not provide any reduction in salt loading to the Colorado River. Without some reduction in salt loading, the salinity concentration at Imperial Dam will continue to increase. Also, without some improvement programs in the Uinta Basin, greater crop yields, improved irrigation efficiencies, and improved water quality would not be possible.

(2) Desalination. - The major problems associated with desalination as an alternative are collection of saline waters to a central plant, providing evaporation ponds for brine disposal, and costs of distilling large quantities of saline water.

The possibility of higher quality water from the desalination plant picking up a greater amount of salts than the more saline waters which now flow from the Duchesne to the Colorado River should also be investigated.

(3) Evaporation. - Collecting and evaporating saline waters as an alternative to the IMS and WSI programs would not be as effective as a control method which combines the proposed programs with evaporation ponds in selected areas.

Evaporation as an alternative would require large amounts of land for ponds which would probably not be available. Also to be considered is the greater quantity of water to be removed from the system under the evaporation alternative.

(4) Pressure systems and sprinkling systems. - Providing onfarm improvements such as pressure systems for delivery of water to the farms and sprinkling systems for application would increase irrigation efficiencies and reduce salt loading from irrigated lands.

The onfarm improvements would be much more effective when used with an effective IMS program and improvements of the entire conveyance system.

(5) Subsurface disposal. - Subsurface disposal of brines or low-quality water should be considered; however, a thorough study must be made of the geology of the Basin before this method of control could be recommended.

d. Lower Gunnison Basin Unit, Colorado. - Alternatives have not been formulated for this project, but use of buried pipe in lieu of concrete lining of canals would be a logical alternative. Also, consideration could be given to improving only areas of most severe canal seepage. A collector system could be designed to collect surface and a subsurface drainage for the treatment in evaporation ponds or a desalting facility.

3. Diffuse Source Control

a. Big Sandy River Unit, Wyoming. - There appeared to be geologic evidence indicating that the saline seeps on the Big Sandy River result from upward leakage from the high-pressure good-quality artesian aquifers of the Wasatch Formation underlying this portion of the Green River Basin. As an alternative to other salinity control measures, investigations were conducted in an effort to determine if the saline seeps can be reduced or stopped by relieving the pressure within the artesian aquifers. It was discovered that an impermeable barrier separated the good-quality water from the upper saline flows and pumping from the deeper aquifer would not decrease the saline seeps.

Another possible alternative would be to pump saline flows by means of drilled wells located close to the seep, and either evaporate or deplete the brine in some other way. Additional studies are underway to examine other disposal possibilities.

Only small amounts of vegetation will be removed at the well sites to facilitate drilling operations. During the drilling process the use of mud pits will be permitted and upon completion, the pits will be backfilled with originally excavated material to natural ground surface. Topsoil will be stockpiled separately and replaced in the top 1 foot of the excavation.

Temporary esthetic impacts will result from the drilling operations. Longer term esthetic impacts will occur due to the presence of piezometer heads.

Wildlife would be displaced in small numbers by the removal of vegetative habitat and by construction activity. The project should not reduce wildlife numbers or change general distribution patterns. The land disturbed during construction will be available to wildlife as natural revegetation occurs.

Land ownership and general land use would not be altered by the minor facilities constructed.

Construction activities would temporarily increase the levels of traffic, noise, and dust along part of the Big Sandy River. However, there are no people residing in or adjacent to the construction area. After the facilities have been constructed there will only be occasional light vehicular traffic to the site to obtain readings from the piezometers.

b. Price River, San Rafael River, and Dirty Devil River Units, Utah. - No definite plans for controlling salt loading from the Price, San Rafael, and Dirty Devil Rivers have been formulated at this time; therefore, all alternatives are still being considered. Continued field investigations should provide the necessary information for selecting a control method.

Some of the problems associated with desalting plants or evaporation ponds which have yet to be resolved are: (1) large areas required for evaporation ponds; (2) storage of large amounts of salt deposits for an extended period of time; (3) leakage of saline water possibly contaminating areas surrounding ponds; accidental discharge of salts into river systems; collection of saline water to a central plant; and costs associated with desalting large quantities of water.

If no action were decided upon, the salt loading of the Colorado River would continue to increase as Upper Basin uses increase.

c. McElmo Creek Unit, Colorado. - Alternatives to evaporation of the flows of McElmo Creek would be desalting or increased irrigation efficiency with or without evaporation or desalting. IMS and WSI programs are being investigated to determine which alternative is the most feasible method of eliminating salts.

E. Other Measures for Salinity Control

1. Return Flow Utilization

The San Diego Gas and Electric Company plans to construct, by 1985, a 900-megawatt nuclear powerplant in the Colorado Desert near Blythe, California. As a water supply for cooling in the water-short Southwest, the company was encouraged to utilize saline agricultural drainage water in order to reduce salinity in the lower main stem. It is planning to use drainage water from the Palo Verde Irrigation District and not return the cooling tower blowdown water to the Colorado River.

Metropolitan Water District has agreed, in principle, to furnish up to a total of 100,000 acre-feet of Colorado River water each year to sites in the Mojave Desert area for powerplant cooling and related purposes. The water is to be distributed as follows: San Diego Gas and Electric Company - 17,000 acre-feet; Los Angeles Department of Water and Power - 33,000 acre-feet; and Southern California Edison Company - 50,000 acre-feet. Metropolitan and the affected parties have executed leters of intent formalizing such allocation, and the terms and conditions under which Metropolitan would furnish this water. In the future, it is anticipated that these leters will be executed as contracts.

The 17,000 acre-feet per year allocated to San Diego Gas and Electric Company are only sufficient for one unit, but the Company's plan also calls for installation of second unit of 900-MW capacity. The company's plans to obtain a water supply for the second unit would still involve the use of drainage water from the Palo Verde District. The company has purchased about 7,000 acres of irrigated farmlands. In the future, it plans either to take a portion of the land out of production or reduce the intensity of crop production. The reduction in demand caused by the above use of the land will be equal to the drainage water taken for cooling plant purposes and no additional demand will be placed on the Colorado River System. The drainage water used by the two units will reduce the tonnage of salt by 59,000 tons per year, equivalent to about 8 mg/l at Imperial Dam.

Other states in the Basin also will encourage use of saline water for cooling purposes, although complicated water rights or location problems often must be solved to permit such use.

CONSULTATION AND COORDINATION

CONSULTATION AND COORDINATION

A. Consultation and Coordination During Plan Development

CONSULTATION AND COORDINATION

A. Consultation and Coordination During Plan Development

1. Cooperating Entities

The investigations involved in the Colorado River Water Quality Improvement Program have been aided by the support of all of the Basin States and most water user organizations. Several other agencies of the Federal Government, particularly the EPA, have contributed effectively to the program in addition to the research efforts already discussed.

It is recognized that any recommendations for improvement of irrigation efficiency must be realistic and capable of being achieved by the farmers. Any structural measures proposed must be acceptable to the farmers and landowners for the improvements to be constructed. Changes in irrigation efficiency that will result from expansion of the IMS program for irrigation scheduling, technical assistance by the Soil Conservation Service, and any other education and demonstration programs to improve irrigation farm management must have wide acceptance. To achieve farmer participation, local coordinating committees are being formed for each study unit as studies get underway. Entities involved include Irrigation and Drainage Districts, conservation districts, and local groups interested in improving irrigation efficiency.

a. Bureau of Land Management. - The Assistant Secretary - Land and Water Resources - has directed the Bureau of Land Management and the Bureau of Reclamation to establish a working relationship to integrate reclamation and public land programs as they relate to improvement of the water quality in the Colorado River Basin. Currently, a task force is being established with representatives from the Bureau of Land Management and the Bureau of Reclamation whose responsibility will include:

Review research on various methods of water quality improvement applicable to the Colorado River Basin natural resource lands.

Recommend implementation of those methods suitable for application and identify specific treatments needing further research.

Determine the need for on-the-ground review on specific sites.

Develop guidelines for use by field personnel to identify potential areas for study (i.e., physical data on salinity concentrations, quantity of flow, geographic location, control measures and associated cost). The guidelines are to be on areas of mutual concern rather than on those that are solely within the responsibility of one organization (i.e., salinity associated with irrigation projects will not be considered).

Identify potential areas for study.

Identify types of programs or treatments that should be considered for improvement of water quality.

Recommend areas of responsibility between Bureaus in relation to the application of remedial treatment practices in specific geographic areas.

Following completion of these tasks, specific programs will be identified to implement measures of reducing salinity in the Colorado River System.

b. <u>Department of Agriculture</u>. - The Colorado River Salinity Control Act (Public Law 93-320) provides authority for the USDA to participate in Colorado River Basin Salinity Control investigations along with the Department of Interior and the Environmental Protection Agency in the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming. A Memorandum of Understanding between the Department of the Interior and the Department of Agriculture, effective November 27, 1974, was entered into which requires full coordination, cooperation, and liaison between Interior and Agriculture in achieving improved irrigation efficiency through research and demonstrations, implementation of onfarm irrigation system improvements, better irrigation management practices, and other activities that would further the objective of the Salinity Control Act. A Memorandum of Agreement, effective March 27, 1975, was entered into between the Bureau of Reclamation and the Soil Conservation Service to implement the specific activities called for under Title II of the Colorado River Basin Salinity Control Act.

In addition to the research underway by the Department of Agriculture, it has also undertaken the examination of the magnitude of program inputs needed to provide definitive appraisals of present and potential contributions to the reduction of the salt load of the Colorado River System. The Department of Agriculture has been working with farmers and ranchers for many years to improve onfarm water management techniques. These onfarm activities significantly compliment the Colorado River Water Quality Improvement Program.

Evaluations proposed or underway by the Department of Agriculture include:

Showing relationships of erosion and sediment production to salt loading.

Identifying land areas having the highest potential to affect salt loading through erosion and sedimentation.

Identifying watershed areas where management and treatment practices will reduce salt loading.

Identifying areas where improved irrigation system and management practices can be utilized.

Showing relationships between such practices and salt loading.

Quantifying effects which can be achieved through technical or financial assistance programs of the Department.

Identifying the impacts of alternative salt load reduction programs on the agriculture, livestock and forest industries.

In particular, the Soil Conservation Service is actively participating in salinity control activities in the Grand Valley area. Through SCS engineering assistance and the Agricultural Conservation Program (ASCS) for cost sharing, farmers have installed 14 miles of ditch lining at a cost of about $300,000. Moreover, it is cooperating with the Bureau in the conduct of the Irrigation Management Services program. It has had a task force appraise required improvements in onfarm irrigation systems. Its role in further improving farm irrigation efficiencies can be highly significant.

c. State Participation. - The Seven Basin States all participated in structuring the Colorado River Water Quality Improvement Program. They have monitored progress of the investigations and have provided helpful assistance and suggestions as the program progressed. For example, in the Grand Valley area, the State of Colorado has assigned personnel to work toward the goal of improving water use efficiency in the Valley. It has financed field trials of advanced onfarm automated irrigation systems including a drip irrigation system in an orchard. The State of Wyoming is participating in a pilot study of the natural freezing process for salt removal in the Big Sandy River. The State of California has accomplished background studies of the salinity problem and has been most helpful in providing results of independent studies relating to economic impacts of saline water use. Nevada has arranged for and provided considerable technical data and background relating to Las Vegas Wash. Such continuing cooperation is essential to successful completion and evaluation of the various salinity control units involved in the program.

2. Interagency Coordination and Review

a. Colorado River Basin Salinity Control Forum. - Enactment of P.L. 92-500, The Federal Water Pollution Control Act, introduced a new management factor into the salinity problem. This legislation has been interpreted by EPA as requiring that numerical criteria be set for salinity on the Colorado River. Consequently, in the fall of 1973, EPA submitted to several of the Colorado River Basin States preliminary views regarding proposed requirements and procedures for Salinity Control in the Colorado River Basin including the establishment of an interstate organization to develop a salinity control plan.

In response to the EPA proposal, the Basin States met in November of 1973 and formed the Colorado River Basin Salinity Control Forum. A statement of the Forum's position for use in discussing the proposed requirements and procedures for salinity control was adopted at that time and states in part:

* *

"The States have established a mechanism for interstate cooperation (Colorado River Basin Salinity Control Forum) and for preparation of semiannual reports on the development of numeric criteria and the adoption of such criteria by October 18, 1975.

"As was concluded by resolution of the Colorado River Basin States Conferees of the Conference in the Matter of Pollution of Interstate Waters of the Colorado River and Its Tributaries held in Las Vegas, Nevada and the Reconvened Seventh Session held in Denver, Colorado, implementation of the Colorado River Salinity Control Program generally as described in the report of the Secretary of the Interior entitled, 'Colorado River Water Quality Improvement Program, February 1972' would carry out the most appropriate plan of implementation for salinity control for the Colorado River system. The appropriate objective of the project is the maintenance of salinity at or below levels found in the lower main stem as of

April 1972, while the Upper Basin States continue to develop their compact-apportioned waters."

* *

The Forum members at the November 1973 meeting also agreed to a request of EPA that:

* *

"(a) The final statement on proposed water quality standards and plan of implementation for salinity control should be consistent for all seven States of the Colorado River Basin; and

"(b) Opportunity should be provided for further direct discussion between representatives of the Environmental Protection Agency and the Forum before the proposed regulations are published in the Federal Register."

* *

Following formation of the Colorado River Basin Salinity Control Forum, meetings were held with representatives of the EPA in January, March, and April 1974 to discuss a proposed regulation on Colorado River Salinity which would require the States to adopt water quality standards for salinity and submit them to EPA by October 1975. The Forum also immediately established procedures and a time schedule for establishing the standards and initiated necessary studies in cooperation with the Bureau of Reclamation and the Environmental Protection Agency.

The proposed regulation was published in the Federal Register on June 13, 1974. After hearings in Las Vegas, Nevada, and Denver, Colorado, in August 1974, the final regulation was made effective on December 18, 1974, in the Federal Register. The regulation sets forth the salinity control policy, procedures and requirements for establishing water quality standards for salinity in the Basin. The full text of this regulation appears in Appendix F.

The "Water Quality Standards for Salinity, Including Numeric Criteria and Plan of Implementation for Salinity Control, Colorado River System" was later adopted by the seven Basin States and published in the Federal Register March 31, 1976 prior to formal approval by the Environmental Protection Agency on a date to be determined.

b. Colorado River Basin Salinity Control Advisory Council. - Public Law 93-320, The Colorado River Basin Salinity Control Act, created an Advisory Council composed of no more than three members from each State appointed by the Governor of each of the Colorado River Basin States. The Council will serve only in an advisory status and shall:

(1) Act as liaison between both the Secretaries of Interior and Agriculture and the Administrator of the Environmental Protection Agency and the States in accomplishing the purposes of Title II control programs.

(2) Receive reports from the Secretary in the progress of the salinity control program and review on said reports.

(3) Recommend to both the Secretary and the Administrator of the Environmental Protection Agency appropriate studies of further projects, techniques, or methods for accomplishing salinity control in the Basin.

The Advisory Council as well as the President and the Congress will receive biannual reports on the Colorado River Salinity Control Program commencing on January 1, 1975. This report for all control plans under Title II of the Act will cover:

(1) Progress of investigations, planning, and construction of salinity control units.

(2) Effectiveness of such units.

(3) Anticipated work needed to be accomplished in the future, emphasizing needs during the 5 years immediately following the date of each report, and any special problems that may be impeding progress.

CONSULTATION AND COORDINATION

B. Consultation and Coordination During Preparation of the Draft EIS

B. Consultation and Coordination During Preperation of the Draft EIS

Las Vegas Wash Unit, Nevada

1. Cooperating Entities. - The following is a list of the various entities that have been consulted and which have assisted in some way with the development of the project plan. The brief narrative describes the nature of their relationship and the type of information that was used in the planning process.

Las Vegas Wash Development Committee. - A planning committee authorized by the Clark County Board of County Commissioners to establish guidelines for the development of the full recreational and educational potential of Las Vegas Wash. Coordination consists of ongoing monthly meetings to coordinate the planning of the Las Vegas Wash Unit with the Committee's plans for a recreational and wildlife area in the wash.

Clark County Sewage and Wastewater Advisory Committee. Monthly meetings in which the committee is apprised of Reclamation's plans and progress.

Facilities Development Section, Clark County Sanitation District (formerly the Wastewater Management Agency). - Continuous contact to coordinate all Reclamation activities in the general Las Vegas area with the County's plans for an Advanced Wastewater Treatment Plant and future discharges of sewage effluent into the Wash. This coordination has required close cooperation with the district's consultant "Nevada Environmental Consultants" (NECON).

Clark County Public Works Department and Regional Planning Council. - Several meetings have been held relative to the Las Vegas Wash Unit's requirements for rights-of-way and matters pertaining to land use.

Basic Management Incorporated. - This industry was contacted regarding the possible use of its property for evaporation ponds.

U.S. Geological Survey. - This agency was contacted to obtain hydrologic data for the flows in Las Vegas Wash. A discussion of data needs led to the installation of a new gaging station.

Nevada Power Company. - Several meetings have been held to discuss the possible joint use of pipelines for the disposal of brine wastes or all collected wash flows in Dry Lake Valley as described in chapter VIII of this statement.

Environmental Protection Agency. - The agency is regularly advised of Reclamation's progress relative to activities in the greater Las Vegas area.

State of Nevada, Division of Colorado River Resources. - This State agency, through their appointee's, represents the State of Nevada on the "Committee of Fourteen." As such, they worked closely with the Bureau of Reclamation during initial planning efforts prior to authorization of the project. They have continually, through the Committee of Fourteen, coordinated the activities of this project with the other Basin States as it relates to the overall Colorado River Salinity Control Project.

Southern Nevada Resource Action Council. - The council has been apprised of the Las Vegas Wash Unit's progress at monthly meetings.

Early in March, 1975, the Environmental Office of Reclamation's Lower Colorado Regional Office contacted the Nevada Department of Fish and Game regarding a biological inventory for Las Vegas Wash. In subsequent meetings with the State Fish and Game, they recommended that Reclamation contact the Biology Department of the University of Nevada at Las Vegas. On August 12, 1975, a followup meeting was held in which the State Fish and Game and the U.S. Fish and Wildlife Service met with the Bureau of Reclamation to discuss the biological study, alternatives of the Las Vegas Wash Unit, and possible mitigation concepts for project impacts.

On July 5, 1974, initial contact was made with the National Park Service, Arizona Archeological Center regarding an archeological survey of Las Vegas Wash. In response to this request, the National Park Service contacted the Nevada Archeological Survey, Southern Division, University of Nevada, Las Vegas, Museum of Natural History, Las Vegas, Nevada. Field work was begun in November, 1974, and was concluded in June, 1975. In its report, the Nevada Archeological Survey has included not only a complete inventory of sites, but also recommendations for site mitigation and estimated costs.

Other institutions that have been specifically consulted and/or coordinated with include the State of Nevada, Governor's Office of Planning Coordination; Arizona State Clearinghouse, Office of Economic Planning and Development; State of California, Office of the Lieutenant Governor, Office of Intergovernmental Management; Clark County Regional Planning Council; and the Business and Economics Department of the University of Nevada, Las Vegas.

Crystal Geyser Unit, Utah

Several Federal and State agencies have coordinated with the Bureau of Reclamation or have been consulted concerning the Crystal Geyser Unit. These agencies and their respective contributions are listed below.

The following Federal agencies provided comments on the report of the proposed project:

National Park Service
Fish and Wildlife Service
Bureau of Land Management
Bureau of Mines

Other input was furnished by:

State of Utah, Division of State History - Archeological and historical studies.

Brigham Young University - Biotic assessment of Crystal Geyser area.

Paradox Valley Unit, Colorado

An interagency planning and consultation meeting and field tour of the Paradox Valley Salinity Control Unit site was held in December of 1974. The following Federal, State, and local agencies participated:

Bureau of Land Management
Soil Conservation Service
National Park Service
Fish and Wildlife Service
Colorado State Water Conservation Board
Colorado State Department of Health
Colorado Division of Wildlife
San Miguel Water Conservancy District
Colorado River Board of California
Metropolitan Water District of Southern California
Sierra Club

In addition to the above participation, review, and consultation meetings, several agencies are currently involved in specific coordination activities. These agencies and their respective activities are listed below.

Bureau of Land Management - Coordination in plans for evaporation pond and geologic drilling at the Radium Reservoir site.

Environmental Protection Agency - Coordination of discharge permit for pump tests.

Fish and Wildlife Service - Coordination of contracts for environmental data.

National Park Service - Coordination of contract for archeological inventory.

Bureau of Mines - Requested assistance in the water sampling program.

Colorado Division of Wildlife - Have a contract with the Bureau to inventory the wildlife and their habitats for the Paradox Valley Unit.

Southwest Water Conservation District - Coordination of various interest groups including Congressmen and other office holders. Other activities which have occurred as part of the Paradox Valley Unit are:

1. Geological Survey - Presented a preliminary administrative analysis report of the data and plan.

2. Colorado State Department of Health - Provided water quality data.

3. Colorado State Engineer's Office - Coordinated with the Bureau in the drilling program.

4. Helene Monberg - Correspondent with Washington Post - held informal briefing session with Bureau personnel.

Grand Valley Unit, Colorado

The Grand Valley Salinity Coordinating Committee was formed during the month of August 1972. This group consists of representatives of 19 local, State, and Federal organizations involved in agricultural activities in the Grand Valley. The purpose of this committee is to coordinate water activities, eliminate duplication of effort, and to bring about a better understanding of the salinity control programs among the citizens of the Grand Valley and other agencies. Meetings have been held monthly or bimonthly since the committee was formed.

Subcommittees for publicity, subdivision development, and technical activities have also been established and are functioning well. Noteworthy is the input of the work of the subcommittee on subdivision development work with the Mesa County Planning Commission in setting standards for subdivision developments.

Bureau of Reclamation personnel have attended many meetings with the various water users' organizations explaining the Bureau's salinity control plans, especially in the Irrigation Management Service Program.

Bureau personnel assisted and participated in a National Public Television Program segment of the P.B.S. "NOVA" Series in the feature entitled "Where has the Colorado Gone."

The local newspaper has had a reporter in attendance at the coordinating committee meetings and many feature articles of the activities of the various agencies have been published by this paper.

Recent consultation and coordination activities include the following:

1. A contract (1975) between Ecology Consultants, Inc., Fort Collins, Colo. and the Bureau of Reclamation to study the flora and fauna of the Grand Valley Unit. Data from this study and recommendations will be incorporated into an environmental assessment or statement of the Grand Valley Unit.

2. The Soil Conservation Service is making an environmental assessment of onfarm improvement aspects of the Salinity Control Unit. This information will be combined with Bureau of Reclamation data for the detailed environmental statement or assessment.

3. Colorado State University has completed a literature review of fauna and flora of the Grand Valley Project area and has provided the Bureau with this information.

4. Since November 1975, public meetings have been held across the valley to acquaint the public with the project.

5. The Agricultural Research Service is conducting research on management practices to find ways of reducing river salt

loading from irrigated lands. These studies are in cooperation with Colorado State University Experiment Station and the Bureau of Reclamation.

Uinta Basin Unit, Utah

The Federal agencies which have participated in the investigations and planning of the Uinta Basin Unit are:

Bureau of Indian Affairs - Coordinated the Irrigation Management Services (IMS) program and plans for the Water Systems Improvement.

Forest Service - Exchanged water quality data.

Geological Survey - Established stream gages.

Agriculture Stabilization and Conservation Service - Provided photos of area.

Other agencies and/or groups which coordinated in the Irrigation Management Service (IMS) program are:

Moonlake Water Users Association
Uinta Basin Irrigation Co.
Ute Indian Tribe

Big Sandy Unit, Wyoming

The coordination and consultations in the investigations of the Big Sandy Unit have involved the following agencies:

University of Wyoming - Contracted with the Bureau to do natural freezing desalting studies.

Geological Survey - Gaging.

Environmental Protection Agency - Coordinated in drilling investigations by issuing discharge permit.

Similar coordinating and publicity activities are planned for the Glenwood-Dotsero, Lower Gunnison, and McElmo Creek Units.

Price, San Rafael, Dirty Devil Units, Utah

Investigations of the Price, San Rafael, and Dirty Devil Rivers are currently in progress. The Bureau has received input from the following listed agencies:

Geological Survey - Installed stream gages.

Bureau of Land Management - Installed some stream gages and is currently making some salinity studies on the San Rafael. Exchange of data with the Bureau has occurred.

Utah State University - Making studies on the San Rafael and Price Rivers concerning overland flow relationships to salinity and salt pickup in natural channels.

CONSULTATION AND COORDINATION

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APPENDIX

APPENDIX A

FLORA AND FAUNA OF THE BASIN

APPENDIX A-1

COMMON PLANTS OF THE UPPER COLORADO RIVER BASIN

Appendix A-1. Common Plants of the Upper Colorado River Basin.

Ferns and Other Non-Seed Plants

Adiantum capillus-veneris

Asplenium resilens
A. septentrionale

Athyrium filixfemina

Chara vulgaris

Cheilanthes eatoni
C. feei

Cryptogramma acrostichoides

Cystopteris bulbifera
C. fragilis

Equisetum avense
E. hyemale
E. kansanum
E. laevigatum
E. pratense

Notholaena limitanea

Pellaea glabella

Polystichum lonchitis

Pteridum aquilinum lanuginosum
P. aquilinum pubescens

Selaginella densa
S. mutica
S. watsonii

Woodsia oregana mexicana
W. scopulina

Grasses

Aegilops cylindrica

Agropyron bakeri
A. cristatum
A. dasystachyum
A. desertorum
A. elongatum
A. griffithsi
A. inerme
A. intermedium
A. pubescens
A. repens
A. riparium
A. saxicola
A. scribneri
A. smithii
A. smithii-molle
A. spicatum-inerme
A. subsecundum
A. trachycalum
A. trichophorum

Agrostis alba
A. borealis
A. exarata
A. hiemalis
A. humilis
A. idahoensis
A. palustris
A. scabra
A. semiverticillata
A. variables

Alopecurur aequalis
A. alpinus
A. aristulatus
A. geniculatus
A. pratenesis

Andropogon scoparis

Aristida fendleriana
A. longiseta
A purpurea

Arrhenatherum elatius

Avena fatua
A. sativa

Beckonannia crucaefarmis
B. syzigachne

Blepharoneuron tricholepis

Bouteloua barbata
B. curtipendula
B. eriopoda
B. gracilis
B. hirsuta

Bromus anamalus
B. carinatus
B. ciliatus
B. inermis
B. japonicus
B. marginatus
B. mollis
B. polyanthus
B. porteri
B. pumpellianus
B. racemosa
B. richardsonii
B. tectorum
B. vulgaris
B. willdenowii

Buchloe dactyloides

Calamagrostis canadensis
C. inexpansa
C. neglecta
C. purpuracens
C. rubecens
C. scopularum
C. scribneri

Calamovilfa longifolia

Catabrosa aquatica

Cinchrus pauciflorus

Cinna latifolia

Dactylis glomerata

Danthonia californica
D. cusickii
D. intermedia
D. parryi
D. spicata
D. unispicata

Deschampsia caespitosa
D. danthonioides
D. elongata

Distichlis spicata-stricta

Echinochloa crusgalli

Eleusine indica

Elymus ambigeus
E. canadensis
E. cinereus
E. condensatus
E. glaucus
E. junceus
E. macounii
E. mollis
E. palinus
E. triticoides simplex
E. virginicus

Eragrostis hyponides
E. trichodes

Festuca arizonica
F. elatior
F. idahoensis
F. octoflora
F. ovina brachyphylla
F. scabrella
F. thurberi

Glyceria borealis
G. grandis
G. pauciflora
G. striata

Helictotrichan mortonianum

Hesperochloa kingi

Hierochloe odorata

Hilaria jamesii
H. vulgaris

Hordeum brachyantherum
H. jubatum

Koeleria cristata

Lolium multiflorum
L. perenne

Melica bulbosa
M. spectabilis
M. porteri

Muhlenbergia andina
M. asperifolia
M. curtifolia
M. cuspidata
M. filiculmis
M. filiformis
M. montana
M. porteri
M. pungens
M. racemosa
M. repens
M. richardsonis
M. torreyi
M. wrightii

Munroa squarrosa

Oryzopsis bloomeri
O. exigua
O. hymenoides
O. micrantha

Panicum capillare
P. obtusum
P. vugatum

Phalaris arundinacea

Phragmites communis

Phleum alpinum
P. pratense

Poa alpina
P. alsodes
P. ampla
P. arida
P. bulbosa
P. canbyi
P. compressa
P. curta
P. cusickii
P. epilis
P. fendleriana
P. interior
P. junciflora
P. longiligula
P. nervosa
P. nevadensis
P. occidentalis
P. palustris
P. pratensis
P. reflexa
P. rupicola
P. sandbergii
P. secunda

Polypogon monspeliensis

Puccinellia airoides

Redfieldia flexuosa

Schedonnardus paniculatus

Secale cereale

Setaria glauca
S. viridis

Sitanion hystrix
S. jubatum

Spartina gracilis
S. pectinata

Sporobolus airoides
S. airoides wrightii
S. asper
S. contractus
S. cryptandrus
S. flexuosus
S. heterolepis

Stipa arida
S. columbiana
S. comata
S. coronata
S. lettermani
S. neomexicana
S. occidentalis
S. pinatorum
S. richardsoni
S. robusta
S. spartea
S. speciosa
S. thurberiana
S. viridula

Torryochloa pauciflora

Tristeum montanum
T. spicatum
T. wolfii

Grasslike Plants

Carex albo-nigra
C. angustior
C. anthrostachyra
C. aquatilis
C. arapahoensis
C. aurea
C. bella
C. bigelovii
C. brivipes
C. buxbaumii
C. canescens
C. capillaris
C. chalciolepis
C. crawfordii
C. disperma
C. douglasii
C. drummondiana
C. ebenea
C. egglestonii
C. elecharis
C. elynoides
C. festivella
C. filifolia
C. foenea
C. geyeri
C. heteroneura
Carex hoodii
C. hookerana
C. illota
C. interior
C. jonesii
C. kellogii
C. lanuginosa
C. lasiocarpa
C. leptalea
C. media
C. microptera
C. misardra
C. nebraskensis
C. nelsonii
C. nigricans
C. nova
C. obtusata
C. occidentalis
C. pachystachya
C. petasata
C. phaeocephala
C. praeceptorum
C. praegracilis
C. praticola
C. pseudoscripoidea
C. raynoldsii
C. rossii
C. rostrata
C. saxatalis
C. scoparia
C. scopulorum
C. simulata
C. tolmiei
C. vallicola
C. viridula

Cyperus americanus
C. microcarpus

Eleocharis bolanderi
E. macrostanhya
E. pauciflora

Eriophorum chamissonis

Juncus badius
J. balticus
J. balticus-montanus
J. confusus
J. drummondii

Juncus filiformis
J. hallii
J. interior-arizonicus
J. longistylis
J. mertensiansus
J. parryi
J. regdii
J. saximontanus

Kobresia bellardi
K. mysuroides

Luzula intermedia
L. multiflora
L. parviflora
L. spicata

Scirpus actus
S. americanus
S. rubrotinctus

Sisyrinchium angustifolium
S. montanum

Sparganium eurycarpum
S. multipedunculatum

Triglochin maritima

Typha latifolia

Forbs

Abronia cycloptera
A. elliptica
A. fragrans
A. pumila

Achillea mullefolium lanulosa

Aconitum columbianum-bakeri
A. columbianum-insigne
A. lutescens

Actaea rubra arguta

Agastache urticifolia

Agoseris aurantiaca
A. glauca
A. glauca taraxacifolia

Allium acuminatum
A. brandegei
A. brevistylum
A. cernuum
A. geveri
A. rubrum
A. schoenoparasum
A. textile

Amaranthus graecizans
A. hybridus
A. powellii
A. retroflexus

Ambrosia artemisifolia
A. psilostachya

Amsinckia intermedia

Amsonia eastwoodiana
A. jonesii
A. tomentosa

Anaphalis margaritacea

Androsace filiformis
A. septentrionalis
A. spetentrionalis glandulosa

Anemane cylindrica
A. globosa
A. multifida
A. zephrya

Angelica grayi
A. pinnata
A. quinquefolia
A. roseana

Attennaria anapholoides
A. corymbosa
A. dimorpha
A. microphylla
A. neglecta
A. parvifolia
A. rosea

Apocynum androsaemifolium
A. cannabinum

Aquilegia chrusantha
A. coerulea
A. elegantula
A. flavescens
A. micrantha

Arabis drummondi
A. glabra
A. holobellii
A. lemmoni
A. lyalli
A. microphylla
A. nuttallii
A. pendulina
A. perennans
A. selbyi

Acreuthobium campylopodum

Aquilegia coerulea
A. flavescens
A. formosa

Arctium minus

Arenaria aculeata
A. congesta
A. fendleri
A. hookeri
A. kingii
A. macrantha
A. obtusiloba

Argemone munita
A. polyanthemus

Arnica chamissonis
A. cordifolia
A. fulgens
A. latifolia
A. longifolia
A. mollis
A. parryi
A. sororia

Artemisia dracunculoides
A. dranculus
A. ludoviciana

Asclepias asperula
A. cryptoceras
A. hallii
A. labriformis
A. latifolia
A. speciosa
A. subverticillata
A. tuberosa

Aster alpigenus
A. canescens
A. chilensis adscendens
A. commutatus crassulus
A. compestris
A. eatonii
A. engelmannii
A. foliaceus apricus
A. foliaceus canbyi
A. glsucodes
A. heperius hesperius
A. integrifolius
A. parryi
A. rubrotinctus
A. venustus

Astragalus aboriginum
A. adsurgens
A. agrestris
A. amphioxys
A. beckwithii
A. biaulactus
A. cibarius
A. cicer
A. coltonii moabensis
A. convallarius
A. cymboides
A. desereticus
A. diversifolius
A. eurekensis
A. flexosus
A. hornii
A. iodopetalus
A. kentraphyta

Astragalus lentiginosus
A. miser
A. miser oblongifolius
A. missouriensis
A. mollissimus tompsonae
A. nuttuallianus
A. pattersonii
A. purshii
A. utahensis
A. saxbulosus
A. scopulorum
A. spatulatus
A. tennellus
A. vexilliflexus
A. wingatanus

Athyrium alpestre americanum

Bahia dissecta
B. nudicaulis
B. ourolepis

Balsmorhiza hirsuta
B. incana
B. sagittata

Bassia hypopifolia

Beuila erecta

Besseya alpina
B. plantaginea
B. riteriana
B. wyomingensis

Bidens macrophylla
B. tenuisecta

Borago officinalis

Brassica kaber pinnatifida
B. nigra
B. rapa

Brickellia acabra
B. californica
B. grandifolia
B. longifolia
B. oblongifolia linifolia
B. scabra

Bryum lonchocaulon

Calochortus elegans
C. gunnisonii
C. nuttallii

Camassia quamash

Caltha leptasepala

Calypso bulbosa

Camelina microscarpa

Campanula parryi
C. rotundifolia
C. uniflora

Cannabis sativa

Cappella bursa-pastoris

Cardamine cordifolia

Cardaria draba

Carum carvi

Castilleja angustifolia
C. chromosa
C. coccinea
C. flava
C. integra
C. leonardi
C. linariaefolia
C. miniata
C. occidentalis
C. pulchella
C. rerexifolia
C. sulphurea

Caulanthus crassicaulis

Centaurea repens

Cerastium arvense
C. beeringianum
C. brachypodium

Chaenactis alpina
C. douglasii
C. stevioides

Chamaechaenactis scaposa

Chenopodium album
C. capitatum
C. glaucum
C. humile
C. leptophyllum

Chimaphila umbellata

Chrysanthemum leucanthemum

Chrysopsis folioso
C. villosa

Cicharium intybus

Cicuta douglasii

Cirsium arvense
C. drummondii
C. foliosum
C. neomexicanum
C. pulchellum
C. rydbergii
C. undulatum
C. utahensis
C. vulgare

Claytonia lanceolata

Clematis columbiana
C. hirsutissima
C. ligusticifolia
C. pseudoalpina

Cleome lutea
C. serrulata

Collinsia grandiflora
C. parviflora

Collomia grandiflora
C. linearis
C. tenella

Comandra umbellata-pallida

Conioselinum scopularum

Conium maculatum

Convolvlus arvensis

Conyza canadensis

Corallorrhiza maculata
C. striata

Cordylanthus kingii
C. wrightii

Corydalus aurea
C. caseana

Crepis acuminata
C. atrabarba
C. occidentalis
C. runcinata

Cruciferae spp.

Crypthantha flava
C. flavoculata
C. fulvocanescens
C. jamesii
C. nana
C. torreyana

Chrysopsis villosa

Cymopterus aboriginum
C. anisatus
C. bulbosus
C. fendleri
C. grayii
C. longipes
C. montanus
C. purpurascens

Cynoglossum officinale

Cypripedium fassiculatum
C. parviflorum

Cystopteris fragilis

Datura meteloides
D. stramonium

Delphinium barbeyi
D. geyeri
D. glacum
D. nelsonii
D. occidentale
D. scaposum

Descurainia pinnata
D. pinnata halictorum
D. richardsonii-incisa
D. trachycarpum

Dicentra uniflora

Dipsacus sylvestris

Dithyrea wislizeni

Dodecatheon alpinum
D. pulchellum
D. radicatum

Dondia spp.

Draba aurea
D. ogliosperma
D. spectabilis

Draeocephalum nuttallii

Dryas octopetala

Echinacea spp.

Encelipsis nudicaulis

Epilobium adenocaulon
E. alpinum
E. angustifolium
E. brevistylum
E. glaberrimum
E. glandulosum
E. hornemanii
E. latifolium
E. paniculatum

Epipactus gigantea

Eremocrinum spp.

Erigeron aphanactis
E. compositus
E. concinnus
E. coulteri
E. divergens
E. eatonii
E. elatior
E. engelmanii

Erigeron flagellaris
E. glabellus
E. leiomirus
E. lonchophyllus
E. micranthus
E. peregrinus
E. pumilus
E. simplex
E. speciosus
E. subtrinervis
E. ursinus
E. vreelandi

Erigonum wrightii

Eriogonum alatum
E. batemani
E. caespitosum
E. campanulatum
E. cernum
E. chrysocephalum
E. corymbosum
E. fasiculatum
E. gordoni
E. heracleoides
E. inflatum
E. leptocladon
E. microthecum
E. ovaliflorum
E. racemosum
E. salsuginosum
E. stellatum
E. umbellatum

Eriophylum lanatum integrifolium

Eritichium nanum elongatum

Erodium cicutarium

Erysimum argillosum
E. capitatum
E. nivale

Erythronium grandiflorum

Eupatorium maculatum
E. occidentale

Euphorbia albomarginata
E. esula
E. fendleri
E. robusta

Eurynchium strigosum

Frageria bracteata
F. glauca
F. vesa
F. virginiana

Fraseria acanthicarpa
F. discolor

Frasera albomarginata
F. speciosa

Fritillaria atropurpurea
F. pudica

Galium aparine
G. bifolium
G. boreale
G. coloradoense
G. multiflorum
G. trifidium pacificum

Gayophytum nuttallii
G. ramosissium

Gentiana offinis
G. algida
G. amarella amarella
G. amarella heterosepala
G. ararilla
G. barbellata
G. calycosa
G. dentosa
G. fremontii
G. holopetala
G. parryi
G. plebia
G. prostrata
G. serrata
G. tenella
G. thermalis

Geranium bicknellii
G. caespitosum
G. fremontii
G. nervosum
G. richardsonii
G. viscossimum

Geum macrophyllum
G. rossii
G. rossii turbinatum
G. triflorum
G. triflorum ciliatum

Gilia aggregata
G. arizonica
G. caudata
G. congesta
G. inconspicua
G. leptomeria
G. stenothyrsa

Gillardia aristida
G. pinnatifida

Glaux maritima

Glycyrrhiza lepidota

Gnaphalium chilense
G. palustre

Goodyera oblongifolia

Grindelia squarrosa

Habenaria dilatata
H. hyperborea
H. sparsiflora
H. unalascenis

Hackelia floribunda
H. patens

Halogeton glomeratus

Haplopappus acaulis
H. armerioides
H. croceus
H. lanceolatus
H. macronema
H. uniflorus

Hedysarum boreale
H. occidentale

Helenium autumnale montanum
H. hoopesii

Helianthella microcephala
H. quinquenervis
H. uniflora

Helianthus annus
H. nuttallii
H. petiolaris

Heraculeum lanatum

Heterotheca subaxillaris

Heuclher cylindrica
H. parvifolia
H. rubescens

Hieracium albiflorum
H. fendleri
H. gracile
H. scouleri

Hippuris vulgaris

Humulus americanus

Hydrophyllum capitatum
H. fendleri

Hymenopappua filifolius cinerus

Hymenoxys acaulis
H. filifolius
H. grandiflora
H. helenioides
H. richardsonii
H. scaposa
H. torreyana

Hyoscyamus niger

Hypericum formosum
H. scouleri

Iliamna rivularis

Iris missouriensis

Isatis tinctoria

Iva axillaris
I. occidentalis
I. xanthifolia

Ivesia gordonii

Lactuca pulchella
L. serriola

Lappula echinata
L. redowskii

Lathyrus arizonicus
L. lanszwertii
L. leucanthus
L. utahensis

Leonurus cardiaca

Lepidium densiflorum
L. divergins
L. latifolium
L. montanum
L. perfoliatum
L. virginicum

Leptodactylon pungens

Lesquerella alpinus
L. ludiviciana
L. rectipes
L. spatulata
L. utahensis

Leucelene ericoides

Lewisia pygmaea
L. rediviva

Liguisticum filicinum
L. porteri

Linanthastrum nuttallii

Linaria vulgaris

Linum aristatum
L. kingii
L. lewisii

Lithophragma bulbifera
L. parviflora
L. tehella

Lithospermum incisum
L. multiflorum
L. ruderale

Lomatium dissectum
L. grayi
L. leptocarpum
L. nevadense
L. nuttallii
L. simplex
L. triternatum

Lotus wrightii

Lupinus alpestris
L. ammophilus
L. argenteus
L. argenteus parviflorus
L. caudatus
L. kingii
L. lepidus
L. lepidus utahensis
L. leucophyllus
L. pusillus
L. sericeus

Lychinis drummondii
L. kingii

Lygodesmia grandiflora
L. juncea
L. spinosa

Machaeranthera griniloides
M. leucanthemifolia
M. tanacetifolia
M. tortifolia

Madia glomeata

Malacothrix sonchoides
M. torryi

Malcolmia africana

Malva neglecta (rotundifolia)

Mammalaria spp.

Marrubium vulgare

Matricaria matricarioides

Medicago luplina
M. sativa
M. sativa ladak
M. sativa nomad
M. sativa rambler

Melilotus albus
M. officinalis

Mentha arvensis
M. spicata

Mentzelia albicaulis
M. dispersa
M. laericaulis
M. multiflora
M. nitens
M. pumila

Menyanthes trifoliata

Mertensia arizonica leonardi
M. brevistyla
M. ciliata
M. franciscana
M. fusiformis
M. lanceolata
M. oblongifolia
M. viridis

Microsteris gracilis
M. nutans

Mimulus lastwoodiae
M. guttatus
M. guttatus depauperatus
M. lewisii
M. moschatus
M. primuloides

Mirabilis multiflora

Mitella pentandra
M. stauropetala

Moldovica parviflora

Monarda fistulosa
M. fistulosa menthaefolia
M. pectinata

Monardella odoractissima

Moneses uniflora

Monolepis nuttalliana

Mantia perfoliata

Myriophyllum hippuroides

Myosotis scorpoides

Najas guadalupensis

Nama spp.

Nasturtium officinale

Navarrentia breweri

Nemophila breviflora

Nepeta cataria

Nicotiana attenuata

Nuphar polysephalum

Oenothera albicaulis
O. brachycorpa
O. caespitosa
O. caespitosa montana
O. coronopifolia
O. breviflora
O. flava
O. hookerii
O. lavandulaefolia
O. pallida
O. scapoidea
O. trichocalyx

Oreoxis spp.

Orobanche fassiculata
O. multiflora
O. uniflora

Orogenia linearifolia

Orthocarpus luteus
O. purpureo-albus
O. tolmiei

Osmorhiza chilensis
O. depauperata
O. occidentalis

Oxybaphus linearis

Oxypolis fendleri

Oxyria digyna

Oxytenia acerosa

Oxytropis delflexa
O. lambertii
O. sericea

Parnassia fimbriata
P. palustris

Paronychia pulvinata
P. sessilifolia

Parrya rydbergii

Pectocarya pinicillata

Pedicularis bracteosa
P. centranthera
P. crenulata
P. grayi
P. groenlandica
P. parryi
P. racemosa
P. scopularum

Penstemon acaulis
P. albomarginatus
P. ambiguus
P. bridgesii
P. caespitosus

Penstemon crandallii
P. cyananthus cyananthus
P. cyanocaulis
P. deustus
P. eatonii
P. floridus
P. hallii
P. harbouri
P. humilis
P. jamesii
P. lentus
P. linarioides
P. mensarum
P. moffatii
P. montanus
P. palmeri
P. pachyphyllus
P. procerus
P. radicosus
P. rydbergii
P. strictus
P. subglaber
P. teacrioides
P. utahensis
P. whippleanus

Perideridia spp.

Petradoria pumila

Phacelia affinis
P. corrugata
P. crenulata
P. hastata
P. heterophylla
P. howelliana
P. idahoensis
P. integrifolia
P. ivesiana
P. sericea

Phlox condensata
P. hoodii
P. linearifolia
P. longifolia
P. stansburyi

Phoradendron juniperinum

Physalis hederaefolia
P. longifolia

Physaria australis
P. newberryi
P. vitulifera

Plagiobothrys spp.

Plantago eriopoda
P. insulatus
P. lanceolata
P. major
P. patagonica
P. purshii
P. tweedyi

Podistera eastwoodae

Polemonium delicatum
P. eximum
P. foliosissimum
P. occidentale
P. pulcherrimum
P. vissosum

Polygonum amphibium
P. aviculare
P. bistortoides
P. coccineum
P. douglasii
P. persicarea
P. viviparum
P. watsonii

Potamogeton alpinus
P. natans
P. pectinatus
P. pusillus

Potentilla ansernia
P. arguta convallaria
P. biennis
P. cocinna
P. diversifolia
P. glabrata
P. glandulosa
P. gracilis
P. platensis
P. pulcherrima
P. quinquefolia

Primula parryi
P. specuicola

Prunella vulgaris

Pseudocymopterus montanus

Psilostrophe bakeri

Psoralea juncea
P. neglantha
P. tenuiflora

Peterospora andromedia

Pulsatilla spp.

Pyrola asarifolia
P. secunda
P. virens

Ranunculus adoneus
R. alismaefoliuis
R. aquatilis
R. cardiophyllus
R. cymbalaria
R. eschscholtzii
R. glabberrimus
R. inamoenus
R. jovis
R. macounii
R. occidentale
R. orthorhynchus
R. repens
R. testiculatus

Roemaria refracta

Rorippa alpina

Redbeckia laciniata
R. occidentalis

Rumex acetosella
R. crispus
R. densiflorus
R. hymenosepalus
R. mexicanus
R. venosus

Sagittaria cuneata
S. latifolia

Salicornia spp.

Salsola kali tenuifolia

Sanguisorba minor

Saponaria vaccaria

Saxifraga bronchialis
S. odontoloma

Scrophularia lanceolata

Scutelloria spp.

Sedum dibile
S. integrifolium
S. rodanthum
S. rosea
S. stenopetalum

Selanginella densa-densa
S. mutica

Senecio amplectens
S. amplectens holmii
S. atratus
S. bigelovii
S. bigelovii hallii
S. canus
S. carthemoides
S. crassulus
S. crocatus
S. cymbalarioides
S. eremophilus
S. fremontii
S. hydrophilus
S. integerrimus
S. longilobus
S. multilobatus
S. pauciflorus
S. pseudauereus
S. serra
S. partioides
S. trangularis
S. tridenticulatus
S. werneriaefolius

Sibbaldia procumbens

Sida hederaea

Sidalcea candida
S. oregana
S. neomexicana

Silene acaulis
S. douglasii
S. menziesii

Sisymbrium altissimum
S. montanum
S. radicatum

Sisyrichium idahoensis
S. montanum
S. occidentale

Smelowskia calycina

Smilacina racemosa
S. stellata

Solanum dulcamara
S. nigrum
S. rostratum
S. triflorum

Solidago canadensis elongatus
S. canadensis salebrosa
S. missouriensis
S. multiradiata
S. sparsiflora
S. pathulata

Sonchus arvensis
S. asper

Sphaeralcea ambigua
S. cocinnea
S. grossulariaefolia
S. leptophylla
S. munroana
S. parviflora

Spiranthes romanzoffina

Spraguea umbellata

Stanleya albescens
S. pinnata

Steironema ciliatum

Stellaria jamesiana
S. longifolia
S. longipes

Stephanomeria exigua
S. tenuifollia

Strepthanthella longirostris

Streptanthus cordatus

Streptopus amplexifolius

Suaeda fructicosa

Swertia perennis

Synthris pinnatifide

Talinum brevifolium

Taraxacum officinale

Thalictrum alpinum
T. fendleri.

Thalspi alpestre
T. arvense
T. fendleri
T. glaucum

Thelesperma subnudum

Telepodium spp.

Thermopsis montana pinetorum

Townsendia annua
T. incana
T. montana
T. strigosa

Tradescantia occidentalis

Tragopogon dubius
T. porrifolius
T. pratensis

Tribulus terrestris

Trifolium brandegei
T. dasyphyllum
T. gymnocarpon
T. hybridum
T. kingii
T. longipes
T. micilentum
T. nanum
T. parryi
T. pratense
T. procumbens
T. repens

Triglochin maritima
T. palustris

Trillium spp.

Trollius laxus

Typha domingensis
T. latifolia

Urtica diorca
U. gracilis
U. lyalli
U. serra

Urticularia vulgaris

Valeriana acutiloba
V. edulis
V. occidentalis

Vanclevea stylosa

Veratrum californicum

Verbascum thapsus

Verbena bracteata
V. hastata

Verbensina encelioides

Veronica americana
V. anagallis-aquatica
V. serphlifolia
V. wormskjoldii

Vicia american
V. americana minor

Viguiera miltiflora

Viola adunca
V. adunca bellidifolia
V. beckwithii
V. biflora
V. canadensis
V. canadensis scopulorum
V. nephrophylla
V. nuttallii
V. nuttalli major
V. purpurea

Trees and Shrubs

Abies concolor
A. lasiocarpa

Acer glabrum
A. grandidentatum
A. negunda

Alnus tenuifolia

Amelanchier alnifolia
A. utahensis

Amorpha spp.

Arctostaphylos canescens
A. coloradensis
A. patula
A. uva-ursi

Artemisia arbuscual
A. bigelovii
A. cana
A. dracunculus
A. filifolia
A. frigida
A. gnaphalioides
A. nova
A. obovata
A. pedatifida
A. scopulorum

Artemisia tridentata tridentata
A. tridentata vaseyana
A. tripartita
A. spinescens

Atriplex canescens
A. confertifolia
A. corrugata
A. gardnerii
A. nuttallii
A. patula
A. tridentata

Baccharis spp.

Berberis fremontii
B. fendleri
B. repens

Betula occidentalis (fontinalis
B. glandulosa

Brickellia californica

Ceanthus fendleri
C. greggii
C. inteterrimus
C. martinit
C. velutinus

Celtis recticulata

Cercocarpus intricatus
C. ledifolius
C. montanus

Chimaphila umbellata

Chrysothamnus depressus
C. nauseosus albicaulis
C. nauseosus cansimilis
C. nauseosus glabratus
C. nauseosus junceus
C. parryi attenuatus
C. parryi parryi
C. vaseyi
C. viscidiflorus
C. viscidiflorus lanceolatus
C. viscidiflorus linifolius
C. viscidiflorus puberlus
C. viscidiflorus steophyllus
C. viscidiflorus viscidiflorus

Climatis coleimbiana
C. hirsutissima
C. ligusticifolia

Coleogyne ramosissima

Cornus stolonifera

Cowania mexican stansburiana

Crataegus chrysocarpa
C. douglasii

Dalea fremontii

Dryas octopetala

Echinocactus polycephalus
E. whipplei

Echinocereus coccfana
E. engelmannii
E. triglochidaiatus

Elaegnus angustifolia
E. commutata

Ephedra cutleri
E. nevadensis
E. torreyana
E. viridis

Eriogonum microthecum

Eurotia lanata

Fallugia paradoxa

Fendlera rupicola

Forestiera neomexicana

Fraxinus anomala

Glossopetalon meionandra
G. nevadense
G. nevadense stipuliferum

Gutierrezia microcephala
G. sarothrea

Grayia spinosa

Holodiscus dumosus

Jamesia spp.

Juniperus communis saxatilis
J. monosperma
J. osteosperma
J. scopulorum

Kalmia palifolia

Kochia americana
K. scoparia
K. vestita

Ledum glandulosa

Leptodactylon pungens
L. watsonii

Linnaea borealis

Lonicera involucrata
L. utahensis

Lycium cooperi
L. fremontii
L. pallidum

Lygodeamia spinosa

Mahonia repens

Mammillania microcarpa

Opuntia corvillei
O. fragilis
O. macrorhiza
O. polyacantha
O. rhodantha

Pachistima myrsinites

Parryella filifolia

Peraphyllum ramosissimum

Petrophytum caespitosum

Phylloduce empetriformis

Physocarpus malvaceus
P. monogynus

Picea engelmanii
P. pungens

Pinus aristata
P. contorta
P. edulis
P. flexilis
P. monophylla
P. ponderosa

Poliomintha incana

Populus acuminata
P. angustifolia
P. fremontii
P. tremuloides

Potentilla fruticosa

Prunus virginiana demissa
P. virginiana melanocarpa

Pseudotsuga menziesii

Purshia tridentata

Quercus gambelii
Q. undulata
A. turbinella

Thamnus alnifolia
R. betulaefolia

Rhus glabra
R. radicans
R. trilobata

Rebes aureum
R. cereum
R. coloradense
R. inerme
R. lacustra
R. montigenum
R. peteolare
R. viscosissimum
R. wolfii

Rosa acicularis
R. manica
R. nutkana-hispida
R. woodsii

Rubus idaeus
R. leucodermis
R. parviflorus
R. strigosus

Salix amygdaloides
S. bebbiana
S. cascadensis
S. drummondiana
S. exigua
S. geyeriana
S. glauca
S. myrtillifolia
S. nivalis
S. phylicifolia
S. scouleriana
S. wolfii

Sambucus coerulea
S. pubens
S. racemosa melanocarpa
S. racemosa microbotrys

Sarcobatus vermiculatus

Shepherdia argentea
S. candensis
S. rotundifolia

Sorbus scopulina

Symphoricarpos albus
S. longiflorus
S. occidentalis
S. oreophilus
S. rotundifolius
S. vacinoides

Tamarix petandra (gallica)

Tanacetum spp.

Tetradymia axillaris
T. canescens
T. glabrata
T. spinosa

Vaccinium caespitosum
V. membranaceum
V. myrtillus
V. scoparium

Yucca angustissima
Y. baccata
Y. baileyi navajoa

APPENDIX A-2

COMMON PLANTS OF THE LOWER COLORADO RIVER BASIN

Appendix A-2. Common Plants of the Lower Colorado River Basin.

Grasses and Grass-like Plants

Agropyron bakeri
A. cristatum
A. desertorum
A. elongatum
A. inerme
A. intermedium
A. repens
A. smithii
A. subsecatum
A. trachycaulum

Agrostis alba
A. exerata
A. humilus
A. scabra

Andropogon barbinodis
A. caucasiaus
A. cirratus
A. gerardii
A. glomeratus
A. hallii
A. ischaemum
A. saccharoides
A. scoparius

Aristids adscensionis
A. arizonica
A. barbata
A. californica
A. divaricata
A. fendleriana
A. glauca
A. glabrsta
A. hamulosa

Aristida longiseta
A. orcuttiana
A. pansa
A. parishii
A. purpurea
A. ternipes
A. wrightii

Blepharoneuron tricholepis

Bouteloua aristidoides
B. barbata
B. chondrosioides
B. curtipendula
B. eludens
3. eriopoda
B. filiformis
B. glandulosa
B. gracilis
B. hirsuta
B. parryi
B. radicosa
B. rochrockii
B. trifida

Bromus anomalus
B. arizonicus
B. carinatus
B. catharticus
B. ciliatus
B. fondosus
B. inermus
B. marginatus
B. rigidus

Bromus rubens
B. tectorum
B. trinii

Buchloe dactyloides

Calamagrostis

Carex aquatalia
C. festivela
C. filifolia
C. geophylla

Chloris gayana
C. verticullata
C. virgata

Cottea pappophoroides

Cynodon dactylon

Cyperus fendlerianus

Dactylis glomerata

Danthonia intermedia
D. parryi

Deschampsia caespitosa
D. elongata

Digitaria sanguinalis

Distichlis stricta

Echinochloa crusgalli

Eleocharis acicularis

Elymus cinereus
E. canadensis
E. glaucus
E. junceus
E. triticoides

Elyonurus barbiculmis

Enneapogon desevauxis

Eragrostis arida
E. barrelieri
E. chloromelas
E. cilianensis
E. curvula
E. diffusa
E. erosa
E. intermedia
E. lehmanniana
E. mexicana
E. pilosa
E. spectabilis
E. superba
E. trichodes

Eriochloa gracilis

Festuca arizonica
F. arundinacea
F. brachyphylla
F. elatior
F. grayi
F. megalura
F. octofloria
F. ovina
F. ovinadurinscula
F. pacifica
F. reflexa
F. rubra
F. sororia
F. thurberi

Glyceria

Heteropogon contortus
H. Melanocarpus

Hierochloe odorata

Hilaria belangeri
H. jamesii
H. mutica
H. rigida

Hordeum arizonicum
H. brachyantherum
H. jubatum
H. pusillum
H. stebbinsii

Imperata brevifolia

Juncus xiphoides
J. torreyi

Koeleria cristata

Leptochloa dubia
L. filiformis
L. viscida

Leptoloma cognatum

Lolium multiflorum
L. perenne
L. rigidum
L. temulentum

Luzula

Lycurus phleoides

Melica frutescens
M. porteri

Muhlenbergia andina
M. appressa
M. arenacea
M. arenicola
M. arizonica
M. aspenfolia
M. curtifolia
M. dubia
M. dumosa
M. emersleyi
M. filiculmis
M. longiligula
M. microsperma
M. montana
M. pauciflora
M. polycaulis
M. porteri
M. pungens
M. racemosa
M. repens
M. richardsonis
M. rigems
M. setifolia
M. sinuosa
M. squarrosa
M. torreyi
M. virescens
M. wrightii

Oyrzopsis hymenoides
O. micrantha

Panicum antodotale
P. arizonicum
P. bulbosum
P. hallii vasey
P. hirticule
P. obtusum

Panicum plenum
P. sonorum
P. stramineum
P. urvilleanum
P. virgatum

Paspalum

Phalaris angusta
P. arundinacea
P. caroliniana

Pleum alpinum
P. pratense

Piptochaltium fimbricata

Poa ampla
P. annua
P. arida
P. bigelovii
P. compresa
P. fendleriana
P. glaucifolia
P. interior
P. longiligula
P. nevadensis
P. pratensis
P. reflexa
P. rupicola
P. secunda

Polypogon monspeliensis

Schismus barbatus

Scirpus americanus
S. olneyi

Scleropogon brevifolius

Setaria geniculata
S. grisebachii
S. liebmanni
S. lutescens
S. macrostachya
S. scheelie
S. verticillata
S. villosissima
S. viridis

Sitanion hystrix
S. jubatum

Sorghastrum nutans

Sorghum halepense

Sphenopholis

Sporobolus airoides
S. contractus
S. cryptandrus
S. flexiuosus
S. gigantrus
S. interruptus
S. nealleyi
S. pulvinatus
S. wrighii

Stipa arida
S. columbiana
S. comata
S. eminens
S. lettermani
S. neomexicana
S. occidentalis
S. pringlei
S. robusta
S. speciosa
S. viridula

Trachypogon secundus

Tragus berteronianus

Trichachne californica
T. insularis

Trichloris crinita

Tridens elongatus
T. eragrostoides
T. grandiflorus
T. latifolia
T. nuticus
T. pilosus
T. pulchellus

Trisetum interruptum
T. spicatum

Forbs

Abronia fragrans

Achillea millifolium
A. lanulosa

Acontium

Agaseris glauca

Allionia incarnata

Allium

Amaranthus albus
A. palmeri

Ambrosia aptera

Amsinkia tesselata

Androstephium breviflorum

Anenome

Antennaria

Aquilegia chrysantha

Argemone platyceras

Arnica

Asclepias subverticillata

Aster canescens

Astragalus amphioxys
A. arizonicus
A. flavus
A. lentiginosus
A. nothoxys
A. nuttallianus
A. preussii
A. wootonii

Bahia absinthifolia

Baileya multiradiata

Calochortus ambiguus
C. flexuosa
C. nuttallii

Calycoseris wrightii

Cassia covesii

Castilleja chromosa
C. integra
C. linariaefolia

Chaenactis stevoides

Chamaesaracha coronopus

Chenopodium album

Cirsium utahensis

Cleome lutea
C. serrulata

Coldemia hispidissima

Cordy lanthus wrightii

Corydalis aurea

Croton californicus

Crypthantha confertifolia
C. pterocarya

Datura meteloides

Delphinium amabile
D. bicolor
D. scaposum

Denothera

Descurainia pinnata
D. sophia

Dichelostemma pulchellum

Dithyrea wislizeni

Drymaria pachyphylla

Dyssodia

Epipactis gigantea

Eriastrum

Erigeron canadensis
E. deflexum
E. divergens
E. inflatum
E. ovalifolium
E. tricopes

Eriophyllum lanosum

Erodium cicutarium
E. texanum

Erysimum asperum
E. capitatum

Eschscholtzia mexicana

Euphorbia albomarginata
E. capitellata
E. setiloba

Franseria acanthiocapra

Froelichia arizonica

Gaillardia pinnatifida

Galium rothrockii

Gaura

Geranium fremontii

Gilia aggregata
G. theirberi

Gnaphalium chilense

Helianthus annus
H. anomalus

Hoffnanseggia densiflora

Hymenoxys acaulis
H. adorata
H. richardsoni

Janusia gracilis

Kallstroemia grandiflora

Lappula redowskii

Layia glandulosa

Lepidium lasiocarpum
L. theirberi

Lesquerella gordoni

Lomatium

Lotus greenei
L. humistratus
L. neomexicanus
L. rigidus
L. wrightii

Lupinus alpestris
L. caudatus
L. concinnus
L. palmeri
L. sparsiflorus

Malva neglecta

Marrelbium vulgare

Melampodium leucanthum

Melilotus indicus

Menodora scoparia

Mentzelia albicaulis
M. laevicaulis
M. pterosperma
M. tricuspis

Mirabilis multiflora

Monarda

Nicotianu attenuata
N. trigonophylla

Oenthera

Pectis papposa

Penstemon barbartus
P. eatonii
P. fendleri
P. Microphyllus
P. parryi
P. utahensis
P. virgatus

Perezia nana
P. wrightii

Petalostemon

Phacelia corrugata
P. crenulata
P. fremontii

Phlox austromontana
P. hoodii
P. longifolia

Phoradendron juniperinum

Physarai newberryi

Plantago insularis
P. major
P. purshii

Polygonum persicaria

Portulaca oleracea

Psilostrophe sparsiflora
P. cooperi

Psoralea tenuiflora

Tafinesquia neomexicana

Ranunculus cymbalaris

Rorippa nasturtium-aquaticum

Rumex hymenosepalus

Salsola kali

Senecio ambrosoides
S. erassulus
S. longilobus
S. multilobatus
S. uintahensis

Sisymbrium irio

Solaneum triflorum

Solidago

Sphaeralcea ambigua
S. grossulariaefolia
S. laxa
S. parvifolia

Stephanomeria

Strephtanthus cordatus

Taraxacum officinale

Thalictrum

Thelysperma subnudum

Tragopogon dubius

Tribulus terrestris

Trifolium

Verbascum thapsus

Verbene

Vicea americana
V. exigua

Viguiera annua
V. multiflora

Viola

Xanthium spinosum

Zigadenus paniculatus

Trees and Shrubs

Abies concolor

Abutilon californicum
A. pringlei
A. sonorae

Acacia augustissima
A. constricta
A. filicoides
A. glabrum
A. greggii

Acamptopappus sphaerocephalus

Acer glabrum
A. grandedentatum

Agave plameri
A. parryi
A. utahensis

Allenrolfea occidentalis

Aloysia wrightii

Amelanchier utahensis

Amorpha californica

Anisacanthus thurberi

Arctostaphylos pringlei
A. pungens

Arenaria

Artemisia bigelovii
A. cana
A. dracunculus
A. filifolia
A. frigida
A. tridentata

Atriplex acanthorcarpa
A. canescens
A. confertifolia
A. elegans
A. obovata
A. polycarpa
A. semibaccata

Baccharis brachyphylla
B. emoryi
B. glutinosa
B. pteronioides
B. sarothroides
B. thesioides
B. wrighii

Bebbia juncea

Beloperone californica

Berberis fremontii
B. haematocarpa
B. repens
B. trifoliata

Bouvardia glaberrima

Brickellia betonicaefolia
B. californica
B. coulteri
B. vernosa

Buddleia utahensis

Calliandra eiophylla

Canotia holacantha

Carpochaete bigelovii

Ceanothus fendleri
C. greggi
C. vestitus

Celtis pallida
C. reticulata

Cercidium floridum
C. microphyllum

Cerocarpus betuloides
C. breviflorus
C. ledifolius
C. montanus
C. occidentalis

Cereus giganterus
C. greggii

Chamaebatiaria millefolium

Chilopsis linearis

Choisya dumosa

Chrysothamnus nauseosus
C. paniculatus
C. viscidiflorus

Coldenia canescens

Coleogyne ramosissima

Condalia lycioides
C. spathulata

Cowania mexicana
C. stansburniana

Dalea formosa
D. fremontii minutifolia
D. spinosa
D. wislizeni

Dasylirion wheeleri

Dyssodia acerosa

Echinoçactus acanthodes

Enchinocerus engelmanii
E. fendleri

Encelia farinosa
E. frutescens

Ephedra fasciculata
E. nevadensis
E. trifurca
E. viridis

Eriodicatyon augustifolium
E. trichocalyx

Erigonum fasiculatum
E. microthecum
E. polifolium
E. shockleyi
E. umbellatum

Erigonum wrightii

Eurotia lanata

Eysenhardtia polystachya

Fallugia paradoxa

Fendlera rupicola

Ferocactus wislezenii

Flourensia cernua

Forestiera neomexicana

Fouquieria splendens

Franseria ambrosioides
F. deltoidea
F. dumosa
F. eriocentra

Fraxinus anomala
F. cuspidata
F. lowellii
F. velutina

Garrya flarescens
G. wrightii

Gilia multifloria

Glossopetalon nevadense
G. spinescens

Gossypium thurberi

Grayia spinosa

Gutierrezia linoides
G. lucida
G. microcephala
G. sarothrae

Haplopappus acradenius
H. cuneatus
H. denudatus
H. gracilis
H. heterophyllus
H. laricifolius
H. linearifolius
H. tenuisectus

Hibiscus denudatus

Holocantha emoryi

Holodisus dumosus

Hymenoclea monogyra
H. pentalepis
H. salsola

Hyptis emoryi

Janusia gracilis

Juglans major

Juniperus deppeana
J. monosperma
J. osteosperma

Koeberlinia spinosa

Krameria grayi
K. parvifolia

Larrea divaricata
L. tridentata

Lonicera albiflora
L. interrupta

Lycium andersonii
L. berlandieri
L. exsertum
L. fremontii
L. pallidum

Macrosiphonia brachysiphon

Mahonia trifoliolata

Menodora scabra
M. scoparia
M. spinescens

Mimosa biuncifera

Mortonia scabrella
M. utahensis

Morus microphylla

Nicotiana glauca
N. attenuata

Nolina microcarpa

Olneya tesota

Opuntia acanthocarpa
O. basilaris
O. bigelovia
O. echinocarpa
O. polyacantha

Parthenium incanum

Parthenocissus inserta

Petradoria pumila

Pinus cembroides
P. edulis
P. leiophylla
P. monophylla
P. ponderosa

Platanus wrightii

Pluchea sericea

Polygala acanthoclada

Populus fremontii
P. tremuloides

Porophyllum gracile

Prosopis juliflora
P. pubescens

Prunus andersonii
P. avium
P. demissa
P. fasciculata
P. fremontii
P. persića
P. virens
P. virginiana

Pseudotsuga taxifolia

Psilostrophe cooperi
P. sparsiflora
P. tagetina

Ptelea angustifolia

Purshia glandulosa
P. tridentata

Quercus arizonica
Q. chrysolepis
Q. dunnii
Q. emoryi
Q. gambelii
Q. grisea
Q. hybred
Q. hypoleucoides
Q. oblongifolia
Q. turbinella
Q. undulata

Rhamnus crocea

Thus choriophylla
R. glabra
R. microphylla
R. ovata
R. trilobata

Ribes aureum
R. velutinum

Robinia neomexicana

Rosa woodii

Salazardia mexicana

Salix bonplandiana
S. exigua
S. gooddingii
S. lasiolepis
S. scouleriana

Salvia carnosa
S. pinguifolia

Sambucus mexicana

Sapindus drummondii
S. saponaria

Sarcobatus vermiculatus

Selloa glutinosa

Senecio longilobus
S. monoensis

Simmondsia chinensis

Suaeda torreyana

Symphoricarpos longiflorus
S. oreophilus
S. parishii
S. utahensis

Tamarix gallica
T. pentandra
T. ramosissima

Tecoma stans

Tetradymia canescens

Thamnosma montana
T. texana

Trixis californica

Vitis arizonica

Yucca arizonica
Y. baccata
Y. brevifolia
Y. elata
Y. schidigera
Y. utahensis

Zinnia grandiflora
Z. pumila

APPENDIX A-3

STATE LISTS OF PLANT SPECIES BEING CONSOLIDATED FOR ADDITION TO ENDANGERED AND THREATENED SPECIES LISTS

(Federal Register, Volume 40 Number 127, July 1, 1975)

Appendix A-3. State Lists of Plant Species Being Consolidated for Addition to Endangered and Threatened Species Lists.
(Federal Register, Volume 40 Number 127, July 1, 1975)

ARIZONA	ENDANGERED	ANACARDIACEAE	RHUS KEARNEYI
ARIZONA	ENDANGERED	APOCYNACEAE	AMSONIA KEARNEYANA
ARIZONA	ENDANGERED	ASTERACEAE	ERIGERON [illegible]
ARIZONA	ENDANGERED	ASTERACEAE	ERIGERON RUSBYI
ARIZONA	ENDANGERED	ASTERACEAE	ERIGERON RELIGIOSUS
ARIZONA	ENDANGERED	ASTERACEAE	GALINSOGA SEMICALVA VAR. PERCALVA
ARIZONA	ENDANGERED	ASTERACEAE	HAPLOPAPPUS SALICINUS
ARIZONA	ENDANGERED	ASTERACEAE	MACHAERANTHERA ARIZONICA
ARIZONA	ENDANGERED	ASTERACEAE	PECTIS RUSBYI
ARIZONA	ENDANGERED	ASTERACEAE	PERITYLE GILENSIS VAR. SALENSIS
ARIZONA	ENDANGERED	ASTERACEAE	PLUMMERA AMBIGENS
ARIZONA	ENDANGERED	ASTERACEAE	SENECIO FRANCISCANUS
ARIZONA	ENDANGERED	ASTERACEAE	STEPHANOMERIA SCHOTTII
ARIZONA	ENDANGERED	BERBERIDACEAE	BERBERIS HARRISONIANA
ARIZONA	ENDANGERED	BORAGINACEAE	CRYPTANTHA ATWOODII
ARIZONA	ENDANGERED	BRASSICACEAE	DRABA ASPRELLA VAR. ASPRELLA
ARIZONA	ENDANGERED	BRASSICACEAE	DRABA ASPRELLA VAR. KAIBABENSIS
ARIZONA	ENDANGERED	BRASSICACEAE	SISYMBRIUM KEARNEYI
ARIZONA	ENDANGERED	BRASSICACEAE	STREPTANTHUS LEMMONII
ARIZONA	ENDANGERED	CACTACEAE	ECHINOCACTUS HORIZONTHALONIUS VAR. NICHOLII
ARIZONA	ENDANGERED	CACTACEAE	ECHINOCEREUS TRIGLOCHIDIATUS VAR. ARIZONICUS
ARIZONA	ENDANGERED	CACTACEAE	OPUNTIA BASILARIS VAR. TRELEASEI
ARIZONA	ENDANGERED	CACTACEAE	PEDIOCACTUS BRADYI
ARIZONA	ENDANGERED	CACTACEAE	PEDIOCACTUS PEEBLESIANUS VAR. PEEBLESIANUS
ARIZONA	ENDANGERED	CACTACEAE	PEDIOCACTUS SILERI
ARIZONA	ENDANGERED	CARYOPHYLLACEAE	SILENE RECTIRAMEA
ARIZONA	ENDANGERED	CHENOPODIACEAE	ATRIPLEX GRIFFITHSII
ARIZONA	ENDANGERED	CONVOLVULACEAE	IPOMOEA EGREGIA
ARIZONA	ENDANGERED	CONVOLVULACEAE	IPOMOEA LEMMONI
ARIZONA	ENDANGERED	CRASSULACEAE	ECHEVERIA COLLOMAE
ARIZONA	ENDANGERED	CRASSULACEAE	ECHEVERIA RUSBYI
ARIZONA	ENDANGERED	CYPERACEAE	CAREX SPECUICOLA
ARIZONA	ENDANGERED	FABACEAE	ASTRAGALUS BEATHII
ARIZONA	ENDANGERED	FABACEAE	ASTRAGALUS CREMNOPHYLAX
ARIZONA	ENDANGERED	FABACEAE	ASTRAGALUS LENTIGINOSUS VAR. MARICOPAE
ARIZONA	ENDANGERED	FABACEAE	ASTRAGALUS XIPHOIDES
ARIZONA	ENDANGERED	FABACEAE	SOPHORA FORMOSA
ARIZONA	ENDANGERED	HYDROPHYLLACEAE	PHACELIA FILIFORMIS
ARIZONA	ENDANGERED	HYDROPHYLLACEAE	PHACELIA WELSHII
ARIZONA	ENDANGERED	LILIACEAE	AGAVE ARIZONICA
ARIZONA	ENDANGERED	LILIACEAE	AGAVE MCKELVEYANA
ARIZONA	ENDANGERED	LILIACEAE	AGAVE SCHOTTII VAR. TRELEASEI
ARIZONA	ENDANGERED	LOASACEAE	MENTZELIA NITENS VAR. LEPTOCAULIS
ARIZONA	ENDANGERED	MALVACEAE	SPHAERALCEA FENDLERI VAR. ALBESCENS
ARIZONA	ENDANGERED	NYCTAGINACEAE	ALLIONIA CRISTATA
ARIZONA	ENDANGERED	OLEACEAE	FRAXINUS GOODDINGII
ARIZONA	ENDANGERED	ONAGRACEAE	CAMISSONIA SPECUICOLA SSP. SPECUICOLA
ARIZONA	ENDANGERED	PAPAVERACEAE	ARCTOMECON HUMILIS
ARIZONA	ENDANGERED	POACEAE	SPOROBOLUS PATENS
ARIZONA	ENDANGERED	POLYGONACEAE	ERIOGONUM CAPILLARE
ARIZONA	ENDANGERED	POLYGONACEAE	ERIOGONUM DARROVII
ARIZONA	ENDANGERED	POLYGONACEAE	ERIOGONUM MORTONIANUM
ARIZONA	ENDANGERED	POLYGONACEAE	ERIOGONUM THOMPSONAE VAR. ATWOODII
ARIZONA	ENDANGERED	POLYGONACEAE	ERIOGONUM ZIONIS VAR. COCCINEUM
ARIZONA	ENDANGERED	POLYGONACEAE	RUMEX ORTHONEURUS

ARIZONA	ENDANGERED	PRIMULACEAE	PRIMULA HUNNEWELLII
ARIZONA	ENDANGERED	RANUNCULACEAE	RANUNCULUS INAMOENUS VAR. SUBAFFINIS
ARIZONA	ENDANGERED	ROSACEAE	COWANIA SUBINTEGRA
ARIZONA	ENDANGERED	RUBIACEAE	GALIUM COLLOMAE
ARIZONA	ENDANGERED	SCROPHULARIACEAE	CASTILLEJA CRUENTA
ARIZONA	ENDANGERED	SCROPHULARIACEAE	LIMOSELLA PUBIFLORA
ARIZONA	ENDANGERED	SCROPHULARIACEAE	PENSTEMON CLUTEI
ARIZONA	ENDANGERED	SCROPHULARIACEAE	PENSTEMON DISCOLOR
ARIZONA	ENDANGERED	SOLANACEAE	MARGARANTHUS LEMMONII
ARIZONA	THREATENED	APIACEAE	CYMOPTERUS NEWBERRYI
ARIZONA	THREATENED	APOCYNACEAE	AMSONIA PALMERI
ARIZONA	THREATENED	APOCYNACEAE	AMSONIA PEEBLESII
ARIZONA	THREATENED	ASCLEPIADACEAE	ASCLEPIAS CUTLERI
ARIZONA	THREATENED	ASTERACEAE	ASTER LEMMONII
ARIZONA	THREATENED	ASTERACEAE	ENCELIA FRUTESCENS VAR. RESINOSA
ARIZONA	THREATENED	ASTERACEAE	ERIGERON ARIZONICUS
ARIZONA	THREATENED	ASTERACEAE	ERIGERON LEMMONII
ARIZONA	THREATENED	ASTERACEAE	ERIGERON LOBATUS
ARIZONA	THREATENED	ASTERACEAE	ERIGERON PRINGLEI
ARIZONA	THREATENED	ASTERACEAE	GUTIERREZIA LINOIDES
ARIZONA	THREATENED	ASTERACEAE	HAPLOPAPPUS SCOPULORUM
ARIZONA	THREATENED	ASTERACEAE	HELENIUM ARIZONICUM
ARIZONA	THREATENED	ASTERACEAE	HYMENOXYS QUINQUESQUAMATA
ARIZONA	THREATENED	ASTERACEAE	HYMENOXYS SUBINTEGRA
ARIZONA	THREATENED	ASTERACEAE	MACHAERANTHERA MUCRONATA
ARIZONA	THREATENED	ASTERACEAE	PERITYLE COCHISENSIS
ARIZONA	THREATENED	ASTERACEAE	PERITYLE LEMMONII
ARIZONA	THREATENED	ASTERACEAE	PERITYLE SAXICOLA
ARIZONA	THREATENED	ASTERACEAE	PLUMMERA FLORIBUNDA
ARIZONA	THREATENED	ASTERACEAE	~~[illegible]~~ SENECIO CARDAMINE
ARIZONA	THREATENED	ASTERACEAE	TAGETES LEMMONII
ARIZONA	THREATENED	BORAGINACEAE	CRYPTANTHA SEMIGLABRA
ARIZONA-	THREATENED	BRASSICACEAE	ARABIS GRACILIPES
ARIZONA	THREATENED	BRASSICACEAE	DRABA ASPRELLA VAR. STELLIGERA
ARIZONA	THREATENED	BRASSICACEAE	LESQUERELLA GOODDINGII
ARIZONA	THREATENED	CACTACEAE	CORYPHANTHA RECURVATA
ARIZONA	THREATENED	CACTACEAE	CORYPHANTHA SCHEERI VAR. ROBUSTISPINA
ARIZONA	THREATENED	CACTACEAE	CORYPHANTHA VIVIPARA VAR. ALVERSONII
ARIZONA	THREATENED	CACTACEAE	CORYPHANTHA VIVIPARA VAR. ROSEA
ARIZONA	THREATENED	CACTACEAE	ECHINOCEREUS LEDINGII
ARIZONA	THREATENED	CACTACEAE	FEROCACTUS ACANTHODES VAR. EASTWOODIAE
ARIZONA	THREATENED	CACTACEAE	MAMMILLARIA ORESTERA
ARIZONA	THREATENED	CACTACEAE	MAMMILLARIA THORNBERI
ARIZONA	THREATENED	CACTACEAE	NEOLLOYDIA ERECTOCENTRA VAR. ACUNENSIS
ARIZONA	THREATENED	CACTACEAE	NEOLLOYDIA ERECTOCENTRA VAR. ERECTOCENTRA
ARIZONA	THREATENED	CACTACEAE	OPUNTIA BASILARIS VAR. LONGIAREOLATA
ARIZONA	THREATENED	CACTACEAE	OPUNTIA PHAEACANTHA VAR. FLAVISPINA
ARIZONA	THREATENED	CACTACEAE	OPUNTIA PHAEACANTHA VAR. MOJAVENSIS
ARIZONA	THREATENED	CACTACEAE	OPUNTIA PHAEACANTHA VAR. SUPERBOSPINA
ARIZONA	THREATENED	CACTACEAE	OPUNTIA WHIPPLEI VAR. MULTIGENICULATA
ARIZONA	THREATENED	CACTACEAE	PEDIOCACTUS PAPYRACANTHUS
ARIZONA	THREATENED	CACTACEAE	PEDIOCACTUS PARADINEI
ARIZONA	THREATENED	CACTACEAE	PEDIOCACTUS PEEBLESIANUS VAR. FICKEISENIAE
ARIZONA	THREATENED	CACTACEAE	SCLEROCACTUS SPINOSIOR
ARIZONA	THREATENED	CAPPARIDACEAE	CLEOME MULTICAULIS
ARIZONA	THREATENED	CROSSOSOMATACEAE	CROSSOSOMA PARVIFLORUM
ARIZONA	THREATENED	EUPHORBIACEAE	MANIHOT DAVISIAE

ARIZONA	THREATENED	FABACEAE	ASTRAGALUS AMPULLARIUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS DESPERATUS VAR. CONSPECTUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS ENSIFORMIS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS GEYERI VAR. TRIQUETRUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS LANCEARIUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS LENTIGINOSUS VAR. AMBIGUUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS STRIATIFLORUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS TITANOPHILUS
ARIZONA	THREATENED	FABACEAE	ASTRAGALUS TROGLODYTUS
ARIZONA	THREATENED	FABACEAE	ERRAZURIZIA ROTUNDATA
ARIZONA	THREATENED	FABACEAE	LUPINUS CUTLERI
ARIZONA	THREATENED	FABACEAE	PETERIA THOMPSONIAE
ARIZONA	THREATENED	FABACEAE	PSORALEA EPIPSILA
ARIZONA	THREATENED	FABACEAE	SOPHORA ARIZONICA
ARIZONA	THREATENED	HYDROPHYLLACEAE	NAMA RETRORSUM
ARIZONA	THREATENED	HYDROPHYLLACEAE	PHACELIA CEPHALOTES
ARIZONA	THREATENED	HYDROPHYLLACEAE	PHACELIA CONSTANCEI
ARIZONA	THREATENED	HYDROPHYLLACEAE	PHACELIA HOWELLIANA
ARIZONA	THREATENED	HYDROPHYLLACEAE	PHACELIA RAFAELENSIS
ARIZONA	THREATENED	HYDROPHYLLACEAE	PHACELIA SERRATA
ARIZONA	THREATENED	ISOETACEAE	ISOETES BOLANDERI VAR. PYGMAEA
ARIZONA	THREATENED	LILIACEAE	AGAVE UTAHENSIS VAR. KAIBABENSIS
ARIZONA	THREATENED	LILIACEAE	ALLIUM GOODDINGII
ARIZONA	THREATENED	LILIACEAE	TRITELEIA LEMMONAE
ARIZONA	THREATENED	LORANTHACEAE	ARCEUTHOBIUM APACHECUM
ARIZONA	THREATENED	OLEACEAE	FRAXINUS ANOMALA VAR. LOWELLII
ARIZONA	THREATENED	OLEACEAE	FRAXINUS CUSPIDATA VAR. MACROPETALA
ARIZONA	THREATENED	ONAGRACEAE	CAMISSONIA CONFERTIFLORA
ARIZONA	THREATENED	ONAGRACEAE	CAMISSONIA EXILIS
ARIZONA	THREATENED	ONAGRACEAE	CAMISSONIA PARRYI
ARIZONA	THREATENED	ONAGRACEAE	CAMISSONIA SPECUICOLA SSP. HESPERIA
ARIZONA	THREATENED	PAPAVERACEAE	ARGEMONE ARIZONICA
ARIZONA	THREATENED	PLUMBAGINACEAE	LIMONIUM LIMBATUM
ARIZONA	THREATENED	POACEAE	PUCCINELLIA PARISHII
ARIZONA	THREATENED	POLEMONIACEAE	PHLOX CLUTEANA
ARIZONA	THREATENED	POLEMONIACEAE	PHLOX JONESII
ARIZONA	THREATENED	POLYGALACEAE	POLYGALA PILIOPHORA
ARIZONA	THREATENED	POLYGONACEAE	ERIOGONUM APACHENSE
ARIZONA	THREATENED	POLYGONACEAE	ERIOGONUM DENSUM
ARIZONA	THREATENED	POLYGONACEAE	ERIOGONUM HEERMANNII VAR. SUBRACEMOSUM
ARIZONA	THREATENED	POLYGONACEAE	ERIOGONUM OVALIFOLIUM VAR. VINEUM
ARIZONA	THREATENED	POLYGONACEAE	ERIOGONUM RIPLEYI
ARIZONA	THREATENED	POLYGONACEAE	ERIOGONUM THOMPSONAE VAR. THOMPSONAE
ARIZONA	THREATENED	POLYPODIACEAE	CHEILANTHES PRINGLEI
ARIZONA	THREATENED	POLYPODIACEAE	CHEILANTHES PYRAMIDALIS VAR. ARIZONICA
ARIZONA	THREATENED	POLYPODIACEAE	NOTHOLAENA LEMMONII
ARIZONA	THREATENED	PRIMULACEAE	PRIMULA SPECUICOLA
ARIZONA	THREATENED	RANUNCULACEAE	AQUILEGIA DESERTORUM
ARIZONA	THREATENED	RANUNCULACEAE	CIMICIFUGA ARIZONICA
ARIZONA	THREATENED	RANUNCULACEAE	CLEMATIS HIRSUTISSIMA VAR. ARIZONICA
ARIZONA	THREATENED	ROSACEAE	POTENTILLA MULTIFOLIOLATA
ARIZONA	THREATENED	ROSACEAE	ROSA STELLATA
ARIZONA	THREATENED	ROSACEAE	VAUQUELINIA PAUCIFLORA
ARIZONA	THREATENED	RUTACEAE	CHOISYA ARIZONICA
ARIZONA	THREATENED	RUTACEAE	CHOISYA MOLLIS
ARIZONA	THREATENED	SCROPHULARIACEAE	CASTILLEJA KAIBABENSIS
ARIZONA	THREATENED	SCROPHULARIACEAE	PENSTEMON BICOLOR SSP. ROSEUS
ARIZONA	THREATENED	SCROPHULARIACEAE	PENSTEMON VIRGATUS SSP. PSEUDOPUTUS

COLORADO	ENDANGERED	APIACEAE	NEOPARRYA LITHOPHILA
COLORADO	ENDANGERED	ASTERACEAE	HAPLOPAPPUS FREMONTII SSP. MONOCEPHALUS
COLORADO	ENDANGERED	ASTERACEAE	SENECIO PORTERI
COLORADO	ENDANGERED	BORAGINACEAE	CRYPTANTHA WEBERI
COLORADO	ENDANGERED	BRASSICACEAE	ARABIS OXYLOBULA
COLORADO	ENDANGERED	BRASSICACEAE	BRAYA HUMILIS SSP. VENTOSA
COLORADO	ENDANGERED	BRASSICACEAE	EUTREMA PENLANDII
COLORADO	ENDANGERED	BRASSICACEAE	LESQUERELLA PRUINOSA
COLORADO	ENDANGERED	CACTACEAE	SCLEROCACTUS GLAUCUS
COLORADO	ENDANGERED	CARYOPHYLLACEAE	STELLARIA IRRIGUA
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS DETERIOR
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS DETRITALIS
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS LUTOSUS
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS MICROCYMBUS
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS NATURITENSIS
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS OSTERHOUTII
COLORADO	ENDANGERED	FABACEAE	ASTRAGALUS SCHMOLLAE
COLORADO	ENDANGERED	FABACEAE	OXYTROPIS OBNAPIFORMIS
COLORADO	ENDANGERED	FABACEAE	TRIFOLIUM [illegible]
COLORADO	ENDANGERED	HYDROPHYLLACEAE	PHACELIA FORMOSULA
COLORADO	ENDANGERED	ONAGRACEAE	GAURA NEOMEXICANA SSP. COLORADENSIS
COLORADO	ENDANGERED	POLYGONACEAE	ERIOGONUM EPHEDROIDES
COLORADO	ENDANGERED	RANUNCULACEAE	AQUILEGIA MICRANTHA VAR. MANCOSANA
COLORADO	THREATENED	BORAGINACEAE	CRYPTANTHA ELATA
COLORADO	THREATENED	BORAGINACEAE	CRYPTANTHA STRICTA
COLORADO	THREATENED	BORAGINACEAE	MERTENSIA VIRIDIS VAR. CANA
COLORADO	THREATENED	BRASSICACEAE	ARABIS GUNNISONIANA
COLORADO	THREATENED	BRASSICACEAE	DRABA [illegible]
COLORADO	THREATENED	BRASSICACEAE	PARRYA NUDICAULIS
COLORADO	THREATENED	BRASSICACEAE	RORIPPA COLORADENSIS
COLORADO	THREATENED	CACTACEAE	SCLEROCACTUS MESAE-VERDAE
COLORADO	THREATENED	CYPERACEAE	CAREX MICROPTERA VAR. CRASSINERVIA
COLORADO	THREATENED	FABACEAE	ASTRAGALUS WETHERILLII
COLORADO	THREATENED	FUMARIACEAE	CORYDALIS CASEANA SSP. CASEANA
COLORADO	THREATENED	POACEAE	PHIPPSIA ALGIDA
COLORADO	THREATENED	POLYGONACEAE	ERIOGONUM BRANDEGEI
COLORADO	THREATENED	POLYGONACEAE	ERIOGONUM SAURINUM
COLORADO	THREATENED	POLYGONACEAE	ERIOGONUM VISCIDULUM
COLORADO	THREATENED	RANUNCULACEAE	AQUILEGIA CHRYSANTHA VAR. RYDBERGII
COLORADO	THREATENED	SAXIFRAGACEAE	SULLIVANTIA PURPUSII
NEW MEXICO	ENDANGERED	ASTERACEAE	ERIGERON RHIZOMATUS
NEW MEXICO	ENDANGERED	ASTERACEAE	HELIANTHUS LACINIATUS SSP. CRINITUS
NEW MEXICO	ENDANGERED	ASTERACEAE	HELIANTHUS PARADOXUS
NEW MEXICO	ENDANGERED	BRASSICACEAE	LESQUERELLA AUREA
NEW MEXICO	ENDANGERED	BRASSICACEAE	LESQUERELLA VALIDA
NEW MEXICO	ENDANGERED	CACTACEAE	ECHINOCEREUS LLOYDII
NEW MEXICO	ENDANGERED	CACTACEAE	PEDIOCACTUS KNOWLTONII
NEW MEXICO	ENDANGERED	CARYOPHYLLACEAE	SILENE PLANKII
NEW MEXICO	ENDANGERED	FABACEAE	ASTRAGALUS CASTETTERI
NEW MEXICO	ENDANGERED	FABACEAE	ASTRAGALUS SILICEUS
NEW MEXICO	ENDANGERED	FABACEAE	PETALOSTEMUM SCARIOSUM
NEW MEXICO	ENDANGERED	PAPAVERACEAE	ARGEMONE PLEIACANTHA SSP. PINNATISECTA
NEW MEXICO	ENDANGERED	POLYGALACEAE	POLYGALA RIMULICOLA
NEW MEXICO	ENDANGERED	POLYGONACEAE	ERIOGONUM GYPSOPHILUM

NEW MEXICO	ENDANGERED	RANUNCULACEAE	AQUILEGIA CHAPLINEI
NEW MEXICO	THREATENED	APIACEAE	ALETES FILIFOLIUS
NEW MEXICO	THREATENED	ASTERACEAE	CHAETOPAPPA HERSHEYI
NEW MEXICO	THREATENED	ASTERACEAE	LAPHAMIA CERNUA
NEW MEXICO	THREATENED	ASTERACEAE	PERITYLE LEMMONII
NEW MEXICO	THREATENED	ASTERACEAE	PERITYLE STAUROPHYLLA
NEW MEXICO	THREATENED	ASTERACEAE	SENECIO CARDAMINE
NEW MEXICO	THREATENED	ASTERACEAE	SENECIO QUAERENS
NEW MEXICO	THREATENED	BRASSICACEAE	DRABA MOGOLLONICA
NEW MEXICO	THREATENED	BRASSICACEAE	LESQUERELLA GOODDINGII
NEW MEXICO	THREATENED	CACTACEAE	CORYPHANTHA SNEEDII VAR. LEEI
NEW MEXICO	THREATENED	CACTACEAE	CORYPHANTHA SNEEDII VAR. SNEEDII
NEW MEXICO	THREATENED	CACTACEAE	PEDIOCACTUS PAPYRACANTHUS
NEW MEXICO	THREATENED	CACTACEAE	SCLEROCACTUS MESAE-VERDAE
NEW MEXICO	THREATENED	CAPPARIDACEAE	CLEOME MULTICAULIS
NEW MEXICO	THREATENED	FABACEAE	ASTRAGALUS ACCUMBENS
NEW MEXICO	THREATENED	FABACEAE	ASTRAGALUS ALTUS
NEW MEXICO	THREATENED	FABACEAE	ASTRAGALUS PUNICEUS VAR. GERTRUDIS
NEW MEXICO	THREATENED	FUMARIACEAE	CORYDALIS CASEANA SSP. CASEANA
NEW MEXICO	THREATENED	HYDROPHYLLACEAE	PHACELIA INTEGRIFOLIA VAR. TEXANA
NEW MEXICO	THREATENED	LILIACEAE	ALLIUM GOODDINGII
NEW MEXICO	THREATENED	ONAGRACEAE	OENOTHERA ORGANENSIS
NEW MEXICO	THREATENED	PLUMBAGINACEAE	LIMONIUM LIMBATUM
NEW MEXICO	THREATENED	POACEAE	PUCCINELLIA PARISHII
NEW MEXICO	THREATENED	POLYGONACEAE	ERIOGONUM DENSUM
NEW MEXICO	THREATENED	POLYPODIACEAE	NOTHOLAENA LEMMONII
NEW MEXICO	THREATENED	ROSACEAE	ROSA STELLATA
UTAH	ENDANGERED	APIACEAE	CYMOPTERUS DUCHESNENSIS
UTAH	ENDANGERED	APIACEAE	CYMOPTERUS MINIMUS
UTAH	ENDANGERED	APOCYNACEAE	CYCLADENIA JONESII
UTAH	ENDANGERED	ASTERACEAE	ERIGERON FLAGELLARIS VAR. TRILOBATUS
UTAH	ENDANGERED	ASTERACEAE	ERIGERON KACHINENSIS
UTAH	ENDANGERED	ASTERACEAE	ERIGERON MAGUIREI
UTAH	ENDANGERED	ASTERACEAE	ERIGERON RELIGIOSUS
UTAH	ENDANGERED	ASTERACEAE	ERIGERON SIONIS
UTAH	ENDANGERED	ASTERACEAE	TOWNSENDIA APRICA
UTAH	ENDANGERED	ASTERACEAE	VIGUIERA SOLICEPS
UTAH	ENDANGERED	BORAGINACEAE	CRYPTANTHA BREVIFLORA
UTAH	ENDANGERED	BORAGINACEAE	CRYPTANTHA GRAHAMII
UTAH	ENDANGERED	BORAGINACEAE	CRYPTANTHA JOHNSTONII
UTAH	ENDANGERED	BORAGINACEAE	CRYPTANTHA JONESIANA
UTAH	ENDANGERED	BORAGINACEAE	CRYPTANTHA OCHROLEUCA
UTAH	ENDANGERED	BRASSICACEAE	GLAUCOCARPUM SUFFRUTESCENS
UTAH	ENDANGERED	BRASSICACEAE	LEPIDIUM BARNEBYANUM
UTAH	ENDANGERED	CACTACEAE	ECHINOCEREUS ENGELMANNII VAR. PURPUREUS
UTAH	ENDANGERED	CACTACEAE	SCLEROCACTUS GLAUCUS
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS CRONQUISTII
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS DETRITALIS
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS HAMILTONII
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS HARRISONII
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS LOANUS
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS LUTOSUS
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS MALACOIDES
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS MINTHORNIAE VAR. GRACILIOR

UTAH	ENDANGERED	FABACEAE	ASTRAGALUS PARDALINUS
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS SAURINUS
UTAH	ENDANGERED	FABACEAE	ASTRAGALUS SERPENS
UTAH	ENDANGERED	FABACEAE	OXYTROPIS OBNAPIFORMIS
UTAH	ENDANGERED	GENTIANACEAE	FRASERA GYPSICOLA
UTAH	ENDANGERED	HYDROPHYLLACEAE	PHACELIA ARGILLACEA
UTAH	ENDANGERED	HYDROPHYLLACEAE	PHACELIA MAMMILLARENSIS
UTAH	ENDANGERED	LILIACEAE	ALLIUM PASSEYI
UTAH	ENDANGERED	ONAGRACEAE	CAMISSONIA MEGALANTHA
UTAH	ENDANGERED	PAPAVERACEAE	ARCTOMECON HUMILIS
UTAH	ENDANGERED	POLEMONIACEAE	GILIA CAESPITOSA
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM AMMOPHILUM
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM ARETIOIDES
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM CORYMBOSUM VAR. DAVIDSEI
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM CRONQUISTII
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM EPHEDROIDES
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM HUMIVAGANS
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM HYLOPHILUM
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM INTERMONTANUM
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM LANCIFOLIUM
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM LOGANUM
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM PELINOPHILUM
UTAH	ENDANGERED	POLYGONACEAE	ERIOGONUM ZIONIS VAR. ZIONIS
UTAH	ENDANGERED	SCROPHULARIACEAE	CASTILLEJA AQUARIENSIS
UTAH	ENDANGERED	SCROPHULARIACEAE	CASTILLEJA REVEALII
UTAH	ENDANGERED	SCROPHULARIACEAE	PENSTEMON CONCINNUS
UTAH	ENDANGERED	SCROPHULARIACEAE	PENSTEMON DECURVUS
UTAH	ENDANGERED	SCROPHULARIACEAE	PENSTEMON GRAHAMII
UTAH	ENDANGERED	SCROPHULARIACEAE	PENSTEMON NANUS
UTAH	THREATENED	APIACEAE	CYMOPTERUS BASALTICUS
UTAH	THREATENED	APIACEAE	CYMOPTERUS COULTERI
UTAH	THREATENED	APIACEAE	CYMOPTERUS [illegible]
UTAH	THREATENED	APIACEAE	CYMOPTERUS [illegible]
UTAH	THREATENED	APIACEAE	LOMATIUM [illegible]
UTAH	THREATENED	ASCLEPIADACEAE	ASCLEPIAS CUTLERI
UTAH	THREATENED	ASCLEPIADACEAE	ASCLEPIAS RUTHIAE
UTAH	THREATENED	ASTERACEAE	ERIGERON [illegible]
UTAH	THREATENED	ASTERACEAE	ERIGERON CRONQUISTII
UTAH	THREATENED	ASTERACEAE	ERIGERON GARRETTII
UTAH	THREATENED	ASTERACEAE	ERIGERON MANCUS
UTAH	THREATENED	ASTERACEAE	HAPLOPAPPUS SCOPULORUM
UTAH	THREATENED	ASTERACEAE	HYMENOPAPPUS FILIFOLIUS VAR. TOMENTOSUS
UTAH	THREATENED	ASTERACEAE	MACHAERANTHERA GRINDELIOIDES VAR. DEPRESSA
UTAH	THREATENED	ASTERACEAE	PARTHENIUM LIGULATUM
UTAH	THREATENED	ASTERACEAE	SENECIO DIMORPHOPHYLLUS VAR. INTERMEDIUS
UTAH	THREATENED	BORAGINACEAE	CRYPTANTHA [illegible] BARNEBYI
UTAH	THREATENED	BORAGINACEAE	CRYPTANTHA COMPACTA
UTAH	THREATENED	BORAGINACEAE	CRYPTANTHA FLAVA
UTAH	THREATENED	BORAGINACEAE	CRYPTANTHA SEMIGLABRA
UTAH	THREATENED	BORAGINACEAE	CRYPTANTHA STRICTA
UTAH	THREATENED	BORAGINACEAE	MERTENSIA VIRIDIS VAR. CANA
UTAH	THREATENED	BORAGINACEAE	MERTENSIA VIRIDIS VAR. DILATATA
UTAH	THREATENED	BRASSICACEAE	ARABIS DEMISSA VAR. LANGUIDA
UTAH	THREATENED	BRASSICACEAE	ARABIS DEMISSA VAR. RUSSEOLA
UTAH	THREATENED	BRASSICACEAE	ARABIS SHOCKLEYI
UTAH	THREATENED	BRASSICACEAE	DRABA SOBOLIFERA
UTAH	THREATENED	BRASSICACEAE	DRABA SUBALPINA
UTAH	THREATENED	BRASSICACEAE	DRABA ZIONENSIS

Appendix A-3. Continued

UTAH	THREATENED	BRASSICACEAE	LESQUERELLA GARRETTII
UTAH	THREATENED	BRASSICACEAE	LESQUERELLA RUBICUNDULA
UTAH	THREATENED	BRASSICACEAE	PARRYA NUDICAULIS
UTAH	THREATENED	CACTACEAE	OPUNTIA WHIPPLEI VAR. MULTIGENICULATA
UTAH	THREATENED	CACTACEAE	SCLEROCACTUS PUBISPINUS
UTAH	THREATENED	CACTACEAE	SCLEROCACTUS SPINOSIOR
UTAH	THREATENED	CACTACEAE	SCLEROCACTUS WRIGHTIAE
UTAH	THREATENED	CARYOPHYLLACEAE	ARENARIA STENOMERES
UTAH	THREATENED	CARYOPHYLLACEAE	SILENE PETERSONII
UTAH	THREATENED	EUPHORBIACEAE	EUPHORBIA NEPHRADENIA
UTAH	THREATENED	FABACEAE	ASTRAGALUS AMPULLARIUS
UTAH	THREATENED	FABACEAE	ASTRAGALUS CHLOODES
UTAH	THREATENED	FABACEAE	ASTRAGALUS CONVALLARIUS VAR. FINITIMUS
UTAH	THREATENED	FABACEAE	ASTRAGALUS COTTAMII
UTAH	THREATENED	FABACEAE	ASTRAGALUS DESPERATUS VAR. CONSPECTUS
UTAH	THREATENED	FABACEAE	ASTRAGALUS DUCHESNENSIS
UTAH	THREATENED	FABACEAE	ASTRAGALUS ENSIFORMIS
UTAH	THREATENED	FABACEAE	ASTRAGALUS LANCEARIUS
UTAH	THREATENED	FABACEAE	ASTRAGALUS NIDULARIUS
UTAH	THREATENED	FABACEAE	ASTRAGALUS SOPHORUS VAR. LONCHOCALYX
UTAH	THREATENED	FABACEAE	ASTRAGALUS RAFAELENSIS
UTAH	THREATENED	FABACEAE	ASTRAGALUS STRIATIFLORUS
UTAH	THREATENED	FABACEAE	ASTRAGALUS WETHERILLII
UTAH	THREATENED	FABACEAE	DALEA THOMPSONAE
UTAH	THREATENED	FABACEAE	LUPINUS MARIANUS
UTAH	THREATENED	FABACEAE	PARRYA RYDBERGII
UTAH	THREATENED	FABACEAE	PETERIA THOMPSONIAE
UTAH	THREATENED	FABACEAE	PSORALEA EPIPSILA
UTAH	THREATENED	FUMARIACEAE	CORYDALIS CASEANA SSP. CASEANA
UTAH	THREATENED	GERANIACEAE	GERANIUM MARGINALE
UTAH	THREATENED	HYDROPHYLLACEAE	NAMA RETRORSUM
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA ANELSONII
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA CEPHALOTES
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA CONSTANCEI
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA DEMISSA VAR. HETEROTRICHA
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA HOWELLIANA
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA INDECORA
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA RAFAELENSIS
UTAH	THREATENED	HYDROPHYLLACEAE	PHACELIA UTAHENSIS
UTAH	THREATENED	ONAGRACEAE	CAMISSONIA PARRYI
UTAH	THREATENED	ONAGRACEAE	EPILOBIUM NEVADENSE
UTAH	THREATENED	POACEAE	PUCCINELLIA PARISHII
UTAH	THREATENED	POLEMONIACEAE	GILIA MCVICKERAE
UTAH	THREATENED	POLEMONIACEAE	PHLOX CLUTEANA
UTAH	THREATENED	POLEMONIACEAE	PHLOX GLADIFORMIS
UTAH	THREATENED	POLEMONIACEAE	PHLOX GRAHAMII
UTAH	THREATENED	POLEMONIACEAE	PHLOX JONESII
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM CLAVELLATUM
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM EREMICUM
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM JAMESII VAR. RUPICOLA
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM NANUM
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM OSTLUNDII
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM PANGUICENSE VAR. ALPESTRE
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM SAURINUM
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM SMITHII
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM THOMPSONAE VAR. ALBIFLORUM
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM THOMPSONAE VAR. THOMPSONAE
UTAH	THREATENED	POLYGONACEAE	ERIOGONUM VIRIDULUM

UTAH	THREATENED	PORTULACACEAE	LEWISIA [illegible] MAGUIREI
UTAH	THREATENED	PRIMULACEAE	[illegible] PRIMULA MAGUIREI
UTAH	THREATENED	PRIMULACEAE	[illegible] " SPECUICOLA
UTAH	THREATENED	SCROPHULARIACEAE	[illegible] CASTILLEJA PARVULA VAR. PARVULA
UTAH	THREATENED	SCROPHULARIACEAE	CASTILLEJA [illegible] SCABRIDA
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON [illegible] ABIETINUS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON [illegible] ACAULIS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON CAESPITOSUS [illegible] VAR. SUFFRATICOSUS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON COMPACTUS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON [illegible] LEIOPHYLLUS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON [illegible] PARVUS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON [illegible] UINTAHENSIS
UTAH	THREATENED	SCROPHULARIACEAE	PENSTEMON [illegible] WARDII
UTAH	THREATENED	VIOLACEAE	VIOLA [illegible] CHARLESTONENSIS
WYOMING	ENDANGERED	BRASSICACEAE	LESQUERELLA FREMONTII
WYOMING	ENDANGERED	FABACEAE	ASTRAGALUS PROIMANTHUS
WYOMING	ENDANGERED	ONAGRACEAE	GAURA NEOMEXICANA SSP. COLORADENSIS
WYOMING	THREATENED	ASTERACEAE	ARTEMISIA PORTERI
WYOMING	THREATENED	ASTERACEAE	ERIGERON ALLOCOTUS
WYOMING	THREATENED	ASTERACEAE	TANACETUM SIMPLEX
WYOMING	THREATENED	ASTERACEAE	TOWNSENDIA SPATHULATA
WYOMING	THREATENED	BORAGINACEAE	CRYPTANTHA STRICTA
WYOMING	THREATENED	BORAGINACEAE	MERTENSIA VIRIDIS VAR. DILATATA
WYOMING	THREATENED	BRASSICACEAE	ARABIS DEMISSA VAR. LANGUIDA
WYOMING	THREATENED	BRASSICACEAE	ARABIS DEMISSA VAR. RUSSEOLA
WYOMING	THREATENED	BRASSICACEAE	DRABA NIVALIS VAR. BREVICULA
WYOMING	THREATENED	BRASSICACEAE	LESQUERELLA CARINATA
WYOMING	THREATENED	BRASSICACEAE	PHYSARIA CONDENSATA
WYOMING	THREATENED	CYPERACEAE	CAREX MICROPTERA VAR. CRASSINERVIA
WYOMING	THREATENED	POACEAE	AGROSTIS ROSSIAE
WYOMING	THREATENED	POACEAE	ORYZOPSIS HYMENOIDES VAR. CONTRACTA
WYOMING	THREATENED	PORTULACACEAE	CLAYTONIA BELLIDIFOLIA
WYOMING	THREATENED	RANUNCULACEAE	AQUILEGIA LARAMIENSIS
WYOMING	THREATENED	SCROPHULARIACEAE	PENSTEMON CARYI
WYOMING	THREATENED	SCROPHULARIACEAE	PENSTEMON PAYSONIORUM

APPENDIX A-4

COMMON FISHES OF THE COLORADO RIVER BASIN

Appendix A-4. Common Fishes of the Colorado River Basin

Common name	Scientific name	Common habitat[1]
Salmonidae		
Rainbow trout	*Salmo gairdneri*	C, R, L
Brown trout	*Salmo trutta*	C, R
Cutthroat trout	*Salmo clarki*	C, R
Mountain whitefish	*Prosopium williamsoni*	C, R
Cyprinidae		
Utah chub	*Gila atraria*	C, R, L
Roundtail chub	*Gila robusta*	CO, R
Bonytail chub	*Gila elegans*	CO, R
Humpback chub	*Gila cypha*	CO, R
Colorado squawfish	*Ptychocheilus lucius*	W, R
Speckled dace	*Rhinichthys osculus*	CO, R
Redside shiner	*Richardsonius balteatus*	CO, R
Fathead minnow	*Pimephales promelas*	W, R, L
Carp	*Cyprinus carpio*	W, R, L
Red shiner	*Notropis lutrensis*	W, R
Sand shiner	*Notropis stramineus*	CO, R
Creek chub	*Semotilus atromaculatus*	CO, R
Catostomidae		
Flannelmouth sucker	*Catostomus latipinnis*	W, R
Bluehead sucker	*Catostomus discobolus*	W, R
White sucker	*Catostomus commersoni*	W, R
Longnose sucker	*Catostomus catostomus*	W, R
Humpback sucker	*Xyrauchen texanus*	W, R
Ictaluridae		
Channel catfish	*Ictalurus punctatus*	W, R, L
Black bullhead	*Ictalurus melas*	W, R, L

[1] C - Cold water
CO - Cool water
W - Warm water
R - Rivers
L - Lakes

Appendix A-4. Continued

Common name	Scientific name	Common habitat
Cyprinodontidae		
Plains killifish	*Fundulus kansae*	W, R
Centrarchidae		
Largemouth bass	*Micropterus salmoides*	W, R, L
Bluegill	*Lepomis machochirus*	W, R, L
Green sunfish	*Lepomis cyanellus*	W, R, L
Percidae		
Walleye	*Stizostedion vitreum*	CO, L
Cottidae		
Mottled sculpin	*Cottus bairdi*	CO, R

APPENDIX A-5

COMMON AMPHIBIANS OF THE COLORADO RIVER BASIN

Appendix A-5. Common Amphibians of the Colorado River Basin

Common name	Scientific name	Common habitat[1]
Ambystomidae		
Tiger salamander	*Ambystoma tigrinum*	R
Pelobatidae		
Great Basin spadefoot	*Scaphiopus intermontanus*	C, U
Bufonidae		
Woodhouse's toad	*Bufo woodhousei*	C, R, U
Ranidae		
Rebpard frog	*Rana pipiens*	L

[1] C - Cropland
R - Riparian
U - Uplands
L - Lakes, ponds, reservoirs

APPENDIX A-6

COMMON REPTILES OF THE COLORADO RIVER BASIN

Appendix A-6. Common Reptiles of the Colorado River Basin

Common name	Scientific name	Common habitat[1]
Testudinidae		
Desert tortoise	*Gopherus agassizi*	C, U
Trionychidae		
Spiny softshell turtle	*Trionyx spiniferus*	R
Iguanidae		
Collared lizard	*Crotaphytus colleris*	U
Sagebrush lizard	*Sceloporus graciosus*	U
Desert spiny lizard	*Sceloporus magister*	U
Colubridae		
Western garter snake	*Thamnophis elegans*	C, R
Striped whipsnake	*Masticophis taeniatus*	R, U
Gopher snake	*Pituophis catenifer*	C, R, U
Crotalidae		
Western diamondback rattlesnake	*Crotalus atrox*	U
Western rattlesnake	*Crotalus viridis*	U
Sidewinder	*Crotalus cerastes*	U

[1] C - Cropland
R - Riparian
U - Uplands
L - Lakes, ponds, reservoirs

APPENDIX A-7

COMMON BIRDS OF THE COLORADO RIVER BASIN

Appendix A-7. Common Birds of the Colorado River Basin

Common name	Scientific name	Common habitat[1]
Loons: Caviidae		
Common loon	*Gavia immer*	L
Grebes: Podicipedidae		
Eared grebe	*Podiceps caspicus*	L
Western grebe	*Aechmophorus occidentalis*	L
Pied-billed grebe	*Podilymbus podiceps*	L
Pelicans: Pelecanidae		
White pelican	*Pelecanus erythrorhynchos*	L
Cormorants: Phalacrocoracidae		
Double-crested cormorant	*Phalacrocorax auritus*	R, L
Herons and bitterns: Ardeidae		
Great blue heron	*Ardea herodias*	R, L
Green heron	*Butorides virescens*	R, L
Common egret	*Casmerodius albus*	R, L
Snowy egret	*Leucophoyx thula*	R, L
Black-crowned night heron	*Hycticorax nyctricorax*	R, L
American bittern	*Botaurus lentiginousus*	R, L
Ibises: Threskiornithidae		
White-faced ibis	*Plegadis chihi*	R, L
Roseate spoonbill	*Ajaia ajaja*	R, L

[1] C - Cropland
R - Riparian
U - Uplands
L - Lakes, ponds, reservoirs

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Swans, geese, and ducks: Anatidae		
Whistling swan	*Olor columbianus*	L
Canada goose	*Branta canadensis*	C, R, L
White-fronted goose	*Anser albifrons*	C, L
Snow goose	*Chen hyperborea*	C, R, L
Mallard	*Anas platyrhnchos*	C, R, L
Gadwall	*Anas strepera*	C, R, L
Pintail	*Anas acuta*	C, R, L
Green-winged teal	*Anas carolinensis*	C, R, L
Blue-winged teal	*Anas discors*	C, R, L
Cinnamon teal	*Anas cyanoptera*	C, R, L
American widgeon	*Mareca americana*	C, R, L
Shoveler	*Spatula clypeata*	R, L
Wood duck	*Aix sponsa*	R, L
Redhead	*Aythya americana*	R, L
Ring-necked duck	*Aythya collaris*	R, L
Canvasback	*Aythya valisineria*	R, L
Lesser scaup	*Aythya affinis*	R, L
Common goldeneye	*Bucephala clangula*	R, L
Bufflehead	*Bucephala albeola*	R, L
Ruddy duck	*Oxyura jamaicensis*	L
Hooded merganser	*Lophodytes cucullatus*	L
Common merganser	*Mergus merganser*	R, L
Red-breasted merganser	*Mergus serrator*	R, L
Vultures: Cathartidae		
Turkey vulture	*Cathartes aura*	C, R, U
Hawks, harriers, and eagles: Accipitridae		
Sharp-shinned hawk	*Accipiter striatus*	C, R, U
Cooper's hawk	*Accipiter cooperii*	C, R, U
Red-tailed hawk	*Buteo jamaicensis*	C, R, U
Swainson's hawk	*Buteo swainsoni*	C, R, U
Ferruginous hawk	*Buteo regalis*	C, R, U
Golden eagle	*Aquila chrysaetos*	C, R, U
Bald eagle	*Haliaeetus leucocephalus*	C, R, U
Marsh hawk	*Circus cyaneus*	C, R, U
Rough-legged hawk	*Buteo lagopus*	C, R, U

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Ospreys: Pandionidae		
Osprey	*Pandion haliaetus*	R, L
Falcons: Falconidae		
Prairie falcon	*Falco mexicanus*	C, R, U
Peregrine falcon	*Falco peregrinus*	C, R, U
Merlin	*Falco columbarius*	R, U
American kestrel	*Falco sparverius*	C, R, U
Quail: Phasianidae		
Gambel's quail	*Lophortyx gambelii*	U
Cranes: Gruidae		
Sandhill crane	*Grus canadensis*	C, R, L
Rails, gallinules, and coots: Rallidae		
Yuma clapper rail	*Rallus longirostris yumanensis*	R
Virginia rail	*Rallus limicola*	R
Sora rail	*Porzana carolina*	R
Common gallinule	*Gallinula chloropus*	R, L
American coot	*Fulica americana*	R, L
Plovers, turnstones, and surfbirds: Charadriidae		
Semipalmated plover	*Charadrius semipalmatus*	R, L
Snowy plover	*Charadrius alexandrinus*	R, L
Killdeer	*Charadrius vociferus*	C, R, L
Mountain plover	*Eupoda montana*	R, L
Snipe, sandpipers, etc.: Scolopacidae		
Common snipe	*Capella gallinago*	R
Long-billed curlew	*Numenius americanus*	C, R
Spotted sandpiper	*Actitis macularia*	C, R, L
Solitary sandpiper	*Tringa solitaria*	C, R, L
Willet	*Catoptrophorus semipalmatus*	R, L
Greater yellowlegs	*Totanus melanoleucus*	R, L
Lesser yellowlegs	*Totanus flavipes*	R, L

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Least sandpiper	*Erolia minutilla*	R, L
Long-billed dowitcher	*Limnodromus scolopaceus*	R, L
Western sandpiper	*Ereunetes mauri*	R, L
Marbled godwit	*Limosa fedoa*	R, L
Sanderling	*Crocethia alba*	R, L
Avocets and stilts: Recurvirostridae		
American avocet	*Recurvirostra americana*	C, R, L
Black-necked stilt	*Himantopus mexicanus*	C, R, L
Phalaropes: Phalaropodidae		
Red phalarope	*Phalaropus fulicarius*	R, L
Wilson's phalarope	*Steganopus tricolor*	R, L
Northern phalarope	*Lobipes lobatus*	R, L
Gulls and terns: Laridae		
Herring gull	*Larus argentatus*	C, R, L
California gull	*Larus californicus*	C, R, L
Ring-billed gull	*Larus delawarensis*	C, R, L
Franklin's gull	*Larus pipixcan*	C, R, L
Bonaparte's gull	*Larus philadelphia*	C, R, L
Forster's tern	*Sterna forsteri*	R, L
Common tern	*Sterna hirundo*	R, L
Black tern	*Chlidonias niger*	R, L
Least tern	*Sterna albitrons*	R, L
Pigeons and doves: Columbidae		
White-winged dove	*Zenaida asiatica*	C, R, U
Mourning dove	*Zenaidura macroura*	C, R, U
Cuckoos and roadrunners: Cuculidae		
Yellow-billed cuckoo	*Coccyzus americanus*	C, R
Roadrunner	*Geococcyx californianus*	R, U
Owls: Tytonidae		
Barn owl	*Tyto alba*	R, U

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Owls: Strigidae		
Screech owl	*Otus asio*	R, U
Great horned owl	*Bubo virginianus*	R, U
Burrowing owl	*Speotyto cunicularia*	U
Long-eared owl	*Asio otus*	R
Short-eared owl	*Asio flammeus*	C, R
Goatsuckers: Caprimulgidae		
Poor-will	*Phalaenoptilus nuttallii*	C, R, U
Common nighthawk	*Chordeiles minor*	R, R, U
Swifts: Apodidae		
Black swift	*Cypseloides niger*	C, R
White-throated swift	*Aeronautes saxatalis*	C, R
Hummingbirds: Trochilidae		
Black-chinned hummingbird	*Archilochus alexandri*	C, R
Costa's hummingbird	*Calypte costae*	C, R
Rufous hummingbird	*Selasphorus rufus*	C, R
Kingfishers: Alcedinidae		
Belted kingfisher	*Megaceryle alcyon*	R
Woodpeckers: Picidae		
Red-shafted flicker	*Colaptes cafer*	R
Yellow-bellied sapsucker	*Sphyrapicus varius*	R, U
Tyrant flycatchers: Tyrannidae		
Western kingbird	*Tyrannus verticalis*	C, R
Ash-throated flycatcher	*Myiarchus cinerascens*	C, R, U
Black phoebe	*Sayornis nigricans*	C, R, U
Say's phoebe	*Sayornis saya*	C, R, U
Western wood peewee	*Contopus sordidulus*	C, U
Olive-sided flycatcher	*Nuttallornis borealis*	C, R, U
Vermillion flycatcher	*Pyrocephalus rubinus*	C, R, U
Dusky flycatcher	*Empidonax oberholseri*	R

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Larks: Alaudidae		
Horned lark	*Eremophila alpestris*	C, U
Swallows: Hirundinidae		
Violet green swallow	*Tachycinota thalassina*	C, R, L
Tree swallow	*Iridoprocne bicolor*	R
Bank swallow	*Riparia riparia*	C, R, L
Rough-winged swallow	*Stelgidopteryx ruficollis*	C, R, L
Barn swallow	*Hirundo rustica*	C, R, L
Cliff swallow	*Petrocheliden pyrrhonota*	C, R, L
Purple martin	*Progne subis*	C, U
Jays, magpies, and crows: Corvidae		
Blackbilled magpie	*Pica pica*	C, R, U
Scrub jay	*Aphelocoma coerulescens*	R, U
Common raven	*Corvus corax*	C, R, U
Titmice: Paridae		
Black-capped chickadee	*Parus atricapillus*	R, U
Mountain chickadee	*Parus gambeli*	R, U
Plain titmouse	*Parus inornati*	U
Bush-tit	*Psaltriparus mimimus*	U
Verdin	*Auriparus flaviceps*	R, U
Nuthatches: Sittidae		
White-breasted nuthatch	*Sitta carolinesis*	R
Reb-breasted nuthatch	*Sitta canadensis*	R
Pigmy nuthatch	*Sitta pygmea*	R
Dippers: Cinclidae		
Water ouzel	*Cinclus mexicanus*	R
Wrens: Troglodytidae		
House wren	*Troglodytes aedon*	C, R
Bewick's wren	*Thryomanes bewickii*	U
Long-billed marsh wren	*Telmatodytes palustris*	R, L

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Mockingbirds and thrashers: Mimidae		
Mockingbird	*Mimus polyglottos*	C, R, U
Catbird	*Dumetella carolinensis*	C, R, U
Bendire's thrasher	*Toxostoma bendirei*	C, R, U
Sage thrasher	*Oreoscoptes montanus*	U
Thrushes, bluebirds, solitaires: Turdidae		
Robin	*Turdus migratorius*	C, R
Hermit thrush	*Hylocichla guttata*	C, R
Western bluebird	*Sialia mexicana*	C, R
Mountain bluebird	*Sialia currucoides*	C, R
Townsend's solitaire	*Myadestes townsendi*	C, R
Gnatcatchers and kinglets: Sylviidae		
Blue-gray gnatcatcher	*Polioptila caerulea*	R, U
Black-tailed gnatcatcher	*Polioptila melanura*	R, U
Ruby-crowned kinglet	*Regulus calendula*	R
Pipits: Motacillidae		
Water pipit	*Anthus spinoletta*	C, R
Waxwings: Bombycillidae		
Bohemian waxwing	*Bombycella garrula*	C, R, U
Cedar waxwing	*Bombycilla cedrorum*	C, R
Shrikes: Laniidae		
Loggerhead shrike	*Lanius ludovicianus*	C, U
Starlings: Sturnidae		
Starling	*Sturnus vulgaris*	C, R
Vireos: Vireonidae		
Bell's vireo	*Vireo bellii*	R
Gray vireo	*Vireo vicinior*	U
Solitary vireo	*Vireo solitarius*	R
Warbling vireo	*Vireo gilvus*	R

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Wood warblers: Parulidae		
Audubon's warbler	*Dendroica auduboni*	R
Black-and-white warbler	*Mniotilta varia*	R
Orange-crowned warbler	*Vermivora celata*	R
Lucy's warbler	*Vermivora luciae*	U
Yellow warbler	*Dendroica petecnia*	R
Townsend's warbler	*Dendroica townsendi*	R, U
Hermit warbler	*Dendroica occidentalis*	R, U
MacGillivray's warbler	*Oporornis tolmiei*	R, U
Common yellowthroat	*Geothlypis trichus*	R
Yellow-brested chat	*Icteria virens*	R
Wilson's warbler	*Wilsonia pusilla*	R, U
American redstart	*Setophaga ruticilla*	R, U
Weaver finches: Ploceidae		
House sparrow	*Passer domesticus*	C, R
Meadowlarks, blackbirds, and orioles: Icteridae		
Western meadowlark	*Sturnella neglecta*	C, R, U
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	R
Red-winged blackbird	*Agelaius phoeniceus*	C, R
Hooded oriole	*Icterus cucullatus*	C, R, U
Scott's oriole	*Icterus parisorum*	C, R, U
Tanagers: Thraupidae		
Western tanager	*Piranga ludoviciana*	R, U
Grosbeaks, finches, sparrows, and buntings: Fringillidae		
Black-headed grosbeak	*Pheucticus melanocephalus*	C, R
Blue grosbeak	*Guiraca caerulea*	C, R, U
Lazuli bunting	*Passerina amoena*	R
American goldfinch	*Spinus tristis*	C, R, U
Lesser goldfinch	*Spinus psaltria*	C, R, U
Green-tailed towhee	*Chlorura chlorura*	R
Rufous-sided towhee	*Pipilo erythrophthalmus*	R, U
Savannah sparrow	*Passerculus sandwichensis*	C, U
Vesper sparrow	*Pooecetes gramineus*	C, U
Lark sparrow	*Chondestes grammacus*	C, U

Appendix A-7. Continued

Common name	Scientific name	Common habitat
Black-throated sparrow	*Amphispiza bilineata*	U
Sage sparrow	*Amphispiza belli*	U
Slate-colored junco	*Junco hyemalis*	C, R
Chipping sparrow	*Spizella passerina*	R, U
Brewer's sparrow	*Spizella breweri*	R, U
White-crowned sparrow	*Zonotrichia leucophrys*	R
Fox sparrow	*Passerella iliaca*	R
Lincoln's sparrow	*Melospiza lincolnii*	R
Song sparrow	*Melospiza melodia*	R
Chestnut-collared longspur	*Calcarius ornatus*	R

APPENDIX A-8

COMMON MAMMALS OF THE COLORADO RIVER BASIN

APPENDIX A-8. Common Mammals of the Colorado River Basin

Common name	Scientific name	Common habitat[1]
Opossums: Didelphiidae		
Common opossum	*Didelphis virginiana*	C, R, U
Leaf-nosed bats: Phyllostomatidae		
California leaf-nosed bat	*Macrotus californicus*	C, R, U
Hognose bat	*Choeronycteris mexicana*	C, R, U
Evening bats: Vespertilionidae		
California myotis	*Myotis californicus*	C, R, U
Fringed myotis	*Myotis thysanodes*	C, R
Red bat	*Lasiurus borealis*	C, R
Hoary bat	*Lasiurus cinereus*	C, R
Western pipistrelle	*Pipistrellus hesperus*	C, R, U
Spotted bat	*Euderma maculata*	C, R, U
Pallid bat	*Antrozous pallidus*	C, R, U
Western yellow bat	*Dasypterus ega*	C, R, U
Big brown bat	*Eptesicus fuscus*	C, R, U
Free-tailed bats: Molossidae		
Mexican free-tailed bat	*Tadarida mexicana*	C, R, U
Big free-tailed bat	*Tadarida macrotis*	C, R, U
Western Mastiff bat	*Eumops perotis*	C, R, U
Hares and rabbits: Leporidae		
Black-tailed jackrabbit	*Lepus californicus*	U
Desert cottontail	*Sylvilagus auduboni*	U
Squirrels and chipmunks: Sciuridae		
Whitetail antelope squirrel	*Ammospermophilus leucurus*	R, U

[1] C - Cropland
R - Riparian
U - Upland

Appendix A-8. Continued

Common name	Scientific name	Common habitat
Beaver: Castoridae		
Beaver	*Castor canadensis*	R
Pocket gophers: Geomyidae		
Valley pocket gopher	*Thomomys bottae*	C, R, U
Pocket mice and kangaroo rats: Heteromyidae		
Rock pocket mouse	*Perognathus intermedius*	C, U
Little pocket mouse	*Perognathus longimembris*	C, U
Desert pocket mouse	*Perognathus penicillatus*	U
Merriam's kangaroo rat	*Dipodomys merriami*	U
Ord kangaroo rat	*Dipodomys ordii*	U
Cricetine mice and rats: Cricetidae		
Western harvest mouse	*Reithrodontomys megalotis*	R, U
Cactus mouse	*Peromyscus eremicus*	U
Deer mouse	*Peromyscus maniculatus*	C, R, U
Southern grasshopper mouse	*Onychomys torridus*	U
Hispid cotton rat	*Sigmodon hispidus*	R, U
White-throated wood rat	*Neotoma albigula*	U
Desert wood rat	*Neotoma lepida*	U
Muskrat	*Ondatra zibethica*	C, R
Old World rats and mice: Muridae		
Norway rat	*Rattus norvegicus*	C, R, U
House mouse	*Mus musculus*	C, R, U
Foxes, wolves, and coyotes: Canidae		
Kit fox	*Vulpes macrotis*	C, R, U
Gray fox	*Urocyon cinereoargenteus*	C, R, U
Coyote	*Canis latrans*	C, R, U
Porcupines: Erethizontidae		
Porcupine	*Erethizon corsatum*	U

Appendix A-8. Continued

Common name	Scientific name	Common habitat
Racoons: Procyonidae		
Raccoon	*Procyon lotor*	C, R
Ringtail cat	*Bassariscus astutus*	C, R, U
Weasels, skunks, and badgers: Mustelidae		
Badger	*Taxidea taxus*	C, R, U
Striped skunk	*Mephitis mephitis*	C, R, U
Spotted skunk	*Spilogale putorius*	C, R, U
Cats: Felidae		
Bobcat	*Lynx rufus*	R, U
Feral house cat	*Felis domestica*	C, R, U
Mountain lion	*Felis concolor*	U
Horses and burros: Equidae		
Wild burro	*Equus assinus*	U
Deer: Cervidae		
Elk	*Cervus canadensis*	U
Mule deer	*Odocoileus hemionus*	C, R, U
Pronghorns: Antilocapridae		
Pronghorn	*Antilocapra americana*	U
Cattle, etc.: Bovidae		
Mountain sheep	*Ovis canatensis*	U
Mountain goat	*Oreamnos americanus*	U

APPENDIX B

FLORA AND FAUNA AND RELATED EFFECTS,
LAS VEGAS WASH UNIT, NEVADA

APPENDIX B-1

DISTRIBUTION OF VASCULAR PLANTS

Appendix B-1. Distribution of vascular plants - Las Vegas Wash Unit, Nevada
Values presented are: A = Abundant, C = Common, U = Uncommon,
R = Rare, D = Definite occurrence, H = Hypothetical occurrence.
Asterick equals community indicator species.

	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Ephedraccae																											
Nevada Joint Fir (*Ephedra nevedensis*)	A						A																				
Torrey's Joint Fir (*Ephedra torreyana*)	A						A																				
Mountain Joint Fir (*Ephedra viridis*)	A						A																				
Typaceae																											
Cat-tail (*Typha angustifolia*)													A*			A			A								
Gramineae																											
Bluebunch (*Agropyron spicatum*)								X			X																
Six-weeks Three-awn (*Aristida adscensionis*)	A			C			A																				
Revarchon Three-awn (*Aristida glauca*)	A																										
Needle Grama (*Bouteloua aristoides*)							C																				
Six-weeks Grama (*Bouteloua barbata*)	C						C																				
Ripgut Grass (*Bromus rigidus*)	A			A			A																				
Foxtail Chess (*Bromus rubens*)	A			A			A																				
Downy Chess (*Bromus tectorum*)	A			A			A																				
Chilean Chess (*Bromus trinii*)	R																										
(*Distichlis spicata*)											X			X		A											

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Bermuda grass (Cynodon dactylon)	A						A									A											
Canada Wild-Rye (Elymus canadensis)							R																				
Six-weeks Fescue (Festuca octoflora)	A			C			A																				
Big Galleta (Hilaria rigida)	A						A																				
Barley (Hordeum leporinum)	C																										
Bush Muhly (Muhlenbergia porteri)	A						A																				
Indian Ricegrass (Oryzopois hymenoides)	A			A			A																				
Common Reed (Phragmites communis)							A			A			A			C											
Mutton Grass (Poa fendleriana)							C			C																	
Nevada Blue Grass (Poa nevadensis)										C																	
Kentucky Bluegrass (Poa pratensis)										C																	
Squirrel tail (Sitanion histrix)										C																	
Sand Dropseed (Sporobolus cryptandrus)							C			C																	
Mesa Dropseed (Sporobolus flexuosus)	C				X		C			C																	
Desert Needle Grass (Stipa speciosa)	A						A																				
Slim Tridens (Tridens muticus)	C						C																				
Fluffgrass (Tridens pulchellus)	A				X		A																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Transitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Cyperaceae																											
Sedge (*Carex aurca*)												X			X						X						
Sedge (*Carex festivella*)												X			X						X						
Sedge (*Carex hassei*)												X			X						X						
Sedge (*Carex praegracilis*)												X			X						X						
Wire Grass (*Juncus brunnescens*)												X															
Spike Rush (*Heleocharis montevidensis*)												X															
Black Sedge (*Schoenus nigricans*)												X															
Bulrush (*Scirpus paludosus*)												X	A*														
Salicaceae																											
Fremont Cottonwood (*Populus fremontii*)																C									A		
Slender Willow (*Salix exigua*)																C											
Willow (*Salix gouddingii*)																R											
Arroyo Willow (*Salix lasiolepis*)																R											
Loranthaceae																											
Desert Mistletow (*Phoradendron californicum*)	A						A																				
Polygonaceae																											
Brittle Spine-flower (*Chorizanthe brevicornu*)	A						A																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Rigid Spiny-herb (Chorizanthe rigida)	A						A																				
Angle-stemmed Buckwheat (Eriogonum angulosum)			X						X																		
Skeleton Weed (Eriogonum deflexum)	A						C																				
Wild Buckwheat (Eriogonum densum)	C						C																				
California Buckwheat (Eriogonum fasciculatum)	A						A																				
Heermann Buckwheat (Eriogonum heermannii)	C																										
Desert Trumpet (Eriogonum inflatum)	A						A																				
Whisk Broom (Eriogonum nidularium)	C						C																				
Kidney-leaved Buckwheat (Eriogonum reniforme)	R						R																				
Thomas eriogonum (Eriogonum thomasii)	A						A																				
Little Trumpet (Eriogonum trichopes)	A						C																				
Wild Rhubarb (Rumex hymenosepalus)	C						C																				
Chenopodiaceae																											
Picklebush, Pickleweed (Allenrolfea occidentalis)				A*									R			C											
Hoary Saltbrush, Wingscale (Atriplex canescens)	R			A*			R										X										
Shadscale (Atriplex confertifolia)	R			A*			R									C											
Desert Holly (Atriplex hymenelytra)	R			A													X										

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Quailbrush, Lenscale (*Atriplex lentiformis*)				A*													X										
Parry Saltbrush (*Atriplex parryi*)					X												X										
Cattle Spinach, Allscale (*Atriplex polycarpa*)				A*			R									C											
Winter Fat (*Eurotia lanata*)	A																										
Spiny Hop-sage (*Grayia spinosa*)	A																										
Sea-Blite (*Suaeda fruticosa*)				A*												C											
Inkweed, Iodine weed, Torrey sea-blite (*Suaeda torreyana*)				A*												C									C		
Russian Thistle (*Salsola pestifer*)	A			A			A																		C		
Amaranthaceae																											
Fringed Amaranthus (*Amaranthus fimbriatus*)	A																										
Honey-sweet (*Tidestromia oblongiflora*)	A			A																		A					
Nyctaginaceae																											
Hairy Sand-verbena (*Abronia villosa*)	A																										
Windmills (*Allionia incarnata*)	A						A																				
Wishbone Bush (*Mirabilis bigelovii*)	A																										
Ranunculaceae																											
Parish Larkspur (*Delphinium parishii*)	R						R																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Transitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Papaveraceae																											
Bear-claw poppy (*Arctomecon californica*)	R			R			R																				
Prickly poppy (*Argemone platyceras*)	C						C																				
Desert-gold poppy (*Eschscholzia glyptosperma*)	A						A																				
Little-gold poppy (*Eschscholzia minutiflora*)	A						A																				
Cruciferae																											
Mustard (*Brassica juncea*)	A						A																				
Mustard (*Caulanthus cooperi*)	A						A																				
Yellow Tansy Mustard (*Descurainia pinnata*)	A			A			A															A			A		
Tansy Mustard (*Descurainia sophia*)	A						A																				
Spectacle-Pod (*Dithyrea californica*)	A			A																							
Spectacle-Pod (*Dithyrea wislizeni*)	R																										
Wedge-leaved Draba (*Draba cuniefolia*)	A																										
Yellow Pepper-grass (*Lepidium flavum*)	C																										
Desert Alyssum (*Lepidium fremontii*)	A			A			A									A						A			C		
Peppergrass (*Lepidium lasiocarpum*)	C																										
Palmer Bead-pod (*Lesquerella palmeri*)	A			A			A																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Tumble-Mustard (*Sisymbrium altissimum*)	C						C																		C		
London-Rocket (*Sisymbrium irio*)	C						C																				
Desert Plume (*Stanleya pinnata*)	A			A			A									A									C		
Long-beaked Twist-flower (*Streptanthella longirostris*)	A						A																		C		
Mustard (*Thelypodium lasiophyllum*)	A						A																				
Fringe-pod (*Thysanocarpus curvipes*)	C						C																				
Rosaceae																											
Desert Range almond, Wild almond (*Prunus fasiculata*)	R						C																				
Leguminosae																											
Cat's-claw (*Acacia greggii*)	A						A																				
Locoweed (*Astragalus amphioxys*)		X						X																			
Locoweed (*Astragalus preussii*)	A																										
Locoweed (*Astragalus tidestromii*)		X						X																			
Desert Cassia (*Cassia armata*)	A			R			A																				
Fremont Dalea (*Dalea fremontii*)	A			R			A																				
Silk Dalea (*Dalea mollis*)	C																										
Little-leaved Ratany (*Krameria parvifolia*)	A						A																				
Arizona Lupine (*Lupinus arizonicus*)	A						A																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Lupine (*Lupinus sparsiflorus*)	A																										
Alfalfa (*Medicago sativa*)	A																										
Mesquite (*Prosopis juliflora*)	A						A*			A																	
Screw Bean, Tornilla (*Prosopis pubescens*)	C						C																				
Geraniaceae																											
Coastal Heron's Bill, Filaree (*Erodium cicutarium*)	A			A			A																				
Desert Heron's Bill (*Erodium texanum*)	C						C																		C		
Zygophyllaceae																											
Creosote Bush (*Larrea divaricata*)	A*			R			C									C											
Puncture vine (*Tribulus terrestris*)	C			C			C																		C		
Rutaceae																											
Thamnosma (*Thamnosma montana*)	R																										
Euphorbiaceae																											
Spurge (*Ditaxis neomexicana*)	C						C																				
Rattlesnake Weed (*Euphorbia albomarginata*)	A			A																					R		
Spurge (*Euphorbia polycarpa*)	A			A																					R		
Vitaceae																											
Wild Grape (*Vitis arizonica*)								X				X															
Malvaceae																											
Desert Five-spot, Lantern Flower, Chinese Lantern																											

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Desert Mallow (*Sphaeralcea ambigua*)	A						A																				
Tamaricaceae																											
Salt-cedar (*Tamarix pentandra*)							A						A			A*											
Loasaceae																											
Sting Bush (*Eucnide urens*)							C															C					
Small-flowered; Blazing Star (*Mentzelia albicaulis*)	A																										
Venus Blazing Star (*Mentzelia nitens*)	C																										
Sping-Haired Blazing Star (*Mentzelia tricuspis*)	A																										
Shiny-leaved Sandpaper plant (*Petalonyx nitidus*)				A																		A					
Thurber Sandpaper plant (*Petalonyx thurberi*)	C			C			C																				
Cactaceae																											
Barrel Cactus (Ferocactus ancantnodes)	A																					R					
Cockseed Cactus (*Mammillaria tetrancistra*)		X																									
Deer-horn Cactus (*Opuntia acanthocarpa*)	A																										
Beavertail Cactus (*Opuntia basilaris*)	A			C			C																				
Thorny-fruited Cactus (*Opuntia echinocarpa*)	A						C																				
Darning-Needle Cactus, Diamond Cactus (*Opuntia ramosissima*)	A						C																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Onagraceae																											
Evening-Primrose (*Gaura coccinea*)	C						R																				
Yellow Cups (*Oenothera brevipes*)	A						C																				
Large White Desert Primrose (Oenothere caespitosa)							C																				
Brown-eyed Primrose (*Oenothera clavaeformis*)	A																										
Woody Bottle-washer (*Oenothera decorticans*)	A						C																				
Dune Primrose (*Oenothera deltoides*)	A						C																				
Frost-stemmed Primrose (*Oenothera multijuga*)	A					X	C																				
Large Yellow Desert Primrose (*Oenothera primiveris*)	R						C																				
Narrow-leaved Primrose (*Oenothera refracta*)	A																										
Oleaceae																											
Spiny Menodora (*Menodora spinescens*)	R						C																				
Apocynaceae																											
Small-leaved Amsonia (*Amsonia brevifolia*)	C						R																				
Dogbane (*Amsonia tomentosa*)	C						R																				
Asclepiadaceae																											
Twiny Milkweed (*Sarcostemma hirtellum*)						C																					
Polemoniaceae																											
Phlox (*Eriastrum diffusum*)	A																										

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Transitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Thread-stemmed Gilia (*Gilia filiformis*)	C						C																				
Broad-leaved Gilia (*Gilia latifolia*)	C																										
Spreading Gilia (*Gilia polycladon*)	C																										
Lesser Gilia (*Gilia inconspicua*)	C																										
Rock Gilia (*Gilia scopulorum*)	A																										
Gilia (*Gilia stellata*)	A						C																				
Phlox (Langloisia setosissima)	C																										
Phlox (*Langloisia schottii*)	C						C																				
Phlox (*Linanthus dimissus*)	C																										
Phlox (*Linanthus jonesii*)	C						C																				
Hydrophyllaceae																											
Small-flowered Eucrypta (*Eucrypta micrantha*)	A						C																				
Chinese Pulsey (Heliotropium curassavicum)				C			C																				
Purple Mat (*Nama demissum*)	A						R																				
Notch-leaved Phacelia (*Phacelia crenulata*)	A																										
Fremont Phacelia (*Phacelia fremontii*)	C						R																				
Palmer's Phacelia (*Phacelia palmeri*)	R																										

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Transitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Specter Phacelia (*Phacelia pedicellata*)	C																										
Waterleaf (*Phacelia pulchella*)							C																				
Round-leaved Phacelia (*Phacelia rotundifolia*)	C																										
Boraginaceae																											
Checker Fiddleneck (*Amsinckia tessellata*)	A						C																				
Narrow-leaved Forget-me-not (*Cryptantha angustifolia*)	C						C																				
Flexuous Forget-me-not (*Cryptantha dumetorum*)		X						X																			
Slender Forget-me-not (*Cryptantha gracilis*)	R						R																				
Purple-rooted Forget-me-not (*Cryptantha micrantha*)	A						A																				
Nevada Forget-me-not (*Cryptantha nevadensis*)	C						C																				
Wing-nut Forget-me-not (*Cryptantha pterocarya*)	A						A																				
Broad-nutted Comb-Bur (*Pectocarya platycarpa*)	A						R																				
Arched-nutted Comb-Bur (*Pectocarya recurvata*)							R																				
Jones Popcorn Flower (*Plagiobothrys jonesii*)	C																										
Verbenaceae																											
Vervain (*Verbena bracteata*)				C																							
Goodding Verbena (*Verbena gooddingii*)	C						C																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Transitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Lebiatae																											
Paper-bag bush (*Salazaria mexicana*)	A						A																				
Chia (*Salvie columbariae*)				A			A																				
Mojave Sage (*Salvia mohavensis*)	C						C																				
Solanceae																											
Western Jimson (*Datura meteloides*)	C						C																				
Anderson Thornbush (*Lycium andersonii*)	C				X			X																			
Peach-Thorn (*Lycium cooperi*)	A				X			X																			
Rabbit-Thorn (*Lycium pallidum*)	A			C				X																			
Tobacco (*Nicotiana attenuata*)	C			C			C																				
Desert Tobacco (*Nicotiana trigonophylla*)	C						C																				
Thick-leaved Ground Cherry (*Physalis crassifolia*)	A			A			A																				
Silver-leaf Nettle (*Solanum elaeagnifolium*)	C			C			C																				
Scrophulariaceae																											
Twining Snapdragon (*Antirrhinum filipes*)	C				X			X																			
Indian Paintbrush (*Castilleja chromosa*)	C							X																			
Bigelow Mimulus (*Mimulus bigelovii*)	A			C			C																				
Lesser Mojavea (*Mojavea breviflora*)	A				X			X																			
Beard-Tongue (*Penstemon bicolor*)	C							X																			

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Scented Penstemon (*Penstemon palmeri*)	C							X																			
Bignoniaceae																											
Desert Willow, Desert Catalpa (*Chilopsis linearis*)							C				X				X												
Orobanchaceae																											
Burro-weed Strangler (*Orobanche ludoviciana*)	C				X																						
Plantaginaceae																											
Woolly Plantain (*Plantago insularis*)	A			A			A				X						X										
Rubiaceae																											
Desert Bedstraw (*Galium stellatum*)	C				X			X																			
Cucurbitaceae																											
Palmate-leaved Gourd (*Cucurbita palmata*)	R				X				X																		
Campanulaceae																											
Bellflower (*Nemacladus glanduliferus*)	C					X			X																		
Compositae																											
Goldenhead (*Acamptopappus shockleyi*)																											
Burrsage (*Ambrosia dumosa*)	A*			C			C																				
Parachute Plant (*Atrichoseris platyphylla*)	C																										
Emory Baccharis (*Baccharis emoryi*)							A			A			A				X										
Broom Baccharis (*Baccharis sarothoides*)							A			A																	

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Desert Baccharis (*Baccharis sergiloides*)							A			A																	
Wild Marigold (*Baileya multiradiata*)							A															C			C		
Woolly Marigold (*Baileya pleniradiata*)																											
Sweetbush, Chuckawalla's Delight (*Bebbia juncea*)							A															C			C		
Spear-leaved Brickellia (*Brickellia arguta*)	C						C																				
California Brickellia (*Brickellia californica*)	C						A																				
Desert Brickellia (*Brickellia desertorum*)							C																				
Wright's Tackstem (*Calycoseris wrightii*)	C																										
Fremont Pincushion (*Chaenactis fremontii*)	A						A																				
Mojave Pincushion (*Chaenactis macrantha*)	C																										
Esteve Pincushion (*Chaenactis stevioides*)							C																				
Mojave Rubberbrush (*Chrysothamnus nauseosus*)				C			C																				
Black-banded Rabbit-brush (*Chrysothamnus paniculatus*)							A																				
Terete-leaved Rubberbrush (*Chrysothamnus teretifolius*)							C																				
Cooper Dyssodia (*Dyssodia cooperi*)																											
Thurber Dyssodia (*Dyssodia thurberi*)																											

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Trans-sitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Brittle-bush (*Encelia farinosa*)	A			A			A									A						A					
Rayless Encelia (*Encelia frutescens*)	C						C																				
Sunflower (*Encelia virginensis*)	A						A																				
Large-flowered Sunray (*Enceliopsis argophylla*)	A			A			A															A					
Naked-stemmed Sunray (*Enceliopsis nudicaulis*)	C			C			C																				
Woolly Eriophyllum (*Eriophyllum lanosum*)	A						A																				
Wallace Eriophyllum (*Eriophyllum wallacei*)	A						A																				
Dwarf Filago (*Filago depressa*)	C						A																				
Desert Sunflower (*Geraea canescens*)	A			A			A																				
Matchweed (*Gutierrezia sarothrae*)	C						C																				
Spiny Goldenbush (*Haplopappus gooddingii*)	C																										
Sunflower (*Helianthus annuus*)							C			C			C														
Cheese-bush (*Hymenoclea salsola*)	C						A*																				
Mojave Aster (*Machaeranthera tortifolia*)	C																										
(*Machaeranthera leucanthemifolia*)	C																										
Snake's Head (*Malacothrix coulteri*)	C						C																				
Desert Dandelion (*Malacothrix glabrata*)	A			A			A																				

Appendix B-1. Continued

Species by Family	Creosote			Salt-Brush			Desert Riparian			Riparian & Cliff			Marsh			Transitional			Open Water			Barren			Urban		
	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H	D	P	H
Yellow-Saucers (*Malacothrix sonchoides*)	C						C																				
Mojave Desert Star (*Monoptilon bellidiforme*)	A						A																				
Spanish Needle (*Palafoxia linearis*)	A			A			A																				
Chinch-weed (*Pectis papposa*)	A																										
Emory Rock Daisy (*Perityle emoryi*)	A						A																				
Desert-Fir (*Peucephyllum schottii*)	A						A																				
Arrow-weed (*Pluchea serica*)							A			A			A			A											
Odora (*Porophyllum gracile*)	A						A																				
Velvet Rosette (*Psathyrotes ramosissima*)	C			C																							
Paper-flower (*Psilostrophe cooperi*)	C						C																				
Chicory (*Rafinesquia neomexicana*)	A						A																				
Sand-wash Groundsel (*Senecio douglasii*)	A			C			A																				
Annual Mitra (*Stephanomeria exigua*)	A			A			A																				
Desert-straw (*Stephanomeria pauciflora*)	A						A																				
Desert Nest Straw (*Stylocline micropoides*)	C																										

APPENDIX B-2

ABUNDANCE, DISTRIBUTION AND NATURAL HISTORY OF FISH

Appendix B-2. Abundance, Distribution and Natural History of Fish in Las Vegas Wash, Las Vegas Bay and Boulder Basin of Lake Mead. Clark County, Nevada.

Species by Family	Las Vegas Wash	Las Vegas Bay Boulder Basin	Habitat	Reproduction	Food
Clupeidae					
Treadfin Shad (Dorosoma pentenense)	-	abundant	pelagic	May - June	algae, zooplankton
Salmonidae					
Coho Salmon (Oncorhynchus kisutch)	-	rare	profundal-sublittoral	-	Shad, zooplankton
Cutthroat Trout (Salmo clarki)	-	rare	profundal-sublittoral	-	Shad, zooplankton
Rainbow Trout (Salmo gairdneri)	-	abundant	profundal-sublittoral	-	Shad, zooplankton
Catostomidae					
Humpback Sucker (Xyrauchen texanus)	-	rare	pelagic-littoral	March - April	algae, insects
Cyprinidae					
Goldfish (Carassius auratus)	rare		lotic	May - Aug.	algae
European Carp (Cyprinus carpio)	rare	abundant	pelagic-littoral	March - July	algae, insects, detritus
Ictaluridae					
Channel Catfish (Ictalurus punctatus)	-	abundant	benthic	May - July	omniverous
Poeciliidae					
Mesquitofish (Gambusia affinis)	rare	-	lotic	May - Sept.	insects
Serranidae					
Stripped Bass (Roccus saxatilis)	-	rare	pelagic-sublittoral	-	Shad
Centrarchidae					
Bluegill (Lepomis cyanellus)	rare	common	littoral	April - Aug.	Shad, insects, zooplankton
Green Sunfish (Lepomis macrochirus)	-	common	littoral	April - Aug.	insects, zooplankton
Largemouth Bass (Micropterus salmoides)	-	abundant	littoral-sublittoral	March - June	Shad, zooplankton
Black Crappie (Pomoxis nigromaculatus)	-	abundant	littoral-sublittoral	March - May	Shad, zooplankton

APPENDIX B-3

DISTRIBUTION AND ABUNDANCE OF AMPHIBIANS

Appendix B-3. The ecological distribution and relative abundance of amphibians by biotic community Las Vegas Wash Unit, Nevada. Values expressed as A = Abundant, C = Common, U = Uncommon.

Species by Family	Creosote bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Ambystomidae									
Tiger Salamander (*Ambystoma tigrium*)						U	U		U
Ranidae									
Bullfrog (*Rana cutesbiana*)					U	C	C		
Leopard Frog (*Rana pipiens*)					U	C	C		
Bufonidae									
Desert Toad (*Bufo punctatus*)				U	U	C	C		
Woodhouse's Toad (*Bufo woodhousei*)		U	U	C	C	U	U		
Hylidae									
Pacific Tree Frog (*Hyla regilla*)					U	C	C		

APPENDIX B-4

NATURAL HISTORY OF AMPHIBIANS

Appendix B-4. Natural history information for amphibians - Las Vegas Wash Unit, Nevada.

Species by Family	Seasonal Use	Segments of Habitat Most Dependent Upon	Primary Food Habits	Special Status	Remarks
Ambystomidae					
Tiger Salamander (*Ambystoma tigrium*)	Spring, summer, fall	Rock, fallen vegetation, wet soil	Invertebrates, terrestrial, aquatic		Hibernates in winter
Ranidae					
Bullfrog (*Rana catesbiana*)	Spring, summer, fall	Riparian bank, aquatic littoral zone	Invertebrates, terrestrial, aquatic	Protected by State Game Laws	Hibernates in winter
Leopard Frog (*Rana pipiens*)	Spring, summer, fall	Riparian bank, aquatic littoral zone	Invertebrates, terrestrial aquatic		Hibernates in winter
Bufonidae					
Desert Toad (*Bufo punctatus*)	Spring, summer, fall	Root tangles, riparian bank, wet soil	Invertebrates, terrestrial, aquatic		Hibernates in winter
Woodhouse's Toad (*Bufo woodhousei*)	Spring, summer, fall	Root tangles, riparian bank, wet soil	Invertebrates, terrestrial, aquatic		Hibernates in winter
Hylidae					
Pacific Tree Frog (*Hyla regilla*)	Spring, summer, fall	Root tangles, riparian bank, littoral zone	Invertebrates, terrestrial, aquatic		Hibernates in winter

APPENDIX B-5

DISTRIBUTION AND ABUNDANCE OF REPTILES

Appendix B-5. The distribution and relative abundance of reptiles - Las Vegas Wash Unit, Nevada Values expressed as A = Abundant, C = Common, U = Uncommon, R = Rare, H = Hypothetical, P = Probable.

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Leptotyphlopidae									
Western Blind Snake (<u>Leptotyphlops</u> <u>humilis</u>)			U	U	U				
Colubridae									
Spotted Leaf-nosed Snake (<u>Phyllorhynchus</u> <u>decurtatus</u>)	C	C	C						
Coachwhip (<u>Masticophis</u> <u>flagellum</u>)	A	C	A	A	A			U	U
Western Patch-nosed Snake (<u>Salvadora</u> <u>hexalepis</u>)	C	C	C	U				P	P
Glossy Snake (<u>Arizona</u> <u>elegans</u>)	A	C	A	U	U			P	
Gopher Snake (<u>Pituophis</u> <u>catenifer</u>)	A	A	A	A	A	P		U	U
Common King Snake (<u>Lampropeltis</u> <u>getulus</u>)	R	R	R	P	P				
Long-nosed Snake (<u>Rhinocheilus</u> <u>lecontei</u>)	R	R	R	H	H				
Western Ground Snake (<u>Sonora</u> <u>semiannulata</u>)	R	R	R		R				
Western Shovel-nosed Snake (<u>Chionactis</u> <u>occipitalis</u>)	C	R	R						
Sonora Lyre Snake (<u>Trimorphodon</u> <u>lambda</u>)			R	R					
Crotalidae									
Sidewinder (<u>Crotalus</u> <u>cerastes</u>)	C	C	A	A	A			P	R
Speckled Rattlesnake (<u>Crotalus</u> <u>mitchellii</u>)	C		C	R				P	P
Mohave Rattlesnake (<u>Crotalus</u> <u>scutulatus</u>)	U		U						
Gekkonidae									
Western Banded Gecko (<u>Coleonyx</u> <u>variegatus</u>)	U	R	R						
Iguanidae									
Desert Iguana (<u>Dipsosaurus</u> <u>dorsalis</u>)	C	U	C					R	

Appendix B-5. Continued

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Chuckwalla (*Sauromalus obseus*)	C		C	C				C	
Zebra-tailed Lizard (*Callisaurus draconoides*)	A	U	A	P	R				
Collared Lizard (*Crotaphytus collaris*)	U		C					P	P
Leopard Lizard (*Crotaphytus wislizeni*)	C	U	U					U	
Desert Spiny Lizard (*Sceloporus magister*)	C	R	R	R	C			P	
Long-tailed Brush Lizard (*Urosaurus graciosa*)	C	R	R	P					
Side-blotched Lizard (*Uta stansburiana*)	A	U	C	U	U			U	C
Desert Horned Lizard (*Phrynosoma platyrhinos*)	A	U	C	U	U				R
Xantusidae									
Yucca Night Lizard (*Xantusia vigilis*)	C		R		C				C
Teidae									
Western Whiptail (*Cnemidophorus tigris*)	A	C	C	C	R		R	R	
Helodermidae									
Gila Monster (*Heloderma suspectum*)	R		U	U				R	
Testudinidae									
Desert Tortoise (*Gopherus agassizi*)	C	R	C						C
Trionchidae									
Spiny Softshell (*Trionyx ferox*)						H	R		

APPENDIX B-6

NATURAL HISTORY OF REPTILES

Appendix B-6. Natural history information for reptiles - Las Vegas Wash Unit, Nevada (As a group reptiles hibernate in the winter.)

Species by Family	Seasonal Use	Segments of Habitat Most Dependent Upon	Primary Food Habits	Special Status	Remarks
Leptotyphlopidae					
Western Blind Snake (*Leptotyphlops humilis*)	Spring, summer, fall	Rocks, root tangles	Terrestrial, invertebrates		
Colubridae					
Spotted Leaf-nosed Snake (*Phyllorhynchus decurtatus*)	Spring, summer, fall	Loose sand, rocks	Vertebrates, poikilotherms		
Coachwhip (*Masticophis flagellum*)	Spring, summer, fall	Rocks, downed vegetation, shrubs	Terrestrial, invertebrates vertebrates, poikilotherms		
Western Patch-nosed Snake (*Salvadora hexalepis*)	Spring, summer, fall	Loose sand, rocks, shrubs	Vertebrates, homeotherms, poikilotherms		
Glossy Snake (*Arizona elegans*)	Spring, summer, fall	Loose sand, rocks, shrubs	Vertebrates, homeotherms, poikilotherms		
Gopher Snake (*Pituophis catenifer*)	Spring, summer, fall	Shrubs	Vertebrates, homeotherms		
Common King Snake (*Lampropeltis getulus*)	Spring, summer, fall	Shrubs	Vertebrates, poikilotherms		
Long-nosed Snake (*Rhinocheilus lecontei*)	Spring, summer, fall	Rocks, shrubs	Terrestrial, invertebrates, vertebrates, homeotherms, poikilotherms		
Western Ground Snake (*Sonora semiannulata*)	Spring, summer, fall	Loose sand, rocks	Terrestrial, invertebrates		
Western Shovel-nosed Snake (*Chionactis occipitalis*)	Spring, summer, fall	Loose sand, shrubs	Terrestrial, invertebrates		
Sonora Lyre Snake (*Trimorphodon lambda*)	Spring, summer, fall	Rocks	Vertebrates, homeotherms, poikilotherms		
Crotalidae					
Sidewinder (*Crotalus cerastes*)	Spring, summer, fall	Loose sand, shrubs	Vertebrates, homeotherms, poikilotherms		
Speckled Rattlesnake (*Crotalus mitchelli*)	Spring, summer, fall	Rocks	Vertebrates, homeotherms, poikilotherms		
Mojave Rattlesnake (*Crotalus scutulatus*)	Spring, summer, fall	Rocks, shrubs	Vertebrates, homeotherms, poikilotherms		
Gekkonidae					
Western Banded Gecko (*Coleonyx variegatus*)	Spring, summer, fall	Rocks, downed vegetation	Terrestrial, invertebrates		
Iguanidae					
Desert Iguana (*Dipsosaurus dorsalis*)	Spring, summer, fall	Loose sand, rocks shrubs	Terrestrial vegetation		

Appendix B-6. Continued

Species by Family	Seasonal Use	Segments of Habitat Most Dependent Upon	Primary Food Habits	Special Status	Remarks
Chuckawalls (<u>Sauromalus obseus</u>)	Spring, summer, fall	Rocks	Terrestrial, vegetation		
Zebra-tailed Lizard (<u>Callisaurus draconoides</u>)	Spring, summer, fall	Loose sand, gravel	Terrestrial and volant invertebrates		
Collared Lizard (<u>Crotaphytus collaris</u>)	Spring, summer, fall	Rocks	Terrestrial, invertebrates		
Leopard Lizard (<u>Crotaphytus wislizeni</u>)	Spring, summer, fall	Loose sand, gravel	Vertebrates, poikilotherms		
Desert Spiny Lizard (<u>Sceloporus magister</u>)	Spring, summer, fall	Rocks, shrubs	Terrestrial, invertebrates		
Long-tailed Brush Lizard (<u>Urosaurus graciosa</u>)	Spring, summer, fall	Shrubs	Terrestrial, invertebrates		
Side-blotched Lizard (<u>Uta stansburiana</u>)	Spring, summer, fall	Loose sand, rock	Arboreal, volant and terrestrial invertebrates		
Desert Horned Lizard (<u>Phrynosoma platyrhinos</u>)	Spring, summer, fall	Loose sand	Terrestrial invertebrates		
Xantusidae					
Yucca Night Lizard (<u>Xantusia vigilis</u>)	Spring, summer, fall	Downed vegetation	Volant and terrestrial invertebrates		
Teidae					
Western Whiptail (<u>Cnemidophorus tigris</u>)	Spring, summer, fall	Loose sand, gravel, rocks	Volant and terrestrial invertebrates		
Helodermidae					
Gila Monster (<u>Heloderma suspectum</u>)	Spring, summer, fall	Rocks	Vertebrates, homeotherms, poikilotherms	Classified as threatened by State Law	
Testudinidae					
Desert Tortoise (<u>Gopherus agassizi</u>)	Spring, summer, fall	Loose sand, gravel rocks	Terrestrial vegetation	Classified as threatened by State Law	
Trionchidae					
Spiny Softshell (<u>Trionyx ferox</u>)	Spring, summer, fall	Aquatic - littoral zone	Aquatic invertebrates, vertebrates - homeotherms		

APPENDIX B-7

SEASONAL USE, OCCURRENCE AND ABUNDANCE OF BIRDS

APPENDIX B-7. Seasonal use, occurrence and abundance of Birds, in the nine biotic communities of the Las Vegas Wash Unit, Colorado River Basin Salinity Control Act, Title II Study Area. Values expressed are: PR = permanent resident, WR = winter resident, SR = summer resident, T = transients, ACC = accidental, A = abundant, C = common, U = uncommon, R = rare, P = probable occurrence and H = hypothetical occurrence. Data from: Austin and Bradley (1971) and Austin (unpublished data).

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Gaviidae						ACC	WR-U		
Common Loon (*Gavia immer*)							WR-R		
Artic Loon (*Gavia arctica*)							WR-R		
Red-throated Loon (*Gavia stellata*)							WR-R		
Popicipedidae									
Red-necked Grebe (*Podiceps grisegena*)							ACC		
Horned Grebe (*Podiceps auritus*)							WR-R		
Earred Grebe (*Podiceps caspicus*)						P	WR-A		
Western Grebe (*Aechmophorus occidentalis*)						WR-U	WR-A		
Pied-billed Grebe (*Podilymbus podiceps*)						PR-U	WR-C		
Pelecanidae									
White Pelican (*Pelecanus erythrorhynchos*)						ACC	T-R		
Brown Pelican (*Pelecanus occidentalis*)							T-R		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Sulidae									
Blue-footed Booby (*Sula nebouxii*)						ACC	ACC		
Brown Booby (*Sula leucogaster*)							ACC		
Phalacrocoracidae									
Double-crested Cormorant (*Phalacrocorax auritus*)						WR-C	WR-C		
Ardeidae									
Great Blue Heron (*Ardea herodias*)						PR-C	PR-C		
Green Heron (*Butorides virescens*)						SR-U	SR-U		
Little Blue Heron (*Florida caerulea*)						ACC	ACC		
Great Egret (*Casmerodius albus*)						T-R	T-R		
Snowy Egret (*Leucophoyx thula*)						T-C	T-C		
Black-crowned Night Heron (*Nycticorax nycticorax*)						PR-U	PR-U		
American Bittern (*Sotaurus lentiginosus*)						T-U	T-U		
Ciconiidae									
Wood Stork (*Mycteria americana*)						ACC			
Threskiornithidae									
White-faced Ibis (*Plegadis chihi*)						T-U	T-U		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Anatidae									
Whistling Swan (Olor columbianus)						ACC	WR-R		
Canada Goose (Branta canadensis)						WR-U	WR-C		
Snow Goose (Chen hyperborea)						WR-R	WR-U		
Mallard (Anas platyrhynchos)						WR-C	WR-C		
Gadwell (Anas strepera)						WR-U	WR-C		
Pintail (Anas acuta)						WR-U	WR-C		
American Green-winged Teal (Anas crecca)						WR-C	WR-A		
Blue-winged Teal (Anas discors)						PR-R	T-U		
Cinnamon Teal (Anas cyanoptera)						SR-C	SR-C		
American Wigeon (Anas americana)						WR-U	WR-U		
Northern Shoveler (Anas clypeata)						WR-C	WR-C		
Wood Duck (Aix sponsa)						WR-R	WR-R		
Redhead (Aythya americana)						WR-U	WR-C		
Ring-necked Duck (Aythya collaris)						WR-U	WR-U		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Canvasback (*Aythya valisineris*)						WR-U	WR-U		
Greater Scaup (*Aythya marila*)						WR-R	WR-R		
Lesser Scaup (*Aythya affinis*)						WR-C	WR-C		
Common Goldeneye (*Bucephala clangula*)						WR-U	WR-U		
Bufflehead (*Bucephala albeola*)						WR-R	WR-U		
White-winged scoter (*Melanitta deglandi*)							ACC		
Ruddy Duck (*Oxyura jamaicensis*)						PR-A	PR-A		
Hooded Merganser (*Lophodytes cucullatus*)						T-R	T-R		
Common Merganser (*Mergus merganser*)						WR-U	WR-C		
Red-breasted Merganser (*Mergus serrator*)						WR-U	WR-C		
Carthartidae									
Turkey Vulture (*Cathartes aura*)	PR-C	PR-C	PR-C	PR-C	PR-C	PR-U		PR-U	
Accipitridae									
Goshawk (*Accipiter gentilis*)					T-R	T-R			
Sharp-shinned Hawk (*Accipiter straitus*)	T-R	T-R	T-R	T-R	T-R	T-U			T-U
Cooper's Hawk (*Accipiter cooperii*)	T-R	T-R	T-R	T-R	T-R	T-U			T-U

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Red-tailed Hawk (Buteo jamaicensis)	PR-C	PR-C	PR-C	PR-C	PR-C	PR-C		P	P
Swainson's Hawk (Buteo swainsoni)			T-U			T-R			
Zone-tailed Hawk (Buteo albonotatus)						ACC			
Rough-legged Hawk (Buteo lagopus)	WR-U		WR-U	P		WR-R			
Ferruginous Hawk (Buteo regalis)	WR-R	WR-R	WR-R	P					
Harris' Hawk (Parabuteo unicinctus)						ACC			
Golden Eagle (Aquila chrysaetos)	WR-U	WR-U	WR-U	P	P				
Marsh Hawk (Circus cyaneus)	PR-U	PR-U	PR-C	PR-C	PR-C	PR-C			
Pandionidae									
Osprey (Pandion haliaetus)						T-R	T-R		
Falconidae									
Prairie Falcon (Falco mexicanus)	WR-U	WR-U	PR-U	P		WR-R			WR-R
Peregrine Falcon (Falco peregrinus)	T-R			WR-R	T-R				
American Kestrel (Falco sparverius)	PR-C	PR-C	PR-C	PR-C	PR-C	PR-U			PR-U
Phasianidae									
Gambel's Quail (Lophortyx gambelii)	PR-C	PR-C	PR-A	PR-C	PR-C				

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Rallidae									
Virginia Rail (*Pallus limicola*)						PR-C			
Sora (*Porzana carolina*)						PR-C			
Common Galinule (*Gallinula chloropus*)						PR-C			
American Coot (*Fulica americana*)						PR-A	PR-C		
Charadriidae									
Semi-palmated Plover (*Charadrius semipalmatus*)						T-U	T-U		
Snowy Plover (*Charadrius alexandrinus*)						T-U	T-U		
Killdeer (*Charadrius vociferus*)					PR-C	PR-C	PR-C		PR-C
Mountain Plover (*Charadrius montanus*)					ACC	ACC	P		
American Golden Plover (*Pluvialis dominica*)							ACC		
Black-bellied Plover (*Pluvialis squatarola*)						T-U	T-U		
Scolopcidae									
Common Snipe (*Capalla gallinago*)						WR-C	WR-C		
Long-billed Curlew (*Numenius americanus*)						T-U	T-R		
Whimbrel (*Numenius phaeopus*)						T-R	T-R		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Upland Sandpiper (Bartramia longicauda)						ACC			
Spotted Sandpiper (Actitis macularia)						SR-C	T-C		
Solitary Sandpiper (Tringa solitaria)						T-U	T-U		
Willet (Catoptrophorus semipalmatus)						T-U	T-U		
Greater Yellowlegs (Tringa melanoleucus)						T-U	T-U		
Lesser Yellowlegs (Tringa flavipes)						T-U	T-U		
Red Knot (Calidris canutus)						T-R	T-R		
Pectoral Sandpiper (Calidris melanotos)						T-U	T-U		
Baird's Sandpiper (Calidris bairdii)					T-U	T-U	T-U		
Least Sandpiper (Calidris minutilla)					T-C	T-C	T-C		
Dunlin (Calidris alpina)					T-U	T-U	T-U		
Short-billed Dowitcher (Limnodromus griseus)					T-R	T-R	T-U		
Long-billed Dowitcher (Limnodromus scolopaceus)					T-C	T-C	T-C		
Stilt Sandpiper (Micropalama himantopus)							ACC		
Semi-palmated Sandpiper (Calidris pusillus)						T-R	T-R		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Western Sandpiper (*Calidris mauri*)					T-C	T-C	T-C		
Marbled Godwit (*Limosa fedoa*)						T-U	T-U		
Sanderling (*Calidris alba*)						ACC			
Recurvirostridae									
American Avocet (*Recurvirostra americana*)						T-C	T-C		
Black-necked Stilt (*Himantopus mexicanus*)						T-C	SR-R		
Phalaropodidae									
Red Phalarope (*Phalaropus fulicarius*)							ACC		
Wilson's Phalarope (*Steganopus tricolor*)							T-C		
Northern Phalarope (*Lobipes lobatus*)							T-C		
Stercorcriidae									
Parasitic Jaeger (*Stercorarius parasiticus*)							ACC		
Laridae									
Glaucous Gull (*Larus hyperboreus*)							ACC		
Glaucous-winged Gull (*Larus glaucescens*)							WR-R		
Herring Gull (*Larus argentatus*)					P	WR-U	WR-U		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Thayer's Gull (*Larus thayeri*)							WR-R		
California Gull (*Larus californicus*)					P	WR-C	WR-C		
Ring-billed Gull (*Larus delawarensis*)						WR-A	WR-A		
New Gull (*Larus canus*)							ACC		
Franklin's Gull (*Larus pipixcan*)							T U		
Bonapartes Gull (*Larus philadelphia*)						T-U	T U		
Sabine's Gull (*Xema sabini*)							ACC		
Forester's Tern (*Sterna forsteri*)						T-U	T-C		
Common Tern (*Sterna hirundo*)							T-U		
Least Tern (*Sterna albifrons*)							ACC		
Caspian Tern (*Hydroprogne caspia*)						P	T-U		
Black Tern (*Chidonias niger*)							T-C		
Alcidae									
Ancient Murrelet (*Synthliboramphus antiquus*)							ACC		
Columbidae									
White-winged Dove (*Zenaida asiatica*)	SR-U	SR-U	SR-U	P	P				

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Mourning Dove (Zenaidura macroura)	SR-A	SR-A	SR-A	P	SR-A	T-C			SR-C
Cuculidae									
Roadrunner (Geococcyx californianus)	PR-C	PR-C	PR-C	PR-U	PR-C				
Tytonidae									
Barn Owl (Tyto alba)	T-U	T-U	T-U	P					
Strigidae									
Great-horned Owl (Bubo virgininianus)	WR-U	WR-U	PR-C	PR-C	PR-C				
Burrowing Owl (Speotyto cunicularia)	PR-C	PR-C	PR-C	P				PR-U	
Short-earred Owl (Asio flammeus)		T-U	T-U	P		WR-R			
Caprimulgidae									
Common Nighthawk (Chordeiles minor)	T-U	T-U	T-C	T-C					T-C
Lesser Nighthawk (Chrodeiles acutipennis)	SR-C	SR-C	SR-C	P					SR-C
Apodidae									
Vaux's Swift (Chaetura vauxii)	T-U	T-U	T-U	T-U	T-U	T-U			
White-throated Swift (Aeronautes sexatalis)	SR-C	SR-C	PR-C	SR-C	PR-C	PR-C			
Trochilidae									
Black-chinned Hummingbird (Archilochus alexandri)			SR-C						

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Costa's Hummingbird (*Calypte costae*)	SR-C	SR-C	SR-C	SR-C					
Broad-tailed Hummingbird (*Selasphorus platycercus*)	T-C	T-C	T-C	P	P				T-C
Rufous Hummingbird (*Selasphorus rufus*)			T-C						
Alcedinidae									
Belted Kingfisher (*Megaceryle alcyon*)			T-C		T-C	PR-C			
Picidae									
Common Flicker (*Colaptes auratus*)	WR-C	WR-C	WR-C	P	WR-C				WR-C
Lewis Woodpecker (*Asyndesmus lewis*)			T-U						
Yellow-bellied Sapsucker (*Sphyrapicus varius*)			WR-C	WR-U	WR-C				WR-C
Ladder-backed Woodpecker (*Dendrocopos scalaris*)	PR-C	PR-U	WR-C	WR-U					WR-C
Tyrannidae									
Eastern Kingbird (*Tyrannus tyrannus*)			ACC		ACC				
Western Kingbird (*Tyrannus verticalis*)	SR-C	SR-C	SR-C	P	SR-C				SR-C
Cassin's Kingbird (*Tyrannus vociferans*)	TU		T-U	P	P				
Ash-throated Flycatcher (*Myiarchus cinerascens*)	SR-C	SR-C	SR-C						
Black Phoebe (*Sayornis nigricans*)	WR-U	WR-U	WR-U	P	WR-U	WR-U			

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Say's Phoebe (*Sayornis saya*)	PR-C	PR-C	PR-C	PR-C	PR-C				
Willow Flycatcher (*Empidonax traillii*)	T-C	T-C	SR-C						
Hammond's Flycatcher (*Empidonax hammondii*)		T-U	T-U		T-U				
Dusky Flycatcher (*Empidonax oberholseri*)	T-U	T-U	T-U	P	P				T-U
Gray Flycatcher (*Empidonax wrightii*)	T-C	T-C	T-C	P	P				T-C
Western Flycatcher (*Empidonax difficillis*)	T-C	T-C	T-C	T-C	T-C				T-C
Western Wood Peewee (*Contopus sordidulus*)	T-C	T-C	T-C	T-C	T-C	P			T-C
Olive-sided Flycatcher (*Nuttallornis borealis*)	T-C	T-C	T-C	T-C	T-C	T-C			T-C
Vermillion Flycatcher (*Pyrocephalus rubinus*)	WR-U	WR-U	PR-U	P	P				
Alaudidae									
Horned Lark (*Eremphila alpestris*)	PR-A	PR-A	PR-C					PR-C	
Hirundinidae									
Violet-green Swallow (*Tachycineta thalassina*)	T-C	T-C	T-C	T-C	T-C	T-A	T-C		
Tree Swallow (*Iridoprocne bicolor*)	T-C	T-C	T-C	T-C	T-C	T-C			
Bank Swallow (*Riparia riparia*)	T-I	T-U	T-U	T-U	T-U	T-U	T-U		
Rough-winged Swallow (*Stelgidopteryx ruficollis*)	T-C	T-C	T-C	T-C	T-C	T-A	T-C		

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Barn Swallow (*Hirundo rustica*)	T-C	T-C	T-C	T-C	T-C	T-C	T-C		
Cliff Swallow (*Petrochelidon pyrrhonota*)	T-C	T-C	T-C	T-A	T-C	T-C	T-C		
Purple Martin (*Progne subis*)			T-R						
Corvidae									
Scrub Jay (*Aphelocoma coerulescens*)						ACC			
Common Raven (*Corvus coras*)	WR-C	WR-C	PR-C	PR-C	PR-C			WR-C	
Common Crow (*Corvus brachyrhynchos*)	WR-U	WR-U	WR-U						
Pinion Jay (*Gymnorhinus cyanocephala*)						ACC			
Paridae									
Verdin (*Auriparus flaviceps*)	PR-C	PR-C	PR-A	PR-A	PR-C				
Bushtit (*Psaltriparus minimum*)	WR-C	WR-C	WR-C	WR-C	WR-C				WR-C
Sittidae									
White-breasted Nuthatch (*Sitta carolinensis*)			T-R	T-R	T-R				T-R
Red-breasted Nuthatch (*Sitta canadensis*)			T-R	T-R	T-R				T-R
Corthiidae									
Brown Creeper (*Certhia familiaris*)			T-R	T-R	T-R				

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Troylodytidae									
House Wren (Troglodytes aedon)	T-C	T-C	WR-C	WR-C	WR-C				
Winter Wren (Troglodytes troglodytes)			WR-R	WR-R	WR-R				
Bewick's Wren (Thryomanes bewickii)	PR-C	PR-C	PR-C	P	P				
Cactus Wren (Campylorhynchus brunneicapillum)	WR-U	WR-U	WR-U						
Long-billed Marsh Wren (Telematodytes palustris)						PR-A			
Rock Wren (Salpinctes obsoletus)	PR-C	PR-C	PR-C	PR-A					
Mimidae									
Mockingbird (Mimus polyglottos)	PR-C	PR-C	PR-C	PR-C	PR-C				PR A
Leconte's Thrasher (Toxostoma lecontei)	WR-U	WR-U	PR-U	PR-U	P				
Crissal Thrasher (Toxostoma dorsale)	PR-C	PR-C	PR-C	PR-C					
Sage Thrasher (Oreoscoptes montanus)	WR-C	WR-C	T-C	T-C	T-C				
Turdidae									
American Robin (Turdus migratorius)	WR-C	WR-C	WR-C	WR-C	WR-C				WR-C
Hermit Thrush (Catharus guttatus)			T-U	T-U					
Swainson's Thrush (Catharus ustulata			T-U						WR-C

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Western Bluebird (<u>Sialia</u> <u>mexicana</u>)	WR-C	WR-C	WR-C	WR-C	WR-C				
Mountain Bluebird (<u>Sialia</u> <u>currucoides</u>)	WR-C	WR-C	WR-C	WR-C	WR-C				WR C
Townsend's Solitaire (<u>Myadestes</u> <u>townsendi</u>)			WR-U	WR-U					
Sylviidae									
Blue-gray Gnatcatcher (<u>Polioptila</u> <u>caerulea</u>)	WR-R	WR-R	WR-R	P	P				P
Black-tailed Gnatcatcher (<u>Polioptila</u> <u>melanura</u>)			PR-C	PR-C					
Golden-crowned Kinglet (<u>Regulus</u> <u>satrapa</u>)			T-R	T-R	T-R				WR-C
Ruby-crowned Kinglet (<u>Regulus</u> <u>calendula</u>)	WR-C	WR-C	WR-C	WR-C	WR-A				
Motacillidae									
Water Pipet (<u>Anthus</u> <u>spinoletta</u>)					WR-A	WR-A			WR-C
Bombycillidae									
Bohemian Waxwing (<u>Bombycilla</u> <u>garrula</u>)			ACC		ACC				WR C
Cedar Waxwing (<u>Bombycilla</u> <u>cedrorum</u>)			WR-C		WR-C				WR-C
Ptilogonatidae									
Phainopepla (<u>Phainopepla</u> <u>nitens</u>)	PR-C	PR-C	PR-A	P	P				
Laniidae									
Northern Shrike (<u>Lanius</u> <u>excubitor</u>)			ACC	T-U	T-U				

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Loggerhead Shrike (*Lanius ludovicianus*)	PR-C	PR-C	PR-C	PR-C	PR-C	PR-C			
Sturnidae									
Starling (*Sturnus vulgaris*)			PR-C	PR-C	PR-A	PR-C			PR-C
Vireonidae									
Bell's Vireo (*Vireo bellii*)			SR-R	SR-R	P				
Solitary Vireo (*Vireo solitarius*)	T-C	T-C	T-C	T-C	T-C				T-C
Red-eyed Vireo (*Vireo olivaceus*)			T-R		T-R				T-U
Warbling Vireo (*Vireo gilvus*)			T-C	T-C	T-C				T-C
Parulidae									
Orange-crowned Warbler (*Vermivora celata*)	T-C	T-C	T-C	T-C	T-C	T-C			T-C
Nashville Warbler (*Vermivora ruficapilla*)			T-C	T-C	P				P
Virginia Warbler (*Vermivora virginiae*)			T-C	T-C	T-C				P
Lucy's Warbler (*Vermivora luciae*)	SR-C	SR-C	SR-C	P	P				
Yellow Warbler (*Dendroica petechia*)	T-C	T-C	SR-R	P	P				T-C
Magnolia Warbler (*Dendroica magnolia*)						ACC			
Yellow-rumped Warbler (*Dendroica coronata*	T-U	T-U	T-U	T-U	T-U				T-U

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Black-throated Gray Warbler (<u>Dendroica</u> <u>nigrescens</u>)			T-C	T-C	P				
Townsend's Warbler (<u>Dendroica</u> <u>townsendi</u>)	T-C	T-C	T-C	T-C	T-C				T-C
MacGillivray's Warbler (<u>Oporonis</u> <u>tolmiei</u>)			T-C	T-C					T-C
Common Yellowthroat (<u>Geothlypis</u> <u>trichas</u>)					SR-C	SR-A			
Yellow-breasted Chat (<u>Icteria</u> <u>virens</u>)					SR-C	SR-C			
Wilson's Warbler (<u>Wilsonia</u> <u>pusilla</u>)	T-C	T-C	T-C	T-C	T-C	T-C			T-C
American Redstart (<u>Setophaga</u> <u>ruticilla</u>)			T-R						
Ploceidae									
House Sparrow (<u>Passer</u> <u>domesticus</u>)			PR-C	PR-C					PR-A
Icteridae									
Western Meadowlark (<u>Sturnella</u> <u>neglecta</u>)	T-C	T-C	PR-C	PR-C	PR-C				
Yellow-headed Blackbird (<u>Xanthocephalus</u> <u>xanthocephalus</u>)					SR-C	SR-A			
Red-winged Blackbird (<u>Agelaius</u> <u>phoeniceus</u>)			PR-C		PR-C	PR-A			PR-C
Hooded Oriole (<u>Icterus</u> <u>cucullatus</u>)			SR-U						
Scott's Oriole (<u>Icterus</u> <u>parisorum</u>)			SR-C	SR-C					SR-C
Northern Oriole (<u>Icterus</u> <u>galbula</u>)			SR-C	SR-C					SR-C

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Brewer's Blackbird (<u>Euphagus cyanocephalus</u>)			WR-C	WR-U	WR-C				WR-A
Great-tailed Grackle (<u>Cassidix mexicanus</u>)						PR-U			
Brown-headed Cowbird (<u>Molothrus ater</u>)	PR-C	PR-C	PR-C	P	PR-C	PR-C			PR-C
Thraupidae									
Western Tanager (<u>Piranga ludoviciana</u>)			T-C	T-C	T-C				T-U
Summer Tanager (<u>Piranga rubra</u>)			T-R	T-R					
Fringillidae									
Black-headed Grosbeak (<u>Pheucticus melanocephalus</u>)			T-C	T-C	T-C				T-U
Blue Grosbeak (<u>Guiraca caerulea</u>)			SR-C	SR-C					
Lazuli Bunting (<u>Passerina amoena</u>)			T-C	T-C	T-C				T-C
Indigo Bunting (<u>Passerina cyanea</u>)			T-U	T-U					
House Finch (<u>Carpodacus mexicanus</u>)	PR-C	PR-C	PR-C	PR-C	PR-C				PR-A
Pine Siskin (<u>Spinus pinus</u>)	WR-U	WR-U	WR-C	WR-C	WR-C				
American Goldfinch (<u>Spinus tristis</u>)			WR-C	P	P				
Lesser Goldfinch (<u>Spinus psaltria</u>)			PR-C	PR-C	PR-C				PR-C
Green-tailed Towhee (<u>Chlorura chlorura</u>)	T-C	T-C	T-C	P	T-C				

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Ryfow-sided Towhee (Pipilo erythrophthalmus)	WR-C	WR-C	WR-C	WR-C	WR-C				WR-C
Abert's Towhee (Pipilo aberti)	PR-C	PR-C	PR-A	PR-C	PR-A				
Savannah Sparrow (Passerculus sandwichensis)	T-C	T-C	WR-C	WR-U	WR-C				
Vosper Sparrow (Pooecetes gramineus)	T-U	T-U	T-U	P	P				P
Lark Sparrow (Chondestes grammacus	T-C	T-C	T-C	T-C	T-C				T-C
Black-throated Sparrow (Amphispiza bilineata)	WR-C	WR-C	WR-C	P	P				
Sage Sparrow (Amphispiza belli)	WR-C	WR-C	WR-C						
Dark-eyed Junco (Junco hyemalis)			WR-C	P	P				WR-C
Gray-headed Junco (Junco caniceps)			WR-C	P	P				WR-C
Tree Sparrow (Spizella arborea)			T-U	T-U	T-U				T-C
Chipping Sparrow (Spizella passerina)	T-C	T-C	WR-C	WR-C	WR-C				WR-C
Brewer's Sparrow (Spizella breweri)	T-C	T-C	WR-C	WR-C	WR-C				WR-C
Harris Sparrow (Zonotrichia querula)	WR-R	WR-R	WR-R						T-R
White-crowned Sparrow (Zonotrichia leucophrys)	WR-C	WR-C	WR-A	WR-C	WR-A				WR-C
Golden-crowned Sparrow (Zonotrichia atricapilla)	T-R	T-R	T-R						T-U

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
White-throated Sparrow (*Zonotrichia albicollis*)			WR-R	WR-R	WR-R				
Fox Sparrow (*Passerella iliaca*)	T-R	T-R	T-R			T-R			
Lincoln's Sparrow (*Melospiza lincolnii*)	T-C	T-C	WR						
Song Sparrow (*Melospiza melodia*)					PR-C	PR-C			

APPENDIX B-8

NATURAL HISTORY FOR BIRDS

APPENDIX B-8. General natural history data for birds in the Las Vegas Wash Unit, Colorado River Basin Salinity Control Act, Title II Study Area. Data taken from: Bent (1953); Austin and Bradley (1971). NA = not applicable.

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Gaviidae				
Common Loon (Gavia immer)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Arctic Loon (Gavia arctica)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Red-throated Loon (Gavia stellata)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Popicipedidae				
Red-necked Grebe (Podiceps grisegena)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Horned Grebe (Podiceps auritus)	Feeding, watering, resting	Vertebrates, poikilotherms, invertebrates, aquatic	NA	
Earred Grebe (Podiceps caspicus)	Feeding, watering, resting	Vertebrates, poikilotherms, invertebrates, aquatic	NA	
Western Grebe (Aechmophorus occidentalis)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Pied-billed Grebe (Podilymbus podiceps)	Breeding	Vertebrates, poikilotherms	Ground-marsh	
Pelecanidae				
White Pelican (Pelecanus erythrorhynchos)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	Protected by State Law
Brown Pelican (Pelecanus occidentalis)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	Protected by State Law
Sulidae				
Blue-footed Booby (Sula nebouxii)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	Very unusual occurrence
Brown Booby (Sula leucogaster)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	Very unusual occurrence

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Ardeidae				
Great Blue Heron (Ardea herodias)	Breeding	Vertebrates, poikilotherms	Tree	
Green Heron (Butorides virescens)	Breeding	Vertebrates, poikilotherms	Tree	
Little Blue Heron (Florida caerulea)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Great Egret (Casmerodius albus)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Snowy Egret (Leucophoyx thula)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Black-crowned Night Heron (Nycticorax nycticorax)	Breeding	Vertebrates, poikilotherms	Tree	
American Bittern (Botaurus lentiginosus)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Ciconiidae				
Wood Stork (Mycteria americana)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Threskiornithidae				
White-faced Ibis (Plegadis chihi)	Feeding, watering, resting	Invertebrate aquatic	NA	Protected by State Law
Anatidae				All members of the Anatidae are protected by State Game Laws
Whistling Swan (Olor columbianus)	Feeding, watering, resting	Vegetation, aquatic, terrestrial	NA	
Canada Goose (Branta canadensis)	Breeding	Vegetation, aquatic terrestrial	Ground-marsh	
Snow Goose (Chen hyperborea)	Breeding	Vegetation, aquatic, terrestrial	Ground-Marsh	
Mallard (Anas platyrhynchos)	Feeding, watering, resting	Vegetation, aquatic, terrestrial	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Cadwell (Anas strepera)	Feeding, watering, resting	Vegetation, aquatic terrestrial	NA	
Pintail (Anas acuta)	Feeding, watering, resting	Vegetation, aquatic terrestrial	NA	
American Green-winged Teal (Anas carolinensis)	Feeding, watering, resting	Vegetation, aquatic terrestrial	NA	
Blue-winged Teal (Anas discors)	Feeding, watering, resting	Vegetation, aquatic, terrestrial	NA	
Cinnamon Teal (Anas cyanoptera)	Breeding	Vegetation, aquatic, terrestrial	Ground-marsh	
American Wigeon (Anas americana)	Feeding, watering, resting	Vegetation, aquatic	NA	
Northern Shoveler (Anas clypeata)	Feeding, watering, resting	Aquatic invertebrates	NA	
Wood Duck (Aix sponsa)	Feeding, watering, resting	Aquatic invertebrates	NA	
Redhead (Aythya americana)	Feeding, watering, resting	Aquatic invertebrates	NA	
Ring-necked Duck (Aythya collaris)	Feeding, watering, resting	Aquatic invertebrates	NA	
Canvasback (Aythya valisineria)	Feeding, watering, resting	Aquatic invertebrates	NA	
Greater Scaup (Aythya marila)	Feeding, watering, resting	Aquatic invertebrates	NA	
Lesser Scaup (Aythya affinis)	Feeding, watering, resting	Aquatic invertebrates	NA	
Common Goldeneye (Bucephala clangula)	Feeding, watering, resting	Aquatic invertebrates	NA	
Bufflehead (Bucephala albeola)	Feeding, watering, resting	Aquatic invertebrates	NA	
White-winged scoter (Melanitta deglandi)	Feeding, watering, resting	Aquatic invertebrates	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Ruddy Duck (Oxyura jamaicensis)	Breeding	Aquatic invertebrates	Ground-marsh	
Hooded Merganser (Lophodytes cucullatus)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Common Merganser (Mergus merganser)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Red-breasted Merganser (Mergus serrator)	Feeding, watering resting	Vertebrates, poikilotherms	NA	
Carthartidae				
Turkey Vulture (Cathartes aura)	Feeding, watering, resting	Carrion	NA	Protected by State and Federal Law
Accipitridae				All members of the family Accipitridae are protected by State and Federal Law
Goshawk (Accipiter gentilis)	Feeding, watering, resting	Homeothorm	NA	
Sharp-shinned Hawk (Accipiater straitus)	Feeding, watering, resting	Homeothorm	NA	
Cooper's Hawk (Accipiter cooperii)	Feeding, watering, resting	Homeothorm	NA	
Red-tailed Hawk (Buteo jamaicensis)	Breeding	Homeothorm	Tree	
Swainson's Hawk (Buteo swainsoni)	Feeding, watering, resting	Homeothorm		
Zone-tailed Hawk (Buteo albonotatus)	Feeding, watering, resting	Homeothorm		
Rough-legged Hawk (Buteo lagopus)	Feeding, watering, resting	Vertebrates, homeothorm	NA	
Ferruginous Hawk (Buteo regalis)	Feeding, watering, resting	Vertebrates, homeothorm	NA	
Harris' Hawk (Parabuteo unicinctus)	Feeding, watering, resting	Vertebrates, homeothorm	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Golden Eagle (Aquila chrysaetos)	Feeding, watoring, resting	Vertebrates, homeothorm	NA	
Marsh Hawk (Circus cyaneus)	Breeding	Vertebrates, homeothorms	Ground	
Panionidae				
Osprey (Pandion haliaetus)	Feeding, watering, resting	Vertebrates, homeothorms	NA	Protected by State and Federal Law
Falconidae				
Prairie Falcon (Falco mexicanus)	Feeding, watering, resting	Vertobrates, homeotherms	NA	Protected by State and Fodoral Law
Poregrine Falcon (Falco peregrinus)	Feeding, watering, resting	Vertobrates, homeothorms	Cavity	Listed on the State and Federal throatoned and endangered list
American Kestrel (Falco sparverius)	Feeding, watering, resting	Terrestrial invortebrates	NA	Protected by State and Federal Law
Phasianidae				
Gambel's Quail (Lophortyx gambelii)	Breeding	Vegetation - seeds	Ground	Protected by State Game law
Rallidae				
Virginia Rail (Rallus limicola)	Breeding	Invertebrates, aquatic	Marsh	
Sora (Porzana carolina)	Breeding	Invertobrates, aquatic	Marsh	
Common Galinule (Gallinula chloropus)	Breeding	Invertebrates, aquatic	Marsh	
American Coot (Fulica americana)	Breeding	Invertebrates, aquatic	Marsh	Protected by State Game Laws
Charadriidae				
Semi-palmated Plover (Charadrius semipalmatus)	Feeding, watoring, resting	Invertebrates, aquatic	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Snowy Plover (*Charadrius alexandrinus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Killdeer (*Charadrius vociferus*)	Breeding	Invertebrates, aquatic	Ground	
Mountain Plover (*Charadrius montanus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
American Golden Plover (*Pluvialis dominica*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Black-bellied Plover (*Pluvialis squatarola*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Scolopacidae				
Common Snipe (*Capella gallinago*)	Feeding, watering, resting	Invertebrates, aquatic	NA	Protected by State Game Laws
Long-billed Curlew (*Numenius americanus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Whimbrel (*Numenius phaeopus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Upland Plover (*Bartramia longicauda*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Spotted Sandpiper (*Actitis maculeria*)	Breeding	Invertebrates, aquatic	Ground	
Solitary Sandpiper (*Tringa solitaria*)	Breeding	Invertebrates, aquatic	Ground	
Willet (*Catoptrophorus semipalmatus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Greater Yellowlegs (*Tringa melanoleucus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Lesser Yellowlegs (*Tringa flavipes*)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Red Knot (*Calidris canutus*)	Feeding, watering, resting	Invertebrates, aquatic	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Pectoral Sandpiper (Calidris melanotos)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Baird's Sandpiper (Calidris bairdii)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Least Sandpiper (Calidris minutilla)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Dunlin (Calidris alpina)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Short-billed Dowitcher (Limnodromus griseus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Long-billed Dowitcher (Limnodromus scolopaceus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Stilt Sandpiper (Micropalama himantopus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Semi-palmated Sandpiper (Calidris pusillus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Western Sandpiper (Calidris mauri)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Marbled Godwit (Limosa fedoa)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Sanderling (Calidris alba)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Recurvirostridae				
American Avocet (Recurvirostra americana)	Breeding	Invertebrates, aquatic	Ground	
Black-necked Stilt (Himantopus mexicanus)	Feeding, watering, resting, breeding	Invertebrates, aquatic	NA	
Phalaropodidae				
Red Phalarope (Phalaropus fulicarius)	Feeding, watering, resting	Invertebrates, aquatic	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Wilson's Phalarope (Steganopus tricolor)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Northern Phalarope (Lobipes lobatus)	Feeding, watering, resting	Invertebrates, aquatic		
Stercorcriidae				
Parasitic Jaeger (Stercorarius parasiticus)	Feeding, watering, resting	Invertebrates, aquatic		
Laridae				
Glaucous Gull (Larus hyperboreus)	Feeding, watering, resting	Invertebrates, aquatic		
Glaucous-winged Gull (Larus glaucescens)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Herring Gull (Larus argentatus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Thayer's Gull (Larus thayeri)	Feeding, watering, resting	Invertebrates, aquatic	NA	
California Gull (Larus californicus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Ring-billed Gull (Larus delawarensis)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Mew Gull (Larus canus)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Franklin's Gull (Larus pipixcan)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Bonapartes Gull (Larus philadelphia)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Sabine's Gull (Xema sabini)	Feeding, watering, resting	Invertebrates, aquatic	NA	
Forester's Tern (Sterna forsteri)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Common Tern (*Sterna hirundo*)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Least Tern (*Sterna albifrons*)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Caspian Tern (*Hydroprogne caspia*)	Feeding, water, resting	Vertebrates, poikilotherms	NA	
Black Tern (*Chidonias niger*)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Alcidae				
Ancient Murrelt (*Synthliboramphus antiquus*)	Feeding, watering, resting	Vertebrates, poikilotherms	NA	
Columbidae				
White-winged Dove (*Zenaida asiatica*)	Breeding	Vegetation, seeds	Tree	Protected by State Game Laws
Mourning Dove (*Zenaidura macroura*)	Breeding	Vegetation, seeds	Tree	Protected by State Game Laws
Cuculidae				
Roadrunner (*Geococcyx californianus*)	Breeding	Invertebrates, terrestrial	Tree	Protected by State Law
Tytonidae				
Barn Owl (*Tyto alba*)	Feeding, watering, resting	Vertebrates, homeotherms	NA	Protected by State Law
Strigidae				
Great-horned Owl (*Bubo virgininianus*)	Breeding	Vertebrates, homeotherms	Tree	All members of the family Strigidae are protected by State Law
Burrowing Owl (*Speotyto cunicularia*)	Breeding	Invertebrates, terrestrial	Ground, Rodent hole	
Short-earred Owl (*Asio flammeus*)	Feeding, watering, resting	Vertebrates, homeotherms	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Caprimulgidae				
Common Nighthawk (*Chordeiles minor*)	Breeding	Invertebrates - volant	Ground	Protected by State Law
Lesser Nighthawk (*Chrodeiles acutipennis*)	Breeding	Invertebrates - volant	Ground	Protected by State Law
Apodidae				
Vaux's Swift (*Chaetura vauxii*)	Feeding, watering, resting	Invertebrates - volant	NA	
White-throated Swift (*Aeronautes sexatalis*)	Breeding	Invertebrates - volant	Cliff	
Trochilidae				
Black-chinned Hummingbird (*Archilochus alexandri*)	Breeding	Nectar	Tree	
Costa's Hummingbird (*Calypte costae*)	Breeding	Nectar	Tree	
Broad-tailed Hummingbird (*Selasphorus platycercus*)	Breeding	Nectar	Tree	
Rufous Hummingbird (*Selasphorus rufus*)	Feeding, watering, resting	Nectar	NA	
Alcedinidae				
Belted Kingfisher (*Megaceryle alcyon*)	Breeding	Vertebrate, poikilotherm	Tree	Protected by State Law
Picidae				
Common Flicker (*Colaptes auratus*)	Feeding, watering, resting	Invertebrate, arboreal	NA	
Lewis Woodpecker (*Asyndesmus lewis*)	Feeding, watering, resting	Inverterbrates, arboreal	NA	
Yellow-bellied Sapsucker (*Sphyrapicus varius*)	Feeding, wetering, resting	Invertebrates, arboreal	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Ladder-backed Woodpecker (Dendrocopos scalaris)	Breeding	Invertebrates, arboreal	Cavity	
Tyrannidae				
Eastern Kingbird (Tyrannus tyrannus)	Feeding, watering, resting	Invertebrates, volant	NA	
Western Kingbird (Tyrannus verticalis)	Breeding	Invertebrates, volant	Tree	
Cassin's Kingbird (Tyrannus vociferans)	Feeding, watering, resting	Invertebrates, volant	NA	
Ash-throated Flycathcer (Myiarchus cinerascens)	Breeding	Invertebrates, volant	Cavity	
Black Phoebe (Sayornis nigricans)	Feeding, watering, resting	Invertebrates, volant	NA	
Say's Phoebe (Sayornis saya)	Breeding	Invertebrates, volant	Buildings, cliffs	
Willow Flycatcher (Empidonax traillii)	Feeding, watering, resting	Invertebrates, volant	NA	
Hammond's Flycatcher (Empidonax hammondii)	Feeding, watering, resting	Invertebrates, volant	NA	
Dusky Flycatcher (Empidonax oberholseri)	Feeding, watering, resting	Invertebrates, volant	NA	
Gray Flycatcher (Empidonax wrightii)	Feeding, watering, resting	Invertebrates, volant	NA	
Western Flycatcher (Empidonax difficilis)	Feeding, watering, resting	Invertebrates, volant	NA	
Western Wood Peewee (Contopus sordidulus)	Feeding, watering, resting	Invertebrates, volant	NA	
Olive-sided Flycatcher (Nuttallornis borealis)	Feeding, watering, resting	Invertebrates, volant	NA	
Vermilion Flycatcher (Pyrocephalus rubinus)	Breeding	Invertebrates, volant	Tree	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Alaudidae				
Horned Lark (Eremphila alpestris)	Breeding	Invertebrates, terrestrial	Ground	
Hirundinidae				
Violet-green Swallow (Tachycineta thalassina)	Feeding, watering, resting	Invertebrates, volant	NA	
Tree Swallow (Iridoprocne bicolor)	Feeding, watering, resting	Invertebrates, volant	NA	
Bank Swallow (Riparia riparia)	Breeding	Invertebrates, volant	Cavity	
Rough-winged Swallow (Stelgidopteryx ruficollis)	Feeding, watering, resting	Invertebrates, volant	NA	
Barn Swallow (Hirundo rustica)	Feeding, watering, resting	Invertebrates, volant	NA	
Cliff Swallow (Petrochelidon pyrrhonota)	Breeding	Invertebrates, volant	Cliff	
Purple Martin (Progne subis)	Feeding, watering, resting	Invertebrates, volant	NA	
Corvidae				
Scrub Jay (Aphelocoma coerulescens)	Feeding, watering, resting	Invertebrates, terrestrial arboreal	NA	
Common Raven (Corvus corax)	Breeding	Carrion	Cliff	
Common Crow (Corvus brachyrhynchos)	Feeding, watering, resting	Carrion	NA	
Pinion Jay (Gymnorhinus cyanocephala)	Feeding, watering, resting	Invertebrates, terrestrial arboreal	NA	
Paridae				
Verdin (Auriparus flaviceps)	Breeding	Invertebrates, arboreal	Tree	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Bushtit (Psaltriparus minimus)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Sittidae				
White-breasted Nuthatch (Sitta carolinensis)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Red-breasted Nuthatch (Sitta canadensis)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Certhiidae				
Brown Creeper (Certhia familiaris)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Troylodytidae				
House Wren (Troglodytes aedon)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Winter Wren (Troglodytes troglodytes)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Bewick's Wren (Thryomanes bewickii)	Breeding	Invertebrates, arboreal	Cavity	
Cactus Wren (Campylorhynchus brunneicapillum)	Breeding	Invertebrates, arboreal	Tree	
Long-billed Marsh Wren (Telematodytes palustris)	Breeding	Invertebrates, arboreal	Marsh	
Rock Wren (Salpinctes obsoletus)	Breeding	Invertebrates, arboreal	Ground	
Mimidae				
Mockingbird (Mimus polyglottos)	Breeding	Invertebrates, arboreal	Tree	
Leconte's Thrasher (Toxostoma lecontei)	Breeding	Invertebrates, terrestrial	Tree	
Crissal Thrasher (Toxostoma dorsale)	Breeding	Invertebrates, terrestrial	Tree	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Sage Thrasher (*Oreoscoptes montanus*)	Feeding, watering, resting	Invertebrates, terrestrial	NA	
Turdidae				
American Robin (*Turdus migratorius*)	Feeding, watering, resting	Invertebrates, terrestrial	NA	
Hermit Thrush (*Catharus guttatus*)	Feeding, watering, resting	Invertebrates, terrestrial	NA	
Swainson's Thrush (*Catharus ustulata*)	Feeding, watering, resting	Invertebrates, terrestrial	NA	
Western Bluebird (*Sialia mexicana*)	Feeding, watering, resting	Fruit	NA	
Mountain Bluebird (*Sialia currucoides*)	Feeding, watering, resting	Fruit	NA	Nevada State Bird
Townsend's Solitaire (*Myadestes townsendi*)	Feeding, watering, resting	Fruit	NA	
Sylviidae				
Blue-gray Gnatcatcher (*Polioptila caerulea*)	Breeding	Invertebrates, arboreal	Tree	
Black-tailed Gnatcatcher (*Polioptila melanura*)	Breeding	Invertebrates, arboreal	Tree	
Golden-crowned Kinglet (*Regulus satrapa*)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Ruby-crowned Kinglet (*Regulus calendula*)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Motacillidae				
Water Pipet (*Anthus spinoletta*)	Feeding, watering, resting	Invertebrates, terrestrial	NA	
Bombycillidae				
Bohemian Waxwing (*Bombycilla garrula*)	Feeding, watering, resting	Fruit	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Cedar Waxwing (Bombycilla cedrorum)	Feeding, watering, resting	Fruit	NA	
Ptilogonatidae				
Phainopepla (Phainopepla nitens)	Breeding	Fruit	Tree	
Laniidae				
Northern Shrike (Lanius excubitor)	Feeding, watering, resting	Invertebrates, terrestrial vertebrates, poikilotherms	NA	
Loggerhead Shrike (Lanius ludovicianus)	Breeding	Invertebrates, terrestrial vertebrates, poikilotherms	Tree	
Sturnidae				
Starling (Sturnus vulgaris)	Breeding	Vegetation, seeds	Cavity	
Vireonidae				
Bell's Vireo (Vireo bellii)	Breeding	Invertebrates, arboreal	Tree	
Solitary Vireo (Vireo solitarius)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Red-eyed Vireo (Vireo olivaceus)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Warbling Vireo (Vireo gilvus)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Parulidae				
Orange-crowned Warbler (Vermivora celata)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Nashville Warbler (Vermivora ruficapilla)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Virginia Warbler (Vermivora virginiae)	Feeding, watering, resting	Invertebrates, arboreal	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Lucy's Warbler (Vermivora luciae)	Breeding	Invertebrates, arboreal	Cavity	
Yellow Warbler (Dendroica petechia)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Magnolia Warbler (Dendroica magnolia)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Yellow-rumped Warbler (Dendroica coronata)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Black-throated Gray Warbler (Dendroica nigrescens)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Townsend's Warbler (Dendroica townsendi)	Feeding, watering, resting	Invertebrates, arboreal	NA	
MacGillivray's Warbler (Oporonis tolmiei)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Common Yellowthroat (Geothlypis trichas)	Breeding	Invertebrates, arboreal	Marsh	
Yellow-breasted Chat (Icteria virens)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Wilson's Warbler (Wilsonia pusilla)	Feeding, watering, resting	Invertebates, arboreal	NA	
American Redstart (Setophaga ruticilla)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Ploceidae				
House Sparrow (Passer domesticus)	Breeding	Vegetation, seeds	Tree	
Icteridae				
Western Meadowlark (Sturnella neglecta)	Breeding	Invertebrates, terrestrial	Ground	
Yellow-headed Blackbird (Xanthocephalus xanthocephalus)	Breeding	Invertebrates, terrestrial aquatic	Marsh	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Red-winged Blackbird (Agelaius phoeniceus)	Breeding	Invertebrates, terrestrial aquatic	Marsh	
Hooded Oriole (Icterus cucullatus)	Breeding	Invertebrates, terrestrial	Tree	
Scott's Oriole (Icterus parisorum)	Breeding	Invertebrates, terrestrial	Tree	
Northern Oriole (Icterus galbula)	Breeding	Invertebrates, terrestrial	Tree	
Brewer's Blackbird (Euphagus cyanocephalus)	Feeding, watering, resting	Invertebrates, terrestrial		
Great-tailed Grackle (Cassidix mexicanus)	Breeding	Invertebrates, terrestrial aquatic	Marsh	
Brown-headed Cowbird (Molothrus ater)	Breeding	Invertebrates, arboreal	Tree	
Thraupidae				
Western Tanager (Piranga ludoviciana)	Feeding, watering, resting	Invertebrates, arboreal	NA	
Summer Tanager (Piranga rubra)	Breeding	Invertebrates, arboreal	Tree	
Fringillidae				
Black-headed Grosbeak (Pheucticus melanocephalus)	Feeding, watering, resting	Vegetation, seeds	NA	
Blue Grosbeak (Guiraca caerulea)	Breeding	Vegetation, seeds	Tree	
Lazuli Bunting (Passerina amoena)	Feeding, watering, resting	Vegetation, seeds	NA	
Indigo Bunting (Passerina cyanea)	Feeding, watering, resting	Vegetation, seeds	NA	
House Finch (Carpodacus mexicanus)	Breeding	Vegetation, seeds	Tree shrub	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Pine Siskin (Spinus pinus)	Feeding, watering, resting	Vegetation, seeds	NA	
American Goldfinch (Spinus tristis)	Feeding, watering, resting	Vegetation, seeds	NA	
Lesser Goldfinch (Spinus psaltria)	Breeding	Vegetation, seeds	Tree	
Green-tailed Towhee (Chlorura chlorura)	Feeding, watering, resting	Vegetation, seeds	NA	
Rufous-sided Towhee (Pipilo erythrophthalmus)	Feeding, watering, resting	Vegetation, seeds	NA	
Abert's Towhee (Pipilo aberti)	Breeding	Vegetation, seeds	Tree	
Savannah Sparrow (Passerculus sandwichensis)	Feeding, watering, resting	Vegetation, seeds	NA	
Vesper Sparrow (Pooecetes gramineus)	Feeding, watering, resting	Vegetation, seeds	NA	
Lark Sparrow (Chondestes grammacus)	Feeding, watering, resting	Vegetation, seeds	NA	
Black-throated Sparrow (Amphispiza bilineata)	Breeding	Vegetation, seeds	Shrub	
Sage Sparrow (Amphispiza belli)	Feeding, watering, resting	Vegetation, seeds	NA	
Dark-eyed Junco (Junco hyemalis)	Feeding, watering, resting	Vegetation, seeds	NA	
Gray-headed Junco (Junco caniceps)	Feeding, watering, resting	Vegetation, seeds	NA	
Tree Sparrow (Spizella arborea)	Feeding, watering, resting	Vegetation, seeds	NA	
Chipping Sparrow (Spizella passerina)	Feeding, watering, resting	Vegetation, seeds	NA	
Brewer's Sparrow (Spizella breweri)	Feeding, watering, resting	Vegetation, seeds	NA	

Species by Family	Primary Use of Habitat	Primary Food Habits	Primary Nest Placement	Special Status and Remarks
Harris Sparrow (*Zonotrichia querula*)	Feeding, watering, resting	Vegetation, seeds	NA	
White-crowned Sparrow (*Zonotrichia leucophrys*)	Feeding, watering, resting	Vegetation, seeds	NA	
Golden-crowned Sparrow (*Zonotrichia atricapilla*)	Feeding, watering, resting	Vegetation, seeds	NA	
White-throated Sparrow (*Zonotrichia albicollis*)	Feeding, watering, resting	Vegetation, seeds	NA	
Fox Sparrow (*Passerella iliaca*)	Feeding, watering resting	Vegetation, seeds	NA	
Lincoln's Sparrow (*Melospiza lincolnii*)	Feeding, watering, resting	Vegetation, seeds	NA	
Song Sparrow (*Melospiza melodia*)	Breeding	Vegetation, seeds	Marsh	

APPENDIX B-9

DISTRIBUTION AND ABUNDANCE OF MAMMALS

Appendix B-9. The distribution and relative abundance of mammals - Las Vegas Wash Unit, Nevada Categories are A = Abundant, C = Common, U = Uncommon, R = Rare, P = Probable, H = Hypothetical.

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Tran-sitional Riparian	Marsh	Open Water	Barren	Urban
Soricidae									
Crawford's Desert Shrew (*Notiosorex crawfordi*)				R	R				
Phyllostomatidae									
California Leaf-nosed Bat (*Macrotus californicus*)	C	R	R	R	C	C	C	P	P
Vespertionidae									
Yuma Myotis (*Myotis yumanensis*)	R	R	R	R	R	R	R	P	P
Fringed Myotis (*Myotis thysanodes*)	R	R	R	R	R	R	R	H	R
Long-legged Myotis (*Myotis volans*)	C	R	R	R	C	R	C	P	P
California Myotis (*Myotis californicus*)	C	C	C	C	C	C	C	R	R
Small-footed Myotis (*Myotis subdulatus*)	R	R	R	R	R	R	R	R	R
Silvery-haired Bat (*Lasionycteris noctivagans*)	R	R	R	R	R	R	R	R	R
Western Pipistrelle (*Pipistrellus hesperus*)	C	C	C	A	C	A	A	C	C
Big Brown Bat (*Eptesicus fuscus*)	C	U	U	U	U	C	C	U	U
Red Bat (*Lasiurus borealis*)	R	R	R	R	R	R	R	R	R
Hoary Bat (*Lasiurus cinereus*)	R	R	R	R	R	R	R	R	R
Spotted Bat (*Euderma maculatum*)	R	R	R	H	R	R	R	H	R
Townsend's Big-earred Bat (*Plecotus townsendii*)	C	R	U	R	R	U	C	R	R
Allen's Big-earred Bat (*Plecotus phyllotis*)	R	H	R	R	R	R	R	R	R
Pallid Bat (*Antrozous pallidus*)	C	R	U	U	U	U	C	R	R
Molossidae									
Brazilian free-tailed Bat (*Tadarida braziliensis*)	R	R	R	R	R	R	R	R	A

Appendix B-9. Continued

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Big Free-tailed Bat (*Tadarida molossa*)	R	R	R	R	R	R	R	R	R
Greater Mastiff Bat (*Eumops perotis*)	R	R	R	R	R	R	R	R	R
Leporidae									
Desert Cottontail (*Sylvilagus audoboni*)	C	U	C	U	U				C
Black-tailed Jackrabbit (*Lepus californicas*)	C	U	C	U	U				C
Sciuridae									
White-tailed Antelope Ground Squirrel (*Ammospermophilus leucurus*)	C	C	C	U	U			R	C
Round-tailed Ground Squirrel (*Spermophilus tereticaudis*)	C		U						R
Geomyidae									
Southern Pocket Gopher (*Thomomys umbrinus*)	R	R	R	?					C
Heteromyidae									
Little Pocket Mouse (*Perognathus longimembrous*)	A	C	A						
Long-tailed Pocket Mouse (*Perognathus formosus*)	A	C	A						
Merriam's Kangaroo Rat (*Dipodomys merriami*)	A								
Desert Kangaroo Rat (*Dipodomys deserti*)	A	R	C						
Cricetidae									
Western Harvest Mouse (*Reithrodontomys megabtus*)				U	A	A			
Canyon Mouse (*Peromyscus crinitus*)	C		C	A				C	
Cactus Mouse (*Peromyscus eremicus*)	C	U	A	A	A				
Deer Mouse (*Peromyscus maniculatus*)	R		U	C	A	A			R
Brush Mouse (*Peromyscus boylei*)					R				
Southern Grasshopper Mouse (*Onychomys torridus*)	U	R	R						
Desert Wood Rat (*Neotoma lepida*)	C	R	C	U	U				R

Appendix B-9. Continued

Species by Family	Creosote Bush	Saltbush	Desert Riparian	Riparian Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Muskrat (*Ondatra zibethicus*)					R	R			
Muridae									
House Mouse (*Mus musculus*)	R	M	M	R	C	A			C
Canidae									
Coyote (*Canis latrans*)	U	R	C	R	R	R		R	R
Kit Fox (*Vulpes macrotus*)	U	M	R	R	R				R
Gray Fox (*Urocyon cinereoargenteus*)	R	R	R	R					
Procyonidae									
Ring-tailed Cat (*Bassariscus astutus*)	R		R	C	R				
Raccoon (*Procyon lotor*)					R	R			
Mustelidae									
Badger (*Taxidea taxus*)	C	R	C	R	M				
Western Spotted Skunk (*Spilogale gracilis*)	R		R	U	C	C			
Striped Skunk (*Mephitis mephitis*)					R	R			
Felidae									
Bobcat (*Lynx rufus*)	U		U	U	U				
Bovidae									
Mountain Sheep (*Ovis canadensis*)	R						R	R	

APPENDIX B-10

NATURAL HISTORY FOR MAMMALS

Appendix B-10. Natural history information for mammals - Las Vegas Wash Unit, Nevada
NA = Not applicable.

Species by Family	Seasonal Use	Primary Habitat Usage	Primary Food Habits	Special Status	Remarks
Soricidae					
Crawford's Desert Shrew (Notiosorex crawfordi)	Year-round	Breeding	Insectivore, terrestrial		Highly secretive habitat specific under debris
Phyllostomatidae					
California Leaf-nosed Bat (Macrotus californicus)	Year-round	See Table	Insectivore, volant		Hibernator
Vespertionidae					
Yuma Myotis (Myotis yumanensis)	Year-round	See Table	Insectivore, volant		Hibernator
Fringed Myotis (Myotis thysanodes)	Spring, summer, fall	See Table	Insectivore, volant		Migratory, hibernator
Long-legged Myotis (Myotis volans)	Spring, fall	See Table	Insectivore, volant		Migratory, hibernator
California Myotis (Myotis califoricus)	Year-round	See Table	Insectivore, volant		Hibernator
Small-footed Myotis (Myotis subdulatus)	Spring, fall	See Table	Insectivore, volant		Migratory, hibernator
Silvery-haired Bat (Lasionycteris noctivagans)	Spring, fall	See Table	Insectivore, volant		Migratory, hibernator
Western Pipistrelle (Pipistrellus hesperus)	Year-round	See Table	Insectivore, volant		Hibernator
Big Brown Bat (Epitescus fuscus)	Spring, summer, fall	See Table	Insectivore, volant		Hibernator
Red Bat (Lasiurus borealis)	Spring, fall	See Table	Insectivore, volant		Migratory, hibernator
Hoary Bat (Lasiurus cinereus)	Spring, fall	See Table	Insectivore, volant		Migratory, hibernator
Spotted Bat (Euderma maculatum)	Unknown seasonal	See Table	Insectivore, volant	Threatened & endangered, Federal & State protected	Unknown
Townsend's Big-earred Bat (Plecotus townsendii)	Year-round	See Table	Insectivore, volant		Hibernator
Allen's Big-earred Bat (Plecotus phyllotis)	Year-round	See Table	Insectivore, volant		Hibernator
Pallid Bat (Antrozous pallidus)	Year-round	See Table	Insectivore, volant		Hibernator
Molossidae					
Brazilian free-tailed Bat (Tadarida braziliensis)	Spring, Summer, fall	See Table	Insectivore, volant		Migratory

Appendix B-10. Continued

Species by Family	Seasonal	Primary habitat Usage	Primary Food Habits	Special Status	Remarks
Big Free-tailed Bat (*Tadarida molossa*)	Spring, fall	See Table	Insectivore, volant		Migratory
Greater Mastiff Bat (*Eumops perotis*)	Spring, fall	See Table	Insectivore, volant		Migratory
Leporidae					
Desert Cottontail (*Sylvilagus audoboni*)	Year-round	Breeding	Vegetation, terrestrial foliage	Protected by State Game Laws	
Black-tailed Jackrabbit (*Lepus californicus*)	Year-round	Breeding	Vegetation, terrestrial foliage	Protected by State Game Laws	
Sciuridae					
White-tailed Antelope Ground Squirrel (*Ammospermophilus leucurus*)	Year-round	Breeding	Vegetation, terrestrial seeds, foliage, terrestrial invertebrates		
Round-tailed Ground Squirrel (*Spermophilus tereticaudis*)	Year-round	Breeding	Vegetation, terrestrial seeds, foliage; terrestrial invertebrates		More abundant in shady areas, hibernator
Geomyidae					
Southern Pocket Gopher (*Thomomys umbrinus*)	Year-round	Breeding	Vegetation, terrestrial roots + foliage		Completely fossorial & especially abundant in urban development
Heteromyidae					
Little Pocket Mouse (*Perognathus longimembrous*)	Spring, summer, fall	Breeding	Vegetation, seeds, foliage		Hibernator
Long-tailed Pocket Mouse (*Perognathus formosus*)	Spring, summer, fall	Breeding	Vegetation, seeds, foliage		Hibernator
Merriam's Kangaroo Rat (*Dipodomys merriami*)	Year-round	Breeding	Vegetation, seeds, foliage		
Desert Kangaroo Rat (*Dipodomys deserti*)	Year-round	Breeding	Vegetation, seeds foliage		Requires sand dune habitat
Cricetidae					
Western Harvest Mouse (*Reithrodontomys megalotus*)	Year-round	Breeding	Vegetation, seeds, foliage		Most abundant near water
Canyon Mouse (*Peromyscus crinitus*)	Year-round	Breeding	Vegetation, seeds, foliage		Prefers rocky habitat
Cactus Mouse (*Peromyscus eremicus*)	Year-round	Breeding	Vegetation, seeds, foliage		
Deer Mouse (*Peromyscus maniculatus*)	Year-round	Breeding	Vegetation, seeds foliage		Prefers somewhat mesic habitat
Brush Mouse (*Peromyscus boylei*)	Year-round	Breeding	Vegetation, seeds, foliage		
Southern Grasshopper Mouse (*Onychomys torridus*)	Year-round	Breeding	Invertebrates, terrestrial; vegetation, terrestrial, seeds, foliage		

Appendix B-10. Continued

Species by Family	Seasonal	Primary Habitat Usage	Primary Food Habits	Special Status	Remarks
Desert Wood Rat (*Neotoma lepida*)	Year-round	Breeding	Vegetation, terrestrial, foliage		
Muskrat (*Ondatra zibethicus*)	Year-round	Breeding	Vegetation, aquatic, foliage - roots		Found in mash areas only
Muridae					
House Mouse (*Mus musculus*)	Year-round	Breeding	Vegetation, terrestrial foliage, seeds		Most abundant near water or urban
Canidae					
Coyote (*Canis latrans*)	Year-round	Breeding	Vertebrates, homeotherms, poikilotherms, carrion	Fur bearer, state regulated season	
Kit Fox (*Vulpes macrotus*)	Year-round	Breeding	Vertebrates, homeotherms, poikilotherms, carrion	Fur bearer, state regulated season	Also protected by State law
Gray Fox (*Urocyon cinereoargenteus*)	Year-round	Breeding	Vertebrates, homeotherms, poikilotherms, carrion	Fur bearer state regulated season	
Procyonidae					
Ring-tailed Cat (*Bassariscus austutus*)	Year-round	Breeding	Vertebrates, homeotherms, vegetation, fruit	Fur bearer, state regulated season	
Raccoon (Procyon lotor)	Year-round	Breeding	Vertebrates, homeotherms, poikilotherms, vegetation terrestrial fruit		
Mustelidae					
Badger (*Taxidea taxus*)	Year-round	Breeding	Vertebrates, homeotherms		
Western Spotted Skunk (*Spilogale gracilis*)	Year-round	Breeding	Vertebrates, terrestrial homeotherms, invertebrates	Fur bearer, state regulated season	
Striped Skunk (*Mephitis mephitis*)	Year-round	Breeding	Vertebrates, terrestrial homeotherms, poikilotherms, invertebrates, vegetation, terrestrial, fruits	Fur bearer, state regulated season	
Felidae					
Bobcat (*Lynx rufus*)	Year-round	Breeding	Vertebrates, homeotherms, carrion	Fur bearer, state regulated season	
Bovidae					
Mountain Sheep (*Ovis canadensis*)	Year-round	Breeding	Vegetation, terrestrial foliage	Protected by state game laws	

APPENDIX B-11

HABITAT USE OF BATS

Appendix B-11. Primary habitat usage of bats by biotic community.

Species by Family	Creosote bush	Saltbush	Desert Riparian	Riparian and Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Phyllostomatidae									
California Leaf-nosed Bat (Macrotus californicus)	Resting, hibernation breeding	Resting, hibernation breeding	Resting, hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting, hibernation breeding	Feeding, watering
Vespertionidae									
Yuma Myotis (Myotis yumanensis)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation breeding	Feeding watering
Fringed Myotis (Myotis thysanodes)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation feeding	Feeding watering
Long-legged Myotis (Myotis volans)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation feeding	Feeding watering
California Myotis (Myotis califoricus)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation feeding	Feeding watering
Small-footed Myotis (Myotis subulatus)	Resting hibernation	Resting hibernation	Resting hibernation	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation	Feeding watering
Silvery-haired Bat (Lasionycteris noctivagans)	Migrating	Migration	Resting hibernation migrating	Resting hibernation feeding	Resting hibernation feeding	Feeding watering	Watering feeding	Migration	Resting hibernation feeding watering
Western Pipistrelle (Pipistrellus hesperus)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation breeding	Feeding watering
Big Brown Bat (Epitescus fuscus)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation breeding	Feeding watering
Red Bat (Lasiurus borealis)	Migrating	Migrating	Resting hibernation migrating	Resting hibernation feeding	Resting hibernation feeding	Feeding watering	Watering feeding	Migrating	Resting hibernation feeding watering
Hoary Bat (Lasiurus cinereus)	Migrating	Migrating	Resting hibernation migrating	Resting hibernation feeding	Resting hibernation feeding	Feeding watering	Watering feeding	Migrating	Resting hibernation feeding watering
Spotted Bat (Euderma maculatum)	Life history unknown								

Appendix B-11. Continued

Species by Family	Creosote bush	Saltbush	Desert Riparian	Riparian and Cliff	Transitional Riparian	Marsh	Open Water	Barren	Urban
Townsend's Big-eared Bat (*Plecotus townsendii*)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation feeding	Feeding watering
Allen's Big-earred Bat (*Plecotus phyllotis*)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation breeding	
Pallid Bat (*Antrozous pallidus*)	Resting hibernation breeding	Resting hibernation breeding	Resting hibernation breeding	Feeding	Feeding	Feeding watering	Watering feeding	Resting hibernation breeding	Feeding watering
Molossidae									
Brazilian Free-tailed Bat (*Tadarida brasiliensis*)	Migrating	Migrating	Migrating	Feeding	Feeding	Feeding watering	Watering feeding	Migrating	Resting feeding watering breeding
Big Free-tailed Bat (*Tadarida molossa*)	Migrating	Migrating	Migrating	Feeding	Feeding	Feeding watering	Watering feeding	Migrating	Resting feeding watering
Greater Mastiff Bat (*Eumops perotis*)	Migrating	Migrating	Migrating	Feeding	Feeding	Feeding watering	Watering feeding	Migrating	Resting feeding watering

APPENDIX C

ARCHEOLOGICAL SITE INVENTORY, LAS VEGAS WASH UNIT, NEVADA

APPENDIX C - ARCHEOLOGICAL SITE INVENTORY, LAS VEGAS WASH UNIT, NEVADA

ARCHEOLOGICAL GLOSSARY

ABORIGINAL TRAIL - A foot trail suspected to be prehistoric in origin.

CIRCULAR CLEARINGS - Archeological features consisting of an irregular clearing in a desert pavement surface that may or may not have a rock alignment around its periphery.

DETRITUS - Undefined waste materials resulting from the manufacture of chipped stone artifacts.

LITHIC SCATTER - Usually a surface archeological manifestation consisting of chipped stone artifacts and manufacturing detritus.

LOCI - A portion of a designated archeological site.

MITIGATION - An attempt to preserve the value of archeological sites by detailed study and data collection. Materials are collected and analyzed using current techniques and theoretical considerations, in order that the material continues to be useful to archeology.

ROCK CAIRNS - Small mound of stone (5-35 centimeters high) of unknown function.

ROCK SHELTERS - Areas with overhead cover created by natural rock features that could provide protection from adverse climates.

SHERDS - Fragments of ceramic artifacts, i.e. pottery vessels.

TESTING PROGRAM - Partial excavation of an archeological site to determine horizontal and vertical distribution of cultural materials and and potential site significance.

APPENDIX C - ARCHEOLOGICAL SITE INVENTORY
LAS VEGAS WASH UNIT, NEVADA

In this appendix data regarding sites has been compiled from surveys conducted for the Los Angeles Water and Power Company and for the Waste Water Management Agency of Clark County, Nevada, as well as the present survey. Each site is described and discussed separately. Mitigation recommendations are made for each site listed that will be affected directly or indirectly through the proposed project construction. The purpose of mitigation is to obtain as much cultural information from an archeological site as possible prior to the adverse effects of construction in an attempt to preserve the intrinsic value of archeological resources. By definition whenever mitigation is proposed it will involve controlled surface collecting, test-pitting or excavation, laboratory cataloging, analysis, and researching of the data obtained.

Site 26 CK-1119

This site is a large lithic scatter associated with small deposits of buff colored mudstones and white colored limestone, both belonging to the Horse Springs Formation. This deposit forms a rough trapezoidal figure that is 1,300 feet north to south and 200 feet on an east to west axis. It divides a terrace into two parts that are connected by a narrow sinuous ridge. Within this area are several loci that are covered by heavy concentrations of chipped stone debris made up primarily of chalcedony. There are also lithics scattered between the loci. Most of this material is quarry detritus and no diagnostic artifacts were found. Cultural affiliations of this site are unclear, but similar material is in the fragile-pattern sites found in this area.

Mitigation of any negative project effects to Site 26 CK-1119 should include a controlled surface collection and test excavation of 3 percent of the units from which cultural material was collected. This cultural material was probably deposited on a fairly old relic or erosional surface on which there has been no soil deposition; consequently, there is probably no subsurface archeological deposition. If the material is found only on the surface, the surface collection should be analyzed, cataloged and described to determine its place in the cultural history of this area. This analysis may reveal site function and give significant information on the ecological adaptation of prehistoric peoples to the Las Vegas Wash.

Site 26 CK-1133

A series of small clusters of chipped stone were found along the western edge of a terrace for a distance of 900 feet. There were 10 clusters containing between 5 and 30 chert flakes. These clusters probably represent specific activity areas, probably tool making with no known cultural affiliations. Mitigation would include mapping, collecting and comparison to ascertain the possible type of activity.

Site 26 CK-1139

This rock shelter is located near the termination of an isolated terrace. It faces a lateral wash to the east and was formed by fine-grained, poorly-cemented sediments belonging to the Horse Springs Formation beneath a 3-foot thickness of the Basal Muddy Creek Conglomerate. The shelter floor is about 50 centimeters higher than the wash elevation and this floor extends east about 4 meters, forming a platform in front of the shelter. This shelter measures 4 meters from the dripline west to the rear, 6 meters from north to south and 10 to 50 centimeters from floor to ceiling. The sediments making up the floor appear to be composed equally of fine-grained sediments and roof fall. The cultural material observed included chert and basalt flakes, grinding stones and pottery. This site has been damaged partially by erosion and amateur collectors. Pottery collected from this site is typologically similar to wares found in this area that have affiliation with the Muddy River Anasazi. This group is known to have exploited the southern Nevada area environment to supplement their agricultural subsistence base. Their adaptation to this area is little known and it is hoped that this site may provide additional information regarding this adaptation.

Mitigation is recommended for this site in the event that it will be threatened by construction. Mitigation should consist of controlled excavation of the deposits in the shelter and on the platform in front of the shelter. The excavation material would then be catalogued and analyzed. An attempt should be made to interpret site function and aboriginal inhabitants' adaptation to the Las Vegas Wash environment.

Site 26 CK-1141

A collapsed rock shelter was found on the side of a small wash that is cut into the terraces overlooking Las Vegas Wash. This shelter faces east and measures 10 meters from dripline to the rear, and twenty meters in length. These dimensions are only approximate since the shelter floor is covered by roof fall. It was formed by erosion of the Horse Spring Formation from beneath the Basal Muddy Creek Conglomerate. This conglomerate is 4 to 6 feet thick and has broken free from the terrace and fractured into large (3-meter-diameter) fragments. A testing program is recommended in the event of any construction effects on this site. This would involve test pit excavations to see if the shelter had been utilized aboriginally. Evidence of use would be cultura debris in a midden at the edge of the roof fall.

Site 26 CK-1277

This is a rock structure whose cultural affiliations are unclear. It has two rectangular rooms that lie adjacent to one another on an east to west axis sharing one wall. The eastern room is rectangular and measures 6 meters east to west and 3 meters north to south. The wall is about 1 meter high and there is a 1-meter-wide entrance that faces the west. The western room is about the same size and shape, but the wall is only 25 centimeters high. The walls are made of unmortared limestone blocks gathered from the Thumb Formation on which this structure is located. These blocks are probably undressed and weigh between 25 and 200 pounds each.

Cultural affiliations of this structure are unclear. It may be of historic origin and possibly related to historic Site 26 CK-1278, which is located on the opposite side of Las Vegas Wash. One of the goals of mitigation of any construction damage to this site should include attempts to establish its cultural affiliations through research of historic records and documents. Mitigation would require detailed mapping and photographs for this structure. To help ascertain cultural affiliations, the internal portions of the larger room should be excavated. Any materials recovered would be catalogued and analyzed.

Site 26 CK-1278

Part of a historic mortared limestone house foundation is visible on the surface and the area is covered by historic debris. Metal fragments, bottle glass, round nails and a clay pipe were noted in this debris. The site covers an area about 25 meters in diameter and stands on a knoll about 2 meters higher than the Wash level.

Mitigation of negative effects of construction on this site should include complete excavation of this structure and any adjacent cultural deposits, cataloging of any recovered cultural material, and analysis of this material and the excavation data. A search of historic records should be made and then the results of this study included in the final report. This site may be found to be important to the recent cultural history of the Wash as it appears to represent the remains of one of the latest episodes in man's cultural adaptation to this area.

Site 26 CK-1279

This site is a large historic dump site. It was the authorized dumping site for the City of Henderson, Nevada, for approximately 20 years. Since this material is recent, dating probably from the 1940's onward, this site is recommended for preservation only if convenient.

Site 26 CK-1282

This site is found on the flood plain of Las Vegas Wash in graded alluvial silts and clays. Within the area several loci, on which pottery was found, were recorded. This site covers an area that measures 400 feet on an east-west axis and 800 feet on a north-south axis. In one locus, located next to the edge of a small gravel quarry, pottery, charcoal, flakes and tortoise bone were eroding out of the ground. In the bank of this gravel, three thin strata of carbonaceous material were evident, the location being at a depth of 1 meter. Several pottery sherds collected from this site were analyzed. They are similar to types known to have Anasazi, possibly southern Paiute, and lower Colorado River cultural affiliations. The sherds are compositionally similar in that they have a fine paste and coarse crystalline quartz temper. The temporal and spatial relationships of the Muddy River Anasazi, the southern Paiute and the peoples that lived along he Colorado River south of Overton, Nevada, are unclear. Since this site has material that is affiliated with all of these groups, it may prove significant in clarifying these relationships. This is one of the few sites that has buried deposits and it may also provide important data concerning adaptation of prehistoric population to the Wash riparian environment.

This site has been heavily damaged by local residents removing the midden to be used as soil components. Within this reporting period soil has been removed on at least three different occasions. On the last occasion, heavy equipment was used to remove midden.

Mitigation of the effect of construction should begin with subsurface testing of this particular deposit in the area on which cultural material was found. If this testing indicates that the site merits further excavation, then the mitigation plan should be expanded to more extensive excavation. Cost estimates for total excavation included in the appendix are based on archeological testing and not expanded excavation.

Site 26 CK-1283

This is an isolated rock alignment composed of a line of evenly spaced blocks of limestone fragments. It is about three meters long and oriented roughly east to west. Archeological significance of this feature is unclear but it should be mapped, photographed and described in the event of any adverse effect due to construction. Mitigation estimates are included with those for 26 CK-1138.

Site 26 CK-1284

This small rock shelter is located on the side of the terrace on which Site 26 CK-1129 is found. It faces Las Vegas Wash and is about 20 feet higher in elevation than the Wash floodplain. The shelter dimensions are approximately 3 meters east to west, 1 meter north to south and about 50 centimeters from floor to ceiling. No cultural material was noted in the interior but there is a 50-centimeter-high rock wall across the front of the shelter just beneath the dripline. A large amount of aeolian sediments have been piled up against this wall on the interior side. These deposits suggest a high rate of sedimentation which might have buried cultural deposits. Significance of this site as an archeological resource can only be determined by a testing program, which would involve several test pits.

Site 26 CK-1295

This site is a historic dump site that was probably associated with the Three Kids Mine. It contains several automobile bodies that date from the 1930's, crockery, bricks, and other miscellaneous debris. A 4-meter-square concrete foundation was encountered at the southern end of this site.

Site 26 CK-1296

A light lithic scatter is found on the wash cut terminus of an alluvial face forming a small site. The material encountered on this location is sparse and is composed of chipped stone waste material. This material covers an area that is 300 feet north to south and 100 feet east to west. In case of construction on this site a controlled surface collection is recommended for mitigation.

Site 26 CK-1297

This small rock shelter faces a large north-south trending wash to the east and is 100 feet higher in elevation than the Wash. This shelter was formed by erosion of the Horse Springs Formation from beneath a more resistant outcrop of igneous rock. It is 10 meters wide, 1.5-2 meters from floor to ceiling and 4 meters from dripline to the rear. In the curve of this shelter there is a rectangular pothole 1 meter by 3 meters and 50 centimeters deep. A small amount of cultural debris was noted at the surface. Two Pueblo-type potsherds were collected from this site.

Despite the damage from vandals, this site may have significance in providing data on the adaptation to the southern Nevada area of the Muddy River Anasazi. These people, although primarily agriculturally based, evidently exploited a wide range of ecological niches in this area. This site appears to have a deep deposit and may yield perishable material not ordinarily found in open sites. Such material may prove to be vital for archeological interpretation of aboriginal life styles. Mitigation to the effects of construction in this area is recommended consisting of test-pitting to determine midden content and laboratory analysis of recovered data.

Site 26 CK-1299

This site is a chalcedony quarry found in the Horse Spring Formation sediments. It is located on and around a small outcrop that is 2 meters high and 15 meters in diameter. The chalcedony is available in tabular blocks that are 3 to 20 centimeters thick. This material is fairly homogeneous, vessiculated cryptocrystalline variety of quartz that is probably igneous in origin. For some distance, an associated lithic scatter is found along the terrace too. Mitigation would consist of controlled collecting, mapping and photography.

Site 26 CK-1301

This is a rock shelter formed by the erosion of unconsolidated Horse Springs Formation sediments from beneath the Basal Muddy Creek Conglomerate. The site dimensions are approximately 3.5 meters from dripline north to the rear, 6 meters from east to west, and 1 meter from floor to ceiling. Should the proposed construction affect this site, test-pitting is recommended to determine the midden potential for the possible necessity of more extended excavation.

Site 26 CK-1316

This site is underneath a high rock overhang which was formed by the erosion of the Horse Springs Formation from beneath the Basal Muddy Creek Conglomerate, where an angular unconformity occurs between these formations. The dimensions of this shelter are 4 meters from dripline to the rear, 20 meters from east to west and 4 meters from floor to ceiling. The cultural deposit appears to be limited to only a portion of this shelter. Noted in this cultural material were chert flakes, tortoise bone, charcoal and a grinding stone. In the center of the cultural deposit is a pothole that is 1.5 meters in diameter and 50 centimeters deep. This site appears to have some depth and may yield valuable chronological data concerning prehistoric human occupation. Mitigation, through excavation and subsequent laboratory analysis will be necessary if the construction work will affect this area.

Site 26 CK-1318

This site is a lithic scatter. Chert artifacts and waste material were noted in this deposit. Controlled collecting and some testing is recommended for this site in the case of any negative impact resulting from construction.

Fragile-Pattern Sites

These sites are defined as any archeological area in which man's material remains lie without depth upon an existing natural surface and thus comprise a pattern which is disturbed or broken by any form of selective artifact collecting.

Some of the aboriginal sites encountered on the terraces adjacent to the wash fit the definition of fragile-pattern sites. These terraces are covered by interlocking igneous gravels that form a surface that is resistant to erosion, referred to as desert pavement. Twenty-eight sites were located on these surfaces which share common traits. Cultural material, excluding recent historic artifacts such as expended rifle cartridges, was composed of cryptocrystalline varieties of quartz and basalt. This material was found either individually scattered over isolated areas or in small clusters. There are both chipped stone artifacts and manufacturing debris. Associated with some of these lithic concentrations are circular or ovular features from which the desert pavement surface has been removed. These features have surfaces that are slightly concave and often 1 or 2 centimeters beneath the level of the desert pavement. These circles are usually between 1 and 5 meters in diameter. They sometimes have either a continuous or interrupted ring of stone around their periphery, composed of cobbles from 25 to 75 centimeters in diameter. These features are sometimes isolated but they often are found in clusters (6 to 30) and are often located at the north end of terraces adjacent to the Wash. Rock cairns, rock alignments, hunting blinds, and a few grinding stone implements were also associated with some of these sites. The distribution of these features and lithic material presents a pattern which might reveal data about aboriginal adaptation to the Mohave Desert. Sites that fit the fragile-pattern site description have a wide geographic distribution and have been described several times in archeological literature.

Before adaptive interpretations of the culture of the aboriginal inhabitants can be made about the sites located in Las Vegas Wash, a functional explanation of the circular features found there needs to be made. An explanation is difficult to derive because of the paucity of information about them as yet available.

Site 26 CK-1116

This site is located on an isolated terrace. Mitigation of the negative impact on this site through controlled collecting, recording and photography was performed during the course of an Environmental Impact Study for Los Angeles Water and Power Navaho Transmission Line (R/W 42). The results of this research are in press.

Site 26 CK-1120

This site is recorded as a fragile-pattern site. A light scatter of lithic debris. small clusters of flakes, and isolated artifacts constituted the aboriginal material found in this area. Before any construction in this area takes place, an intensive surface collection and photography is recommended.

Site 26 CK-1122

This site is a fragile-pattern site located on an isolated terrace. There are seven circular features found on this site and a light lithic scatter. This is 75 feet in diameter and mitigation of the effects of construction is recommended through controlled collecting, a few test pits within the circular features, mapping and photography.

Site 26 CK-1124

This site is located on an isolated finger that slopes downward from a large terrace. It has fourteen circular features that range in size between 1 and 2 meters in diameter. There is a lithic scatter associated with this site and the site dimensions are 900 feet north to south and 350 feet from east to west. In the event of construction in this area mitigation is recommended through controlled collection, testing within the circular features, mapping and photography.

Site 26 CK-1125

This site is located in the central portion of a large terrace and has ten clearings in the desert pavement that range in size from 1 to 1.8 meters in diameter. There are few lithics associated with this cluster and it is approximately 100 feet in diameter. In the event of construction in this area mitigation is recommended for the site through mapping, testing of the circular clearings and photography.

Site 26 CK-1126

This site is located on a finger parallel to Site 26 CK-1124 sloping downward off a large terrace. There are 40 pavement clearing features located within the site that vary from 1 to 2.6 meters in diameter. In one area on the site, about 75 feet in diameter, these features are clustered so thickly that they almost cover the entire surface. The heaviest lithic concentrations on fragile-pattern sites are found in this area of the Wash. The site dimensions are 950 feet from north to south and 200 feet from east to west. Mitigation of damage to this site through construction is recommended by controlled and extensive collecting, testing (particularly in the clustered features), mapping and photography.

Site 26 CK-1127

This site is located in a lateral wash that has partially divided two terraces. There is a cluster of 53 well-defined cleared circular features that are an average of about 2 meters in diameter. This site is 75 feet in diameter and there is a light scatter of lithic cultural remains. In the event of construction on this site mitigation is recommended through controlled collection, testing of a small percentage of the features, mapping and photography.

Site 26 CK-1129

This site is located on an isolated terrace. For the purposes of this report it has been divided into three components. Component A is a cluster of eight circular clearings that range in size from 2 meters to 5.2 meters in diameter together with a rock cairn that is 1.2 meters in diameter. Component B is composed of three "C"-shaped rock features that lie in a roughly north-south orientation. These features are 1 to 2 meters in diameter and about 25 centimeters high. Component C is composed of three circular features. Mitigation of damage through construction on this site is recommended by test-pitting all three components, mapping and photography.

Site 26 CK-1131

This site is located on a narrow ridge and is composed of a lithic scatter and one circular feature is found on the surface. This site has been severely damaged by a round cut running down the longest axis. The site is 500 feet northwest to southeast and 75 feet northeast to southwest. Mitigation of damage related to construction on this site is recommended through controlled collecting, mapping and photography.

Site 26 CK-1132

This site is located on a narrow terrace. The cultural manifestations found on this site consist of two clearings that are between 1.5 and 2 meters in diameter and a lithic scatter. The site measures 300 feet on a northwest to southeast axis and 50 feet on a northeast to southeast axis. Mitigation of construction effects on this site is recommended through controlled collecting, mapping and photography.

Site 26 CK-1134

This site is found on an isolated terrace. There were three clusters of circular features that are described as separate components. Component A has seven circular features that are between 0.75 and 1.5 meters in diameter. Component B is located on an isolated finger projecting away from the terrace and it contains seven features none of which have rock alignments surrounding the circular clearings that range from 50 centimeters to 2 meters in diameter. Component C is on the southern central portion of this terrace and it contains four circular features. These features measure from 1 to 1.5 meters in diameter and two of them have been damaged by vandals. Associated with these features and the area inbetween the clusters, there is a small amount of scattered lithics. Should construction affect this site it is recommended that mitigation consist of test-pitting in the features of each component, controlled collecting, mapping and photography.

Site 26 CK-1136

This site is located on a narrow terrace. Four features were scattered along this terrace and they range from 1.5 to 2 meters in diameter. The site is approximately 200 feet north to south and 25 feet east to west. Mitigation of the effects of construction would consist of minimal testing of the features, mapping and photography.

Site 26 CK-1140

This site is found on the northern edge of an isolated terrace. Scattered through this area were 42 lined or unlined circular features between 1 and 3 meters in diameter. Chipped stone artifacts and debris were scattered throughout this area. The site dimensions are 500 feet north to south and 1,000 feet east to west. Mitigation of the effects of construction will necessitate testing of both lined and unlined features, controlled collecting, mapping and photography.

Site 26 CK-1280

This site is located on the side of a low hill. There are six unlined circular features found on the side of this hill and at the base of the hill there is a possible shelter site formed by a large boulder. This site is approximately 200 feet in diameter and contains almost no lithic cultural material. Mitigation of this site should it be affected by construction would involve limited testing of the features and the possible shelter, mapping and photography.

Site 26 CK-1281

This is an isolated circular depression that covers an area about 4 meters in diameter. The depression is about 1 meter in depth and is surrounded by 100 to 200 slate-like limestone fragments. Should construction necessitate mitigation, a test pit and photography are recommended.

Site 26 CK-1285

This site is located on the wash bank. It contains four poorly defined circular features that are 1 to 1.5 meters in diameter and it has a section of aboriginal trail that parallels the Las Vegas Wash. Next to this trail two bifacially flaked scrapers were found. They are composed of agate that is similar to material found in a quarry site near Lava Butte located in the Horse Spring Formation 2 miles to the northeast. The site is 350 feet east to west and 200 feet north to south. It is recommended that this section of trail be avoided if possible during construction. Mitigation of this site would involve limited testing, mapping and photography.

Site 26 CK-1293

This site is a fragile-pattern site located on an isolated terrace in the west half of Sec. 28, T. 21 S., R. 63E. It contains six circular clearings that are between 1 and 3 meters in diameter and a light lithic scatter. This site is 50 feet in diameter. Mitigation is recommended in case of impact resulting from construction and would involve controlled collecting, limited testing, mapping and photography.

Site 26 CK-1294

This site has six circular features that are between 1 and 2.2 meters in diameter. Lithic cultural material was scattered sparsely over this area. This site measures 100 feet on a northwest to southwest axis and 75 feet on a northeast to southwest axis. Should construction necessitate mitigation limited testing, surface collecting, mapping and photography are recommended.

Site 26 CK-1298

This site is found along a narrow terrace. It is a light scatter of chipped stone debris and artifacts. It is 1,500 feet from northwest to southeast and 100 to 200 feet from northeast to southwest. The material is similar to that found at 26 CK-1299. In the event of of construction in this area, controlled collecting, mapping and photography are recommended.

Site 26 CK-1300

This site is a lithic scatter located on a knoll. It is about 10 meters in diameter and contains chipped stone artifacts and waste material, composed of cryptocrystalline varieties of quartz. Should construction be proposed on this site controlled collecting and photography are recommended.

Site 26 CK-1303

This site is a rectangular rock alignment that is approximately 12 feet long and 8 feet wide, with the remnants of two wooden pegs found projecting above the surface. To the south of this feature there is a "U"-shaped rock alignment that is composed of mud-mortared rock fragments. No artifacts were found in association with this site. Mitigation is recommended in the event of any construction including test pits in the vicinity of the rock alignments on both sides, mapping and photography.

Sites 26 CK-1304, -1305, and -1306

These sites each contain isolated circular features that are between 1.65 and 3 meters in diameter. Mitigation of any negative impact to this site due to construction is recommended involving test-pitting to determine if there is subsurface material, mapping and photography.

Site 26 CK-1315

This site has four circular features that are 1.5 to 2.3 meters in diameter and it has a light lithic scatter. Mitigation of any construction effects is recommended through controlled collecting, limited testing, mapping and photography.

Site 26 CK-1317

This is a fragile-pattern site with cultural manifestations consistting of four circular features that are between 1.5 and 2.3 meters in diameter and a light lithic scatter. Mitigation of any impact to this site as a result of construction is recommended consisting of limited testing, controlled collecting, mapping and photography.

Site 26 CK-1138

This site is a strongly typical fragile-pattern site located on an isolated terrace. The desert pavement surface on which it is found is fairly delicate and sensitive to the activities of modern man. Because of these factors and a need to evaluate the research potential of these types of sites it was decided to test some of the features of the site to determine their archeological significance.

The NAS staff developed a testing program designed to collect the maximum data from the area. This program included detailed mapping of the site features and controlled surface collections on a specific segment of the site. Features were tested and all recovered material was cataloged and analyzed. The results provided information pertaining to the relative significance of the site, its research potential and the estimated costs of this type of testing program for these cultural manifestations that are described as fragile-pattern sites.

METHODOLOGY

Using a transit the area to be tested was gridded into 3-meter squares. These units were examined individually and all cultural material was placed in labeled bags, except when it was found within a circular feature. These were mapped and bagged separately. There were 31 circular features, one rock cairn, and one rock alignment which were mapped and described. The interiors of five features, F-1, -2, -3, -4 and -5, were dug in 5-centimeter levels. All material removed from the features were screened through 1/8-inch mesh screens and artifacts found in situ were mapped place.

Results

The surface collection produced the following aboriginal material: scrapers, choppers, hammerstones, a possible projectile point fragment and lithic detritus. Excavation of F-1 produced scattered charcoal grains in several portions of this feature and small deposits of charcoal and ash in several loci in one area 50 centimeters in diameter. Six grams of charcoal were collected from one of these loci of ash and charcoal. The soil underneath this deposit was stained slightly redder in color than the surrounding soil suggesting oxidation. In F-4 a few scattered grains of charcoal and a possible point fragment were collected. The remaining features contained no cultural material.

Analysis

The surface collection material was subjected to distributional analysis so that a better site area definition could be provided. A 5-gram charcoal sample found in a possible hearth in feature F-1 was sent to the Geochronology Laboratory at the University of Georgia along with a charcoal sample collected from a cleared circular feature found on Site 26 CK-1116. The charcoal from these two samples were slightly more active than modern samples, indicating that they were very recent samples or possibly contaminated.

A sample of the ash material was processed to separate any pollen. Several pollen grains were noted despite a highly unfavorable environment for pollen preservation. This sample and samples of soil collected from each of the features will be subjected to further analysis in the future.

Summary of Testing Site 26 CK-1138

An attempt to establish the age of this fragile-pattern site that was tested was only partially successful. Charcoal from the possible hearth deposit in feature F-1 and charcoal from a similar site, Site 26 CK-1116, 500 meters to the east, when subjected to radiocarbon (C-14) analysis gave a reading slightly more active than modern C-14. In a telephone conversation, Dr. B. L. Brandau of the Geochronology Laboratory at the University of Georgia suggested that these samples were possibly contaminated. The results of the C-14 dating are problematic because of this possible contamination. Since no pottery or other diagnostic artifacts are found on any of these fragile-pattern sites there is no means of cross-dating typologically with the known chronology of the Southern Great Basin.

It is possible that these sites were occupied by later inhabitants of the Southern Great Basin, the Southern Paiute who subsisted by exploitation of various environmental zones on a seasonal basis, and were known to have utilized the Wash as late as the 1900's. Although incomplete, superficial pollen analysis of the hearth material supports the idea of recent deposition. Since this hearth was between 1 to 2 centimeters beneath the surface, this would allow oxidation to take place. In addition, the soil is extremely alkaline and in combination with the oxidation, creates a corrosive environment for pollen and it would not be preserved for any length of time.

An estimation of the age of the fragile-pattern sites at this time would be highly debatable. Efforts are needed to obtain additional charcoal samples and attempts should be made to isolate and eliminate any contamination factors. Mitigation of the impact to this site from construction will necessitate a more exhaustive study than has been undertaken in the testing program. This would include sampling excavations from the remaining 46 features, additional mapping of the 25 unmapped features and cataloging and analysis of the materials recovered during mitigation. It is hoped additional charcoal samples and soil samples can be obtained for analysis.

APPENDIX D

FLORA AND FAUNA;
CRYSTAL GEYSER UNIT, UTAH

APPENDIX D-1

COMMON PLANT SPECIES

Appendix D-1. Common plant species

Common Plant Species of the Crystal Geyser Unit

	Species	Common name
Grasses:	Aristida fendleria	(3-awn)
	Sitanion hystrix	(Squirreltail)
	Bromus tectorum	(Cheatgrass)
	Distichlis stricta	(Salt grass)
	Festuca octoflora	(Six weeks fescue)
	Hilaria jamesii	(Galleta grass)
	Oryzopsis hymenoides	(Indian ricegrass)
	Sporobolus airoides	(Alkali sacaton)
	Sporobolus cryptandrus	(Sand dropseed)
	Stipa comata	(Needle-and-thread grass)
	Tridens pulchella	(Pretty tridens)
Forbs:	Abronia fragrans	(Snowball sand-verbena)
	Ambrosia artemisiafolia	(Common ragweed)
	Androstephium breviflorum	(?)
	Aster sp.	(Aster)
	Astragalus amphioxys	(Locoweed)
	Astragalus cymboides	(Locoweed)
	Astragalus flavus variargillosus	(Locoweed)
	Atriplex powellii	(Saltbush)
	Bahia ourolepis	(Bahia)
	Calochortus nuttallii	(Sego lily)
	Chaenactis steviodes	(Sunflower family)
	Chenopodium incanum	(Goosefoot)
	Cleomella plamerana	(?)
	Cryptantha flava	(Yellow cryptantha)
	Cryptantha gracilis	(Borage family)
	Cymopterus newberryi	(Umbrella plant family)
	Cymopterus purpurasons	(Umbrella plant family)
	Descurainia pinnata	(Tansymustard)
	Descurainia sofia	(Flixweed tansymustard)
	Enceliopsis nutans	(Nodding enceliopsis)
	Eremocrinum albomarginatum	(?)
	Eriastrum sapphirinum	(?)
	Erigeron canadensis	(Fleabane)
	Erigeron concinnus	(Daisy)
	Eriogonum inflatum	(Bottlestopper)
	Eriogonum (annual)	(Eriogonum)
	Euphorbia fendleri	(Fendler's euphorbia)
	Franseria acanthocarpa	(Annual bursage)
	Gaillardia gracilis	(Graceful gaillardia)
	Gaillardia spathulata	(Yellow gaillardia)
	Gilia leptomeria	(Gilia family)

Appendix D-1. Continued

	Species	Common name
Forbs: (cont.)	*Gilia polycladon*	(Gilia family)
	Gilia tweedyi	(Annual gilia)
	Grindelia squarrosa	(Curlycup gumweed)
	Halogeton glomerata	(Halogeton)
	Kockia scoparia	(Summer cyprus)
	Lappula redowskii	(Stickweed)
	Lepidium densiflorum	(Prairie pepperweed)
	Lepidium montanum	(Pepperweed)
	Machaeranthea canescens	(?)
	Oenothera scapoidea	(Yellow, annual evening primrose)
	Petalostemon occidentale	(Petalostemon)
	Phacelia crenulata	(Crenulate phacelia)
	Solidago graminifolia	(Grassleafed goldenrod)
	Stanleya pinnata	(Prince's plume)
	Thelesperma subnuda	(Thelesperma)
	Townsendia incana	(Perennial townsendia)
	Tragopogon dubius	(Yellow goatsbeard)
	Xanthium strumarium	(Cocklebur)
Shrubs:	*Allenrolfea occidentalis*	(Pickleweed)
	Amelanchier utahensis	(Utah serviceberry)
	Artemisia bigelovii	(Bigelow sagebrush)
	Artemisia spinescens	(Budsage)
	Atriplex canescens	(Fourwing saltbush)
	Atriplex confertifolia	(Shadscale)
	Atriplex corrugata	(Saltbush)
	Atriplex cuneata	(Saltbush)
	Brickellia scabra	(Brickellbush)
	Chrysothamnus nauseosus	(Rubber rabbitbrush)
	Chrysothamnus viscidiflorus	(Littleleaf rabbitbrush)
	Coleogyne ramosissima	(Blackbrush)
	Ephedra torreyana	(Torrey's mormon tea)
	Echinocactus whipplii	(Whipple's fishhook cactus)
	Fraxinus anomala	(Singleleaf ash)
	Gutierrezia sarothrae	(Matchweed)
	Opuntia polyacantha	(Pricklypear)
	Phlox grahamii	(Spiny phlox)
	Rhus trilobata	(Squawbush)
	Tamarix ramosissima	(Tamarix)
	Salix amygdaloides	(Peach-leaf willow)
	Salix exigua	(Sandbar willow)
	Sarcobatus vermiculatus	(Black greasewood)
	Suaeda fruticosa	(Sea blite)
Trees:	*Juniperus osteosperma*	(Utah juniper)
	Populus fremontii	(Fremont cottonwood)
	Eleagnus angustifolia	(Russian olive)

APPENDIX D-2

WILDLIFE SPECIES LIST

Appendix D-2. Wildlife species list

Fish Species of the Crystal Geyser Unit

Species	Common name
Salmo clarki	(Cutthroat trout)
Salmo trutta	(Brown trout)
Prosopium williamsoni	(Mountain whitefish)
Cyprinus carpio	(Carp)
Gila atraria	(Utah chub)
Gila robusta	(Colorado chub)
Gila copei	(Leatherside chub)
Richardsonius balteatus hydrophlox	(Red-side shiner)
Ptychocheilus lucius	(Colorado squawfish)
Rhinichthys osculus	(Speckled dace)
Rhinichthys cataractae	(Long-nose dace)
Pimephales promelas	(Fat-head minnow)
Castostomus ardens	(Utah sucker)
Castostomus latipinnis	(Flannel-mouth sucker)
Pantosteus platyrhynchus	(Mountain sucker)
Pantosteus clarki	(Blue-head sucker)
Xyrauchen texanus	(Hump-back sucker)
Ictalurus punctatus	(Channel catfish)

Appendix D-2. Continued

Amphibian and Reptile Species of the Crystal Geyser Unit

Species	Common name
Ambystoma tigrinum	(Utah tiger salamander)
Scaphiopus intermontanus	(Great basin spadefoot)
Bufo woodhousei	(Rocky mountain toad)
Rana pipiens	(Western leopard frog)
Crotaphytus collaris	(Collared lizard)
Crotaphytus wislizenii	(Leopard lizard)
Sceloporus undulatus	(Northern plateau lizard)
Sceloporus graciosus	(Northern sagebrush lizard)
Sceloporus magister	(Desert spiny lizard)
Uta stansburiana	(Northern side-blotched uta)
Urosaurus ornatus	(Northern cliff lizard)
Phrynosoma douglassi	(Mountain short-horned lizard)
Cnemidophorus tigris	(Northern whiptail)
Thamnophis elegans	(Wandering garter snake)
Masticophis taeniatus	(Desert-striped whipsnake)
Elaphe guttata	(Great plains rat snake)
Pituophis melanoleucus	(Great basin gopher snake)
Lampropeltis triangulum	(Utah milk snake)
Hypsiglena torquata	(Night snake)
Crotalus viridis	(Midget-faded rattlesnake)

Appendix D-2. Continued

Avifauna of the Crystal Geyser Unit

Species	Common name
Ardea herodias	(Great blue heron)
Leucophoyx thula	(Snowy egret)
Branta canadensis	(Canada goose)
Anas platyrhynchos	(Mallard)
Anas acuta	(Pintail)
Anas cyanoptera	(Cinnamon teal)
Bucephala clangula	(Common goldeneye)
Fulica americana	(American coot)
Mergus merganser	(Common merganser)
Mergus serrator	(Red-breasted merganser)
Cathartes aura	(Turkey vulture)
Accipiter gentilis	(Goshawk)
Accipiter striatus	(Sharp-shinned hawk)
Accipiter cooperi	(Cooper's hawk)
Buteo jamaicensis	(Red-tailed hawk)
Buteo swainsoni	(Swainson's hawk)
Buteo regalis	(Ferruginous hawk)
Buteo lagopus	(Rough-legged hawk)
Aquila chrysaetos	(Golden eagle)
Haliaeetus leucocephalus	(Bald eagle)
Circus cyaneus	(Marsh hawk)
Falco mexicanus	(Prairie falcon)
Falco peregrinus	(Peregrine falcon)
Falco columbarius	(Pigeon hawk)
Falco sparverius	(Sparrow hawk)
Pedioecetes phasianellus	(Sage grouse)
Lophortyx californicus	(California quail)
Lophortyx gambelii	(Gambel's quail)
Phasianus colchicus	(Ringed-neck pheasant)
Alectoris graeca	(Chukar)
Charadrius vociferus	(Killdeer)
Actitis macularia	(Spotted sandpiper)
Tringa solitaria	(Solitary sandpiper)
Erolia minutilla	(Least sandpiper)
Ereunetes mauri	(Western sandpiper)
Recurvirostra americana	(American avocet)
Himentopus mexicanus	(Black-necked stilt)
Larus californicus	(California gull)
Larus delawarensis	(Ring-billed gull)
Zenaidura macroura	(Mourning dove)
Coccyzus americanus	(Yellow-billed cuckoo)
Otus asio	(Screech owl)
Bubo virginianus	(Great horned owl)
Otus flammeolus	(Flammulated owl)
Glaucidum gnoma	(Pygmy owl)

Appendix D-2. Continued

Species	Common name
Strix occidentalis	(Spotted owl)
Asio otus	(Long-eared owl)
Chordeiles minor	(Common nighthawk)
Phalaenoptilus nuttallii	(Poor-will)
Aeronautes saxatalis	(White-throated swift)
Archilochus alexandri	(Black-chinned hummingbird)
Selasphorous platycercus	(Broad-tailed hummingbird)
Selasphorous rufus	(Rufous hummingbird)
Megaceryle alcyon	(Belted kingfisher)
Colaptes auratus	(Common flicker)
Asyndesmus lewis	(Lewis' woodpecker)
Melanerpes erythrocephalus	(Red-headed woodpecker)
Dryocopus pileatus	(Pileated woodpecker)
Sphyrapicus varius	(Yellow-bellied sapsucker)
Dendrocopus villosus	(Hairy woodpecker)
Tyrannus tyrannus	(Eastern kingbird)
Tyrannus verticalis	(Western kingbird)
Tyrannus vociferans	(Cassin's kingbird)
Myiarchus cinerascens	(Ash-throated flycatcher)
Empidonax trailii	(Willon flycatcher)
Sayornis saya	(Say's phoebe)
Sayornis nigricans	(Black phoebe)
Contopus sordidulus	(Western wood pewee)
Eremophilia alpestris	(Horned lark)
Tachycineta bicolor	(Tree swallow)
Tachycineta thalassina	(Violet-green swallow)
Riparia riparia	(Bank swallow)
Stelgidopteryx ruficollis	(Rough-winged swallow)
Hirundo rustica	(Barn swallow)
Petrochelidon pyrrhonota	(Cliff swallow)
Aphelocoma coerulescens	(Scrub jay)
Gymnorhinus cyanocephala	(Pinyon jay)
Corvus corax	(Common raven)
Corvus brachyrhynchaa	(Common crow)
Pica pica	(Black-billed magpie)
Parus inornatus	(Plain titmouse)
Psaltriparus minimus	(Common bushtit)
Troglodytes aedon	(House wren)
Thryomanes bewickii	(Bewick's wren)
Catherpes mexicanus	(Canyon wren)
Salpinctes obsoletus	(Rock wren)
Dumetella carolinensis	(Catbird)
Mimus polyglottos	(Mockingbird)
Toxostoma bendirei	(Bendire's thrasher)
Oreoscoptes mantanus	(Sage thrasher)
Turdus migratorius	(Robin)
Hylocichla guttata	(Hermit thrush)
Hylocichla ustulata	(Swainson's thrush)
Sialia mexicana	(Western bluebird)
Sialia currucoides	(Mountain bluebird)

Appendix D-2. Continued

Species	Common name
Myadestes townsendii	(Townsend's solitaire)
Polioptila caerulea	(Blue-gray gnatcatcher)
Lanius ludovicianus	(Loggerhead shrike)
Sturnus vulgaris	(Starling)
Vireo vicinior	(Gray vireo)
Vireo bellii	(Bell's vireo)
Vireo solitarius	(Solitary vireo)
Vireo gilvus	(Warbling vireo)
Vireo olivaceus	(Red-eyed vireo)
Vermivora celata	(Orange-crowned warbler)
Vermivora virginiae	(Virginia's warbler)
Dendroica petechia	(Yellow warbler)
Dendroica coronata	(Yellow-rumped warbler)
Oporornis tolmiei	(MacGillivray's warbler)
Dendroica nigrescens	(Black-throated gray warbler)
Wilsonia pusilla	(Wilson's warbler)
Geothlypis trichas	(Yellowthroat)
Icteria virens	(Yellow-breasted chat)
Sturnella neglecta	(Western meadowlark)
Agelaius phoeniceus	(Red-winged blackbird)
Xanthocephalus xanthocephalus	(Yellow-headed blackbird)
Icterus bullockii	(Bullock's oriole)
Euphagus cyanocephalus	(Brewer's blackbird)
Molothrus ater	(Brown-headed cowbird)
Piranga ludoviciana	(Western tanager)
Pheucticus melanocephalus	(Black-headed grosbeak)
Guiraca caerulea	(Blue grosbeak)
Passerina amoena	(Lazuli bunting)
Carpodacus mexicanus	(House finch)
Spinus tristis	(American goldfinch)
Spinus psaltria	(Lesser goldfinch)
Chlorura chlorura	(Green-tailed towhee)
Pipilo erythrophthalmus	(Rufous-sided towhee)
Passerculus sandwichensis	(Savannah sparrow)
Pooecetes gramineus	(Vesper sparrow)
Chondestes grammacus	(Lark sparrow)
Amphispiza bilineata	(Black-throated sparrow)
Amphispiza belli	(Sage sparrow)
Junco hyemilas	(Darked-eyed juncos)
Zonotrichia leucophrys	(White-crowned sparrow)
Melospiza melodia	(Song sparrow)
Spizella breweri	(Brewer's sparrow)
Spizella arborea	(Tree sparrow)
Spizella passerina	(Chipping sparrow)

Appendix D-2. Continued

Mammal Species of the Crystal Geyser Unit

Species	Common name
Myotis lucifugus	(Big myotis)
Myotis evotis	(Long-eared myotis)
Myotis thysanodes	(Fringed myotis)
Myotis volans	(Long-legged myotis)
Myotis californicus	(California myotis)
Myotis subulatus	(Small-footed myotis)
Lasionycteris noctivagans	(Silver-haired bat)
Pipistrellus hesperus	(Western pipistrelle)
Eptesicus fuscus	(Big brown bat)
Enderma maculatum	(Spotted bat)
Corynorhinus rafinesquii	(Big-eared bat)
Antrozous pallidus	(Pallid bat)
Tadarida mexicana	(Free-tailed bat)
Sylvilagus audubonii	(Desert cottontail)
Lepus californicus	(Black-tailed jackrabbit)
Eutamias quadrivittatus	(Colorado chipmunk)
Eutamias minimus	(Least chipmunk)
Citellus variegatus	(Rock squirrel)
Ammospermophilus leucurus	(Antelope ground squirrel)
Cynomys leucurus	(White-tailed prairie dog)
Cynomys gunnisoni	(Gunnison's prairie dog)
Thomomys bottae	(Botta's pocket gopher)
Perognathus apache	(Apache pocket mouse)
Perognathus parvus	(Great basin pocket mouse)
Dipodomys ordii	(Ord's kangaroo rat)
Castor canadensis	(Beaver)
Reithrodontomys megalotis	(Western harvest mouse)
Peromyscus maniculatus	(Deer mouse)
Peromyscus crinitus	(Canyon mouse)
Peromyscus boylii	(Brush mouse)
Peromyscus truei	(Pinyon mouse)
Onychomys leucogaster	(Northern grasshopper mouse)
Neotoma cinerea	(Bushy-tailed wood rat)
Neotoma lepida	(Desert wood rat)
Microtus longicaudus	(Long-tailed meadow mouse)
Mus musculus	(House mouse)
Erethizon dorsatum	(Porcupine)
Canis latrans	(Coyote)
Vulpes fulva	(Red fox)
Urocyon cinereoargenteus	(Gray fox)
Bassariscus astutus	(Ring-tailed cat)
Mustela frenata	(Long-tailed weasel)
Taxidea taxus	(Badger)
Spilogale gracilis	(Western spotted skunk)
Mephitis mephitis	(Striped skunk)

Appendix D-2. Continued

Species	Common name
Lynx rufus	(Bobcat)
Felis concolor	(Mountain lion)
Odocoileus hemionus	(Mule deer)

APPENDIX E

Public Law 93-320, The Colorado River Basin Salinity Control Act

Public Law 93-320
93rd Congress, H. R. 12165
June 24, 1974

An Act

88 STAT. 266

To authorize the construction, operation, and maintenance of certain works in the Colorado River Basin to control the salinity of water delivered to users in the United States and Mexico.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Colorado River Basin Salinity Control Act".

Colorado River Basin Salinity Control Act. 43 USC 1571 note.

TITLE I—PROGRAMS DOWNSTREAM FROM IMPERIAL DAM

SEC. 101. (a) The Secretary of the Interior, hereinafter referred to as the "Secretary", is authorized and directed to proceed with a program of works of improvement for the enhancement and protection of the quality of water available in the Colorado River for use in the United States and the Republic of Mexico, and to enable the United States to comply with its obligations under the agreement with Mexico of August 30, 1973 (Minute No. 242 of the International Boundary and Water Commission, United States and Mexico), concluded pursuant to the Treaty of February 3, 1944 (TS 994), in accordance with the provisions of this Act.

U.S. and Mexico, water quality improvement. 43 USC 1571.

TIAS 7708. 59 Stat. 1219.

(b)(1) The Secretary is authorized to construct, operate, and maintain a desalting complex, including (1) a desalting plant to reduce the salinity of drain water from the Wellton-Mohawk division of the Gila project, Arizona (hereinafter referred to as the division), including a pretreatment plant for settling, softening, and filtration of the drain water to be desalted; (2) the necessary appurtenant works including the intake pumping plant system, product waterline, power transmission facilities, and permanent operating facilities; (3) the necessary extension in the United States and Mexico of the existing bypass drain to carry the reject stream from the desalting plant and other drainage waters to the Santa Clara Slough in Mexico, with the part in Mexico, subject to arrangements made pursuant to section 101(d); (4) replacement of the metal flume in the existing main outlet drain extension with a concrete siphon; (5) reduction of the quantity of irrigation return flows through acquisition of lands to reduce the size of the division, and irrigation efficiency improvements to minimize return flows; (6) acquire on behalf of the United States such lands or interest in lands in the Painted Rock Reservoir as may be necessary to operate the project in accordance with the obligations of Minute No. 242, and (7) all associated facilities including roads, railroad spur, and transmission lines.

Desalting complex, construction and maintenance.

(2) The desalting plant shall be designed to treat approximately one hundred and twenty-nine million gallons a day of drain water using advanced technology commercially available. The plant shall effect recovery initially of not less than 70 per centum of the drain water as product water, and shall effect reduction of not less than 90 per centum of the dissolved solids in the feed water. The Secretary shall use sources of electric power supply for the desalting complex that will not diminish the supply of power to preference customers from Federal power systems operated by the Secretary. All costs associated with the desalting plant shall be nonreimbursable.

Desalting plants, treatment capacity.

Nonreimbursable

88 STAT. 267

Replacement water, studies.

59 Stat. 1219.

82 Stat. 887. 43 USC 1512.

(c) Replacement of the reject stream from the desalting plant and of any Wellton-Mohawk drainage water bypassed to the Santa Clara Slough to accomplish essential operation except at such times when there exists surplus water of the Colorado River under the terms of the Mexican Water Treaty of 1944, is recognized as a national obligation as provided in section 202 of the Colorado River Basin Project Act (82 Stat. 895). Studies to identify feasible measures to provide adequate replacement water shall be completed not later than June 30, 1980. Said studies shall be limited to potential sources within the States of Arizona, California, Colorado, New Mexico, and those portions of Nevada, Utah, and Wyoming which are within the natural drainage basin of the Colorado River. Measures found necessary to replace the reject stream from the desalting plant and any Wellton-Mohawk drainage bypassed to the Santa Clara Slough to accomplish essential operations may be undertaken independently of the national obligation set forth in section 202 of the Colorado River Basin Project Act.

U.S. section, IBWC, funds, advance.

TIAS 7708.

(d) The Secretary is hereby authorized to advance funds to the United States section, International Boundary and Water Commission (IBWC), for construction, operation, and maintenance by Mexico pursuant to Minute No. 242 of that portion of the bypass drain within Mexico. Such funds shall be transferred to an appropriate Mexican agency, under arrangements to be concluded by the IBWC providing for the construction, operation, and maintenance of such facility by Mexico.

Desalted water exchange.

(e) Any desalted water not needed for the purposes of this title may be exchanged at prices and under terms and conditions satisfactory to the Secretary and the proceeds therefrom shall be deposited in the General Fund of the Treasury. The city of Yuma, Arizona, shall have first right of refusal to any such water.

Return flow reduction.

(f) For the purpose of reducing the return flows from the division to one hundred and seventy-five thousand acre-feet or less, annually, the Secretary is authorized to:

(1) Accelerate the cooperative program of Irrigation Management Services with the Wellton-Mohawk Irrigation and Drainage District, hereinafter referred to as the district, for the purpose of improving irrigation efficiency. The district shall bear its share of the cost of such program as determined by the Secretary.

Irrigable acreage reduction.

43 USC 613. Limitation.

(2) Acquire, by purchase or through eminent domain or exchange, to the extent determined by him to be appropriate, lands or interests in lands to reduce the existing seventy-five thousand developed and undeveloped irrigable acres authorized by the Act of July 30, 1947 (61 Stat. 628), known as the Gila Reauthorization Act. The initial reduction in irrigable acreage shall be limited to approximately ten thousand acres. If the Secretary determines that the irrigable acreage of the division must be reduced below sixty-five thousand acres of irrigable lands to carry out the purpose of this section, the Secretary is authorized, with the consent of the district, to acquire additional lands, as may be deemed by him to be appropriate.

Acquired lands, disposal.

(g) The Secretary is authorized to dispose of the acquired lands and interests therein on terms and conditions satisfactory to him and meeting the objective of this Act.

System improvements, installation assistance.

(h) The Secretary is authorized, either in conjunction with or in lieu of land acquisition, to assist water users in the division in installing system improvements, such as ditch lining, change of field layouts, automatic equipment, sprinkler systems and bubbler systems, as a means of increasing irrigation efficiencies: *Provided, however,* That all costs associated with the improvements authorized herein and allocated to the water users on the basis of benefits received, as determined by the Secretary, shall be reimbursed to the United States in amounts and on terms and conditions satisfactory to the Secretary. Costs, reimbursement to U.S.

(i) The Secretary is authorized to amend the contract between the United States and the district dated March 4, 1952, as amended, to provide that— Contract amendment.

(1) the portion of the existing repayment obligation owing to the United States allowable to irrigable acreage eliminated from the division for the purposes of this title, as determined by the Secretary, shall be nonreimbursable; and

(2) if deemed appropriate by the Secretary, the district shall be given credit against its outstanding repayment obligation to offset any increase in operation and maintenance assessments per acre which may result from the district's decreased operation and maintenance base, all as determined by the Secretary.

(j) 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 acquisition 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. Land acquisition for storage. TIAS 7708.

(k) To the extent desirable to carry out sections 101(f)(1) and 101(h), the Secretary may transfer funds to the Secretary of Agriculture as may be required for technical assistance to farmers, conduct of research and demonstrations, and such related investigations as are required to achieve higher on-farm irrigation efficiencies. Transfer of funds.

(l) All cost associated with the desalting complex shall be nonreimbursable except as provided in sections 101(f) and 101(h). Nonreimbursable costs.

Sec. 102. (a) To assist in meeting salinity control objectives of Minute No. 242 during an interim period, the Secretary is authorized to construct a new concrete-lined canal or, to line the presently unlined portion of the Coachella Canal of the Boulder Canyon project, California, from station 2 plus 26 to the beginning of siphon numbered 7, a length of approximately forty-nine miles. The United States shall be entitled to temporary use of a quantity of water, for the purpose of meeting the salinity control objectives of Minute No. 242, during an interim period, equal to the quantity of water conserved by constructing or lining the said canal. The interim period shall commence on completion of construction or lining said canal and shall end the first year that the Secretary delivers main stream Colorado River water to California in an amount less than the sum of the quantities requested by (1) the California agencies under contracts made pursuant to section 5 of the Boulder Canyon Project Act (45 Stat. 1057), and (2) Federal establishments to meet their water rights acquired in California in accordance with the Supreme Court decree in Arizona against California (376 U.S. 340). Canal or canal lining, construction. 43 USC 1572. 43 USC 617d.

(b) The charges for total construction shall be repayable without interest in equal annual installments over a period of forty years beginning in the year following completion of construction: *Provided*, Repayment.

Repayment contract.

That, repayment shall be prorated between the United States and the Coachella Valley County Water District, and the Secretary is authorized to enter into a repayment contract with Coachella Valley County Water District for that purpose. Such contract shall provide that annual repayment installments shall be nonreimbursable during the interim period, defined in section 102(a) of this title and shall provide that after the interim period, said annual repayment installments or portions thereof, shall be paid by Coachella Valley County Water District.

Private lands, acquisition.

(c) The Secretary is authorized to acquire by purchase, eminent domain, or exchange private lands or interests therein, as may be determined by him to be appropriate, within the Imperial Irrigation District on the Imperial East Mesa which receive, or which have been granted rights to receive, water from Imperial Irrigation District's capacity in the Coachella Canal. Costs of such acquisitions shall be nonreimbursable and the Secretary shall return such lands to the public domain. The United States shall not acquire any water rights by reason of this land acquisition.

Imperial Irrigation District, construction charges, credit.

(d) The Secretary is authorized to credit Imperial Irrigation District against its final payments for certain outstanding construction charges payable to the United States on account of capacity to be relinquished in the Coachella Canal as a result of the canal lining program, all as determined by the Secretary: *Provided*, That, relinquishment of capacity shall not affect the established basis for allocating operation and maintenance costs of the main All-American Canal to existing contractors.

Cocopah Tribe of Indians, transfer of lands by U.S.

(e) The Secretary is authorized and directed to cede the following land to the Cocopah Tribe of Indians, subject to rights-of-way for existing levees, to be held in trust by the United States for the Cocopah Tribe of Indians:

Township 9 south, range 25 west of the Gila and Salt River meridian, Arizona:

Section 25: Lots 18, 19, 20, 21, 22, and 23;

Section 26: Lots 1, 12, 13, 14, and 15;

Section 27: Lot 3; and all accretion to the above described lands.

Bridges, construction.

The Secretary is authorized and directed to construct three bridges, one of which shall be capable of accommodating heavy vehicular traffic, over the portion of the bypass drain which crosses the reservation of the Cocopah Tribe of Indians. The transfer of lands to the Cocopah Indian Reservation and the construction of bridges across the bypass drain shall constitute full and complete payment to said tribe for the rights-of-way required for construction of the bypass drain and electrical transmission lines for works authorized by this title.

43 USC 1573.

SEC. 103. (a) The Secretary is authorized to:

Well fields, construction and maintenance. TIAS 7708. 59 Stat. 1219.

(1) Construct, operate, and maintain, consistent with Minute No. 242, well fields capable of furnishing approximately one hundred and sixty thousand acre-feet of water per year for use in the United States and for delivery to Mexico in satisfaction of the 1944 Mexican Water Treaty.

Land acquisition.

(2) Acquire by purchase, eminent domain, or exchange, to the extent determined by him to be appropriate, approximately twenty-three thousand five hundred acres of lands or interests therein within approximately five miles of the Mexican border on the Yuma Mesa: *Provided, however*, That any such lands which are presently owned by the State of Arizona may be acquired or exchanged for Federal lands.

(3) Any lands removed from the jurisdiction of the Yuma Mesa Irrigation and Drainage District pursuant to clause (2) of this subsection which were available for use under the Gila Reauthorization Act (61 Stat. 628), shall be replaced with like lands within or adjacent to the Yuma Mesa division of the project. In the development of these substituted lands or any other lands within the Gila project, the Secretary may provide for full utilization of the Gila Gravity Main Canal in addition to contracted capacities.

Land replacement.
43 Stat. 1057.
43 USC 620.

(b) The cost of work provided for in this section, including delivery of water to Mexico, shall be nonreimbursable; except to the extent that the waters furnished are used in the United States.

Nonreimbursable costs.

Sec. 104. The Secretary is authorized to provide for modifications of the projects authorized by this title to the extent he determines appropriate for purposes of meeting the international settlement objective of this title at the lowest overall cost to the United States. No funds for any such modification shall be expended until the expiration of sixty days after the proposed modification has been submitted to the appropriate committees of the Congress, unless the Congress approves an earlier date by concurrent resolution. The Secretary shall notify the Governors of the Colorado River Basin States of such modifications.

Project modification.
43 USC 1574.

Sec. 105. The Secretary is hereby authorized to enter into contracts that he deems necessary to carry out the provisions of this title in advance of the appropriation of funds therefor.

Contract authority.
43 USC 1575.

Sec. 106. In carrying out the provisions of this title, the Secretary shall consult and cooperate with the Secretary of State, the Administrator of the Environmental Protection Agency, the Secretary of Agriculture, and other affected Federal, State, and local agencies.

Interagency cooperation.
43 USC 1576.

Sec. 107. Nothing in this Act shall be deemed to modify the National Environmental Policy Act of 1969, the Federal Water Pollution Control Act, as amended, or, except as expressly stated herein, the provisions of any other Federal law.

43 USC 1577.
83 Stat. 852.
42 USC 4321 note.
86 Stat. 816.
33 USC 1251 note.

Sec. 108. There is hereby authorized to be appropriated the sum of $121,500,000 for the construction of the works and accomplishment of the purposes authorized in sections 101 and 102, and $34,000,000 to accomplish the purposes of section 103, based on April 1973 prices, plus or minus such amounts as may be justified by reason of ordinary fluctuations in construction costs involved therein, and such sums as may be required to operate and maintain such works and to provide for such modifications as may be made pursuant to section 104. There is further authorized to be appropriated such sums as may be necessary to pay condemnation awards in excess of appraised values and to cover costs required in connection with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 90-646).

Appropriation.
43 USC 1578.

84 Stat. 1894.
42 USC 4601 note.

TITLE II—MEASURES UPSTREAM FROM IMPERIAL DAM

Sec. 201. (a) The Secretary of the Interior shall implement 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 in the States of California, Colorado, Utah, Arizona, Nevada, New Mexico, and Wyoming, held in Denver, Colorado, on April 26–27, 1972, under the authority of section 10 of the Federal Water Pollution Control Act (33 U.S.C. 1160), and approved by the Administrator of the Environmental Protection Agency on June 9, 1972.

43 USC 1591.
70 Stat. 506;
80 Stat. 1250.

88 STAT. 271

(b) The Secretary is hereby directed to expedite the investigation, planning, and implementation of the salinity control program generally as described in chapter VI of the Secretary's report entitled, "Colorado River Water Quality Improvement Program, February 1972".

Interagency cooperation.

(c) In conformity with section 201(a) of this title and the authority of the Environmental Protection Agency under Federal laws, the Secretary, the Administrator of the Environmental Protection Agency, and the Secretary of Agriculture are directed to cooperate and coordinate their activities effectively to carry out the objective of this title.

Salinity control units, construction and maintenance. 43 USC 1592.

SEC. 202. The Secretary is authorized to construct, operate, and maintain the following salinity control units as the initial stage of the Colorado River Basin salinity control program.

(1) The Paradox Valley unit, Montrose County, Colorado, consisting of facilities for collection and disposition of saline ground water of Paradox Valley, including wells, pumps, pipelines, solar evaporation ponds, and all necessary appurtenant and associated works such as roads, fences, dikes, power transmission facilities, and permanent operating facilities.

(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. Measures shall include lining of canals and laterals, and the combining of existing canals and laterals into fewer and more efficient facilities. Prior to initiation of construction of the Grand Valley unit the Secretary shall enter into contracts through which the agencies owning, operating, and maintaining the water distribution systems in Grand Valley, singly or in concert, will assume all obligations relating to the continued operation and maintenance of the unit's facilities to the end that the maximum reduction of salinity inflow to the Colorado River will be achieved. The Secretary is also authorized to provide, as an element of the Grand Valley unit, for a technical staff to provide information and assistance to water users on means and measures for limiting excess water applications to irrigated lands: *Provided*, That such assistance shall not exceed a period of five years after funds first become available under this title. The Secretary will enter into agreements with the Secretary of Agriculture to develop a unified control plan for the Grand Valley unit. The Secretary of Agriculture is directed to cooperate in the planning and construction of on-farm system measures under programs available to that Department.

(3) The Crystal Geyser unit, Utah, consisting of facilities for collection and disposition of saline geyser discharges; including dikes, pipelines, solar evaporation ponds, and all necessary appurtenant works including operating facilities.

(4) The Las Vegas Wash unit, Nevada, consisting of facilities for collection and disposition of saline ground water of Las Vegas Wash, including infiltration galleries, pumps, desalter, pipelines, solar evaporation facilities, and all appurtenant works including but not limited to roads, fences, power transmission facilities, and operating facilities.

43 USC 1593. Planning reports.

SEC. 203. (a) The Secretary is authorized and directed to—

(1) Expedite completion of the planning reports on the following units, described in the Secretary's report, "Colorado River Water Quality Improvement Program, February 1972":

(i) Irrigation source control:
Lower Gunnison
Uintah Basin
Colorado River Indian Reservation
Palo Verde Irrigation District
(ii) Point source control:
LaVerkin Springs
Littlefield Springs
Glenwood-Dotsero Springs
(iii) Diffuse source control:
Price River
San Rafael River
Dirty Devil River
McElmo Creek
Big Sandy River

(2) Submit each planning report on the units named in section 203(a)(1) of this title promptly to the Colorado River Basin States and to such other parties as the Secretary deems appropriate for their review and comments. After receipt of comments on a unit and careful consideration thereof, the Secretary shall submit each final report with his recommendations, simultaneously, to the President, other concerned Federal departments and agencies, the Congress, and the Colorado River Basin States.

Reports.

Submittal to President and Congress.

(b) The Secretary is directed—

(1) in the investigation, planning, construction, and implementation of any salinity control unit involving control of salinity from irrigation sources, to cooperate with the Secretary of Agriculture in carrying out research and demonstration projects and in implementing on-the-farm improvements and farm management practices and programs which will further the objective of this title;

Research and demonstration projects.

(2) to undertake research on additional methods for accomplishing the objective of this title, utilizing to the fullest extent practicable the capabilities and resources of other Federal departments and agencies, interstate institutions, States, and private organizations.

Sec. 204. (a) There is hereby created the Colorado River Basin Salinity Control Advisory Council composed of no more than three members from each State appointed by the Governor of each of the Colorado River Basin States.

Colorado River Basin Salinity Control Advisory Council.
43 USC 1594.
Establishment.
Duties.

(b) The Council shall be advisory only and shall—

(1) act as liaison between both the Secretaries of Interior and Agriculture and the Administrator of the Environmental Protection Agency and the States in accomplishing the purposes of this title;

(2) receive reports from the Secretary on the progress of the salinity control program and review and comment on said reports; and

(3) recommend to both the Secretary and the Administrator of the Environmental Protection Agency appropriate studies of further projects, techniques, or methods for accomplishing the purposes of this title.

Sec. 205. (a) The Secretary shall allocate the total costs of each unit or separable feature thereof authorized by section 202 of this title, as follows:

Costs, allocation.
43 USC 1595.

(1) In recognition of Federal responsibility for the Colorado River as an interstate stream and for international comity with Mexico, Federal ownership of the lands of the Colorado River Basin from which most of the dissolved salts originate, and the policy embodied in the Federal Water Pollution Control Act Amendments of 1972 (86 Stat. 816), 75 per centum of the total costs of construction, operation, maintenance, and replacement of each unit or separable feature thereof shall be nonreimbursable.

33 USC 1251 note.

(2) Twenty-five per centum of the total costs shall be allocated between the Upper Colorado River Basin Fund established by section 5(a) of the Colorado River Storage Project Act (70 Stat. 107) and the Lower Colorado River Basin Development Fund established by section 403(a) of the Colorado River Basin Project Act (82 Stat. 895), after consultation with the Advisory Council created in section 204(a) of this title and consideration of the following items:

43 USC 620d.

43 USC 1543.

(i) benefits to be derived in each basin from the use of water of improved quality and the use of works for improved water management;

(ii) causes of salinity; and

(iii) availability of revenues in the Lower Colorado River Basin Development Fund and increased revenues to the Upper Colorado River Basin Fund made available under section 205(d) of this title: *Provided*, That costs allocated to the Upper Colorado River Basin Fund under section 205(a)(2) of this title shall not exceed 15 per centum of the costs allocated to the Upper Colorado River Basin Fund and the Lower Colorado River Basin Development Fund.

Costs, limitation.

(3) Costs of construction of each unit or separable feature thereof allocated to the upper basin and to the lower basin under section 205(a)(2) of this title shall be repaid within a fifty-year period without interest from the date such unit or separable feature thereof is determined by the Secretary to be in operation.

Construction costs, repayment.

(b)(1) Costs of construction, operation, maintenance, and replacement of each unit or separable feature thereof allocated for repayment by the lower basin under section 205(a)(2) of this title shall be paid in accordance with subsection 205(b)(2) of this title, from the Lower Colorado River Basin Development Fund.

(2) Section 403(g) of the Colorado River Basin Project Act (82 Stat. 896) is hereby amended as follows: strike the word "and" after the word "Act," in line 8; insert after the word "Act," the following "(2) for repayment to the general fund of the Treasury the costs of each salinity control unit or separable feature thereof payable from the Lower Colorado River Basin Development Fund in accordance with sections 205(a)(2), 205(a)(3), and 205(b)(1) of the Colorado River Salinity Control Act and"; change paragraph (2) to paragraph (3).

43 USC 1543.

(c) Costs of construction, operation, maintenance, and replacement of each unit or separable feature thereof allocated for repayment by the upper basin under section 205(a)(2) of this title shall be paid in accordance with section 205(d) of this title from the Upper Colorado River Basin Fund within the limit of the funds made available under section 205(e) of this title.

(d) Section 5(d) of the Colorado River Storage Project Act (70 Stat. 108) is hereby amended as follows: strike the word "and" at the end of paragraph (3); strike the period after the word "years" at the end of paragraph (4) and insert a semicolon in lieu thereof followed by the word "and"; add a new paragraph (5) reading:

43 USC 620d.

"(3) the costs of each salinity control unit or separable feature thereof payable from the Upper Colorado River Basin Fund in accordance with sections 205(a)(2), 205(a)(3), and 205(c) of the Colorado River Salinity Control Act.".

Electrical energy rates, adjustments.

(e) The Secretary is authorized to make upward adjustments in rates charged for electrical energy under all contracts administered by the Secretary under the Colorado River Storage Project Act (70 Stat. 105, 43 U.S.C. 620) as soon as practicable and to the extent necessary to cover the costs of construction, operation, maintenance, and replacement of units allocated under section 205(a)(2) and in conformity with section 205(a)(3) of this title: *Provided*, That revenues derived from said rate adjustments shall be available solely for the construction, operation, maintenance, and replacement of salinity control units in the Colorado River Basin herein authorized.

Report to President, Congress and Advisory Council. 43 USC 1595.

SEC. 206. Commencing on January 1, 1975, and every two years thereafter, the Secretary shall submit, simultaneously, to the President, the Congress, and the Advisory Council created in section 204(a) of this title, a report on the Colorado River salinity control program authorized by this title covering the progress of investigations, planning, and construction of salinity control units for the previous fiscal year, the effectiveness of such units, anticipated work needed to be accomplished in the future to meet the objectives of this title, with emphasis on the needs during the five years immediately following the date of each report, and any special problems that may be impeding progress in attaining an effective salinity control program. Said report may be included in the biennial report on the quality of water of the Colorado River Basin prepared by the Secretary pursuant to section 15 of the Colorado River Storage Project Act (70 Stat. 111; 43 U.S.C. 620n), section 15 of the Navajo Indian irrigation project, and the initial stage of the San Juan Chama Project Act (76 Stat. 102), and section 6 of the Fryingpan-Arkansas Project Act (76 Stat. 393).

43 USC 620n. 43 USC 615ww. 43 USC 616c. 43 USC 1597.

SEC. 207. Except as provided in section 205(b) and 205(d) of this title, with respect to the Colorado River Basin Project Act and the Colorado River Storage Project Act, respectively, nothing in this title shall be construed to alter, amend, repeal, modify, interpret, or be in conflict with the provisions of the Colorado River Compact (45 Stat. 1057), the Upper Colorado River Basin Compact (63 Stat. 31), the Water Treaty of 1944 with the United Mexican States (Treaty Series 994; 59 Stat. 1219), the decree entered by the Supreme Court of the United States in Arizona against California and others (376 U.S. 340), the Boulder Canyon Project Act (45 Stat. 1057), Boulder Canyon Project Adjustment Act (54 Stat. 774; 43 U.S.C. 618a), section 15 of the Colorado River Storage Project Act (70 Stat. 111; 43 U.S.C. 620n), the Colorado River Basin Project Act (82 Stat. 885), section 6 of the Fryingpan-Arkansas Project Act (76 Stat. 393), section 15 of the Navajo Indian irrigation project and initial stage of the San Juan-Chama Project Act (76 Stat. 102), the National Environmental Policy Act of 1969, and the Federal Water Pollution Control Act, as amended.

43 USC 1501 note. 83 Stat. 852. 42 USC 4321 note. 86 Stat. 816. 33 USC 1251 note.

Project modifications. Funds, expenditure. 43 USC 1598.

SEC. 208. (a) The Secretary is authorized to provide for modifications of the projects authorized by this title as determined to be appropriate for purposes of meeting the objective of this title. No funds for any such modification shall be expended until the expiration of sixty days after the proposed modification has been submitted to appropriate committees of the Congress, and not then if disapproved by said com-

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mittees, except that funds may be expended prior to the expiration of such sixty days in any case in which the Congress approves an earlier date by concurrent resolution. The Governors of the Colorado River Basin States shall be notified of these changes.

Contract authority. Appropriation.

(b) The Secretary is hereby authorized to enter into contracts that he deems necessary to carry out the provisions of this title, in advance of the appropriation of funds therefor. There is hereby authorized to be appropriated the sum of $125,100,000 for the construction of the works and for other purposes authorized in section 202 of this title, based on April 1973 prices, plus or minus such amounts as may be justified by reason of ordinary fluctuations in costs involved therein, and such sums as may be required to operate and maintain such works. There is further authorized to be appropriated such sums as may be necessary to pay condemnation awards in excess of appraised values and to cover costs required in connection with the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646).

84 Stat. 1894. 42 USC 4601 note.

43 USC 1599.

SEC. 209. As used in this title—

(a) all terms that are defined in the Colorado River Compact shall have the meanings therein defined;

"Colorado River Basin States."

(b) "Colorado River Basin States" means the States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming.

Approved June 24, 1974.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 93-1057 (Comm. on Interior and Insular Affairs).
SENATE REPORT No. 93-906 accompanying S. 2940 (Comm. on Interior and Insular Affairs).
CONGRESSIONAL RECORD, Vol. 120 (1974):
June 11, considered and passed House.
June 12, considered and passed Senate, amended, in lieu of S. 2940.
June 13, House concurred in Senate amendment.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 10, No. 26:
June 24, Presidential statement.

APPENDIX F
COLORADO RIVER SYSTEM SALINITY CONTROL POLICY AND STANDARDS PROCEDURES

Title 40—Protection of Environment

CHAPTER I—ENVIRONMENTAL PROTECTION AGENCY

[FRL 298-8]

PART 120—WATER QUALITY STANDARDS

Colorado River System; Salinity Control Policy and Standards Procedures

The purpose of this notice is to amend 40 CFR Part 120 to set forth a salinity control policy and procedures and requirements for establishing water quality standards for salinity and a plan of implementation for salinity control in the Colorado River System which lies within the States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming pursuant to section 303 of the Federal Water Pollution Control Act, as amended (33 U.S.C. 1313). A notice proposing such policy and standards procedures was issued on June 10, 1974 (39 FR 20703, 39 FR 24517).

High salinity (total dissolved solids) is recognized as a significant water quality problem causing adverse impacts on water uses. Salinity concentrations are affected by two basic processes: (a) Salt loading—the addition of mineral salts from various natural and man-made sources, and (b) salt concentrating—the loss of water from the system through stream depletion.

Studies to date have demonstrated that the high salinity of stream systems can be alleviated. Although further study may be required to determine the economic and technical feasibility of controlling specific sources, sufficient information is available to develop a salinity control program.

Salinity standards for the Colorado River System would be useful in the formulation of an effective salinity control program. In developing these standards, the seven States must cooperate with one another and the Federal Government to support and implement the conclusions and recommendations adopted April 27, 1972, by the reconvened 7th Session of the Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and its Tributaries.

Public hearings on the proposed regulation were held in Las Vegas, Nevada, on August 19, 1974, and in Denver, Colorado, on August 21, 1974. Public comments were provided at the hearings and also by letter during the review period. A summary of major comments and Environmental Protection Agency response follows:

(1) The Colorado River Basin Salinity Control Forum stated that it did not object to the proposed regulation, and believed that it satisfied the requirements of section 303(b)(2) of P.L. 92-500 until October 18, 1975. The Forum reported that the seven Colorado River Basin States were actively working on the development of water quality standards and a plan of implementation for salinity control.

(2) The Colorado River Water Conservation District inquired as to whether the definition of the Colorado River Basin contained in Article II(f) of the Colorado River Compact of 1922 would be followed in the development of salinity standards and the salinity control plan.

The requirement for establishing water quality standards and an implementation plan apply to the Colorado River System as defined in Part 120.5(a) of this regulation. This definition is consistent with the definition of the Colorado River System contained in Article II(a) of the Compact. The regulation states that the salinity problem shall be treated as a basinwide problem. Articles II(f) and II(g) define the Basin to include the System plus areas outside the drainage area which are served by the Colorado River System. The Environmental Protection Agency (EPA) will require that the standards and implementation plan consider the impacts of basinwide uses, e.g., transmountain diversions, on salinity effects in the System, but the establishment of standards and implementation plans pursuant to this regulation will not be required for streams located outside the System.

The District also questioned the feasibility of relying on irrigation improvement programs as a means of alleviating the salinity problem.

EPA believes that adequate information is available to initiate controls for irrigated agriculture, yet at the same time acknowledges that additional work is needed to demonstrate the efficacy of certain control measures. Projects presently being supported by EPA and others should demonstrate the adequacy of various control measures including management and non-structural techniques. These measures will be considered during the development of the implementation plan.

(3) The Environmental Defense Fund (EDF) testified that it believed that EPA was not complying with the requirements of the Federal Water Pollution Control Act, as amended, chiefly because of EPA's late response to the timetable delineated in the Act for establishing standards, and also because numerical standards still have not been set for the Colorado River System. EDF called upon EPA to withdraw the proposed regulation and promptly promulgate numerical limits for salinity.

EPA believes that a move to promulgate numerical standards at this time could cause even further delays in controlling salinity due to the problems involved with obtaining interstate cooperation and public acceptance of such a promulgation.

(4) The Sierra Club raised a number of objections to the proposed regulation, principally because, in its opinion, it permits further development of the waters of the Colorado River without requiring that adequate salinity controls be on line prior to development. Specific suggestions are:

(a) Section 120.5(c)(2). Shorten the deadline for submission of the standards and implementation plan to May 30, 1975.

EPA believes that this would not allow adequate time due to the complexities of the problem, the interstate coordination needed and the time requirements for public hearings. The October 18, 1975, date is consistent with the requirements of the Federal Water Pollution Control Act, as amended, for the three year review and revision of standards. The schedule set forth by the Colorado River Basin Salinity Control Forum calls for development of draft standards and an implementation plan by February 1975 in order to allow time for public participation prior to promulgation.

(b) Section 120.5(c)(2). Delete "as expeditiously as practicable."

The date of July 1, 1983, remains the goal for accomplishment of implementation plans as stated in § 120.5(c)(2)(iii). It is the purpose of this language to accelerate progress by the States toward this goal where possible.

(c) Section 120.5(c)(2)(ii). Delete "while the basin States continue to develop their compact apportioned waters."

In recognition of the provisions of the Colorado River Compact of 1922 and until such time that the relationship between the Compact and the Federal Water Pollution Control Act, as amended, is clarified, EPA believes that development may proceed provided that measures are taken to offset the salinity increases resulting from further development.

(d) Section 120.5(c)(2)(iv). Add language to describe conditions under which temporary increases above the 1972 levels will be allowed.

EPA believes that this matter should be addressed in further detail in the formulation, review and acceptance of the implementation plan, not in the regulation.

(e) Add a new subsection on financing of control measures.

EPA believes that this, too, is an issue that should be handled as part of the implementation plan.

(f) Add a new subsection delineating requirements for evaluating control plans and restricting consideration of controls for the Blue Spring on the Little Colorado River.

EPA believes these issues should also be addressed as part of the implementation plan. It should be noted that nothing in this regulation removes the requirement for assessing environmental impacts and preparing environmental impact statements for control measures.

(g) Add a new section requiring public hearings.

EPA's public participation regulations appear at 40 CFR 105 and apply to all actions to be taken by the States and Federal Government pursuant to the Act. States have provided for public participation throughout the initial water quality standards review process. We expect the States to do so in this situation and see no need to set forth additional requirements.

(h) Add a new section stating that the implementation plan will be published in the FEDERAL REGISTER.

EPA expects there will be substantial public participation at the State and local level prior to adoption of the plan. The salinity standards are expected to be published in the FEDERAL REGISTER, but the size and complexity of the plan may militate against its publication. At the very least, the plan will be available for review at appropriate EPA and State offices. Notice of its availability will be published in the FEDERAL REGISTER, and 60 days will be allowed for public review and comment.

(i) Add a new subsection stating that EPA will promulgate standards if the States fail to do so as prescribed in this regulation.

Section 303 of the Federal Water Pollution Control Act provides for promulgation by EPA where the States fail to adopt standards requested by the Administrator, or where the Administrator determines Federal promulgation is necessary to carry out the purposes of the Act. EPA's responsibility to promulgate standards if the States fail to do so is thus expressed in the statute itself; the Agency does not believe that recitation of the statutory duty in this particular rulemaking is necessary.

(5) The American Farm Bureau Federation, California Farm Bureau Federation, Nevada Farm Bureau Federation, and the New Mexico Farm and Livestock Bureau believe that standards should not be set until further evaluation of the problems and opportunities for control are completed.

EPA believes that adequate information is available for setting standards and formulating controls, and while it recognizes that additional work is needed on specific aspects of solutions, it believes that further delay without any action is not appropriate.

Records of the hearings and comments received by letter during the review period are available for public inspection at the regional offices of the Environmental Protection Agency at 1860 Lincoln Street in Denver, Colorado, at 100 California Street in San Francisco, California, at 1600 Patterson Street in Dallas, Texas, and at the Environmental Protection Agency Freedom of Information Center at 401 M Street SW in Washington, D.C.

This regulation sets forth a policy of maintaining salinity concentrations in the lower main stem of the Colorado River at or below 1972 average levels and requires the Colorado River System States to promulgate water quality standards and a plan for meeting the standards. The first step will be the establishment of procedures within 30 days of the effective date of these regulations which will lead to adoption on or before October 18, 1975, of water quality standards for salinity including numeric criteria and an implementation plan for salinity control.

Except as provided in this regulation, the interstate and intrastate standards previously adopted by the States of Arizona, California, Colorado, Nevada, New Mexico, Utah and Wyoming and approved by the Environmental Protection

Agency are the effective water quality standards under section 303 of the Act for interstate and intrastate waters within those States. Where the regulations set forth below are inconsistent with the referenced state standards, these regulations will supersede such standards to the extent of the inconsistency.

In consideration of the foregoing, 40 CFR Part 120 is amended as follows:

1. Section 120.5 is added to read as set forth below:

§ 120.5 *Colorado River System Salinity Standards and Implementation Plan.*

(a) "Colorado River System" means that portion of the Colorado River and its tributaries within the United States of America.

(b) It shall be the policy that the flow weighted average annual salinity in the lower main stem of the Colorado River System be maintained at or below the average value found during 1972. To carry out this policy, water quality standards for salinity and a plan of implementation for salinity control shall be developed and implemented in accordance with the principles of paragraph (c) below.

(c) The States of Arizona, California, Colorado, Nevada, New Mexico, Utah, and Wyoming are required to adopt and submit for approval to the Environmental Protection Agency on or before October 18, 1975:

(1) Adopted water quality standards for salinity including numeric criteria consistent with the policy stated above for appropriate points in the Colorado River System; and,

(2) A plan to achieve compliance with these standards as expeditiously as practicable providing that:

(i) The plan shall identify State and Federal regulatory authorities and programs necessary to achieve compliance with the plan.

(ii) The salinity problem shall be treated as a basinwide problem that needs to be solved in order to maintain lower main stem salinity at or below 1972 levels while the basin States continue to develop their compact apportioned waters.

(iii) The goal of the plan shall be to achieve compliance with the adopted standards by July 1, 1983. The date of compliance with the adopted standards shall take into account the necessity for Federal salinity control actions set forth in the plan. Abatement measures within the control of the States shall be implemented as soon as practicable.

(iv) Salinity levels in the lower main stem may temporarily increase above the 1972 levels if control measures to offset the increases are included in the control plan. However, compliance with 1972 levels shall be a primary consideration.

(v) The feasibility of establishing an interstate institution for salinity management shall be evaluated.

(d) The States are required to submit to the respective Environmental Protection Agency Regional Administrator established procedures for achieving (c) (1) and (c) (2) above within 30 days of the effective date of these regulations and to submit progress reports quarterly thereafter. EPA will on a quarterly basis determine the progress being made in the development of salinity standards and the implementation plan.

§ 120.10 [Amended]

§ 120.10 is amended by adding to the paragraphs entitled "Arizona", "California", "Colorado", "Nevada", "New Mexico", "Utah", and "Wyoming" a salinity control policy and procedures and requirements for establishing water quality standards for salinity control in the Colorado River System.

(Sec. 303, Pub. L. 92-500, 86 Stat. 816 (33 U.S.C. 1313))

Effective date: December 18, 1974.

Dated: December 11, 1974.