Utah State Water Plan

WEST COLORADO RIVER BASIN

Division of Water Resources

August 2000

State Water Plan - West Colorado River Basin

Section

1	Foreword
2	Executive Summary
3	Introduction
4	Demographics and Economic Future
5	Water Supply and Use
6	Management
7	Regulation/Institutional Considerations
8	Water Funding Programs
9	Water Planning and Development
10	Agricultural Water
11	Drinking Water
12	Water Quality
13	Disaster and Emergency Response
14	Fisheries and Water-Related Wildlife
15	Water-Related Recreation
16	Federal Water Planning and Development
17	Water Conservation
18	Industrial Water
19	Groundwater
A	Acronyms
B	Bibliography

State Water Plan

West Colorado River Basin

Utah Board of Water Resources
1594 West North Temple, Suite 310
Salt Lake City, UT 84114-6201

August 2000

Section 1

West Colorado River Basin - Utah State Water Plan

Foreword

A *State Water Plan* was distributed in early 1990 to provide the foundation for establishment of state water policy. Within the framework of water policy planning, the state meets its obligation to plan and implement programs to best serve the needs of the people.

In addition to the *State Water Plan*, more detailed plans are being prepared for each of the 11 river basins. The West Colorado River basin is one of these. This plan discusses water and water-related problems, needs, demands and alternatives for potential conservation and development measures. Final selection of alternatives will rest with local decision makers.

Like the *State Water Plan,* this basin plan is designed to be flexible. Continuous re-evaluation is needed to identify adjustments that can be made to the plan to reflect changing situations. Planning needs the active participation of all concerned entities and individuals and their responses to issues. The success of this planning process is enhanced through public involvement, resulting in broader support to implement recommendations. In addition, there is a greater need for coordination at all levels of government. Progress is more difficult when individual agendas are fostered. This basin plan is intended to help bring about greater coordination between those involved to assure the needs and demands of the local people are met. ●

Cleal Bradford, Chair

Warren Peterson

Lucille G. Taylor, Vice Chair

J. Paul Riley

Dr. M. Karlynn Hinman

Larry S. Ross

Bill Marcovecchio

Harold Shirley

Section 2 - West Colorado River Basin
Executive Summary

2.1	Foreword	2-1
2.3	Introduction	2-1
2.4	Demographics and Economic Future	2-2
2.5	Water Supply and Use	2-2
2.6	Management	2-3
2.7	Regulation/Institutional Considerations	2-3
2.8	Water Funding Programs	2-4
2.9	Water Planning and Development	2-4
2.10	Agricultural Water	2-5
2.11	Drinking Water	2-5
2.12	Water Quality	2-5
2.13	Disaster and Emergency Response	2-6
2.14	Fisheries and Water-Related Wildlife	2-6
2.15	Water-Related Recreation	2-7
2.16	Federal Water Planning and Development	2-7
2.17	Water Conservation	2-7
2.18	Industrial Water	2-8
2.19	Groundwater	2-8

Section 2

West Colorado River Basin - Utah State Water Plan

Executive Summary

This section summarizes sections 1 and 3 through 19 of the *West Colorado River Basin Plan*. This basin plan contains 19 sections and is modeled after the *State Water Plan* (1990). In addition, it contains Section A, Acronyms, Abbreviations and Definitions, and Section B, Bibliography. Individual sections should be studied for more detailed

2.1 Foreword

The *State Water Plan* provides a foundation for state water policy. This helps the state meet its obligation to implement programs to best serve the needs of the people.

More detailed plans have been prepared for the Bear River, Cedar/Beaver, Kanab Creek/Virgin River, Jordan River, Sevier River, Utah Lake and Weber River and Uinta Basin hydrologic basins. Plans of the remaining basins will be completed by late 2000. This plan was prepared under the direction of the Board of Water Resources.

The West Colorado River Basin is unique in that it is actually made up of five separate river drainages that flow into the Colorado River System. These are the Price, San Rafael, Dirty Devil (made up of Muddy Creek and the Fremont River), Escalante and Paria rivers.

2.3 Introduction

Water planning has always been a part of Utah's history. Preparation of this plan has involved many local, state and federal entities, as well as members of the public, who are involved in and have expertise in water resources.

The West Colorado River Basin is located in south-central Utah. It covers nearly 9.8 million acres (15,000 square miles) which contain large variations in topography, climate, soils and vegetation. Elevations range from 11,530 feet to about 3,700 feet with precipitation ranging from more than 30 inches to less than 8 inches. Growing seasons in agricultural areas range from 163 days at Green River to 88 days at Loa. The geologic parent materials provide a wide variety of soils producing vegetation from alpine conifer forest complexes to mostly desert shrubs and grasses. Private lands cover only about 8 percent of the area, while federally administered lands account for 86 percent and state lands 6 percent.

The West Colorado River Basin contains some of the nation's finest natural scenic areas including Capitol Reef National Park and portions of Bryce Canyon National Park, Canyonlands National Park, Glen Canyon National Recreation Area (Lake Powell) and the new Grand Staircase-Escalante National Monument. Three national forests and eight state parks are also located within the basin boundaries.

Although the Anasazi, Fremont and Sevier cultures may have irrigated land for crops as early as 1,500 years ago, livestock grazers from Sanpete County settling in Emery County in the late 1800's were the first modern irrigators. Settlements soon sprang up all around the basin along with small developments for culinary and irrigation water.

Construction of storage reservoirs became necessary to manage the basin's water resources around 1900. In 1917 Carbon County began to develop its water resources with the attempted construction of Mammoth Dam (100 feet downstream of Scofield Dam). This dam failed, but the first Scofield dam was completed in 1926 to irrigate about 25,000 acres near Price in Carbon County. The dam was eventually deemed unsafe, and the existing Scofield Dam was completed in 1946 as the first phase of the Bureau of Reclamation's (BOR) 1933 Gooseberry Project Plan. The BOR's Emery County Project was completed in 1966 and provides irrigation and power plant cooling water for much of western Emery County through Joes Valley and Huntington North reservoirs. Millsite Reservoir was funded by the Board of Water Resources and Department of Agriculture in 1971 as part of the SCS Ferron Watershed Project. This reservoir stores water used for agriculture, municipal and industrial uses around Ferron in Emery County. Utah Power completed Electric Lake in 1973 to provide water storage for the Huntington Power Plant.

Wayne County's largest storage projects began with the 1889 purchase of Fish Lake from the Paiute Indians. Johnson Valley Reservoir was built in 1899. Forsyth Reservoir was completed in 1917 to settle water right conflicts addressed in the 1902 McCarthy Court Decree. The Board of Water Resources financed the construction of Mill Meadow Reservoir in 1955. All of these store water for use in Rabbit Valley.

Garfield County's large storage reservoirs include Jacobs Valley, built in 1911 by the Pine Valley Irrigation Company, and Wide Hollow Reservoir, completed in 1954 by the New Escalante Irrigation Company. Both of these provide water for irrigation in and around Escalante.

Though not used for water storage in this basin, Lake Powell, located in Kane, Garfield and San Juan counties, provides 7.5 million acre-feet to the Lower Basin States (California, Nevada and Arizona) as required by the 1922 Colorado River Compact. This allows the Upper Basin States (Utah, Colorado, New Mexico and Wyoming), of which the West Colorado River Basin is part, to still develop its share of the river.

For the last 100 years, smaller water developments were built throughout the basin and provide numerous communities their existence. Even today, projects are still being planned and facilities built to make the best use of the water and related resources.

2.4 Demographics and Economic Future

The West Colorado River Basin is mostly controlled by the economics of the agricultural industry. However, in Carbon and Emery counties, coal mining, power production and government employment have the greatest impact on the regional economy. Price is the basin's largest city as well as the service and trade center for Carbon and Emery counties.

The 1998 population of the basin was about 38,400 people. The area is expected to grow to about 50,000 people by 2020. The annual growth rate is 1.2 percent, which is lower than the 2 percent overall state growth rate. Total job growth is expected to parallel the population. Presently, government services and trades are the leading employers. These will remain the leading employers in 2020. Also, tourism-related activities and employers will become bigger factors in the basin's economic future.

2.5 Water Supply and Use

Most of the water supply comes from precipitation in the five river drainages in the basin. This precipitation produces mainly surface water and some groundwater. Most of the precipitation is used directly by native vegetation (primarily in the upper watershed areas), some is also used by cultivated crops. Approximately 4.0 million acre-feet annually enter Lake Powell from the Green River, and 5.4 million acre-feet enter from the Colorado River. Over the last 20 years, about 10.7 million acre-feet annually has been released downstream through Glen Canyon Dam. Although flowing through the basin, very little of the water in the mainstems of the Green or Colorado rivers is used in Utah.

Total basin yield of the West Colorado River Basin is 630,000 acre-feet. The five river drainages in the basin are the Price, San Rafael, Dirty Devil, Escalante and the Paria. All of these begin in the high elevations of the Wasatch, Fishlake, Awapa, Aquarius or Paunsaugunt plateaus and then flow down to enter either the Green or Colorado river systems. There are 13 exports out of the West Colorado River Basin that deliver 9,340 acre-feet of water to the Sevier River Basin. Another small export of about 100 acre-feet is delivered out of the Price River drainage to the Indianola area in the Utah Lake Basin. The major import to the basin is 4,800 acre-feet delivered to the Tropic area through the Tropic Canal from the East Fork of the Sevier.

Groundwater is not a significant part of the developed water supply of the West Colorado River Basin. The only exception is the Upper Fremont Valley in Wayne County where wells and springs supply agriculture and municipal needs. Other areas of the basin have small amounts of developed groundwater which are utilized mostly by small municipalities.

Total diversions for agricultural irrigation are 295,050 acre-feet; culinary use, 14,600 acre-feet; and secondary lawn and garden, 8,367 acre-feet. Industrial use is 36,292 acre-feet. The four power plants in Carbon and Emery counties use about 32,000 acre-feet of this total. After water is diverted for use, the unused portion returns to the various river drainages as return flow eventually entering the Colorado River System.

Water quality deteriorates in all five major drainages as the flows move downstream. Water quality in the upper reaches is good with total dissolved-solids of around 200 mg/L. This increased substantially to about 3,600 mg/L at the mouth of the Price River, 1,600 mg/L at the mouth of the San Rafael River, 2,000 mg/L at the mouth of the Dirty Devil, 900 mg/L at the mouth of the Escalante River, and 1,700 mg/L at the mouth of the Paria River.

2.6 Management

Management of the water resources became imperative when demands exceeded the average long-term supply. Storage reservoirs were built, beginning with Scofield Reservoir on the Price River, in order to save water during high flows for later use. There are several water users' associations and water conservancy districts throughout the West Colorado River Basin which assist with water management and development. More than 40 major water storage reservoirs have been built by water users. Twelve mutual irrigation companies in the basin serve more than 1,000 acres each and an additional 30 irrigation companies serve less than 1,000 acres each. Also, 92 public drinking water systems serve 95 percent of the basin's population. The remaining population uses its own private sources.

The Colorado River Salinity Control Program is a federally funded management plan to control the salinity in the Colorado River. The Price-San Rafael Rivers Unit included in this basin will improve irrigation water management and irrigation efficiencies in Carbon and Emery counties to the degree that 161,000 tons of salt will be prevented from entering the Colorado River System.

A real-time monitoring system has been installed by the Emery Water Conservancy District to more efficiently manage its water supply. The issue at the end of this section addresses the possibility for more real-time monitoring stations.

2.7 Regulation/Institutional Considerations

State agencies are required by law to provide administrative control and regulatory authority over the state's water resources. The state engineer (the director of the Division of Water Rights) has responsibility for administering the state water rights and for dam safety programs. Three area offices (Price, Richfield, Cedar City) cover portions of the West Colorado River Basin. Currently, there are 17 high hazard reservoir dams located in the basin that could cause considerable property damage and possible loss of life if they failed.

Other entities also have responsibilities for managing certain aspects of the water resources. These include mutual irrigation companies, water conservancy districts, special service districts, drainage districts, and cities and towns. These entities can levy taxes and assessments for their maintenance and operation of their facilities.

Water quality regulations are administered by the Water Quality Board and the Drinking Water Board. The divisions of Water Quality and Drinking Water (Department of Environmental Quality), respectively, are staff for these two boards.

Water is an important part of our environment, making it possible to have healthy lives and pleasing surroundings. It is important to improve or at least maintain the quality of the water resources in order to provide a good, clean water supply for human use and for wildlife habitat.

Problems associated with summer home areas around Scofield, Joes Valley and Boulder Mountain possibly deteriorating the water quality of these local groundwater basins by the use of septic tanks needs to be monitored and controlled. Coal mine operations intercepting underground water affecting local water entity supplies in Carbon and Emery counties is a major issue discussed in this section. Better coordination between the Utah Department of Environmental Quality and the Department of Natural Resources divisions of Oil, Gas and Mining and Water Rights is needed, as well as improved cooperation between local mining companies and water entities.

2.8 Water Funding Programs

Funds have always been needed to develop water resources. In the days of early settlement, most of the funds came from local sources. With the construction of the Gooseberry Project, Emery County Project and the Ferron Watershed Project, the federal government began to provide major funding. Later, the state began to fund many water developments through the Board of Water Resources and the Drinking Water Board. Other boards and programs were also involved.

Many state and federal programs have funding available for water development, using either grants or loans or a combination of both. More than $30 million of state funds and $200 million of federal funds have been made available for water resource development in the basin. Since loan funds have to be repaid, much of this investment eventually comes out of the pockets of the local users.

2.9 Water Planning and Development

Since agriculture and the power industry in Carbon and Emery counties are the largest water users, management of the river systems is centered around meeting these demands. Development of more storage is needed to provide better water management for some users with only direct flow rights. Water quality (primarily salinity) and irrigation efficiencies in the Price and San Rafael River drainages are problems. The Price-San Rafael Rivers Unit of the Colorado River Salinity Control Program is currently being implemented to aid water users with these problems.

Total depletions for all uses were about 205,100 acre-feet for 1998. This is expected to increase to about 229,000 acre-feet by the year 2050. The extra water to meet this increased demand is expected to come from more efficient use of the existing supplies and water rights recently obtained from Flaming Gorge Reservoir through the Board of Water Resources.

Some potential water projects that could increase basin water depletions include the Gunnison Butte Mutual Irrigation Project in Green River, the Narrows Project serving irrigated lands in Sanpete County, and the Lake Powell pipeline serving communities in Kane and Washington counties. The latter two projects would be exports out of the West Colorado River Basin.

Some environmental factors could affect future water development basin-wide. These include proposed wilderness areas, wild and scenic river designation, and the newly formed Grand Staircase-Escalante National Monument. Currently there are 1,731,000 acres of BLM wilderness study areas in the West Colorado River Basin. An additional 1,523,000 acres are being considered.

Water education for young people is becoming more important. This is carried out through such programs as Project WET (Water Education for Teachers) and the Young Artists' Water Education Poster Contest. The goal of Project WET is to facilitate and promote awareness, appreciation, knowledge and stewardship of water resources. This is done by providing hands-on-training to public and private school teachers.

Major issues identified that could affect future water development and use in the basin are: 1) Preservation of potential reservoir sites, 2) proposed wilderness areas and wild and scenic rivers designations, 3) the need for long-range planning, and 4) draining Lake Powell.

2.10 Agricultural Water

Much of the economy of the West Colorado River Basin is centered around agriculture. The major agricultural operation is cow/calf and beef production. Most of the irrigated agriculture supports these operations.

The number of farms has decreased slightly over the years while the average farm size has increased. Presently, 295,050 acre-feet of water are diverted onto 91,924 acres of irrigated lands. About 285,050 acre-feet of this water is diverted from surface water supplies and 10,000 acre-feet from groundwater. The major crops are pasture, alfalfa, small grains, grass hay and corn silage. There is virtually no dry cropland in the West Colorado River Basin, although about 5,000 acres of irrigated pasture lands receive water only at the beginning of the irrigation season and remain dry thereafter.

Like most areas in Utah, the West Colorado River Basin does not have a full water supply for all the irrigable lands. Currently, 162,000 acre-feet is depleted annually. Problems with low on-farm application efficiencies affect some areas. In addition, overgrazing in the upper watersheds has caused some erosion problems. Increased water use efficiency and restoring and maintaining healthy watersheds can help to overcome these problems.

2.11 Drinking Water

About 60 percent of the 14,075 acre-feet annual public community drinking water supplies come from surface water treatment plants with the remainder from groundwater (either springs or wells). Systems are both publicly and privately owned, with 33 public community water systems and nearly 60 smaller public systems. These are all subject to the state and federal safe drinking water regulations.

Public community water systems delivered 10,504 acre-feet of culinary quality water during 1996. The basin-wide use was 253 gallons per capita per day, slightly lower than the 268 gpd state-wide average. Average use varied from 197 gallons per capita day in Emery County to 335 gallons per capita per day in Wayne County.

Future culinary water demands in the year 2020 will be over 19,000 acre-feet. Water to meet future demand will come from existing undeveloped rights for wells and springs. It is also possible that agricultural water rights will be converted to culinary use.

2.12 Water Quality

The highest water quality is found in the upper reaches of the drainages. As the water flows downstream in all of the basin's major drainages, the quality of the water deteriorates. The following water salinity data come from surface water measurements taken from recent studies: Price River near Scofield, 191 mg/l; Wellington, 1,585 mg/l; Price River at the mouth, 3,602 mg/l, Huntington Creek near Huntington, 193 mg/l; Cottonwood Creek near Orangeville, 227 mg/l; Ferron Creek near Ferron, 227 mg/l; San Rafael River near Castledale, 2,542 mg/l; Muddy Creek near Emery, 219 mg/l; Fremont River near Fremont, 123 mg/l; Fremont River near Caineville, 1,145 mg/l; Dirty Devil River near Hanksville, 2,043 mg/l; Escalante River near Escalante, 865 mg/l; and the Paria River near Glen Canyon, Utah, 1658 mg/l. The beneficial use classifications for the storage reservoirs and streams are mostly 2B and 3A. All water bodies had use Classification 4.

The Price, San Rafael and Dirty Devil rivers flow through areas of marine shales and sandstone surface geologic formations. Deep percolation from agricultural lands over the Mancos shale and saline soils and rocks can produce return flows having total dissolved solid levels approaching 4,000 milligrams per liter (mg/l).

The Price-San Rafael River Unit of the Colorado River Salinity Control Program would treat approximately 16,350 acres of farmland with gravity-pressure sprinkle irrigation, and about 9,650 acres with pump pressure sprinkle systems. This project will reduce salt loading to the Colorado River by 161,000 tons per year.

Two major issues discussed are the need for groundwater quality monitoring programs in the basin and specific monitoring of coal-bed methane gas industry saline water extraction and re-injection.

2.13 Disaster and Emergency Response

Natural disasters and other major emergencies are perennial problems. Water-related disasters are generally floods and droughts. Local governments have the responsibility to initiate the first action in response to a disaster or emergency. If an event is beyond the scope of local government, the governor can declare an emergency and make state assistance available. The Division of Comprehensive Emergency Management is the lead agency at the state level, coordinating state and, if necessary, federal assistance.

Flooding is the most frequent natural disaster. For this reason, flood-prone communities should have a flood insurance program in place. Flood plain maps have been prepared for most communities. Potential canal breaks above some communities could be a problem. Droughts can also have a disastrous impact, especially in prolonged situations.

Two major issues presented in this section concern flood plains and flood prevention. It is recommended non-participating communities should become qualified under the National Flood Insurance Program and establish flood water control committees. Another issue discusses the need for each county to prepare a drought response plan.

2.14 Fisheries and Water-Related Wildlife

A wide diversity of fish, wildlife and plant species is found in the basin, interacting to contribute to a fairly well-functioning ecosystem. Ten threatened or endangered species are found in the West Colorado River Basin. The basin supports 27 different species of sport fish. These range from trout at higher elevations of the drainages to warm water species at the lower elevations of Lake Powell. The Colorado River cutthroat trout is the only native sport fish, and the distribution of these fish in this basin is extremely limited. Recovery efforts are under way to restore this fish species in the West Colorado River Basin.

The Colorado and Green rivers, located within the basin, contain four endangered fish. These are the Colorado pikeminnow, humpback chub, bonytail chub and the razorback sucker. Utah, Colorado and Wyoming; the federal government; water users; and environmental groups have joined to create the Upper Colorado River Basin Endangered Species Recovery Program. The goal is to implement a program to recover and de-list these fish. The Utah Division of Wildlife Resources (DWR) currently manages Lake Powell as a sport fishery with inflowing tributaries managed for native fish. This reservoir receives more angling pressures than any other water in the basin.

Wetland areas provide food, cover and nesting sites for wildlife. The basin contains many acres of wetlands including about 26,000 acres of man-made wetlands located within irrigated cropland areas. The two managed wetlands in the West Colorado River Basin include Desert Lake Waterfowl Management Area near Emery in Emery County and Bicknell Bottoms near Bicknell in Wayne County.

Major issues discussed include: 1) The DWR should use best management practices to protect and enhance identified significant wetland and riparian areas, 2) a management plan should be set up to provide instream flows in Lower Fish Creek below

Scofield Reservoir, 3) conservation pools should be purchased to protect against winter fish kills in the basin's many storage reservoirs, 4) fish eradication and stocking projects should be conducted on these basin waters where introduced exotic fish species have negatively impacted populations of native fish, 5) private pond owners should follow established state policies to prevent the expansion of whirling disease, 6) coordination among all interested groups is needed in planning for future growth to offset the demand that tourism and increasing population is having on fish and wildlife resources in the state.

2.15 Water-Related Recreation

The reservoirs, clear streams, alpine scenery and world-class red rock plateaus of the West Colorado River Basin are prime attractions. Water is often the focal point for outdoor recreation whether it is involved directly or just part of the setting. Glen Canyon National Recreation Area, which contains Lake Powell, is a world class boating, swimming and fishing destination. The other federal parks, including Capitol Reef National Park, Bryce Canyon National Park, Canyonlands National Park and the new Grand Staircase-Escalante National Monument, all contain some water-related recreational opportunities. Also, the Division of Parks and Recreation (DPR) manages eight state parks in the basin, all having water as an on-site use or amenity. Local community parks are an important part of the scene, as are other federal recreation areas. Recreation visits to the West Colorado River Basin are popular and are increasing at an accelerating rate.

Two major issues discussed include: 1) The DPR and recreationists should obtain ideas to determine ways to reduce conflicts by unethical behavior in recreational settings, and 2) the DPR should continue to prepare and update management plans to achieve and balance the future use of water resources for recreation.

2.16 Federal Water Planning and Development

The federal role and involvement in planning and development is changing. Many past activities concerned development of the resource, but they are now oriented toward conservation and protection. The main concern is the part federal agencies should play, compared to state and local involvement. Coordinated planning and use is needed, especially with the large land areas which are administered by the federal government.

Major local projects with federal agency involvement include assistance with the real-time monitoring network by the Bureau of Reclamation, Glen Canyon Adaptive Management Workgroup, and watershed protection and flood prevention projects by the Natural Resources Conservation Service.

2.17 Water Conservation

Conservation is one of the most economical ways to make an existing water supply go farther. In many cases, it can be achieved without sacrificing our existing lifestyles. Water conservation was a way of life in the early days of settlement; it needs to be made a part of our lives again.

The culinary water use for 1996 in the West Colorado River Basin was 253 gallons per capita day (gpcd). This is under the statewide average use of 268 gpcd. Secondary water use for 1996 was 196 gpcd, compared to 56 gpcd statewide. The total per capita use is 449 gpcd, compare to a statewide average of 324 gpcd.

Several water conservation methods can be implemented. Conservation of irrigation water can be achieved through improving efficiencies. Culinary water use can be reduced by using low volume plumbing fixtures, increased outside watering application efficiencies, not watering during the day, replacing high water-using landscapes with vegetation using less water, and changing price rate structures. Also, education on water availability and use is another way to assure future generations will find the need for conservation.

Only one major issue is discussed. Local water providers should adopt water rate structures to encourage water conservation.

2.18 Industrial Water

Self-supplied industries are major water users in Carbon and Emery counties and an important part of the total water supply. Total self-supplied industrial water use is 36,292 acre-feet, of which 4,092 acre-feet is potable. Public community systems provide 359 acre-feet of the potable amount. Of the four coal-fired power plants operating in the basin, three are owned by Pacific Corp and one by Sunnyside Cogeneration Associates. Also, a small hydroelectric plant near Boulder is owned by GarKane Power.

Industrial requirements for water are not expected to increase significantly in the future. Future water requirements will total 41,310 acre-feet in 2020. Most of these increases will be for light industries using culinary water from existing public water suppliers.

2.19 Groundwater

Groundwater is not a major source of water in the West Colorado River Basin. This is due to several reasons: 1) The general absence throughout the basin of productive and easily developed alluvial aquifers, 2) the unfractured consolidated aquifers generally have hydraulic properties that are not conducive to large-scale groundwater development, 3) the quality of the groundwater in many parts of the basin is unsuitable for domestic, municipal, and/or agricultural uses, and 4) the economics of drilling and pumping water from deep buried consolidated aquifers is uneconomical for many of today's uses.

The West Colorado River Basin contains 4,900 springs and 1,386 wells. Average withdrawals from groundwater are 17,871 acre-feet. The quality of groundwater varies from good to poor, depending on the location and depth. Wells used for culinary purposes penetrate the deeper, better quality aquifers while those used for irrigation water are of lesser quality.

Past studies indicate there may be several million acre-feet of water in the Navajo Sandstone. This 400 to 1,600 feet thick aquifer underlies most of the West Colorado River Basin. More studies are needed to determine the quantity and quality of this future water source, as well as an economic analysis to determine its viability. ●

Section 3 - West Colorado River Basin

Introduction

3.1	Background	3-1
3.2	Planning Guidelines	3-1
3.3	Basin Description	3-2
3.4	Water-Related History	3-23

Figures

3-1	Location Map	3-3
3-2	Climatological Stations	3-10
3-3	Annual Precipitation	3-12
3-4	Grand Staircase	3-15
3-5	General Geology	3-16
3-6	Picture of San Rafael Swell	3-19
3-7	Soil Survey Areas	3-20
3-8	Colorado River Map	3-30

Tables

3-1	West Colorado River Basin Communities	3-5
3-2	Normal Temperatures and Frost-Free Days	3-11
3-3	Normal Precipitation and Evapotranspiration	3-13
3-4	Snow/Precipitation Data	3-14
3-5	Climatic Zones	3-21
3-6	Vegetative Types	3-22
3-7	Land Areas	3-24
3-8	Land Ownership and Administration	3-24
3-9	Federal Land Administration	3-24

Section 3

West Colorado River Basin - Utah State Water Plan

Introduction

3.1 Background

The people of Utah have always planned for the protection and use of water resources through cooperative efforts. State directed water planning was formalized by specific legislation in 1963 and re-emphasized in the 1980s. The *West Colorado River Basin Plan* is part of the *State Water Plan (1990)*, which describes a process for planning, conserving and developing the state's water resources and is another step in that process.

The *West Colorado River Basin Plan* covers all aspects of Utah's water Resources and has the flexibility to be changed as future conditions require.

3.2 Planning Guidelines [17]

The *State Water Plan* describes basic premises and lays the foundation for all state water planning. This ensures continuity and consistency of individual basin plans with the statewide plan and with each other.

3.2.1 Principles

Many values, uses and interests are involved in preparing a basin plan. Certain guiding principles should also be considered. These are listed below.

- All waters, whether surface or subsurface, are held in trust by the state as public property and their use is subject to rights administered by the state engineer.
- Water is essential to life. It is our responsibility to leave good quality water to meet the needs of the generations to follow.
- The diverse present and future interests of Utah's residents should be protected.
- Water uses for which beneficiaries are difficult to identify, such as recreation and aesthetics, should be included in program evaluation.
- Public input is vital to water resources planning.
- All residents of the state are encouraged to exercise water conservation and implement wise use practices.

Confluence of the Colorado and Green rivers

- Water rights owners are entitled to transfer their rights under free market conditions and in accordance with state water right laws.
- Water resources projects should be technically, economically and environmentally sound.
- Water planning and management activities of local, state and federal agencies should be coordinated.
- Local governments, with state assistance as appropriate, are responsible for protecting against emergency events such as floods and droughts.
- Designated water uses and quality should be improved or maintained unless there is evidence the loss in quantity or quality is outweighed by other benefits.
- Educating Utahns about water is essential. Effective planning and management requires a broad-based citizen understanding of water's physical characteristics, potential uses and scarcity values.

3.2.2 Purpose

The main purpose of this basin plan is to provide basic water data, identify issues, and describe future alternatives and possible development to provide for the water needs of future generations. Irreversible commitments could be very costly and prevent the fulfillment of future needs. Coordinated planning between state and federal agencies and local entities can be the vehicle to involve all concerned parties.

3.2.3 Organization

State water planning is the responsibility of the Division of Water Resources (DWRe) under the auspices of the Board of Water Resources. Several other state agencies with major water-related missions are involved in the water planning process.

With this in mind, a state water plan coordinating committee representing 12 state agencies assisted in the preparation of the *West Colorado River Basin Plan*. A steering committee also exists consisting of the chair and vice chair of the Board of Water Resources, executive director of the Department of Natural Resources, and director and assistant director of the Division of Water Resources. This committee provides policy guidance, resolves issues, and reviews the plan prior to final acceptance by the Board of Water Resources.

In addition, 20 federal and state agencies participate as cooperating entities. These agencies have particular expertise in various fields to assist with plan development. The local Basin Planning Advisory Group for the West Colorado River Basin also provides input by way of advice, review and decision-making. Most of the members of this group reside within or are directly involved in basin affairs. They represent various local interests and provide geographical representation within the basin.

3.2.4 Process

During the review and approval process, four drafts of the *West Colorado River Basin Plan* were prepared. These were: (1) In-House Review Draft, (2) Committee Review Draft, (3) Advisory Review Draft, and (4) Public Review Draft. Revised drafts occurred where warranted. After this process, the final basin plan is distributed to the public for its information and use. Once the final plan is distributed, the DWRe may periodically update the basin plan as conditions change. Local entities may also petition the DWRe to update the plan if they feel that situations within the basin have changed considerably. Much of the basin water data in the plan will be continually updated by the DWRe through ongoing planning efforts.

3.3 Basin Description

The West Colorado River Basin, covering nearly 15,000 square miles (9,783,815 acres) in south central Utah, is shown on Figure 3-1. The basin is bounded by the following features, described in a clockwise path, beginning at Soldier Summit (at the top of Spanish Fork Canyon) and following along the Book Cliffs, then south along the Green River to the confluence with the Colorado River, then southwesterly along the Colorado River

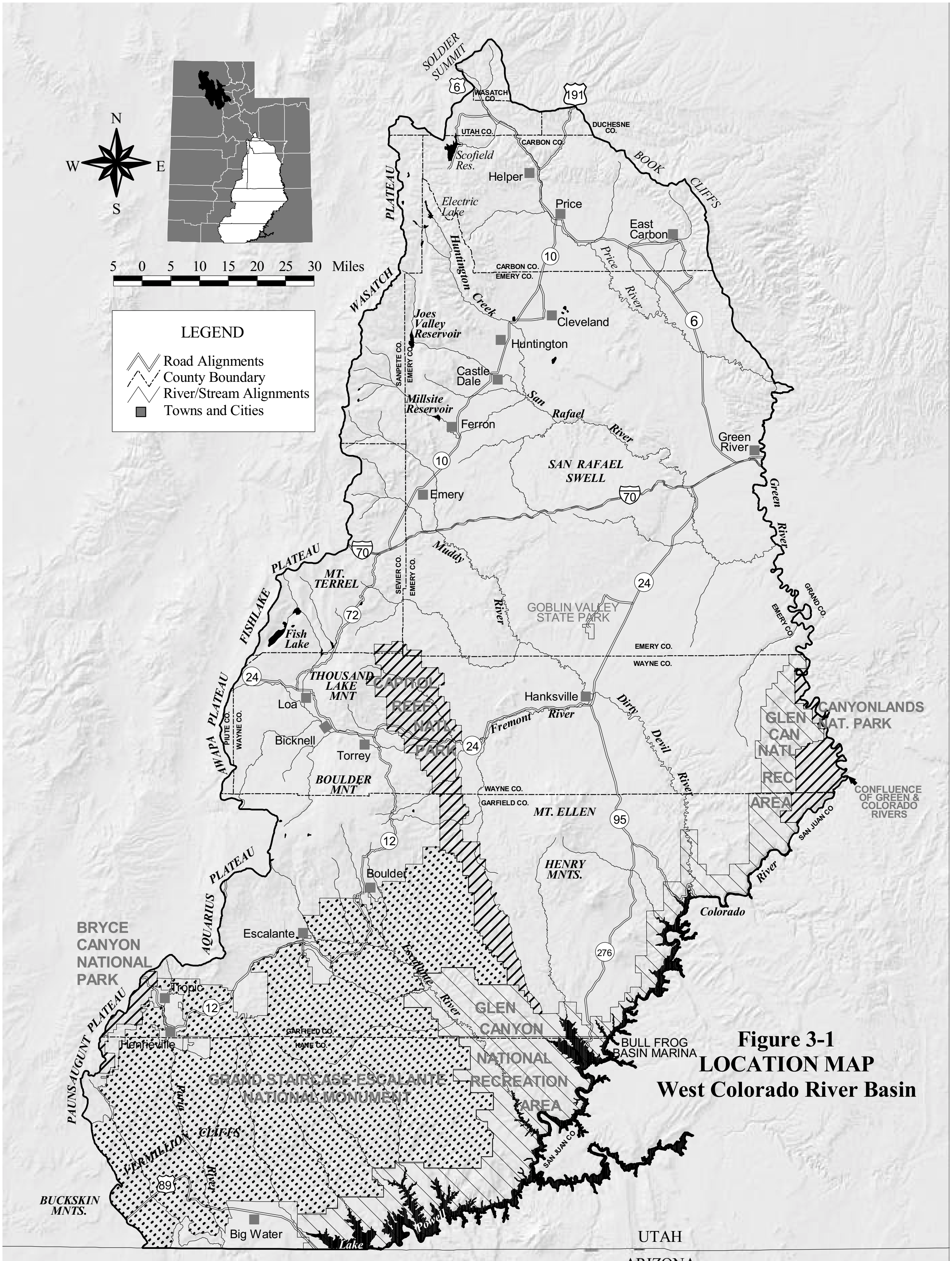


Figure 3-1
LOCATION MAP
West Colorado River Basin

and the eastern shoreline of Lake Powell (to include the entire surface of the lake). It then goes west along the Utah-Arizona state line to Buckskin Mountain, then bisecting the Vermillion Cliffs northwesterly to the rim of Bryce Canyon (Paunsaugunt Plateau), along the Aquarius Plateau, the Awapa Plateau, the Fish Lake Plateau, and along the Wasatch Plateau back to Soldier Summit. The irrigated area around Green River and the part of town on the eastern side of the Green River (located in Grand County) are included within the boundaries of this basin.

The basin covers all or part of 13 counties: Carbon, Duchesne, Emery, Garfield, Grand, Kane, Piute, San Juan, Sanpete, Sevier, Utah, Wasatch and Wayne. Major communities of the basin and their populations are shown in Table 3-1. In all, the West Colorado River Basin contains 25 incorporated towns and cities.

The West Colorado River Basin consists of five separate hydrologic river drainages, all flowing into the Green or Colorado river systems. These include the Price River, San Rafael River, Dirty Devil River (the combined Muddy and Fremont rivers), Escalante River and Paria River (Utah portion). The entire Utah portion of Lake Powell is located within the West Colorado River Basin.

Notable physiographic features are the San Rafael Swell, Henry Mountains, Boulder Mountain, Kaiparowits Plateau, Fishlake Plateau and the Wasatch Plateau. The area includes Capitol Reef National Park, and portions of Bryce Canyon National Park, Canyonlands National Park (the Maze and Horseshoe Canyon districts), Glen Canyon National Recreation Area (Lake Powell), and the new Grand Staircase-Escalante National Monument. Eight state parks in the basin are Scofield, Huntington, Millsite, Green River, Anasazi Indian Village, Escalante Petrified Forest, Goblin Valley and Kodachrome Basin. The three national forests located in the basin are Dixie, Fishlake and Manti-La Sal.

3.3.1 History and Settlement [7, 45, 46]

The history and settlement of the West Colorado River Basin is varied. In prehistoric times, dinosaurs roamed the area in a much different environment and climate than today. The Anasazi, Sevier and Fremont tribes were among the more recent early human inhabitants about 1,500 to 600 years ago. In the mid to late 1800s, most areas were settled by expansion of The Church of Jesus Christ of Latter-day Saints (Mormons). Coal mining in the northern part of the basin added more people in the early part of the 20th century.

Geologic History - Approximately 230 million years ago the basin was covered with blowing sand dunes. The San Rafael Swell and the Grand Staircase-Escalante National Monument have evidence of these ancient dunes. Dinosaurs roamed the area and tracks are found throughout the basin,

Cleveland-Lloyd Quarry Museum

covering the Triassic (Chinle Formation) and the Lower Jurassic (Navajo and Kayenta Formations) Periods of the Mesozoic Era. Following the desert-like conditions of these periods, the Middle Jurassic Period (about 200 million years ago) is marked by a series of invasions from the north by an interior seaway. The Entrada Sandstone formation of this

Table 3-1
West Colorado River Basin Communities

Community	County	1998 Population
Incorporated		
East Carbon	Carbon	1,517
Helper	Carbon	2,423
Price	Carbon	9,239
Scofield	Carbon	56
Sunnyside	Carbon	328
Wellington	Carbon	1,806
Castle Dale	Emery	1,800
Cleveland	Emery	556
Elmo	Emery	281
Emery	Emery	260
Ferron	Emery	1,739
Green River	Emery	704
Huntington	Emery	1,921
Orangeville	Emery	1,674
Boulder	Garfield	225
Cannonville	Garfield	147
Escalante	Garfield	994
Henrieville	Garfield	165
Tropic	Garfield	414
Big Water	Kane	420
Bicknell	Wayne	340
Hanksville	Wayne	160
Loa	Wayne	499
Lyman	Wayne	223
Torrey	Wayne	145
Unincorporated		
Carbonville	Carbon	350
Clear Creek	Carbon	50
Spring Glen	Carbon	800
Clawson	Emery	150
Caineville	Wayne	50
Fremont	Wayne	250
Teasdale	Wayne	175

period near Goblin Valley State Park and other areas shows evidence of this with fossilized marine invertebrates and numerous dinosaur tracks. The Upper Jurassic Period (about 150 million years ago) is represented by fluvial sediments which have yielded many fossilized dinosaur bones located in Emery County at the Cleveland-Lloyd Quarry.

The Lower Cretaceous Period (about 125 million years ago) contained many new species of dinosaurs, including the now famous Utah raptor. Dinosaur eggshell material from this period has been found in the Cedar Mountain Formation of the San Rafael Swell. Episodes of mountain building that formed the Rocky Mountains began at the end of the Upper Cretaceous Period (about 80 million years ago). As the seas were retreating for the last time, extensive swamps formed along the edges. The Blackhawk Formation of this period is found in the coal mines of Carbon and Emery counties and contains numerous dinosaur tracks and fossilized plant life.

At the beginning of the Cenozoic Era (about 60 million years ago), the San Rafael Swell began to fold upward. Continued warping of the Colorado Plateau produced giant lakes over most of the basin about 40 million years ago. After this, the plateau began a gradual uplift which continues today. From this, the major river basins formed, producing the beautiful canyons and features that millions of tourists from around the world come to see. The Cleveland-Lloyd Museum (Emery County), the Museum of the San Rafael (Castle Dale), and the College of Eastern Utah Prehistoric Museum (Price) provide interesting information on the geologic history of this area.

Pre-History - The initial human occupants of the West Colorado River Basin were apparently nomadic hunters of the Paleo-Indian period (12,000-8,500 years ago) who sought after the mammoths, camels, and bison of the late Pleistocene. Five kill/butchering sites have been found in the basin. About 8,500 years ago, groups characterized by the use of the atlatl (dart-throwing weapon), milling stones and a variety of textiles, appeared in Utah. Five sites of this Archaic-Indian culture (8,500-2,500 years ago) have been identified within the basin.

The Agriculturists period (1,500-600 years ago) contained the Anasazi, Fremont and Sevier cultures. The northern and central portion of the West Colorado River Basin contains numerous sites of the Fremont culture, while the southern portion contains Anasazi sites. The Sevier culture is also in evidence on the extreme western side of the basin. All of these cultures are marked by peoples who subsisted, at least in part, on domesticated crops and shared a number of technological and adaptive characteristics such as pottery, the bow and arrow, and settled villages. There is some evidence that these cultures may have irrigated their crops. For unknown reasons, the Sevier and Fremont cultures disappeared from Utah about A.D. 1300. At the height of these cultures, it is estimated that the population found within the state's boundaries was as high as 500,000. The Anasazi Indian Village State Park (Boulder) and the Fremont Indian State Park (Sevier River Basin) provide information about these cultures.

The arrival of modern Indian groups ushered in the last and present period. Competition with these groups may have contributed to the disappearance of the Sevier and Fremont and the withdrawal of the Anasazi cultures. About 1,000 years ago the Southern Paiutes arrived in the extreme southern portion of the West Colorado River Basin. Among the Paiute Tribe, the Shivwits Band occupied the greatest area while the Fish Lake Paiutes lived in and around Fish Lake. The Ute Tribe occupied the remainder of the basin to the north. Economics determined that these people lived in small bands of fewer than 200 people. No Indian reservations are located within the West Colorado River Basin.

History - The first Europeans to enter the state and the West Colorado River Basin were in the Dominguez-Escalante expedition. On their return to Sante Fe in 1776, after exploring western Colorado, the Uinta Basin, Utah Lake area, western Utah and southwestern Utah, the party came upon the Colorado River at the mouth of the Paria River. They determined crossing there was not feasible (a century later it would become Lee Ferry Crossing), so they went up river to a point three miles north of the Arizona-Utah border ("Crossing of the Fathers").

During the early 1800s, fur trappers explored mainly northern Utah. There are records, however, that Etienne Provost (1824-1825) and Jedediah Smith (1826-1829) went through parts of the West Colorado River Basin. Between 1829 and 1848, a trade route was opened up between Sante Fe and Los Angeles. This trail, known as the Spanish Trail, was used chiefly by New Mexico traders who found a ready market for woolen goods in California. The 1,120 mile trail entered the West Colorado River Basin from the east along present day I-70, crossed the Green River at Green River, continued through the San Rafael Swell, then down Salina Canyon and into the Sevier River Basin. With the gold rush in California and the subsequent growth in population there, a move to promote a transcontinental railroad arose.

John W. Gunnison received a government commission in 1853 to survey a proposed route for the railroad. He came through the West Colorado River Basin near Green River south along the Book Cliffs and located a passage through the Wasatch Mountains into the Great Basin (Soldier Summit). He was later killed by Indians in the Sevier River Basin. But he was credited with establishing a military road and determining that his southern railroad route was far inferior to the northern route across Wyoming.

John Wesley Powell led a 10-man party down the Green and Colorado rivers in 1869. Compared to all previous western government expeditions, Powell's were highly scientific surveys. The results of his surveys are contained in his famous *Report on the Lands of the Arid Regions of the United States*. Included in this report was his recommendation that minimum homesteads in non-irrigable pasture lands of the west should be 2,500 acres. Although this concept was too revolutionary to find acceptance by Congress at the time, subsequent legislation recognized the need for larger tracts of land in the arid west. The John Wesley Powell Museum (Green River) provides information on these government expeditions.

Settlement - The majority of the settlement of the West Colorado River Basin was a result of Mormon exploration and expansion. Upon entering the Salt Lake Valley on July 24, 1847, Brigham Young stated that his intentions were to "explore every hole and corner from the Bay of San Francisco". At his death in 1877, Young had fulfilled that pledge and had been successful in colonizing large portions of the Intermountain West.

Carbon County settlements were established by the Mormons along the Price River in the late 1870s, including Price, Spring Glen and Wellington. Farming and ranching became early economic activities, giving Carbon County a tradition of cowboys and outlaws with the likes of Butch Cassidy and "Gunplay" Maxwell roaming the area. The Nine Mile Canyon freight road from Price to the Uinta Basin became an important transportation link. During the early 1880s, the Denver and Rio Grande Western Railroad (D&RGW), seeking a route from Denver to Salt Lake City, discovered and opened up the vast coal lands of the county.

Coal mining became the major catalyst for development. Coal companies often built and ran towns and imported many southern and eastern European and Japanese laborers to work in the coal mines and on railroad gangs. Mine explosions and major strikes from 1900-1930 brought tragedy, violence, and eventual unionization to the mines. Coal mining continues to play a vital role in Carbon County's economic development, with ups and downs in the industry creating periods of boom and bust. The College of Eastern Utah (Price) was established in 1937 and promises to become a more important facet of the county's economic and social development.

Emery County's settlement, similar to Carbon County, started in 1875 when livestock raisers from Sanpete County brought cattle and sheep into Castle Valley to graze. With a shortage of sufficient land and water in Sanpete County and a strong desire of Mormon leaders to acquire unoccupied land in the region before non-Mormons did, families began moving into Castle Valley in the fall of 1877. They took up homesteads in what would become Huntington, Ferron, Castle Dale and Orangeville. The completion of the D&RGW through the county in 1883 and the development of coal mines in Carbon County ensured the county's economic stability. The D&RGW also re-established the town of Green River, although it had already been a mail station and an important part of the Old Spanish Trail.

The southeastern Utah uranium boom in the 1950s provided a temporary economic stimulus. The establishment of the Utah Launch Complex of the White Sands Missile Base in 1964 brought a temporary boom to Green River. However, the closing of the complex in the 1970s led to another economic downturn. During the late 1970s, Emery County's population grew significantly because of the construction, by Utah Power and Light Company, of large power plants in Castle Dale and Huntington and the opening of large coal mines to fuel them. Today the power plants, along with their coal mines, farming and tourism, provide a solid basis for Emery County's economy.

Because of Wayne County's remote location, most of its towns were settled after 1880. The first settlement was in Rabbit Valley between Fremont and Loa. The town of Bicknell was originally called Thurber, but its name was changed when Thomas Bicknell, a prominent educator from Rhode Island, offered a library to any town that would take his name. Raising livestock was the main reason for settlement, although Fruita (now part of Capitol Reef National Park) was settled for its fruit-growing potential. Getting cattle to market was difficult. Until good roads were built in the 1930s, stock was driven some 100 miles north to railheads at Nephi, Green River, and later to a D&RGW branch line in Sevier County. The creation of national forests in the early 1900s reduced the number of cattle that could be grazed (See Section 3.4). In the central portion of Wayne County, Capitol Reef National Monument, established in 1937 (later Capitol Reef National Park), and Lake Powell recreationalists stopping for supplies now fuel a tourism-related economy. In the Upper Fremont Valley (western portion of Wayne County), agriculture still dominates the economy.

Eastern Garfield County was settled by people from Beaver and Parowan (Cedar/Beaver River Basin) via Panguitch (Sevier River Basin). Escalante was settled in 1875, and later settlements were made in Cannonville (1876), Henrieville (1878), Boulder (1889) and Tropic (1892). Boulder was considered the most isolated town in Utah until the mid-1930s when Civilian Conservation Corps (CCC) workers constructed a road from Boulder to Escalante over "Hell's Backbone". Vast rangelands and some of the state's largest forest reserves made cattle-ranching and lumbering Garfield County's most important industries.

The creation of Bryce Canyon National Park in 1928 increased the importance of tourism in the area. The local economy, with the additions of Capitol Reef National Park, Glen Canyon National Recreation Area and the new Grand Staircase-Escalante National Monument, is being greatly influenced by recreation and tourism. However, with the reopening of the lumber mill in Escalante and the continued dependence on agriculture, lumbering and agriculture will continue to be factors affecting the local economy.

The eastern portion of Kane County was settled with creation of Lake Powell. The city of Glen Canyon (later renamed Big Water) was created in 1956 as a construction camp. Big Water and nearby Church Wells are small communities with many residents commuting to work to Page, Arizona. The remainder of the county located in the West Colorado River Basin is rugged land now mostly within the boundaries of the Grand Staircase-Escalante National Monument. Therefore, similarly to Garfield County, recreation and tourism will probably become important aspects of the local economy. Existing oil, coal and gas leases located throughout the county, however, could provide a boost to the local economy. Also, the recent 50,000 acre state/federal land exchange along Highway 89 west of Big Water could provide areas for retirement communities or tourist facilities.

3.3.2 Climate [3]

Precipitation in the area is influenced by two major storm patterns: one, frontal systems from the Pacific Northwest during winter and spring; the other, late summer and early fall thunderstorms from the south and southwest. The Southern Utah Low, a high altitude low pressure system often covering parts of several states, causes wide-spread precipitation between the winter frontal systems and summer thunderstorms.

The basin has 27 climatological stations where daily temperatures and precipitation are measured and 10 snow course sites where winter snowpack is measured. Nine telemetry systems have been installed within the basin to make data available on a continuous basis (SNOTEL sites). The 1961-1990 base period is used in this report. The climatological and SNOTEL stations are shown on Figure 3-2. All of these stations are extremely important to local, state and federal water managers.

Annual water surface pan evaporation varies from about 45 inches at Loa to 58 inches at Hite Marina on Lake Powell. Possible sunshine varies from 85 percent during the summer to 45 percent during the winter. Prevailing winds are generally from the southwest at four to six miles per hour. Maximum wind movement generally occurs during May.

Temperature - Temperatures fluctuate every year from a maximum of over 100° F to a minimum below zero with daily variations as much as 40° F. The mean annual temperature in the agricultural valleys varies from 44° F in Loa (Wayne County), 46° F in Emery (Emery County), 49° F in Price (Carbon County) and Escalante (Garfield County), and 53° F in Green River (Emery County). The average agricultural frost-free periods range from 80 days in Loa to 165 days in Green River. Temperature data are given in Table 3-2.

Precipitation - The precipitation ranges from over 30 inches in the Wasatch and Fish Lake plateaus to less than eight inches in the desert areas of the central and southern parts of the basin. Climate in the agricultural areas is arid to semi-arid with an average precipitation of about 10 inches. Precipitation can be highly variable, some wet years receiving three times that in the drier years. The annual precipitation for the basin is shown on Figure 3-3. The annual precipitation for all basin stations is shown in Table 3-3.

Evapotranspiration - Evapotranspiration varies among crops. Instead of calculating evapotranspiration for each crop, it is customary to calculate values for a reference crop to obtain a *reference evapotranspiration* value. The reference value is multiplied by a crop coefficient for another crop to obtain an evapotranspiration value for that crop. Care must be exercised in applying crop coefficients because different researchers use different reference crops. The reference evapotranspiration values for the basin stations given in Table 3-3 use perennial rye grass for the reference crop.

Snow course records show accumulated water content collected during the winter months. The National Resources Conservation Service operates mountain SNOTEL sites that automatically record snowpack data. Both types of stations can be accessed to determine monthly, daily or even single storm accumulations. The April 1 forecast is the water supply indicator for the coming season. This is based on the snow course soil moisture levels, snow pack water content and other factors. Snow water equivalent and total precipitation for the basin's snow course and SNOTEL sites are shown in Table 3-4.

3.3.3 Physiography and Geology [22, 35, 51]

The West Colorado River Basin as described here falls entirely within the Colorado Plateau Physiographic Province. The basin contains 9,783,810 acres (15,000 square miles) and is about 205 miles from north to south and 107 miles from east to west. It includes the through-flowing Green and Colorado rivers and the following major tributaries: 1) Price River system, 2) San Rafael River system, 3) Dirty Devil River system (the combined Muddy and Fremont rivers), 4) Escalante River system, and 5) Paria River system.

The Colorado Plateau Physiographic Province is characterized by high relief between the many high tablelands or plateaus and the intervening

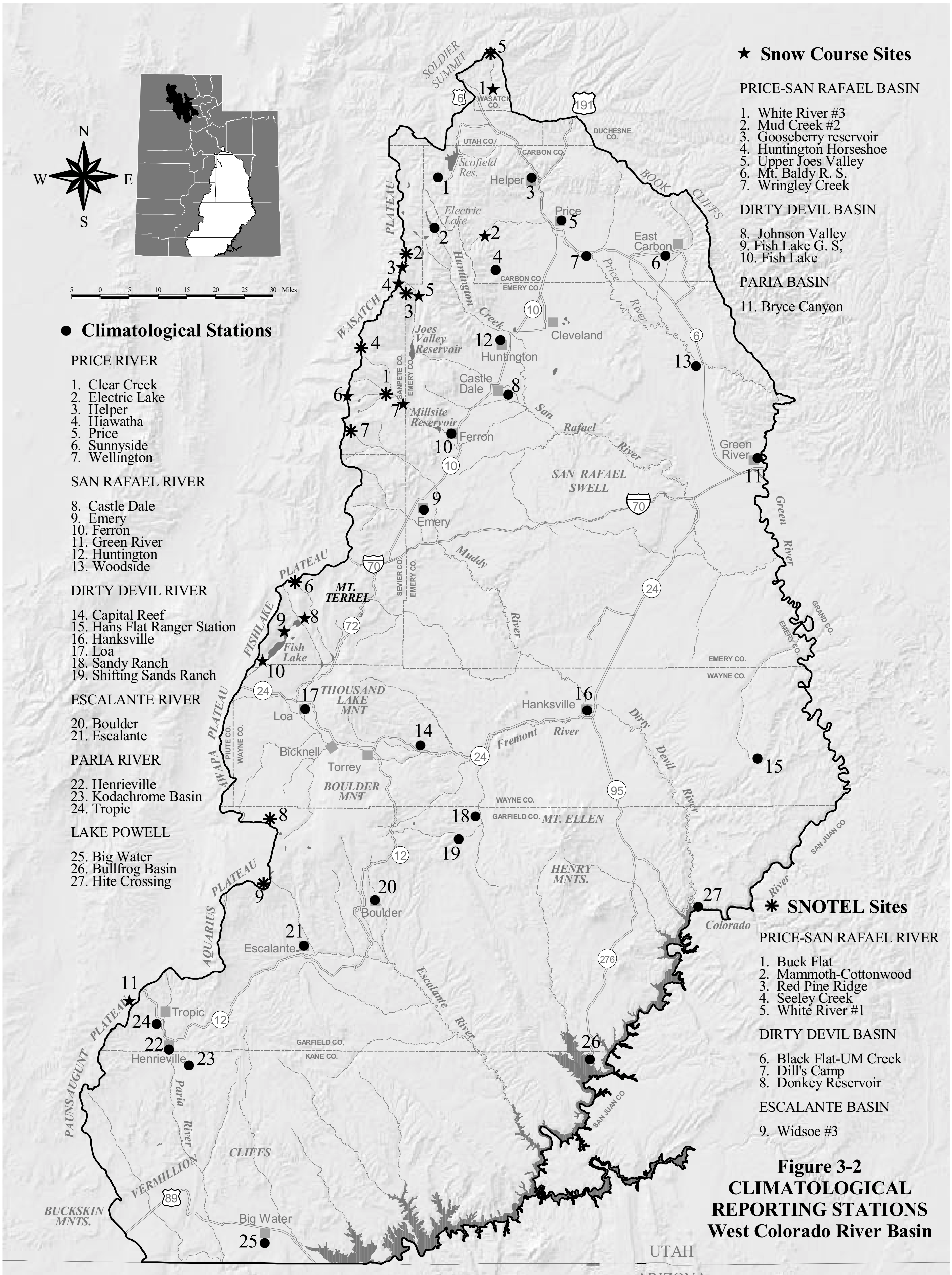


Figure 3-2
CLIMATOLOGICAL REPORTING STATIONS
West Colorado River Basin

Table 3-2
Normal Temperatures and Frost-Free Days

Station	January Max. (°F)	January Min. (°F)	July Max. (°F)	July Min. (°F)	Mean Annual (°F)	Frost-Free Days
Price River System						
Clear Creek	31.3	6.5	76.7	41.7	38.0	52
Green River Aviation	37.1	8.7	96.7	60.4	51.9	163
Hiawatha	32.8	13.2	81.6	54.9	44.5	128
Price Game Farm	36.8	10.9	90.9	56.5	49.1	146
Scofield	31.6	0.0	76.7	40.6	36.7	42
Scofield Dam	27.6	-1.6	77.5	44.5	36.9	74
Scofield-Skyland Mine	32.3	9.0	73.8	45.3	38.4	73
Sunnyside	34.1	13.8	84.3	55.3	45.7	126
Sunnyside City Center	32.5	14.3	85.7	57.0	48.3	147
San Rafael River System						
Castle Dale	35.8	7.6	89.6	53.8	47.4	124
Electric Lake UP&L	26.7	-0.4	71.8	41.4	34.2	67
Emery	36.4	11.2	84.2	53.1	46.1	126
Ferron	35.5	10.5	87.1	57.7	47.8	136
Dirty Devil River System						
Capitol Reef National Park/Fruita	39.8	18.1	92.2	63.1	53.7	179
Hanksville	40.3	10.2	98.8	58.1	53.1	154
Hans Flat Ranger Station	36.3	18.6	85.7	61.1	50.4	158
Loa	39.4	7.4	82.8	47.2	43.6	83
Sandy Ranch	39.2	12.2	91.6	57.9	50.3	137
Shifting Sands Ranch	34.9	12.3	90.1	61.7	52.0	188
Escalante River System						
Boulder	38.7	15.8	84.6	57.9	48.5	137
Escalante	41.0	14.1	89.9	54.7	49.7	138
Henrieville	42.3	13.4	88.1	52.7	48.3	118
Kodachrome Basin	44.2	14.4	89.8	51.7	49.3	119
Tropic	40.9	14.7	84.9	51.6	46.9	119
Colorado River System						
Big Water	44.3	20.5	98.7	64.9	56.7	189
Bullfrog Basin	44.5	24.5	99.4	70.3	59.4	219
Hite	47.8	26.4	100.0	70.9	61.0	234

Note: All temperatures are 1961-90 normal values. Frost-free days are from average last spring to first fall freezes (32°F).
Source: Utah Climate.

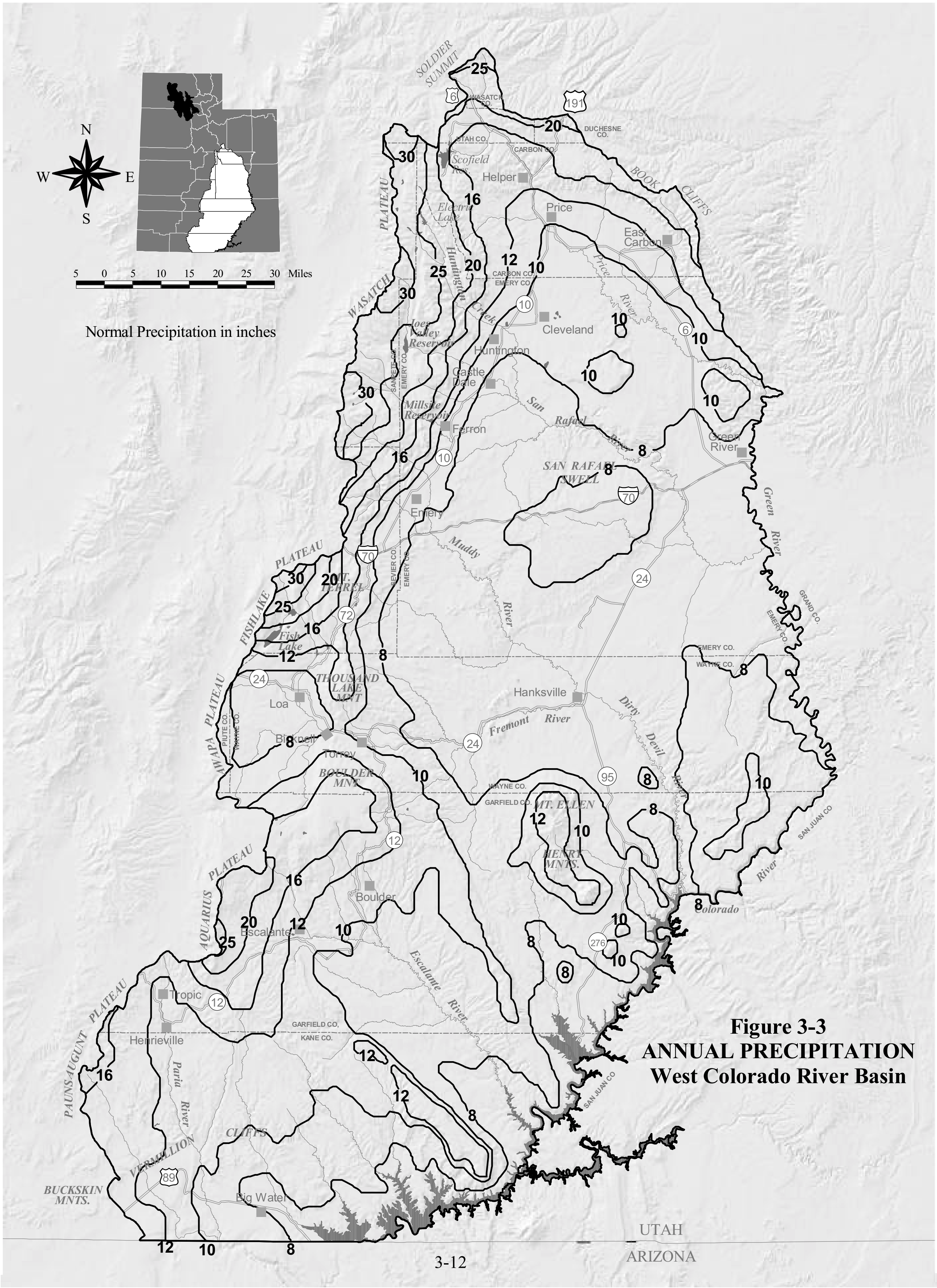


Figure 3-3
ANNUAL PRECIPITATION
West Colorado River Basin

Table 3-3
Normal Precipitation and Evapotranspiration

Station	Annual Precipitation	Reference Evapotranspiration
	(inches)	
Price River System		
Clear Creek	23.05	36.98
Green River Aviation	6.51	55.86
Hiawatha	14.60	38.63
Price Game Farm	9.75	48.78
Scofield	17.22	37.64
Scofield Dam	14.07	36.72
Scofield-Skyland Mine	23.33	34.48
Sunnyside	13.87	41.23
Sunnyside City Center	11.57	42.85
San Rafael River System		
Castle Dale	7.52	48.07
Electric Lake UP&L	24.91	31.77
Emery	7.56	44.27
Ferron	8.47	45.14
Dirty Devil River System		
Capitol Reef N.P./Fruita	7.48	49.74
Hanksville	5.72	56.17
Hans Flat Ranger Station	10.15	41.98
Loa	7.85	44.93
Sandy Ranch	7.56	51.00
Shifting Sands Ranch	6.89	48.06
Escalante River System		
Boulder	10.73	43.60
Escalante	10.04	48.89
Henrieville	10.38	49.62
Kodachrome Basin	11.92	49.30
Tropic	12.33	46.96
Colorado River System		
Big Water	6.92	57.15
Bullfrog Basin	5.93	55.24
Hite	5.68	57.91

Note: All data for 1961-90 time period.
Source: Utah Climate.

Table 3-4
Snow/Precipitation Data

Station	Elevation	Average April 1 Snow Water Equivalent (inches)	Average Total Precipitation (inches)
SNOW COURSE SITES			
Price-San Rafael Basin			
Gooseberry Reservoir	8,700	11.5	N/A
Huntington Horseshoe	9,800	24.3	N/A
Mt. Baldy R. S.	9,500	24.1	N/A
Mud Creek #2	8,600	13.6	N/A
Upper Joes Valley	8,900	10.3	N/A
White River #3	7,400	6.8	N/A
Wringley Creek	9,000	11.3	N/A
Dirty Devil Basin			
Fish Lake	8,700	8.0	N/A
Johnson Valley	8,850	7.1	N/A
Paria Basin			
Bryce Canyon	8,000	4.2	N/A
SNOTEL SITES			
Price-San Rafael Basin			
Buck Flat	9,800	18.1	18.4
Mammoth-Cottonwood	8,800	21.0	17.6
Red Pine Ridge	9,200	18.0	20.6
Seeley Creek	10,000	15.3	15.3
White River #1	8,550	13.9	14.6
Dirty Devil Basin			
Black Flat-U. M. Creek	9,700	10.3	12.9
Dill's Camp	9,200	15.1	16.8
Donkey Reservoir	9,800	9.1	11.6
Escalante River Basin			
Widstoe #3	9,500	14.0	13.9

Note: Averages based on April 1 snowpack from 1961-90.
Source: U. S. Natural Resources Conservation Service

stream cut valleys and deep, steep-sided canyons. Elevations over 11,000 feet are found in the Henry Mountains, Thousand Lake Mountain, Boulder Mountain and on the Fishlake Plateau. Mt. Ellen, located in the Henry Mountains, stands 11,522 feet; Mt. Terrel, on the Fish Lake Plateau, stands at 11,530 feet; Thousand Lake Mountain stands at 11,306 feet; and Boulder Mountain is just over 11,000 feet. Elevations begin at 3,700 feet above mean sea level in Lake Powell at the southern tip of the basin and increase throughout several valleys and into higher plateaus. Much of this difference in elevation is made up in great step-like features, consisting of a series of retreating cliffs or escarpments and structural benches that result from erosion of the flat to gently dipping sedimentary rocks which are of variable hardness and thus offer more or less resistance to erosion. The Grand Staircase in Garfield and Kane counties is a good example of this type of geologic feature (see Figure 3-4). The Green and Colorado rivers fall 500 feet from the Price River's confluence with the Green to Lake Powell, a distance of over 128 miles. The average fall is just less than four feet per mile.

Within this basin, each plateau, mountain and canyon has its own character, which influences soil forming processes and the surface and groundwater hydrology. Past erosion and deposition cycles have left pediment slopes and terraces. Erosion has produced the spectacular scenery of Bryce Canyon, Capitol Reef, Goblin Valley and Glen Canyon. Rocks from all eras of geologic time are found here with the greatest area being covered by sedimentary rocks of Mesozoic age (see Figure 3-5). Included in this group is the Navajo Sandstone which is an important source of groundwater. Igneous rock is found on many of the basin's mountain ranges. In many places they occur as Tertiary age extrusive

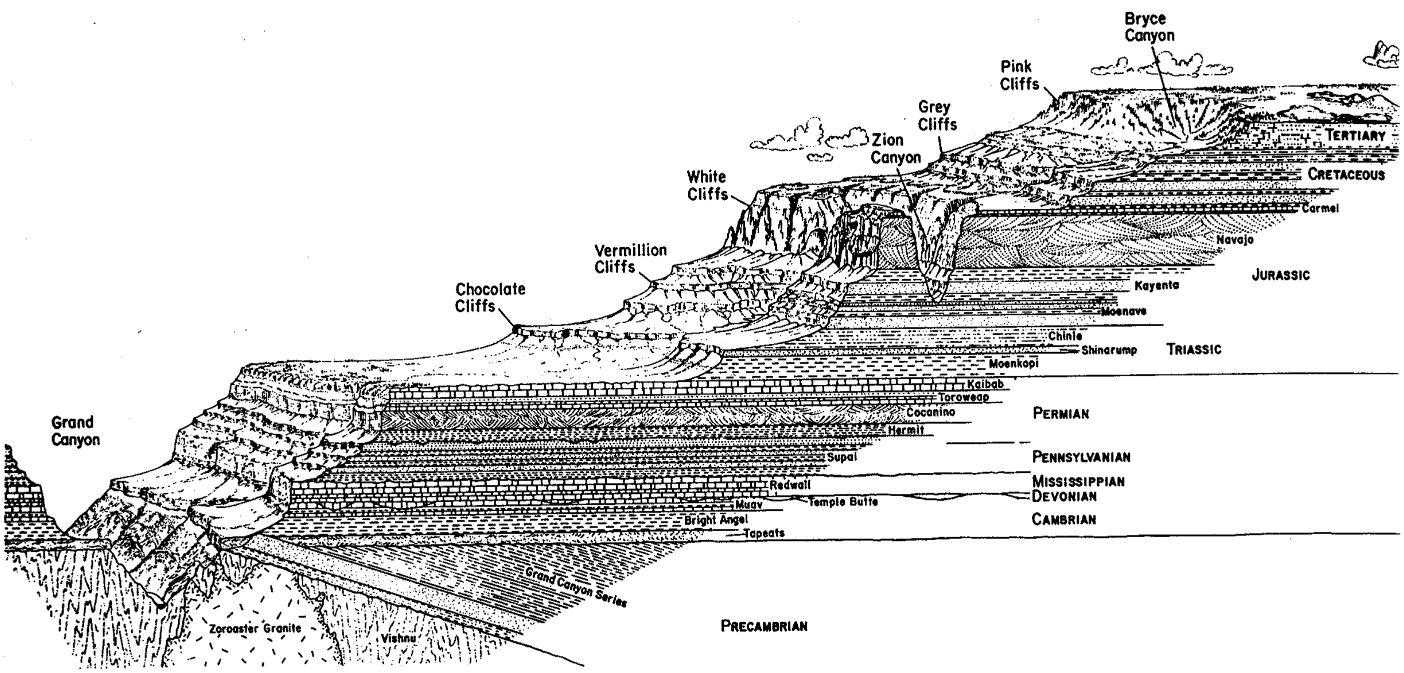


Figure 3-4 Perspective sketch showing the "Grand Staircase" in south central Utah and north central Arizona. Vertical scale greatly exaggerated. Sketch by W.K. Hamblin.

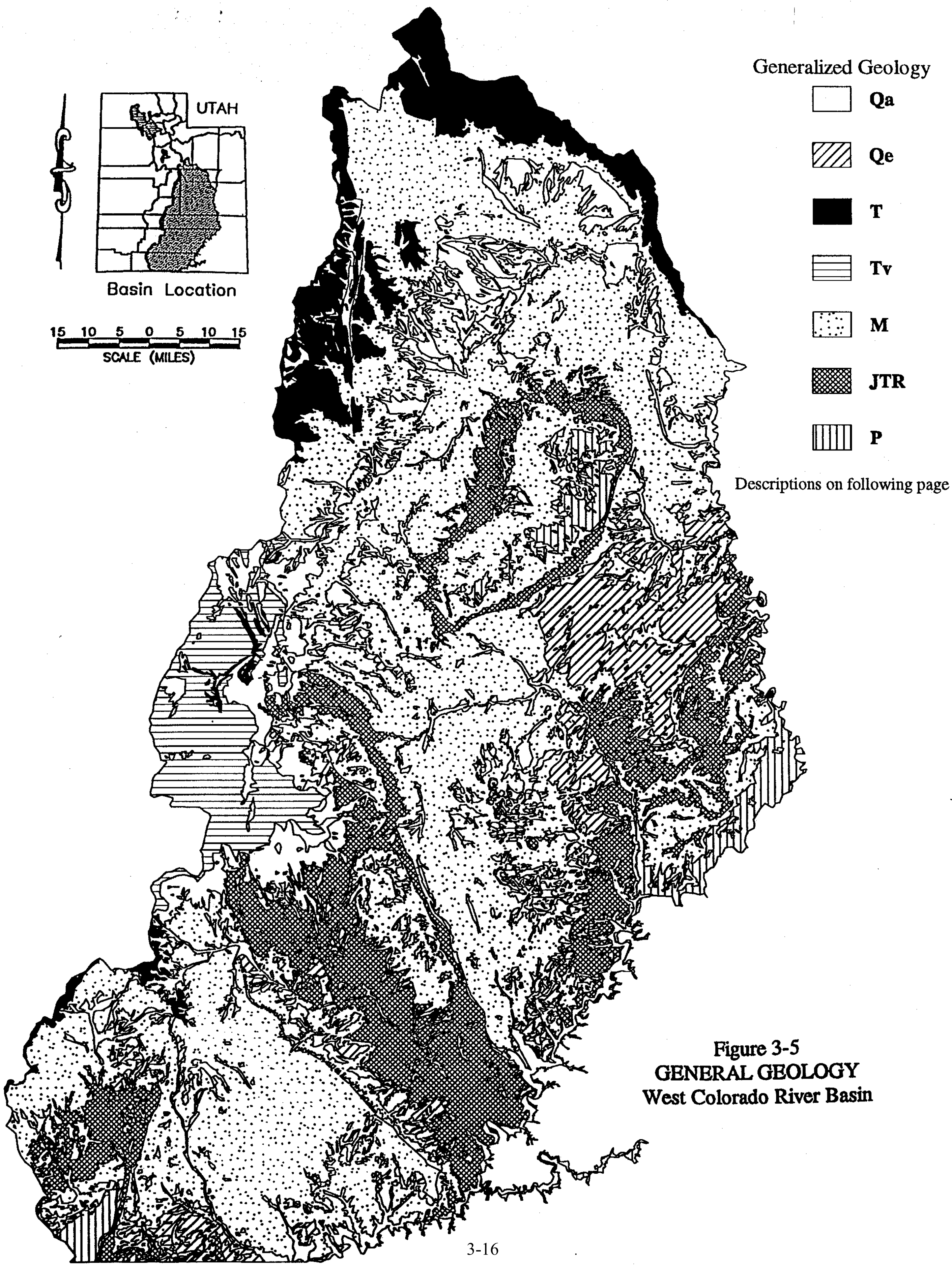


Figure 3-5
GENERAL GEOLOGY
West Colorado River Basin

Figure 3-5 Legend

West Colorado River Basin
Generalized Geologic Units

Quaternary

QaUnconsolidated deposits of alluvium, colluvium, glacial and landslide origin.
QeUnconsolidated deposits of windblown (eolian) origin.

Tertiary

TWeakly to semi-consolidated sedimentary basin-filling rocks of the Bald Knoll, Gray Gulch, Crazy Hollow, Green River, and Flagstaff Formations.

TvIgneous rocks of Tertiary age; includes intrusive rocks of the Henry Mountains and volcanic rocks of the Fish Lake and Boulder Mountain areas.

Mesozoic

MConsolidated sedimentary rocks locally include the North Horn, Price River, Blackhawk, Mancos Shale, Dakota, Morrison, Summerville, Curtis, Entrada,Carmel, Navajo, Kayenta, Wingate, Chinle, Shinarump and Moenkopi Formations.
JTRNavajo Sandstone

Paleozoic

PConsolidated sedimentary rocks locally include the following formations; Kaibab Limestone, White Rim Sandstone, DeChelly Sandstone, Organ Rock Shale, Cedar Mesa Sandstone, Halgaito, Elephant Canyon, Rico, Honaker Trail, Paradox and Redwall Limestone.

basalt, andesite, and latite lava flows and dacitic to rhyolitic ash-flow tuffs. Small areas are covered by unconsolidated eolian and alluvial deposits.

While the Colorado Plateau is characteristically aseismic and lacks the large faults found in the transition zone to the west, the rocks in this basin have suffered much structural deformation. Powerful forces at work in the crust of this area have resulted in the formation of large folds; anticlines, synclines, and monoclines. The two largest such features are the San Rafael Swell (see Figure 3-6) and the Henry Mountains structural basin. Many other smaller features are also present and likewise exert a tremendous influence on the occurrence and movement of surface water and groundwater. Some of these are the Waterpocket Fold, the East Kaibab Monocline, the Cockscomb Ridge, Circle Cliffs Uplift, Caineville Monocline, Teasdale Anticline, and the Saleratus Creek Syncline.

3.3.4 Soils, Vegetation and Land Use [3]

Resource data on the soils and vegetation vary in detail, particularly across land ownership and administration boundaries. Land use data vary depending on the purpose for collecting the data and on the methodology used.

Soils - Interagency coordination has improved soil surveys. See Figure 3-7 for survey orders and areas. Soil survey information is found in reports available from the Natural Resources Conservation Service, Forest Service and Bureau of Land Management. Soil surveys were conducted at different levels of detail to accommodate the land uses. In general, the information was collected at three levels: 2nd, 3rd and 4th order mapping.

The 2nd order surveys are made for intensive land uses requiring detailed information for making predictions of suitability for use and treatment needs, i.e., croplands areas. The 3rd order surveys are made for land uses not requiring precise knowledge of small areas or detailed soil information, i.e., forest and range lands. The 4th order surveys are made for extensive land uses requiring general soil information for broad statements concerning land use potential and general land management.

The West Colorado River Basin has five climatic soil zones. The zones are summarized in Table 3-5. Generalized soil zone descriptions are:

DESERT CLIMATIC ZONE soils generally have little development and are found on alluvial fans and flood plains. They are dominantly well-drained and somewhat excessively drained.

SEMI-DESERT CLIMATIC ZONE soils in the West Colorado River Basin are quite well developed and are usually found in alluvial deposits and lake sediments. These soils include the ochric and calcic horizons, have a pH of more than 8.0 and are usually very deep. The surface ochric horizons are light in color with little development. Calcic horizons show accumulations of calcium carbonates. Problematic saline and gypsiferous soils are common within this zone, especially in Carbon and Emery counties. The majority of the cropland production occurs in this zone.

UPLAND CLIMATIC ZONE soils have moderate development and are usually found on alluvial fans and hills. The soil features usually include mollic and argillic horizons. Mollic horizons are organically enriched surface layers showing dark colors. Usually this horizon is minimally expressed. The argillic horizon is expressed by textural clay accumulation in the subsoil, which helps contain water in the upper subsoil. These soils have a pH from about 7.5 to 8.0 due to the higher precipitation which leaches the calcium carbonate. The majority of this zone is used for rangeland; only a small amount of it is cropland.

MOUNTAIN CLIMATIC ZONE soils have high development and are usually found on mountain slopes. The soil features include mollic and argillic horizons. Mollic horizons are organically enriched surface layers displaying dark colors. The argillic horizon is expressed by textural clay accumulation in the subsoil, which helps contain water in the upper subsoil. These

Figure 3-6

Looking south - Jurassic strata exposed along the east side of the San Rafael Swell near Green River, Utah. Interstate I-70 enters the Swell here. Chinle (Ch) Formation is at the right edge. Light-colored flatirons are Wingate (W) Kayenta (K) and Navajo (N) Sandstones. Carmel (Ca) Formation forms low, dark flatirons. Entrada (E) Formation forms the strike valley. Curtis (Cu) Formation forms the low ridge at left, while the Summerville and Morrison (S) Formations are at the left edge of the photo.

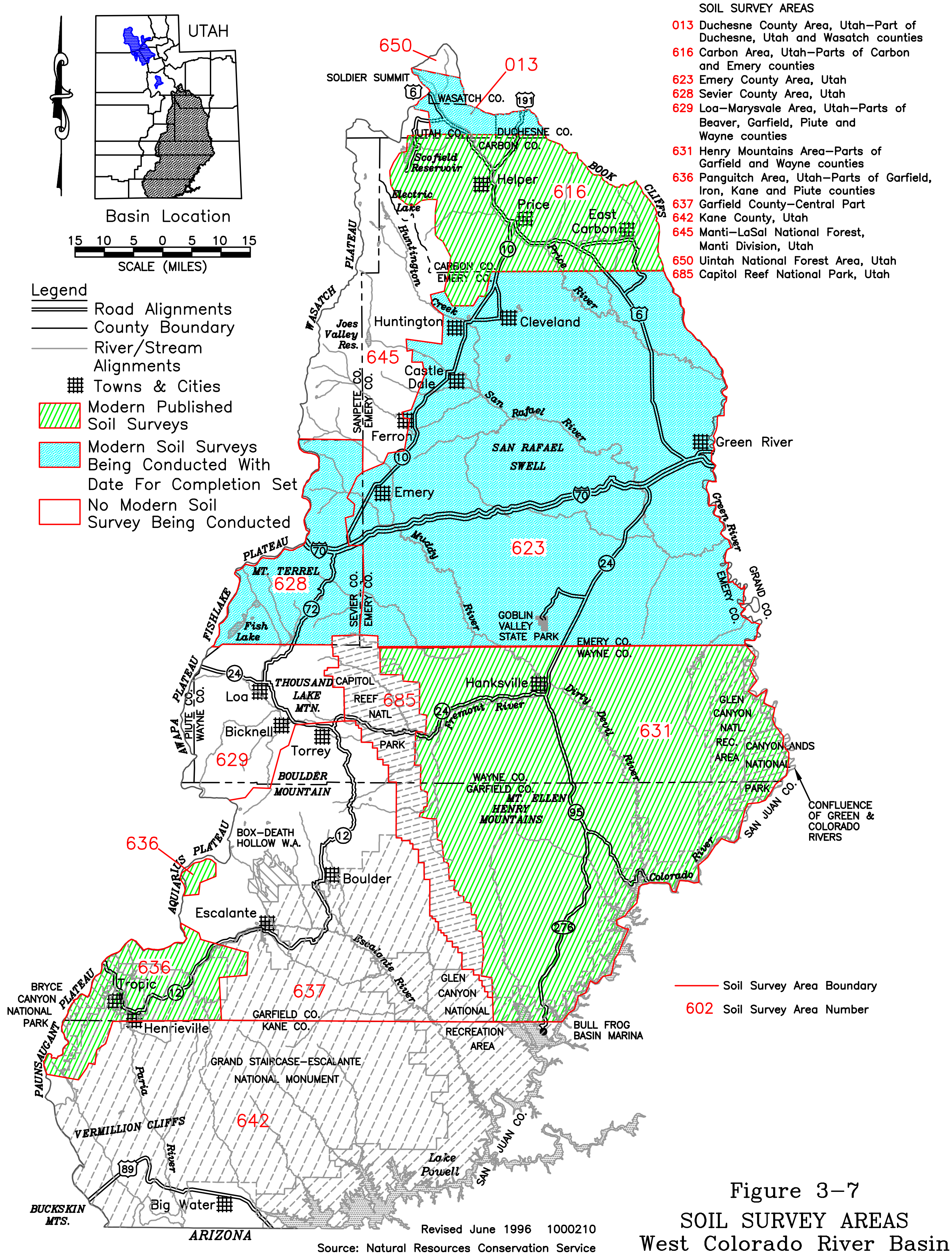


Figure 3–7
SOIL SURVEY AREAS
West Colorado River Basin

Table 3-5 Climatic Zones				
Climatic Zone	Precipitation (inches)	Temperature (°F)	Freeze-Free Period (days)	Elevation (feet)
High Mountain	22-40	34-45	40-90	8,000-10,000
Mountain	16-22	42-50	70-170	6,000-8,200
Upland	12-16	45-59	120-170	4,500-6,900
Semi-desert	8-12	52-59	120-190	4,500-6,300
Desert	6-8	59-67	175-205	2,400-4,500

soils have a pH of about 7.0 to 8.0 due to the higher precipitation. The majority of this zone is used for rangeland, and there is some timber production.

HIGH MOUNTAIN CLIMATIC ZONE soils have high development and are usually found on mountain slopes and in mountain valleys. The soil features include thick mollic and argillic horizons. Mollic horizons are organically enriched surface layers, well expressed with dark colors. The argillic horizon is expressed by textural clay accumulation in the subsoil which helps contain water in the upper subsoil. These soils have a pH of about 6.0 to 7.5 due to the higher precipitation. The majority of this zone is used for rangeland and timber production.

Vegetation - Many vegetative types have been identified in the West Colorado River Basin. Table 3-6 shows the vegetative types within each river system. The vegetative types roughly follow the higher elevations to the valley floors and areas with annual precipitation of 35 inches to lower areas of eight inches.

The conifer-hardwood forest type lies above the 8,000-foot elevation. It consists mostly of white fir, Douglas fir, spruce and quaking aspen. The mountain brush type lies predominantly between 7,500 and 8,500 feet elevation. It consists mainly of gambel oak, serviceberry and curlleaf mountain mahogany. The pinyon-juniper forest type is predominantly pinyon and Utah juniper and it occurs between 5,800 and 7,500 feet elevation. The sagebrush type is found throughout the basin from the desert valley floors up to mountain valleys slopes.

The predominant vegetative communities are salt desert scrub, desert grasslands. These grass vegetative types are found in the semi-desert zone at about 5,000 feet. Other important plants include Indian ricegrass, needle and thread grass, bottle brush, squirreltail, galleta and winterfat.

Land Use - The Natural Resources Conservation Service capability groupings show, in a general way, the suitability of the soil for most field crops. Soils are grouped according to their limitations and the way they respond to treatment.

The capability system groups soils at three levels: 1) capability class, 2) sub class, and 3) unit. Capability classes, the broadest group, run from one to eight. The numbers indicate progressively greater limitations and narrower choices for practical uses of agricultural cultivation. Other uses, such as for grazing or wildlife, may not be as restrictive.

The lower numbers are the more choice lands suitable for growing irrigated crops. As the numbers increase, the land becomes more suitable for permanent pasture and progressively to grasslands, forested areas and rocklands. Most of the cropland is found in the first four classes. Lands used for farming can also be defined according to their agricultural production ability and potential.

About 89,000 acres of farmland are currently irrigated; only about 3 percent of the basin area. The balance of the area is used for

Table 3-6
Vegetative Types

Vegetative Type	Drainage (acres)									
	Price	San Rafael	Dirty Devil	Escalante	Paria	Lower Green	Lake Powell	San Juan	Wahweep	TOTAL
Water	2,573	2,560	4,791	1,831	0	2,780	39,788	12,995	42,155	109,473
Alpine	0	6,995	18,631	14,863	0	0	108	0	0	40,597
Spruce-Fir/Mountain Shrub	15,038	52,222	157,279	59,619	1,791	0	5,486	0	51	291,486
Ponderosa Pine/Mountain Shrub	26,762	14,567	98,697	46,686	16,351	0	2,102	0	951	206,116
Mountain Fir/Mountain Shrub	62,010	31,794	31,184	8,505	1,843	0	1,429	0	125	136,890
Aspen	80,162	76,257	63,880	25,149	482	0	1,637	0	0	247,567
Aspen/Conifer	7,330	7,069	3,949	2,898	37	0	121	0	10	21,414
Juniper/Pinyon	227,246	263,854	558,702	376,813	292,513	52,773	138,533	0	205,502	2,115,936
Oak/Mtn. Mahogany/Mountain Shrub	38,484	33,010	45,593	14,072	16,602	53	16,165	0	1,566	165,546
Sagebrush/Perennial Grass	257,353	211,455	328,179	127,004	99,189	13,280	19,241	0	81,834	1,137,535
Grassland/Desert Grassland	69,600	406,771	516,243	243,683	75,939	119,907	126,078	0	61,934	1,620,155
Meadow	39,578	23,828	44,164	6,190	2,822	0	349	0	3,238	120,169
Mountain Riparian	1,263	2,320	1,974	877	104	0	157	0	0	6,695
Lowland Riparian	2,162	2,898	764	692	220	3,587	101	0	1,074	11,498
Salt Desert Scrub/Rangeland Brush	339,112	337,020	753,985	307,229	125,807	333,376	486,937	0	449,795	3,133,261
Lava	0	0	67	0	0	0	0	0	0	67
Barren	5,657	51,355	127,015	49,718	27,945	9,285	29,347	0	10,097	310,419
Agriculture	26,697	30,278	29,454	6,597	2,945	3,250	0	0	0	99,221
Urban	3,803	2,147	2,204	502	413	493	48	0	154	9,764
TOTALS	1,204,830	1,556,400	2,786,755	1,292,928	665,002	538,784	867,627	12,995	858,486	9,783,809

Source: Utah Division of Wildlife Resources

rangeland, although some higher rockland areas are unsuitable for grazing. Forest resources found in many areas provide opportunities for commodity production in addition to utilizing the grazing resource.

3.3.5 Land Status

The total area of the West Colorado River Basin is nearly 10 million acres. The hydrologic study areas are shown in Table 3-7. The federal government has the responsibility to administer about 86 percent of the lands in the basin. The state administers about 6 percent and 8 percent is privately owned. The breakdown of land ownership and administration is shown in Table 3-8. The federally administered land is under the jurisdiction of three agencies: 1) Forest Service, 2) Bureau of Land Management, and 3) National Park Service. Table 3-9 shows the areas under each of these jurisdictions.

3.4 Water-Related History [6]

As the early settlers began moving into the basin, they immediately dug ditches and built small storage facilities to irrigate their croplands. Soon after settlement, the effects of changes in land use began to appear near expanding communities, particularly in the Wasatch Plateau. Timber harvesting and grazing by increasing numbers of livestock began to weaken the vegetation holding the friable soil on steep slopes causing erosion of upland range. Loss of vegetation and gullying of slopes had the hydrologic effect of increasing flood peaks and decreasing base flow in streams upon which irrigators depended. As the result of pressure from western farmers and ranchers, Congress passed the Forest Reserve Act of 1891 and the Organic Act of 1897 under which forest reserves could be set aside for the protection of timber resources and watersheds. Congress established the Forest Service in 1905, giving it the responsibility to manage the forest reserves for multiple use purposes.

Comprehensive management evolved slowly until the widespread floods of the 1920s and 1930s. In the 1930s, federal assistance under the CCC and the Works Project Administration was applied to large scale watershed rehabilitation projects on the Manti National Forest as well as other forests in Utah. The Taylor Grazing Act of the 1930s restricted grazing on Public Domain lands. By 1950 the Forest Service and the Bureau of Land Management aggressively reduced livestock numbers on public lands. The decrease in mud flows and damaging floods since 1940 can be at least partly attributed to multiple-use land management, although variations in climate may have also played a part.

As the settlements grew, they collected spring water and dug wells for their culinary (domestic) water needs. These early developments, although small, provided then and still provide a portion of the water supply in the basin. Some larger projects which provide the majority of the current water supply are major contributors to the economic life of the basin.

Price River/San Pitch River Developments

Irrigation concerns in Sanpete County were addressed as early as 1867 when the Fairview Lakes were constructed. Water was first delivered from the lakes to Cottonwood Canyon by way of a ditch that discharged into the White Pine Fork of the Sevier River Basin. The Mammoth Reservoir Company was incorporated and made filings on the flood waters of the Price River in 1896. A group of San Pitch River (Sevier River Basin) farmers obtained the rights of the company in 1900 to store water on Gooseberry Creek and convey it by transmountain diversion to their lands. During 1902, they had financial difficulties and the project passed into the hands of the Irrigated Lands Company. This company abandoned the transbasin diversion and made plans to irrigate 25,000 acres near Price. The company borrowed money from the state of Utah and proceeded with construction of Mammoth Dam. Financial difficulties caused the Irrigated Lands Company to be reorganized in 1911 to form the Price River Irrigation Company. They built the Mammoth Dam approximately 100 feet downstream of the present Scofield Dam. The dam failed in June 1917 before it was finished, releasing about 11,000 acre-feet of water and causing flood damage estimated at $1 million to railroad and mining property. The dam was never rebuilt.

The first Scofield Dam on Price River was completed in 1926 by the Price River Water Conservation District, forming a 61,000 acre-foot capacity reservoir to replace the Mammoth Reservoir. The Scofield Dam partially failed in 1928 when the reservoir filled for the first time.

Table 3-7
Land Areas

Sub-Basin	Utah	Wasatch	Sanpete	Duchesne	Carbon	Emery	COUNTY Grand (acres)	Sevier	Piute	Wayne	Garfield	Kane	San Juan	TOTAL
Price	69,075	39,742	31,118	22,911	612,180	428,276	0	0	0	0	0	0	0	1,203,302
San Rafael	0	0	143,660	0	3,558	1,381,813	0	0	0	26,302	0	0	0	1,555,333
Dirty Devil	0	0	38,157	0	0	609,662	0	363,053	18,051	1,324,246	431,313	0	0	2,784,482
Escalante	0	0	0	0	0	0	0	0	0	1,348	1,007,380	285,588	0	1,294,316
Paria	0	0	0	0	0	0	0	0	0	0	152,793	512,775	0	665,568
Lower Green	0	0	0	0	0	316,193	1,473	0	0	214,832	3,038	0	0	535,536
Lake Powell	0	0	0	0	0	0	0	0	0	9,334	763,461	100,995	0	873,791
Wahweep	0	0	0	0	0	0	0	0	0	0	10,200	848,287	0	858,487
San Juan	0	0	0	0	0	0	0	0	0	0	0	0	12,995	12,995
TOTAL	69,075	39,742	212,935	22,911	615,738	2,735,944	1,473	363,053	18,051	1,576,062	2,368,185	1,747,645	12,995	9,783,809

Table 3-8
Land Ownership and Administration

Status	Utah	Wasatch	Sanpete	Duchesne	Carbon	Emery	COUNTY Grand (acres)	Sevier	Piute	Wayne	Garfield	Kane	San Juan	TOTAL
Private	49,848	13,683	12,448	15,701	284,363	234,848	1,473	20,791	122	56,240	55,897	25,519	0	770,933
State	3,155	163	2,709	5,955	76,840	289,745	0	16,026	16,437	191,030	192,257	223,823	0	1,018,140
Federal	16,072	25,896	197,778	1,255	254,535	2,211,351	0	326,236	1,492	1,328,792	2,120,031	1,498,303	12,995	7,994,736
TOTAL	69,075	39,742	212,935	22,911	615,738	2,735,944	1,473	363,053	18,051	1,576,062	2,368,185	1,747,645	12,995	9,783,809

Table 3-9
Federal Land Administration

Agency	Utah	Wasatch	Sanpete	Duchesne	Carbon	Emery	COUNTY Grand (acres)	Sevier	Piute	Wayne	Garfield	Kane	San Juan	TOTAL
Forest Serv.	9,219	25,896	197,778	58	31,913	210,327	0	246,520	272	160,165	446,775	11,203	0	1,340,126
Bureau of Land Mgmt.	6,853	0	0	1,197	222,622	1,998,705	0	74,414	1,220	894,028	1,253,710	1,116,355	0	5,569,104
Nat'l Park	0	0	0	0	0	2,319	0	5,302	0	274,599	419,546	370,745	12,995	1,085,506
TOTAL	16,072	25,896	197,778	1,255	254,535	2,211,351	0	326,236	1,492	1,328,792	2,120,031	1,498,303	12,995	7,994,736

Source: Utah Geographic Reference Center

Storage in the reservoir was thereafter restricted by the state engineer to a maximum content of 20,000 acre-feet until 1936 and 30,000 acre-feet after that.

In 1933 the Bureau of Reclamation recognized the need to develop a comprehensive water development plan on the Price River System to meet the water needs of Carbon and Sanpete (Sevier River Basin) counties. The plan evolved to become known as the Gooseberry Project Plan. Originally the Gooseberry Project Plan included three major features: (1) A dam on Gooseberry Creek with feeder canals from Brooks Canyon and Cabin Hollow Creeks, (2) a transmountain tunnel, and (3) an enlarged Scofield Reservoir to provide water by exchange to support a transmountain diversion of water for the dam site on Gooseberry Creek.

Scofield Reservoir

Replacement of Scofield Dam was expedited during World War II because potential failure of the existing dam posed a threat to the war effort. The Scofield Project was completed in 1946 and replaced the existing unsafe dam to stabilize the water supply in Carbon County. In addition, the reservoir storage capacity was enlarged to store surplus flows so that the remainder of the Gooseberry Project Plan could be completed.

A plan to complete the Gooseberry Project was formulated in 1953 by the Bureau of Reclamation. In 1964 a transmountain tunnel (the Narrows Tunnel) was constructed with a loan from the Utah Board of Water Resources. After the tunnel was completed, controversy developed over the use of Gooseberry Creek water for the transmountain diversion and further work on the plan came to a halt. Acceptance of the 1999 Environmental Impact Statement is currently holding up the project.

Emery County Project

Natural flows from Huntington Creek were first appropriated in 1876 when small ditches were dug to divert water onto about 320 acres of land. Canals were constructed in 1878 to divert irrigation water from Cottonwood and Huntington creeks. By about 1900, all dependable natural flows of the two creeks had been appropriated. The individual canal companies of the Huntington area consolidated in 1932 into the Huntington-Cleveland Irrigation Company. The small companies in the Cottonwood area joined in 1937 to form the Cottonwood Creek Consolidated Irrigation Company.

Wide seasonal fluctuations in available water supply led to inefficient irrigation practices in much of Emery County. Plans were investigated in the late 1940s to early 1950s to alleviate this problem, resulting in the Emery County Project which was completed by the Bureau of Reclamation in 1966.

The Emery Water Conservancy District was formed April 4, 1961 by order of the Seventh Judicial District Court of the state of Utah in and for Emery County. It serves as a general contracting and administrative agency for the Emery County Project. The Huntington-Cleveland Irrigation Company and the Cottonwood Creek Consolidated Irrigation Company purchase project water from the conservancy district which distributes it into the canals in their systems. The Emery County Project provided further storage regulation of the flows of Cottonwood and Huntington creeks in order to increase the irrigation water supply for 18,004 acres of land and provide a full supply for 771 acres of new land. The project also provided benefits to recreation and fish and wildlife.

The principal project storage is the 62,500-acre-foot Joes Valley Reservoir that is formed by a dam on Seeley Creek, a major tributary of Cottonwood Creek. Water is released from the reservoir as needed for irrigation flows in Seeley Creek to Cottonwood Creek, from which it is diverted for distribution by the existing canals and by the project's new Cottonwood Creek-Huntington (CC&H) Canal. This canal delivers project water to the Huntington Canal, the North Ditch and some private ditches, all of which divert from Huntington Creek. Other project water in Cottonwood Creek is distributed through the Blue Cut and Great Western canals and private ditches diverting from the creek.

Huntington Creek water available through the project is diverted through the North Ditch to the Huntington North Reservoir located adjacent to Highway 10 about one mile northeast of Huntington, Utah. The reservoir has a capacity of 5,420 acre-feet. The stored water is released as needed into the Huntington North Service Canal in which it is returned to the North Ditch and may also be conveyed to the south branch of the Cleveland Canal. Some lands irrigated from Huntington Creek that are at a higher elevation than the Cottonwood Creek-Huntington (CC&H) Canal are irrigated by the Cleveland Canal. These lands receive additional water from Huntington Creek in exchange for replacement project water delivered to lands below the CC&H Canal.

Not all of the acres presently irrigated in the Emery Project area received project water. Some of the lands already had a full water supply, and other lands were not productive enough to justify additional water.

Project irrigators were to limit early-season diversions under pre-project water rights in order to make more water storable for late season use and to impede damaging water accumulations in parts of the project area. The irrigators also planned to improve irrigation efficiencies by rotating water turns and discontinuing the practice of a constant division of the available stream flow along laterals on a percentage basis. The project also included lining of some of the existing canals.

Fishery benefits were provided at Joes Valley and Huntington North reservoirs. Four small reservoirs above the Joes Valley site, with combined capacities of about 264 acre-feet, were acquired by the project and maintained at constant water elevations for fishery purposes. Replacement storage for these reservoir owners was provided in


Joes Valley Reservoir

the reservoir. Minimum flows of 10 cfs in the creek channel below Joes Valley Reservoir will be maintained for domestic and stock-watering use. Private lands above Joes Valley Reservoir were acquired and national forest lands were improved in order to replace the big game grazing range within the reservoir basin.

The Bureau of Reclamation constructed the recreational facilities at Joes Valley Reservoir. The Forest Service now maintains and operates the campground, picnic area and boat launch facilities. Limited recreational facilities at Huntington North Reservoir were originally planned by the National Park Service. The state now maintains and operates Huntington State Park, which consists of a campground, picnic area and boat launch facilities.

In the 1960s, Utah Power (previously Utah Power and Light Company) began purchasing shares of stock in the Cottonwood Creek Consolidated Irrigation Company and the Huntington Cleveland Irrigation Company to use for process water for power generation at the proposed Huntington coal-fire plant. Utah Power also obtained 6,000 acre-feet of project water and also has primary water shares in the Ferron Canal and Reservoir Company.

Utah Power completed the Huntington coal-fire plant in 1977 with two units (845,000 kw) and began generating power. Later the Hunter plant was completed in 1987 with coal/fire/steam generation units. At that time the company obtained another 2,574 acre-feet of project water to firm up a water supply for a third unit at the Hunter plant. The third unit was completed in 1983, and the Hunter plant has a present power generation capacity of 1,240 mw.

Utah Power is now using 8,574 acre-feet of project water as well as its primary water rights in Cottonwood, Huntington and Ferron creeks for power production at the Huntington and Hunter power plants. The use of water for power production by Utah Power has resulted in a decrease in the salt loading to the Colorado River.

Ferron Watershed Project

Millsite Reservoir (funded by the Board of Water Resources) was completed in 1971 as part of the Ferron Watershed Project under the authority of the Watershed Protection and Flood Prevention Act. This project was designed by the U.S. Soil Conservation Service (now the Natural Resources Conservation Service) and included upgrading water quality, sediment and flood retention, irrigation distribution, and rangeland stabilization of the Ferron Creek drainage. The 18,000 acre-foot reservoir's primary function is to provide irrigation storage; however, it also provides a conservation pool for fish, recreational opportunities, and serves local municipal and industrial water needs. The Hunter Power Plant receives about 30 percent of its water from this facility. Other smaller reservoirs were also built, as well as the recreational facilities at Millsite State Park, as part of this watershed project.

Millsite Reservoir

Under the Ferron Watershed Project, eight debries basins and a livestock pipeline to replace the use of Ferron Creek for livestock water were also constructed. Three reservoirs in the upper watershed (Duck Fork, Willow Lake and Ferron Reservoir) were converted from irrigation storage to fisheries. About 10 percent of the Ferron irrigation system was improved (earth ditches converted to pipeline). The upper watershed was treated by the Forest Service to improve vegetative cover.

Electric Lake

Electric Lake, completed in 1973, is owned by Utah Power. The 31,500 acre-foot reservoir was built to provide water storage for use in the company's Huntington Power Plant. Other than a constant fishery release and an obligation to release lease-back privileges to farmers affected by the power plant, most of the water for the plant is released on call.

Electric Lake

Wayne County Developments

In the late 1800s, many ditches and canals were built for irrigation in the vicinities of Fremont, Loa and Bicknell. The Fremont Irrigation Company (FIC) was formed in 1889 to "promote good feelings among the water users of Fish Lake and the Fremont River and to manage such waters." Fish Lake was purchased in 1889 by the FIC from the Paiute Indians. The FIC first built the Thurber Canal (now the Highline Canal) and then in 1890 negotiated with

Forsyth Reservoir

Johnson Valley ranchers for the purchase of their land to construct Johnson Valley Reservoir, completed in 1899. A controversy over water rights between stockholders and non-stockholders began. The McCarthy Court Decree of 1902 and the construction of Forsyth Reservoir (completed in 1917) were the solutions to the dispute. Forsyth Dam washed out in 1921, but was rebuilt in 1925. Mill Meadow Dam was built in 1955 for the irrigation company and financed by the Utah Water and Power Board (now the Utah Board of Water Resources).

Farmers around Teasdale built several small reservoirs on Donkey Creek and Bullberry Creek. In 1950 the dam on Bullberry Creek washed out; it has never been rebuilt. Farmers in and around Grover began irrigating lands in 1893 and built outlet structures on Fish Creek Lake to draw more water out of this small natural lake.

Between 1955 and 1985, the U. S. Agricultural Stabilization and Conservation Service (ASCS) and the Utah Board of Water Resources provided funding for the conversion of flood irrigation practices to sprinkler irrigation. Western Wayne County is one of the first areas of the state where all of the farmland was completely converted to sprinkler irrigation.

Garfield County Developments

Wide Hollow Reservoir was built by the New Escalante Irrigation Company in 1954. It was designed by the Soil Conservation Service (now Natural Resources Conservation Service) and financed by Farmers Home Administration. It originally held 2,400 acre-feet of water, but sedimentation has reduced its capacity to 1,400 acre-feet. Presently, there is a plan to reduce the capacity of Wide Hollow to 400 acre-feet and construct a new reservoir of between 4,000 to 6,000 acre-feet (see Section 9).

North Creek Reservoir was originally completed in 1932. This dam immediately failed, and a new dam was completed in 1941. About 400 acre-feet of water is stored for irrigation use by the New Escalante Irrigation Company, and recreation is also provided. Jacobs Reservoir was constructed in 1911. It contains 1,967 acre-feet of storage for the Pine Creek Irrigation Company which is used to irrigate lands just north and east of Escalante.

Several small lakes used for irrigation are above the town of Boulder. Spectacle Lake Reservoir dam was originally constructed in 1932 and raised 10 feet in 1934. The dam failed in 1938, and repair and improvement was completed in 1949 with financial help from the Utah Water and Power Board (now Utah Board of Water Resources). The dam was repaired in 1991. A third of the costs were paid by Garkane Power Association, Inc., which used this water source for hydropower production. McGath

Wide Hollow Reservoir

Lake Dam was built in 1896 and stores water for use in the Salt Gulch area west of Boulder. Most of the agricultural lands around Boulder have been put under sprinkler irrigation.

Tropic Reservoir (capacity 1,850 acre-feet) was built on the East Fork of the Sevier in 1901 to provide irrigation water for use in Bryce Valley (Tropic area). The reservoir also supplies water to Otter Creek Reservoir in the Sevier River Basin. A canal was constructed and today flows through Bryce Canyon National Park to the town of Tropic. The dam's spillway washed out in 1935. In 1936 the dam was reconstructed. The dam and reservoir are owned by the Tropic and East Fork Irrigation Company. This import into the West Colorado River Basin is the only major import into the entire Colorado River system.

Lake Powell

On October 15, 1956, President Dwight D. Eisenhower pushed a button at his White House desk, initiating the blast that started construction of the Glen Canyon Dam in Arizona eight miles south of the Utah border. This put in motion a mammoth building project by the Bureau of Reclamation to harness the power of the Colorado River. A knowledge of its history is essential in understanding the West.

The dam and reservoir were built as part of the Colorado River Storage Project and was needed to assure that the Upper Basin states could meet their Lower Basin delivery obligations under the 1922 Colorado River Compact without curtailing Upper Basin uses. The dam is 580 feet high and impounds 26 million acre-feet of water. The dam and associated 800-megawatt plant are operated by the Bureau of Reclamation. The dam has backed up the flows of the Colorado and San Juan rivers 186 miles and 71 miles respectively, creating 1,960 miles of shoreline (more than along the entire New England coast). It is one of the largest man-made lakes in the United States.

Forecasters estimated in the 1950s that Lake Powell would have up to a half-million visitors during a year; it now receives visitation like that on Labor Day weekend alone. Some come to fish, others to swim and boat, still others to explore; but all come to enjoy the red rock, sand and sun for which Lake Powell is famous. Marinas located at Page, Wahweap, Bullfrog, Hall's Crossing and Hite sit on land that used to be visited only by Navajos, Paiutes and an occasional white man, but now serve millions of people.

Colorado River

The steep and turbulent Colorado River falls more than 12,000 feet in its 1,440-mile course from the Rocky Mountains in Colorado and Wyoming to its natural outlet in the Gulf of California. The river has a huge drainage basin that covers over 244,000 square miles located in parts of seven states and Mexico. The seven states are referred to as the Colorado River Basin states and comprise about one-twelfth of the area of the continental United States. (See Figure 3-8.) Despite the size of the watershed, the Colorado River ranks only sixth among the nation's rivers in volume of flow with an average annual undepleted flow in excess of 17.5 million acre-feet (15 million acre-feet at Lee Ferry, the compact division point). In comparison, the Columbia River's drainage is about the same size but its flow is about 12 times greater. Demands on the Colorado River are not limited to needs within the Colorado River Basin. In fact, more water is exported from the basin than from any other river system in the country. The Colorado River provides municipal and industrial water for more than 20 million people living in the major metropolitan areas of Los Angeles, Phoenix, Las Vegas, Salt Lake City,

Rainbow Bridge National Monument, Lake Powell

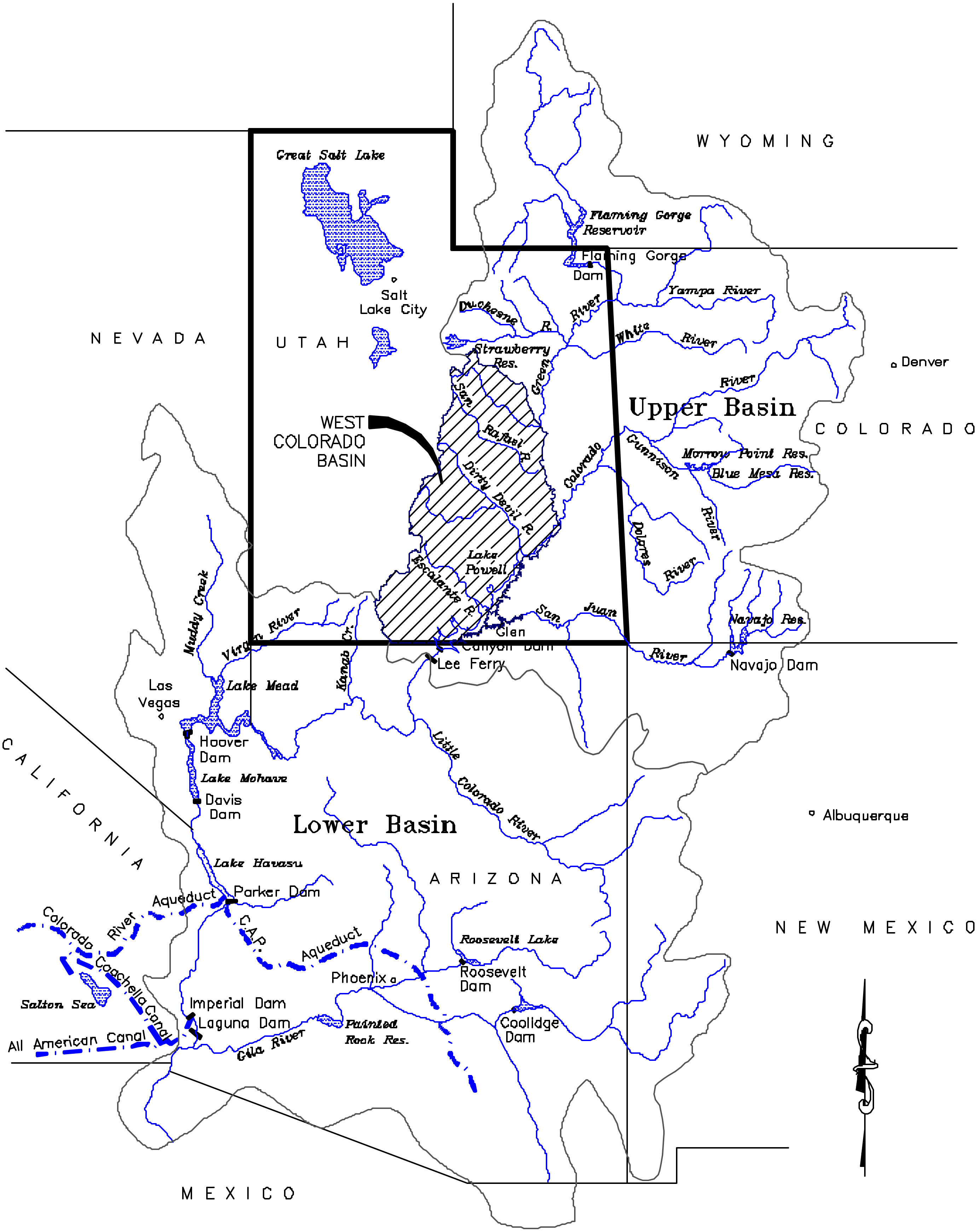


Figure 3-8
COLORADO RIVER DRAINAGE BASIN
West Colorado River Basin

Denver, San Diego and hundreds of other communities in the seven states. It also provides irrigation water to more than 1.5 million acres of land. The river has more than 60 million acre-feet of storage capacity (most is in Lake Powell and Lake Mead), 4,000 megawatts of hydroelectric-generating capacity and provides more than 20 million annual visitor-days of outdoor recreation.

Because of the critical role of water to all social and economic activity in the arid West, the Colorado River has been the subject of extensive negotiations and litigation. From this has developed a complex set of federal laws, compacts, court decisions, treaties, state laws and other agreements collectively known as "The Law of the River". The principal historical documents forming the "Law of the River" are:

– Colorado River Compact of 1922,
– Boulder Canyon Project Act of 1928,
– Mexican Treaty of 1944,
– Upper Colorado River Basin Compact of 1948,
– Colorado River Storage Project Act of 1956,
– U.S. Supreme Court Arizona v. California decision (1963),
– Colorado River Basin Project Act of 1968,
– Criteria for Coordinated Long-Range Operation of Colorado River Reservoirs of 1970,
– Minute 242 of the 1973 International Boundary and Water Commission,
– Colorado River Basin Salinity Control Act of 1974,
– The Grand Canyon Protection Act of 1992.

Dividing the River - The Colorado River is often described as the most regulated river in the world. Considering its importance to the basin states, American Indian Tribes and Mexico, it is surprising any agreement has been reached to divide the river's water.

In the late 1800s and early 1900s, a sizeable agricultural development emerged in California's Imperial Valley. Water was delivered to the valley from the Colorado River through a canal that went through Mexico. Mexico allowed Imperial Valley farmers to use the channel in exchange for a portion of the water. American farmers were unhappy with the Mexican government controlling their water supply from the river, so they began to push for the construction of a new canal built entirely within the United States, an "All American" canal. Disastrous flooding occurred in 1905 along the Colorado River. The river broke through a temporary diversion through the river bank and for two years the entire flow of the river poured into the Imperial Valley before it could be diverted back to the river channel. The flooding destroyed homes and thousands of acres of agricultural land, filling a natural depression known as the Salton Sink and creating today's Salton Sea. As additional flooding occurred in 1910 and the Mexican Revolution began, pressure intensified to construct an All-American canal to bring Colorado River water to the valley and build a flood control dam and storage reservoir on the lower mainstem Colorado River. In addition, Los Angeles was interested in developing hydroelectric power to meet needs of its growing population.

California realized construction of a project to harness the river would require the federal government's assistance, which would raise legal and political issues. The other six basin states did not oppose structural control of the river but were determined to resist a project for California, unless they received satisfactory assurance of their future use of the river's water. Such use by California, they feared, would establish appropriative claims to the water (first in time, first in right) and would prejudice the equity of any future apportionment of the Colorado River among the states. The solution appeared to be the development of an interstate compact between the basin states that would detail the division of the water in the Colorado River.

1922 Colorado River Compact - Compact discussions began on January 26, 1922, and on November 24, 1922, the basin states and federal government compact negotiators approved the Colorado River Compact. The compact split the river system into an Upper Basin (Arizona, Colorado, New Mexico, Wyoming and Utah) and a

Lower Basin (Arizona, California, Nevada, New Mexico and Utah) and apportioned the rights to the water between Lower and Upper basins. The dividing line and measuring point was at Lee Ferry, approximately 17 miles below Glen Canyon Dam and two miles below the confluence with the Paria River. (The gage is actually at Lees Ferry, about four miles upstream of Lee Ferry.) The compact apportioned from the Colorado River in perpetuity to the Upper and Lower basins the exclusive, beneficial consumptive use of 7.5 million acre-feet of water per annum. The Upper Basin agreed to guarantee the Lower Basin an average of 75 million acre-feet in any consecutive 10-year period. In addition, the Lower Basin received the right to increase its annual beneficial consumptive use of water by 1.0 million acre-feet. Even though the compact negotiators were unsuccessful in their attempt to divide the water between the individual states as originally intended, the compact reduced the Upper Division states' concern that the faster-growing Lower Division states would monopolize use of the Colorado River. The compact set aside the prior appropriation doctrine of "first in time, first in right" and allowed each basin to develop its apportioned water as needed without fear of losing it through non-use. The compact side-stepped quantification of Indian water rights.

The Arizona legislature, in contrast to other basin states, refused to ratify the compact because it felt the compact left Arizona unprotected against rapid development in California. Arizona also opposed including tributary water (specifically the Gila River) in the compact's apportionment. Because of Arizona's refusal to approve the compact, Congress did not ratify the compact until 1928 when the Boulder Canyon Project Act was passed. The act allowed the compact to become law with the approval of six states and the enactment by California of a statute limiting its use of Colorado River water. Arizona finally ratified the compact in 1944. The California Self Limitation Act was passed March 4, 1929. It provides that: "...the State of California agrees irrevocably and unconditionally with the United States and for the benefit of the states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming as an express covenant and in consideration of the passage of the said Boulder Canyon Project Act that the aggregate annual consumptive use of water of and from the Colorado River for use in the State of California ... shall not exceed four million four hundred thousand acre-feet of the waters apportioned to the lower basin states by Paragraph A of Article 3 of the said Colorado River Compact, plus not more than one-half of any excess or surplus waters unapportioned by said compact..."

For clarity, the 1922 Colorado River Compact says the term "states of the Upper Division" means the states of Colorado, New Mexico, Utah and Wyoming, and the term "states of the Lower Division" means the states of Arizona, California and Nevada. It further says the term "Upper Basin" means those parts of the states of Arizona, Colorado, New Mexico, Utah and Wyoming within and from which waters naturally drain into the Colorado River system above Lee Ferry. The term "Lower Basin" means those parts of the states of Arizona, California, Nevada, New Mexico and Utah within and from which waters naturally drain into the Colorado River system below Lee Ferry. (See Figure 5-1.)

Water for Mexico - The last 75 miles of the Colorado River is in Mexico, where the water is used for irrigation. Mexico's share of the Colorado River is determined under provisions of a treaty signed in 1944. The treaty guarantees Mexico 1.5 million acre-feet to be increased in years of surplus to 1.7 million acre-feet and reduced in years of extraordinary drought in proportion to the reduction of consumptive uses in the United States. No mention was made in the treaty about water quality, but a subsequent agreement between the United States and Mexico, called "Minute 242, International Boundary and Water Commission, September 4, 1973," contains a provision guaranteeing Mexico water within certain water quality parameters.

The water delivered at the international boundary must have an average annual salinity of no more than 115 (±30) ppm over the salinity of water which arrives at Imperial Dam. The Salinity Control Act was passed in 1974, authorizing the use of federal funds to help control salinity in the Colorado

River. Title I of the act authorized construction of a desalination plant near Yuma, Arizona, to desalt 80,000 acre-feet of return irrigation flows from farms in the Welton Mohawk Irrigation District prior to the water being diverted by Mexico. The desalting plant was completed in 1992 at a cost of $250 million. Because of the high annual operating cost of over $25 million, the plant is not being operated at the present time. Title II of the act and subsequent amendments authorized federal agencies to cost share with state and local organizations for the construction of projects, mostly in the Upper Basin, to control the salinity of the river by decreasing the amount of salt entering the river. One of the projects in Utah funded by the program is the Uintah Basin Salinity Control Project, where the irrigation efficiency on approximately 94,000 acres of farm land has been improved by implementing land leveling, border irrigation or converting from flood to sprinkler irrigation practices. This has resulted in the reduction of over 84,000 tons/year of salt entering the Colorado River. A new project in the Price-San Rafael drainage of the West Colorado River Basin has recently been authorized. As improvements are made, significant results are expected here as well.

Upper Colorado River Basin Compact - Formal negotiations on an Upper Colorado River Basin Compact were initiated on July 31, 1946. They were prompted by the desire of the Upper Basin states to continue water development which had been put on hold in 1941 by wartime restrictions. The Upper Basin states wanted to construct a major federal project, but federal funding was contingent on an Upper Colorado River Basin Compact. On October 11, 1948, the Upper Basin states entered into the Upper Colorado River Basin Compact to apportion allowable depletions between the states. The four Upper Division states were uncertain how much water would remain after they met their Colorado River Compact requirement to deliver the Lower Division 7.5 million acre-feet per annum and how the Mexican Treaty obligation might affect the available water supply. So they apportioned the remaining water as follows: Colorado, 51.75 percent; New Mexico, 11.25 percent; Utah, 23.00 percent; Wyoming, 14.00 percent; Arizona, 50,000 acre-feet (deducted prior to calculating other state shares).

The Upper Colorado River Basin Compact gave the states the final protection they needed in order to develop and use their water gradually, without fear of losing it through non-use.

Boulder Canyon Project Act - Even though Arizona refused to ratify the Colorado River Compact until 1944, it became law in 1929 with the passage of the Boulder Canyon Project Act. This act authorized construction of the All-American Canal, Hoover Dam and Power Plant, and gave Arizona, California and Nevada the option of developing a Lower Basin Compact to divide their Colorado River Compact apportionment. The Lower Division states were never able to agree on the division of the water, and the final apportionment was not decided until the Supreme Court ruled in Arizona v. California in 1963.

Arizona v. California - In 1963, after 11 years of legal battles, the U.S. Supreme Court, in its decision in Arizona v. California, confirmed the 1928 Boulder Canyon Project Act Lower Division apportionment of mainstem Colorado River as: California 4.4 million acre-feet and 50 percent of all surplus, Arizona 2.8 million acre-feet and 46 percent of all surplus, and Nevada 300,000 acre-feet and 4 percent of all surplus. The court also held that Arizona's use of the Gila River and its tributaries would not reduce its entitlement of 2.8 million acre-feet from the mainstem Colorado River.

The 1908 Winters v. United States Supreme Court decision established the doctrine of Indian reserved water rights. The courts held that such rights existed whether or not the tribes were using the water. This decision was reaffirmed by the court in Arizona v. California when the court awarded water rights to five Indian reservations in the Lower Basin. The court determined the only feasible way the tribes' reserved water rights could be measured was on the amount of "practicably irrigated acreage" on the reservations. ●

Section 4 - West Colorado River Basin
Demographics and Economic Future

4.1	Introduction	4-1
4.2	Demographics	4-1
4.3	Employment	4-3
4.4	Economic Future	4-4

Figures

4-1	Population and Projections	4-3
4-2	Employment Projections	4-7

Tables

4-1	Basin Population and Projections	4-2
4-2	Basin Employment Projections	4-5

Section 4

West Colorado River Basin - Utah State Water Plan

Demographics and Economic Future

4.1 Introduction

Price, the largest city in the basin, is 75 miles from Provo (the nearest major Wasatch Front commercial center). Many of the residents in the basin do business in Richfield; which is 83 miles from Price, 50 miles from Loa and 140 miles from Escalante.

Although the trade and government sectors each exceed agriculture in employment, the economy of the West Colorado River Basin is largely characterized by agricultural commodity production, mostly beef, dairy and irrigated crops.

Main Street in Price

Alfalfa, grass hay, pasture, grain and corn are grown mainly for livestock feed within all the counties of the basin. Some dairy farms are located in Emery and Wayne counties. Mining is also a major contributor to the basin's economy, especially in Carbon and Emery counties. A major addition to agricultural production and mining is taking shape.

The West Colorado River Basin consists of stable farm and ranch enterprises and small rural communities

Although the region is lacking in adequate facilities, recreation and tourism with Capitol Reef National Park, Glen Canyon Recreation Area (Lake Powell) and the new Grand Staircase-Escalante National Monument could become major economic factors in the southern portion of the basin, mostly Kane, Garfield and Wayne counties.

As growth occurs, proper planning at all levels of government will depend on reliable and consistent data. This section presents data to help local leaders anticipate the need for timely water resources development. Combining these data with the latest technology for delivering, using and conserving available water should result in coordinated planning and manageable economic growth.

4.2 Demographics

The West Colorado River Basin population is projected to grow at an average annual rate of 1.2 percent from 1998 to 2020, which is lower than the 2.0 percent expected growth of the entire state. Percentage growth rates of counties in the basin are: Carbon, 1.2; Emery, 0.9; Garfield, 2.0; Wayne, 2.0; and Kane, 1.9. The towns of Boulder and Torrey will experience the greatest percentage growth rates, while Price and Helper will have the greatest population increases. (See Table 4-1, Figure 4-1.)

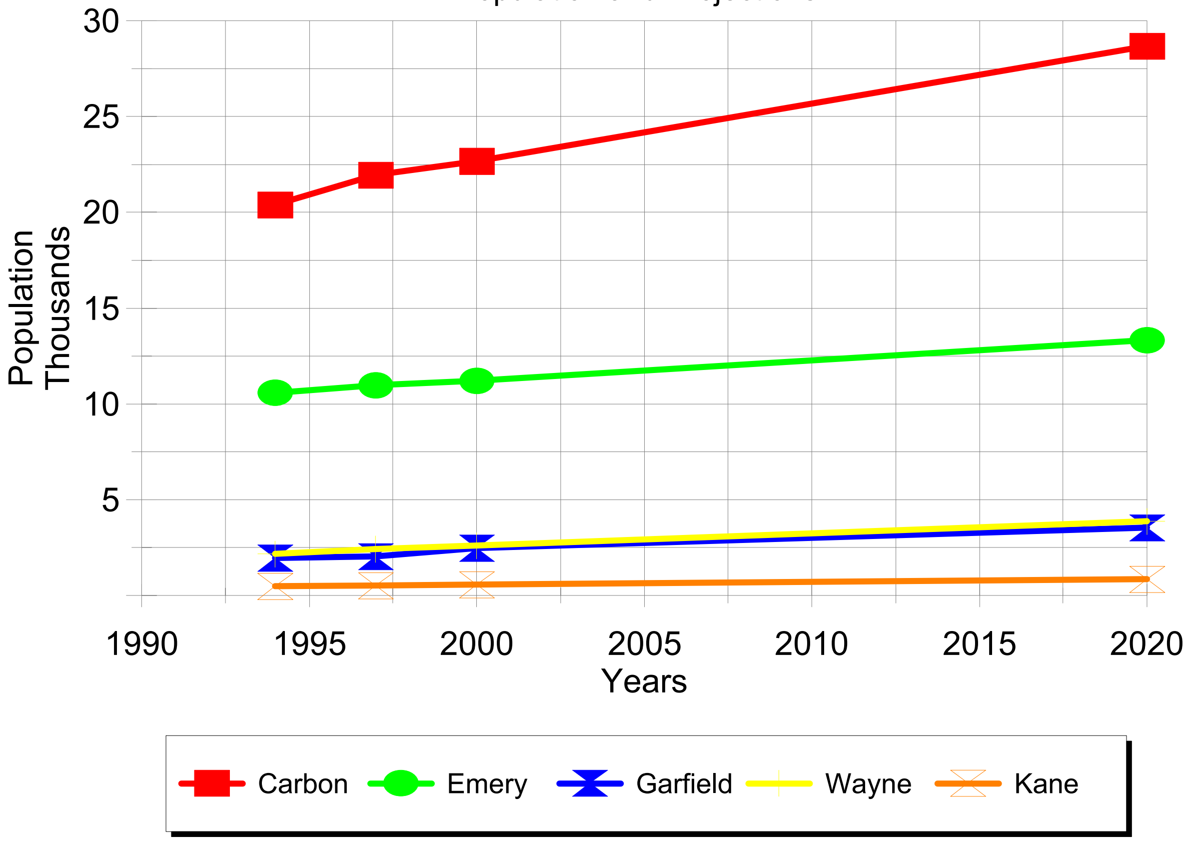
Table 4-1
Basin Population and Projections

County/City	Year 1990	1998	2000	2010	2020
Carbon					
East Carbon	1,264	1,517	1,550	1,724	1,913
Helper	2,141	2,423	2,477	2,755	3,058
Price	8,716	9,239	9,480	10,740	12,136
Scofield	40	56	57	65	72
Sunnyside	333	328	335	372	413
Wellington	1,616	1,806	1,853	2,100	2,373
Unincorporated Area	6,049	6,783	6,946	8,276	8,718
Total County	20,159	22,152	22,698	26,032	28,683
Emery					
Castle Dale	1,702	1,800	1,836	2,079	2,162
Clawson	151	159	163	185	192
Cleveland	499	556	568	644	670
Elmo	267	281	287	325	338
Emery	298	260	266	302	314
Ferron	1,610	1,739	1,777	2,035	2,116
Green River (partially located in Grand Co.)	758	704	718	813	846
Huntington	1,867	1,921	1,963	2,228	2,317
Orangeville	1,451	1,674	1,708	1,934	2,011
Unincorporated Area	1,712	1,963	1,925	2,343	2,376
Total County	10,315	11,057	11,211	12,888	13,342
Wayne					
Bicknell	331	340	354	390	438
Loa	450	499	506	547	494
Lyman	199	223	227	250	277
Torrey	123	145	153	200	254
Unincorporated Area	1,086	1,306	1,381	1,822	2,240
Total County	2,189	2,513	2,621	3,209	3,703
Garfield					
Boulder	125	225	250	350	450
Cannonville	129	147	157	177	202
Escalante	813	994	1,063	1,354	1,546
Henrieville	160	165	169	193	220
Tropic	375	414	430	569	639
Unincorporated Area	100	130	140	160	180
Total County	1,702	2,075	2,209	2,803	3,237
Kane					
Big Water	326	420	450	662	845
Unincorporated Area	140	167	174	210	252
Total County	466	587	624	872	1,097
Basin Total	34,831	38,384	39,363	45,804	50,062

Source: 1990 estimates are from U. S. Bureau of Census. Projections for 1998 and beyond have been produced by the Southeastern Association of Governments, controlled by the Utah Governor's Office of Planning and Budget county totals.

Note: Garfield and Kane counties are only partially located within the basin.

Figure 4-1
Population and Projections



The Governor's Office of Planning and Budget (GOPB) has developed the procedures and criteria for making population projections. The Utah Process Economic and Demographic (UPED) model is part of this. Local planners in the Association of Governments (AOGs) office prepared the population estimates for GOPB review. The projection model takes into account many variables regarding the demographics and industrial mix of an area. This model incorporates historical employment growth rates into the future growth patterns. Assumptions regarding labor force participation rates, non-employment related migration rates, and constant age-specific fertility and survival rates are also incorporated.

4.3 Employment

In Carbon County, government is the largest employment sector with 2,255 employees in 1998. The trade sector is second with 2,080, followed by services with 1,890. Agriculture and finance, insurance and real estate had the lowest employment with 243 and 187 respectively. The outlook for Carbon County employment is positive with a 33 percent increase projected from 1998 to 2020. The fastest growing sector will be construction with a 64 percent increase. Services are predicted to increase 58 percent. Agriculture is the only sector showing negative growth. Employment in this sector is expected to decline from 243 in 1998 to 210 in 2020. Mining jobs are expected to increase 26 percent during this period.

In Emery County, mining is the largest job provider with 948 jobs in 1998. Government and self-employed (non-farm proprietors) are close behind with 891 and 820 jobs respectively. Transportation, communication and public utilities (TCPU) have employment of 773, while services and trades provide 457 and 446 jobs respectively. Looking to the future, construction employment is expected to grow from 282 in 1998 to 722 in 2020, an increase of 156 percent. The service sector is expected to show employment growth of 51 percent. Agriculture and manufacturing are projected to lose 14 and 19 percent respectively by 2020. Other sectors will see increases of between 8.9 percent in TCPU to almost 25 percent in mining.

In Garfield County, services is the leading employment sector with 880 jobs in 1998. Non-farm proprietors is a distant second with 535, and government is third with 531. Trade is in fourth place with 296 jobs, just ahead of agriculture with 280. Most sectors will experience strong growth from 1998 to 2020, led by manufacturing with 57 percent. Agriculture will lose 14 percent of its jobs, while all other sectors will see increases from 19 to 54 percent.

In Wayne County, the leading employment sectors are government with 317 jobs, services with 292 jobs and agriculture with 250 jobs. In the future, agriculture will lose jobs, while government, services, trade and construction jobs will increase.

Table 4-2 and Figure 4-2 show employment changes for the entire basin, minus Kane County where only the small community of Big Water is located within the West Colorado River Basin.

4.4 Economic Future [41]

Natural resources such as coal, oil and natural gas will continually play an important role in the economic future of the West Colorado River Basin. Coal mining in Carbon and Emery counties will continue its importance, although some experts insist there are only about 30 years of minable ore remaining. The new methane gas production facilities show promise to provide another boost to these local economies. The vast tar sand and oil shale resources found throughout the basin could be an economic boom to local economies should another 1970-style energy crisis develop.

Business district in Tropic

Tourism is becoming very important to all the counties in the basin and will increase dramatically as the area becomes more widely known and more tourist-related facilities are built. The national parks, monuments and Lake Powell are important resources for basin residents, and their future use and visitation will continue to influence the local and regional economies. The recent federal-state land exchange in Kane County (although all counties within the basin were affected) could have a huge impact on the economy of the southern portion of the basin. Kane County would like to market this land to developers for tourist-related facilities and possible retirement communities. While agriculture will continue to decline in employment, it is expected to maintain its position as a generator of local income and a source of animal and feed products for the state. But increased wilderness, federal government allotment decreases and other environmental constraints all threaten the economic viability of the cattle-ranching business. ●

Table 4-2 Basin Employment Projections					
Industry	Year				
	1990	1998	2000	2010	2020
Carbon County					
Agriculture[a]	240	243	241	228	210
Mining	1,359	1,133	1,222	1,520	1,428
Construction	142	271	301	396	445
Manufacturing	288	480	538	580	527
TCPU[b]	467	518	535	611	683
Trade	1,764	2,080	2,127	2,388	2,650
FIRE[c]	164	187	191	214	233
Services[d]	1,459	1,890	1,990	2,504	2,983
Government	2,021	2,255	2,319	2,738	3,024
Non-Farm Proprietors[e]	1,240	1,436	1,482	1,687	1,838
Total Employment	9,144	10,493	10,946	12,866	14,021
Non-Agriculture W&S	7,649	8,801	9,208	10,935	11,959
Emery County					
Agriculture[a]	500	506	502	475	437
Mining	1,002	948	979	1,341	1,183
Construction	267	282	383	646	722
Manufacturing	13	69	98	103	56
TCPU[b]	766	773	773	797	842
Trade	437	446	446	490	513
FIRE[c]	42	45	45	50	53
Services[d]	286	457	476	599	689
Government	819	891	875	961	1,054
Non-Farm Proprietors[e]	745	820	827	925	980
Total Employment	4,877	5,237	5,404	6,387	6,529
Non-Agriculture W&S	3628	3,908	4,071	4,983	5,108
Garfield County (Includes portion in Sevier River Drainage)					
Agriculture[a]	286	280	278	263	242
Mining	7	125	128	143	149
Construction	23	82	80	86	98
Manufacturing	209	110	116	146	173
TCPU[b]	59	115	120	147	168
Trade	189	296	308	379	431
FIRE[c]	22	25	26	30	32
Services[d]	517	880	940	1,239	1,496
Government	459	531	547	697	792
Non-Farm Proprietors[e]	352	535	561	713	818
Total Employment	2,123	2,979	3,104	3,843	4,399
Non-Agriculture W&S	1,474	2,151	2,252	2,852	3,324

Table 4-2 (continued)
Basin Employment Projection

Industry	Year				
	1990	1998	2000	2010	2020
Wayne					
Agriculture[a]	249	250	249	235	217
Mining	0	1	1	2	2
Construction	40	54	72	126	148
Manufacturing	76	41	41	46	53
TCPU[b]	10	24	25	31	37
Trade	82	195	204	253	304
FIRE[c]	0	9	9	11	13
Services[d]	68	292	311	411	511
Government	273	317	320	371	431
Non-Farm Proprietors[e]	132	194	205	260	311
Total Employment	930	1,377	1,437	1,746	2,027
Non-Agriculture W&S Employment[a]	542	926	977	1,244	1,492
Basin Totals[f]					
Agriculture[a]	1,275	1,276	1,270	1,201	1,106
Mining	2,368	2,207	2,330	3,006	2,762
Construction	472	689	836	1,254	1,413
Manufacturing	586	700	793	875	809
TCPU[b]	1,302	1,430	1,453	1,586	1,730
Trade	2,472	3,017	3,085	3,510	3,898
FIRE[c]	228	266	271	305	331
Services[d]	2,330	3,519	3,717	4,753	5,679
Government	3,572	3,994	4,061	4,767	5,301
Non-Farm Proprietors[e]	2,469	2,985	3,075	3,585	3,947
Total Employment	17,074	20,083	20,891	24,842	26,976
Non-Agriculture W&S Employment[a]	13,293	15,786	16,508	20,014	21,883

[a]Agriculture and non-agriculture wage and salary employment includes specific agriculture support services.

[b]Transportation, communications and public utilities.

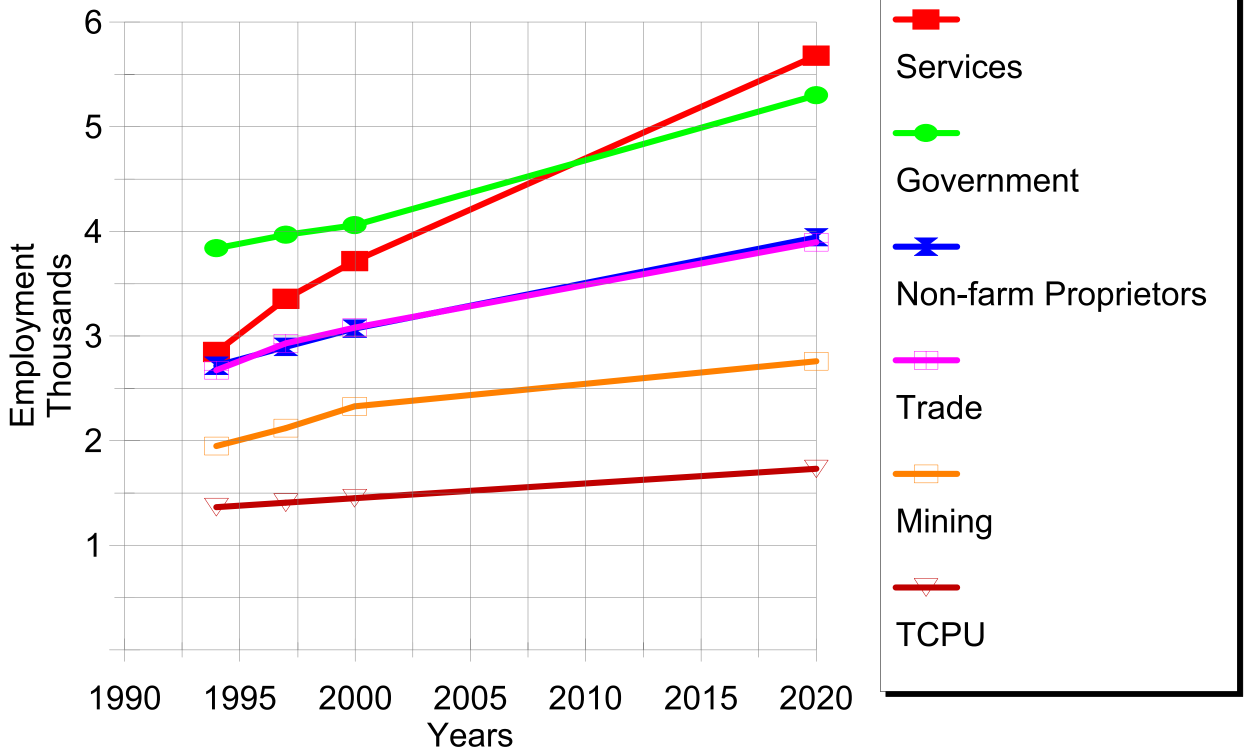
[c]Finance, insurance and real estate.

[d]Includes private household employment; excludes agricultural employment.

[e]Utah Department of Employment Security definition.

[f]Basin Totals include all employment within Carbon, Emery, Garfield and Wayne counties, even though Garfield and Wayne counties are only partially included in the West Colorado River Basin. Also, Kane County is not shown because only the community of Big Water is located in the basin.

Figure 4-2
EMPLOYMENT PROJECTIONS



Section 5 - West Colorado River Basin
Water Supply and Use

5.1	Introduction	5-1
5.2	Background	5-1
5.3	Water Supply	5-3
5.4	Water Use	5-27
5.5	Interbasin Diversions	5-31
5.6	Water Budgets	5-31
5.7	Water Supply and Use Problems	5-31
5.8	Water Quality	5-36
5.9	Issues and Recommendations	5-36

Figures

5-1	Hydrologic Study Areas	5-2
5-2	Flow Diagram, Price River	5-4
5-3	Flow Diagram, San Rafael River	5-5
5-4	Flow Diagram, Dirty Devil River	5-6
5-5	Flow Diagram, Escalante River	5-7
5-6	Flow Diagram, Paria River	5-8
5-7	Stream Flow Gaging Stations	5-11
5-8	Annual Flows, Price River Near Heiner	5-12
5-9	Annual Flows, Huntington Creek Near Huntington	5-12
5-10	Annual Flows, Cottonwood Creek Near Orangeville	5-13
5-11	Annual Flows, Ferron Creek Near Ferron	5-13
5-12	Annual Flows, Muddy Creek Near Emery	5-14
5-13	Annual Flows, Fremont River Near Bicknell	5-14
5-14	Annual Flows, Pine Creek Near Escalante	5-15
5-15	Annual Flows, Escalante River Near Escalante	5-15
5-16	Annual Flows, East Fork Boulder Creek Near Boulder	5-16
5-17	Annual Flows, Paria River Near Cannonville	5-16
5-18	Monthly Streamflow Probabilities, Price River Near Heiner	5-18
5-19	Monthly Streamflow Probabilities, Huntington Creek Near Huntington	5-18
5-20	Monthly Streamflow Probabilities, Cottonwood Creek Near Orangeville	5-19
5-21	Monthly Streamflow Probabilities, Ferron Creek Near Ferron	5-19
5-22	Monthly Streamflow Probabilities, Muddy Creek Near Emery	5-20
5-23	Monthly Streamflow Probabilities, Fremont River Near Bicknell	5-20
5-24	Monthly Streamflow Probabilities, Pine Creek Near Escalante	5-21

5-25	Monthly Streamflow Probabilities, Escalante River Near Escalante	5-21
5-26	Monthly Streamflow Probabilities, East Fork Boulder Creek Near Boulder	5-22
5-27	Monthly Streamflow Probabilities, Paria River Near Cannonville	5-22
5-28	Lake Powell Water Budget, 1976-1995	5-26
5-29	Transbasin Diversions	5-33
5-30	Supply and Use Charts	5-35

Tables

5-1	Water Budget Yields (1961-1990)	5-3
5-2	Mean Monthly and Annual Stream Flow	5-9
5-3	Peak Flows	5-17
5-4 to 5-7	Flood Frequencies	5-23
5-8 to 5-11	Flood Frequencies	5-24
5-12 to 5-13	Flood Frequencies	5-25
5-14	GSENM Stream Gages	5-28
5-15	Current Water Supply Uses	5-29
5-16	Current Irrigation Water Use	5-29
5-17	Current Culinary Water Use	5-30
5-18	Current Secondary Water Use	5-30
5-19	West Colorado River Basin Transbasin Diversions	5-32
5-20	Summary Water Budget Analysis (1961-1990)	5-34
5-21	Water Rights Versus Yield	5-37

Section 5

West Colorado River Basin - Utah State Water Plan

Water Supply and Use

5.1 Introduction

This section discusses the present water supply and use of surface water as well as groundwater. Surface water supply comes primarily from the high mountain plateaus of the Price, San Rafael, Dirty Devil, Escalante and Paria hydrologic drainages.

Agriculture is the largest water user, with municipal and industrial use making up most of the remaining demand. Expanding development of industry and recreation areas will add to the water demand.

The basin water supply is provided from precipitation, mostly snow that collects in high mountain drainages.

Huntington Creek

5.2 Background

The water supply in the basin is influenced by storm paths and topography. Storms from the Pacific Ocean, and from the south and northwest, produce the largest amounts of precipitation, mostly in the form of snow. The base period for determining the surface water supply is water years 1941 through 1990. Some of the groundwater recharge and discharge data are discussed for different time periods. These will vary depending on the reports used. These reports were published by the U.S. Geological Survey, Division of Water Resources or Division of Water Rights.

Even though the Colorado River, its major tributary, the Green River, and Lake Powell form the eastern boundaries of the basin, very little water is actually diverted from these rivers or the lake for use in the basin. Hydrologically, the West Colorado River Basin is part of eight separate major drainage units, or hydrologic subareas (See Figure 5-1). Portions of the Lower Green, Lake Powell, San Juan and the Wahweap hydrologic subareas split at the basin boundary (the eastern Lake Powell shoreline). The Price, San Rafael, Dirty Devil, Escalante, and the Utah portion of the Paria, are all completely contained within the boundaries of the basin. Many normally dry drainages occasionally experience high-volume, short-duration flood flows produced by highly intense cloudburst storms. These can occur at any location within the basin and often cause considerable damage in the more populated areas.

The primary use of water in the West Colorado River Basin is for irrigation of crops. The power plants in Carbon and Emery counties account for the second biggest users of water within the basin.

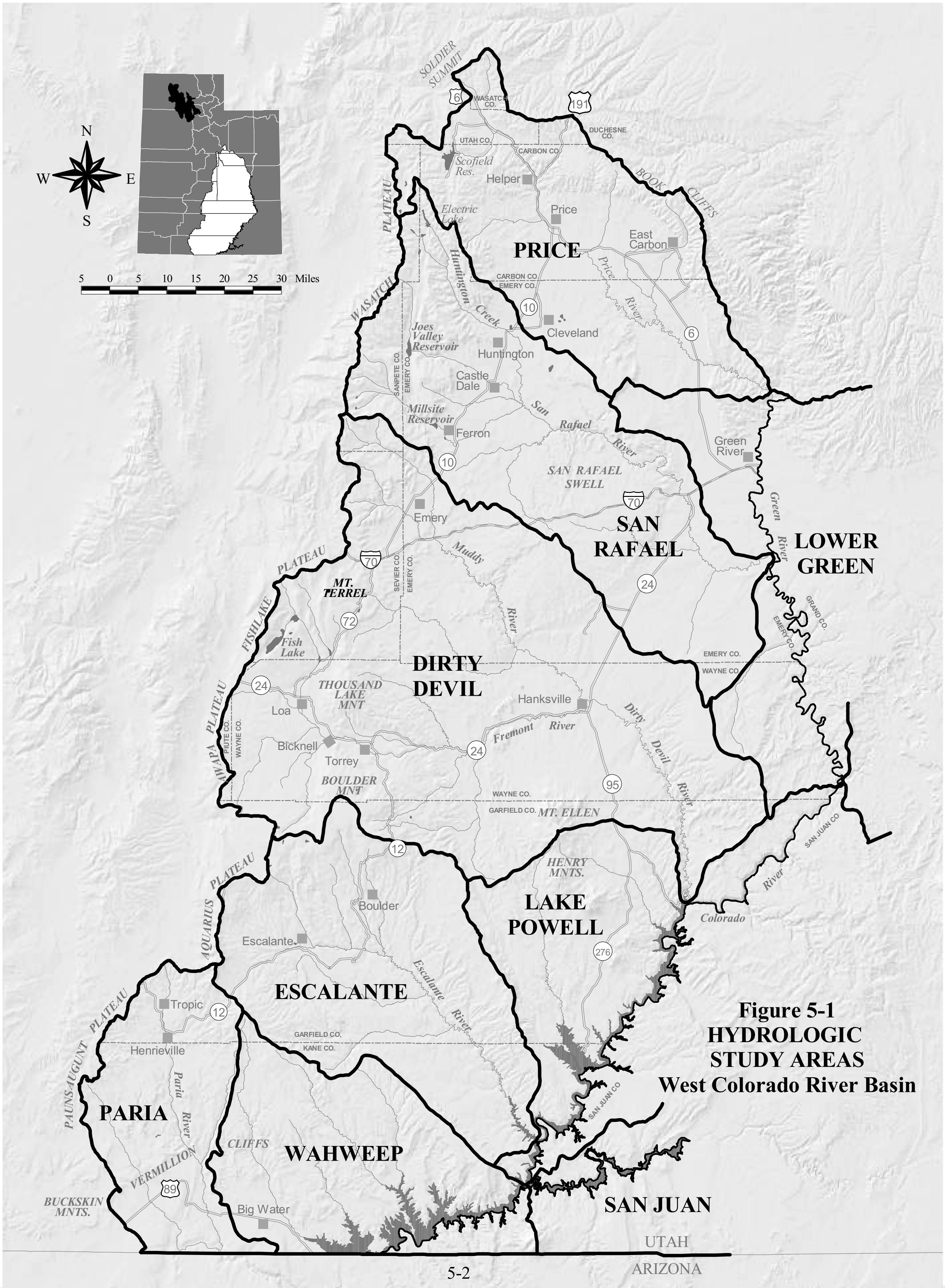


Figure 5-1
HYDROLOGIC
STUDY AREAS
West Colorado River Basin

5.3 Water Supply

Most of the water used in the West Colorado River Basin is diverted from local streams and rivers. Some municipalities also use wells and springs for their water supplies.

5.3.1 Surface Water Supply

Although streams in the basin peak at different times depending on the watershed aspect, elevation and configuration, much of the surface water runoff comes from snowmelt during the months of April, May and June. What is not diverted for irrigation and municipal and industrial (M&I) uses in most of the basin eventually flows into the Colorado River System. This water and other Upper Colorado River basin states' (Wyoming, New Mexico and Colorado) non-diverted water is stored in Lake Powell.

Figures 5-2 through 5-6 show graphical representations of the average annual streamflows and diversions for the period 1941-1990 for five major river drainages that make up the West Colorado River Basin: Price, San Rafael, Dirty Devil, Escalante and Paria rivers. The volumes are derived or estimated from stream gages or other records by correlation, all of which are maintained and read by the U.S. Geological Survey. The yield for each subbasin is shown in Table 5-1. The annual and monthly mean flows for gaged streams are given in Table 5-2, and the locations are shown in Figure 5-7.

The annual flows at several locations in the basin are shown in Figures 5-8 through 5-17. The extreme maximum and minimum daily flows are given in Table 5-3.

The dampening effect of the major reservoirs is apparent as shown by gages just below those facilities. The only exceptions are during extremely wet years such as 1983-84. Variations in runoff patterns will be different in a watershed such as East Fork Boulder Creek which is steeper and shorter than one like the Fremont River. Vegetation and soils also influence runoff patterns. The flows at different probability levels of each of these 10 gages are shown on Figures 5-18 through 5-27, respectively. A probability level of 90 percent means nine times in 10 the flows will be greater than the values shown. A level of 50 percent means near average conditions. The numbers are based on a log normal frequency analysis.

During water budget compilation, river inflow into the area was mostly determined from gage records. The yield of a subbasin is defined as outflow minus inflow plus man-caused depletions. It is the water the basin would yield if mankind were not there.

Table 5-1
Water Budget Yields (1961-1990)

Subarea	Yield (Ac-Ft/Yr.)
Price	138,000
San Rafael	233,000
Dirty Devil	147,000
Escalante	86,000
Paria	21,000
Lower Green	5,000
Lake Powell	0
Wahweap	12,000
Total	630,000

Source: Utah Division of Water Resources

Most of the basin is prone to flash flooding from high-intensity, convective, summer thunderstorms. This type of flooding has more impact on tributaries than on the main stems of the five major river systems. Rapid snowmelt or rain on snow generally has more impact on main stem flows. The floods of 1983-84 were caused by a sudden increase in temperature melting a greater than normal snow pack with a moisture filled soil profile. As a result, flood flows in the main stems of the basin's five major rivers continued well into the summer. Flood frequencies for the ten gages used before are given in Tables 5-4 through 5-13.

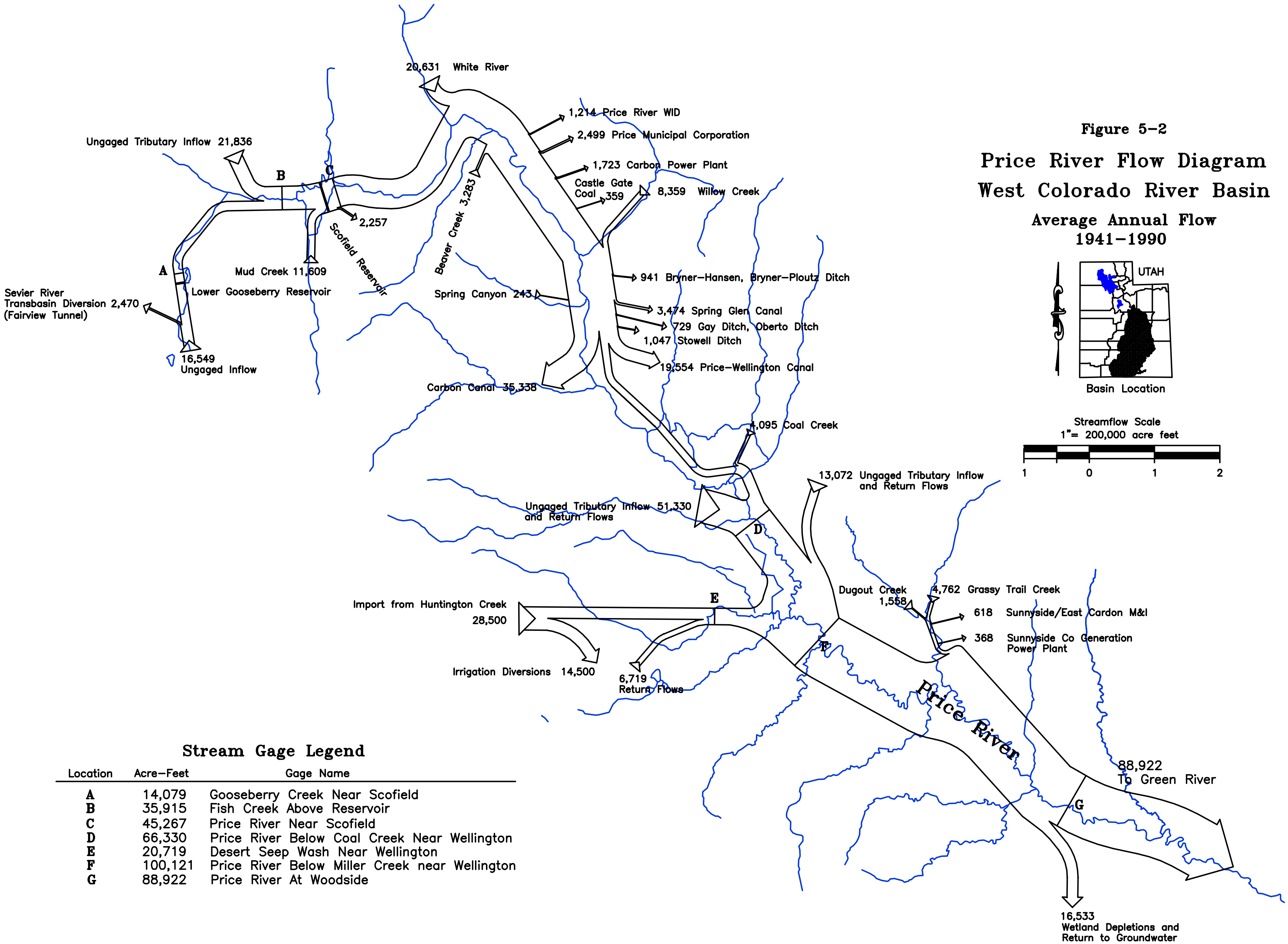
5.3.2 Groundwater Supply [4]

Good quality groundwater is not a significant part of the total economically developable water supply of the West Colorado River Basin except in the Upper Fremont Valley in Wayne County. This supply is utilized through wells (pumped and flowing), springs, and subsurface water which supports vegetation, although most is pumped. Other areas in the basin have small amounts of groundwater which are utilized mostly by municipalities pumping wells or tapping springs. See Section 19 for more information on groundwater.

Figure 5-2

Price River Flow Diagram
West Colorado River Basin

Average Annual Flow
1941-1990



Stream Gage Legend

Location	Acre-Feet	Gage Name
A	14,079	Gooseberry Creek Near Scofield
B	35,915	Fish Creek Above Reservoir
C	45,267	Price River Near Scofield
D	66,330	Price River Below Coal Creek Near Wellington
E	20,719	Desert Seep Wash Near Wellington
F	100,121	Price River Below Miller Creek near Wellington
G	88,922	Price River At Woodside

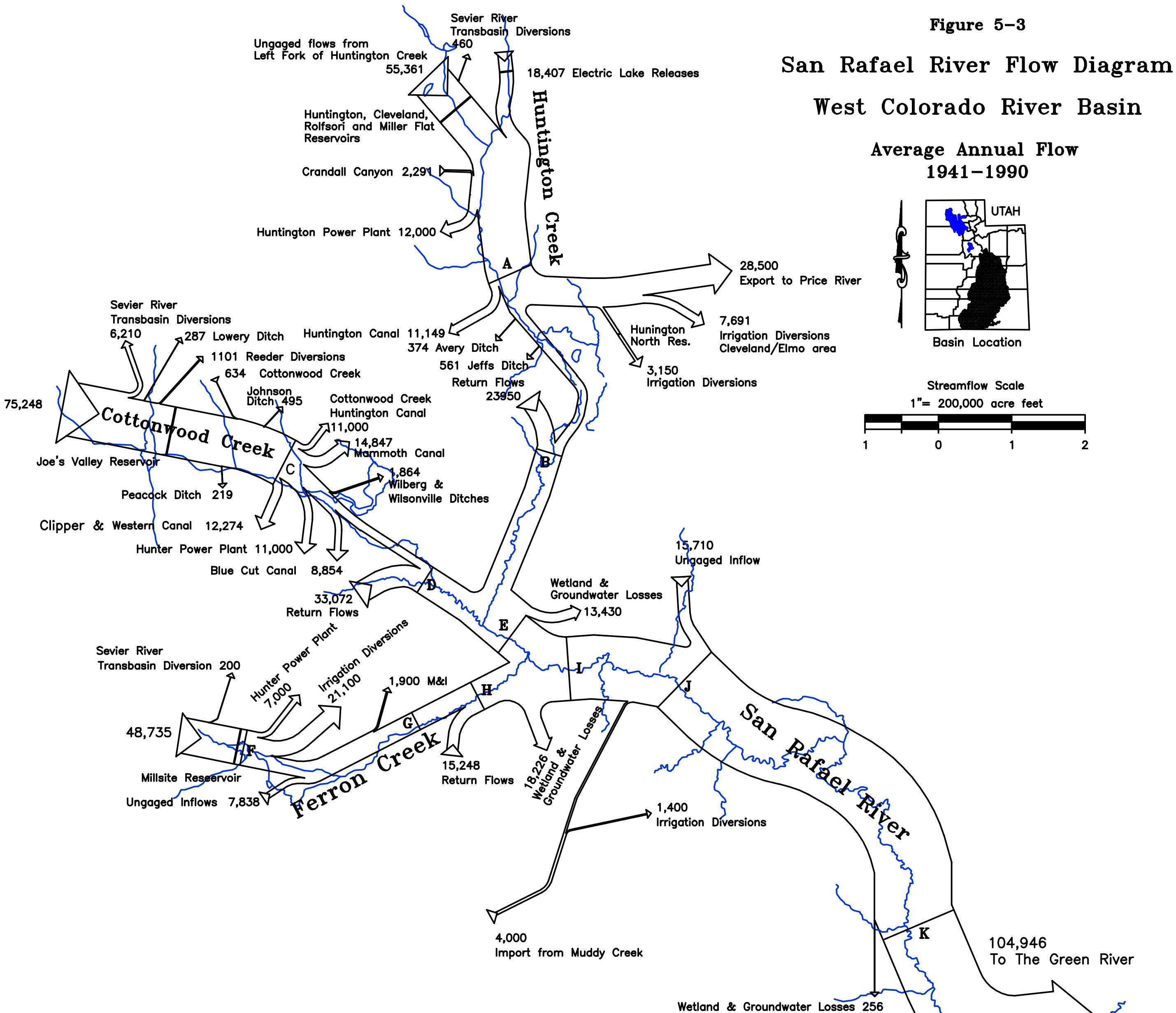


Figure 5-3

San Rafael River Flow Diagram

West Colorado River Basin

Average Annual Flow
1941-1990

Stream Gage Legend

Location	Acre Feet	Gage Name
A	63,599	Huntington Creek Near Huntington
B	36,124	Huntington Creek Near Castle Dale
C	67,570	Cottonwood Creek Near Orangeville
D	40,803	Cottonwood Creek Near Castle Dale
E	63,497	San Rafael River Above Ferron
F	48,535	Ferron Creek (Upper Station) Near Ferron
G	26,373	Ferron Creek Near Castle Dale
H	41,621	Ferron Creek Below Paradise Ranch
I	86,892	San Rafael River Near Castle Dale
J	105,202	San Rafael River At San Rafael Bridge Campground
K	104,946	San Rafael River Near Green River

Figure 5-4

Dirty Devil River Flow Diagram
West Colorado Basin

Average Annual Flow
1941-1990

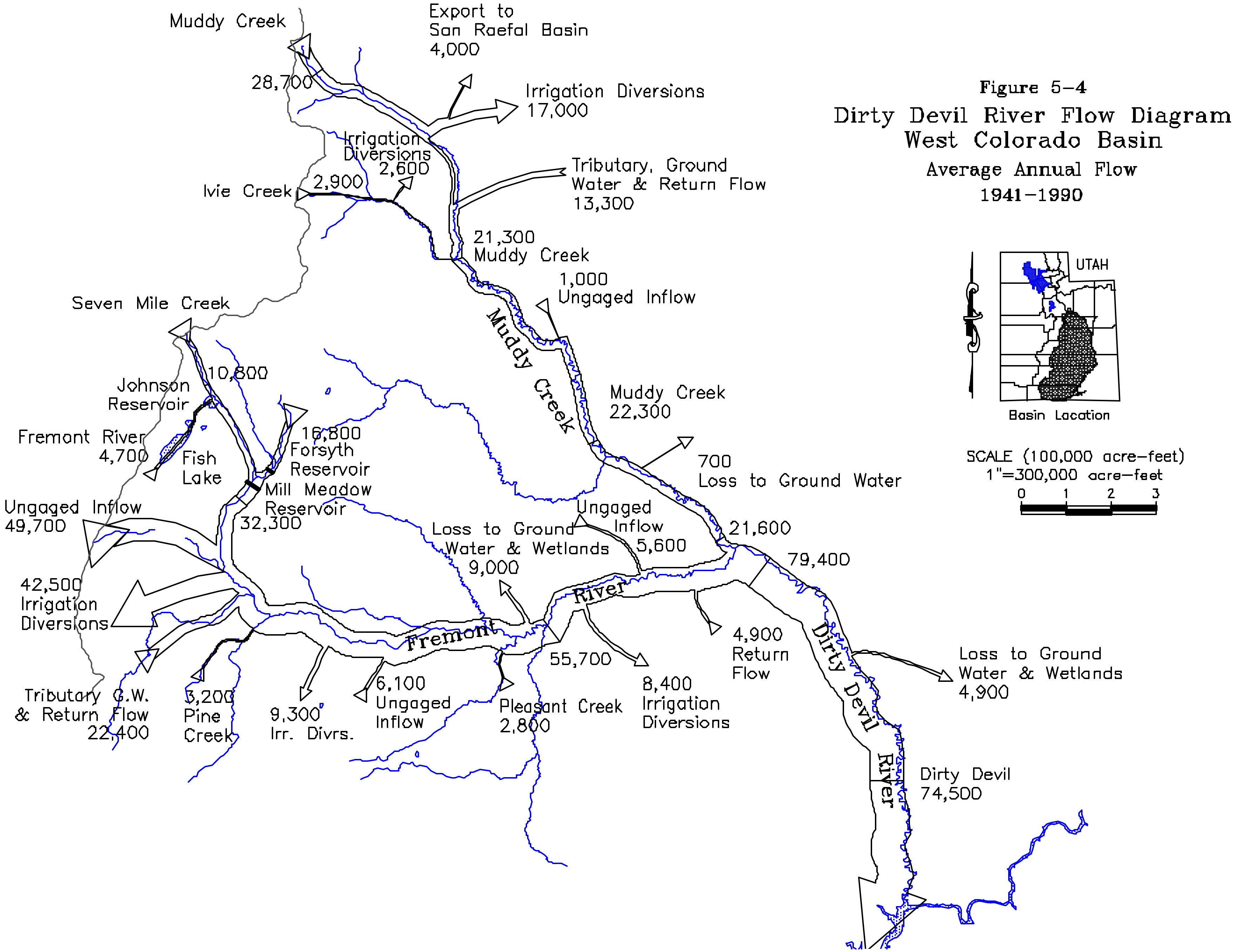


Figure 5-5
Escalante River Flow Diagram
West Colorado Basin

Average Annual Flow
1941-1990

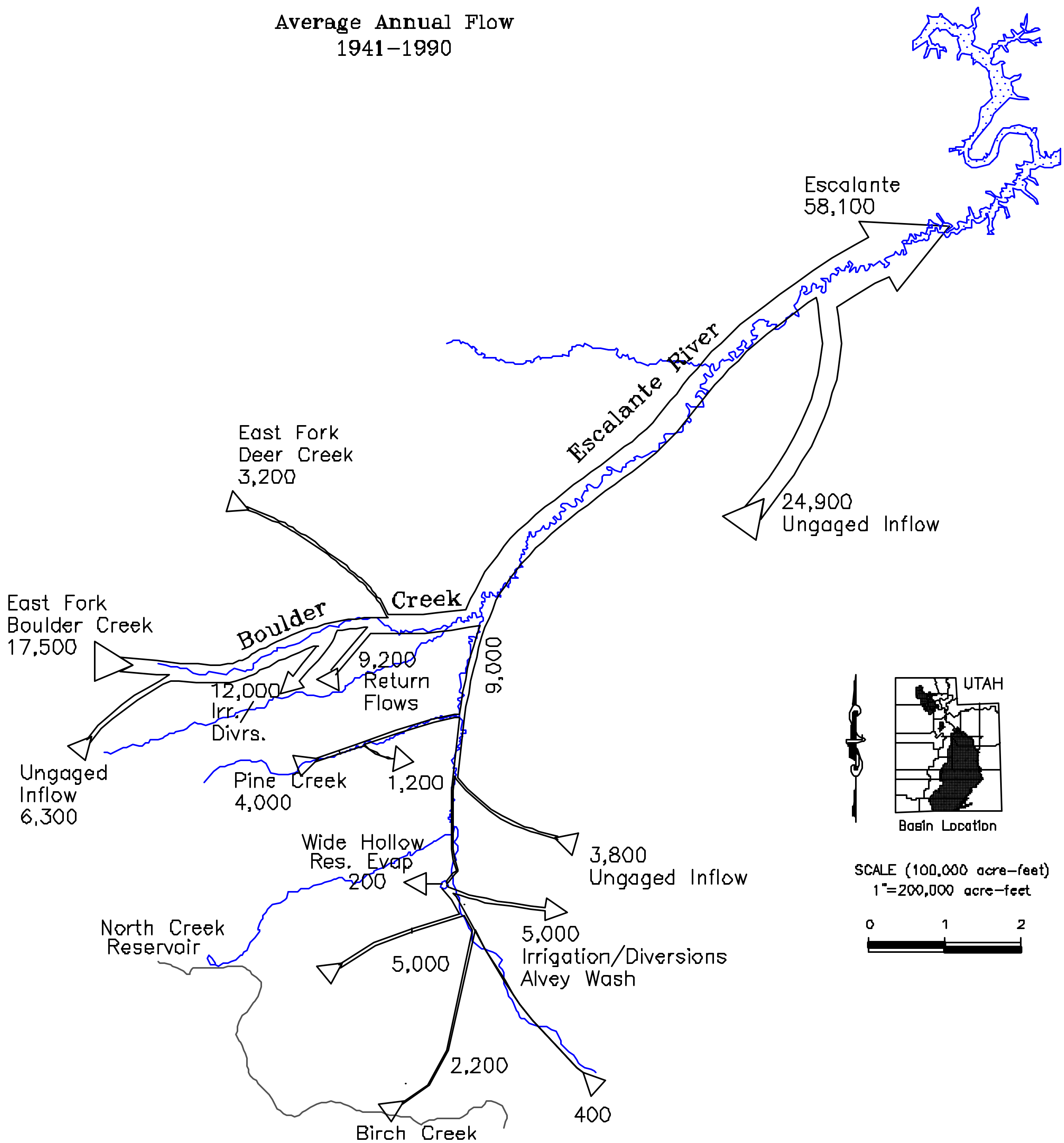


Figure 5-6

Paria River Flow Diagram
West Colorado Basin

Average Annual Flow
1941-1990

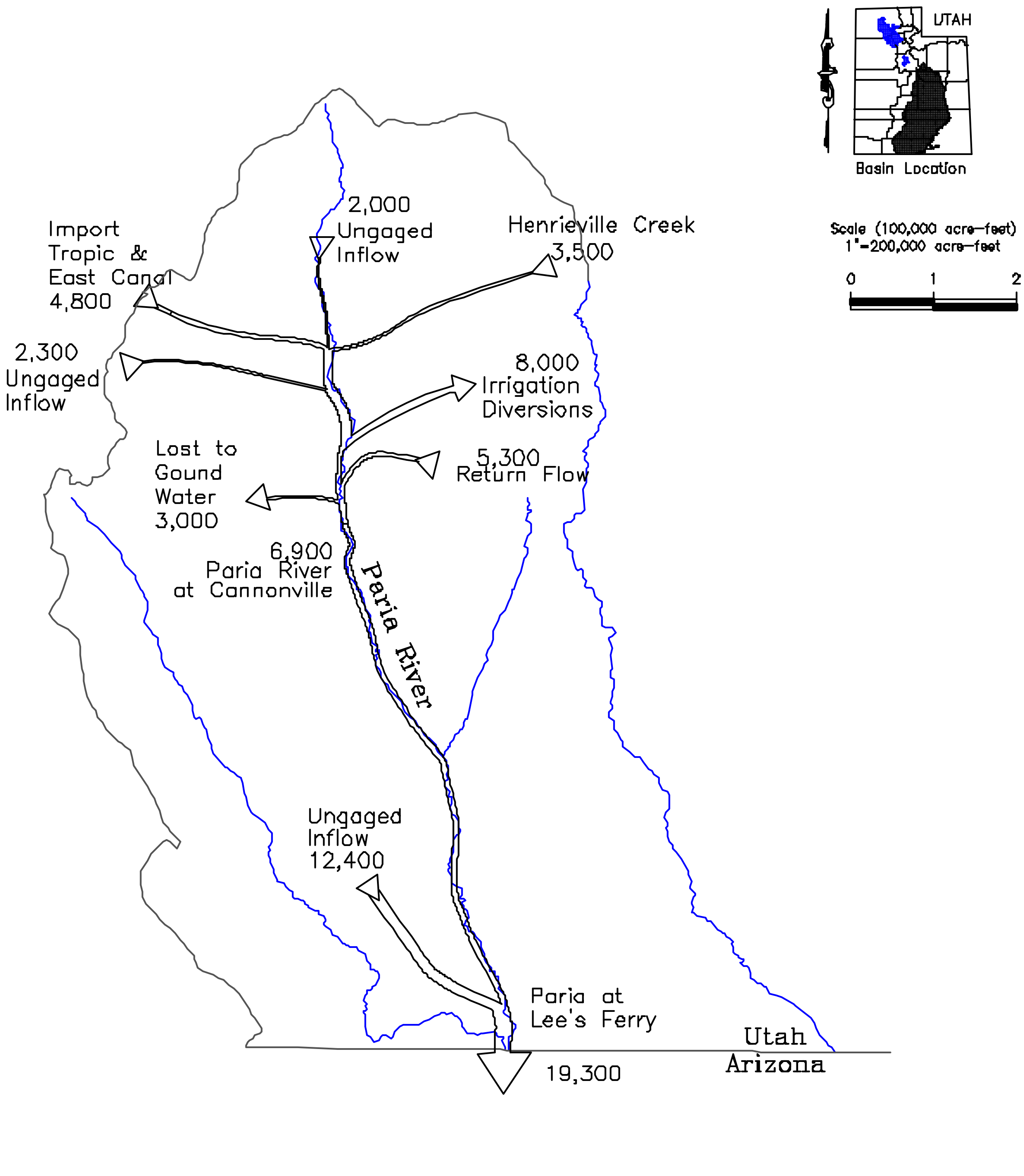


Table 5-2
Mean Monthly and Annual Stream Flow
(Acre-feet)

GAGE #	GAGE NAME	YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
PRICE RIVER SYSTEM															
09309500	FAIRVIEW DITCH NEAR FAIRVIEW, UT	50-65	0	0	0	0	0	0	0	16	339	536	387	123	1,002
09310000	GOOSEBERRY CREEK NEAR SCOFIELD, UT	31-33	302	273	234	213	192	263	1,095	6,255	3,634	871	445	298	13,860
		40-98													
09310500	FISH CREEK ABOVE RESERVOIR, NEAR SCOFIELD, UT	31-33	700	667	599	544	519	818	3,648	16,383	8,425	1,864	901	652	35,453
		39-98													
09310550	PONTOWN CREEK NEAR SCOFIELD, UT	79-81	72	40	45	54	52	62	415	2,755	1,512	180	97	319	5,382
09310575	BOARDINGHOUSE CREEK AT MOUTH SOUTH OF SCOFIELD	83-86	73	64	57	51	47	53	96	733	823	233	121	99	2,531
09310600	ECCLES CANYON NEAR SCOFIELD, UT	80-87	110	91	91	90	85	107	208	1,002	1,038	277	167	144	3,410
09310700	MUD CREEK BLW WINTER QUARTERS CANYON AT SCOFIELD	78-87	433	368	338	326	320	479	1,070	3,833	3,512	920	519	460	12,567
		90-98													
09311500	PRICE RIVER NEAR SCOFIELD, UT	18-22	1,826	481	360	175	233	528	1,685	8,496	10,364	9,463	6,213	4,317	44,663
		25-32													
		39-70													
		79-82													
09311700	PRICE RIVER NEAR SOLDIER CUMMIT, UT	61-63	625	685	770	350	240	390	875	4,395	7,905	11,260	4.659	2,532	37,540
09312000	NORTH FORK WHITE RIVER NEAR SOLDIER SUMMIT, UT	42-47	46	49	34	42	45	173	1,932	2,132	495	79	39	23	4,537
09312500	WHITE RIVER NEAR SOLDIER SUMMIT, UT	38-67	233	209	183	166	171	408	3,253	6,294	1,784	605	309	223	14,051
09312600	WHITE R. BLW TABBYUNE CR. NR SOLDIER SUMMIT, UT	67-98	335	301	262	244	274	767	3,668	9,721	3,546	1,034	462	304	20,751
09312700	BEAVER CREEK NEAR SOLDIER SUMMIT, UT	61-90	64	54	50	49	52	99	342	1,452	826	194	72	49	3,304
09312800	WILLOW CREEK NEAR CASTLE GATE, UT	80-82	139	90	64	65	104	423	1,412	2,639	1,006	388	216	150	6,695
09312900	WILLOW CREEK AT CASTLE GATE, UT	80-82	191	121	62	86	103	210	1,468	3,575	1,272	411	218	235	7,949
09313000	PRICE RIVER NEAR HEINER, UT	34-71	2,553	1,043	764	625	755	2,395	9,339	20,936	14,984	11,746	7,862	4,999	78,412
		80-83													
		90-98													
09313040	SPRING CANYON BLW SOWBELLY GULCH AT HELPER, UT	79-82	26	21	20	19	15	15	15	18	12	15	19	20	215
09313500	PRICE RIVER NEAR HELPER, UT	09-34	3,181	2,028	1,828	1,854	1,900	5,330	14,547	36,319	20,038	7,702	5,845	4,602	98,885
09313965	COAL CREEK NEAR HELPER, UT	78-82	72	45	0	0	0	0	0	1,838	489	165	161	153	0
09313975	SOLDIER CREEK BELOW MINE NEAR WELLINGTON, UT	78-84	103	62	0	0	0	50	633	1,533	687	243	145	123	0
09313985	DUGOUT CREEK NEAR SUNNYSIDE, UT	80-82	18	7	0	0	0	0	0	607	159	52	22	52	0
09314000	PRICE RIVER BELOW COAL CREEK NEAR WELLINGTON, UT	50-58	1,956	1,675	1,450	1,381	1,675	2,624	8,742	17,149	8,378	3,180	4,267	2,157	54,634
09314250	PRICE RIVER BLW MILLER CREEK NEAR WELLINGTON, UT	72-86	5,136	3,387	2,116	2,062	3,154	7,548	14,734	26,826	21,025	6,030	4,374	4,596	105,565
09314280	DESERT SEEP WASH NEAR WELLINGTON, UT	72-86	2,504	1,684	869	687	933	1,991	1,873	2,317	2,198	2,205	1,966	2,223	21,812
09314340	GRASSY TRAIL CREEK AT SUNNYSIDE, UT	78-85	152	139	133	126	107	143	503	2,913	2,111	437	225	172	7,165
09314374	HORSE CANYON NEAR SUNNYSIDE, UT	78-82	19	20	17	22	16	15	28	41	27	25	23	20	270
09314500	PRICE RIVER AT WOODSIDE, UT	46-93	5,697	3,894	2,588	2,329	3,469	7,118	10,814	17,767	13,485	6,135	7,114	6.542	88,109
SAN RAFAEL RIVER SYSTEM															
09317000	BOULGER CREEK NEAR FAIRVIEW, UT	38-49	77	64	55	51	46	52	210	1,140	657	181	98	71	2,798
09317500	CANDLAND DITCH NEAR MOUNT PLEASANT, UT	50-58	0	0	0	0	0	0	6	43	109	48	10	3	310
09317919	CRANDALL CANYON AT MOUTH NEAR HUNTINGTON, UT	78-84	54	31	31	34	30	39	125	864	1,107	311	126	74	1,590
09317920	TIE FORK CANYON NEAR HUNTINGTON, UT	78-82	38	35	34	21	27	43	78	562	525	125	60	44	1,476
09317997	HUNTINGTON CREEK NER HUNTINGTON, UT	79-82	3,787	2,289	1,932	1,893	1,905	2,437	4,797	12,124	15,062	7,192	5,823	4,622	63,862
		86-90													
09318000	HUNTINGTON CREEK NEAR HUNTINGTON, UT	09-18	2,406	1,820	1,681	1,642	1,605	2,116	5,247	20,608	17,620	8,434	5,291	3,126	69,967
		19-74													
		78-81													
09318500	HUNTINGTON CREEK NEAR CASTLE DALE, UT	11-21	1,620	1,499	1,456	1,524	1,643	2,604	3,997	14,826	14,099	1,890	1,471	1,108	57,425
09321000	COAL FORK DITCH NEAR MOUNT PLEASANT, UT	49-59	3	0	0	0	587	0	10	74	133	47	10	5	0
		76-77													
09321500	TWIN CREEK TUNNEL NEAR MOUNT PLEASANT, UT	50-58	2	0	0	0	0	0	0	28	150	51	3	1	0
09322000	BLACK CANYON DITCH NEAR SPRING CITY, UT	50-58	4	0	0	0	0	0	3	41	192	53	3	0	0
09322500	CEDAR CREEK TUNNEL NEAR SPRING CITY, UT	49-58	7	6	6	6	6	6	7	75					
09323500	REEDER DITCH NEAR SPRING CITY, UT	49-58	9	5	0	0	0	0	7	63	106	59	24	12	0
09324000	SEELY CREEK NEAR ORANGEVILLE, UT	53-57	1,393	1,148	1,150	1,135	1,043	1,265	2,770	13,565	21,778	7,565	2,850	1,858	57,518
09324200	COTTONWOOD CR. AB STRAIGHT CANYON NR ORANGEVILLE,UT	78-82	36	30	20	16	18	33	42	146	247	85	47	41	537
09324500	COTTONWOOD CREEK NEAR ORANGEVILLE, UT	10-28	2,419	1,356	1,231	1,080	1,068	1,746	4,172	18,884	24,948	9,057	4,498	3,274	73,096
		33-72													
		75-87													

Table 5-2 (Continued)
Mean Monthly and Annual Stream Flow

GAGE #	GAGE NAME	YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	ANNUAL
09325000	COTTONWOOD CREEK NEAR CASTLE DALE, UT	47-58	676	775	841	895	1,058	929	1,440	11,204	17,746	2,347	1,203	581	39,667
09325100	SAN RAFAEL R. AB FERRON CR. NE CASTLE DALE, UT	65-71	2,592	2,216	2,559	2,034	2,125	2,964	3,135	10,615	24,672	8,364	5,042	3,217	69,533
09326500	FERRON CREEK (UPPER STATION) NEAR FERRON, UT	12-24	1,102	867	650	539	548	877	2,672	13,434	17,672	6,363	2,616	1,441	48,526
		48-98													
09327500	FERRON CREEK NEAR CASTLE DALE	12-15	563	579	523	521	525	697	1,607	6,959	9,848	1,851	668	505	25,765
		48-59													
09327550	FERRON CR. BL PARADISE RANCH NR CLAWSON, UT	76-86	1,103	742	547	435	574	588	954	6,015	24,449	5,195	1,670	1,120	43,393
09328000	SAN RAFAEL RIVER NEAR CASTLE DALE, UT	48-65	3,588	3,171	2,553	2,345	3,487	4,731	5,642	18,234	35,342	8,934	4,163	3,305	95,605
		72-87													
09328100	S. R. R..AT S. R. BR CAMPGROUND NEAR C. DALE, UT	75-86	5,539	3,987	2,944	2,537	4,095	5,618	7,249	16,168	48,984	14,851	6,078	5,711	123,761
09328500	SAN RAFAEL RIVER NEAR GREEN RIVER, UT	10-19	5,669	3,961	2,895	2,728	4,039	6,570	6,545	19,428	34,110	10,028	5,593	4,396	106,310
		46-98													
DIRTY DEVIL RIVER SYSTEM															
09330500	MUDDY CREEK NEAR EMERY, UT	11-14	1,116	710	1,740	1,871	1,721	1,303	1,940	6,312	7,389	4,306	2,512	1,551	32,469
		50-96													
09331950	CHRISTIANSEN WASH NEAR EMERY, UT	78-84	258	136	74	90	118	164	232	298	411	422	356	236	2,878
09332800	MUDDY CREEK AT MOUTH NEAR HANKSVILLE, UT	76-80	149	897	56	358	1,641	2,216	2,598	4,980	3,496	927	284	3,415	21,018
09334500	WHITE CANYON NEAR HANKSVILLE, UT	51-70	498	278	182	49	94	70	242	73	77	561	1,070	502	3,696
09329050	SEVEN MILE CREEK NEAR FISH LAKE, UT	65-98	573	498	459	420	365	430	846	2,923	2,271	844	672	580	10,886
09330210	PLEASANT CREEK NEAR CAINVILLE, UT	69-73	301	185	202	149	123	139	148	426	226	183	295	254	2,288
09331500	IVIE CREEK ABOVE DIVERSIONS NEAR EMERY, UT	51-61	138	139	128	114	129	192	314	606	370	272	278	148	2,829
09332100	MUDDY CREEK BELOW I-70 NEAR EMERY, UT	73-86	1,126	803	750	756	923	1,306	1,996	5,711	5,665	2,291	996	739	23,062
09333000	DIRTY DEVIL RIVER NEAR HANKSVILLE, UT	46-48	5,775	7,160	5,477	6,027	9,873	10,240	10,647	4,613	3,287	1,030	13,795	3,545	82,950
09329500	FREMONT RIVER NEAR FREMONT, UT	49-58	2,361	389	361	367	355	562	1,141	5,453	6,547	5,928	4,364	2,437	29,822
09330000	FREMONT RIVER NEAR BICKNELL, UT	9-14	5,355	5,483	5,675	5,774	5,694	6,704	7,605	5,525	4,192	4.257	4,698	4,777	64,556
		38-59													
		77-95													
09331900	QUITCHUPAH CREEK NEAR EMERY, UT	78-81	158	258	267	335	370	581	636	1,025	657	316	159	975	6,102
09332700	MUDDY CREEK AT DELTA MINE NEAR HANKSVILLE	76-86	1,078	743	524	598	1,196	1,358	2,077	5,655	5,582	2,226	1,150	1,478	23,664
09330230	FREMONT RIVER NEAR CAINVILLE, UT	67-95	6,150	7,721	5,468	9,078	7,598	6,362	5,620	3,854	2,586	2,847	3,572	3,659	54,421
09331850	CONVULSION CANYON NEAR EMERY, UT	81-85	48	78	0	0	0	0	0	76	78	52	58	43	0
09332500	MUDDY CREEK BELOW IVIE CREEK NEAR EMERY, UT	50-61	347	297	287	268	419	744	1,378	3,155	2,301	489	845	559	11,131
09333500	D. DEV. R.. AB POISON SPR. WASH NR HANKSVILLE	48-95	6,092	7,550	5,926	6,011	7.625	8,502	6,393	5,160	4,194	3,494	5,944	5,170	72,027
09329000	FREMONT RIVER BELOW FISH LAKE, UT	39-45	87	30	33	24	22	24	21	21	1,688	1,925	797	178	5,083
09330410	BULL CREEK NEAR HANKSVILLE, UT	83-91	45	31	22	17	16	20	68	368	285	122	74	71	1,175
09334000	NORTH WASH NEAR HANKSVILLE (HITE), UT	50-70	67	90	30	31	28	22	15	40	58	105	233	133	868
09329900	PINE CREEK NEAR BICKNELL, UT	65-80	233	219	182	176	155	195	279	629	160	189	239	233	2,888
ESCALANTE RIVER SYSTEM															
09335500	NORTH CREEK NEAR ESCALANTE, UT	50-55	377	247	166	159	238	382	538	1,179	942	524	421	335	5,538
09336000	BIRCH CREEK NEAR ESCALANTE, UT	50-51	54	19	0	6	15	12	53	55	63	35	61	22	391
09336500	BIRCH CREEK AT MOUTH NEAR ESCALANTE, UT	52-55	133	124	82	105	160	213	137	302	237	265	191	169	2,366
09337000	PINE CREEK NEAR ESCALANTE, UT	50-56	177	160	131	127	117	158	402	1.053	430	340	294	213	3,611
		57-96													
09337500	ESCALANTE RIVER NEAR ESCALANTE, UT	12-13	499	411	464	520	587	791	888	1,455	1,133	433	553	997	8,865
		43-56													
		72-96													
09338000	EAST FORK BOULDER CREEK NEAR BOULDER, UT	50-56	1,261	1,204	1,162	1,146	1,035	1,136	1,232	3,079	2,142	1,290	1,301	1,226	17,192
		57-72													
09338500	EAST FORK DEER CREEK NEAR BOULDER, UT	50-55	83	63	53	57	49	87	127	119	89	91	94	78	987
09339000	BOULDER CREEK NEAR BOULDER, UT	50-55	797	1,425	1,911	2,021	1,873	2,013	1,255	2,030	1,000	701	824	734	16,681
09339500	ESCALANTE RIVER AT MOUTH NEAR ESCALANTE, UT	50-55	5,080	4,548	5,311	5,798	5,353	5,815	4,099	4,598	2,272	4,070	9,247	3,602	61,628
PARIA RIVER SYSTEM															
09381500	PARIA RIVER NEAR CANNONVILLE, UT	51-55	374	480	600	509	640	1,007	434	137	53	693	1,299	321	7,021
09381000	HENRIEVILLE CREEK NEAR HENRIEVILLE, UT	50-55	244	267	265	248	338	423	389	284	197	315	346	311	3,751
09382000	PARIA RIVER AT LEES FERRY, AZ	24-94	1,839	1,414	1,296	1,377	2,172	2,440	1,280	662	428	1,545	3,455	3,140	21,028
COLORADO RIVER SYSTEM															
09335000	COLORADO RIVER AT HITE, UT	47-58	349,273	367,727	309,545	297,909	305,455	458,455	905,545	2,165,091	2,730,364	1,097,727	522,192	312,442	9,783,455
09380000	COLORADO RIVER AT LEES FERRY, AZ	12-97	581,612	543,642	525,170	532,178	500,036	608,118	1,003,773	1,929,492	2,193,388	1,165,846	780,647	632,071	10,975,972
09379504	LAKE POWELL INFLOW (GREEN + COLORADO0	14-18	421,782	388,866	343,733	327,320	338,947	496,275	947,933	2,179,689	2,475,011	1,034,556	484,861	373,185	9,764,819
		23-85													
09315000	GREEN RIVER AT GREEN RIVER, UT	95-00	184,946	168,298	140,614	138,563	154,406	276,152	435,840	970,662	1,148,936	503,475	230,683	167,810	4,522,635

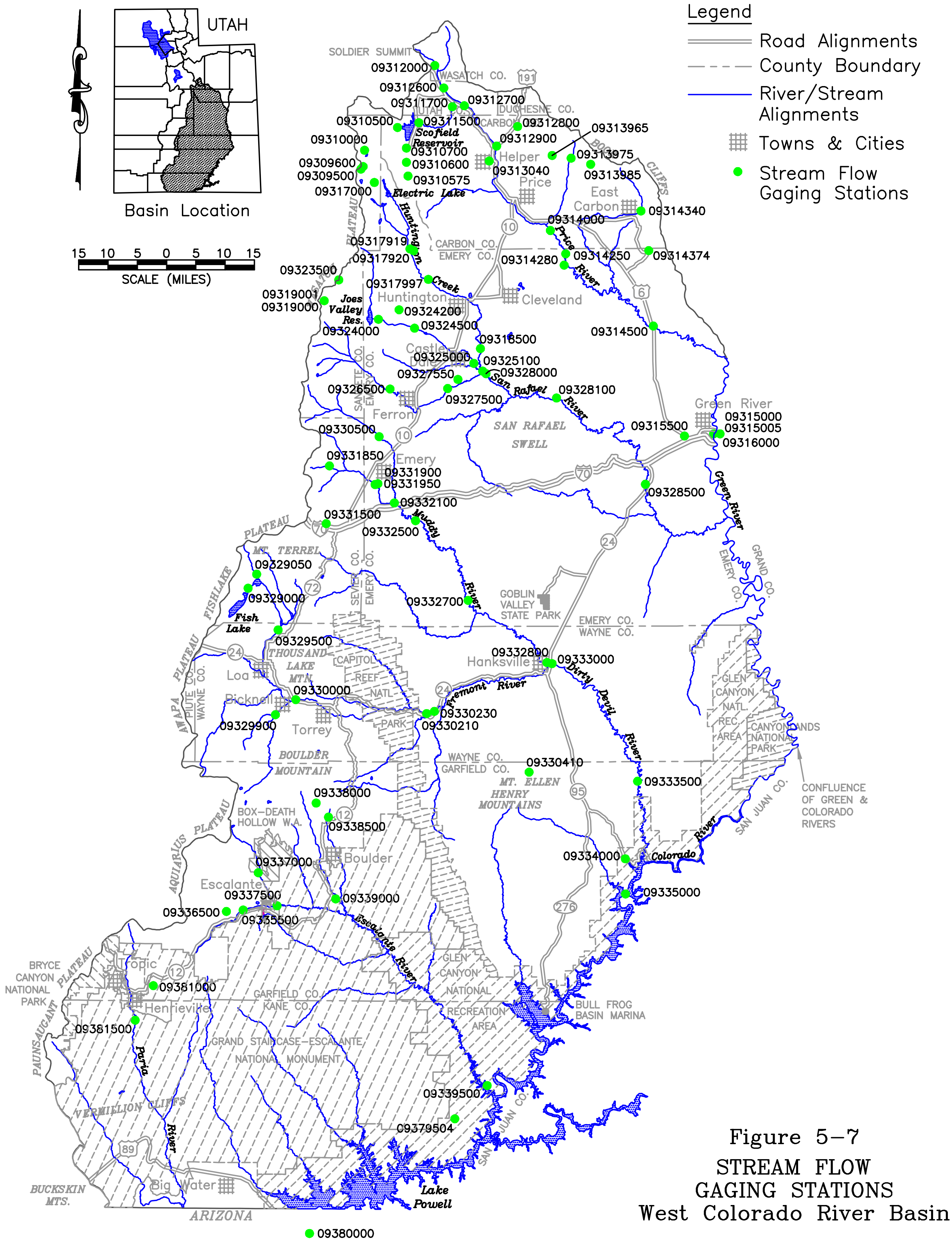


Figure 5-7
STREAM FLOW GAGING STATIONS
West Colorado River Basin

FIGURE 5-8

Annual Flows

Price River near Heiner (Helper)

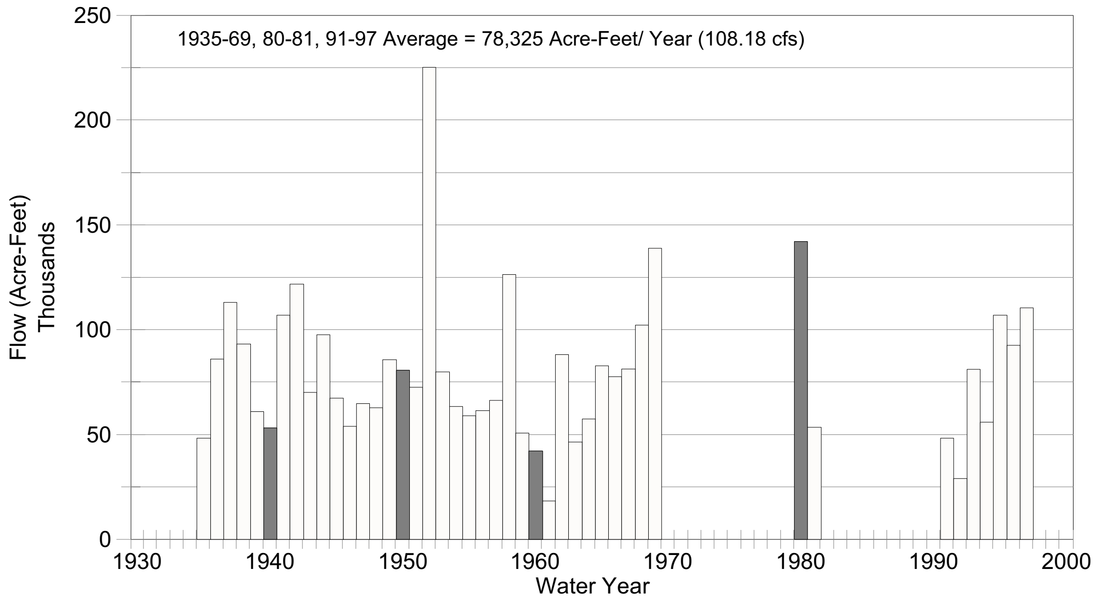


FIGURE 5-9

Annual Flows

Huntington Creek near Huntington

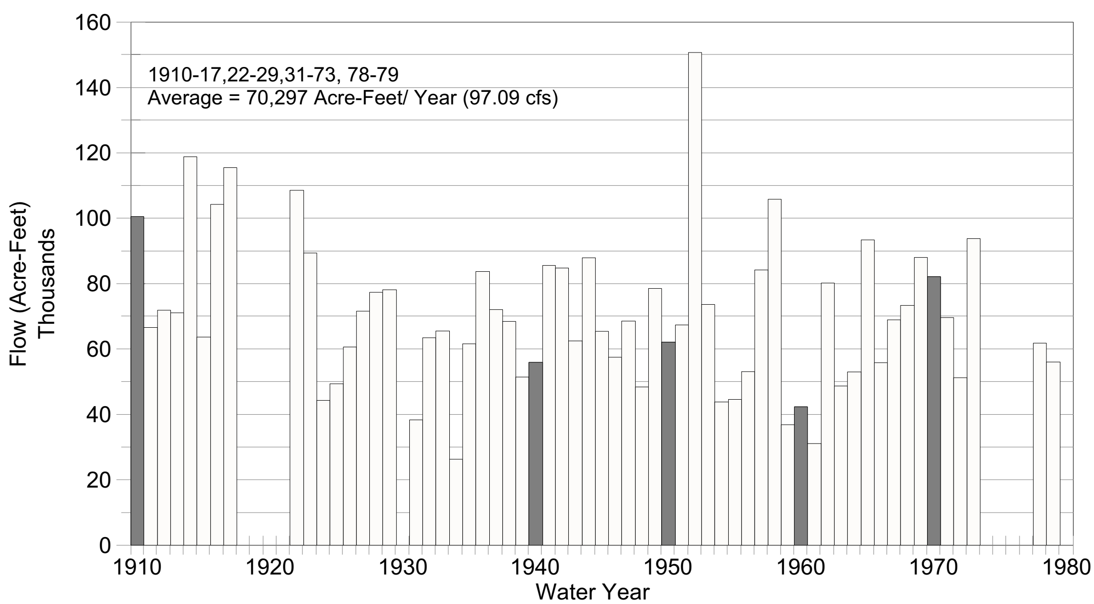


FIGURE 5-10
Annual Flows
Cottonwood Creek near Orangeville

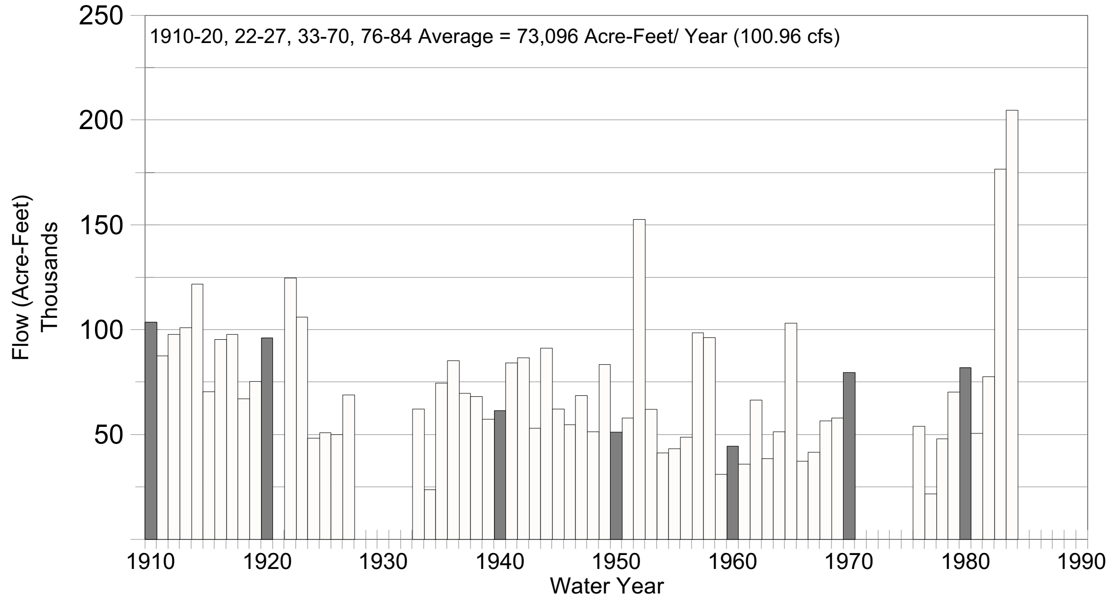


FIGURE 5-11
Annual Flows
Ferron Creek (Upper Station) nr Ferron

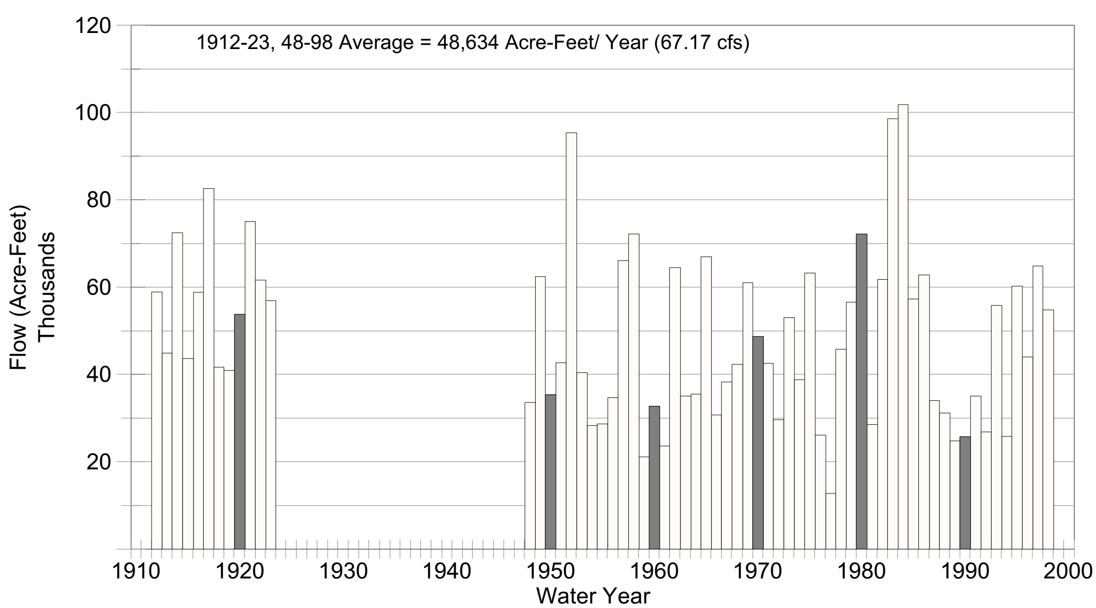


FIGURE 5-12
Annual Flows
Muddy Creek near Emery

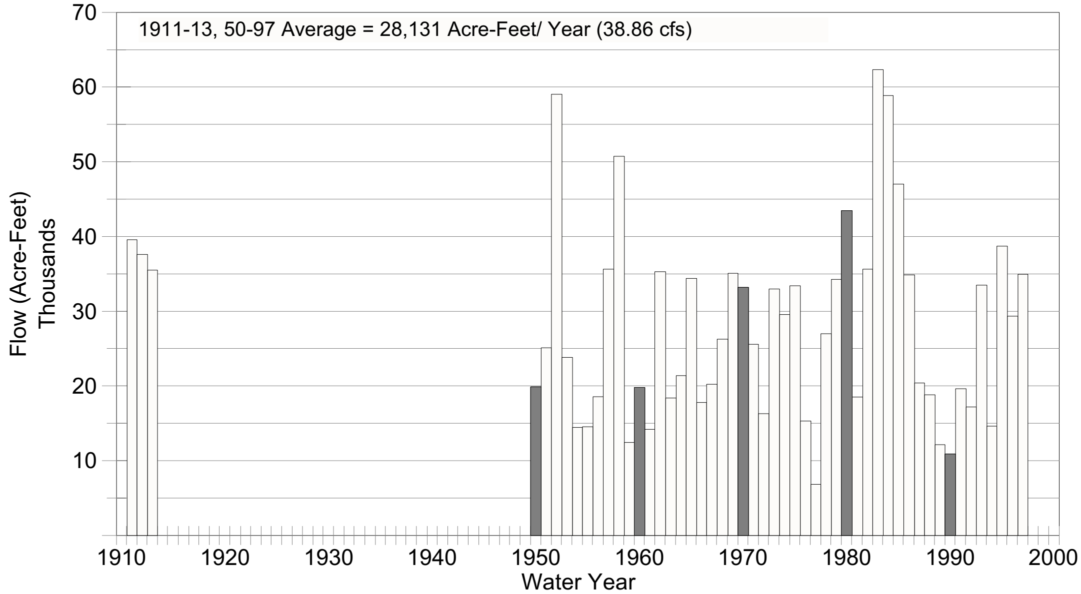


FIGURE 5-13
Annual Flows
Fremont River near Bicknell

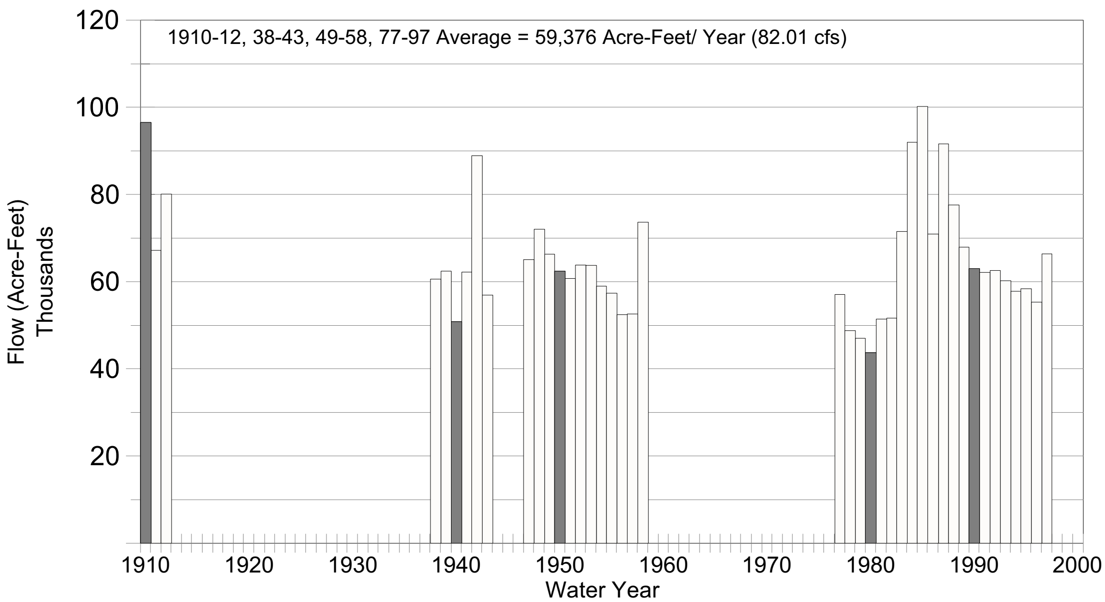


FIGURE 5-14
Annual Flows
Pine Creek near Escalante

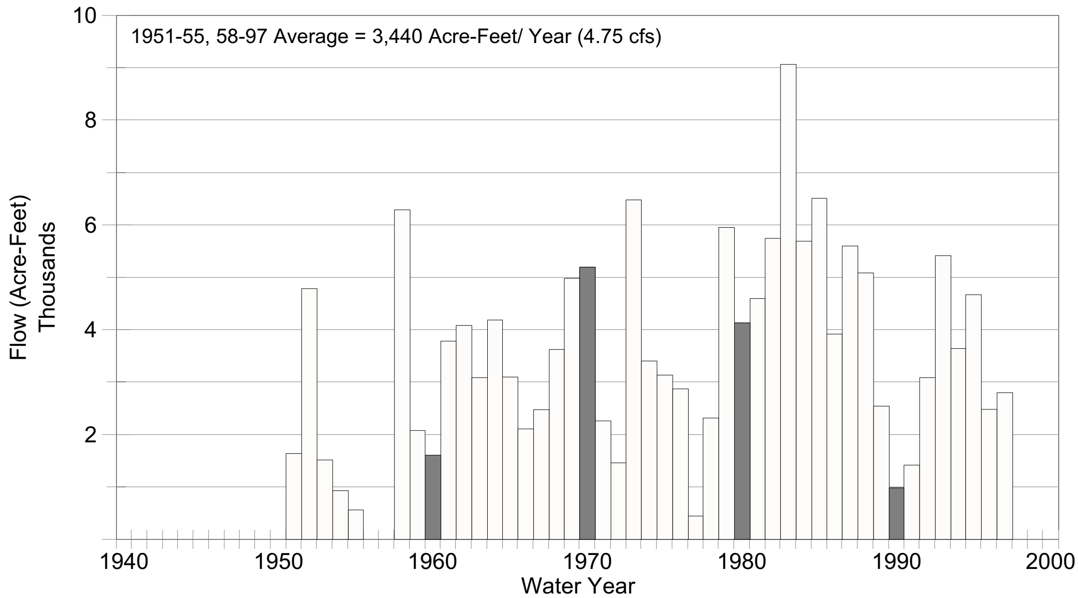


FIGURE 5-15
Annual Flows
Escalante River near Escalante

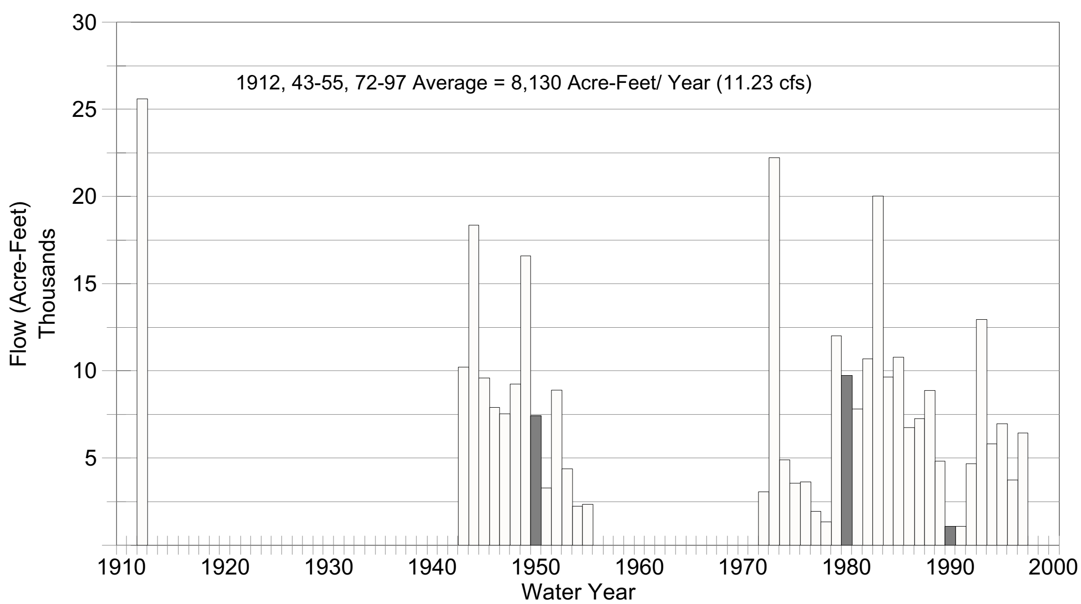


FIGURE 5-16
Annual Flows
East Fork Boulder Creek near Boulder

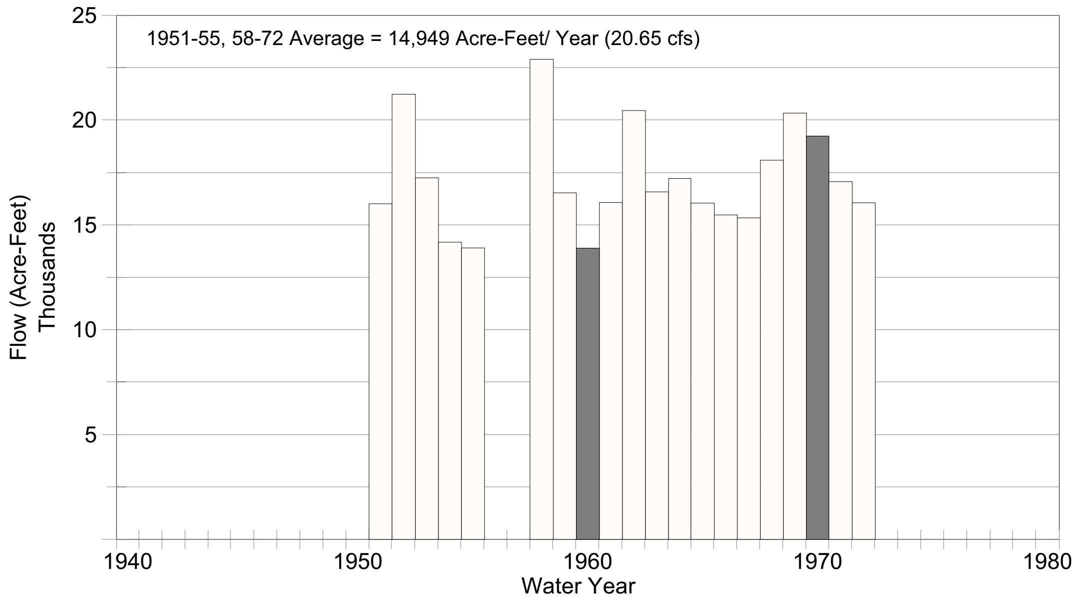


FIGURE 5-17
Annual Flows
Paria River near Cannonville

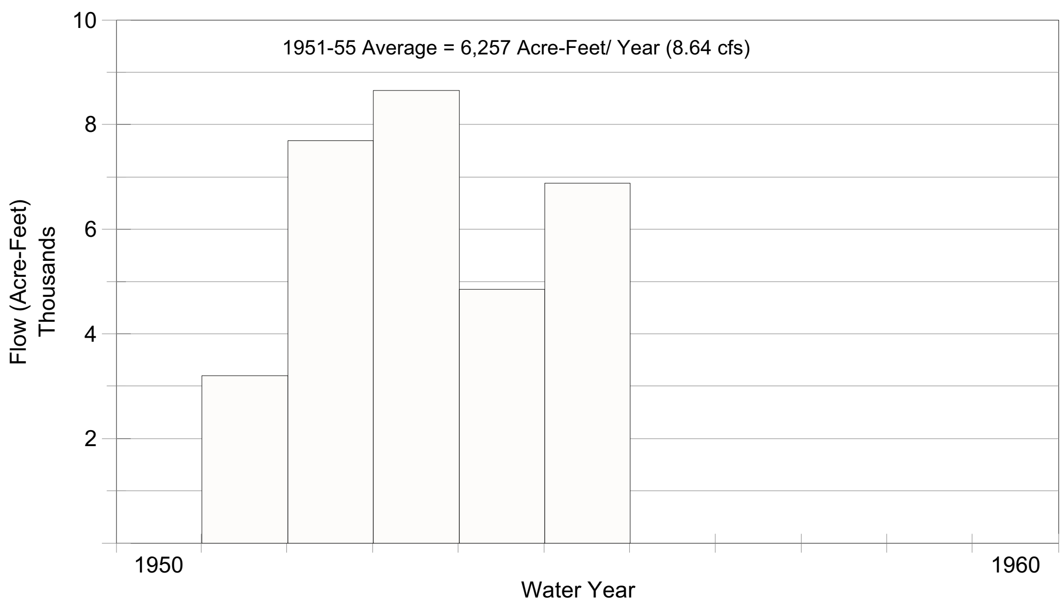


Table 5-3
Peak Flows
West Colorado River Basin

Station	HDM[a] CFS	HDM[a] Date	LDM[b] CFS	LDM[b] Date
Price River near Heiner	9,340	9/13/40	0.4	8/21/61
Price River at Woodside	11,200	9/7/91	0	1960,1961 1963,1992
Huntington Creek near Huntington	1,680	5/24/84	3	2/5/81
Cottonwood Creek near Orangeville	7,220	8/1/64	1.2	4/8/66
Ferron Creek (Upper) near Ferron	4,180	8/27/52	0	10/19-21/1976
San Rafael River near Green River	12,000	9/2/09	0	Many years
Seven Mile Creek near Fish Lake	424	6/12/95	1.3	10/30/94
Fremont River near Bicknell	1,200	4/5/42	18	6/15/12
Muddy Creek near Emery	3,340	5/10/52	0	4/13/11
Dirty Devil River near Hanksville	35,000	11/4/57	0	Many years
Pine Creek near Escalante	1,010	8/2/67	0	Many years
Escalante River near Escalante	3,450	8/1/53	0.07	7/11/90
East Fork Boulder Creek near Boulder	483	5/20/64	8.2	11/5/51
Paria River near Cannonville	11,600	8/31/63	0	Many years
Paria River at Lee's Ferry, Arizona	16,100	10/5/26	0	1928

[a]High daily maximum
[b]Low daily minimum

Source: U.S. Geological Survey

Figure 5-18
MONTHLY STREAMFLOW PROBABILITIES
Price River near Heiner (Helper)

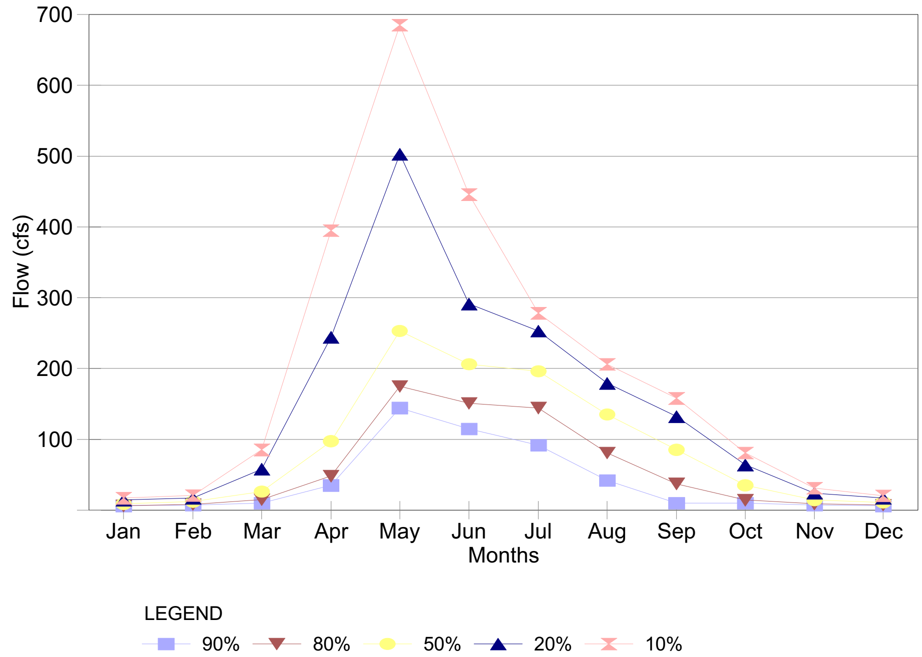


Figure 5-19
MONTHLY STREAMFLOW PROBABILITIES
Huntington Creek near Huntington

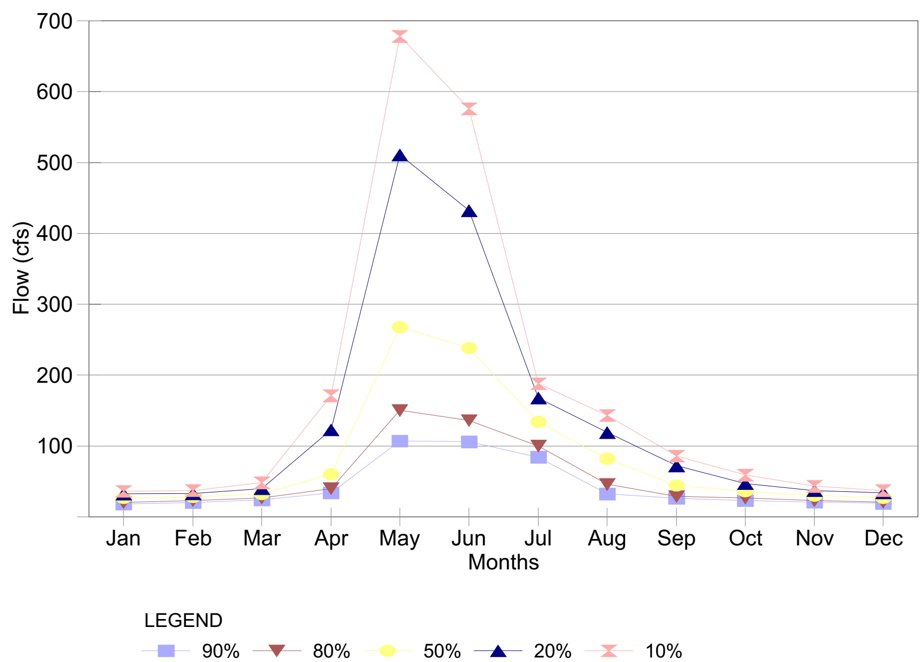


Figure 5-20

MONTHLY STREAMFLOW PROBABILITIES

Cottonwood Creek near Orangeville

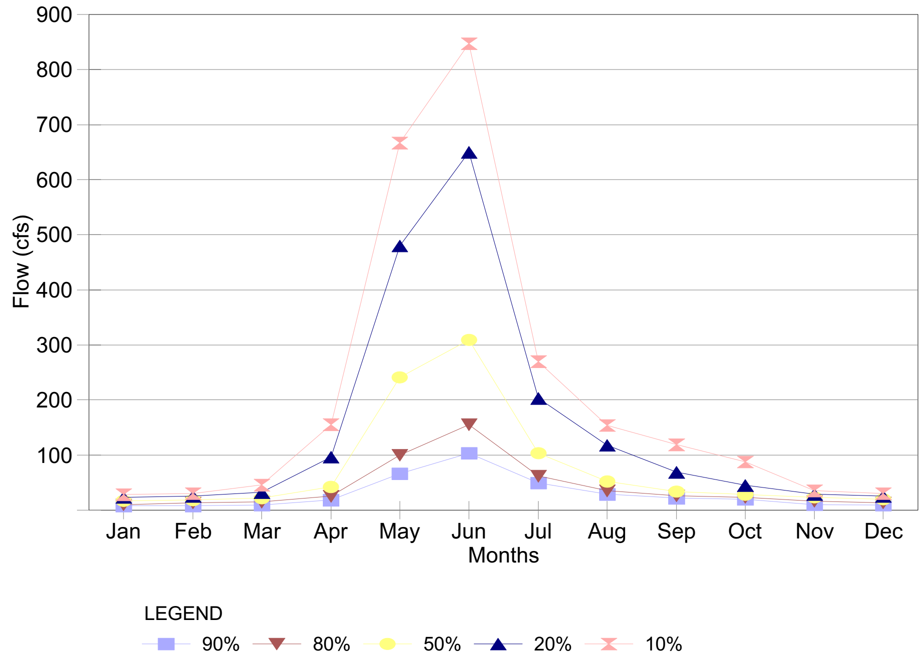


Figure 5-21

MONTHLY STREAMFLOW PROBABILITIES

Ferron Creek (Upper Station) nr Ferron

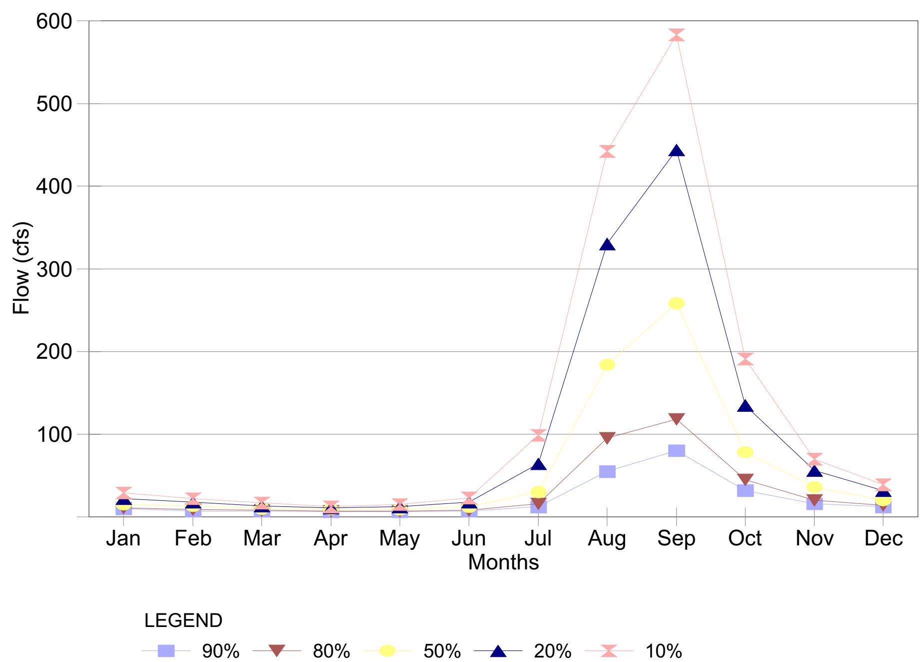


Figure 5-22
MONTHLY STREAMFLOW PROBABILITIES
Muddy Creek near Emery

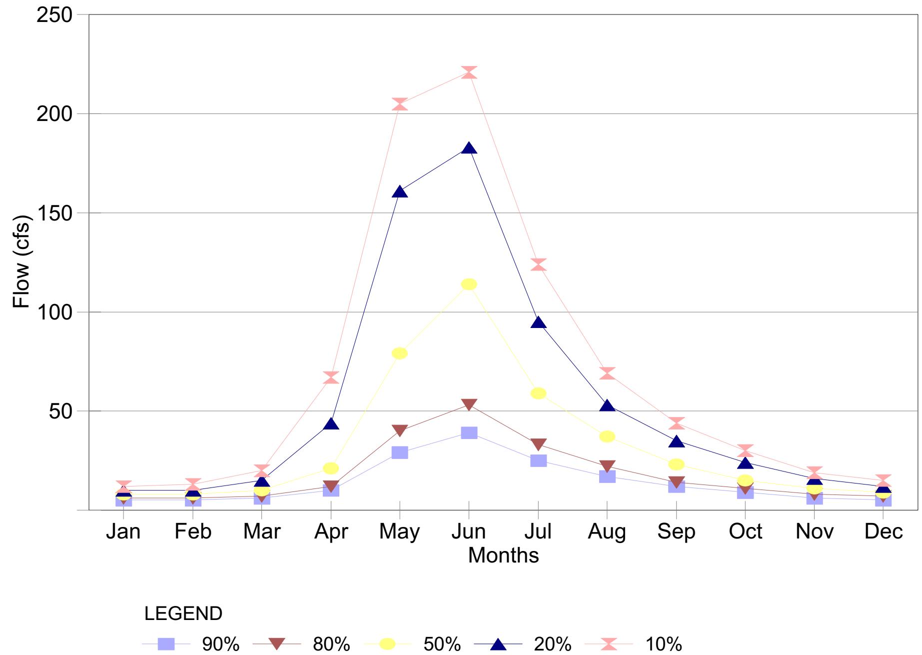


Figure 5-23
MONTHLY STREAMFLOW PROBABILITIES
Fremont River near Bicknell

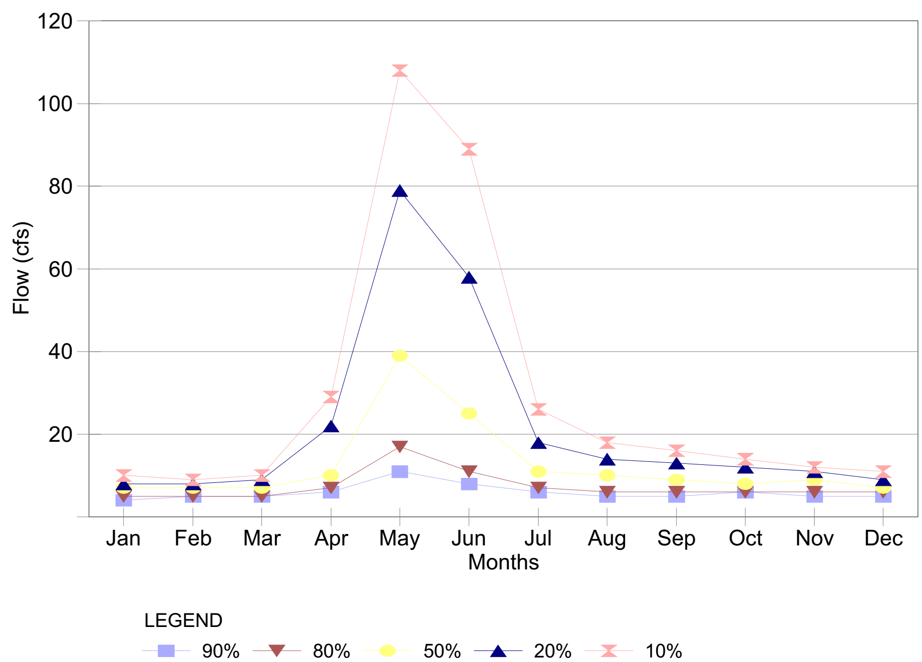


Figure 5-24
MONTHLY STREAMFLOW PROBABILITIES
Pine Creek near Escalante

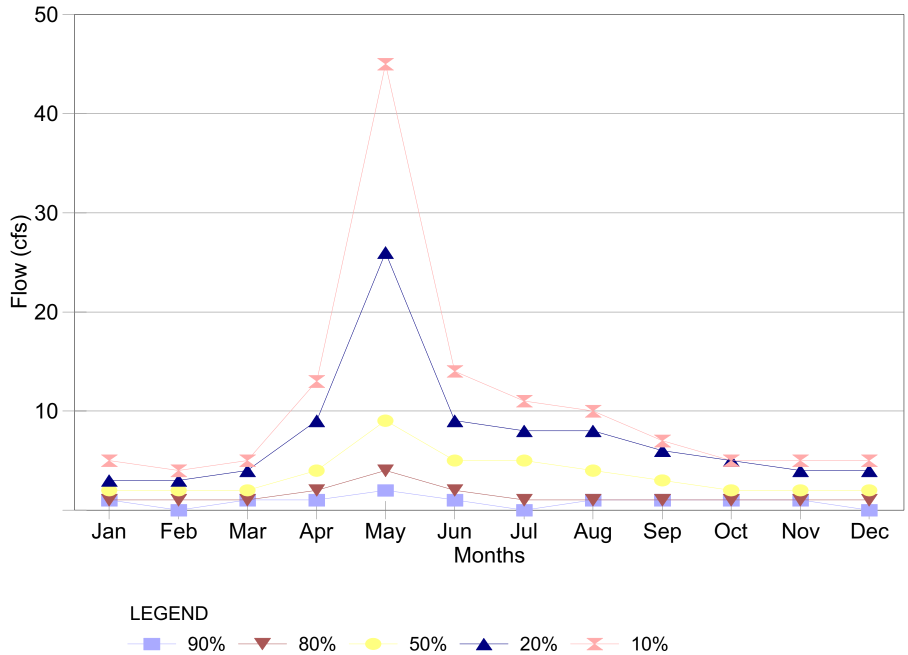


Figure 5-25
MONTHLY STREAMFLOW PROBABILITIES
Escalante River near Escalante

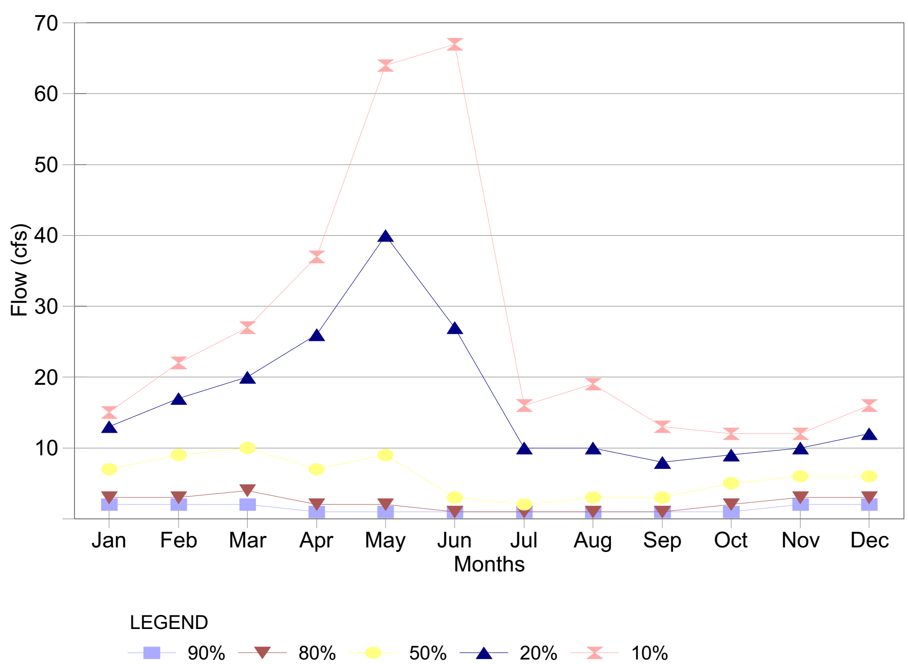


Figure 5-26
MONTHLY STREAMFLOW PROBABILITIES
East Fork Boulder Creek near Boulder

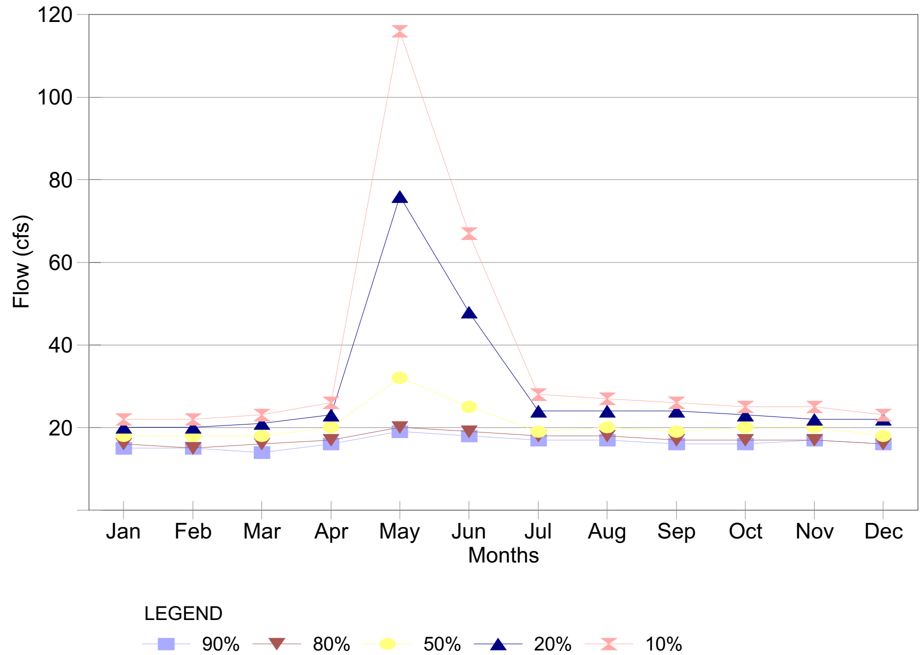


Figure 5-27
MONTHLY STREAMFLOW PROBABILITIES
Paria River near Cannonville

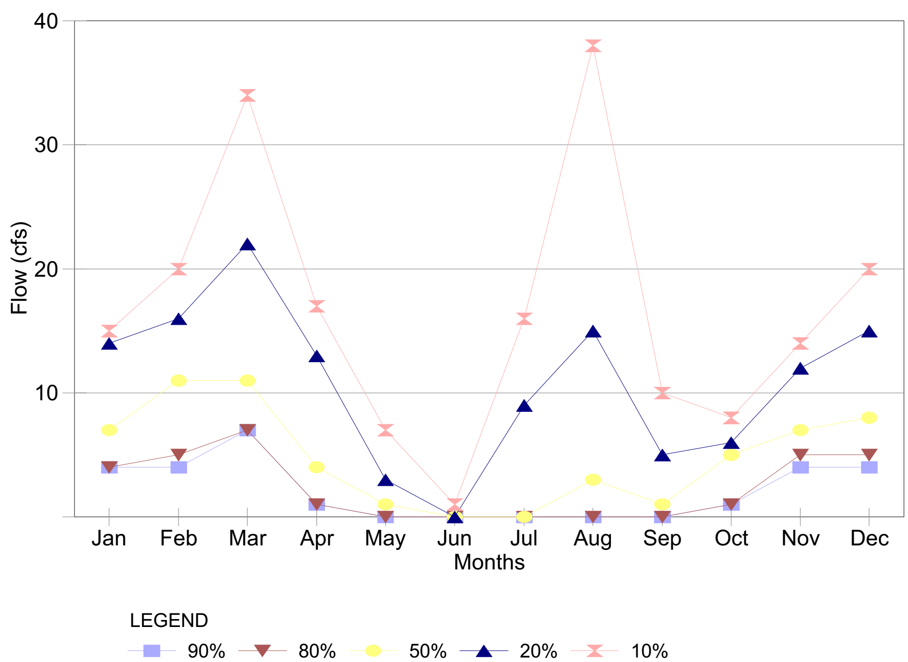


Table 5-4
Flood Frequency For Price River Near Heiner (Helper), Utah
1935-1969 and 1980-1981 and 1990-1991

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	977
5 YEARS	20	1945
10 YEARS	10	2916
25 YEARS	4	4659
50 YEARS	2	6430
100 YEARS	1	8713
200 YEARS	0.5	11637
500 YEARS	0.2	16781

Table 5-5
Flood Frequency For Huntington Creek Near Huntington, Utah
1909-1979

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	819
5 YEARS	20	1302
10 YEARS	10	1626
25 YEARS	4	2032
50 YEARS	2	2328
100 YEARS	1	2616
200 YEARS	0.5	2901
500 YEARS	0.2	3269

Table 5-6
Flood Frequency For Cottonwood Creek Near Orangeville, Utah
1910-1927 and 1932-1970 and 1976-1984

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	1154
5 YEARS	20	1961
10 YEARS	10	2549
25 YEARS	4	3337
50 YEARS	2	3950
100 YEARS	1	4576
200 YEARS	0.5	5222
500 YEARS	0.2	6103

Table 5-7
Flood Frequency For Ferron Creek (Upper Station) Near Ferron
1912-1923 and 1948-1997

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50.0	840
5 YEARS	20.0	1383
10 YEARS	10.0	1794
25 YEARS	4.0	2369
50 YEARS	2.0	2835
100 YEARS	1.0	3330
200 YEARS	0.5	3862
500 YEARS	0.2	4618

Table 5-8
Flood Frequency For Fremont River Near Bicknell, Utah
1938-1943 and 1945-1958 and 1977-1996

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	262
5 YEARS	20	474
10 YEARS	10	672
25 YEARS	4	1008
50 YEARS	2	1333
100 YEARS	1	1734
200 YEARS	0.5	2228
500 YEARS	0.2	3061

Table 5-9
Flood Frequency For Muddy Creek Near Emery, Utah
1909 and 1911-1914 and 1949-1996

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	505
5 YEARS	20	1075
10 YEARS	10	1627
25 YEARS	4	2571
50 YEARS	2	3484
100 YEARS	1	4605
200 YEARS	0.5	5973
500 YEARS	0.2	8243

Table 5-10
Flood Frequency For Pince Creek Near Escalante, Utah
1951-1955 and 1958-1996

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	165
5 YEARS	20	367
10 YEARS	10	544
25 YEARS	4	814
50 YEARS	2	1047
100 YEARS	1	1303
200 YEARS	0.5	1585
500 YEARS	0.2	1996

Table 5-11
Flood Frequency For Escalante River Near Escalante, Utah
1910-1912 and 1943-1955 and 1972-1996

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	789
5 YEARS	20	1697
10 YEARS	10	2347
25 YEARS	4	3142
50 YEARS	2	3693
100 YEARS	1	4200
200 YEARS	0.5	4663
500 YEARS	0.2	5209

Table 5-12
Flood Frequency For East Fork Boulder Creek Near Boulder, Utah
1951-1955 and 1958-1972

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	202
5 YEARS	20	304
10 YEARS	10	371
25 YEARS	4	454
50 YEARS	2	514
100 YEARS	1	572
200 YEARS	0.5	630
500 YEARS	0.2	704

Table 5-13
Flood Frequency For Paria River Near Cannonville, Utah
1951-1955 and 1959-1974

RETURN PERIOD	PROBABILITY	VALUE (cfs)
2 YEARS	50	2720
5 YEARS	20	4817
10 YEARS	10	6655
25 YEARS	4	9565
50 YEARS	2	12222
100 YEARS	1	15341
200 YEARS	0.5	19005
500 YEARS	0.2	24828

5.3.3 Lake Powell Water Budget [43]

The U. S. Bureau of Reclamation (USBR) operates Glen Canyon Dam and Lake Powell for water supply, electrical power generation, recreation, and fish and wildlife benefits. The USBR keeps records of reservoir releases, reservoir storage and evaporation, and bank storage estimates. Bank storage is the quantity of water stored in the rock surrounding the lake.

The Division of Water Resources recently conducted a water budget analysis for Lake Powell. The analysis used the USBR records for reservoir releases, reservoir storage and net evaporation. Inflow data were obtained from USGS records for Green River at Green River, USGS No. 09315000; Colorado River near Cisco, USGS No. 09185000; and San Juan River near Bluff, Utah Station No. 09379500. Tributary inflows from the San Rafael, Dirty Devil and Escalante rivers were obtained from water budget studies and represent the gaged flows of these tributaries into Lake Powell. Ungaged flow estimates were obtained from analysis of land use studies.

Figure 5-28 shows the Lake Powell (1976-1995) water budget analysis. The average annual releases from Lake Powell were 10,713,100 acre-feet during the period analyzed. This is greater than the annual release of 8.23 million acre-feet called for in the long range operating criteria. The increase is primarily due to the above average inflows of the mid-1980s and 1995, and the criteria requirement for equalization with Lake Mead. Additionally, there were 541,300 acre-feet of reservoir evaporation, 122,000 acre-feet change in storage from year to year, and 70,900 acre-feet of bank storage during this time period.

The mainstream storage reservoir evaporation is accounted to the states based on compact apportionment. Utah's long-term share of Upper Colorado River Compact mainstream reservoir evaporation annually is 120,000 acre-feet. Lake Powell's water supply is used to guarantee the

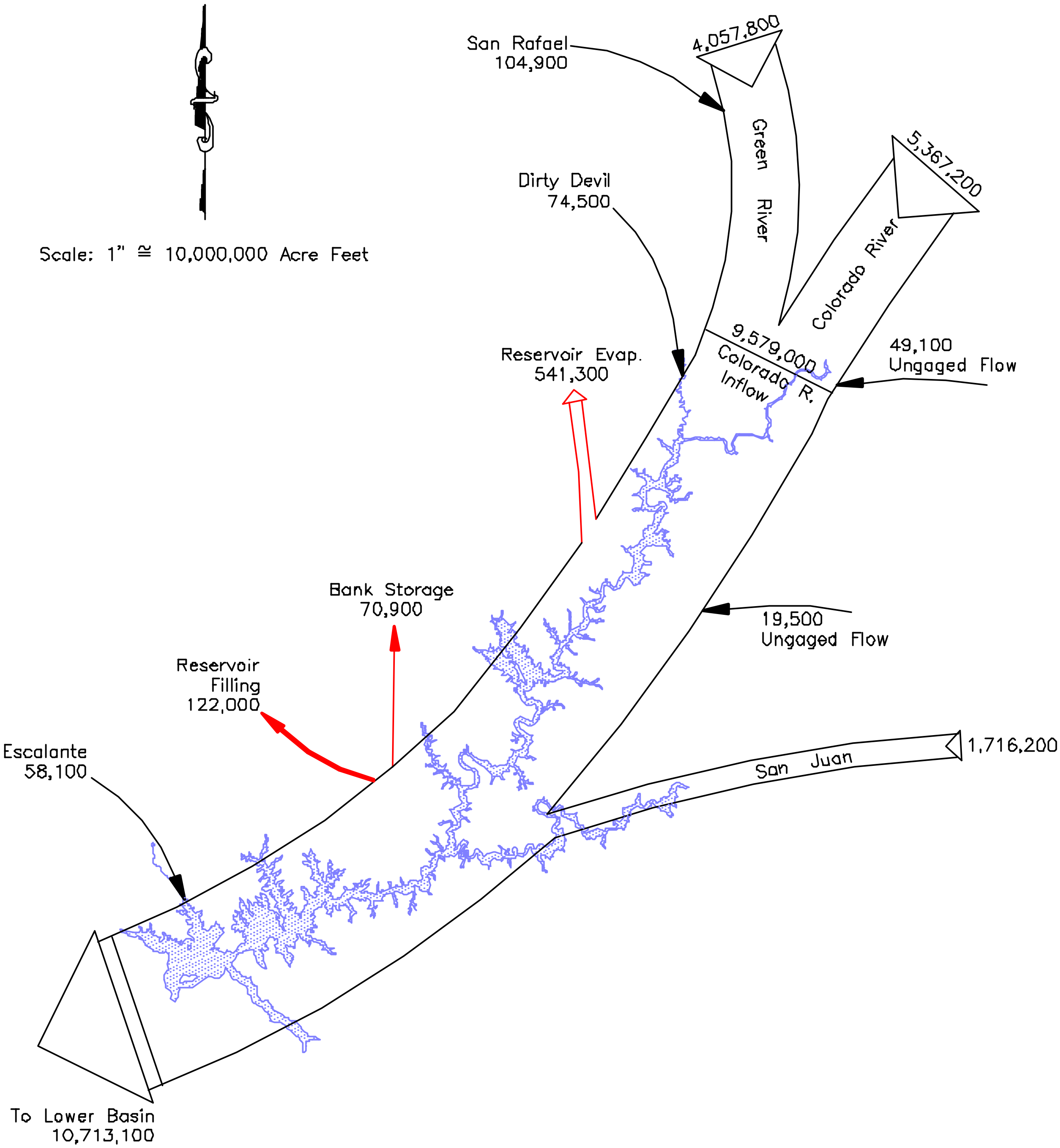


Figure 5-28
LAKE POWELL WATER BUDGET
1976-1995
West Colorado River Basin

Lower Colorado River Users the annual compact amount of 7.5 million acre-feet, while allowing the Upper Basin states to develop their allocated amounts. Based on present hydrology and apportionment by the compact, it is estimated that Utah's allowable depletion is about 1,369,000 acre-feet of Colorado River water.

5.3.4 Grand Staircase-Escalante National Monument Supply

The Division of Water Resources has recently completed a preliminary water supply study for the new Grand Staircase-Escalante National Monument (GSENM). Six streams with USGS stream flow gages were analyzed. Table 5-14 shows the data obtained for these stations. The data show that for most of the streams within the GSENM, summer thunderstorms produce nearly as much runoff volume as the spring snowmelt.

The BLM, USGS and the Division of Water Resources are cooperating to help gather more water base data. This informal arrangement hopes to gage more of the streams flowing into and through the monument. This base data will help in other future scientific studies conducted within the monument as well as to gain an understanding of the monument's water resources.

5.4 Water Use

Water is consumptively used for municipal and industrial (M&I) purposes, agricultural and livestock purposes, and wetland and riparian areas. Water is also non-consumptively used for instream flows and hydropower generation. Diversion and use of water requires a water right (see Section 7). Table 5-15 is a summary of water supplies that could be developed and consumptive uses in the West Colorado River Basin.

5.4.1 Agricultural Water Use

Water for irrigation of croplands is diverted from most rivers and streams flowing into the valley areas. About 95 percent of the water diverted for irrigation is surface water and five percent is groundwater from springs and wells. Surface water is diverted from streamflows and from surface storage reservoirs. Groundwater comes from wells drilled mostly in the Rabbit Valley area (Upper Fremont River drainage). Some wells are used only to supply supplemental irrigation water during the drier years or for late season shortages.

Surface water storage reservoirs make it possible to store water during periods of high runoff so it can be used during periods of low streamflows. This also makes irrigation feasible on the higher areas of the valley floors where groundwater is generally not available or too costly to pump. The existing surface water storage reservoirs are shown in Section 6, Table 6-1 and on Figure 6-1. Many of the reservoirs are also used for flood control and recreational purposes.

The irrigated lands are located within the six drainage basins in seven major areas. The Price drainage includes lands in and around Price City and the Cleveland/Elmo area. The San Rafael drainage includes lands located in and around communities of western Emery County (Huntington, Cleveland and Ferron). The Dirty Devil drainage includes two sub-drainages, Muddy Creek and the Fremont River. The irrigated lands along Muddy Creek are located in southwestern Emery County (Emery and Moore). The Fremont River lands are located in Wayne County in and around the communities of Fremont, Loa, Lyman, Bicknell, Cainville and Hanksville. The Escalante drainage lands are located in and around the communities of Boulder and Escalante in eastern Garfield County. The Paria drainage lands are mostly located in and around the communities of Tropic, Henrieville and Cannonville in southern Garfield County. The Lower Green drainage lands are located around Green River in eastern Emery County and western Grand County. The areas of irrigated land, water diversions and depletions are shown in Table 5-16.

5.4.2 Municipal and Industrial Culinary Water Use

Municipal and industrial (M&I) culinary water is used in homes, businesses, industry and public institutions. It also includes culinary water

Table 5-14
USGS Streamflow Gaging Stations in Grand Staircase-Escalante National Monument
West Colorado River Basin

Station	Elev. (feet)	Drain Area sq.mi.	Station Name	Period of Record	Mean Monthly and Annual Discharge (acre-feet)												
					Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
9337000	6400	68	Pine Creek near Escaalante, UT	1955 1957-1997	194	178	140	135	124	166	403	1,044	426	345	304	224	3,593
9337500	5760	320	Escalante R near Escalante, UT	1912-1912 1943-1955/1972-Present	499	411	462	510	596	800	888	1,455	1,133	433	557	414	8,260
9338000	9315	21	E Fork Boulder Cr.Near Boulder	1949-1955 1957-1972	1,261	1,204	1,162	1,146	1,035	1,136	1,232	3,079	2,142	1,290	1,301	1,226	17,192
9381000	6100	29	Henrieville Cr Nr Henrieville, UT	1950-1955	244	267	265	248	338	423	389	284	197	315	346	311	3,751
9381500	5440	220	Paria River near Cannonville, UT	1951-1955	374	480	600	509	640	1,007	434	137	53	693	1,299	321	7,021
9403600	5060	198	Kanab Creek near Kanab, UT	1979-Present	669	649	740	835	1,028	1,672	1,614	642	429	433	527	659	9,611

Table 5-15 Current Water Supply Uses			
Type/Category		Diversion (acre-feet)	Depletion (acre-feet)
Surface Water:			
Agriculture		285,050	156,200
Municipal & Industrial:			
Public Systems' Culinary		6,730	3,800
Public Systems' Secondary		8,367	4,200
Self-Supplied Industries		32,200	30,800
	SUBTOTAL	332,347	195,000
Groundwater:			
Agriculture		10,000	5,500
Municipal & Industrial:			
Public Systems' Culinary		4,186	2,400
Self-Supplied Industries' Culinary		3,685	2,200
	SUBTOTAL	17,871	10,100
TOTALS		350,218	205,100

Table 5-16
Current Irrigation Water Use

Drainage Basin	Area (acres)	Diversions (acre-feet)	Depletions (acre-feet)
Price	25,100	84,450	43,000
San Rafael	29,000	81,700	52,700
Dirty Devil	27,700	83,400	43,600
Escalante	4,400	23,100	12,400
Paria	2,700	7,750	3,500
Lower Green	3,000	14,650	6,500
Total	91,900	295,050	161,700

used to irrigate lawns and gardens and for other outside uses. Generally, population determines the demand for M&I water.

About one-half of the culinary water usage comes from groundwater, two-thirds from springs and one-third from wells. In most cases, these are treated by chlorination to bring them up to standard. Refer to Section 11, Drinking Water, for more information.

The divisions of Water Rights, Water Resources and Drinking Water collect data under the Utah Water Use Program in cooperation with the USGS. Data are collected from public water suppliers and industries using self-supplied water. The Division of Water Resources conducted a detailed M&I study in 1996. The diversions and depletions for current culinary water use are summarized by county in Table 5-17. Depletions are calculated as a percentage of the water diverted which does not return to the river or stream system. Most cities in the basin have sewage lagoons, which result in higher depletion values than other areas of the state.

Table 5-17
Current Culinary Water Use

County	Diversions (acre-feet)	Depletions (acre-feet)
Utah	1	0
Carbon	9,048	5,100
Sanpete	2	0
Emery*	3,582	2,500
Wayne	872	210
Sevier	22	20
Garfield	633	350
Kane	441	220
Total	14,601	8,400

*Includes some use in the Grand County side of Green River.

Also, industries using culinary water deplete nearly all of their demand. There is one hydroelectric power plant and four coal-fire plants in the basin. See Section 18 for more information

5.4.3 Municipal and Industrial Secondary Water Use

Water from secondary (dual) systems is used to irrigate lawns and gardens, parks, cemeteries and golf courses. These systems use untreated water and may be owned and operated by municipalities, irrigation companies, special service districts or other entities. Nearly every community in the basin has some users of secondary water within their boundaries. Castle Valley Special Service District operates its own secondary system for the communities in western Emery County.

The Huntington and Hunter power plants in Emery County and the Carbon and Sunnyside Co. generation power plants in Carbon County use large quantities of untreated water for coal-fired electrical power generation. Nearly all of this water is depleted. Current diversions and depletions for secondary water use are summarized in Table 5-18.

Table 5-18
Current Secondary Water Use[1]

County	Diversions (acre-feet)	Depletions (acre-feet)
Carbon	3,121[2]	2,700
Emery	35,601[3]	31,400
Wayne	1,141	570
Garfield	704	350
Totals	40,567	35,000

[1]Includes residential, institutional and industrial secondary water. Includes some pastures served within the Castle Valley Special Service District in Emery County.
[2]Includes power plants use of 2,000 acre-feet.
[3]Includes power plants use of 30,000 acre-feet.

5.4.4 Wetland and Riparian Water Use

Wetland and riparian areas include land and vegetation adjacent to rivers, streams, springs, bogs, wet meadows, lakes and ponds. These areas account for about 1 percent of the total land area. Wetlands and riparian areas are important habitat for migrating waterfowl and raptors during the winter months. They are also important for year-long wildlife residents. The Desert Lake and Bicknell Bottoms Waterfowl Management areas are very important for waterfowl in the Pacific Flyway. Other areas used for nesting and resting include the Colorado and Green river corridors.

5.5 Interbasin Diversions

The interbasin diversion from the East Fork of the Sevier River in the Sevier River Basin into the Tropic area (Paria River) is the only major import in the entire Colorado River Basin. This diversion has historically averaged about 4,800 acre-feet annually. The New Escalante Irrigation Company in Garfield County has a water right diligence claim on an import from Iron Spring Draw above Otter Creek Reservoir in the Sevier River Basin. An earthen ditch collects a small amount of the spring runoff and transports it into the Escalante River drainage. This right is currently being challenged by irrigators in the Sevier River Basin.

Tropic Canal

Exports out of the West Colorado River Basin are numerous. A small export is made from Fish Creek; tributary of the Price River system, to the Indianola Irrigation Company on Thistle Creek in the Utah Lake Drainage System. The Fairview (Narrows) Tunnel diverts water out of upper reaches of the Price River system to Fairview in the Sevier River Basin. There are 12 transbasin diversions from the Upper San Rafael drainage to the Sevier River drainage. Table 5-19 shows the amounts, and Figure 5-29 shows the locations for all of the West Colorado River Basin exports.

Existing evidence shows some groundwater movement out of Upper Fremont River to Antimony Creek in the Sevier River Basin. Springs in the upper reaches of Antimony Creek yield 10,000 acre-feet per year, which appear to be too high to come from within their own drainage.

5.6 Water Budgets

Eight hydrologic study areas are part of the West Colorado River Basin (see Figure 5-1). These study areas are used for preparing water-related land use inventories, water budget reports, and municipal and industrial water supply and use reports. The water budget is an accounting of the water supplies, uses and outflows for a given subarea. Table 5-20 shows a summary of the water budget analysis for the eight hydrologic study areas of the West Colorado River Basin. The water budget base period is 1961-1990, although in some cases a different period is based on the available data. Because of the different base periods used, the outflows for each drainage are slightly different than the flow diagrams shown in Figures 5-2 through 5-6. Figure 5-30 contains pie charts showing the supply and use in the basin among various categories.

5.7 Water Supply and Use Problems

Like many areas of the state and throughout the western U. S., the San Rafael River drainage appears to have had a decrease in its water yield over the past 80 years. While there could be many reasons for this, such as climate change or improved watershed conditions, one apparent prevailing theory is the decline of aspen in the western United

Table 5-19
West Colorado River Basin Transbasin Diversions

Number	Diversion	Average (1941-1990) (ac-ft/yr.)
	EXPORTS	
	Price River to Utah Lake Basin	
1	Lucy Fork (Indianola) Ditch (Estimated)	100
	Subtotal	100
	Price River to Sevier River Basin	
2	Fairview (Narrows) Tunnel (Gaged)	2,470
	Subtotal	2,470
	San Rafael to Sevier River Basin	
3	Candland Ditch (Estimated)	200
4	Coal Fork Ditch (Estimated)	260
5	Twin Creek Tunnel (Estimated)	200
6	Cedar Creek Tunnel (Estimated)	340
7	Black Canyon Ditch (Estimated)	290
8	Spring City Tunnel (Gaged)	1,900
9	Reeder Ditch (Estimated)	250
10	Horseshoe Tunnel (Estimated)	600
11	Larsen Tunnel (Estimated)	690
12	Ephraim Tunnel (Gaged)	1,900
13	Madsen Ditch (Estimated)	40
14	John August Ditch (Estimated)	200
	Subtotal	6,870
	Total Exports	9,440
	IMPORTS	
	Sevier River to Paria River	
1	Tropic Canal	4,800
2	Iron Spring Draw	N/A
	NET EXPORTS	4,600

Source: U.S. Geological Survey and Upper Colorado River Commission

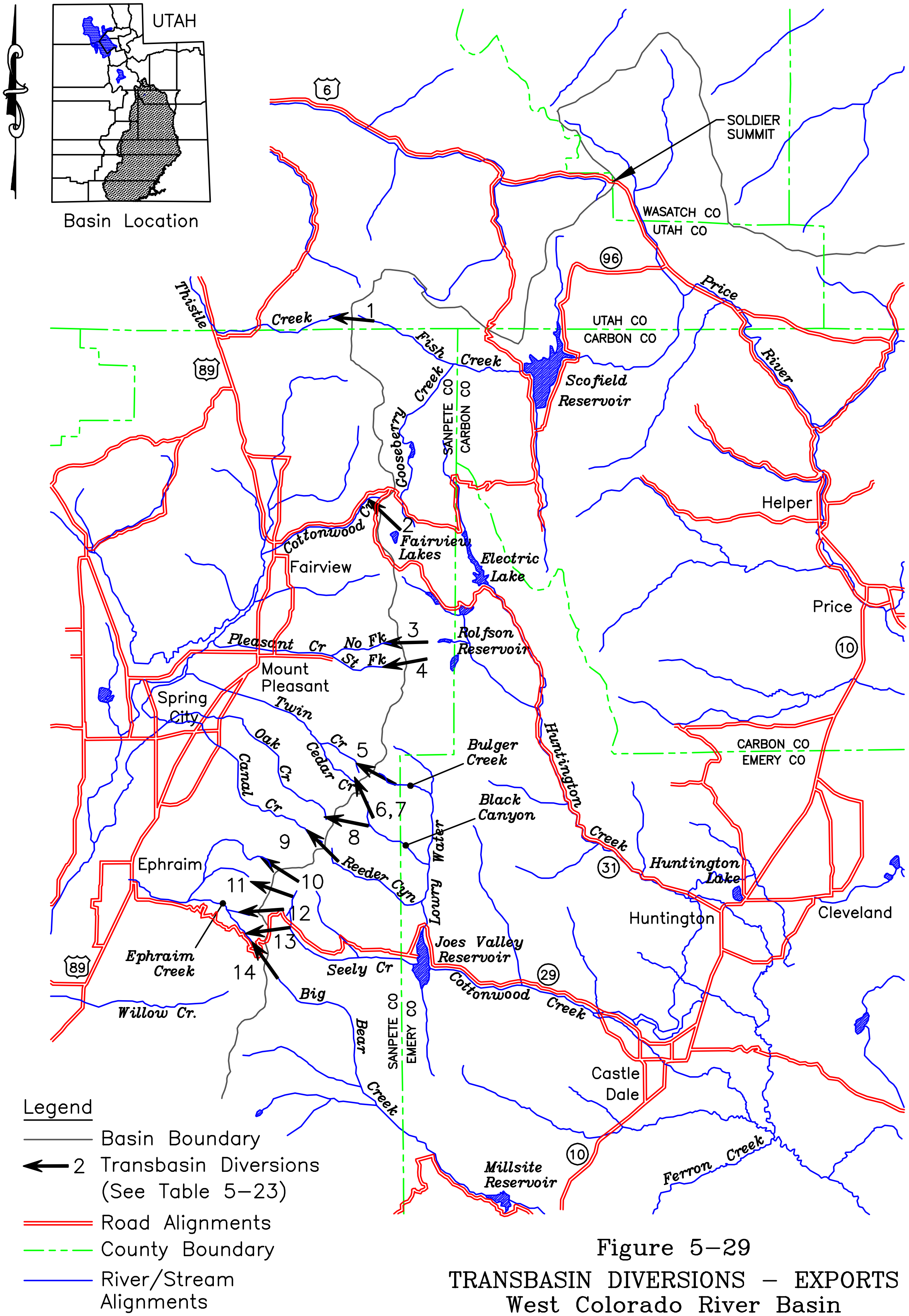


Figure 5–29

TRANSBASIN DIVERSIONS – EXPORTS
West Colorado River Basin

Table 5-20
Summary Water Budget Analysis (1961-1990)
West Colorado River Basin
(acre-feet/yr.)

Drainage	Yield	Agricultural Depletion	Municipal & Industrial Depletion	Wet/Open Water Depletion	Exports	Imports	Outflow
Price River	138,000	43,000	8,800	17,000	2,600	29,000	95,600
San Rafael	233,000	52,700	32,400	23,000	35,900	4,000	93,000
Dirty Devil	147,000	43,600	1,000	18,000	4,000	0	80,400
Escalante	86,000	12,400	400	12,000	0	0	61,200
Paria	21,000	3,500	300	2,000	0	4,800	20,000
Lower Green	5,000	6,500	500	6,000	0	8,000	0
Total	630,000	161,700	43,400	78,000	42,500	45,800	350,200

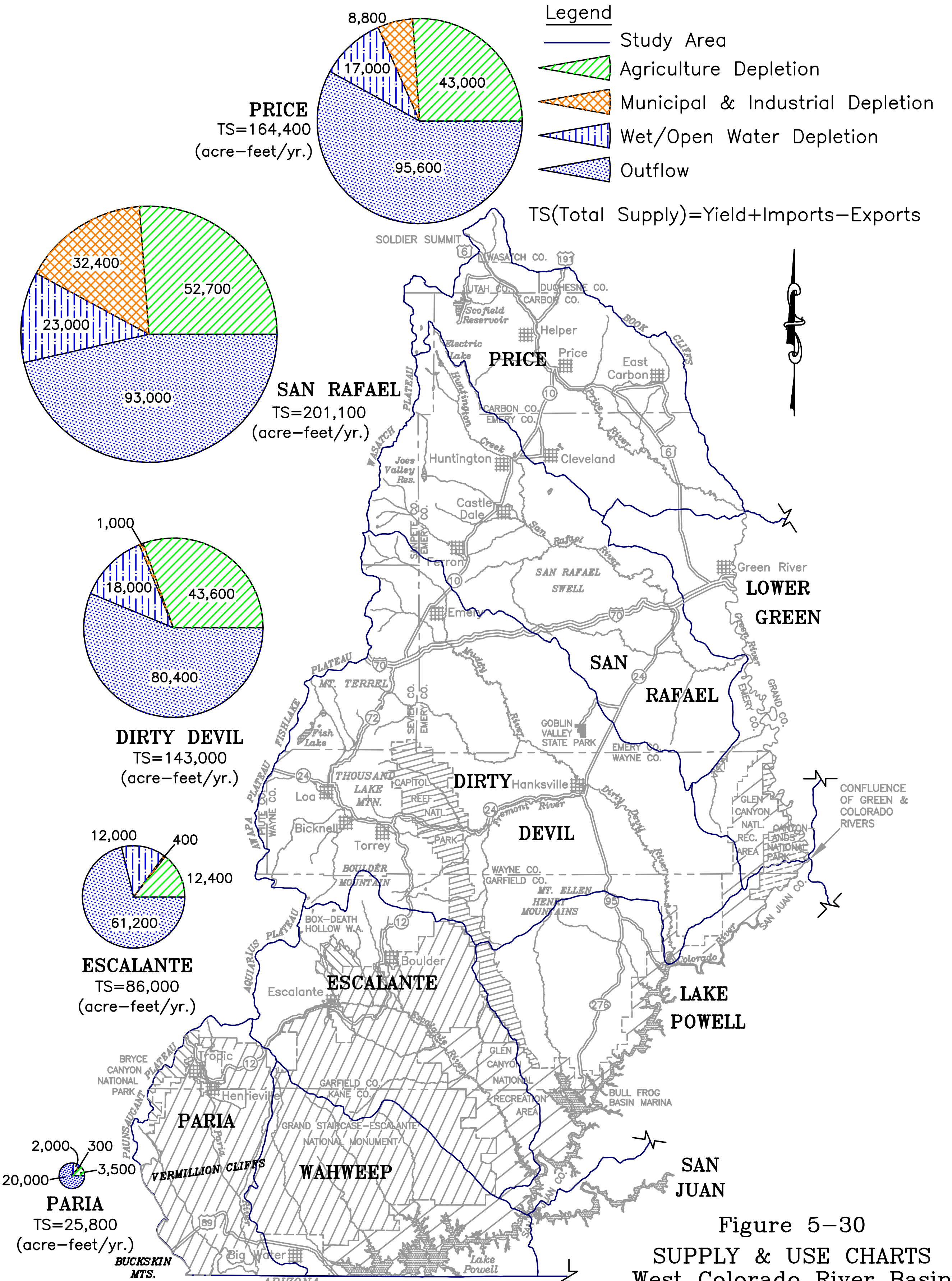


Figure 5−30
SUPPLY & USE CHARTS
West Colorado River Basin

States. The mountainous areas of this drainage have experienced a loss of about 100,000 acres of aspen-dominated landscapes to mixed conifer landscapes. Mixed conifer landscapes consume about 250-500 acre-feet per 1,000 acres more than aspen landscapes. This would result in about 35,000 acre-feet loss of the water supply through additional transpiration. Much more research needs to be conducted to verify this theory.

5.8 Water Quality

Streams in the West Colorado River Basin originate in areas that are considerably different from each other in aspect, geology, land use, vegetation and altitude. These affect the quality of water flowing from a given area.

The quality of the groundwater reservoirs is impacted by the recharge water. This water comes from surface tributary inflow recharging the groundwater as it flows over alluvial fans and from groundwater tributary inflow. Groundwater is also supplied by losses from surface streams, canals and deep percolation from irrigation of croplands.

The quality of surface water and groundwater supplies varies throughout the basin. This affects the use and management of these water resources. Stream and river flows are generally of good quality in the upper reaches, but deteriorate as they flow downstream. Water quality in the upper reaches of all the major drainages is good with total dissolved-solids of around 200 mg/L. This increased substantially to about 3,600 mg/L at the mouth of the Price River, 1,600 mg/L at the mouth of the San Rafael River, 2,000 mg/L at the mouth of the Dirty Devil, 900 mg/L at the mouth of the Escalante River and 1,700 mg/L at the mouth of the Paria River. Refer to Sections 12 and 19 for data on the water quality.

5.9 Issues and Recommendations

The only issue discussed is over-appropriation of existing water supplies.

5.9.1 Over-Appropriation of Existing Water Supplies

Issue - The Price and San Rafael drainages are over-appropriated.

Discussion - The West Colorado River Basin, like many other areas of the state, has a problem in overall supply and uses with regards to water rights. Much of the basin is over-appropriated and, as a result, late season shortages exist in many of the agricultural areas. Table 5-21 shows the perfected water rights versus the yields of the major drainages within the basin. The San Rafael River is the most over-appropriated drainage in the basin. As a result, river commissioners have been appointed in Cottonwood and Huntington creeks to administer the rights properly, especially in dry years. The Price River also has a river commissioner.

Recommendation - The state engineer should study this situation and adjudicate the Price and San Rafael drainages. ●

Table 5-21
Water Rights Versus Yield

Drainage	Yield (acre-feet)	Use		Perfected Water Rights (Depletion)[1] (acre-feet)
Price	138,000	Irrigation		80,566
		M&I		64,147
			Subtotal	144,713
San Rafael	233,000	Irrigation		267,003
		M&I		41,128
			Subtotal	308,131
Dirty Devil	147,000	Irrigation		57,059
		M&I		27,864
			Subtotal	84,923
Escalante	86,000	Irrigation		14,616
		M&I		4,207
			Subtotal	18,823
Paria	21,000	Irrigation		6,644
		M&I		5,966
			Subtotal	12,610

[1]Includes some water rights based on high flows that only occasionally occur.

Section 6 - West Colorado River Basin Management

6.1	Introduction	6-1
6.2	Setting	6-1
6.3	Irrigation Systems	6-6
6.4	Municipal and Industrial Systems	6-6
6.5	Management Problems and Needs	6-6
6.6	Colorado River Salinity Control Program	6-6
6.7	Utah's Unused Colorado River Water	6-9
6.8	Issues and Recommendations	6-10

Figure

6-1	Existing Lakes and Reservoirs	6-5

Tables

6-1	Existing Lakes and Water Storage Reservoirs	6-2
6-2	Irrigation Companies	6-7
6-3	Upper Colorado River Depletions	6-10

Section 6
West Colorado River Basin - Utah State Water Plan

Management

6.1 Introduction

Although irrigated crop production is a major industry in the basin, increasing requirements for other uses may result in minor conflicts over use of the existing supplies. Also, some local agricultural areas in the basin, such as the Boulder area in Garfield County, are currently using 100 percent of the supply. To ease the situations, there is a need for innovative management. This section describes present water management and discusses potential management alternatives.

Water is a most valuable natural resource and often in short supply. For this reason, the management of water use is a primary concern of local water users.

Diversion structure in Emery County

6.2 Setting [61]

With the settlement of Escalante in 1875 and Carbon and Emery counties in 1877, the first water was diverted to irrigate crops. As the number of settlements increased, usually at the mouth of a canyon or near a stream, water continued to be developed, primarily for culinary and agricultural uses. Some areas were founded for other reasons, such as Green River City because of the railroad near the turn of the century. Agricultural practices have vastly improved since the early days of settlement. The modern delivery of culinary water is a far cry from carrying or hauling it in buckets or barrels from streams and ditches to the individual homes.

It soon became evident more permanent water control structures were needed to withstand the effects of floods on the various water systems. As a result, more functional facilities were installed to divert and convey water and to utilize it better. Modern pipelines are now used to convey water from wells and springs to the place of use on agricultural lands and in communities and individual homes.

Surface water storage reservoirs have been constructed on many of the rivers and streams and are an important part of the management of water delivery systems. Related benefits include flood control, water-based recreation and improved fisheries. The existing lakes and surface water storage reservoirs over 100 acre-feet in capacity are listed in Table 6-1 and shown on Figure 6-1. Many

Table 6-1
Existing Lakes and Water Storage Reservoirs (Greater Than 100 Acre-Feet)

Fig. 6-1 Number	Name	Stream	Location T	Location R	Capacity (ac-ft)	Surface Area (acres)	Purpose
	Price River Drainage						
1	Fairview Lakes	Gooseberry Creek	13S	5E	1949	105	I,R
2	Lower Gooseberry	Gooseberry Creek	13S	6E	212	56	R
3	Scofield	Price River	12S	7E	73,600	2,815	FC,I,R
4	Grassy Trail Reservoir	Grassy Trail Creek	14S	14E	916	29	MI
5	Horse Bench Reservoir	Dry Lake Wash	22S	15E	245	4	I
6	Olsen Reservoir	Marsing Wash	16S	11E	150	15	I
7	Desert Lake	Desert Wash	17S	10E	808	202	R
	San Rafael River Drainage						
8	Electric Lake	Huntington Creek	14S	6E	35,500	425	FC,P,R
9	Huntington Reservoir	Left Fork Huntington Creek	14S	6E	5,616	129	FC,I,R,P
10	Cleveland Reservoir	Left Fork Huntington Creek	14S	6E	5,340	185	FC,I,R,P
11	Rolfsen Reservoir	Left Fork Huntington Creek	14S	6E	900	45	FC,I,R
12	Huntington No. Reservoir	Huntington Cr (Off Stream)	17S	9E	5,690	225	FC,I,R
13	Miller Flat	Miller Flat Creek	15S	6E	5,560	160	FC,I,R,P
14	Grassy Lake	Littles Creek	17S	5E	132	11	R
15	Petes Hole Reservoir	Seely Creek (Off Stream)	18S	5E	180	50	R
16	Joes Valley Reservoir	Seely Creek	17S, 18S	6E	71,900	1,183	FC,I,MI,P, R
17	Duck Fork Reservoir	Duck Fork - Ferron Creek	19S	4E	850	48	R

Table 6-1 (Continued)
Existing Lakes and Water Storage Reservoirs (Greater Than 100 Acre-Feet)

Fig. 6-1 Number	Name	Stream	Location T	Location R	Capacity (ac-ft)	Surface Area (acres)	Purpose
18	Ferron Reservoir	Indian Creek	19S	4E	980	57	R
19	Willow Lake	Willow Creek	19S	5E	120	20	R
20	Wrigley Spring Reservoir	Slide Hollow	20S	6E	133	11	R
21	Millsite Reservoir	Ferron Creek	20S	6E	18,000	435	FC,I,MI,R
22	Buckhorn Reservoir	Buckhorn Wash	18S	10E	2,002	150	I
	Dirty Devil River Drainage						
23	Emery Reservoir	North Fork Muddy Creek	20S	4E	145	15	I
24	Spinners Reservoir	North Fork Muddy Creek	20S	4E	575	51	R
25	Julius Flat Reservoir	North Fork Muddy Creek	20S	4E	725	41	I
26	Sheep Valley Reservoir	North Creek-Ivie Creek	24S	3E	465	126	I
27	Fish Lake	Lake Creek-Fremont River	26S	2E	212,500[1]	2,500	I,R
28	Johnson Valley Reservoir	Fremont River	25S	2E	9,997	704	I,R
29	Forsyth Reservoir	UM Creek	26S	3E	3,639	171	FC,I,R
30	Mill Meadow Reservoir	Fremont River	26S	3E	5,232	156	FC,I,R
31	Donkey Reservoir	Donkey Creek	30S	4E	200	40	I
32	Fish Creek Lake	Fish Creek	30S	4E	357	27	I
33	Lower Bowns Reservoir	Pleasant Creek (Off Stream)	31S	6E	3,450	140	I,R
34	Oak Creek Reservoir	Oak Creek	31S	5E	915	38	I,R

Table 6-1 (Continued)
Existing Lakes and Water Storage Reservoirs (Greater Than 100 Acre-Feet)

Fig. 6-1 Number	Name	Stream	Location T	Location R	Capacity (ac-ft)	Surface Area (acres)	Purpose
	Escalante River Drainage						
35	Long Willow Bottom Res.	Twitchell Creek	33S	1W	100	4	R
36	North Creek Reservoir	North Creek	34S	1E	400	29	FC,I,R
37	Wide Hollow Reservoir	North Creek	35S	2E	2,324	145	I,R
38	Roundy Reservoir	Pine Creek	32S	2E	150	30	I
39	Jacobs Valley Reservoir	Pine Creek	32S	3E	1,967	359	I
40	Spectacle Lake	West Fork Boulder Creek	31S	4E	1,348	70	I,R
	Paria River Drainage						
41	Tropic Reservoir	East Fork Sevier	37S	4W	1,850	180	I,R
	Lake Powell Drainage						
42	Lake Powell	Colorado River	*		26,373,000	135,000	F,FC,I, MI,P

*Located in many sections in San Juan, Kane, Garfield counties in Utah and Coconino County, Arizona.
[1]Storage capacity is limited to 6,300 acre-feet in Fish Lake.
Purpose: FC - Flood Control   I - Irrigation and Stock Watering   MI - Municipal and Industrial   P - Power   R - Recreation/Wildlife

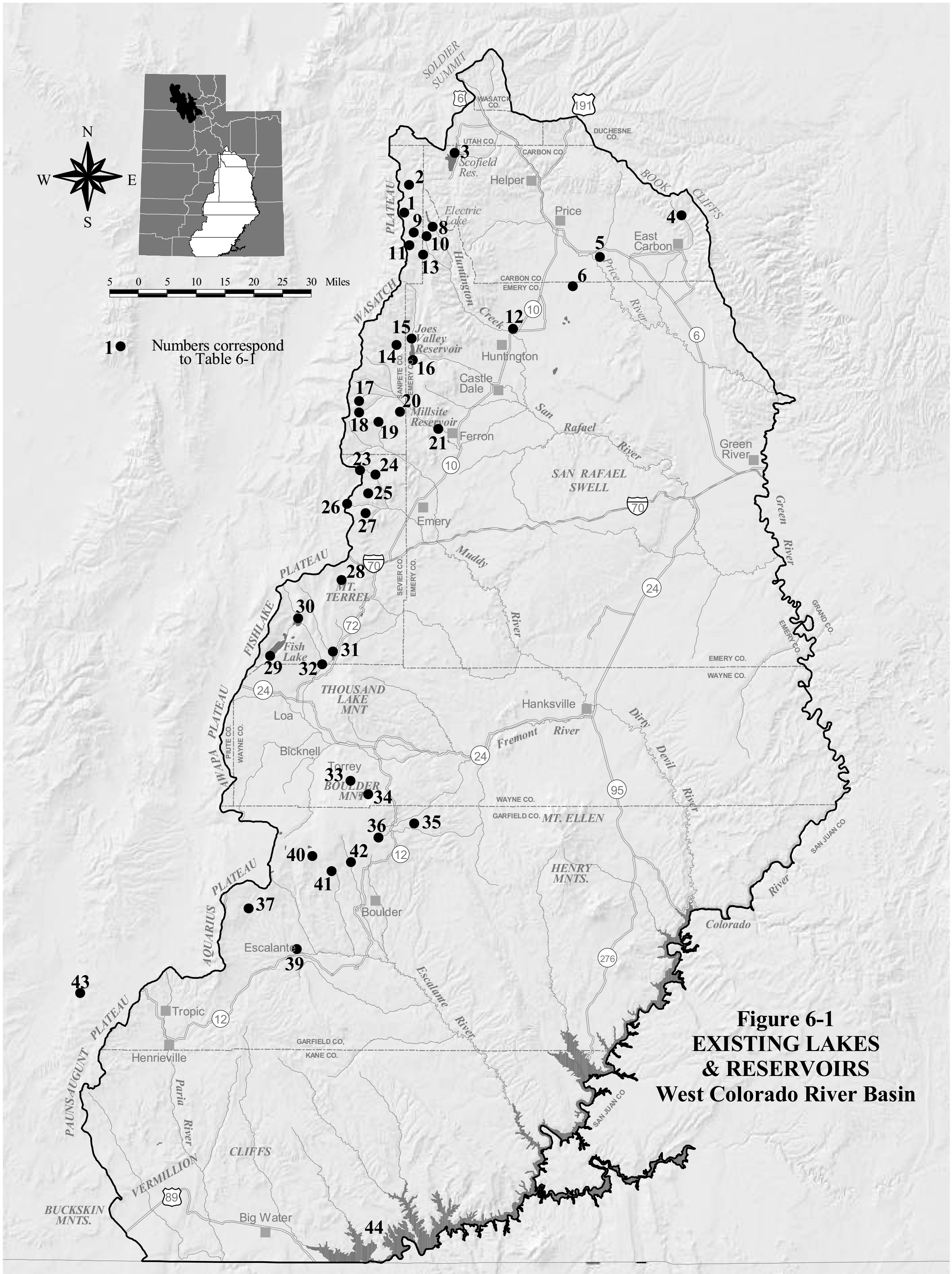


Figure 6-1
EXISTING LAKES & RESERVOIRS
West Colorado River Basin

other smaller lakes and reservoirs are located throughout the basin. Those that are used as fisheries are listed in Section 14, Table 14-2.

All water supplies are delivered and distributed according to state law by various entities that have the rights for use and distribution of this resource. This mainly deals with the quantity of water by appropriated right, but also there is increasing pressure to regulate the quality of water distributed. Quality is particularly important where water is used for culinary purposes.

6.3 Irrigation Systems

Incorporated mutual irrigation companies serve the majority of the irrigated land in the basin, while private irrigation systems serve about one-third. These irrigation companies and private systems are responsible for managing nearly 90 percent of the developed water supply. Table 6-2 lists the basin's irrigation companies along with their irrigated acreage.

6.4 Municipal and Industrial Systems [16]

The basin has 92 drinking water systems. Thirty-five are classified as "Public Community" suppliers and 57 as "Public Non-Community" suppliers (transient and non-transient). Most systems use groundwater as their sole supply source. Price River Water Improvement District, Clawson, Orangeville, Castledale, Emery, Ferron, East Carbon, Sunnyside and Green River use surface water as their principal supply.

Some industries use water that is delivered through the public water systems. Heavy industries such as mining companies and power companies use self-supplied water, treated and untreated, from municipalities and irrigation companies (see Section 18).

Water used for municipal and industrial purposes is usually well-managed. Most of the public water suppliers continue to upgrade their systems and strive to maintain an approved rating from the Department of Environmental Quality.

6.5 Management Problems and Needs

In order to properly manage the water supplies for various uses, facilities need to be maintained or replaced. This can also improve water use efficiencies. Concrete structures deteriorate with time and eventually need to be replaced. Reservoirs such as Wide Hollow and Scofield are losing capacity because of sediment.

6.5.1 Irrigation Systems

Delivery and on-farm efficiencies can be improved through proper irrigation water management and installation of sprinklers, gated pipe, canal lining, pipelines or land leveling.

6.5.2 Municipal and Industrial Systems

Management of municipal and industrial water systems is a key to the maintenance or improvement of the quality and quantity of existing supplies. Areas around springs and wells must be protected to avoid contamination. Timely maintenance of conveyance and distribution systems can reduce the volume of water lost through leaks and prevent contamination from entering culinary pipe lines. Systems should be metered as a means to save water and detect leaks.

6.6 Colorado River Salinity Control Program

In the 1960s and early 1970s, the seven Colorado River Basin states and representatives of the federal government discussed the problem of salinity levels increasing in the lower reaches of the Colorado River. The federal government enacted the Clean Water Act in 1972 while Mexico and the United States were discussing the increasing salinity of Colorado River water being delivered to Mexico. The basin states established the Colorado River Basin Salinity Control Forum in 1974 with representatives from each of the seven basin states. These representatives are appointed by the governors of the respective states for the purpose of interstate cooperation and providing the states with the information necessary to comply with the Environmental Protection Agency's (EPA) 1974 Regulation 40 CFR, Part 120, entitled, *Water Quality Standards, Colorado River System: Salinity Control*

Table 6-2
Irrigation Companies

Company	Water Right Irrigated Area (acres)
Carbon County	
Allred Ditch Company	725
Bryner Hansen Ditch Company	43
Bryner-Ploutz Ditch Company	82
Carbon Canal Company	12,555
Gay Ditch Company	82
Oberto Ditch Company	50
Pioneer Ditch Company No. 1	625
Pioneer Water Company No. 2	500
Price Canal Company	825
Price River Water Users Association	18,700
Spring Glen Canal Company	950
Stowell Mutual Water & Canal Company	175
Wellington Canal Company	3,700
Emery County	
Cottonwood Creek Consolidator Irrigation Company	15,091
Ferron Canal and Reservoir Company	14,435
Green River Canal Company	1,450
Huntington Cleveland Irrigation Company	32,957
Muddy Creek Irrigation Company	7,657
Gunnison Butte Mutual Irrigation Company	5,526
Grand County	
East Side High Ditch Irrigation Company	580
Wayne County	
Caineville Canal Company	496
Fremont Irrigation Company	10,200

Table 6-2 (Continued) Irrigation Companies	
Company	Water Right Irrigated Area (acres)
Grover Irrigation Company	800
Hanksville Canal Company	650
Chadburn/Leavitt/Hickman Company	250
Jensen & Hiskey Irrigation Company	110
Maxfield/Blackburn/Black Irrigation Company	220
Pine Creek Irrigation Company	110
Road Creek Water Users Association	700
Sand Creek Irrigation Company	260
Teasdale Irrigation Company	400
Torrey Irrigation Company	940
Garfield County	
Boulder Irrigation & Water Development Company	1,800
Cannonville Irrigation Company	271
Clifton Irrigation Company	500
Henrieville Irrigation Company	528
New Escalante Irrigation Company	2,440
Pine Creek Irrigation Company	456
Seep Ditch Company	N/A
Tropic & East Fork Irrigation Company	1,600
Wooden Shoe Ditch Company	N/A

Note: Data are not available where N/A is listed.
Source: Division of Water Rights

Policy and Standards Procedures, and Section 303(a) and (b) of the Clean Water Act.

Below Imperial Dam, salinity is controlled as a federal responsibility to meet the terms of agreement with Mexico contained in Minute No. 242 of the International Boundary and Water Commission (IBWC). Minute No. 242 requires that Colorado River water delivered to Mexico upstream from Morelos Dam will have an average annual salinity concentration no more than 115 $\pm$ 30 parts per million (ppm) total dissolved solids (TDS) higher than the average annual salinity concentration of Colorado River water arriving at Imperial Dam.

With the forum's support, Congress enacted the Colorado River Basin Salinity Control Act (P.L. 93-320) in 1974. Title I of the Act addresses the United States' commitment to Mexico and provides the means for the United States to comply with the provisions of Minute No. 242.

Title II of the act created a water quality program for salinity control in the United States. Primary responsibility for the federal program was given to the Secretary of the Interior, with the Bureau of Reclamation (BR) being instructed to investigate several salinity control units. The Secretary of Agriculture was instructed to support the program.

Under the program's original authorities, a total of 621,400 tons of salt control has been achieved. In order to meet the goal of 1.48 million tons of salinity control by 2015, it will be necessary to fund and implement potential new measures which ensure the removal of an additional 855,200 tons of salt.

To help achieve this goal, the *Price-San Rafael Rivers Unit Planning Report/Final Environmental Impact Statement* was completed in 1993. This report indicated that through improved irrigation water management and a system of on-farm and off-farm irrigation improvements, 161,000 tons of salt could be removed annually from the Colorado River system. Currently, the Huntington, Ferron, Price and Wellington irrigation areas are working with the BR through the Price-San Rafael Rivers Unit Salinity Control Program.

Although the Price-San Rafael River Unit was identified as a prime cost-effective area per ton of salt removed, any area or irrigation company in the basin can apply for assistance to the BR for a salinity control project. These requests will have to be analyzed against other identified beneficial projects throughout the basin states and will be ranked by dollars spent per tons of salt removed.

6.7 Utah's Unused Colorado River Water

The state of Utah's compact allocation of Colorado River water is 1.369 million acre-feet. The state is currently using less than 900,000 acre-feet of its compact allocation, leaving approximately 450,000 acre-feet of water available for future development within the state. With the completion of the Central Utah Project over the next 10 years, the state's use of Colorado River water will increase to about 950,000 acre-feet. This results in about 400,000 acre-feet of water being available for use within the state. The same situation exists in Colorado and Wyoming where both states have 600,000 acre-feet and 300,000 acre-feet, respectively, available for future use. Table 6-3 shows Utah's current and projected depletions of Colorado River water.

Due to restrictive federal legislation, i.e., the Endangered Species Act, the Clean Water Act, the Wild and Scenic River Act, proposed wilderness legislation, and lack of financially feasible water development projects, it will be difficult for the citizens of the state to develop all of the state's remaining compact water supply. Because of this, the state of Utah has been investigating the possibility of leasing a portion of its unused allocation (50,000 acre-feet) to one of the three lower basin states. The administration and the Utah Legislature passed a resolution in 1996 directing the Department of Natural Resources, the Division of Water Resources, the State Engineer and the Attorney General to investigate the feasibility of leasing a portion of Utah's unused Colorado River water. The unused Upper Basin water is currently going down the river and is being used free of charge by the state of California. The Lower Basin states have a 7.5 maf allocation of Colorado River water, but for the past five years have been using in excess of 8.0 maf. If Utah or the Upper Basin states could develop a revenue base from the lease of some of this unused water, revenues could be used to fund the Endangered Species Mitigation Fund and/or the financing of additional water development projects.

Table 6-3 Upper Colorado River Depletions	
	Depletions (acre-feet)
Utah Share of 6.0 Million Acre-Feet	1,369,000
Current Depletions	
State Share of Mainstem Evaporation	120,000
Agriculture	539,000
Municipal and Industrial	74,000
Exports/Imports	154,000
Subtotal	887,000
Future Depletions (Years 2000-2050)	
Agriculture	78,000
Municipal and Industrial	22,000
Exports	165,000
Ute Indian Settlement	100,000
Subtotal	335,000
Unused Remaining Supply	117,000

Utah officials continue to study the issue, but no decision has been made at this time to lease any of the state's Upper Colorado River Basin allocation.

6.8 Issues and Recommendations

The only issue discussed is real-time monitoring and control systems.

6.8.1 Real-Time Monitoring and Control Systems

Issue - Improved irrigation water management systems and methods can improve control, save water and reduce costs.

Discussion - Water is a valuable commodity as well as a finite resource. It is becoming imperative that water be managed and used to obtain the best returns possible. The cost of improving the management and use of water is considerably less than developing additional supplies. A real-time monitoring and control system is the most cost-effective means available to achieve these goals.

There is often a time lag between the need to change gate settings and the physical ability to make the adjustments. For instance, when flood flows approach diversion structures, silt and debris diverted into the canals. A solar-powered control system operated from a base station would make gate closures possible in a fraction of the time and would save a costly clean-up operation. A more sophisticated system can be installed for even better control. Instead of adjusting the gates up or down by remote control, a predetermined canal flow can be set and the gates will move automatically to maintain this flow rate.

Monitoring stations can also be established at given reaches of the river system and at critical points along the canals. This will assist the water master in making sure the canals are operating as is intended. This will allow management of the water supply to meet the requirements of the water rights. Communication is by line-of-sight radio and telephone. Repeaters would be required to maintain contact in remote areas.

The Emery Water Conservancy District's installation of real-time monitoring on Huntington and Cottonwood creeks has helped to make their water supply much more efficient. This could be critical, especially during the inevitable dry years. There will also be a savings in the cost of water management.

Recommendation - Other West Colorado River Basin water users should investigate and the Emery Water Conservancy District should continue to install solar-powered, real-time monitoring and control systems. ●

Section 7 - West Colorado River Basin
Regulation/Institutional Considerations

7.1	Introduction	7-1
7.2	Setting	7-1
7.3	Problems and Needs	7-4
7.4	Water Rights Regulation	7-4
7.5	Water Quality Control	7-5
7.6	Drinking Water Regulation	7-6
7.7	Dam Safety	7-6
7.8	Policy Issues and Recommendations	7-6

Figure

7-1	Water Rights Map	7-2

Table

7-1	High Hazard Dams	7-7

Section 7

West Colorado River Basin - Utah State Water Plan

Regulation/Institutional Considerations

7.1 Introduction [17]

This section presents a brief discussion of several regulations now in place to protect and manage the water resources of the West Colorado River Basin. It also discusses the major related problems and needs.

The Department of Environmental Quality and the Division of Water Rights are the state agencies primarily responsible for water regulation. Water quality is regulated by the Division of Water Quality and the Division of Drinking Water within the Department of Environmental Quality. These agencies operate in accordance with the Utah Water Quality Act and the Utah Safe Drinking Water Act. Water quality is also regulated by various federal controls. The Division of Water Rights, Department of Natural Resources, is responsible for water allocation and distribution according to state water law. The detailed functions of these agencies are described in the *Utah State Water Plan (1990)*, Sections 7, 11 and 12. The Division of Water Resources regulates the cloud seeding program as described in Section 9, and is responsible for state water planning and assists with water development.

7.2 Setting

Water regulation is generally carried out under the direction of state agencies, although some federal agencies become involved when it includes their mandates. Local public and private institutions and entities usually manage and operate the various water systems at the basin level.

Consideration of water rights, water quality and the environment are prerequisite to the management of the water resources. Regulations are required to avoid or resolve conflicts as they arise and for protection of the water user.

7.2.1 Current Regulation

Water law, based on the doctrine of prior appropriation, is administered by the Utah State Engineer. The Division of Water Rights has a regional engineer in Price who carries out the day-to-day activities for Carbon, Emery and the portions of Utah, Duchesne, Wasatch, Sanpete and Sevier counties; another in Richfield for Wayne and the portions of Sevier, Piute and Garfield counties in the Dirty Devil River drainage basin; and another in Cedar City for the portions of Garfield and Kane counties in the Escalante and Paria river drainages (see Figure 7-1).

River commissioners were created in response to a petition to the court or state engineer. These commissioners are administered by the Division of Water Rights. An appointed "river commissioner" is charged with distribution and/or measurement of surface and/or underground waters. Assessments are made to pay the commissioner and for other costs. Members in each system elect a board that represents them and conducts business as required. In this basin, there are four appointed river

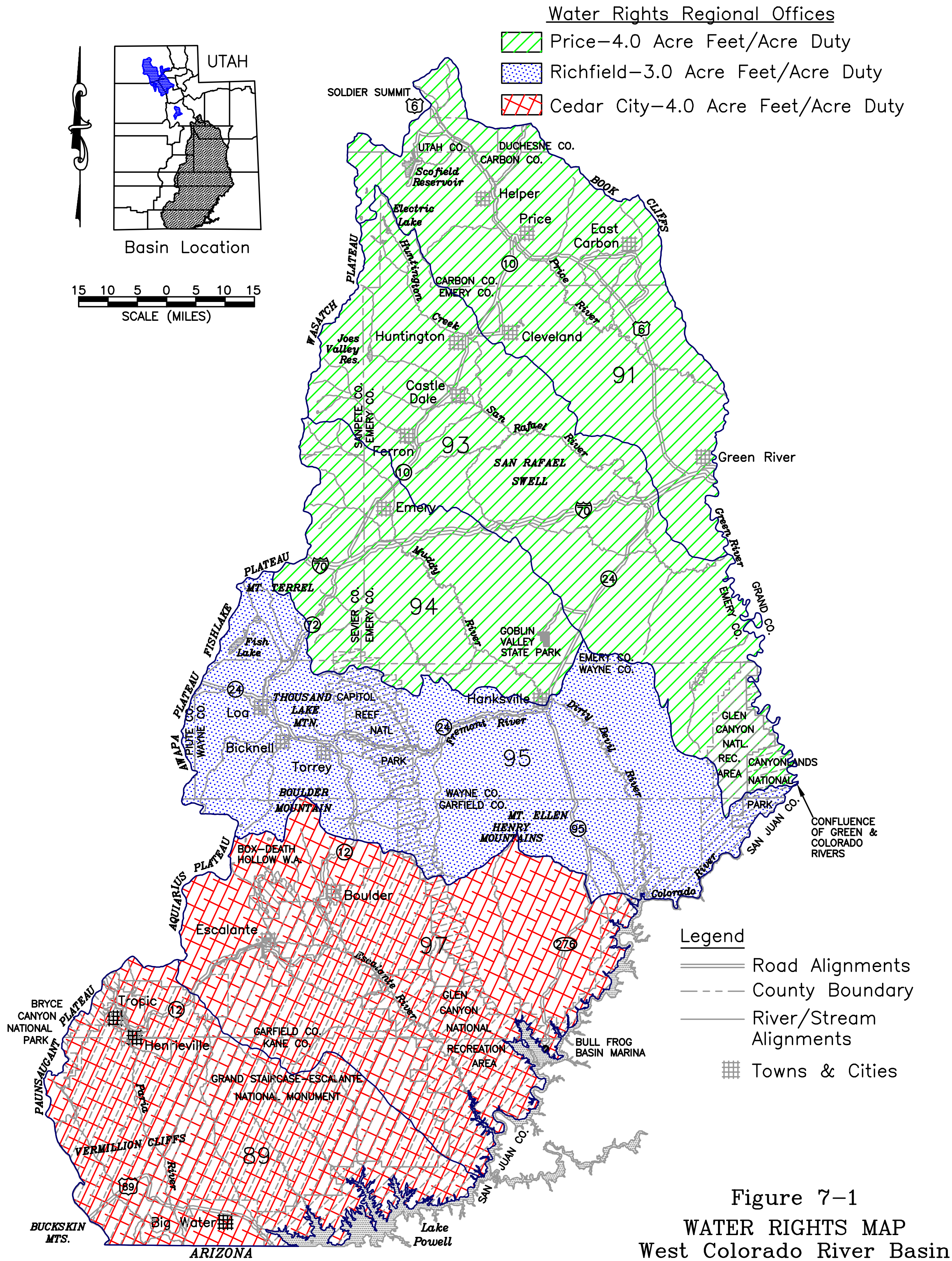


Figure 7–1
WATER RIGHTS MAP
West Colorado River Basin

commissioners on the Price, Huntington, Cottonwood creeks and Fremont river systems.

The quality of water is determined under standards for allowable contaminant levels according to the use designations. These designations and the standards are published by the Utah Department of Environmental Quality in the *Standards of Quality for Waters of the State*. The Utah Water Quality Board implements the regulations, policies and activities necessary to control water quality. These are carried out by the staff of the Division of Water Quality.

The Utah Drinking Water Board is responsible for assuring a safe water supply for domestic culinary uses. It regulates any system defined as a public water supply whether publicly or privately owned. The Drinking Water Board has adopted *State of Utah Rules for Public Drinking Water Systems*, including the Source Protection Program to help assure pure drinking water. This includes monitoring delivered drinking water quality as well as water source protection. These responsibilities are carried out by the staff of the Division of Drinking Water.

7.2.2 Existing Local Water Institutions and Organizations [54, 61]

Local organizations generally carry out the distribution of water in accordance with water rights and rules and regulations administered by the State Engineer. These local institutions, entities and organizations have also completed most of the water development in Utah. Distribution systems along with local entities formed under specific enabling legislation are described below.

Water Conservancy Districts - These are created under Title 17A-2-1401 of the *Utah Code Annotated*. They are established by the district court in response to a formal petition and are governed by a board of directors appointed by the county commission when the district consists of a single county. Directors for multi-county districts are appointed by the governor. Water conservancy districts have very broad powers which include constructing and operating water systems, levying taxes and contracting with government entities. These districts include incorporated and unincorporated areas. There are six districts in the basin: Carbon County and Emery Water Conservancy districts include most of Carbon and Emery counties; Wayne County Water Conservancy District includes the Upper Fremont River drainage, Kane County Water Conservancy District includes Kane County, Upper Sevier Water Conservancy District includes Tropic and Cannonville in Garfield County, and the Wide Hollow Water Conservancy District includes the lands irrigated by the New Escalante Irrigation company in Garfield County.

Mutual Irrigation Companies - These are the most common water development and management entities in the basin. They may be either profit or non-profit; most are non-profit. They are generally formed under the state's corporation code. In general, stockholders are granted the right to a quantity of water proportional to the number of shares they hold and assessments are levied similarly. There are 44 mutual irrigation companies in the West Colorado River Basin.

Private Water Companies - Organized as corporations, these include for-profit and non-profit companies (which are regulated by the Public Service Commission). For-profit companies, must provide service on request while the non-profit companies only need to supply shareholders. The basin has 31 water companies.

Special Service Districts - The basin has seven special service districts dealing with water. These districts have many of the same duties and authorities of other districts and can be created by either counties or municipalities. They can be established to provide water, sewer, drainage, flood control and non-water-related service.

City Water Utilities - These are utilities operated by incorporated cities and towns to provide water to residents and subscribers. Municipalities can form corporations to deliver water inside of all or any part of a city boundary. Counties have the same authority in unincorporated areas. The *Utah Code Annotated* and local ordinances provide the legal framework for water system operation. Local entities may pass ordinances regulating water use. There are 14 city water utilities.

Water User Associations - The organizations are groups formed to deliver water for various purposes. They are often informal groups, but they can also be incorporated under Utah law. The Fremont Water Users in Wayne County, New Paria Subdivision in Kane County and Salt Gulch Irrigation Association in Garfield County are examples in the basin of these types of organizations.

Other - The National Park Service delivers culinary and irrigation water to Capitol Reef National Park and the Bullfrog, Hite, Halls Crossing and Dangling Rope marinas in Glen Canyon National Recreation Area. The Division of Parks and Recreation, U.S. Forest Service and the Bureau of Land Management provide culinary water in the state parks, campgrounds and picnic areas. Also, individuals in isolated locations have private wells for domestic water purposes.

7.3 Problems and Needs

Problems are developing in some areas where summer homes are becoming popular. The areas around Scofield and Joes Valley reservoirs are examples, as well as Boulder Mountain. In these areas, potable water is generally obtained by drilling individual wells or maybe one well serving two or three homes. Sewage disposal in these same areas is through the use of septic tanks. In the case of the Boulder Mountain area, there is a chance that these septic fields could affect the Navajo sandstone aquifer. There is a need to provide controls so local wells and future groundwater sources are not contaminated by wastes.

7.4 Water Rights Regulation

The state engineer is responsible for determining whether there is unappropriated water and if additional applications will be granted. This is accomplished through data analysis and consideration of public input.

Before approving an application to appropriate water, the state engineer must find: (1) There is unappropriated water in the proposed source, (2) the proposed use will not impair existing rights, (3) the proposed plan is physically and economically feasible, (4) the applicant has the financial ability to complete the proposed works, and (5) the application was filed in good faith and not for the purpose of speculation or monopoly. The state engineer shall withhold action on or reject an application if it will interfere with a more beneficial use of water or prove detrimental to the public welfare or to natural resources.

Utah water law allows changes in the point of diversion, place of use, and/or nature of use of an existing right. To accomplish such a change, the water user must file a change application with the state engineer. The approval or rejection of a change application depends largely on whether or not the proposed change will impair other vested rights; however, compensation can be made, or conflicting rights may be acquired. Perfected water rights are considered real property. Pending applications and stock in mutual water companies are considered personal property. As such, they can be bought and sold in the open market.

In the appropriation process, the state engineer analyzes the available data and, in most cases, conducts a public meeting to present findings and receive input before adopting a final policy regarding future appropriation and administration of water within an area. Through regulatory authority, the state engineer influences water management by establishing diversion limitations (duty of water, usually 3.0 or 4.0 acre-feet per acre for irrigation in this area, see Figure 7-1) for various uses and by setting policies on water administration for surface water and groundwater supplies.

The Division of Water Rights is responsible for a number of functions which include:
(1) distribution of water in accordance with established water rights, (2) adjudication of water rights under an order of a state district court, (3) approval of plans and specifications for the construction and maintenance of dams and inspection of existing structures for safety, (4) licensing and regulating the activities of water well drillers, (5) regulation of geothermal development, (6) authority to control streamflow and reservoir storage or releases during a flooding emergency, and (7) regulation of stream channel alteration activities.

In addition, the state engineer works with federal agencies on water rights as needed. These situations are handled according to the state water laws.

7.5 Water Quality Control

The discharge of pollutants is regulated by the Utah Water Quality Act (UWQA). The Utah Water Quality Board (UWQB) implements the rules, regulations, policies, and continuing planning processes necessary to prevent, control and abate new or existing water pollution, including surface water and groundwater. This is carried out through the Utah Department of Environmental Quality, Division of Water Quality.

Utah Water Quality Rules developed under authority of *Utah Code Annotated (UCA)* 26-11-1 through 20, 1953, amended, have been implemented by the UWQB under authority of the UWQA. They are described in Section 7 of the *State Water Plan*.

Water quality certification by the state is under Section 401 of the Federal Water Pollution Control Act, 1977, as amended (Clean Water Act, CWA). This act states that any applicant for a federal license or permit to conduct any activity which may result in discharge into waters, and/or adjacent wetlands of the United States, shall provide the licensing or permitting agency a certification from the state in which the discharge originates or will originate. These activities include, but are not limited to, the construction or operation of the discharging facilities. Any discharges will comply with applicable state water quality standards and the applicable provisions of the Clean Water Act.

In addition, Ground Water Protection Regulations were adopted and are now enforced by the UWQB. These regulations are the building blocks for a formal program to protect the present and probable future beneficial uses of groundwater in Utah.

The three main regulatory concepts are: (1) To prohibit the reduction of groundwater quality, (2) prevent groundwater contamination rather than clean up after the fact, and (3) provide protection in all areas based on the different existing groundwater quality. The five significant administrative components are: (1) Groundwater quality standards, (2) groundwater classification, (3) groundwater protection levels, (4) aquifer classification procedures, and (5) groundwater discharge permit system. Statutory authority for the regulations is contained in Chapter 19-5 of the *Utah Code Annotated*, authorizing the Water Quality Board.

These regulations contain a groundwater discharge permitting system which will provide the basic means for controlling activities that may effect groundwater quality. A groundwater discharge permit will be required if, under normal circumstances, there may be a release either directly or indirectly to groundwater. Owners of existing facilities will not be obligated to apply for a groundwater discharge permit immediately. An existing facility is defined as a facility or activity that was in operation or under construction before February 10, 1990. Owners of these facilities should have notified the executive secretary of the UWQB of the nature and location of their discharge.

The regulations contain provisions for a permit by rule for certain facilities or activities. Many operations which pose little or no threat to groundwater quality or are already adequately regulated by other agencies are automatically extended a permit and need not go through the formal permitting requirements. Therefore, facilities qualifying according to the provisions of Section R448-6-6.2 will administratively be extended a groundwater discharge permit (Permit by Rule). These operations, however, are not exempt from the applicable class TDS limits or groundwater quality standards.

The authority for CWA, Section 401 certification, commonly known as 401 Water Quality Certification, is delegated to and implemented administratively through the Utah Water Quality Board by the Division of Water Quality. The Clean Water Act provides the focus for and the delegation of responsibility and authority to the U.S. Environmental Protection agency (EPA) to develop and implement its provisions. Whether or not EPA administers a CWA program directly within a state or indirectly by delegation to a state, the EPA retains the oversight role necessary to insure compliance with all rules, regulations and policies.

Local communities may want to set up and carry out a local aquifer protection management plan. If so, they can contact the Division of Water Quality for information.

7.6 Drinking Water Regulation

The Utah Drinking Water Board is empowered to adopt and enforce rules establishing standards prescribing maximum contaminant levels in public water systems. This authority is given by Title 26, Chapter 12, Section 5 of the *Utah Code Annotated, 1953(5)*. The rules and regulations setting drinking water standards were adopted after public hearings. These standards govern bacteriologic quality, inorganic chemical quality, radiologic quality, organic chemical quality and turbidity. Standards are also set for monitoring frequency and procedures.

The Utah Drinking Water Board, through the Division of Drinking Water, also operates under the federal Safe Drinking Water Act. This act sets federal drinking water standards and regulations. The Safe Drinking Water Act was recently re-authorized. The intent of the Safe Drinking Water Act (SDWA) is to encourage the state, local governments and water companies to be proactive, to ensure all water systems are capable of maintaining and protecting the supply of safe drinking water at an affordable cost. To accomplish this, a working partnership must be formed between the Division of Drinking Water, local health departments, Rural Water Association of Utah, American Water Works Association, private engineering firms, county planners and the water suppliers.

7.7 Dam Safety [20]

All dams that impound over 20 acre-feet of water are assigned a hazard rating. Dams impounding less than 20 acre-feet may be ruled exempt if they do not constitute a threat to human life or property. Hazard ratings reflect either high, moderate or low damage potential if the dam failed. It does not reflect the condition or reliability of the dam but rather the potential for loss of life or property damage in the event the dam were to fail. This determines the frequency of inspection. High-, moderate- and low-hazard dams are inspected every one, two and five years, respectively.

Following the inspection, a letter from the state engineer suggests maintenance needs and requests specific repairs. The state engineer can declare the dam unsafe and order it drained and even breached after drainage. Efforts are always made to work with dam owners to schedule necessary repairs.

The state engineer has outlined design standards in a publication entitled, *State of Utah Statutes and Administration Rules for Dam Safety*. Plans and specifications must be consistent with these standards. Dam safety personnel monitor dam construction to insure compliance with plans, specifications and design reports. Any problems are resolved before final approval.

The state engineer is currently assessing the ability of all high-hazard dams to meet minimum safety requirements. The assessment includes seismic stability and the dam's capability to pass the appropriate Inflow Design Flood (IDF). Table 7-1 shows the dams classified as high-hazard in the West Colorado River. The Division of Water Rights rates federal dams, but these are exempt from requirements of the State Dam Safety Program. The Bureau of Reclamation inspects dams constructed under its programs.

7.8 Policy Issues and Recommendations

One issue dealing with coal mines in Carbon and Emery counties is presented.

7.8.1 Mining Problems in Carbon and Emery Counties

Issue - Coal mining operators intercepting underground water may affect local water entities' supplies.

Discussion - Numerous underground coal mines operate in Emery and Carbon counties, providing a solid economic base for the areas and also generating much needed coal for industries on a local, national and international scale. Some of the water encountered by mining is utilized by mining

Table 7-1
High Hazard Dams

Name	Owner	Year Completed or Modified	Height (ft.)	Capacity (ac.-ft.)
Price Drainage				
Fairview Lake	Cottonwood and Gooseberry Irrigation Co.	1869	33	1,949
Grassy Trail	East Carbon City	1952	89	916
Scofield*	Bureau of Reclamation	1946	125	73,600
San Rafael Drainage				
Cleveland	Huntington-Cleveland Irrigation Co.	1985	61	5,340
Electric Lake	Utah Power	1973	229	31,500
Ferron Debris Basin No. 5	Ferron Canal and Reservoir Co.	1970	35	109
Huntington	Huntington-Cleveland Irrigation Co.	1991	55	5,616
Huntington North*	Bureau of Reclamation	1966	74	5,420
Joes Valley*	Bureau of Reclamation	1966	192	62,400
Miller Flat	Huntington-Cleveland Irrigation Co.	1949	73	5,560
Millsite	Ferron Canal and Reservoir Co.	1971	115	18,000
Rolfson	Huntington-Cleveland Irrigation Co.	1953	36	600
Dirty Devil Drainage				
Forsyth	Fremont Irrigation Co.	1986	71	3,639
Johnson	Fremont Irrigation Co.	1966	31	10,350
Mill Meadow	Fremont Irrigation Co.	1954	115	5,232
Oak Creek (*aka* Upper Bowns)	Sandy Ranch	1982	45	915
Escalante Drainage				
Wide Hollow	New Escalante Irrigation Co.	1954	50	2,324

*Federal dams inspected and maintained by the Bureau of Reclamation.

operations, and excess water is pumped to points of discharge at mine portals. This interception of groundwater may alter natural flow patterns, and existing seeps and springs may be impacted. New mining techniques using long wall equipment result in massive caving following extraction of the coal seam. This method of mining causes subsidence cracks that sometimes reach the ground surface. Concerns have been expressed by local water user groups that subsidence has further resulted in the diminution or loss of seeps and springs.

The Coal Regulatory Program Rules, also commonly referred to as "the Water Replacement Rules," adopted by the Utah Board of Oil, Gas and Mining on March 15, 1998, provide a substantial basis for the protection of water rights and water quality. These new rules require any state-appropriated water that is diminished in quality or quantity or which is lost due to mining activities will be replaced. Several state agencies administer the numerous regulations associated with mining. The Division of Environmental Quality (DEQ) regulates the point and quality of mine discharge water. The Division of Oil, Gas and Mining (DOGM) regulates the hydrological effects of mining and administers the water replacement rules. The Division of Water Rights (DWRi) regulates the distribution of all appropriated surface water and underground water within the state. The responsibilities of these three agencies, however, overlap and sometimes conflict. The interception, collection and discharge of water by and from coal mines in Emery County is substantial. In excess of 5,000 acre-feet per year are discharged from the coal mines. Discharge of this water may be to drainages other than those from which the water originated or into which it previously flowed. Great care should be taken to ensure that the water rights of individuals and entities within the drainage basins affected by the coal mining activities are not jeopardized or diminished.

Until recently, the actual effects of subsidence have not been monitored. However, concerns over subsidence-related issues have promoted local water user groups, including the Emery Water Conservancy District and the Castle Valley Special Service District, to monitor the flow from various springs, creeks and rivers in Emery County.

As water is encountered by the mine operators, a report thereof should be made to DOGM which should then investigate the interception in greater detail and report its findings to the Division of Water Rights and to water users which may be potentially affected. A written agreement should then be developed to protect affected water rights and to further protect and enhance the quality of that water. In addition to the Water Replacement Rules, plans should be implemented prior to DOGM's issuance of any mining permit that will more fully address ways to avoid or minimize the impact of subsidence damage as it relates to the diminution and loss of groundwater and water quality.

Recommendations - There is a need for better correlation and development of definitive boundaries of authority between the three state agencies (DEQ, DOGM and DWRi) to avoid confusion and frustration to the mining industry and the various water users. Cooperation between DOGM, mining companies and local entities should be required to avoid duplication of efforts and to provide a means by which data can be shared between the state and local entities, water users and the coal mine operators for the protection of water resources. ●

Section 8 - West Colorado River Basin
Water Funding Programs

8.1	Introduction	8-1
8.2	Background	8-1
8.3	State Funding Programs	8-1
8.4	Federal Water Funding Programs	8-2
8.5	Local Water Funding Programs	8-2

Tables

8-1	State Water-Related Funding Programs	8-3
8-2	State Water-Related Expenditures	8-4
8-3	Federal Water-Related Funding Programs	8-5
8-4	Federal Water-Related Expenditures	8-6
8-5	Large U.S. Bureau of Reclamation Project Expenditures	8-6
8-6	Local Funding Sources	8-6

Section 8
West Colorado River Basin - Utah State Water Plan

Water Funding Programs

8.1 Introduction[17]

This section briefly describes state, federal and local funding sources available to help manage and conserve water resources in the West Colorado River Basin. State and federal agencies have funds available for planning and construction of water projects. Generally, the planning funds are not a part of the project funds available for construction.

The planning programs of specific agencies are discussed in various sections of this basin plan. River basin planning by the Division of Water Resources and others responsible for preparing this document is discussed in Section 3. Other planning programs include the Division of Water Rights' funding for groundwater and related studies, U.S. Geological Survey stream gaging and groundwater measurement and modeling, Bureau of Land Management and Forest Service watershed management planning, Corps of Engineers flood control studies, and Natural Resources Conservation Service river basin planning. Refer to the *State Water Plan* (1990), Section 3, Introduction, and Section 8, State and Federal Water Resources Funding Programs, for additional information.

Funding water development and conservation requires the combined efforts of all concerned. It requires cooperation, persistence and ingenuity. This was true in the early days of settlement and is still required today. A reduced federal role in water-related funding is shifting responsibilities to state and local entities.

8.2 Background

Initial water development funding in the basin began with "sweat equity" of the early pioneers. In the early 1900s, federal water development began with Scofield Reservoir and then later the Emery Project (Joes Valley and Huntington North reservoirs).

Most of the water developed in the early years was for agriculture. Much of the money spent in the last 10 years has been for municipal and industrial uses. Early state-funded water projects were built through the Water and Power Board (currently the Board of Water Resources). Agricultural lands of Wayne County and many other counties of the basin have been put under sprinkler irrigation, with help from the Utah Board of Water Resources' revolving loan programs.

Price River Water Improvement District recently completed construction of an enlarged water treatment plant on the Price River. Total cost of the project was $5.2 million. East Carbon City recently installed a new storage tank and culinary system improvements costing $2.6 million. Torrey Town also recently made improvements to its culinary system, which cost $390,000.

These are some examples of recent Board of Water Resources funded projects. See Table 9-1 for a complete listing of Board of Water Resources water projects for the West Colorado River Basin.

8.3 State Funding Programs

It is difficult to determine the total funds spent historically for planning and implementation of water and water-related projects in the West Colorado River Basin. One thing is certain, local entities and individuals provided much of the financing from their own resources through either up-front funding or by repaying development loans. Tables 8-1 and 8-2 show the funding programs and the recent funding provided by state agencies for water-related projects. The time periods shown vary due to available data. Presently, funding for projects can be grants and/or loans and they can be provided by more than one agency. Funds for dam safety repairs are provided by the Board of Water Resources to help meet the requirements of the state Dam Safety Act.

8.4 Federal Water Funding Programs

Seven federal agencies have water funding programs. Most have funds available for construction of facilities. There are some agencies with funds available for planning. The Bureau of Reclamation has provided planning funds for water management purposes.

Funds available from the Environmental Protection Agency are generally distributed through state agencies. There are some grant funds available for water quality planning. Federal programs and expenditures for planning and construction are shown in Tables 8-3 and 8-4. Table 8-5 shows expenditures on large federal projects in the West Colorado River Basin by the U. S. Bureau of Reclamation.

8.5 Local Water Funding Programs

While all funding ultimately comes from the pockets of the taxpayers and the water users, this becomes more obvious at the local level. The local water users obtain their funds from more observable sources such as user fees, water company assessments, local taxes or from local private lending institutions. These are shown in Table 8-6. ●

Table 8-1
State Water-Related Funding Programs

Funding Agency/Program	Contact	Purpose	Type
Board of Parks and Recreation			
Land and Water Conservation Fund	Division of Parks and Recreation	Recreational facilities	Cost-Share
Riverway Enhancement Program			
Board of Water Resources			
Revolving Construction Fund	Division of Water Resources	Small irrigation/culinary projects	Loans
Cities Water Loan Fund		Municipal culinary systems	Loans
Conservation & Development Fund		Large water projects	Loans
Dam Safety		Dam Safety studies	Grants
Community Development Block Grants			
Block Grants	Division of Community Development	Rural living environment improvement	Grants
Permanent Community Impact Board			
Permanent Community Impact Fund	Division of Community Development	Rural living environment improvement	Grants/Loans
Disaster Relief Board Fund		Disaster repair	Grants
Safe Drinking Water Board			
Financial Assis. Program	Division of Drinking Water	Drinking water system	Loans
Soil Conservation Commission			
Agriculture Resource Development Loan	Department of Agriculture and Food	Improve private agricultural land	Loans
Nonpoint Source Program		Watershed improvement	Grants
Utah Wildlife Board			
Wallop-Breaux Act	Division of Wildlife Resources	Fish habitat and boating	Grants
Water Quality Board			
Revolving Construction Loan Program	Division of Water Quality	Wastewater treatment facility	Loans
Federal Construction Grants		Wastewater treatment facility	Grants
State Loan Program			Loans

Table 8-2
State Water-Related Expenditures

Funding Agency Program	Grants ($1000)	Loans	Period
Board of Parks and Recreation			
Land and Water Conservation Fund	1,277	1,378	1966-1997
Riverway Grants	120		1990-1998
Board of Water Resources			
Cities Water Loan Fund		7,556	1976-1999
Conservation and Development Fund Revolving		7,789	1978-1999
Construction Fund		6,738	1947-1999
Dam Safety	111		1993-1999
Community Development			
Community Dev. Block Grants	1,815		1992-1996
Permanent Community Impact Board			
Permanent Community Impact Fund	40	270	1998
Disaster Relief Board Fund	61		1983
Safe Drinking Water Board			
Financial Assistance Program	178[a]	1,250	
Soil Conservation Commission			
Agriculture Resource Dev. Loans		469	1993-97
Water Quality Board			
State Revolving Loan Program		2,542	1990-1997

[a]Includes all of Southeast Area Association of Governments.

Table 8-3
Federal Water-Related Funding Programs

Agency	Program	Purpose	Funds
Department of Agriculture			
Farm Service Agency	Ag. Conservation Program	Soil, water, energy conservation	Grant
	Emergency Cons. Program	Disaster damaged farmland rehab.	Grant
	Cons. Resource Program	Reduce erosion, maintain wetland	Grant
Rural Development	Rural Development	Water supply, wastewater disposal	Grant,Loan
Natural Resources Conservation Service	Watershed Protection & Flood Prevention	Flood control and water development	Grant/Cost Share
	Emergency Watershed Program	Reduce sedimentation & flooding	Grant/Cost Share
Department of the Army			
Corps of Engineers	Civil Works (Large Water Resource Projects)	Flood protection, water supply, recreation, etc.	Cost Share
	Continuing Auth. Programs	Flood protection, environmental restoration.	Cost Share
	Emergency Activities	Flood protection	Cost Share
	Flood Plain Mgt. Program	Flood plain delineation	Grant
Environmental Protect Agency	Nonpoint Source Program	Water quality	Grants
Dept of the Interior			
Bureau of Reclamation	Investigation Program	Water management	Loan
Federal Emergency Management Agency	Presidential-Declared Disaster Flood	Damage mitigation	Grant
	Plain Management	Stream acquisition-flood plains	Grant

Table 8-4
Federal Water-Related Expenditures

Funding Agency Program	Grants ($1,000)	Loans ($1,000)	Period
Farm Service Agency			
Agriculture Conservation Program	209		1993-1997
Corps of Engineers			
Civil Works	200		1990-1997
Emergency Activities	5		
Rural Development			
Rural Development	344	85	1990-1997
Federal Emergency Management Agency			
Presidential Declared Disaster	51		1983
Natural Resources Conservation Service			
Environmental Quality Improvement Program	689		1990-1997

Table 8-5
Large U.S. Bureau of Reclamation Project Expenditures

Project		Amount ($1,000)	Completion Date
Scofield Dam (Gooseberry Project)		5,200	1926
Emery County Project		13,800	1966
Glen Canyon Dam		157,000	1956
Glen Canyon Dam Additions		38,000	1957 - Present
	Total	214,000	

Note: Amounts only include construction costs. They do not include operation and maintenance costs.
Source: USBR

Table 8-6
Local Funding Sources

Entity	Purpose	Type
Private Financial Institutions	Any Approved Water-Related Project	Loan
Cities and Towns	Water Systems	Bonding, Cash Flow
Western Farm Credit Bank	Agricultural Projects	Loans

Section 9 - West Colorado River Basin

Water Planning and Development

9.1	Introduction	9-1
9.2	Background	9-1
9.3	Water Resources Problems	9-7
9.4	Water Resources Demands and Needs	9-7
9.5	Water Development and Management Alternatives	9-13
9.6	Projected Water Depletions	9-18
9.7	Policy Issues and Recommendations	9-19

Figures

9-1	Price-San Rafael Salinity Control Project Map	9-6
9-2	Wilderness Lands	9-11
9-3	Potential Reservoir Sites	9-16
9-4	Gunnison Butte Mutual Irrigation Project	9-20
9-5	Bryce Valley	9-22

Tables

9-1	Board of Water Resources Development Projects	9-3
9-2	Salinity Control Project Approved Costs	9-7
9-3	Wilderness Lands	9-8
9-4	Current and Projected Culinary Water Use	9-12
9-5	Current and Projected Secondary Water Use	9-12
9-6	Current and Projected Agricultural Water Use	9-13
9-7	Summary of Current and Projected Water Demands	9-14
9-8	Historical Reservoir Site Investigations	9-17

Section 9

West Colorado River Basin - Utah State Water Plan

Water Planning and Development

9.1 Introduction

This section describes the major existing water development projects and proposed water planning and development activities in the West Colorado River Basin. The existing water supplies are vital to the existence of the local communities while also providing aesthetic and environmental values.

This plan provides local decision-makers with data to solve existing problems and to plan for future implementation of the most viable alternatives.

9.2 Background

Development in the late 1800s was by groups of individuals with a common cause. It was a matter of surviving in a newly settled area.

Wide Hollow Replacement Reservoir site

The coordination and cooperation of all water-related government agencies, local organizations and individual water users will be required as the basin tries to meet its future water needs.

As demands for municipal and industrial (M&I) water increase, supplies will come primarily from additional surface water treatment, which will develop existing water rights and conservation. Additional water supplies could come from cloud seeding activities and possibly tapping the basin-wide Navajo Sandstone aquifer. Of the total water diverted for all uses, (not including wetlands and open water evaporation) nearly 85 percent is for agricultural and livestock purposes. The current diversion for municipal and industrial (M&I) water is about 15 percent of the total, which will probably increase slightly in the future.

9.2.1 Past Water Planning and Development

At the time of the earliest settlements, individuals and groups generally did their own planning and development of the water needed for various uses. Later, technical and financial assistance became available from state and federal agencies.

Many projects and facilities have been constructed over the years to develop the needed water resources. Eighteen storage reservoirs with capacities over 1,000 acre-feet have been constructed in the basin, primarily for irrigation purposes. Of these, Scofield, Joes Valley and

Huntington North were funded and constructed by the federal government (Bureau of Reclamation and Department of Agriculture). See Section 6, Table 6-1, Existing Lakes and Reservoirs. Figure 6-1 shows their locations. Many smaller reservoirs for single and multiple purposes have been built for irrigation, flood control, stock watering and fishing. The total surface water storage capacity in the basin is over 475,000 acre-feet. In addition, Lake Powell has 26,373,000 acre-feet of capacity, but no water is delivered from Lake Powell to water users in the basin.

Other projects have been carried out through the Agricultural Conservation Program and the Agricultural Resource Development Loan Program. These include sprinklers, pipelines and other agricultural-related projects.

The Natural Resources Conservation Service has spent considerable effort planning and developing irrigation projects. These projects reduce erosion, provide sediment control, flood water and irrigation water storage, and provide conveyance systems and on-farm improvements.

Much of the water planning and development carried out by the state has been through the Division of Water Resources. The Utah Board of Water Resources has provided technical assistance and much needed funding for 97 projects totaling nearly $20.5 million.

In the last five years, seven Board of Water Resources projects have been constructed in the West Colorado River Basin. These include culinary improvements in Carbon and Wayne counties, irrigation projects in Carbon and Wayne counties, and a dam repair project in Emery County (see Table 9-1).

9.2.2 Current Water Planning and Development

The Price-San Rafael Rivers Unit of the Colorado River Salinity Control Program is currently being implemented to help water users in Carbon and Emery counties improve farm irrigation efficiencies and to reduce salt loading in the Colorado River system by 161,000 tons. Salinity contributed to the Colorado River from the Price and San Rafael river drainages comes from dissolved salts in return flows from irrigation and surface runoff. An estimated 430,000 tons of salt per year reach the Colorado River from these two drainages. Of this amount, approximately 60 percent is attributed to agriculture.

Five alternative plans for reducing Colorado River salt-loading have been evaluated by the Bureau of Reclamation (BR), the Natural Resources Conservation Service (NRCS) and the Department of Agriculture (USDA). These alternatives include: 1) Improving irrigation systems, 2) using drain water for power plant cooling, 3) collecting saline water and disposing of it through deep well injection, evaporation ponds, or a desalting plant, 4) using saline water for energy development (coal washing, tar sands, or coal slurry pipeline), and 5) retiring land from irrigation. Of these, the irrigation systems improvement alternative passed the four tests of viability (completeness, effectiveness, efficiency and acceptability).

The current plan combines the BR and USDA programs of irrigation improvements, primarily sprinkler irrigation systems. The plan would also eliminate winter water from the canal system by installing a rural stock water distribution system. The preferred plan will include installing 97 miles of pipe for irrigation water, 26,000 acres of improved irrigation systems, 10,040 acres of improved irrigation surface systems, 36,050 acres of improved irrigation water management, lining 83 stock ponds, adding 213 connections to culinary systems to provide winter livestock water, and installing 10.6 miles of pipe to improve the livestock water facilities. Local landowners would install on-farm systems with technical assistance from USDA. Figure 9-1 shows a general map of the project area. A joint BR/USDA planning report and final environmental impact statement was completed in December 1993. Construction of portions of this unit started in 1998 under the USBR basin-wide salinity program and the USDA EQUIP program. The Division of Water Resources has cost-shared on three local salinity projects, Wellington City, Ferron Canal and Reservoir Company, and Price-Wellington Control Board.

Table 9-1
Board of Water Resources Development Projects

Sponsor	Type	Year
Carbon County		
Book Cliff Water Company	Culinary System	1987
Carbonville Water Co.	Culinary Pipe	1972
East Carbon City	Culinary Treatment Plant	1983
East Carbon City	Culinary Tank	1995
East Price Water Co.	Culinary Pipe	1958
Emery Star Water Co.	Culinary System	1983
Haycock Lane Water Corp.	Culinary Pipe	1985
Helper City	Culinary Tank	1980
Kenilworth Utilities Co., Inc.	Culinary System	1983
Miller Creek Water SSD	Culinary System	1983
Price City	Culinary Tank	1981
Price River WID	Culinary System	1976
Price River WID	Culinary Tank	1982
Price River WID	Culinary Tank	1982
Price River WID	Diversion Dam	1986
Price River WID	Culinary System	1989
Price River WID	Culinary Treatment Plant	1996
South Price Water Co.	Culinary Pipe	1973
Stowell Mutual Water & Canal Co.	Low Head Pipe	1993
Wellington Canal Co.	Miscellaneous	1950
Wellington Canal Co.	Miscellaneous	1952
Wellington Canal Co.	Low Head Pipe	1977
West Side Water Co.	Culinary Tank	1973
Carbon County Total	23	
Emery County		
Castle Dale City	Culinary Pipe	1976
Castle Valley SSD	Dual Water System	1982
Castle Valley SSD	Culinary Pipe	1984
Castle Valley SSD	Culinary Pipe	1984
Clawson Area S&WID	Culinary Tank	1983
Clawson Waterworks Co.	Culinary Pipe	1970
Cottonwood Cr. Consol. Irr. Co.	Pressurized Pipe	1977
Ferron Canal & Reservoir Co.	Dam and Reservoir	1968
Ferron Canal & Reservoir Co.	Dam Repair	1992
Ferron City	Culinary Pipe	1976
Huntington City	Culinary Tank	1976
Huntington-Cleveland Irr. Co.	Dam Enlargement	1953
Huntington-Cleveland Irr. Co.	Dam Repair	1976
Independent Canal & Res. Co.	Dam and Reservoir	1952
Orangeville City	Culinary Pipe	1976
Emery County Total	15	

Table 9-1 (Continued)
Board of Water Resources Development Projects

Sponsor	Type	Year
	Garfield County	
Boulder Irr. & Water Dev. Co.	Dam Repair	1947
Boulder Irr. & Water Dev. Co.	Sprinkle Irrigation System	1966
Boulder Irr. & Water Dev. Co.	Sprinkle Irrigation System	1974
Boulder Irr. & Water Dev. Co.	Pressurized Pipe	1984
Boulder Irr. & Water Dev. Co.	Pressurized Pipe	1991
Cannonville Irr. Co.	Sprinkle Irrigation System	1986
Cannonville Town	Culinary Tank	1976
Christensen Ranches, Inc.	Sprinkle Irrigation System	1958
Escalante Town	Pressurized Pipe	1961
Escalante Town	Culinary Pipe	1983
Escalante Town	Culinary Tank	1991
Henrieville Irr. Co.	Sprinkle Irrigation System	1981
Henrieville Town	Culinary Pipe	1983
New Escalante Irr. Co.	Sprinkle Irrigation System	1981
Pine Creek Irr. Co.	Irrigation Well	1976
Pine Creek Irr. Co.	Sprinkle Irrigation System	1981
Ticaboo SSD	Culinary Well	1979
Tropic & East Fork Irr. Co.	Canal Lining	1962
Tropic & East Fork Irr. Co.	Dam Repair	1978
Tropic & East Fork Irr. Co.	Sprinkle Irrigation System	1987
Tropic & East Fork Irr. Co.	Pressurized Pipe	1990
Garfield County Total	21	
	Wayne County	
Caineville SSD	Culinary System	1988
East Bicknell Irr. Co.	Sprinkle Irrigation System	1963
Fremont Irrigation Co.	Dam and Reservoir	1953
Fremont Irrigation Co.	Sprinkle Irrigation System	1965
Fremont Irrigation Co.	Sprinkle Irrigation System	1968
Fremont Irrigation Co.	Sprinkle Irrigation System	1972
Fremont Irrigation Co.	Sprinkle Irrigation System	1973
Fremont Irrigation Co.	Sprinkle Irrigation System	1975
Fremont Irrigation Co.	Sprinkle Irrigation System	1975
Fremont Irrigation Co.	Dual Water System	1985
Fremont Irrigation Co.	Dam Repair	1986
Fremont Irrigation Co.	Dual Water System	1988
Fremont Irrigation Co.	Pressurized Pipe	1988
Fremont Irrigation Co.	Dual Water System	1989
Fremont Irrigation Co.	Pressurized Pipe	1993
Fremont Waterworks Co.	Culinary System	1967
Fremont Waterworks Co.	Culinary Spring	1997
Hanksville Canal Co.	Diversion Dam	1948

Table 9-1 (Continued)
Board of Water Resources Development Projects

Sponsor	Type	Year
Wayne County (Continued)		
Hanksville Cul. Waterworks Co.	Culinary System	1978
Hanksville Cul. Waterworks Co.	Culinary Well	1992
Loa Waterworks Co., Reinc.	Culinary Pipe	1977
Lyman Water System	Culinary Pipe	1977
Lyman Water System	Culinary Spring	1983
Road Creek Water Users Assn.	Sprinkle Irrigation System	1973
Road Creek Water Users Assn.	Regulatory Pond	1986
Road Creek-Dry Valley WU	Sprinkle Irrigation System	1975
Sand Creek Irr. Co.	Dual Water System	1977
Sand Creek Irr. Co.	Diversion Dam	1993
Teasdale Irr. Co.	Pressurized Pipe	1960
Teasdale Irr. Co.	Sprinkle Irrigation System	1971
Teasdale Irr. Co.	Sprinkle Irrigation System	1977
Teasdale Irr. Co.	Dam Repair	1983
Teasdale Irr. Co.	Dual Water System	1988
Torrey Irr. Co.	Miscellaneous	1977
Torrey Town	Culinary Spring	1983
Torrey Town	Culinary Tank	1995
West Bicknell Irr. Co.	Sprinkle Irrigation System	1961
Wayne County Total	37	
Kane County		
Church Wells S&D	Culinary System	1984
Kane County Total	1	

As of March 1999, $1.127 million had been spent for on-farm systems and $25.3 million for off-farm features. Total expenditures are shown in Table 9-2.

9.2.3 Environmental Considerations

Water is often viewed as a commodity for people's use with little thought given to other purposes and the processes of the hydrologic cycle. The upper portions of most of the rivers and streams flow through forested lands providing opportunities for camping, fishing, hunting, hiking and many other recreational activities. To some, sprinklers irrigating green crops in a desert climate provide a pastoral beauty not found in many arid areas. Proper development can provide an adequate quantity and quality of water for all uses including those crucial to maintaining healthy wildlife habitats. The West Colorado River Basin contains many historic places, artifact sites, and archeological sites. Future development should take all of these into consideration.

Providing instream flows as a beneficial use to maintain fish and wildlife populations, riparian vegetation and stream channels, is widely recognized as important. Although construction of reservoirs such as Joes Valley and Scofield cover some riparian habitat, they provide instream flows during the summer when streams would normally be too low to support a fishery. This is a side benefit to the primary purpose of storing and releasing irrigation water.

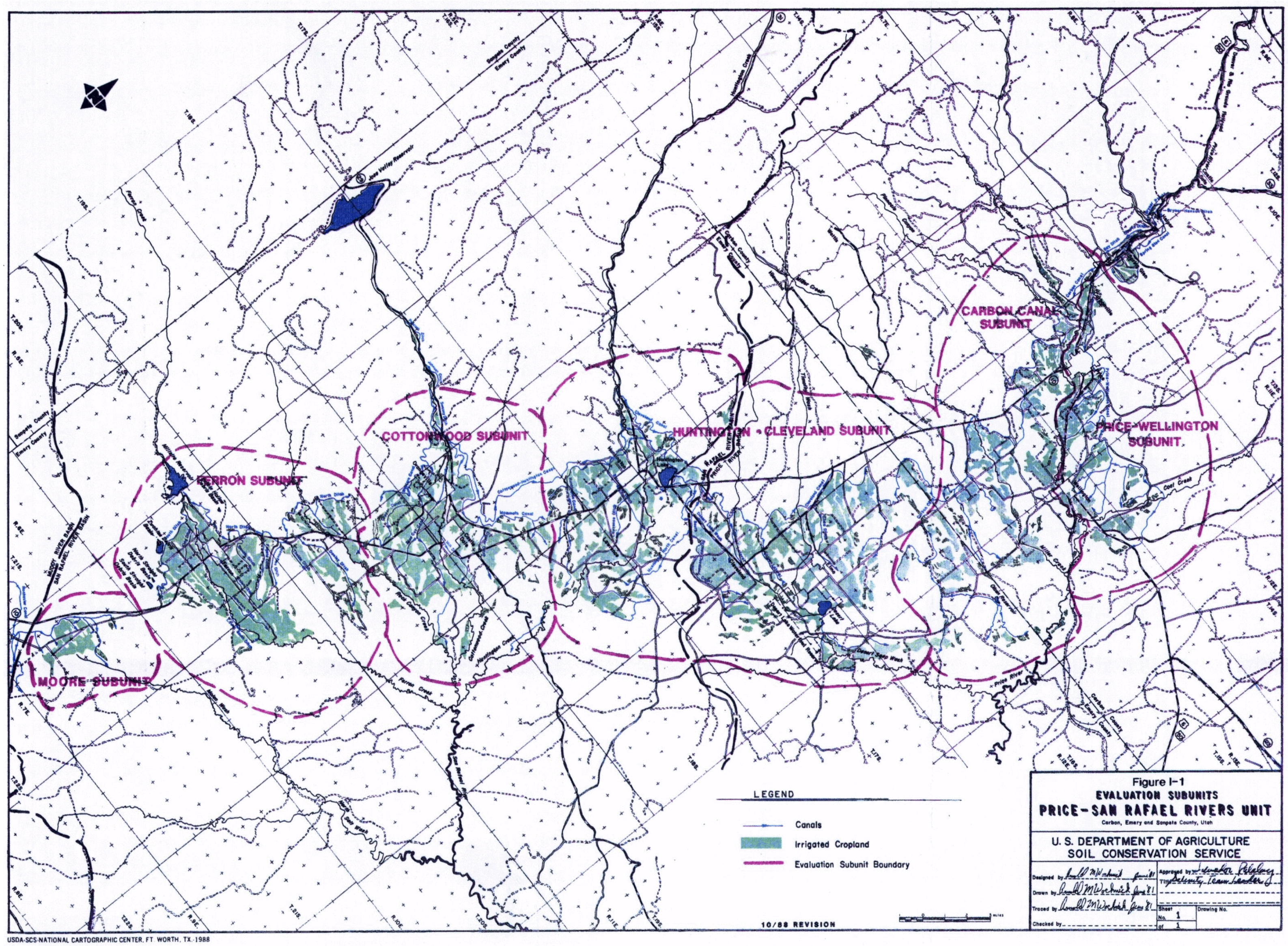


FIGURE 9-1
PRICE - SAN RAFAEL
SALINITY CONTROL PROJECT

Table 9-2 Salinity Control Project Approved Costs	
Feature	Total Cost
Off-farm pipeline systems	$30,183,300
On-farm irrigation systems	
(Federal cost share)	21,196,700
(Basin states cost share)	22,061,900
Culinary system - capital cost	1,043,000
Stockwater Ponds and Cottonwood Creek Pipeline	4,136,000
Project Total	$78,620,900

Other important factors that could affect water use and development are wilderness areas, wild and scenic designations, and the newly-created Grand Staircase-Escalante National Monument. The only designated wilderness area in the basin is the Paria Canyon Wilderness Area southwest of Big Water. However, there are 23 Wilderness Study Areas (WSAs) totaling nearly 1,731,000 acres. These WSAs are currently being managed as wilderness areas until Congress acts on their designation. An additional 1,523,000 acres of BLM lands were re-inventoried in 1999 and determined to have wilderness characteristics. The WSAs and the re-inventoried lands are listed in Table 9-3, and their locations are shown in Figure 9-2.

The Grand Staircase-Escalante National Monument has completed a three-year management analysis and a final Environmental Impact Statement (EIS) has been issued. A number of water-related issues are included in the final EIS. Also, there have been preliminary inventories made of wild and scenic rivers eligibility. All of these issues can be found in the Proposed Management Plan EIS, July 1999.

9.3 Water Resources Problems

Many agricultural lands in the San Rafael River, upper Muddy Creek and lower Fremont River area experience water shortages late in the irrigation season. This is primarily a problem for “direct-flow” users. The San Rafael and Price rivers are also over-appropriated. This compounds the problem (see Section 5.9).

Many locations are subject to flash flooding from summer thunderstorms resulting in high, instantaneous peak flows causing erosion, sediment deposition and other property damage. In many of the basin’s storage reservoirs, part of the capacity is eventually used for sediment storage which reduces the effective water storage capacity.

9.4 Water Resources Demands and Needs [16, 18]

Municipal and industrial (M&I) water demands will continue to be the catalyst for the transfer of water from other uses. Estimates of population growth given in Section 4 are used to project M&I water needs. Agricultural water uses will decrease slightly as supplies are reallocated to satisfy M&I demands.

9..4.1 Culinary Municipal and Industrial Water Demands

Culinary water use will increase by an estimated 30 percent, or about 4,500 acre-feet, by the year 2020. This also reflects a 25 percent conservation factor (see Section 11). The current and projected culinary water diversions and depletions are shown in Table 9-4.

If additional groundwater, either from wells or springs, is developed for municipal and industrial uses, it will generally not need treatment. Surface water must be treated to meet drinking water standards.

Table 9-3
Wilderness Lands

Name	Acreage
Wilderness Study Areas	
Bull Mountain	13,251
Burning Hills	63,352
Carcass Canyon	47,440
Crack Canyon	26,640
Death Ridge	62,595
Desolation Canyon	85,519
Devils Canyon	9,111
Devils Garden	638
Dirty Devil	72,150
Escalante Canyons	760
Fiddler Butte	73,791
Fifty Mile Mountain	149,095
Fremont Gorge	2,845
French Spring-Happy Canyon	24,211
Horseshoe Canyon (North)	20,211
Horseshoe Canyon (South)	39,855
Link Flats ISA	855
Little Rockies	40,792
Mexican Mountain	58,929
Mount Ellen-Blue Hills	81,450
Mount Hillers	19,186
Mount Pennel	77,024
Mud Spring Canyon	38,159
Muddy Creek	31,138
North Escalante Canyons/The Gulch	119,806
Paria Canyon-Vermilion Cliffs Wilderness	22,551
Paria-Hackberry	137,011
Paria-Hackberry (202)	394
Phipps-Death Hollow	42,755
San Rafael Reef	63,006
Scorpion	36,074
Sids Mountain/Sids Cabin	78,716
Steep Creek	22,139
The Blues	19,572
The Cockscomb	9,919
Turtle Canyon	5,697
Wahweap	133,940
Subtotal	1,730,577

Table 9-3 (Continued)
Wilderness Lands

Wilderness Lands	
Name	Acreage
1999 Re-Inventoried Wilderness Lands	
Box Canyon	2,968
Bull Mountain	5,190
Bullfrog	32,983
Burning Hills	12,577
Carcass Canyon	33,934
Cave Point	5,894
Cedar Mountain	17,296
Colt Mesa	27,878
Desolation Canyon	45,192
Devils Canyon	10,615
Dirty Devil/French Springs	112,992
Dogwater Creek	3,137
East of Bryce	787
Fiddler Butte	19,962
Fifty Mile Bench	12,897
Fiftymile Mountain	31,763
Forty Mile Gulch	5,379
Fremont Gorge	16,073
Hondu Country	22,390
Horse Mountain	12,345
Horse Spring Canyon	31,758
Horseshoe Canyon	25,118
Hurricane Wash	9,027
Jones Bench	3,318
Labyrinth Canyon	43,633
Lamp Stand	3,480
Limestone Cliffs	27,615
Little Egypt	22,341
Little Rockies	31,915
Long Canyon	17,716
Mexican Mountain	46,797
Mount Ellen-Blue Hills	40,398
Mount Hillers	4,014
Mount Pennell	71,751
Mud Spring Canyon	22,176
Muddy Creek-Crack Canyon	214,892
Mussentuchit Badland	26,547
Nipple Bench	29,345
North Escalante Canyons	25,856
Notom Bench	6,961

Table 9-3 (Continued)
Wilderness Lands

Name	Acreage
Paria-Hackberry	33,359
Phipps-Death Hollow	4,678
Ragged Mt	29,266
Red Desert	34,674
San Rafael Reef	45,181
Scorpion	13,587
Sids Mountain	28,861
Squaw Canyon	14,689
Steep Creek	8,027
Studhorse Peaks	22,278
The Blues	1,608
The Cockscomb	1,442
Turtle Canyon	7,340
Upper Muddy Creek	20,345
Wahweap-Death Ridg	44,011
Warm Creek	23,719
Wildhorse Mesa	53,888
Subtotal	1,523,863
TOTAL WILDERNESS LANDS	3,254,442

9.4.2 Secondary Municipal and Industrial Water Needs

Secondary (dual) water systems provide irrigation water for landscape and turf irrigation. Parks, golf courses and other large grass areas are ideal candidates for secondary systems along with any other outside uses not requiring water of culinary standards. Many communities in the basin have secondary water systems so the potential for additional dual systems is not as great here as in other parts of the state.

Castle Valley Special Service District delivers secondary water to most of the communities in Emery County. Other communities of the basin use ditch and pressurized systems from various irrigation companies for lawn and garden watering.

The four coal-fire power plants (Price, Huntington, Hunter and Sunnyside) use untreated surface water for cooling their electrical steam generation plants. The projected diversion needed by the year 2020 is an additional 6,000 acre-feet. Current and projected secondary water diversions and depletions are shown in Table 9-5.

9.4.3 Irrigation Water Needs

Due to small amounts of farmland taken out of production, the area of irrigated cropland decreased by about 5 percent from 1968 to 1991. As the future population grows, particularly in the Garfield County area, some of the new residential and commercial developments may displace presently irrigated farmland. Overall, the irrigated land area is expected to change only slightly in the next 30 years except in the Green River area which may see an increase in agriculture because of the new Gunnison Butte Mutual Irrigation and Eastside High Ditch Project. Surface supplies are the major source of irrigation water in the entire West Colorado River Basin. Overall, about 95 percent of the irrigation water supply comes from surface water sources. Groundwater supplies a small amount of irrigation water in the Loa/Bicknell area. Table 9-6 shows the current and projected irrigation water diversions and depletions.

9.4.4 Fish and Wildlife Water Needs

Wetlands and riparian areas are important habitats for fish and wildlife. Many of the wetlands

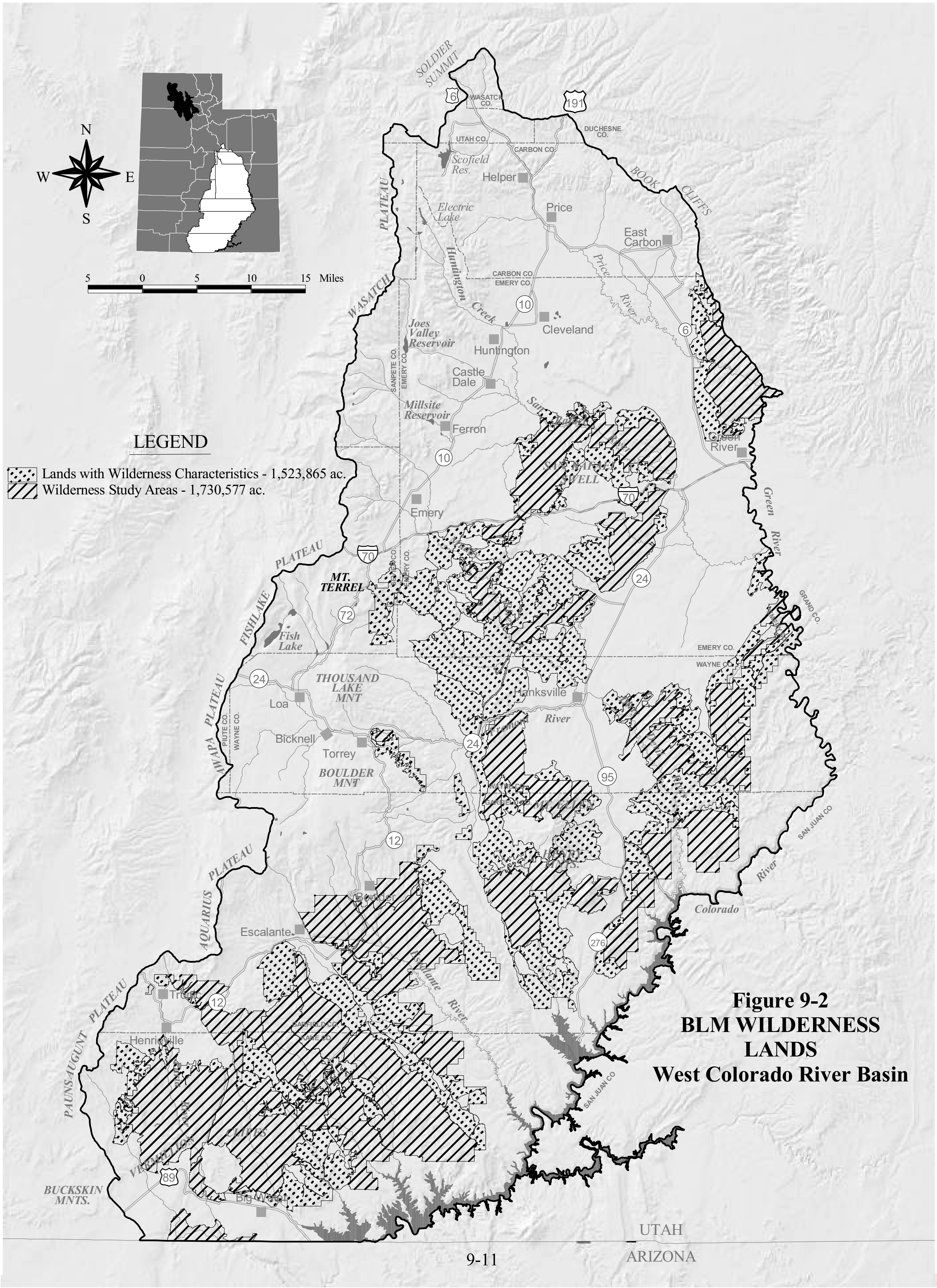


Figure 9-2
BLM WILDERNESS LANDS
West Colorado River Basin

Table 9-4
Current and Projected Culinary Water Use

Year	County (acre-feet)								Total Diversion	Depletion
	Carbon	Emery	Wayne	Garfield	Kane	Utah	Sevier	Sanpete		
1996	9,048	3,582	872	633	441	1	22	2	14,601	8,400
2010	10,600	4,100	1,100	800	600	1	30	3	17,234	9,900
2020	11,700	4,300	1,400	1,000	700	1	40	5	19,146	11,000

Table 9-5
Current and Projected Secondary Water Use[1]

Year	County (acre-feet)								Total Diversion	Depletion
	Carbon	Emery	Wayne	Garfield	Kane	Utah	Sevier	Sanpete		
1996	3,121	35,601	1,141	704	0	0	0	0	40,567	35,000
2010	3,500	38,000	1,500	900	0	0	0	0	43,900	38,000
2020	4,000	40,000	1,800	1,000	0	0	0	0	46,800	41,000

[1]Includes self-supplied industrial power plants and mining water use in Carbon and Emery counties. Also contains some pasture land irrigated within the cities served by the Castle Valley Special Service District's secondary water system.

Table 9-6 Current and Projected Agricultural Water Use				
	1990		2020	
Drainage	Diversions	Depletions	Diversions	Depletions
		(acre-feet)		
Price	84,450	43,000	80,000	45,000
San Rafael	81,700	52,700	78,000	55,000
Dirty Devil	83,400	43,600	80,000	42,000
Escalante	23,100	12,400	22,000	12,000
Paria	7,750	3,500	7,000	3,000
Lower Green	14,650	6,500	40,000	22,000
Total	295,050	161,700	307,000	179,000

in Carbon and Emery counties east of the Wasatch Plateau were artificially created by irrigation return flows. Cottonwood Irrigation Company dedicated 145 acres of wetlands through one of its irrigation projects. Utah Power donated a 38.99 cfs instream flow right for 65 miles on the Lower San Rafael River. Projects such as these should continue to ensure multiple use of the basin's water resources. Some areas should be preserved to accommodate amphibians and non-game species. Habitat in some areas can be improved from poor or fair condition to good condition. Waterfowl areas can be improved by interseeding, stabilizing the water supply and provided nesting facilities. Fisheries can be rehabilitated by using stream bank and channel measures to stabilize streambeds and provide pools. Priorities could be given to areas where there is greater potential for improvement, when a review of existing water uses would allow it.

9.4.5 Recreational Demands

The West Colorado River Basin contains eight state parks, one national park (small parts of two others), one national recreation area, one national monument, three national forests, and numerous other recreational areas of various kinds. The recreational activities range from camping, hiking, nature study, hunting, river-running, golfing and water sports in the summer to cross-country skiing, snowmobiling, hunting, ice fishing and sledding in the winter.

Sightseeing is popular at any time of the year. Opportunities for recreation range from the colorful desert areas such as Capitol Reef National Park and the Grand Staircase-Escalante National Monument to the majestic mountain areas such as those found in the Manti-La Sal, Fish Lake and Dixie National forests. Water-based recreation is provided by the many lakes, reservoirs and streams in the basin. Joes Valley, Scofield and Wide Hollow reservoirs and Fish Lake provide water skiing and boating as well as fishing. Lake Powell is a world-class houseboating and waterskiing destination. Fishing is popular on many rivers and streams, including the White River, Seely Creek, Huntington Creek and the Fremont River. World class river-rafting is found on the Colorado and Green rivers through Cataract, Gray, Labyrinth and Stillwater canyons.

9.4.6 Water Use Summary

All current water use and projected demands are based on currently available data. These are shown in Table 9-7 for 1995, 2020 and 2050.

9.5 Water Development and Management Alternatives

The existing water supplies can be enhanced through reservoir storage, transbasin diversions,

Table 9-7 Summary of Current and Projected Water Demands						
Use	1998[1] Diversions	Depletions	2020 Diversions	Depletions (acre-feet)	2050 Diversions	Depletions
Municipal and Industrial						
Culinary	14,600	8,400	19,200	11,000	25,000	14,000
Untreated:						
Residential Secondary	8,370	4,200	14,600	10,200	17,800	13,200
Industrial	32,200	30,800	36,500	35,000	36,500	35,000
Irrigation	295,050	161,700	281,000	179,000	262,000	167,000
Basin Total	350,220	205,100	351,300	235,200	341,300	229,200

[1]M&I based on 1996 study. Irrigation based on 1990 water budget.

weather modification, water transfers, and water education and conservation.

9.5.1 Water Supply Management

By bringing in industry, improving watersheds, converting to sprinkler irrigation, and developing secondary dual water systems, the West Colorado River water users have accomplished much in the way of water supply management. But there are always additional opportunities to improve the efficient use and management of the water resources. This applies to all uses. Users can better manage their water supplies by increasing efficiencies which in turn can reduce costs, and by using prudent application of water for landscaping and other outside residential purposes. There is a need to properly manage the groundwater reservoirs in the West Colorado River Basin. Water managers should always be searching for ways to conserve the available supply so development of other costly sources can be eliminated or postponed. Education and training can be an effective tool.

One of the tools used in planning and design of water projects is computer modeling. This can be used to simulate river systems to determine reservoir yields, hydroelectric power production, water shortages and the effect on the river systems as new developments become operational. Reservoir operation procedures can be fine-tuned with models to maximize the available water for use and minimize any problems associated with changing flow regimes. Computer models are also a useful tool for simulating operation of groundwater reservoirs.

"Real time" water-management systems can help irrigation companies become more efficient. The Emery Water Conservancy District has had such a system for the Cottonwood and Huntington irrigation districts for the last six years. This sophisticated computer-controlled system has greatly increased the efficiency of the large distribution canals located in Emery County.

9.5.2 Surface Water Storage Facilities [15]

Over the years, many potential reservoir sites have been investigated to varying degrees of detail. Investigations have been made by the Utah State Engineer, Division of Water Resources, Corps of

Engineers, Natural Resources Conservation Service (NRCS), and the Bureau of Reclamation. Local entities, with help from engineering firms, also have conducted investigations on reservoir sites. Locations of these sites are shown on Figure 9-3. Sites, along with the sponsors, are included in Table 9-8. Many of these sites are on the same stream segment. In these segments, only one of these sites would ever be developed. Future water storage reservoirs will only be feasible if constructed as multipurpose projects. Planning for these projects most include biological and environmental studies.

Currently the New Escalante Irrigation Company, through the Wide Hollow WCD, is investigating replacing Wide Hollow Reservoir (see Table 9-8) with a new reservoir. The BLM is currently working on an Environmental Assessment (EA) for this project. A new off-stream reservoir would be built with a capacity of between 4,000-6,000 acre-feet. The existing Wide Hollow Reservoir does not meet dam safety standards, and the capacity would be reduced to 400 acre-feet. Water would be directed from North Creek and Birch Creek in a pipeline and delivered to the new reservoir.

9.5.3 Water Conveyance and Delivery Systems

Much has been done to improve the conveyance and delivery systems for all uses. Pipelines and canal lining have been installed in many areas of the basin to reduce the loss of irrigation water. Water management with sprinkler systems is very effective in increasing on-farm efficiencies. Gated pipe is also effective where pressurized systems are not available or too costly.

Improvements have been made in systems delivering municipal and industrial water. However, there will be locations where systems will need to be upgraded. By keeping distributions systems in good condition, current water supplies can be stretched to meet most of the future needs.

9.5.4 Weather Modification

Weather modification or cloud seeding, has long been recognized as a means to enhance existing water supplies. Cloud seeding had its beginnings in 1946 at the General Electric Research Laboratories in Schenectady, New York. Cloud seeding can assist nature in the formation of precipitation, with appropriate types and numbers of nuclei at the proper times and places. Cloud seeding projects have been carried out in over 20 countries. Projects are generally conducted either during the winter or summer months. While wintertime projects target the enhancement of mountain snow-pack within a watershed, summertime projects are aimed at enhancing precipitation and/or reducing damage from hail.

"Seeding" winter storm clouds over mountains is well established and understood. Clouds form as moist air is lifted and cooled during its passage across mountain ranges. Left to nature, many clouds are highly inefficient precipitators, retaining more than 90 percent of their moisture. By cloud seeding, the precipitation efficiency can be greatly improved. Generally, silver iodide is used in ground generators to produce artificial ice nuclei that form ice crystals. Spreading the nuclei via aircraft is also common. These crystals attract moisture from the surrounding air forming droplets that grow large enough to fall to the ground as snow. Some projects using ground-based silver iodide generators to seed winter storms over mountain areas in the western United States have operated continuously since 1950.

Precipitation data from a number of cloud seeding projects have been examined in detail for evidence of downwind effects. Results from these analyses show a slight increase in precipitation in areas up to 90 miles downwind from the project area. No decrease in precipitation has been detectable farther downwind from any long-term cloud seeding project.

The first cloud seeding project in Utah began in the early 1950s in the central portion of the state. Cloud seeding started again in 1973 and has continued to the present. In 1973 the Utah Legislature passed the Utah Cloud Seeding Act. This law provided for licensing cloud seeding operators and permitting cloud seeding projects by the Utah Division of Water Resources. The act states that for water right purposes all water derived from cloud seeding will be treated as though it fell naturally. The act also allowed for the division to sponsor and/or cost share in cloud seeding projects.

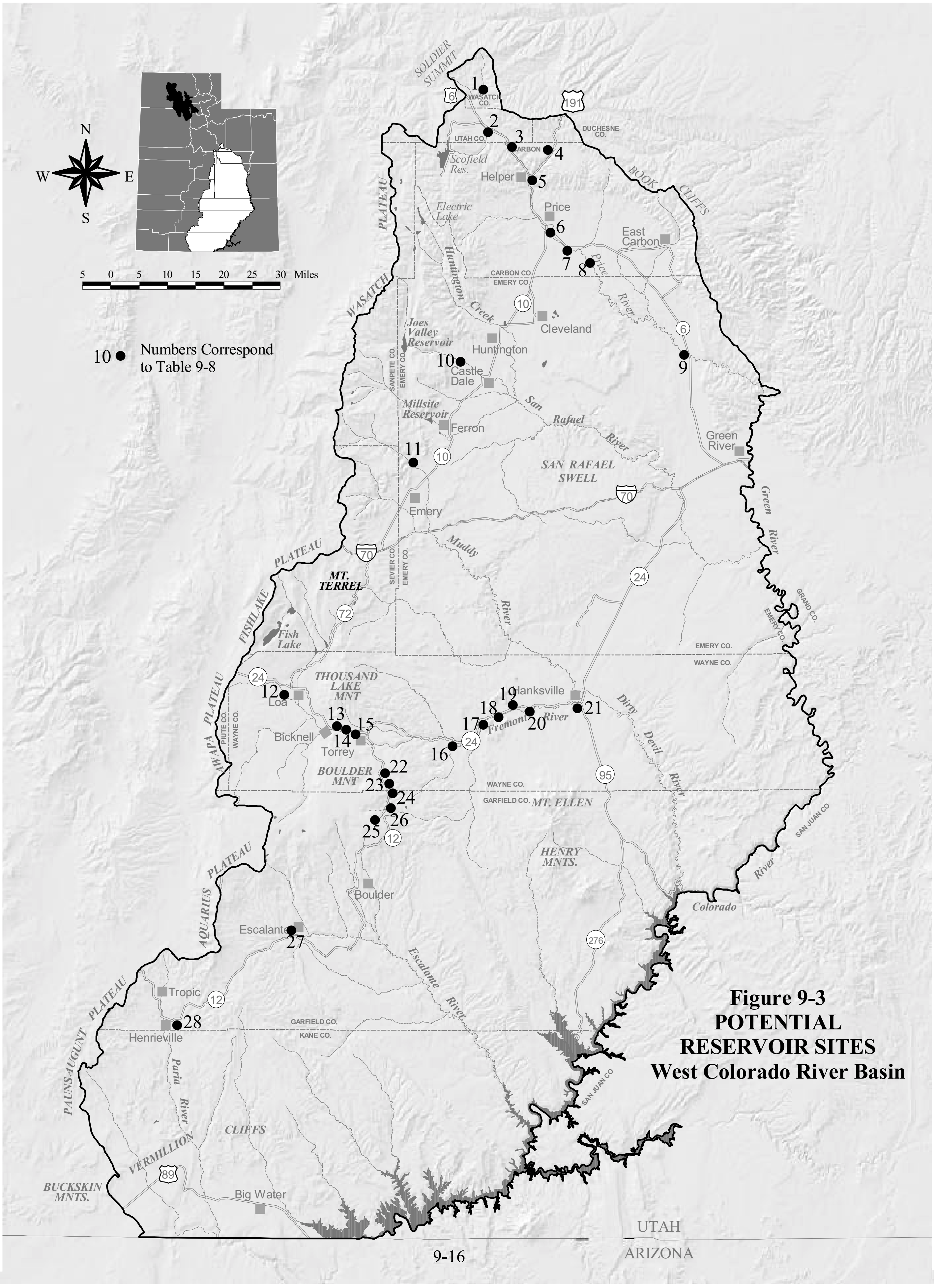


Figure 9-3
POTENTIAL RESERVOIR SITES
West Colorado River Basin

Table 9-8
Historical Reservoir Site Investigations

Figure 9-2 No.	Name	Stream	Sponsor	Type
	Price River			
1	White River	White River	Price River Water Users	R
2	Coulton	Price River	US Bureau of Reclamation(USBR)	R
3	Richards	Price River	USBR	R
4	Willow Creek	Willow Creek	USBR	R
5	Helper	Price River	USBR	R
6	Farnham	Price River	USBR	R
7	Edwards	Price River	USBR	R
8	Wellington	Price River	USBR	R
9	Woodside	Price River	USBR	R
	San Rafael River			
10	Adobe Wash	Cottonwood Creek (Off-stream)	Cottonwood Irrigation Company	R
	Dirty Devil River			
11	Muddy Creek	Muddy Creek	Four Corners Regional Commission	G,D
12	Road Creek	Road Creek		
13	Torrey (Poverty Flat)	Fremont River	Wayne County Water Conservancy District(WCWDCD)	R,G, S,D
14	Garkane	Fremont River	WCWCD	R,S
15	Hickman	Fremont River	WCWCD	R
16	Aldrich	Fremont River	WCWCD	R
17	Caineville #2	Fremont River	WCWCD	G,S
18	Caineville Reef	Fremont River	WCWCD	R
19	Caineville Wash	Fremont River (Off-stream)	WCWCD	R
20	Blue Valley	Fremont River	WCWCD	G,S
21	Hanksville Offstream Ponds	Fremont River	WCWCD	R
22	Rock Springs Draw	Rock Creek	Division of Water Rights(DWRi)	R
23	Snow	Rock Creek	DWRi	R
24	Beef Meadows	Rock Creek	DWRi	R
25	Pleasant Meadows	Pleasant Creek	DWRi	R
26	Pleasant Creek	Pleasant Creek	DWRi	R
	Escalante River			
27	Wide Hollow Replacement Dams	Escalante River (Off-stream)	Wide Hollow Water Conservancy District	R
	Paria River			
28	Henrieville	Henrieville Creek	Tropic Irrigation Company	R
29	Bryce Valley Sites	Offstream	Tropic, Henrieville and Cannonville	R

Investigation Type
R = Reconnaissance Report S = Seismic (Geophysics)
G = Geology Investigation/Drilling D = Design Report

Since 1976, the state, through the Division and Board of Water Resources has cost shared with local entities for cloud seeding projects. Recent cost sharing by the board has varied between 25-50 percent, depending on the size of the program.

There are two winter time cloud seeding projects in the West Colorado River Basin. The large central and southern Utah project, using silver iodide, targets the headwaters of most watersheds in the West Colorado River Basin. A small project using liquid propane is operated on the Wasatch Plateau above Joes Valley Reservoir.

Statistical analyses of the Central and Southern Utah Project with over 20 years of operation and data indicate a December through March precipitation increase of about 15 percent and an April 1 snow water content increase of about 10 percent. Runoff analysis in Utah indicates a 10 percent increase in April 1 snow water content will result in a 10 to 20 percent increase in the April-July runoff depending on individual watersheds.

9.5.5 Water Education

Water education provides an excellent approach to help children learn how to be responsible citizens. As they learn about water, they gain a respect for this resource which will become more and more important as water-related issues become prominent. The purpose of the Division of Water Resources (DWRe) Water Education Program is to educate students in grades K-12 about water from where it comes to where it goes. Children in turn learn to make decisions based on a knowledge of water and its origins.

Water education is achieved through various means. The state of Utah participates in the international water education program called Project WET (Water Education for Teachers). Project WET workshops are held throughout the state in order to train educators to use the collection of 90 innovative, interdisciplinary activities. Teachers are required to teach various aspects of water, and Project WET is a good tool for them to use. The program fits into a wide range of curriculum from science to social studies.

The water education program is ever expanding. The goal is to give educators the best resources possible. Part of the program includes outreach to schools. School programs are presented on topics relating to water, which are required to be taught in the state curriculum. Also, brochures and resource lists are provided to educators relating to water. The DWRe has been active in sponsoring water fairs for schools. These water fairs will continue to be an important avenue to teach children about all aspects of water.

The annual Young Artists' Water Education Poster Contest is an event which continues to be the highlight of October, which is Water Education Month. Children in grades K-6 participate in this statewide contest each year. Themes chosen each year all relate to water as a resource. The West Colorado River Basin is highly active in the contest. In 1998, all divisions were won by children from Emery County.

9.6 Projected Water Depletions

Projected in-basin water depletions are shown in Table 9-7. Two potential projects will also export water out of this basin for uses in other parts of the state. Other potential projects could develop up to 50,000 acre-feet on the lower Fremont River in Wayne County and 25,000 acre-feet near Green River in Emery and Grand counties.

9.6.1 Gunnison Butte Mutual Irrigation Project

The Gunnison Butte Mutual Irrigation Company was recently incorporated in the Green River area. They are preparing to divert water directly out of the Green River to irrigate about 5,000 acres of new lands that they currently own or have leased, and about 1,500 acres of supplemental lands. This will supply established markets with melons, corn, alfalfa, sod and various row crops. Additionally, there are school trust lands that could be included in the project if water were available. The irrigation company recently received a water right from the Utah Board of Water Resources' Flaming Gorge Water Right for 24,825 acre-feet of diversion and 15,143 acre-feet of depletion.

The project area has over 100 years of successful agricultural production. There are established farmers and water delivery systems, including a major diversion dam on the Green River, which will reduce the farming costs and add to the project's financial feasibility. There are established markets and transportation systems. Green River melons and alfalfa are known for their quality and excellence.

City of Green River officials have contributed significantly to the successful formation of the Gunnison Butte Mutual Irrigation Company, which was organized exclusively to receive and develop Flaming Gorge water. The company members are enthusiastic and some have expended considerable effort to evaluate their proposed farming applications. Figure 9-4 shows the location of the proposed project's agricultural lands.

9.6.2 Wayne County Water Conservancy District Project

The Wayne County Water Conservancy District has a 50,000 acre-foot water right on the Fremont River which was approved in 1963. Numerous potential reservoir sites have been proposed by the district as multi-use projects including irrigation, municipal and industrial, and recreational water benefits to the lower Fremont River system. To date, none has been found to be economically feasible.

A new proposal is looking at possibly changing this water right from a surface right to a groundwater right. This project would then pump water (possible from the Navajo Sandstone aquifer) to irrigate approximately 6,000 acres of new arable lands in the Cainville and Hanksville area as well as providing municipal and industrial water for local communities.

9.6.3 Narrows Project [52]

The Sanpete Water Conservancy District is sponsoring the completion of the Gooseberry Project (see Section 3.4). This project would export about 5,400 acre-feet of water out of the Price River drainage and into the Sevier River Basin. The project is controversial and is in the final permitting stage. For more information, see the *Sevier River Basin Plan, June 1999.*

9.6.4 Lake Powell Pipeline

The Washington County Water Conservancy District (WCWCD) commissioned the Lake Powell Pipeline Study to further investigate the feasibility of delivering a portion of Utah's Upper Colorado River water from Lake Powell to Washington County to accommodate the projected growth in the area. The pipeline would deliver about 70,000 acre-feet of water to Washington County and 6,000 to Kane County. A pump station would be located at Lake Powell southeast of Big Water. The pipeline would follow U.S. Highway 89 west through the Grand Staircase-Escalante National Monument toward Kanab and St. George. This would be an export from the West Colorado River Basin and an import to the Virgin River/Kanab Creek Basin. The projected time frame for constructing the project is 2025-2035.

9.7 Policy Issues and Recommendations

Four policy issues are discussed. These are: 1) Preservation of potential reservoir sites, 2) water development in proposed new federal designations, 3) long-range planning, and 4) draining Lake Powell.

9.7.1 Preservation of Potential Reservoir Sites

Issue - Potentially feasible reservoir sites should be identified and protected.

Discussion - Construction of additional water storage facilities may be needed in order to provide for projected needs and demands. Other developments often infringe on these sites, prohibiting their use for water storage facilities or requiring expensive relocation costs. Also, the possible development of some sites is prevented when the areas are withdrawn for other purposes such as proposed wilderness areas or for wild and scenic river designation. Preservation of potential reservoir sites would eliminate this problem.

Over the years, many potential reservoir sites have been investigated in the West Colorado River Basin. Investigation detail varies from cursory on-site evaluations to geotechnical work. Many of the sites have been or will be disqualified in the future as more detailed investigations or other factors eliminate them from consideration. In the final analysis, only a few of the sites will actually be utilized to provide water storage.

Recommendation - Water conservancy districts and other appropriate entities should act to identify

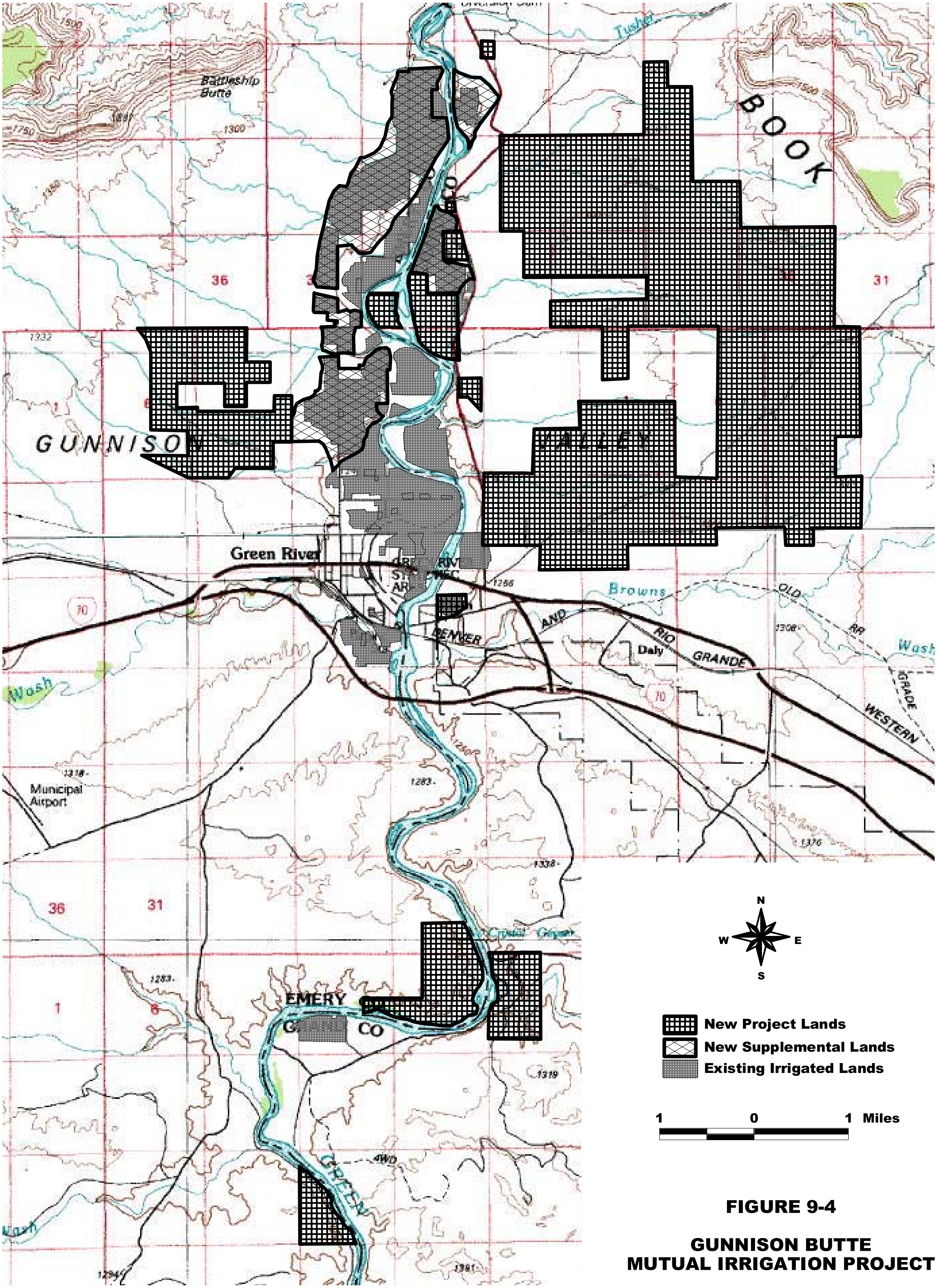


FIGURE 9-4

GUNNISON BUTTE MUTUAL IRRIGATION PROJECT

and petition the appropriate state or federal agency to protect potential water storage sites. The Forest Service and Bureau of Land Management should identify and evaluate potential reservoir storage sites in their planning processes.

9.7.2 Federal Land Designations

Issue - Designation of proposed new wilderness areas and the new Grand Staircase-Escalante National Monument may restrict or prohibit future water resource development and maintenance of existing water supply facilities.

Discussion - The basin contains 37 wilderness study areas as well as new re-inventoried lands with wilderness characteristics, totaling about 3,255,000 acres (See Table 9-3 and Figure 9-2). Several of the proposed wilderness lands contain potential sites for wells and sources of surface water which could be used to meet future municipal, industrial, livestock and wildlife water needs. Recent studies show that potential reservoir sites in Bryce Valley (sometimes referred to as Tropic Valley) exist in some of the proposed wilderness lands as well as in the new Grand Staircase-Escalante National Monument (GSENM). Existing water developments projects can still be used, but future access for operation and maintenance will be more difficult. Due to its proximity to the new GSENM, Bryce Valley (sometimes referred to as Tropic Valley) is expecting to grow at a greater rate than the rest of the basin. Figure 9-5 shows the complexity of this area, surrounded by Bryce Canyon National Park and the new GSENM. Similar situations exist around Escalante and Boulder.

Recommendation - Water users, county commissioners, mayors, and state officials should continue to keep Congress and appropriate federal agencies aware of the need to allow watershed improvement and surface water and groundwater resources development within future federal land designations.

9.7.3 Long-Range Planning

Issue - Coordinated long-range planning is needed at all levels in the use and management of the water and water-related land resources.

Discussion - The natural resources of the West Colorado River Basin, particularly those related to water, are vitally important to every individual, organization and government entity involved in their conservation, development and use. The ultimate use and disposition of resources should be coordinated among all appropriate entities, including individuals. Land owners, resource users, and administrators of federal, state, and local agencies should strive for acceptable compromises and have a willingness to work toward a common goal.

Long-range plans are a tool to help develop and conserve the existing resources to meet future demands. Water and land provide the basics to support life. Other important considerations include preserving areas for recreation and leisure activities and providing wildlife and habitat for the enjoyment of future generations.

Resource planning can also help where federal laws and mandates dictate use of lands. Local long-range resource plans can require federal agencies to take local desires and needs into consideration.

Past planning has dealt more with resource quantities. Future planning should also emphasize the quality aspects of resources. To assist with this, the present state policy is to provide technical assistance to help counties conduct resource inventories and prepare plans. The resources of the Governor's Office of Planning and Budget have been made available when needed. Additional planning assistance is also available from several state and federal agencies. Recently, Carbon, Emery and Wayne counties used the Governor's Office of Planning and Budget to write their plans.

Recommendation - Local governments and water user groups should prepare long-range plans concerning the basin's natural resources. Counties should take the lead through their land-use planning process with assistance from state and federal agencies.

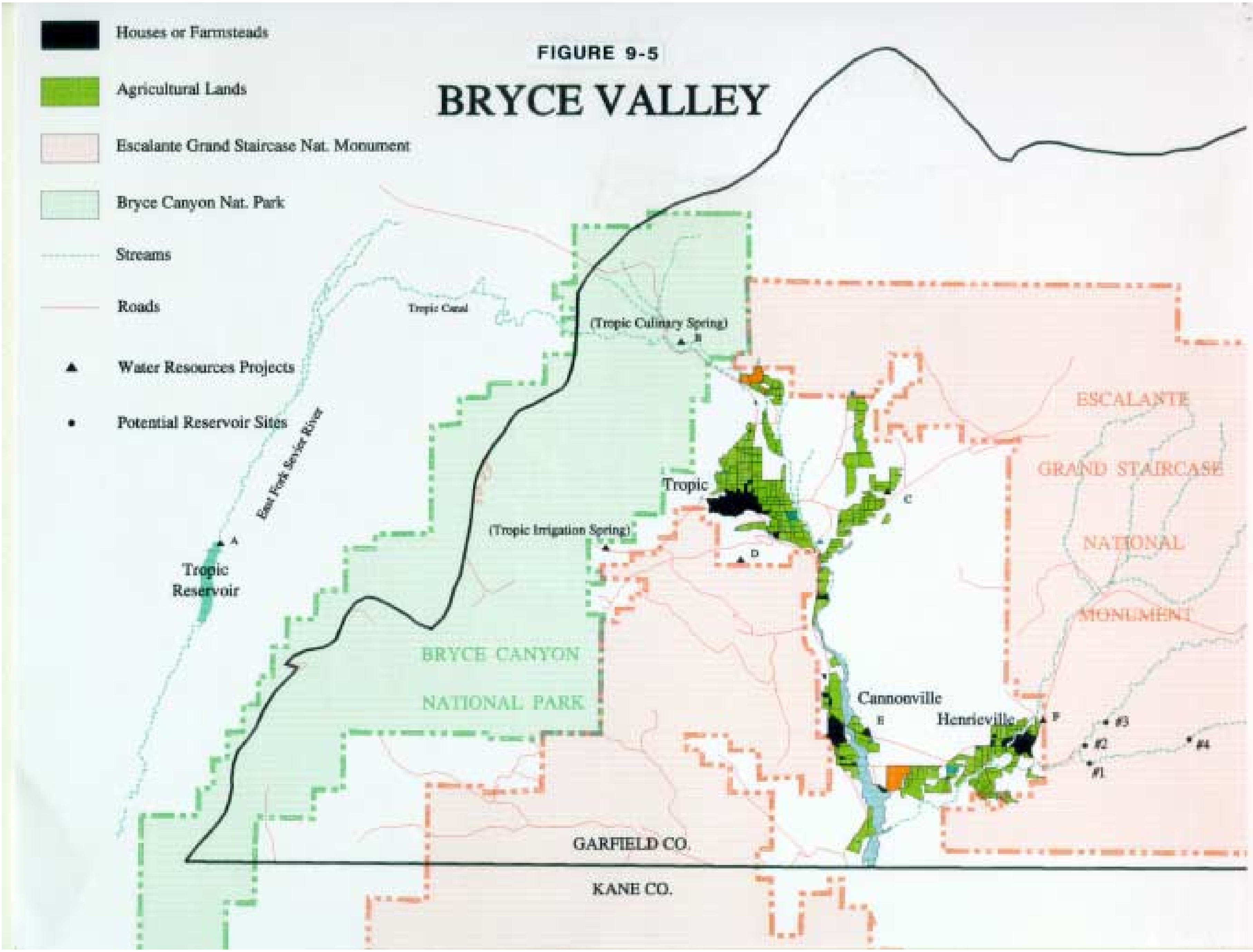
9.7.4 Draining Lake Powell

Issue - The Sierra Club and the Grand Canyon Institute have proposed to restore Glen Canyon by draining Lake Powell.

Discussion - Impacts of Draining Lake Powell from information presented at the April 1998 Congressional Hearing by the basin states, federal

FIGURE 9-5

BRYCE VALLEY



agencies, tribes, power users, recreationists and water users, the following impacts of draining Lake Powell have been identified.

Recreation Opportunities Lost

- Almost three-million people annually visit Glen Canyon National Recreation Area. Lake Powell draws the vast majority of these visitors. Without it, visitation would be minimal.
- About one-half million boating days are logged annually at Lake Powell. Draining the lake would provide more "wild river" for river runners, but the number of new opportunities would pale compared to the boating days that would be lost. Also, the entire river rafting industry in the Grand Canyon has been made possible by the regulation provided by Glen Canyon Dam. This too would be severely impacted.
- About 30,000 angler-days are spent annually on the blue-ribbon trout fishery below the Glen Canyon Dam. That fishery, those days and the warm-water angler-days on the lake itself would be lost.
- The trade-off for draining Lake Powell would be a loss of recreational opportunities for millions of people in exchange for a different type of recreation (river running through Glen Canyon) for a few thousand.

Economic Impacts

- Visitation to the Glen Canyon National Recreation Area, including boat rental at the lake and the fishing activity below the dam, is estimated to generate in excess of $400 million per year to local and regional economies. The vast majority of this would be lost.
- Some 2,000 private boats are berthed at Lake Powell. By federal law, the vast majority of these boats are registered in the state of Utah, and annual property taxes are paid as part of the registration process. Utah counties could lose hundreds of thousands of dollars annually in tax revenue.
- The Navajo Tribe would experience a significant financial loss. The Navajo Generation Station, one of few such amenities that has been provided to an Indian Tribe, could be shut down with a loss of over 1,900 jobs and associated power. If the Navajo Power Project were to remain operational, significant and costly modification would be required increasing energy costs to more than three million customers. In addition, tourism industry revenues would be lost to the tribe.
- If the proposal is pursued, a costly EIS would likely be required. Extent of the cost is uncertain, but the recently completed Glen Canyon EIS cost $80 million and took about 10 years to complete.
- Structural modifications to Glen Canyon Dam to allow Lake Powell to be drained would be expensive.
- Glen Canyon Dam provides flood control benefits to the Lower Basin states and Mexico. It is impossible to quantify future costs that might be incurred without its ability to control flood flows, but it is expected that such costs could be substantial.
- Loss of 3,500 gigawatt hours of hydroelectric power, producing revenues of $80 million yearly.

Environmental

- Post-dam riparian conditions in the Grand Canyon appear no worse than before the dam was constructed, but they are substantially different. Operation of the dam has created a refuge for birds of regional significance, a cold-water blue-ribbon trout fishery, and a regulated river with high biodiversity. If the lake is drained, all this will be lost.
- A complete restoration of Glen Canyon is questionable. Draining the lake would leave formations around the reservoir bleached (bathtub ring), expose significant debris, and create potential problems with sediment that has been deposited in the reservoir. This may dry along rock walls

and become airborne during windstorms creating dust and air quality problems.
- If it becomes necessary to replace the lost energy generation, it could become environmentally significant and will be expensive.

Water Supply
- Upper Basin States would be further constrained in developing their remaining compact allocations. During a prolonged drought, some existing Upper Basin uses might be curtailed.
- Lake Mead would fill with sediment at a much faster rate, decreasing its life expectancy.
- The construction of the Lake Powell pipeline for the delivery of water to southwest Utah would not be feasible.

Legal Issues
- Federal legislation would be required to drain Lake Powell.
- The delicate balance of water rights and water supply between the Upper and Lower Basin States could be destroyed, resulting in costly long-term negotiations or litigation and significant modification to the "Law of the River."

Arguments to Drain Lake Powell - The following points have been made by environmental groups on why Lake Powell should be drained:

- We have a stewardship to protect all of God's creations. We had no right to destroy Glen Canyon, nor the plants, animals and fish that existed in the canyon prior to the dam.
- The government misled the people in 1956; and if NEPA had existed, Glen Canyon Dam would never have been built. No one ever thought of the impacts to the environment.
- Glen Canyon Dam drowned out one of nature's finest creations and destroyed an ecosystem which can still be uncovered and restored. The decision made in 1956 can be reversed, and we can still restore Glen Canyon so we can see it again in the future.
- U.S. consumption of Colorado River water has destroyed the ecosystem of the Sea of Cortez and Colorado River Delta.
- The Grand Canyon is suffering from the construction of the dam, which has changed the temperature of the water, cut off the supply of sediment to rebuild beaches and prevents cleansing seasonal floods. Draining Lake Powell will save the Grand Canyon.
- Will help recover Colorado River endangered fish by re-establishing habitat lost under the reservoir.
- Lake Powell will fill with sediment someday; hydropower generation and water storage will be lost.
- Loss of 1.0 maf of water to evaporation and bank storage each year at Lake Powell.

Recommendation - The state of Utah feels this proposal is without merit. Lake Powell is an integral part of the water management system of the western United States, and the state should continue and expect its efforts to educate the public about the benefits and costs of water resource management. ●

Section 10 - West Colorado River Basin

Agricultural Water

10.1	Introduction	10-1
10.2	Background	10-1
10.3	Agricultural Lands	10-2
10.4	Watershed Management	10-2
10.5	Agricultural Water Problems and Needs	10-5
10.6	Agricultural Water Conservation And Development Alternatives	10-5

Figure

10-1	Irrigated Agriculture	10-4

Tables

10-1	Irrigated Land By Crops	10-3
10-2	Past, Current and Projected Irrigated Cropland Water Use	10-5

Section 10

West Colorado River Basin - Utah State Water Plan

Agricultural Water

10.1 Introduction

This section describes the agricultural industry in the basin as well as its problems, needs and future outlook. The success of the agricultural industry is dependent on the market, climate and the water supply.

Agriculture to support livestock production plays a major role in the basin's economy.

Agriculture has a direct impact on the economy of the area. Spinoff from agriculture helps support employment and production in other sectors along with providing economic diversity. Agriculture also adds environmental diversity to the basin by providing open green space and improving watershed qualities.

10.2 Background [18, 19, 53]

Irrigated cropland amounts to 91,924 acres, less than 1 percent of the total basin area of 10.5 million acres. Much of the basin contains arable soils, but they cannot be cropped because of the lack of irrigation water or insufficient precipitation. Typically, the irrigated cropland is in the valley bottoms where the land is relatively flat. Rangeland is found from the low-lying desert areas to the high mountain forest lands.

The number of farms has decreased slightly over the years, and this has been accompanied by an increase in the average farm size. This reflects the need for more acreage to maintain a viable farm unit. The average farm in Carbon County contains about 1,600 acres, while Emery, Wayne and Garfield counties farms contain about 550 acres. These amounts include rangeland and irrigated croplands. Over the long term, the existing irrigated acreage base will decline slightly due to increased population pressures while some new lands (several thousand acres) may be brought under irrigation in the Green River and western Wayne County areas.

Cow-calf production is currently the major farm-related industry. Also, dairies are located in Ferron in Emery County and near Loa in Wayne County. Most of the crops grown, along with pasture and rangelands, are used to support these activities.

Alfalfa fields near Henrieville

10.3 Agricultural Lands [9, 18, 19]

Private agricultural lands cover only a small portion of the West Colorado River Basin. The lands used for grazing are under federal administration and cover most of the basin.

10.3.1 Irrigated Cropland

The Division of Water Resources completed a water-related land use survey of West Colorado River Basin cropland areas in 1998 and determined there are 91,924 acres of irrigated cropland, plus an additional 8,350 acres that are idle. The major crops grown include pasture, 45 percent; alfalfa, 39 percent; small grains, 7 percent; grass hay, 4 percent; and corn silage, 3 percent. The irrigated land by crop is shown in Table 10-1, and the locations are shown in Figure 10-1. The total farmed acreage in 1967 was just over 105,000 acres. Farmed acreages have decreased 5 percent over the past 30± years because of salinity problems and the purchase of irrigation water shares for the power plants in Emery County.

Table 10-2 shows the past, present and future irrigation water use in the basin. This use will remain fairly constant in the future. Some lands will be taken out of production as existing water supplies are transferred to other uses. In some areas (Green River and eastern Wayne County), new replacement lands may be developed if agricultural economics justify the investment and federal permits can be acquired.

10.3.2 Dry Cropland

Very little dry cropland (non-irrigated) exists in the basin. However, about 5,000 acres of irrigated pasture lands receive water only at the beginning of the irrigation season and remain dry throughout the remainder of the season. Most of these are grazed by livestock and wildlife.

10.3.3 Rangelands

Over 70 percent the West Colorado River Basin area is used for grazing purposes. Some of this land is forested, but most is desert-type rangeland. Much of the grazed area is located in the lower elevations, making it suitable for winter grazing. Permitted grazing on public lands declined after the 1940s, but since then it has remained fairly stable. Lately, however, there have been some slight declines in many areas. Considerable work has been done in localized areas to increase livestock and wildlife forage on rangelands with practices such as pinyon-juniper and brush chaining and re-seeding with grass. Management practices have been improved over the years. Despite this, federal land managers on national forest and BLM lands continually reduce the cattle allotments threatening the basin's cattle ranching economic stability.

10.4 Watershed Management [25]

Watershed management is the protection, conservation and use of all the natural resources of a specific watershed in such a way as to keep the soil mantle in place and productive. It also assures water yield and water quality meet the desired uses. If not properly protected, watershed lands are readily damaged from erosion, floods, sediment and fire. Following are some of the treatment measures used to keep the watersheds a viable producer of resources:

- Livestock and wildlife grazing management.
- Vegetation improvement, improved cropping sequences, and improved irrigation systems and management are important.
- Structural measures, such as contour trenching, debris basins, gully control and stream channel stabilization, all in conjunction with vegetation improvement and grazing management.
- Spring areas protected from wildlife and livestock by fencing. Watering facilities provided outside the fenced area.

Erosion is a problem in parts of the basin, particularly where sparse plant cover provides little protection to the soil. Intense thunderstorms frequently produce flash floods, eroding the landscape. Heavy rains soon after fires also cause increased erosion. In these areas, a majority of the erosion is geologic or background, but in some areas it has been accelerated by man's activities.

Table 10-1
Irrigated Land By Crops

Crop	County									Total
	Utah	Carbon	Sanpete	Emery	Grand	Sevier	Wayne	Garfield	Kane	
	(acres)									
Surface Irrigated Crops										
Fruit/Nursery	0	21	0	59	0	0	34	53	0	167
Small Grain	0	655	0	2,741	27	110	2,671	174	18	6,396
Corn Silage	0	749	0	2,088	212	0	33	0	0	3,082
Vegetables	0	14	0	116	25	0	0	0	0	155
Alfalfa	0	5,222	0	14,648	629	296	9,832	5,222	162	36,011
Grass Hay	0	359	0	2,778	9	0	147	257	0	3,550
Grass/Turf	0	0	0	0	10	0	0	0	0	10
Pasture	33	5,043	0	23,098	276	0	2,733	1,452	36	32,671
Fallow	0	233	0	622	56	7	46	182	0	1,146
Surface Subtotal	**33**	**12,296**	**0**	**46,150**	**1,244**	**413**	**15,496**	**7,340**	**216**	**83,188**
Sub-Irrigated Crops										
Sub-Irrigated Pasture	0	387	0	4,563	0	403	3,322	8	53	8,736
Total	**33**	**12,683**	**0**	**50,713**	**1,244**	**816**	**18,818**	**7,348**	**269**	**91,924**

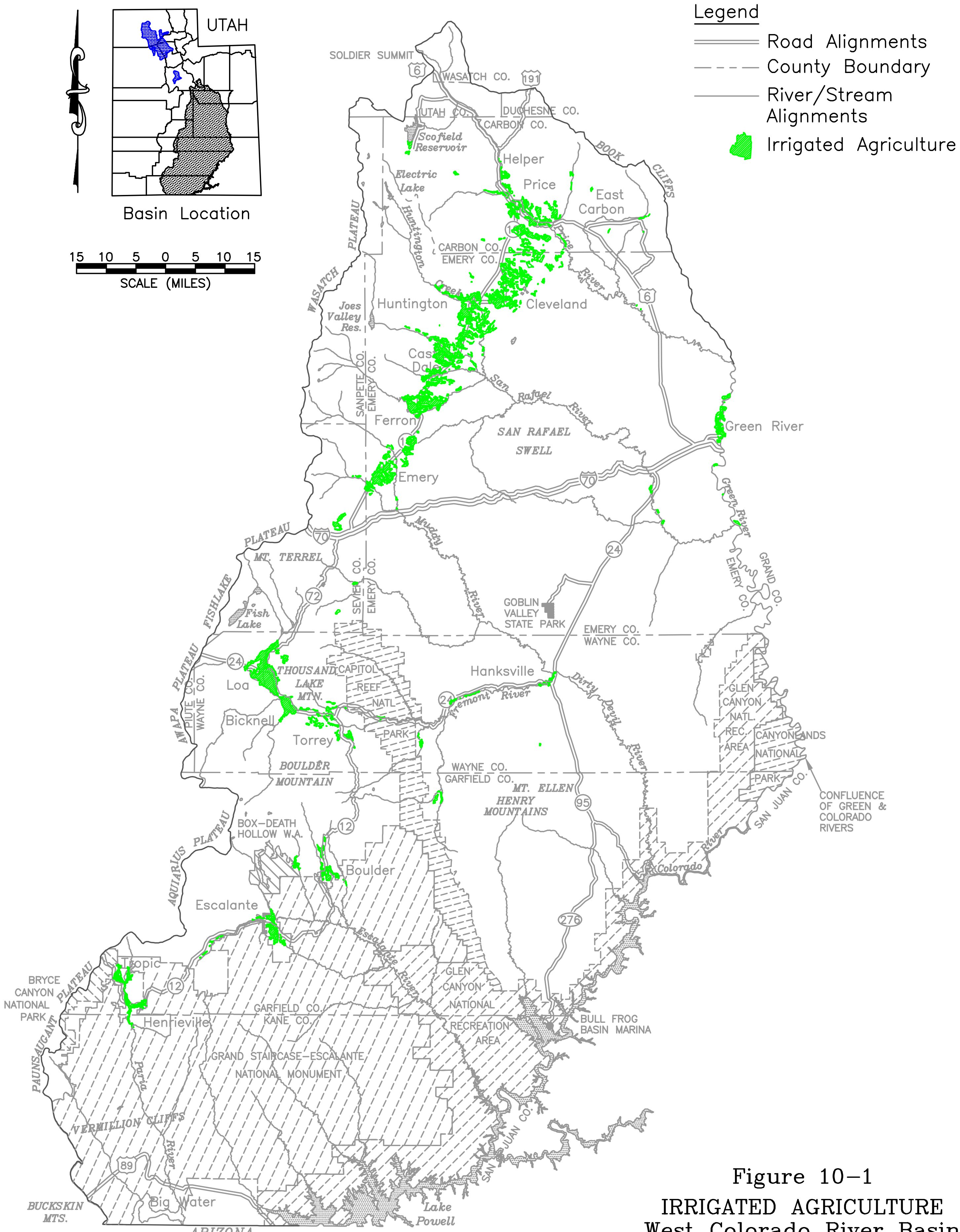


Figure 10-1
IRRIGATED AGRICULTURE
West Colorado River Basin

Table 10-2
Past, Current and Projected Irrigated Cropland Water Use

Year	Area (acres)	Diversions (acre-feet)	Depletions (acre-feet)
1991	89,064	303,000	165,900
1998	91,924	295,050	161,700
2020	93,000	281,000	179,000

10.5 Agricultural Water Problems and Needs

The West Colorado River Basin does not have a full water supply for all the irrigable lands. Irrigation of crops on presently irrigated lands depletes nearly 162,000 acre-feet of water annually. If all the existing lands with a valid water right were to receive a full water supply, an additional 264,000 acre-feet would be depleted (see Section 5, Table 5-21). The water deficit can be reduced in many cases by reducing seepage and evaporation and improving irrigation efficiencies. But it is not possible to salvage enough water from improved irrigation practices to meet the needs of all cropland acres.

Sprinkler Irrigation in Wayne County

In some areas, particularly where rangeland is used for grazing, water quality may be impacted where livestock and wildlife concentrate for watering. There is a need to improve and provide watering facilities to better distribute livestock and wildlife.

10.6 Agricultural Water Conservation and Development Alternatives

One way of realizing additional monetary benefits from the existing water supply is to improve water use efficiency. Water use efficiency can be evaluated in two parts: off-farm conveyance and on-farm application. Delivery systems can be upgraded by lining high seepage areas in canals with concrete or other material or by installing pipelines. Installing or upgrading diversion structures and effective measurement and management controls can also increase efficient use of water.

Many of the irrigation companies have already completed or planned projects to improve overall irrigation efficiencies. These projects include reducing seepage losses by improving system management through real-time monitoring, lining canals, and installing pipelines. Projects to reduce on-farm losses include selecting a different irrigation method or improving an existing method. Operation and maintenance procedures have been recommended through soil conservation district plans for some of the irrigation companies.

An opportunity exists to do this with the Tropic and East Fork canals in Garfield County. It has been estimated that about one third of the water diverted at Tropic Reservoir is lost to seepage.

Another opportunity exists to pipe some of the small ditches on Boulder Mountain above the town of Boulder in Garfield County. This would reduce seepage on these ditches.

Incentives to improve efficiencies and conserve water are many. Where there is a shortage of irrigation water, increased efficiencies can make water go farther and increase the number of acres with a full supply. Increasing irrigation efficiencies can also reduce the cost of irrigation. By applying less water to irrigate crops, there will be less deep percolation into the groundwater reservoir. This will reduce leaching of salts and help maintain a good quality groundwater. Financial incentives are available through several state and federal programs. See Section 8 for more information on funding.

The joint Bureau of Reclamation-Natural Resources Conservation Service Price-San Rafael Salinity Control Program is an excellent opportunity for farmers in Carbon and Emery counties to take advantage of federal matching funds to convert to sprinkler irrigation which will increase on-farm irrigation efficiencies. This program will also aid irrigation companies to line and pipe canals which will help increase the conveyance efficiency. Section 9 explains this program in more detail. ●

Section 11 - West Colorado River Basin
Drinking Water

11.1	Introduction	11-1
11.2	Setting	11-1
11.3	Local Regulatory Organizations	11-2
11.4	Drinking Water Problems	11-7
11.5	Culinary Water Use And Projected Demand	11-8
11.6	Alternative Solutions	11-8

Figures

11-1	Public Community System Boundaries	11-4
11-2	Per Capita Water Use	11-5

Tables

11-1	Public Community Water Supply and Use	11-3
11-2	Culinary Water Diverted Per Capita Day	11-6
11-3	Total Culinary Use	11-7
11-4	Current and Projected Culinary Water Diversions	11-8

Section 11

West Colorado River Basin - Utah State Water Plan

Drinking Water

11.1 Introduction [16]

This section discusses the public and private water supplies in the West Colorado River Basin and reviews the systems and their conditions.

State of Utah Administrative Rules for Public Drinking Water Systems, R309-300 through R309-211, define a public water system (PWS) as one that has at least 15 connections or serves an average of at least 25 people at least 60 days per year. This distinguishes between public and private water systems, which include self-supplied industrial facilities and individual home wells or springs.

All public water systems are further categorized into three different types: community (CWS), non-transient non-community (NTNCWS), and transient non-community (TNCWS). The CWSs and NTNCWSs are more strictly regulated because of the rationale that the same people are impacted every day by the system's water quality. The CWSs are those that serve at least 15 service connections used by year-round residents or those that regularly serve at least 25 year-round residents. The NTNCWs serve at least 25 of the same non-resident persons per day for more than six months per year, such as students at a school. The TNCWs generally impact different people every day. Examples include campgrounds or food establishments whose staff number does not exceed 25.

11.2 Setting [16, 21]

Surface water sources require mechanical treatment to meet state approval. The earliest basin settlers developed high water quality springs and wells to supply safe and reliable culinary water to communities. The water from springs has remained relatively high in quality.

Culinary water is always in demand and vigilance is needed to assure a high quality supply. Expected growth in the basin will require development of additional supplies of potable water.

However, vigilant protection of spring and well recharge zones is necessary to avoid contamination. It is expected that future culinary water demand will be met from surface and groundwater supplies.

The amount of culinary water used for irrigating lawns and gardens can substantially

Price Water Treatment Plant

increase the daily culinary water use. In the West Colorado River Basin, outside culinary water use is about 35 percent of the total. Substitution of non-potable (secondary) water for outside use in many communities has significantly alleviated culinary water demand.

The Division of Water Resources recently conducted a municipal and industrial water study to obtain more detailed data of current use and source capacity. This includes residential uses inside and outside the home, as well as commercial, institutional and industrial uses. Data are shown in Table 11-1. Figure 11-1 shows the locations of the community water systems in the basin.

As can be seen, some communities have reached the limit of their source and/or system capacity. When the demand for water deliveries increases, more water will need to be diverted from existing supplies, or supplemental water sources will need to be developed.

The per capita use for each CWS as shown in Table 11-2 varies from community to community. Much of this can be attributed to whether culinary water or non-culinary water is used for outside irrigation. Water consumption at different times of the year also varies as there is typically more outside use during the summer months than during the winter.

The 1996 basin-wide average culinary water use in gallons per capita per day (gpcd) was 253 gpcd (Figure 11-2). The statewide average was 268 gpcd in 1998. The use in the basin's cities and towns ranges from 92 gpcd for Trail Canyon Residential System in Emery County to 740 gpcd for Torrey Culinary Water System in Wayne County. The reason for the basin's lower per capita rate relative to the statewide average is that many communities utilize available secondary for outside watering. The combined secondary water and culinary water use is 449 gpcd, which is higher than the statewide average of 324 gpcd.

Total basin culinary use including public community, public non-community, private domestic and self-supplied industrial water systems is 14,601 ac-ft per year. (See Table 11-3.) About 60 percent of this is supplied by surface water treatment plants operated by Price City, Price Water Improvement District, Green River City and Castle Valley Special Service District. The remainder is served through wells and springs.

11.3 Local Regulatory Organizations

All public drinking water supplies are subject to the Utah Safe Drinking Water Act and the Utah Administrative Rules for Public Drinking Water Systems. Federal regulations and state rules are administered by the Utah Department of Environmental Quality, Division of Drinking Water.

The intent of the Safe Drinking Water Act (SDWA) is to encourage states, local governments and water companies to be proactive and to ensure all water systems are capable of maintaining and protecting the supply of safe drinking water at an affordable cost.

The federal government authorized over $12.5 million for Utah to be used starting in 1997 in a Drinking Water State Revolving Fund (DWSRF) program. The state has the responsibility to prepare an intended use plan (IUP), which is a prioritized list of eligible applicants to use this funding. Interim guidelines from the federal government have been given to the states, which define how this money and future funding is to be allocated.

The State Division of Drinking Water (DDW), working with Rural Water Association of Utah (RWAU), American Water Works Association (AWWA) Intermountain Section, and the local health departments (LHDs) assisted each county in preparing regional water management plans. These plans were completed in 1999. They are intended to be updated every 10 years. Once regional boundaries have been established by the county planners, water companies within each region were notified of the planning agenda and allowed to become a party to this planning process.

Personnel from DDW, RWAU or AWWA, and any affected LHD met with local county officials and gave initial guidelines and interim input concerning the scope of the study to be completed. Generally, private consulting engineering firms were then be employed by the county or association of

Table 11-1
Public Community Water Supply and Use

Water Supplier	Total Source Capacity (acre-feet)	Reliable Source Capacity (acre-feet)	Current M&I Use (acre-feet)
CARBON COUNTY			
East Carbon City	672	384	384
Helper Municipal Water System	2,482	1,043	933
Price City Water	3,548	2,997	2,997
River View	NA	NA	31
Price River Water Improvement District	6,720	2,949	951
Non-Public Water Companies[1]	NA	NA	81
Carbonville Water Company	NA	NA	59
East Carbonville Water Company	NA	NA	22
South Price Water Company	NA	NA	64
Spring Glen Water Company	NA	NA	132
Wellington Culinary Water	NA	NA	380
Scofield Town	35	18	10
Sunnyside City Water	672	279	234
CARBON COUNTY TOTALS	14,109	7,670	6,278
EMERY COUNTY			
Castle Valley Special Service District [2]	5,200	2,320	1,726
Green River Municipal Water	1,680	720	502
North Emery Water Users	575	269	228
Trail Canyon Residents	19	12	12
EMERY COUNTY TOTALS	7,474	3,320	2,468
WAYNE COUNTY			
Bicknell Culinary Water System	141	66	61
Caineville Special Service District	44	19	17
Capitol Reef National Park	40	18	10
Fremont Waterworks Company, Inc.	210	105	105
Hanksville Culinary Water Works	129	57	39
Loa Water Works Company	355	166	166
Lyman Culinary Water System	97	45	34
Teasdale Special Service District	129	78	78
Torrey Culinary Water System	452	290	290
WAYNE COUNTY TOTALS	1,597	843	800
GARFIELD COUNTY			
Boulder Farmstead Water Company	181	76	65
Cannonville Town	161	71	36
Escalante Town	2,534	1,092	324
Henrieville	65	33	19
Tropic	323	140	108
GARFIELD COUNTY TOTALS	3,263	1,412	548
KANE COUNTY			
Church Wells Special Service District	387	164	41
Glen Canyon SSD #1 (Big Water)	300	189	189
Glen Canyon-Bullfrog (National Park Service)	300	189	189
KANE COUNTY TOTALS	1,816	830	415
WEST COLORADO RIVER BASIN TOTALS	28,258	14,075	10,509

[1]Price River Water Improvement District delivers water to Brotherson Water Co., Carbon County Industrial Park, Central Trailer Park, Lessar Water Co., Machello Water Co., Pillings Trailer Park, Pinnacle Peak Water Co., North Blue Cut Water Co., South Hwy. Water Co. and Thomas Trailer Park.
[2]Delivers water to the communities of Clawson, Cleveland, Elmo, Emery, Ferron, Huntington and Orangeville.
Note: Totals do not include uses outside public community supplier areas. Current data based on 1996 values.
Source: DWRe 1996 West Colorado M&I Water Supply Studies.

CARBON COUNTY
1. East Carbon & Columbia Municipal Water
2. Helper Municipal Water System
3. Price Municipal Water System (River View)
4. Price River Water Improvement District
5. Carbonville Water Company
6. E. Carbonville Water Company
7. South Price Water Company
8. Spring Glen Water Company
9. Wellington Culinary Water
10. Scofield Town
11. Sunnyside City Water

EMERY COUNTY
12. Castle Valley Special Service District
13. Green River Municipal Water
14. North Emery Water Users
15. Trail Canyon Residential System

WAYNE COUNTY
16. Bicknell Culinary Water System
17. Cainenville Special Service District
18. Capitol Reef National Park
19. Fremont Waterworks Company, Inc.
20. Hanksville Culinary Water Works
21. Loa Water Works Company
22. Lyman Culinary Water System
23. Teasdale Special Service District
24. Torrey Culinary Water System

GARFIELD COUNTY
25. Boulder Farmstead Water Company
26. Cannonville Town Water
27. Escalante Culinary Water
28. Henrieville
29. Ticaboo Special Service Dist. #1
30. Tropic

KANE COUNTY
31. National Park Service, Bullfrog Rec. Site
32. Church Wells Special Service District
33. Glen Canyon Special Service District #1 (Big Water)

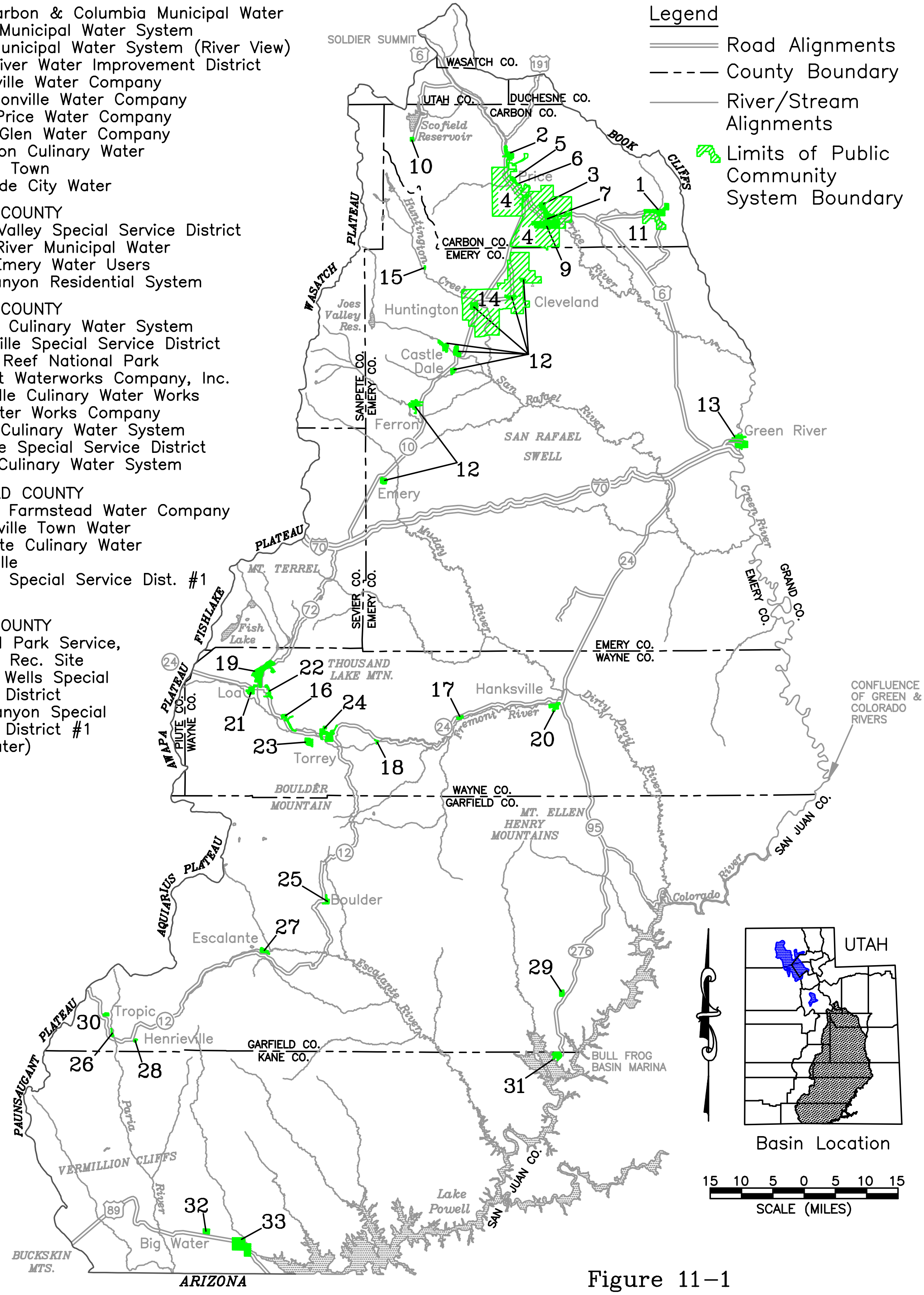
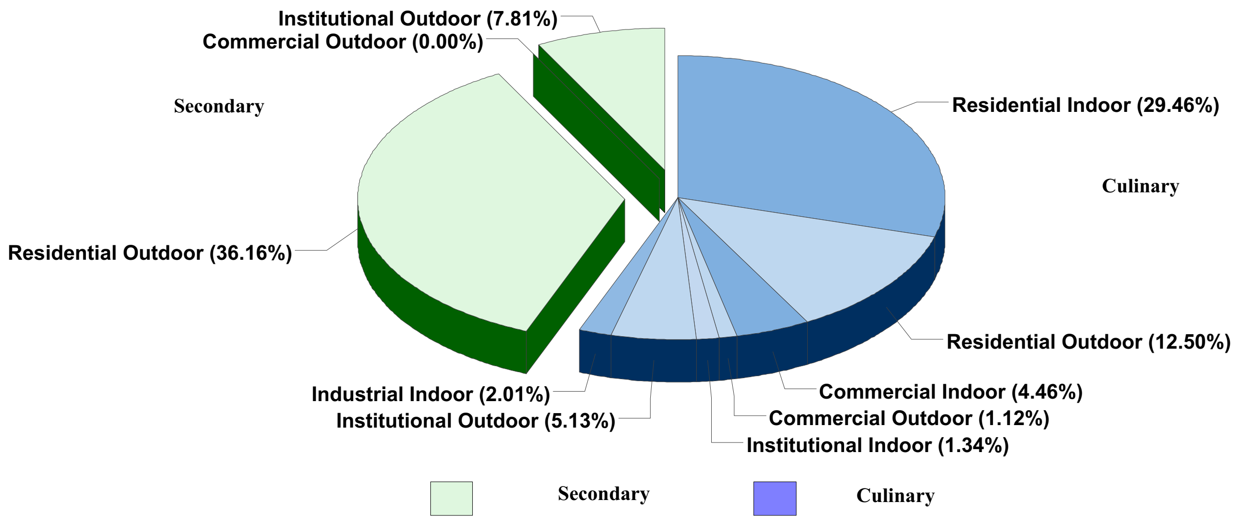


Figure 11-1
PUBLIC COMMUNITY SYSTEM BOUNDARIES
West Colorado River Basin

Figure 11-2

WEST COLORADO RIVER BASIN
PER CAPITA WATER USE
(Percent of Total)



WATER USE CATEGORY
PER CAPITA WATER USE
(gpcd)

Culinary	
Residential Indoor	132
Residential Outdoor	58
Commercial Indoor	20
Commercial Outdoor	5
Institutional Indoor	6
Institutional Outdoor	23
Industrial Indoor	9
Sub-Total	**253**
Secondary	
Residential Outdoor	161
Commercial Outdoor	0
Institutional Outdoor	35
Sub-Total	**196**
TOTAL	**449**
Total Per Capita	
Residential	**351**
Commercial	**25**
Institutional	**64**
Industrial	**9**
Sub-Total	**449**
TOTAL	**449**

Table 11-2
Culinary Water Diverted Per Capita Day

Water Supplier	Population	Per Capita Use (Gallons)
CARBON COUNTY		
East Carbon City	1,270	270
Helper Municipal Water System	2,350	354
Price City Water	8,712	307
River View	250	110
Price River Water Improvement District	3,800	223
Non-Public Water Companies	450	160
Carbonville Water Company	300	176
East Carbonville Water Company	175	113
South Price Water Company	553	103
Spring Glen Water Company	800	148
Wellington Culinary Water	1,632	208
Scofield Town	92	95
Sunnyside City Water	400	523
CARBON COUNTY TOTALS	20,784	270
EMERY COUNTY		
Castle Valley Special Service District*	8,055	191
Green River Municipal Water	1,500	299
North Emery Water Users	1,500	136
Trail Canyon Residents	112	92
EMERY COUNTY TOTALS	11,167	197
WAYNE COUNTY		
Bicknell Culinary Water System	390	141
Caineville Special Service District	40	368
Capitol Reef National Park	57	161
Fremont Waterworks Company, Inc.	250	374
Hanksville Culinary Water Works	170	203
Loa Water Works Company	500	296
Lyman Culinary Water System	200	151
Teasdale Special Service District	175	399
Torrey Culinary Water System	350	740
WAYNE COUNTY TOTALS	2,132	335
GARFIELD COUNTY		
Boulder Farmstead Water Company	150	387
Cannonville Town	156	208
Escalante Culinary Water	1,050	276
Henrieville	180	94
Tropic	396	243
GARFIELD COUNTY TOTALS	1,932	257
KANE COUNTY		
Church Wells SSD	105	344
Glen Canyon SSD #1 (Big Water)	450	368
Glen Canyon - Bullfrog Recreation Site	800	211
KANE COUNTY TOTALS	1,355	274
WEST COLORADO RIVER BASIN TOTAL	37,370	253

*Delivers water to the communities of Clawson, Cleveland, Elmo, Emery, Ferron, Huntington and Orangeville.
Note: Data based on 1996 values.

Public Suppliers	Carbon	Emery	Garfield	Kane	Sanpete	Sevier	Wayne	Utah	Total
	(acre-feet per year)								
Community Systems	6,278	2,468	601	416	0	0	800	0	10,563
Non-Community Systems	31	6	4	5	2	17	7	1	73
Private Domestic Systems	160	5	25	20	0	5	65	0	280
Self-Supplied Industrial	2,579	1,103	3	0	0	0	0	0	3,685
TOTALS	9,048	3,582	633	441	2	22	872	1	14,601

Table 11-3
Total Culinary Use

governments to complete the water management plan.

The Drinking Water Board authorized $900,000 to fund the regional water management plans in 1998 and 1999. In addition, the Community Impact Board and Community Development Block Grant Board are each currently considering funding $250,000 to this planning effort.

Regional water management plans analyze every community water system and non-transient non-community water system with respect to source protection, operator certification, monitoring, managerial, financial, and technical capabilities. Alternatives such as joint source protection studies, joint use of operators, managers, equipment and facilities, existing and proposed, as well as consolidation of water systems are also considered.

Local owners of each water company will have the opportunity to accept or reject the recommendations of the regional water plan. If a water company is not in compliance with state rules and federal regulations, and is not willing to accept the options to be in compliance as presented in the regional planning report, the water company will not be eligible for Drinking Water State Revolving Fund programs.

Information from the regional water management plans will be used to prepare an intended use plan. The intended use plan will be: (1) Prepared by the state with recommendations from local officials, (2) updated annually, and (3) subject to public comment procedures. This plan will indicate who is eligible and the priority of each project to be funded by the DWSRF.

The Division of Drinking Water serves as staff for the Drinking Water Board to assure compliance with the standards. At the local level, considerable reliance is placed on public water supply operators.

11.4 Drinking Water Problems

The demand for high quality drinking water and the potential for contamination of drinking water supplies will increase as the population increases. About one-half of the drinking water delivered in the basin is pumped from groundwater aquifers, so culinary water delivery could be impacted by declining groundwater quality.

The North Emery Water Users Association is carefully monitoring its source springs because of possible groundwater interference by local mining companies. This relates to quantity and quality of the groundwater supply.

Problems can originate from several sources. One source of poor water quality that cannot be controlled is caused by geologic (background) conditions such as dissolved minerals. Other sources of contamination include human activities such as seepage from landfills, chemical contamination from agricultural activities, mineral exploration, mining, construction and hazardous waste spills.

Public systems are rated by the Utah Division of Drinking Water. Systems with below standard water quality are not approved when no action is being taken to correct the problem. When corrective action is underway, this is indicated in the rating. In the West Colorado River Basin, there are currently no unapproved community or non-community water systems.

11.5 Culinary Water Use and Projected Demand

Population projections for the cities and towns in the basin were made by the Governor's Office of Planning and Budget. (See Section 4). These estimates of future population growth are used to project culinary water needs. Many public water suppliers expect an increased demand in the next 20 to 30 years. Table 11-4 shows the current and projected culinary water diversions for the basin’s counties.

Table 11-4
Current and Projected
Culinary Water Diversions[1]

County	1996	Year 2010 (acre-feet)	2020
Carbon	9,048	10,600	11,700
Emery	3,582	4,100	4,300
Garfield	633	800	1,000
Kane	441	600	700
Sanpete	2	3	5
Sevier	22	30	40
Wayne	872	1,100	1,400
Utah	1	1	1
TOTALS	14,601	17,234	19,146

[1]Includes public community and non-community water systems, private domestic and self supplied industries.

11.6 Alternative Solutions

Needed water source development will be a reflection of the basin’s population increases. The water needed could come from several sources, including surface water, groundwater and conservation.

It is expected the increased use of culinary water will mostly come from undeveloped water rights and the purchase of agricultural water rights. Future development of the Navajo sandstone groundwater aquifer should be investigated. This is particularly true in Garfield and Wayne counties where considerable use is currently from groundwater (also see Section 19). Surface water will probably provide an increasing proportion of the culinary water supply in Carbon and Emery counties. In order to use developed and undeveloped surface water efficiently, existing treatment plants will need to be enlarged. These water use projections can be used to help determine when new water supplies will be needed to meet future culinary demands. All water suppliers face challenges of water source capacity, storage capacity, legal capacity and distribution system capacity. Suppliers will face ongoing challenges of procuring water rights and maintaining water infrastructure to meet peak daily flow and annual water delivery requirements.

Storage facilities must have sufficient capacity to meet indoor water demands, lawn and garden irrigation needs, and fire flow demands. The water distribution system capacity must be adequate to meet demands at the point of use. Even if there is adequate water at the supply source and storage sufficient to meet peak demands, it will all be for naught if the distribution system is inadequate. During drought years, outside watering could be curtailed. ●

Section 12 - West Colorado River Basin
Water Quality

12.1	Introduction	12-1
12.2	Setting	12-1
12.3	Regulatory Organizations	12-5
12.4	Water Quality Problems	12-12
12.5	Water Quality Needs	12-15
12.6	Alternative Solutions	12-16
12.7	Policy Issues and Recommendations	12-16

Tables

12-1	Wastewater Systems	12-2
12-2	Surface Water Quality of Selected Streams	12-3
12-3	Point Source Discharge Permits	12-7
12-4	Surface Storage Classifications	12-8
12-5	Stream Classifications	12-10

Section 12

West Colorado River Basin - Utah State Water Plan

Water Quality

12.1 Introduction

Passage of the Utah Water Pollution Control Act of 1953 ushered the state into maintaining high quality water resources. The Federal Water Pollution Control Act in 1972 brought about major changes, particularly in the wastewater treatment plant program.

The Utah Water Quality Board has adopted regulations and set water quality standards that are enforced statewide. Significant progress has been made since 1972 on improving water quality; however, there is still much to be accomplished.

The Governor of Utah issued an executive order in 1984 to prepare and implement a plan for the protection of groundwater. As a result, the Utah Department of Environmental Quality (DEQ) prepared and, after public comment, implemented the *Ground Water Quality Protection Strategy for the State of Utah*. The DEQ also issued a proposed strategy in 1997 to implement the Safe Drinking Act in Utah which contains some water quality regulations (see Section 11).

12.2 Setting [34, 48, 55]

Many smaller communities use individual family septic tanks. The majority of incorporated towns use lagoons. The communities with wastewater treatment facilities are listed in Table 12-1. Boulder and Cannonville are planning centralized wastewater treatment facilities in the near future.

Streams in the basin flow from areas considerably different from each other in geology, land use, vegetation, altitude and climate. Water quality is measurably affected by these differences. The kinds of minerals dissolved in water and affecting water quality are determined by rock and soil composition, climate, biological effects of plants and animals, and water management and use as the water flows downstream.

Good quality water is an indicator of a healthy, well-managed environment.

Table 12-2 shows electro-conductivity (EC) and total dissolved solids (TDS) values for selected streams within the West Colorado River Basin. Average values are all flow weighted.

When natural erosion levels are high, it is generally because of low densities of native vegetation, steep gradients and unstable substrates. This erosion contributes to sediment-loading, turbidity, concentration of trace elements, high biological oxygen demand and salinity. Accelerated erosion from man-caused sources compounds these same problems.

Sewage lagoons near Cannonville

Table 12-1 Wastewater Systems	
Facility	Type
SOUTHEAST DISTRICT HEALTH DEPARTMENT	
Carbon County	
Clear Creek	Drainfield
Columbia	Total Containment Lagoon
East Carbon	Total Containment Lagoon
Hiawatha	Total Containment Lagoon
Kenilworth	Total Containment Lagoon
Price River	Trickling Filter/Solids Contact
Scofield SSD	Drainfield
Soldier Creek Campground	Total Containment Lagoon
Emery County	
Castle Dale/Orangeville	Aerated Discharging Lagoon/ Slow Sand Filter
Cleveland	Total Containment Lagoon
Elmo	Total Containment Lagoon
Emery	Total Containment Lagoon
Ferron	Aerated Discharging Lagoon
Green River	Total Containment Lagoon
Hunter Power Plant	Total Containment Lagoon
Huntington	Aerated Discharging Lagoon/ Slow Sand Filter
Huntington Power Plant	Facultative Discharging Lagoon
Clawson	Total Containment Lagoon
SOUTHWEST DISTRICT HEALTH DEPARTMENT	
Garfield County	
Escalante	Total Containment Lagoon
Ticaboo	Total Containment Lagoon
Tropic	Total Containment Lagoon
CENTRAL UTAH DISTRICT HEALTH DEPARTMENT	
Sevier County	
Fish Lake	Total Containment Lagoon
Wayne County	
Hanksville	Total Containment Lagoon

Source: Department of Environmental Quality

Table 12-2
Surface Water Quality of Selected Streams

Stream Gage Number and Name	Electro Conductivity (Micromho/CM @ 25°C)			Total Dissolved Solids (mg/l)			No. of Samples
	Max.	Min.	Av.	Max.	Min.	Av.	EC/TDS
09309600 Fairview Tunnel near Fairview, Utah	420	150	272				44/
09310000 Gooseberry Creek near Scofield, Utah	550	120	289	146	90	113	124/4
09310500 Fish Creek above reservoir near Scofield, Utah	640	25	341	226	169	196	143/15
09310575 Boardinghouse Creek at mouth south of Scofield, Utah	560	235	307	312	155	182	20/17
09310700 Mud Creek at Scofield, Utah	1050	295	422	391	171	238	91/41
09311500 Price River near Scofield, Utah	353	298	328	203	175	191	13/5
09312600 White River below Tabbyune Creek near Soldier Summit, Utah	900	240	544	372	312	319	171/7
09312700 Beaver Creek near Soldier Summit, Utah	600	240	357	271	203	214	109/7
09312800 Willow Creek near Castle Gate, Utah	1360	360	667	510	410	446	153/2
09312900 Willow Creek at Castle Gate, Utah	1220	450	644	749	279	378	21/10
09313000 Price River near Heiner, Utah	930	265	447	584	188	253	50/22
09313950 Price River at Wellington, Utah	2940	864	1984	1780	612	1585	4/2
09313965 Coal Creek near Helper, Utah	1100	760	829	567	475	525	18/4
09313975 Soldier Creek below mine near Wellington, Utah	1190	500	639	634	353	399	31/15
09314250 Price River below Miller Creek near Wellington, Utah	5000	720	1318	3050	1020	1853	131/7
09314280 Desert Seep wash near Wellington, Utah	10400	1390	6361	5970	2200	5670	98/3
09314340 Grassy Trail Creek at Sunnyside, Utah	2450	510	700	1350	332	425	44/19
09314500 Price River at Woodside, Utah	7540	760	2489	7060	480	2078	966/807
09314600 Price River at mouth, near Green River, Utah	6770	3750	4273	6270	3040	3602	3/3
09315000 Green River at Green River, Utah	3240	7	679	3440	196	468	1284/1052
09316100 Floywash at Hwy Bridge 6&50 near Green River, Utah	3760	2080	3175	1930	1930	1930	13/1
09317919 Crandall Canyon at mouth near Huntington, Utah	580	375	445	304	229	250	20/10
09317920 Tie Fork Canyon near Huntington, Utah	580	410	454	259	185	239	17/5
09317997 Huntington Creek near Huntington, Utah	470	290	348	253	164	193	24/12
09319000 Ephraim Tunnel near Ephraim, Utah	390	200	274	125	125	125	42/1
09324000 Seely Creek near Orangeville, Utah	928	278	383	267	141	165	13/11

Table 12-2 (Continued)
Surface Water Quality of Selected Streams

Stream Gage Number and Name	Electro Conductivity (Micromho/CM @ 25°C)			Total Dissolved Solids (mg/l)			No. of Samples
	Max.	Min.	Av.	Max.	Min.	Av.	EC/TDS
09324200 Cottonwood Creek above Straight Canyon near Orangeville, Utah	660	470	576	341	299	321	12/3
09324500 Cottonwood Creek near Orangeville, Utah	1700	340	390	1170	200	227	100/88
09326500 Ferron Creek (Upper Station) near Ferron, Utah	920	340	424	331	217	227	185/7
09327550 Ferron Creek below Paradise Ranch near Clawson, Utah	6030	11	1134	5760	391	922	92/79
09328000 San Rafael River near Castle Dale, Utah	6900	600	1432	6010	2210	2542	112/7
09328100 San Rafael R. at San R. Bridge Campground near Castle Dale, Utah	7200	660	1593	6030	453	1759	103/83
09328500 San Rafael River near Green River, Utah	6270	56	1931	6430	416	1604	1318/878
09329050 Seven Mile Creek near Fish Lake, Utah	195	77	114	86	69	74	102/2
09329500 Fremont River near Fremont, Utah	380	190	198	270	115	123	5/5
09329900 Pine Creek near Bicknell, Utah	290	60	121				85/
09330000 Fremont River near Bicknell, Utah	650	105	485	365	317	337	95/3
09330210 Pleasant Creek near Caineville, Utah	1600	612	1026	712	448	613	21/3
09330230 Fremont River near Caineville, Utah	3060	320	670	3010	402	1145	172/14
09330410 Bull Creek near Hanksville, Utah	720	245	332	462	462	462	31/1
09330500 Muddy Creek near Emery, Utah	730	286	393	250	175	219	382/16
09331850 Convulsion Canyon near Emery, Utah	1360	690	943	796	417	517	10/8
09331900 Quitchupah Creek near Emery, Utah	4150	890	1727	2690	1160	1488	66/18
09331950 Christiansen Wash near Emery, Utah	5550	690	1753	4100	449	1387	82/34
09332100 Muddy Creek below I-70 near Emery, Utah	5370	580	1424	3450	673	1598	288/38
09332700 Muddy Creek at Delta mine near Hanksville, Utah	5890	870	1916	4500	694	1522	130/96
09332800 Muddy Creek at mouth near Hanksville, Utah	9200	1430	5013	6730	922	3879	68/66
09333500 Dirty Devil River above Poison Spring Well near Hanksville, Utah	5000	900	1804	3240	1500	2043	151/5
09337000 Pine Creek near Escalante, Utah	1140	3	334				135/
09337500 Escalante River near Escalante, Utah	4350	280	856	3240	456	865	142/6
09381900 Paria River at White House Ruins near Glen Canyon, Utah	2880	1060	1963	2770	786	1658	18/16

Source: EPA - SRORET

The Division of Water Quality (DWQ) is initiating a more formal water quality planning process called the Watershed Protection Approach. This will be a systematic effort to be carried over a five-year cycle which will cover an entire watershed and/or groundwater recharge area, and will incorporate all of the division's water quality programs. This will allow an intensified monitoring program and will fit the National Point Discharge Elimination System programs licensing cycle.

The DWQ is currently conducting an intensive study of the West Colorado River Basin surface water quality. The Watershed Protection Approach has as its goal the protection of the watershed through the efforts of stakeholders, those influential and interested parties throughout the watershed that can resolve water quality problems in the basin.


Non-point source pollution in Fremont Valley

12.3 Regulatory Organizations

Leadership in maintaining water quality rests with local governments, with assistance from state and federal regulatory agencies and programs.

12.3.1 Local

Towns, cities and counties have primary responsibilities for water quality within their respective entities. These responsibilities and authorities are contained in Titles 10, 11, 17, 19 and 73 of the *Utah Code Annotated*, 1953, amended.

The Board of Health also has certain responsibilities for the control of public waste water, water pollution, septic tank construction and installation, and vector (mosquito) control. These duties are carried out through their staff. The Southwest, Southeast and Central Utah Public Health departments and the Utah Department of Environmental Quality work together on related regulations and activities for the basin.

12.3.2 State [27, 40]

The DWQ is responsible to adopt, enforce and administer state and federal water quality regulations. This includes the Utah Water Quality Act and the federal Clean Water Act. They are charged to maintain acceptable levels of water quality for a growing population. Increasing numbers of people also bring more recreational activity with added potential for pollution to surface streams and reservoirs as well as groundwater. In addition, water quality agencies and water rights administrators will be required to correlate their activities to assure state standards are met.

The Clean Water Act gives responsibility to the DWQ for the enforcement of regulations dealing with point and non-point source discharges. The DWQ is responsible for administration of the National Pollutant Discharge Elimination Systems (NPDES). The DWQ is also responsible for implementing the non-point source pollution program, in conjunction with the Utah Department of Agriculture and Food.

Limits on loading rates of various pollutants are usually established by the state with consideration given to Environmental Protection Agency guidelines. Municipal wastewater treatment facilities and industries discharging pollutants into Utah waters are issued a Utah Pollutant Discharge

Elimination System (UPDES) permit. These permits are valid for five years and must be renewed with a reevaluation of pollutant limitations.

Enforcement of NPDES/UPDES permit requirements is accomplished by effluent monitoring programs supervised by DWQ. Currently, four wastewater facilities and 34 industries have discharge permits. See Table 12-3 for a list of permittees.

The DWQ developed a *Ground Water Quality Protection Strategy* for the state of Utah based on an executive order by the governor in 1984. Groundwater discharge permits are required for activities with the potential for pollution. The DWQ has also established classifications for surface water in Utah based on anticipated uses. To help control water quality, the streams and lakes are given beneficial use designations. These uses are: 1) Source for drinking water, 2) for swimming and indirect contact recreation, 3) stream/lake/wetland dependent fish and wildlife, and 4) agriculture. Table 12-4 shows the current water quality classes and other pertinent information for the water storage facilities. Table 12-5 shows the classification of streams.

The Utah Department of Agriculture and Food, Environmental Quality Section, and the state DWQ administer a non-point water pollution control and prevention program. This program is funded by Environmental Protection Agency grants and matching funds from state and local agencies and private sources. The program includes watershed management projects, surface water and groundwater monitoring, and information and education. Public information programs include newsletters, brochures, videos and slide shows. These are also extended to public schools and adult education.

12.3.3 Federal

Congress passed the federal Water Pollution Control Act in 1972 to establish regulatory programs to improve the quality of the nation's waters. The act was amended in 1977 and became known as the Clean Water Act (CWA). Additional amendments were made in 1987.

The CWA amendments provided regulations to deal with the growing national toxic water pollution problem and to further refine the Environmental Protection Agency's (EPA) enforcement priorities. The amendments substantially increased EPA's authority to enforce all water quality regulations associated with new federal mandates to clean up the nation's streams, rivers, reservoirs and lakes.

In the mid-1950s, the federal government began offering funding programs to state water pollution control agencies to help in the ongoing construction of wastewater facilities. These early grants provided funding to pay for 30 to 55 percent of the total construction costs. This source of funds, along with monies provided through the Utah Water Pollution Control Act, helped finance most wastewater treatment facilities. More than $2.5 million in EPA grants have been spent to construct or enlarge wastewater treatment and collection facilities in the West Colorado River Basin.

Federal public works expenditures drastically decreased by 1990 and most grant programs for construction and upgrades were eliminated. Today, federal wastewater treatment funding is only available through revolving loan programs administered by the Division of Water Quality. In the year 1997, about $2 million was spent for new construction in the West Colorado River Basin.

Federal standards for solid waste and hazardous material are set forth under the Comprehensive Environmental Response and Comprehensive Liability Act (CERCLA) and regulated by the EPA. Compliance is verified through local health department monitoring programs.

Table 12-3
Point Source Discharge Permits

Watershed	Facility	Receiving Water
Price River	Amax Coal-Castle Gate (Mine & Sed Ponds)	Sowbelly, Hardscrabble, Spring creeks & Price River
	Anadarko (Cockrell Oil)	Summit Creek
	Andalex Resources-Pinnacle (Mine & Sed Pond) (Price Airport)	Deadman Creek
	Andalex Resources-Wildcat (Sed Ponds)	Gordon Creek
	Castle Valley Resources (Sed Ponds)	Price River
	Coastal States Energy-Skyline Mine (Sed Pond)	Eccles Creek
	Cyprus-Blackhawk (Sed Ponds)	Willow Creek
	Cyprus-Plateau Mine (Mine & Sed Ponds)	Mudwater Creek
	Horizon Coal Mine	Price River
	Horse Canyon Mine (Mine & Sed Ponds)	Horse Canyon
	Mountain Coal (Sed Ponds)	Gordon Creek
	PacifiCorp-Carbon (Sed Ponds)	Price River
	Price WWTP	Price River
	Savage Industries - CV Spur (Beaver Creek Coal)	Ditch
	Soldier Creek Coal (Mine & Sed Ponds)	Soldier Creek
	Soldier Creek Coal - Dugout Canyon (Mine & Sed Ponds)	Dugout Creek
	Soldier Creek Coal - Load Out US6 (Sed Ponds)	Grassy Trail Creek
	Sunnyside Coal (Mine & Sed Ponds)	Grassy Trail Creek
	Sunnyside Cogeneration (Sed Ponds)	Grassy Trail & Icelander US Fuels
	US Fuels Morhland Mine (Mine & Town Tank)	Cedar & Huntington creeks
	White Oak Mining (Mine & Sed Ponds)	Eccles Creek
San Rafael River	Castledale Lagoons	Cottonwood Creek
	Co-op Mining-Bear/Trail (Mine & Sed Ponds)	Huntington Creek
	Ferron Lagoons	Ferron Creek
	Genwal Coal	Crandle Canyon/Huntington Creek
	Huntington Lagoons	Huntington Creek
	PacifiCorp-Trail Mountain Mine (Mine & Sed Ponds)	Cottonwood Creek
	PacifiCorp-Hunter Sed Ponds	Rock Canyon Creek
	PacifiCorp-Wilberg (Mine & Sed Ponds)	Grimes Wash
	PacifiCorp-Deer Creek (Mine & Sed Ponds)	Deer & Huntington creeks
	PacifiCorp-Des Bee Dove (Mine)	Grimes Wash
Muddy Creek	Consolidated Coal Lagoons	Quitchupah Creek
	Southern Utah Fuel (Mine & Sed Pond)	Quitchupah Creek
Fremont River	Brown Trout Farm FH	Irrigation Canal
	Road Creek FH - Loa	Irrigation Ditch to Spring Creek
	UDWR - Loa FH	Spring Creek
	UDWR - Egan FH	Pine Creek
Lake Powell	Andalex-Smokey Hollow (Mine)	Warm Creek

Source: Division of Water Quality

Table 12-4
Surface Storage Classifications

Name	Beneficial Use Classes*						Trophic Status
Carbon County							
Grassy Trail Creek Reservoir	1C		2B	3A		4	
Olsen Pond			2B		3B	4	
Scofield Reservoir	1C		2B	3A		4	M
Emery County							
Cleveland Reservoir			2B	3A		4	E
Electric Lake			2B	3A		4	M
Huntington Reservoir			2B	3A		4	M
Huntington North Reservoir		2A	2B		3B	4	M
Joes Valley Reservoir	1C	2A	2B	3A		4	O
Millsite Reservoir	1C	2A	2B	3A		4	M
Garfield County							
Barney Lake			2B	3A		4	H
Cyclone Lake			2B	3A		4	
Deer Lake			2B	3A		4	
Jacob's Valley Reservoir			2B	3C	3D	4	M
Lower Bowns Reservoir			2B	3A		4	
North Creek Reservoir			2B	3A		4	
Oak Creek Reservoir (Upper Bowns)			2B	3A		4	
Pleasant Lake			2B	3A		4	
Posey Lake			2B	3A		4	M
Purple Lake			2B	3A		4	
Raft Lake			2B	3A		4	
Row Lake #3			2B	3A		4	
Row Lake #7			2B	3A		4	
Spectacle Reservoir			2B	3A		4	
West Deer Lake			2B	3A		4	
Wide Hollow Reservoir			2B	3A		4	M

Table 12-4 (Continued) Surface Storage Classifications						
Name	Beneficial Use Classes*					Trophic Status
Sanpete County						
Duck Fork Reservoir		2B	3A		4	O
Fairview Lakes	1C	2B	3A		4	O
Ferron Reservoir		2B	3A		4	O
Lower Gooseberry Reservoir	1C	2B	3A		4	M
Miller Flat Reservoir		2B	3A		4	M
Rolfson Reservoir		2B		3C	4	
Twin Lakes		2B	3A		4	
Willow Lake		2B	3A		4	
Sevier County						
Fish Lake		2B	3A		4	O
Forsyth Reservoir		2B	3A		4	E
Johnson Valley Reservoir		2B	3A		4	H
Sheep Valley Reservoir		2B	3A		4	M
Wayne County						
Blind Lake		2B	3A		4	
Cook Lake		2B	3A		4	M
Donkey Reservoir		2B	3A		4	M
Fish Creek Reservoir		2B	3A		4	H
Mill Meadow Reservoir		2B	3A		4	H
Raft Lake		2B	3A		4	

*See Table 12-5.
Trophic Status Index (TSI) refers to the nutrient status, biological production and morphological characteristics of the water.

TSI less than 40 = Oligotrophic or “O”, TSI 40 to 50 = Mesotrophic or “M”,
TSI 50-60 = Eutrophic or “E”, TSI over 60 = Hypereutrophic or “H”. The lower the index number, the better the water.

Source: Division of Water Quality

Table 12-5
Stream Classifications

Stream	Use Classifications					
Price River and tributaries, from confluence with Green River to Carbon Canal Diversion at Price City Golf Course.		2B			3C	4
Price River and tributaries, from Carbon Canal Diversion at Price City Golf Course to Price City Water Treatment Plant intake.		2B	3A			4
Price River and tributaries, from Price City Water Treatment Plant intake to headwaters.	1C	2B	3A			4
Grassy Trail Creek and tributaries, from Grassy Trail Creek Reservoir to headwaters.	1C	2B	3A			4
Range Creek and tributaries, from confluence with Green River to Range Creek Ranch.		2B			3C	4
Range Creek and tributaries, from Range Creek Ranch to headwaters.	1C	2B	3A			4
Rock Creek and tributaries, from confluence with Green River to headwaters.		2B	3A			4
Nine Mile Creek and tributaries, from confluence with Green River to headwaters.		2B	3A			4
Pariette Draw and tributaries, from confluence with Green River to headwaters.		2B		3B	3D	4
Willow Creek and tributaries (Uintah County), from confluence with Green River to headwaters.		2B	3A			4
Bitter Creek and tributaries, from White River to headwaters.		2B	3A			4
Green River and tributaries, from confluence with Colorado River to state line except as listed below:	1C	2B		3B		4
Thompson Creek and tributaries, from Interstate Highway 70 to headwaters.		2B			3C	4
San Rafael River and tributaries, from confluence with Green River to confluence with Ferron Creek.		2B			3C	4
Ferron Creek and tributaries, from confluence with San Rafael River to Millsite Reservoir.		2B			3C	4
Ferron Creek and tributaries, from Millsite Reservoir to headwaters.	1C	2B	3A			4

Table 12-5 (Continued)
Stream Classifications

Stream	Use Classifications				
Huntington Creek and tributaries, from confluence with Cottonwood Creek to Highway U-10 crossing.		2B		3C	4
Huntington Creek and tributaries, from Highway U-10 crossing to headwaters.	1C	2B	3A		4
Cottonwood Creek and tributaries, from confluence with Huntington Creek to Highway U-57 crossing.		2B		3C	4
Cottonwood Creek and tributaries, from Highway U-57 crossing to headwaters.	1C	2B	3A		4
Cottonwood Canal, Emery County.	1C	2B			4
Fremont River and tributaries, from confluence with Muddy Creek to Capitol Reef National Park.		2B		3C	4
Fremont River and tributaries, through Capitol Reef National Park to headwaters.	1C	2B	3A		4
Pleasant Creek and tributaries, from confluence with Fremont River to east boundary of Capitol Reef National Park.		2B		3C	
Pleasant Creek and tributaries, from east boundary of Capitol Reef National Park to headwaters.	1C	2B	3A		
Muddy Creek and tributaries, from confluence with Fremont River to Highway U-10 crossing.		2B		3C	4
Muddy Creek and tributaries, from Highway U-10 crossing to headwaters.		2B	3A		4
Quitchupah Creek and tributaries, from Highway U-10 crossing to headwaters.		2B	3A		4
Ivie Creek and tributaries, from Highway U-10 to headwaters.		2B	3A		4
Dirty Devil River and tributaries, from Lake Powell to Fremont River.		2B		3C	
Escalante River and tributaries, from Lake Powell to confluence with Boulder Creek		2B		3C	
Escalante River and tributaries, from confluence with Boulder Creek, including Boulder Creek, to headwaters.		2B	3A		4
Deer Creek and tributaries, from confluence with Boulder Creek to headwaters.		2B	3A		4

Table 12-5 (Continued) Stream Classifications				
Stream	Use Classification			
Paria River and tributaries, from state line to headwaters.	2B		3C	4
All tributaries to Lake Powell, except as listed separately.	2B	3B		4

Class 1 Culinary raw water source.
Class 1C Domestic use with prior treatment.
Class 2 Instream recreational use and aesthetics.
Class 2A Primary human contact-swimming.
Class 2B Secondary human contact-boating, wading etc.
Class 3 Instream use by aquatic wildlife.
Class 3A Habitat maintenance for cold water game fish, water-related wildlife and food chain organisms.
Class 3B Habitat maintenance for warm water game fish, water-related wildlife and food chain organisms.
Class 3C Habitat for non-game, water-related wildlife and food chain organism.
Class 3D Habitat for water fowl, shore birds, water-related wildlife, and food chain organisms.
Class 4 Agricultural-livestock and irrigation water.
Class 5 Great Salt Lake general use, primary and secondary human contact, water-related wildlife, and mineral extract.
Class 6 General use restricted and/or governed by environmental and health standards and limitations.

Source: Division of Water Quality

12.4 Water Quality Problems

The Utah Department of Environmental Quality, U. S. Geological Survey and others have reports and data on the water quality in the West Colorado River Basin.

Water quality problems caused by pollution from natural geologic conditions is almost impossible to control. This type of pollution becomes more evident as the high water quality in the upper watersheds decreases as the rivers and streams flow downstream.

Other sources of pollution include contaminants from man-caused non-point sources. Concerns have been expressed about contamination from sewer lagoons and dense concentrations of septic tanks. Concerns also exist about water treatment plant effluent contaminating the groundwater. Bacterial contamination can be a problem along with chemical pollution.

12.4.1 Surface Water Problems [56]

Monitoring - The Utah Division of Water Quality and Emery Water Conservancy District have initiated an intensive monitoring program on the San Rafael River drainage system. This program is designed to set the benchmark for further studies which will define sources of pollutants entering rivers in the area. Further studies of chemical and biological loadings will be done where parameters are in exceedence of state water quality standards. The approach is to determine where the problems are, quantify them, and then set out in a systematic approach to reduce them where possible. Where it is impossible to reduce certain exceedences in the state water quality standards, an analysis will be made to evaluate changing the beneficial use classifications to meet the "real world."

A most important component in this effort is the involvement of the local private land owners. They know the problems better than anyone and probably have the best handle on how problems could be solved in their areas. In this regard, citizen advisory boards and steering committees will be established in the future which will give that very important local input to this process. The end result of this extensive effort will be a consensus of all parties as to what needs to be done and what can be done to have all rivers and streams in southeast Utah in compliance with state water quality standards.

Table 12-2, in addition to showing average, maximum, and minimum conductivity and total dissolved solids levels for the various rivers and streams in the study area, reveals a general trend in the Price, San Rafael and Dirty Devil river systems of good quality water high in the watershed and unsuitable water for either agriculture or municipal purposes near the confluence with the Colorado River.

Salinity - As early as 1924 during his fieldwork, Gilludy (1929, page 76) noted :

> "The water of both San Rafael and Muddy Rivers is sometimes so concentrated that even stock will not drink it, but this happens only during the hottest and driest periods."

The Price, San Rafael and Dirty Devil rivers flow through areas where marine shales and sandstone are surface geologic formations and the source of the region's soils. Deep percolation from agricultural lands such as through the Mancos shale saline soils and rocks can produce return flows having total dissolved solids levels approaching 4,000 milligrams per liter (mg/l).

The Bureau of Reclamation estimated in 1986 that 60 percent of the salt loading at the river mouths comes from the irrigation sector in the Price-San Rafael study units, mostly from water lost to deep percolation. Of this amount, about 70 percent originates from salt dissolution caused by deep percolation from agricultural lands, 28 percent from canal seepage, and 2 percent from stock pond seepage. The remaining salt load mostly originates with natural runoff in the desert rangeland area, with some coming from mountain runoff. In order to reduce the amount contributed by irrigated agriculture, higher irrigation efficiencies are recommended. Each acre-foot of water not returning to the system through deep percolation reduces the salt load to the Colorado River by 2.4 tons per year.

The USBR Salinity Control Price-San Rafael Unit would treat approximately 16,350 acres of farmland with gravity-pressure sprinkle irrigation, about 9,650 acres with pump pressure sprinkle systems, and 10,050 acres with improved surface irrigation systems. This project will reduce salt loading to the Colorado River by 161,000 tons per year (See Section 6.6).

Mining Impacts - The impact on the Price, San Rafael and Green rivers from anticipated mining was examined in 1986 by the USGS. It was estimated that mining activities augment the flow of the Price River by as much as 12.6 cfs downstream of Scofield Reservoir and increase the salinity in the river at that point from 10 to 97 percent. In the San Rafael River, mining activities augment the flow from 2.9 to 6.7 cfs at the river outlet and decrease the salinity from 5.3 percent in March to an increase of 0.6 percent in May. As a result of anticipated mining activities in the Price and San Rafael rivers, the salinity of the Green River is expected to increase about 0.8 percent and flow about 0.3 percent.

Sedimentation - A significant water quality problem in the Price and San Rafael rivers drainage is sedimentation. In the central Price River area, four of the seven surveyed reservoirs had lost about 30 percent of their original storage capacity because of sediment deposition. Estimates based on non-standard suspended-sediment samples indicates that the sediment discharge of Price River at Woodside during the 1970 water year was at least 1,400,000 tons. This amount of sediment would cover one square mile to a depth of about one foot. At least one-third of the 1,500 square miles of drainage area upstream from Price River at Woodside probably contributes little sediment to the Price River. The remaining area contributes about 0.8 acre-foot of sediment per square mile.

Aquaculture - Fish farms within the Fremont River Basin affect the water quality of downstream rivers. Runoff from fish farms in the form of concentrated nutrients and fish pathogens can complicate downstream water treatment, decrease impounded water quality and adversely affect fisheries. Downstream waters tend to have higher pH and biological oxygen demand. Point discharge permits for fish farms in the basin are listed back in Table 12-3.

Lake Water Quality - Water quality problems are described below for some of the West Colorado River Basin selected lakes and reservoirs: Cleveland, Electric Lake, Fairview #2, Fish Lake, Huntington, Lake Powell, and Scofield reservoirs. These are, with the exception of Lake Powell, all included on Utah's 303(d) list of water quality impaired water bodies.

The water quality of Cleveland Reservoir is very good. Its waters are considered to be moderately hard with CaCO3 concentrations ranging from 111-126 mg/l. The only parameter outside state water quality standards for defined beneficial uses is occasionally phosphorus. Trophic State Index (TSI) values indicate the reservoir is eutrophic based on secchi depth and chlorophyll measurements, except for 1989 when the reservoir was classified at mesotrophic. During the summer the lake stratifies and has significantly lower dissolved oxygen concentrations in the lower layers.

Electric Lake has been classified as mesotrophic and oligotrophic, but in the latest classification was mesotrophic. The water quality of Electric Lake is good, but dissolved oxygen levels fall off rapidly below the thermocline at six to 11 meters to bottom levels of 1.6 mg/l. Occasionally pH levels rise above the wildlife standard of 9.0, which is not uncommon for lakes during period of high algal production near the surface during the daylight hours.

Good quality water fills Fairview Lake #2, a shallow lake high in the Price River Basin. However, it exceeds state water quality standards for beneficial uses in phosphorus, 36 mg/l measured in 1990, and pH, less than 3 measured in 1992. The latest survey showed the lake to be oligotrophic, but it has been classified as mesotrophic. While oxygen levels are adequate in summer months, fish kills are reported during the winter showing that there is significant biological oxygen demand in the reservoir.

Fish Lake is the largest natural mountain lake in Utah. It is on the Fish Lake Plateau (the sixth highest mountains in the state) and its water quality is good. The lake water is considered soft with a hardness concentration of approximately 46 mg/L (CaCO3). The only parameter that exceeds state standards is phosphorus. Generally, total phosphorus levels have not exceeded the state phosphorus pollution indicator with the exception of a reading of 34.3 in 1989 when total phosphorus values exceeded the indicator throughout the water column. This typically oligotrophic lake was characterized as mesotrophic in that instance. Near the bottom of the lake, anoxic conditions have existed in the last two lake surveys. Since the retention period of the lake, 58.5 years, is so high, water quality problems which arise from pollutant loading could persist for many years.

Huntington Reservoir is a mesotrophic reservoir high in the Huntington Creek watershed with very good water quality. The only parameter that has exceeded state standards for beneficial use is phosphorus, 42 mg/l in the hypolimnion during June 1992.

Water quality in Lake Powell, one of the largest man-made reservoirs in the United States, is good. However, records indicate that some records within the lake have exceeded state standards in coliform counts and have had exceedences of selenium and mercury concentrations for wildlife. Federal and state studies are assessing and documenting the effect and hazard of heavy metals found in the food chain within the reservoir. One researcher indicated that in the early 1990s a striped bass from Lake Powell was tested that exceeded standards for selenium in the tissues for edible fish. Fish tested from Lake Powell tend to have heavy metals contamination similar to deep sea fish like tuna, 0.2 to 0.7 parts per million. The most recent classification of the reservoir showed it to be oligotrophic, but characterizations have ranged between mesotrophic and oligotrophic.

Scofield Reservoir is located high in the drainage of the Price River and has fair water quality. Water quality impairments have been observed with excesses of phosphorus and too little dissolved oxygen in the water column. The average concentrations of total phosphorus in the water column has usually exceeded the recommended phosphorus pollution indicator level with concentrations of up to 54 mg/l. A Phase I Clean Lakes 314 Study was completed in 1983 for Scofield Reservoir which indicated that the water quality of the reservoir was good by most standards. The latest studies of the reservoir have shown it to vary between hypereutrophic to mesotrophic (1990-1992). At times, dissolved oxygen levels have been low near the surface and dropped rapidly with no oxygen below a depth of 5 meters.

In the fall of 1991, Scofield Reservoir was treated for the removal of rough fish such as carp. Prior to treatment, one factor contributing to the increased eutrophication of the reservoir was the increase in the internal phosphorus loading to the reservoir from the resuspension of sediments by non-game fish. With the eradication of rough fish, the water quality of the lake seems to have improved.

12.4.2 Groundwater Quality Problems

Potential sources of groundwater pollution include those from agricultural operations, various types and methods of waste disposal, and operations such as mining and oil and gas exploration. See Section 19, Figure 19-3 for location of the groundwater reservoirs.

The protection of groundwater recharge areas for consolidated rock and alluvium are critical to water quality. In potential recharge areas where the aquifer is exposed, it can be contaminated by precipitation and streamflow leaching pollutants left in or on the land. Alluvial aquifers are especially vulnerable to pollution and, in some cases, the aquifers have already been adversely affected by the activities of people.

Groundwater is found in large areas in the West Colorado River Basin, but only a few reservoirs are suitable for municipal or agricultural uses. Groundwater quality in the upper watershed area in each drainage is suitable for either irrigation or municipal purposes. The water quality deteriorates in the mid and lower portions of the Price, San Rafael and Dirty Devil basins, due to the geology.

Aquifers intimately connected to surface recharge zones tend to be fresher than deeper, less connected aquifers. Deeper sandstone aquifers containing water trapped in storage for long periods of time and disconnected from the surface hydrologic cycle have mean salinities within a range of 6,200 milligrams per liter to 14,000 milligrams per liter of total dissolved solids.

In the northern San Rafael Swell area, the Navajo Sandstone is the shallowest, the most permeable, and contains the freshest water. Because of the proximity of saline aquifers below it as well as the poor quality surface water near the aquifer, large scale development of the Navajo sandstone aquifer is generally not practical.

12.5 Water Quality Needs

Man-caused pollution along with natural causes and recent and future growth and development will impact the water quality. The following ongoing water quality and monitoring programs are needed so the water resources can be adequately analyzed:

- Routine and intensive monitoring is needed. There may be locations where monitoring of exceptional events is needed.
- A detailed inventory of severely eroding watersheds is needed. This will provide a base for monitoring of best management practices (BMPs) applied to critical areas. Testing of surface water as well as groundwater is also needed to determine if and where nutrient (fertilizer) and/or pesticide contamination has occurred.

- Further studies and sampling are needed of lakes and reservoirs and of water quality near mines.
- Monitoring septic tanks and leaking underground storage tanks can determine whether they are causing contamination and to what extent.

In addition, riparian communities need to be re-established along parts of the river corridors where recreational impacts and grazing have destroyed the vegetation and compacted the soils. These impacts increase runoff which, in turn, increases salt and suspended solids in the streams. Many of the stream segments where riparian vegetation has been severely damaged are located in areas where there is accelerated erosion.

12.6 Alternative Solutions

Pollution caused by man's activities can be controlled or at least reduced. Landfill locations can be controlled by elected officials and government agencies working together. They should be located in areas where surface water or groundwater will not become contaminated through leaching or runoff. Controls on construction and other land surface disturbances will also reduce pollution.

Increasing irrigation efficiencies can go a long way toward reducing the leaching of chemicals out of the soil. Technology is available to help reduce this source of pollution. Nutrient management, hayland management, cropping sequence and waste utilization are good alternative solutions.

In some areas, domestic livestock and/or wildlife or other causes have depleted the land cover. Practices to re-establish vegetation will reduce erosion and the resulting pollution. In the case of federal Forest Service or BLM lands, best management practices (BMPs) will be implemented and grazing practices can be changed. Logging practices may require a buffer to protect streams.

All local government entities should work with state agencies in implementing local groundwater protection programs. Groundwater recharge areas should be identified, zoned and use controlled where there is danger of contamination.

The Environmental Protection Agency's Section 319 Nonpoint Source Pollution Control Program administered by the Division of Water Quality and carried out by the Utah Department of Agriculture can provide funds and technical assistance to reduce non-point pollution in critical watersheds. Controlling erosion and the resultant sediment production can reduce contamination of surface water flows. Where private land is involved the solution is the same. For example, if a particular private operation is contributing to elevated fecal coliform bacteria and nutrients into a river, this program could give financial assistance to provide constraint berms or cement manure bunkers to keep this waste from the river.

12.7 Policy Issues and Recommendations

The two issues are water quality monitoring and management throughout the basin and methane gas production in Carbon and Emery counties.

12.7.1 Groundwater Quality Monitoring

Issue - Groundwater quality should be more closely monitored in the West Colorado River Basin.

Discussion - The groundwater quality and its vulnerability is not well documented, making it difficult to monitor and measure possible changes. The impact of groundwater quality problems is likely to increase in the future. Increased long-term monitoring is imperative to manage the groundwater reservoirs. This will require an increase in program funding that should be shared at local, state and federal levels.

Recommendation - The divisions of Water Quality and Water Rights, in cooperation with the U. S. Geological Survey, should develop and carry out a groundwater quality monitoring program with assistance from local units of government.

12.7.2 Methane Gas Production from Extracted Coal-bed Saline Water

Issue - Saline water extracted from one aquifer and re-injected into another should be monitored.

Discussion - Coal-bed methane gas is being extracted by several entities in Emery and Carbon counties and may continue for several years. In this process, groundwater is extracted, collected and re-injected under high pressure into the deeper Navajo sandstone aquifer. The protection of groundwater quality within adjacent aquifers is critical. The results of that process on water quality are, for the most part, unknown. Local government has expressed the desire for the regulatory agencies which oversee the extraction of coal-bed methane to gather more data on the effects of this process.

Water monitoring wells and existing production wells could be used to identify the groundwater, its quality, and the effects of the extraction and re-injection into the deeper aquifers.

Recommendation - Communication, coordination and cooperation by and among DOGM, DEQ, DWRe, DWRi, gas companies, local water user groups, and other affected persons and entities should be encouraged for the benefit and protection of groundwater within the basin. ●

Section 13 - West Colorado River Basin
Disaster and Emergency Response

13.1	Introduction	13-1
13.2	Background	13-1
13.3	Organizations and Regulations	13-1
13.4	Water-Related Problems	13-2
13.5	Flood Preventions and Drought Reduction Alternatives	13-8
13.6	Disaster Response Recommendations	13-8
13.7	Policy Issues and Recommendations	13-11

Figures

13-1	Price 100-Year Flood Plain	13-4
13-2	Castle Dale 100-Year Flood Plain	13-5
13-3	Loa 100-Year Flood Plain	13-6
13-4	Escalante 100-Year Flood Plain	13-7

Tables

13-1	Disaster Response Responsibility	13-3
13-2	Available Flood Plain Maps	13-8
13-3	Major West Colorado River Basin Canals	13-9

Section 13

West Colorado River Basin - Utah State Water Plan

Disaster and Emergency Response

13.1 Introduction

This section discusses flood hazard mitigation and disaster response related to possible pre-disaster or immediate actions at the time of the disaster to protect the water resources. It also describes programs and mechanisms now in place along with those needed.

It is generally inefficient to react to a disaster or emergency after it has occurred. This wastes time, money and other resources. There is also the possibility of loss of life and threats to health and welfare. Pre-disaster activities such as flood plain management, hazard mitigation and mitigation planning are the preferred approaches.

13.2 Background [17]

All levels of government have the statutory authority to carry out disaster-related programs, including pre- and post-disaster hazard activities. There is one problem. No one entity has all of the necessary authority to implement actions to mitigate a specific hazard or disaster. The *Utah State Water Plan* (1990) discusses the specific authorities and assistance programs available to the various agencies. These are discussed in Section 3, Introduction; Section 13, Disaster and Emergency Response; and Section 16, Federal Water Planning and Development. The Division of Comprehensive Emergency Management (CEM) is responsible for disaster and emergency response at the state level while the Federal Emergency Management Agency and the Corps of Engineers are responsible at the federal level. Requests for federal assistance should be made through CEM.

Society must protect its water resources from any disaster or emergency. Preparedness is the key to alleviating traumatic experiences for those affected.

13.3 Organizations and Regulations [54]

To effectively prepare for most types of disasters and manage the eventual clean-up and/or rebuilding process, a complex organization consisting of local, state and federal agencies has been put in place.

13.3.1 Local

Local governments are required by the Division of Comprehensive Emergency Management to carry out the following tasks to provide an effective first response:

- Prepare an emergency operations plan for the coordination of local and county emergency responses, and link it to potential assistance from appropriate federal and state agencies.
- Provide necessary resources (including special supplies and equipment) to support emergency relief operations and list these resources. Procedures to be followed for obtaining assistance and use of resources in the emergency operation plans should be included.
- Assign and train personnel needed to carry out disaster relief functions.
- Provide the State Disaster Coordinating Officer with copies of current emergency operations plans.

- Recommend changes to state and local emergency disaster relief procedures and assigned functions as needed.

Cities and counties have primary responsibility for disaster response as stated in Titles 10 and 17 of *Utah Code Annotated*, *1953*, as amended. Most local governments have delegated disaster responsibilities to specific individuals. Positions responsible for disaster response in each county are shown in Table 13-1.

13.3.2 State

The Division of Comprehensive Emergency Management (CEM) provides a statewide system or plan encouraging and assisting counties and cities with activities relating to emergencies and disasters including emergency response and management plans. These are comprehensive in scope but allow effective and close cooperation with state and federal agencies in event of a disaster beyond local capabilities. The CEM also works closely with other state and federal agencies to assure needed resources reach areas seriously affected by a major disaster. This is done primarily through the Inter-Agency Technical Team (IAT) consisting of technical experts from virtually every discipline relating to water and natural resources representing many state and federal agencies. The CEM's hazard mitigation officer is the coordinator for the IAT and may be contacted at 538-3400 for assistance.

When the extent of the disaster or emergency is beyond local capability, the governor, at his discretion, can declare a "state of emergency" and provide state assistance. The governor may also request federal assistance if deemed necessary. At this time, the State Disaster Coordinating Officer (SDCO) becomes the governor's primary contact and assumes all responsibility for distributing state and federal assistance to alleviate local disasters. This is carried out in cooperation with local disaster officials.

13.3.3 Federal [23]

The President of the United States may declare a major disaster at any time, usually at the governor's request. At this time, federal assistance is provided for disaster response, recovery, preparedness and mitigation through the Federal Emergency Management Agency (FEMA). This assistance is distributed under the direction of the federal coordinating officer designated by FEMA and the SDCO.

Other federal agencies also have disaster-related assistance programs. Most of these can be invoked under agency policies and guidelines even though a presidential disaster declaration does not exist. These are generally coordinated through state and local officials. Specific programs are provided by agencies such as the Corps of Engineers, Farm Service Agency, Natural Resources Conservation Service and Civil Air Patrol.

The National Flood Insurance Program (NFIP) is administered by FEMA. This program requires flood insurance on all development in the flood plains as determined by topographic surveys. Lack of flood insurance denies use of any federal or federally insured monies for development in flood plains.

13.4 Water-Related Problems

Water-related problems are going to occur; it's just a matter of where and when. Preparing ahead of time can reduce the effects of disasters and emergencies, saving time, money, suffering, and possibly even preventing loss of life.

13.4.1 Floodwater Problems

Emergency flooding in the West Colorado River Basin is caused by three types of storms. One of these is the general winter storm occurring between November and April, producing the upper watershed snowpack. The other two are the general storms occurring between May and October and the summer thunderstorms which normally occur between July and October.

Sustained flooding is usually a result of extremely high snow packs in the upper watershed areas. Floods of this nature usually impact the Price River, San Rafael River, Muddy Creek, Fremont River, and Escalante and Paria rivers. High peak flood flows are the result of local thunderstorms concentrating in smaller areas.

Table 13-1
Disaster Response Responsibility

County	Responsible Position	Telephone Number
Carbon	Director - Emergency Services	(435) 636-3290
Emery	Sheriff - Civil Defense	(435) 381-2404
Garfield	Sheriff - Emergency Services	(435) 676-2678
Grand	Director - Emergency Management	(435) 259-1363
Kane	Director - Emergency Services	(435) 644-2551, Ext. 40
Sanpete	Director - Civil Defense	(435) 835-2191
Sevier	Director - Emergency Services	(435) 896-4890
Utah	Director - Emergency Management	(801) 343-4131
Wayne	Director - Emergency Management	(435) 425-3040

Natural and man-made obstructions such as bridges across streams, brush, large trees and other vegetation growing along streambanks in floodplain areas can also effect flooding. In general, obstructions restrict flood flows and can cause over-bank flows; unpredictable areas of flooding; destruction of or damage to bridges, homes and businesses; and increased flow velocity immediately downstream resulting in channel scouring. A new flash-flood potential indicator is now used by the National Weather Service, National Park Service and local television stations to warn recreationists using these areas.

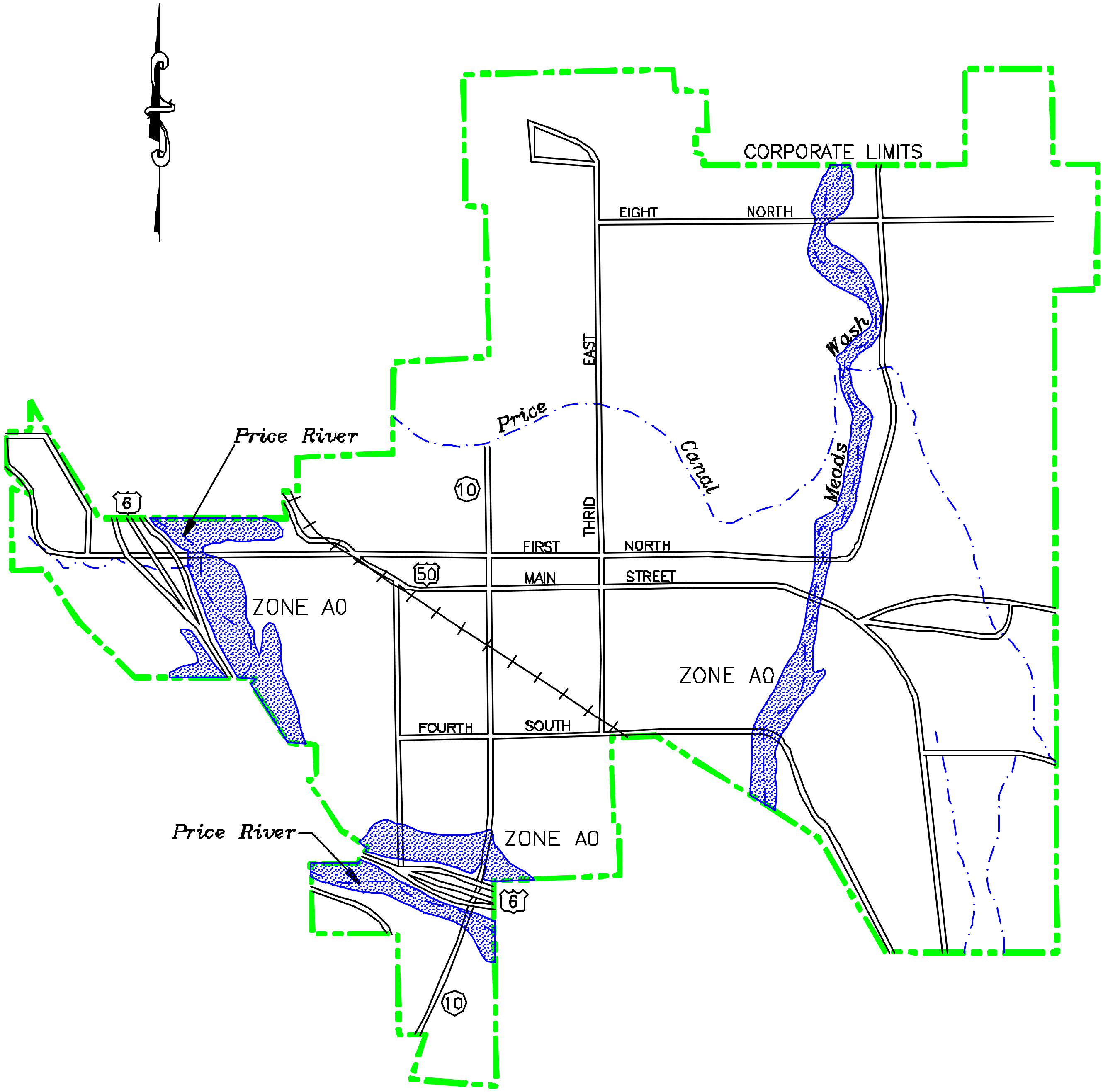
Alluvial fan flooding is usually characterized by unpredictable flow paths and high velocities that occur with little advance warning. Development pressure on alluvial fan areas is intensifying, creating a critical need to provide guidance to communities, developers and citizens on how to safely accommodate growth while protecting lives and property.

Flood plain maps have been prepared for many communities. Figures 13-1, 13-2, 13-3 and 13-4 show examples for Price, Castle Dale, Loa and Escalante. Table 13-2 lists all of the Division of Community Emergency Management flood plain maps available in the West Colorado River Basin. The Federal Emergency Management Agency flood plain boundaries shown are approximate, and those living outside the boundaries should not assume they are without risk from flooding.

In many communities located within the West Colorado River Basin, the danger of potential irrigation canal breaks exists. Many canals are built on hillsides above towns and pose a threat to the population. Table 13-3 lists the basin's major canals that may have a potential for damages to the resident population if they were to breach or break.

13.4.2 Droughts

Drought caused by low average precipitation is a continuing problem because most of the basin is low in elevation with only the western rim, the Wasatch Plateau and the Boulder Mountains rising high enough to have a major orographic effect. The relatively low snowpack limits the annual water yield rates along with corresponding streamflow volumes and groundwater aquifer recharge. Refer to Section 5, Water Supply and Use, for streamflow data and to Section 19, Groundwater, for aquifer information.



Legend

100–Year Flood Plain Area

Zone A0 Flood Depths 1–3 Feet and Velocities Determined.

Source: Federal Emergency Management Agency (FEMA)
Effective date: 12–3–93

Figure 13–1

PRICE 100–YEAR FLOOD PLAIN
West Colorado River Basin

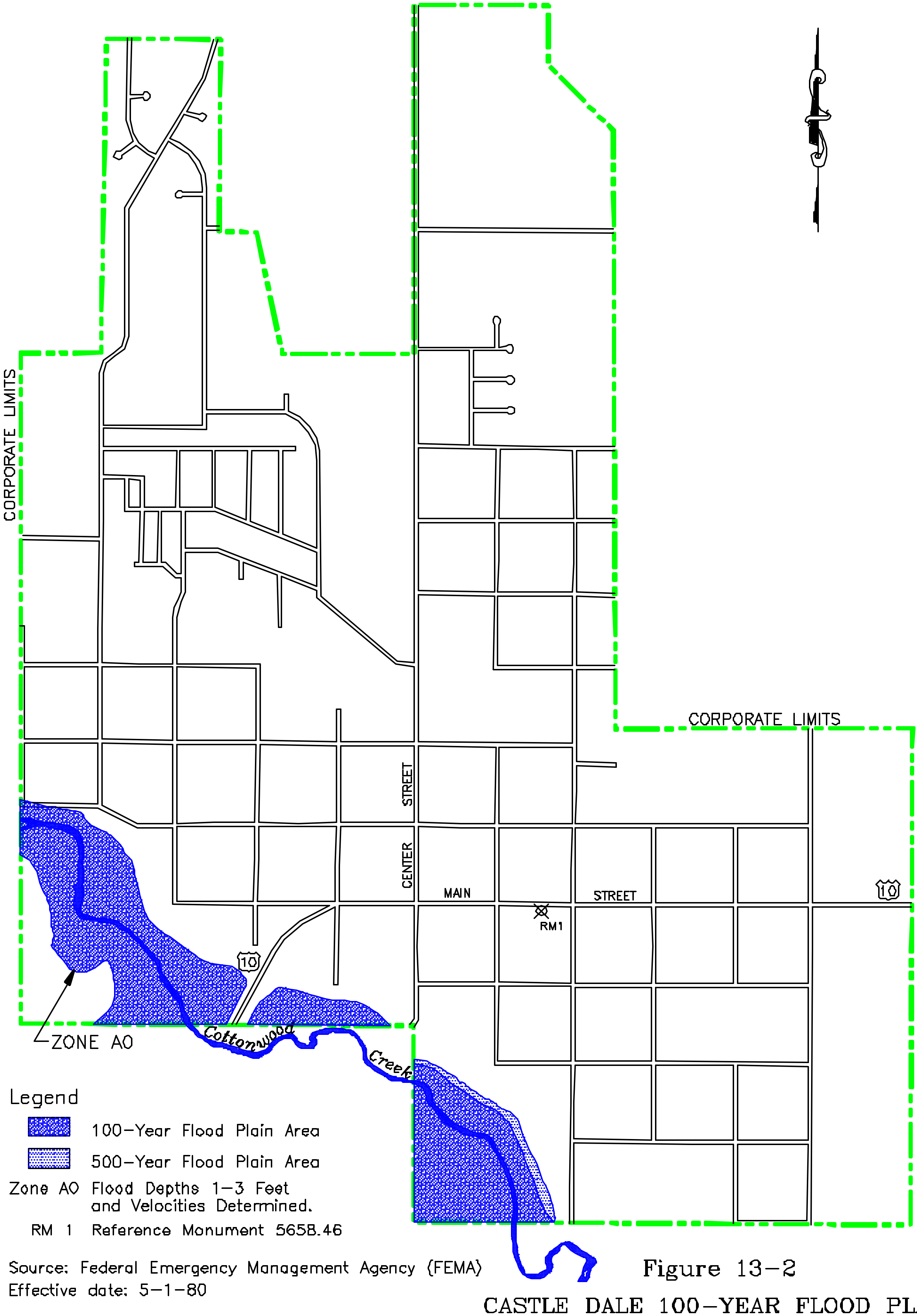


Figure 13-2

CASTLE DALE 100-YEAR FLOOD PLAIN
West Colorado River Basin

Legend

100-Year Flood Plain Area

Zone AO Flood Depths 1-3 Feet
and Velocities Determined.

Source: Federal Emergency Management Agency (FEMA)
Effective date: 12-20-74

Figure 13-3

LOA 100-YEAR FLOOD PLAIN
West Colorado River Basin

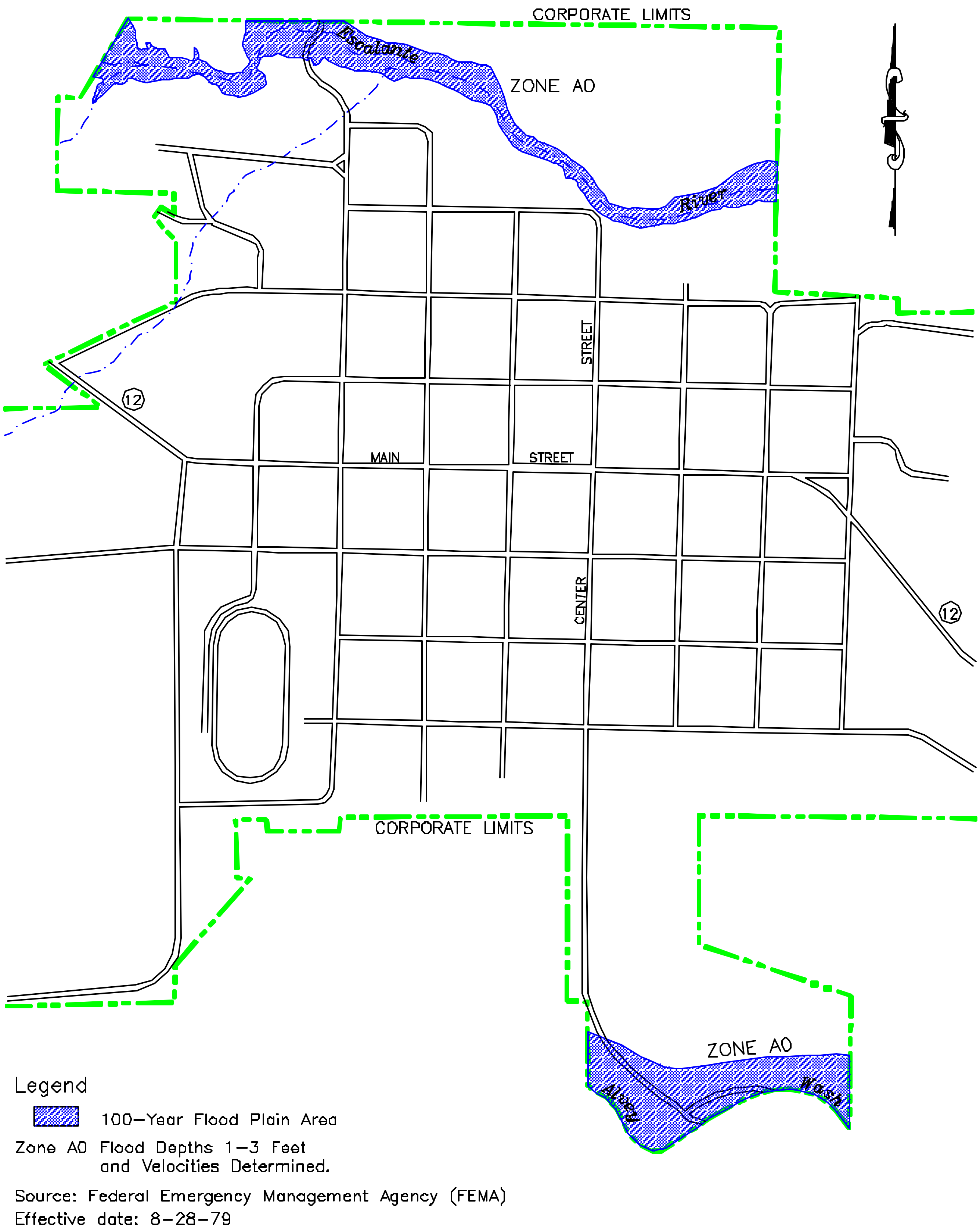


Figure 13–4

ESCALANTE 100–YEAR FLOOD PLAIN
West Colorado River Basin

Table 13-2
Available Flood Plain Maps

Counties	Towns or Areas
Carbon	Unincorporated County Helper Price East Carbon Sunnyside
Emery	Castle Dale Emery Green River Orangeville Huntington Ferron
Wayne	Loa
Garfield	Unincorporated County Escalante Tropic Henrieville
Kane	Unincorporated County

13.4.3 Other Water-Related Disasters

Other disasters can impact water supplies. These disasters include such things as structural failure of water supply facilities, toxic spills, sabotage, landslides and earthquakes. Generally, these are more localized in nature than flooding or drought. Toxic spills are most likely to occur along highways such as those in Price Canyon, Huntington Canyon, along I-70, the lower Fremont River, and through Escalante and Boulder.

13.5 Flood Prevention and Drought Reduction Alternatives

For the most part, water storage reservoirs only have a moderate effect on the flood flows in major drainages. Their effect is greater as the drainages become smaller. Studies should be made to determine the flood control possibilities of reservoirs on the major drainages where there are recurring floods. Recent studies of the West Colorado River Basin by the Corps of Engineers have determined flood control structures are not economically justified from a federal perspective. However, local efforts should be undertaken if flood control funds become available. See Section 9.5.2 for data on potential reservoir sites that could include flood control features.

In conjunction with the flood control studies, investigations should be conducted in the upper watershed areas to determine the possibility of long-range flood reduction through installation of non-structural measures and applying good management activities. Flood plain management is a viable alternative especially where they serve as groundwater recharge zones.

13.6 Disaster Response Recommendations

It is always more effective to have plans and/or facilities in place prior to any disaster response requirements. There are several actions that could be put in place to alleviate disaster situations. Suggested actions include the following:

- Better planning and zoning.
- Development of disaster response plans by individual communities and counties.
- Continuation of cloud-seeding programs.
- Family emergency plans.

The Division of Comprehensive Emergency Management suggests all residents prepare a 72-hour emergency survival kit. According to experts in the field, this will allow adequate time for relief efforts to reach most residents. Along with preparing this kit, families should develop their own emergency plan outlining each member's responsibility during a disaster. Emergency preparedness drills are a good way to familiarize family members with their duties and help ensure their safety.

Hazard mitigation may include structural and non-structural activities as they relate to flood prevention. Continued active involvement in the National Flood Insurance Program is essential to ensure adequate floodplain management objectives are in place to reduce flood losses. Hazard mitigation plans can be implemented by communities to deal with specific identified

Table 13-3
Major West Colorado River Basin Canals

Canal Name by Owner	Capacity (cfs)	Length (miles)	Lining Type	Potential Populated Disaster Areas
Price River Drainage - Carbon County				
Carbon Canal Company				
Carbon Canal	140	38	Earth	West side of Price, Westwood and Robertson subdivisions
Price River Water Users Association				
Price-Wellington Canal	90	32	Earth[1]	North half of Price and Wellington
Spring Glen Canal Company				
Spring Glen Canal	36	12	Earth	Spring Glen
San Rafael River Drainage - Emery County				
Cottonwood Creek Consolidator Irrigation Co.				
Blue Cut Canal	40	6	Earth (Piped through Orangeville)	None
Great Western Canal	74	3	Earth	None
- Clipper Canal	40	4	Earth	Orangeville
- Western Canal	40	4	Earth	Orangeville
Mammoth Canal	90	10	Earth	North side of Orangeville
BOR/Emery Water Conservation District				
Cottonwood Creek-Huntington Canal (Joes Valley Canal)	175	17	5 mi. membrane, 12 mi. earth	Orangeville, Castledale, Huntington
Huntington North Reservoir Service Canal	35	3	1 mi. concrete, ½ mi. clay, 2.5 miles earth	None

Table 13-3 (Continued)
Major West Colorado River Basin Canals

Canal Name by Owner	Capacity (cfs)	Length (miles)	Lining Type	Potential Populated Disaster Areas
Huntington Cleveland Irrigation Company				
Cleveland Canal	220	30	Earth	Cleveland
Huntington Canal	100	25	Earth	Huntington
- Lawrence Branch	40	5	Earth	Lawrence
North Ditch	100	15	Earth	Farm homes north side of Huntington
Ferron Canal and Reservoir Company				
North Ditch	20[2]	8	Earth	None
South Ditch	40[2]	3	Earth	None
Dirty Devil River Drainage - Emery and Wayne Counties				
Caineville Canal Company				
Caineville Canal	17	8	Earth	Farm homes in Caineville
Fremont Irrigation Company				
Fremont Town Ditch	30	4	Earth	Fremont
Highline Canal	100	15	Earth	Lyman
Loa Town Canal	50	4	Earth	Loa
Hanksville Canal Company				
Hanksville Canal	12	1.5	Earth	Hanksville sewage lagoons and some farm homes in Hanksville
Muddy Creek Irrigation Company				
Emery Canal	110	9	Earth	North part of Emery
Independence Canal	40	3	Earth	None
Torrey Irrigation Company				
Torrey Canal	40	12	Earth	Small portion of Torrey

[1]Currently being replaced by pipe.
[2]Capacities after pipeline project. Completion date spring 2000.

potential disasters, such as flooding and alluvial fan development.

13.7 Policy Issues and Recommendations

Three policy issues regarding hazards, disasters and emergencies are discussed below. Local units of government have the prime responsibility for resolving most of these policies. Refer to the *Utah State Water Plan (1990)*, Section 13, for related issues and information.

13.7.1 Flood Plain Management

Issue - Local governments need to become aware of their responsibilities as they relate to flood plain management.

Discussion - The National Flood Insurance Program (NFIP) was established by Congress in 1968 as a result of large federal outlays for structural measures and disaster relief. Its purpose is to (1) reduce flood losses, (2) prevent unwise development in floodplains, and (3) provide affordable flood insurance to the public. Local entities should conduct educational programs on flood hazard awareness and the benefits of participation in the NFIP.

All counties within the West Colorado River Basin participate in the NFIP. A community agrees to enact and enforce minimum flood plain management requirements as stated in the *Code of Federal Regulation* (CFR), Part 60.3. In exchange for enforcing these regulations, flood insurance is made available within the participating community. These regulations apply to new construction and substantial improvements.

The Division of Comprehensive Emergency Management is the state coordinating agency for the NFIP. The office can assist local participating communities in the implementation of the flood plain management objectives defined by the NFIP.

Also, the Corps of Engineers, through its Flood Plain Management Program, can develop flood plain boundary maps at no cost for those communities which need one or update those which do not adequately reflect current conditions.

Recommendation - Non-participating local entities should become qualified to participate in the National Flood Insurance Program. The Division of Comprehensive Emergency Management can assist communities in these objectives.

13.7.2 Flood Prevention and Floodwater and Sediment Control

Issue - Measures need to be taken to prevent future damages from flooding.

Discussion - Records are available of floods occurring since the earliest settlements in the basin. These floods have mostly damaged agricultural developments and facilities. In recent times, they have caused increasing damage to residential areas. Water control structures can be constructed for floodwater control and sediment storage or these features can be included in storage reservoirs constructed for other purposes. Other measures for controlling floodwater and sediment include non-structural and structural measures as well as proper management activities in the upper watershed areas.

Several state and federal agencies have programs and funding for floodwater and sediment control. These agencies should be consulted for assistance to local entities.

Recommendation - Counties should establish floodwater control committees to develop and carry out flood prevention plans and to assist other entities with flood problems. Appropriate state agencies should assist.

13.7.3 Drought Plans

Issue - Each county should have a drought response plan in place.

Discussion - The affects of drought can be alleviated by preparing ahead of time. The most significant impacts will be on agriculture, culinary water supplies, tourism and wildlife. Electric power generation and water quality can also be affected. As the demand for water increases in the future, the impacts of drought may be more devastating and far reaching.

When drought plans are prepared, communities can be ready to deal with water shortages. Drought plans should establish priorities of water use and alternative sources of supply and plans can also bring about the timely application of the resources available statewide.

It may be desirable for two or more counties or parts of counties to join together and prepare one drought plan. This is particularly true where they are similar in climate and physiography as well as have similar socio-economic factors.

Recommendation - Each county should prepare or have available a drought response plan. ●

Section 14 - West Colorado River Basin
Fisheries and Water-Related Wildlife

14.1	Introduction	14-1
14.2	Background	14-1
14.3	Sport Fish	14-3
14.4	Native Fish	14-4
14.5	Upper Colorado River Basin Endangered Species Recovery Program	14-4
14.6	Lake Powell	14-4
14.7	Wildlife, Wetlands and Riparian Areas	14-8
14.8	Organizations and Regulations	14-9
14.9	Fish, Wildlife and Habitat Problems and Needs	14-9
14.10	Alternative Solutions	14-10
14.11	Policy Issues and Recommendations	14-10

Tables

14-1	Selected Fish and Wildlife Species	14-2
14-2	Reservoir Physical and Fish Data	14-5

Section 14
West Colorado River Basin - Utah State Water Plan

Fisheries and Water-Related Wildlife

14.1 Introduction

This section of the *West Colorado River Basin Plan* describes the fisheries and other water-related wildlife in the basin, along with a number of water-related issues. The needs of sensitive, threatened, and endangered species are emphasized. At the same time, it is recognized that game species must remain abundant in order to provide important recreational opportunities valued by people of all ages.

A wide diversity of fish, wildlife, and plant species are found in the basin, interacting to contribute to a functioning ecosystem. Table 14-1 presents a list of some fish and wildlife species present. Federally listed threatened or endangered species are shown in Section 16, Table 16-1. The Colorado River cutthroat trout, a state sensitive species, is covered by a conservation agreement. Many other state sensitive species of fish, birds, mammals, amphibians, reptiles, and mollusks also are present in the basin.

Water does more than just offer wild animals a drink, it also provides habitat, including wetlands and riparian vegetation used by a variety wildlife for nesting, feeding, and hiding. These plants also provide the shade needed to keep water temperatures suitable for cold water species of fish and aquatic invertebrates. Riparian zones increase habitat diversity and are used by wildlife as travel and migration corridors. Riparian vegetation also stabilizes stream banks, filters sediment and chemicals from runoff, absorbs flood waters and slowly releases water over time, and provides recreational and aesthetic values.

The West Colorado River Basin provides a unique and varied environment, hosting a variety of fish and wildlife species. All species depend on a sufficient quantity and quality of water.

14.2 Background

Prior to the influx of modern-day settlers, the area was home to generally healthy populations of native fish and wildlife species. In more recent times, declines in some fish and wildlife species have occurred in the basin due mostly to man-caused effects.

Fly fishing on Huntington Creek

Table 14-1
Selected Fish and Wildlife Species*

BIG GAME MAMMALS	SMALL GAME MAMMALS	FURBEARING MAMMALS
Mule deer (N)	Black bear (N)	Beaver(N), Mink(N), Badger(N),
Elk (N)	Cottontail rabbit (N)	Bobcat(N), Muskrat(N), Coyote(N),
Desert bighorn sheep (N)	Cougar (N)	Weasel(N), Ringtail(N),
Rocky Mountain bighorn (N)	Lynx (N)	Red fox(N), Grey fox(N), Kit fox(N),
Pronghorn antelope (N)	Snowshoe hare (N)	Racoon(E),
Moose (N)		River otter (N)
Bison (E)		Marten (N)
NON-GAME MAMMALS	GAME BIRDS	NON-GAME BIRDS
Prairie dog (N)	Waterfowl (N)	Shorebirds (N)
Black-footed ferret (N)	Sage grouse(N)	Golden eagle (N)
	Wild turkey (N)	Bald eagle (N)
	Bandtail pigeon (N)	Osprey (N)
	Mourning dove (N)	Mexican spotted owl (N)
	Forest grouse (N)	Peregrine falcon (N)
	Chukar partridge (E)	Red-tail hawk (N)
	California quail (E) Ringnecked	Ferruginous hawk (N)
	pheasant (E)	Rough-legged hawk (N)
	Canadian goose (E)	Southwestern willow
	Mallard duck (N)	flycatcher (N)
	Pintail (N)	
	Teals (N)	
AMPHIBIANS	GAME FISH	NON-GAME FISH
Tiger salamander (N)	Cutthroat trout (N,E)	Humpback chub (N)
Great Basin spadefoot (N)	Rainbow trout (E)	Bonytail(N)
New Mexico spadefoot (N)	Brook trout (E)	Roundtail chub (N)
Great Plains toad (N)	Brown trout (E)	Utah chub (E)
Red-spotted toad (N)	Tiger trout (E)	Leatherside chub (E)
Woodhouse's toad (N)	Lake trout (E)	Colorado pikeminnow (N)
Canyon treefrog (N)	Splake (E)	Razorback sucker (N)
Boreal chorus frog (N)	Arctic grayling (E)	Flannelmouth sucker (N)
Northern leopard frog (N)	Largemouth bass (E)	Bluehead sucker (N)
Boreal toad (N)	Smallmouth bass (E)	White sucker (E)
	Striped bass (E)	Mottled sculpin (N)
REPTILES	Bluegill (E)	Speckled dace (N)
Utah mountain	Green sunfish (E)	Red shiner (E)
kingsnake (N)	Black crappie (E)	Redside shiner (E)
Utah milk snake (N)	Channel catfish (E)	Sand shiner (E)
Painted desert glossy	Walleye (E)	Fathead minnow (E)
snake (N)	Northern pike (E)	Bullhead minnow (E)
Sonora lyre snake (N)	Black bullhead (E)	Threadfin shad (E)
Glen Canyon	Yellow bullhead (E)	Common carp (E)
chuckwalla (N)	Yellow perch (E)	Triploid grass carp (E)
Plateau striped		Plains killifish (E)
whiptail (N)		Mosquitofish (E)
		Mountain sucker (N)

*N=native (indigenous) and E=exotic (introduced).

Source: Utah Division of Wildlife Resources

The Utah Division of Wildlife Resources (UDWR) classifies lakes and streams for sport fisheries use. Some waters are also classified by quality (see Section 12). The UDWR classification system for lakes is described as follows:

- *Class I Lakes.* These are large bodies of water that satisfy heavy fishing pressure. Productivity supports a high fish population in good condition of one or more species of game fish. Natural reproduction and/or stocking of small fish maintain an excellent sport fishery.
- *Class II Lakes*. These are also important because of their recreational value. Productivity is such that it supports a high fish population in good condition of one or more species of game fish. Coldwater lakes in this class require stocking of small fish to maintain good fishing. Some Class II lakes are smaller and may have lower aesthetic ratings or biological deficiencies.
- *Class III Lakes and Reservoirs.* These normally provide angling for those who reside within 50 miles. Some are in an area where there is little fishing and may be very important locally.
- *Class IV, V, and VI Lakes and Reservoirs.* These contribute little to fishing opportunities. Some provide fishing where little fishery exists, except when stocked with catchable fish.

Most streams have been classified for fish habitat to assist in management decisions. The classifications for selected streams are shown in Section 12, Table 12-4. Stream classifications are described as follows:

- *Class I Streams*. These are top quality fishing waters. These streams are generally outstanding in natural beauty and are of a unique type. Their productivity supports high fish populations of one or more species of the more desirable game fish in good condition. Natural reproduction or the stocking of small fish maintains an excellent sport fishery.
- *Class II Streams*. These are of great importance for fishing. They are productive streams with high esthetic value. Fishing and other recreational uses should be the primary consideration. They are moderate to large in size and may have some human development along them. Many Class II streams may be comparable to Class I, except for size.
- *Class III Streams*. These are the most common and support the bulk of stream fishing pressure in the West Colorado River Basin.
- *Class IV Streams*. These are typically poor in quality with limited fishery value. Fishing should be considered a secondary use. A few provide an important catchable fishery in areas where no other fishery exists.
- *Class V Streams.* These are now practically valueless for sport fishing. However, they are often important to non-game fish and other wildlife.
- *Class VI Streams*. These have stream channels which are dewatered for significant time periods during the year. Many of the stream sections could support good to excellent fish populations if appropriate minimum flows could be provided.

14.3 Sport Fish

This basin supports a diversity of sport fish species (see Table 14-1). Fishing is a popular pastime on lakes, reservoirs and streams. Game fish range from trout at high elevations to warmwater species at low elevations. Trout species include native and introduced species, whereas no warmwater game species are native. Lake Powell is the largest reservoir in the basin and by far supports the most angling pressure.

The UDWR manages sport fish primarily by stocking and fishing regulations. The type and level of fish stocking at each stream or lake is based on habitat capacity and angler use. The UDWR is currently working on management plans for the Price, San Rafael, Muddy, Dirty Devil, Fremont, Escalante, Green and Colorado river drainages.

These plans identify major aquatic resources, issues, management objectives and strategies for recreational waters. Lakes and reservoirs containing sports fish are shown in Table 14-2. Also see Section 12, Table 12-4 for additional data.

14.4 Native Fish

Native fish species are also diverse and include cold water and warm water species (see Table 14-1). Protection of these species is important to keep functioning ecosystems intact.

Colorado River cutthroat trout are the only native fish which are also considered a sport fish species. While once abundant in small streams, distribution of this species is now extremely limited. Other native species have also been extirpated in local areas. Declines can be attributed to natural causes and some of man's activities. Recovery of native Colorado River cutthroat trout and healthy populations of other native fish hinge on improving habitat conditions, including maintenance or enhancement of water flows in streams and rivers.

14.5 Upper Colorado River Basin Endangered Fishes Recovery Program

The Colorado River system, including the Green and San Juan rivers, contains four endangered fish. These are the Colorado pikeminnow, humpback chub, bonytail chub and razorback sucker. Efforts to recover these species are overseen by the Recovery Implementation Program (RIP) for Endangered Fishes of the Upper Colorado River Basin. Recovery efforts on the San Juan River are covered under the San Juan RIP.

The Upper Colorado River Basin RIP is a 15-year, interagency partnership aimed at recovering these four endangered fishes. The program was launched in 1988, when the governors of Colorado, Utah and Wyoming, the Secretary of the Interior, and the Administrator of Western Area Power Administration signed a cooperative agreement committing each participant to implementing the program's elements. The recovery program elements include: habitat management; habitat development; research monitoring and data management; and non-native species, sport fishing, and public information and involvement.

Accomplishments which affect the West Colorado River Basin include the following:

- FWS has waived charges for new depletions less than 100 acre-feet per year.
- DWR stocked 2,000 bonytails in Colorado River during 1995-97 and 6,000 bonytails near Dewey Bridge in 1996 and 1998.
- DWR stocked about 100,000 pikeminnows in the San Juan River in 1996, 100,000 in 1997 and 10,000 in 1998.
- FWS stocked 3,400 razorback suckers in Gunnison River and 1,600 in San Juan River in 1997. They also stocked 2,000 razorback suckers in the Green and Colorado rivers in 1995 and 1996 and stocked 350 in 1998.
- Federal and state biologists completed a comprehensive report summarizing the first seven years of efforts to track endangered, native and non-native fish populations. Biologists continue to conduct annual monitoring efforts to track Colorado pikeminnow and sympatric species. In 1998, program was expanded to humpback chub and razorback sucker.
- Federal and state wildlife agencies in Colorado, Utah and Wyoming have finalized an agreement on stocking of non-native sport fish. Recovery Program participants have coordinated public involvement activities on key program actions.
- The Recovery Program has developed and distributed a wide range of informational products to the public.
- The Recovery Program has established a web site.

14.6 Lake Powell

The construction of Glen Canyon Dam and Lake Powell has provided annual storage of nearly 27 million acre-feet of water, benefitting millions of water users. It has also provided hydroelectric generation. Lake Powell is acknowledged as a prime recreational site for millions of tourists and vacationers every year.

Table 14-2
Reservoir Physical and Fish Data

Reservoir/Lake	Elevation (feet)	Surface Area (acres)	Maximum Depth (feet)	Fish Species*
Manti Mtn. Area:				
Academy Mill Reservoir	8,798	6	15	BK
Bastian Reservoir	-	-	-	BK
Benchs Pond	-	3	10	RT
Blue Lake	10,261	3	22	BK, GR
Boulger Pond	-	3	14	RT, CT
Cleveland Reservoir	8,812	185	56	RT, CT, MS
Cove Lake	-	8	8	RT, BK, GR
Duck Fork Reservoir	9,305	47	35	CT, RT
Electric Lake	8,575	425	217	CT, RT, RS
Emerald Lake	10,135	-	26	RT
Emery (Larson) River	9,439	-	22	BK
Ferron Reservoir	9,472	57	30	RT, CT
Gooseberry Reservoir	8,424	57	16	RT, CT, MS
Grassy Lake Reservoir	8,809	11	15	RT, BK, TG
Grassy Trail Reservoir	7,613	29	68	RT, BT, TG
Huntington Ponds	-	-	-	RT, UC
Huntington North	5,839	225	56	RT,BT,LB,BG,GS,CC, BS,UC
Huntington Reservoir	9,014	118	85	TG, CT
Jewkes-VanBuren Lake	-	2	-	RT, BK
Joes Valley Reservoir	6,990	1,183	169	RT, CT, SP, BS, UC
Marys Lake	-	-	-	RT, BK
Miller Flat Reservoir	8,462	160	64	RT
Millsite Reservoir	6,211	435	102	RT, CT, BS
Petes Hole	8,867	13	17	RT, CT
Potters Pond #1	8,978	8	18	RT
Potters Pond #2	8,970	8	11	RT
Scofield Reservoir	7,618	2,815	66	RT, CT, MS, RS
Snow Lake	-	5	21	RT, GR
Soup Bowl Reservoir	8,744	2	17	RT, CT
Spinners Reservoir	9,621	25	-	RT
Willow Lake	9,700	25	12	RT, BK, TG, GR
Wrigley Spring River	-	11	18	RT, BK, TG
Fremont River Drainage Area:				
Aberdunk Lake	-	3	30	BK,CT
Artery Lake	-	0.5	10	BK
Beaver Dams Reservoir	-	8	6	BK,MS
Big Lake	10,850	21	11	BK
Blind Lake	-	2	18	BT
Blind Lake	10,233	52	75	BK,CT,RT,SP
Bobs Hole Reservoir	9,500	6	20	BK
Clark Lake	-	2	16	-

Table 14-2 (Continued)
Reservoir Physical and Fish Data

Reservoir/Lake	Elevation (feet)	Surface Area (acres)	Maximum Depth (feet)	Fish Species*
Fremont River Drainage Area: (Continued)				
Clear Lake	-	2	17	BK
Coleman Reservoir	10,000	5	16	BK,RT
Cook Lake	10,000	10	12	BK,RT
Cub Lake	11,600	1	19	BK
Dead Horse Lake	11,000	3	7	BK
Deep Creek Lake	10,100	5	14	BK
Donkey Lake	10,106	27	27	BK,CT
Fish Creek Reservoir	10,300	28	20	BK,CT,RT,MS
Fish Lake	8,900	2500	117	BK,BT,CT,RT,KS, LK,SP,UC,CP,RS, FS,SC
Forsyth Reservoir	8,000	171	80	BK,RT,SC
Grass Lake	10,650	2	6	CT
Green Lake	10,300	7	18	BK
Honeymoon Lake	-	1	10	BK
Johnson Reservoir	8,381	704	21	CT,RT,UC,US
Lava Lake	-	1	16	BK
Left Hand Reservoir	-	13	9	BK
Lightning Lake	11,000	4	7	-
Long Lake	-	1	-	-
Lost Lake	10,200	6	41	BK
Lower Bowns Reservoir	7,200	90	45	CT,RT
Lower Pine Creek Pond	8,400	3	6	BK
Meeks Lake	7,800	4	26	BK,RT
Mill Meadow Reservoir	-	156	90	BT,CT,RT,UC,RS
Miller Lake	10,100	6	11	BK,RT
Moss Lake	9,000	2	14	BK
Ned’s Reservoir	9,000	4	NA	BK
Escalante River Drainage Area:				
Barker Reservoir	9,900	13	11	BK,RT
Barney Griffin Pond	10,000	1	22	BK
Blue Lake	9,900	2	10	BK
Chriss Lake	10,000	5	13	BK,CT,RT
Circle Lake	10,800	7	7	BK
Crater Lake	10,950	7	20	BK,CT
Crescent Lake	10,800	9	26	CT
Deer Creek Lake	10,000	22	28	BK,CT

Table 14-2 (Continued)
Reservoir Physical and Fish Data

Reservoir	Elevation (feet)	Surface Area (acres)	Maximum Depth (feet)	Fish Species
Escalante River Drainage Area: (Continued)				
Divide Lake	9600	7	2	BK
Dougherty Basin	10000	3	13	BK
East Lake	10740	3	13	BK
Elbow Lake	1120 0	5	3	-
Flat Lake	9900	8	4	BK
Garkane Beaver Pond	-	2		BK
Garkane Reservoir, East	7700	2	13	BK, CT, RT
Garkane Reservoir, Main	7000	2	12	RT
Grass Lake	9750	12		BK, CT
Green Lake	10050	4	30	CT
Half Moon Lake	10400	15	12	BK, CT
Horseshoe Lake	10740	12	16	BK
Jacobs Valley Reservoir	10300	391	7	BK
Joy Lay Reservoir	9200	4	9	BK
Kings Pasture Pond	9400	1		RT
Ledge Lake	10600	2	7	BK, CT
Long Willow Bottoms	9500	5	17	BK, CT
Lower Barker Reservoir	9200	5	20	-
McGath Lake	9372	60	13	BK
Meeks Lake	10750	5	8	BK
Mooseman Lake	9880	4	10	BK, CT
Mooseman Pond, East	9850	3		CT
Mooseman Pond, West	9890	1		CT
Noon Lake	10900	2	8	CT
North Creek Reservoir	9400	30	47	-
Posey Lake Beaver Dam	-	1		BK, CT
Posey Lake	9700	8	17	BK, RT
Ridge Lake	11080	2	7	-
Rin Lake	10950	8	19	BK
Round Willow Bottom	9900	9	11	BK, CT
Shaort Lake	10132	2	8	BK, CT
Spectacle Reservoir	10950	21	24	BK, CT, RT
Steep Creek Reservoir	10000	7	5	BK
Tule Lake	9000	2	20	BK
Wide Hollow Reservoir	5870	145	29	RT
Yellow Lake	9900	6	5	BK
Lake Powell	3700	135000	560	LB, SB, WA, ST, CC, BG, GS, NP, BC, BB, RZ, RS, FM, TS, FS

*BB-black bullhead, BC-black crappie, BG-bluegill, BK-brook trout, BS-bluehead sucker, BT-brown trout, CC-channel catfish, CT-cutthroat trout, FS- flannelmouth sucker, GF-goldfish, GR-arctic grayling, GS-green sunfish, LB-largemouth bass, MS-mountain sucker, NP-northern pike, RS-redside shiner, RT-rainbow trout, RZ-razorback sucker, SB-smallmouth bass, SC-scolpin, SP-splake, ST-stripped bass, TG-tiger trout, TS-threadfin shad, UC-Utah chub, US-Utah sucker, WA-walleye.

Source: Utah Division of Wildlife Resources

Lake Powell backs up 186 miles of river system above Glen Canyon Dam. The clear, deep-water environment of the lake is radically different from the fast-flowing and turbid historic Colorado River. Colorado River fish cannot complete their life cycle in the reservoir because of predation by better-adapted exotic fish. Native species must rely on the remaining flowing reaches of the rivers without dams for survival.

Some limited use of Lake Powell's inflow areas by native and endangered fish occurs where the tributaries enter. These productive locations where nutrient-rich water is converted to planktonic life by sunlight in clear water provide a food-rich situation for small fish of all species. Although young native fish which have drifted downstream have been found in these inflow areas, predation by exotic fish is high. Colorado River pikeminnow have overwintered in the inflow areas and then migrated back upstream. Use of inflow areas by native fish is being investigated by the UDWR, the National Park Service and Bureau of Reclamation in an attempt to enhance their survival.

The UDWR currently manages Lake Powell as a sport fishery with inflowing tributaries managed for native fish. The lake, due to its large size and diverse assemblage of warm water sport fish species, receives much more angling pressure than any other water in the basin.

14.7 Wildlife, Wetlands and Riparian Areas

This basin supports a diversity of wildlife species, and maintaining healthy and self-sustaining populations of these species requires suitable habitat. In general, wildlife benefit from, and many species need, the same habitat which provides good conditions for fish.

Riparian areas generally offer all four major habitat components needed by wildlife: food, water, cover and living space. Where there is adequate water and deep soils, production of plant and animal biomass increases. The contrast with the surrounding desert-like vegetation in much of the basin increases the habitat diversity and produces various microclimates. Linear riparian zones serve as connectors between habitat types and provide travel lanes and migration routes for such animals as birds, bats, deer and elk. Where streams have been dewatered, wildlife habitat and watering sources are reduced.

Desert Lake Waterfowl Management Area

Because riparian areas are so important to wildlife, even streams with naturally low or intermittent flows, and streams which do not support fisheries, need to be protected for amphibians and other wildlife. Protection of riparian vegetation will produce benefits including absorption of flood waters, reduced erosion, filtering of sediment and chemicals from runoff, and esthetic and recreational values.

Other wetlands are also important to wildlife, especially to waterfowl and amphibians. Within the water budget area surveyed by the Division of Water Resources, there are about 26,000 acres of man-made wetlands/open water areas located within the irrigated cropland area. In addition, many more acres of wetlands/open water areas are outside the irrigated portions of the West Colorado River Basin. Most of the vegetation is greasewood, rabbitbrush, and saltgrass. Two wetlands in the basin managed specifically for waterfowl are Desert Lake Waterfowl Management Area (approximately 3,000 acres) near Emery, and Bicknell Bottoms (659 acres) near Bicknell.

Construction of water storage facilities has expanded distribution of some wildlife and increased recreational opportunities. At the same time, the increased demand for water and building of communities has sometimes been in direct conflict with the needs of many wildlife species. Destruction of, or any work in, wetlands or riparian areas usually requires a federal permit. This includes activities associated with water development. The UDWR, USFWS and other agencies comment on these proposals and recommend mitigation for loss of wildlife habitat.

14.8 Organizations and Regulations

Local, state and federal agencies have a part in passing and enforcing laws to regulate management of water facilities affecting wildlife. Private organizations work with public entities to protect fish and wildlife habitat.

14.8.1 Local

Cities, irrigation companies and water districts control most of the water facilities affecting fish and wildlife. Their impact may be either direct or indirect. Early irrigation rights holders were not required to leave water in the streams during times of low flow. As a result, there are no instream flow water rights in any of the streams in the West Colorado River Basin.

Several wildlife groups are in the West Colorado River Basin. They are involved in the policy making process by providing local input to the Regional Advisory Council (RAC). This group makes recommendations about regulations to Utah's Wildlife Board.

14.8.2 State

The DWR has responsibility for the management, protection, propagation and conservation of the state's wildlife resources. The DWR recognizes that planning for wildlife habitat needs is an integral part of basin water planning. Fishing, hunting and non-game wildlife activities contribute financially to the economy.

The DWR assesses water development plans and identifies benefits and adverse impacts, recommends possible mitigation and minimization of impacts, and, if this is not possible, suggests project termination. The division also provides factual information regarding consequences of unmitigated and mitigated impacts to wildlife resources.

Title 73-3-3 of the *Utah Code Annotated* allows the division to file for minimum instream flow water rights. The division can also file requests for permanent changes in the operation of certain streams and rivers to preserve critical fish habitat and to provide permanent enhancement of the state's stream and river fisheries. Water releases from reservoirs could be used to provide instream flows. All filings must be approved by the state engineer and adhere to the state's appropriation doctrine.

14.8.3 Federal

The USFWS is charged with carrying out the Fish and Wildlife Coordination Act which requires consultation between USFWS and state agencies on specific activities. The USFWS is also charged with administering the Endangered Species Act. All federal agencies are charged to further the purposes of the act by carrying out programs for the conservation of threatened and endangered species. See Section 16.4.8 for more details.

In 1996 the Corps of Engineers received authority from Congress to study and develop projects and participate in environmental stream and river restorations. Appropriate objectives of such projects include fish and wildlife habitat, wetland and river meander restoration, restoration of riparian areas, and stabilization of riverbanks and beds.

14.9 Fish, Wildlife and Habitat Problems and Needs

Many people are attracted to the West Colorado River Basin because of the unique year-round attractions and facilities. This results in more pressure on the environment as a whole and on the water resources in particular. Conflicts will increase in the future due to finite land and water resources and an expanding human population. Some groups advocate preserving the resources from all development and use, while other groups depend on these and other resources to be developed for their livelihood.

Preserving native species is important to keep functioning ecosystems intact. Water quality problems associated with agricultural water use, such as high salinity, accumulation of toxic substances and other pollution need to be monitored and addressed.

There is a need to preserve quality fisheries. Fish populations in wild fish waters are especially sensitive to alterations and impacts to their habitat. Many streams no longer support abundant fish populations because of high silt loads, unnatural water flows and degredation of riparian vegetation. Most perennial streams are either captured in storage reservoirs or diverted, primarily for irrigation, during the growing season.

State and federal agencies have become heavily involved in these water issues and the protection of habitat for fish and wildlife populations. However, much more effort is needed to coordinate development with water developers/managers and seek for win-win solutions to problems.

Determining wildlife habitat needs is recognized as an integral part of basin planning. Fishing, hunting and non-game wildlife activities contribute financially to the economy and need to be considered in water development plans.

The UDWR is currently working on management plans for the drainages in the basin. These plans identify major resource issues and solutions, and they outline management objectives and strategies for aquatic resources and recreational waters. The UDWR should include the Division of Water Resources and local entities in preparation of these plans.

14.10 Alternative Solutions

Early communication with the UDWR in the planning process could identify and alleviate impacts on fish, wildlife, and habitat resources and avoid the necessity for mitigation. Where mitigation becomes necessary, it can be made a part of project plans. Water-related mitigation alternatives include maintenance of native fish communities and habitat, or replacement of these values with similar facilities in a nearby location.

Habitat can be classified according to value. Four categories of habitat used in Utah are: critical, high-priority, substantial-value and limited-value. Mitigation goals vary with habitat value, wildlife species and project plans.

Several approaches to mitigation are listed below in order of importance.

- Avoiding the impact altogether by not taking a certain action.
- Minimizing impacts by limiting the magnitude of an action or its implementation.
- Rectifying the impact by repairing, rehabilitating or restoring the affected environment.
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
- Compensating for the impact by replacing or providing substitute resources or environment within the same area.

Whenever reservoir storage projects are constructed, consideration should be given to providing conservation pools or purchases of storage water. This may enhance fish and wildlife values, provide holdover storage during dry periods, and enhance instream flows for sport fisheries.

One way to reduce problems of livestock overgrazing in riparian areas is to provide water upland from stream banks. Options include upland ponds, horizontal wells, and wind power or solar energy to pump water to upland areas. Fencing of riparian habitat may be needed in areas with the most severe problems in order for recovery to occur. Constructing instream and bank structures is another technique to assist with acceleration of regrowth on riparian areas. These may include small impoundments or low head dams (much like those built by beavers), rock weirs, streambank modifications, rock or log barbs and vanes, vegetative plantings, and anchoring trees or rocks to streambanks to prevent further erosion.

14.11 Policy Issues and Recommendations

Five issues are presented on fish and water-related wildlife.

14.11.1 Loss of Wetlands and Riparian Habitat

Issue - There is a need to protect wetlands and riparian habitat and reduce sedimentation of lakes, reservoirs and streams.

Discussion - The West Colorado River Basin has many acres of wetlands and riparian areas, including about 26,000 acres within and around the irrigated cropland areas. Wetlands should be protected because of their importance to wildlife and humans. Desert Lake and Bicknell Bottoms Waterfowl Management areas are the only managed waterfowl habitat. Other areas include farm ponds, reservoirs, and other water sources including springs and seeps. These are used primarily as resting areas for migrating birds, although some species live year-round in these areas. The UDWR should be contacted during project planning to provide input and suggest mitigation practices.

Riparian areas include land directly influenced by sufficient water to sustain growth. Even though riparian areas account for a minor part of the total land area in the basin, the vast majority of wildlife species are associated with them at some point in their life cycle. As such, they are important areas to wildlife. Where spring areas have been impacted by wildlife and livestock, rehabilitation should be investigated.

When riparian areas are in good condition, they provide streambank stability, maintain channel contours, reduce sedimentation, regulate water flow, and enhance water quality. A good riparian community has abundant and diverse plant life covering most of the soil and showing a diversity in age distribution and structure. Poorly located, designed and maintained gravel/dirt roads can contribute significant amounts of sediment to lakes and streams.

Recommendation - The UDWR should identify wetlands and riparian areas with significant wildlife values to aid in their protection. Best Management Practices (BMP) should be used to protect and enhance wetlands and riparian areas.

14.11.2 Lack of Instream Flows for Trout Below Scofield Reservoir

Issue - There is a need to provide year-round water flows for trout populations in Lower Fish Creek below Scofield Reservoir.

Discussion - Nearly every fall, the irrigation companies controlling the water in Scofield Reservoir completely shut off the outflow in order to store the following year's water supply. Instream flow rights were not established at the time the dam was built. The result is that thousands of trout are stranded and die in Lower Fish Creek. Local fly fishing clubs have expressed concerns about this problem. Solving the problem would create a blue-ribbon trout fishery.

Recommendation - A management plan should be set up to provide instream flows in Lower Fish Creek.

14.11.3 Winter Fish Kills

Issue - Some irrigation storage reservoirs are frequently dewatered, resulting in winter fish kills and lost or reduced recreational opportunities.

Discussion - Various lakes such as Miller Flat, Huntington North, Mill Meadow, Johnson Valley, Left Hand, Forsyth, and Wide Hollow reservoirs might allow water to be purchased for conservation purposes. Size of conservation pools could be increased at other waters, including Scofield and Huntington reservoirs. On all of these waters, one must realize that the primary purpose of these facilities is for irrigation.

Recommendation - Conservation pools should be purchased if opportunities allow.

14.11.4 Exotic (Non-native) Fish Species

Issue - Introduced exotic fish species can negatively impact populations of native fishes.

Discussion - Exotic fish often out-compete native species for food, cover, and space and prey on their eggs and young. This may reduce populations of native species such as Colorado River cutthroat trout, bluehead sucker, flannelmouth sucker and roundtail chub. Some exotic trout species readily hybridize with native trout, thereby reducing their genetic purity.

Recommendation - Fish eradication and subsequent restocking projects should be conducted, fish migration barriers constructed, and the public educated about the impacts of illegal/inadvertent introductions of undesirable fish species.

14.11.5 Whirling Disease

Issue - Whirling disease problems are expanding in Utah. If it enters the West Colorado River Basin, it may seriously jeopardize wild trout fisheries.

Discussion - Several private fishing ponds are located in the basin. Whirling disease could be introduced into the basin if stocking of fish from unauthorized sources occurs, although the exact cause has not been determined. McGath Lake on Boulder Mountain in Garfield County may already be infected. Whirling disease causes mortality in young trout and is a significant threat to wild, reproducing trout populations. Many streams and lakes in the basin are managed as wild trout fisheries, including some streams containing native Colorado River cutthroat trout.

Permits should not be approved for ponds on natural stream channels or in other cases where wild and stocked fish could mix. Pond owners should be encouraged to obtain UDWR inspections and the proper permits before stocking. The public should be educated regarding what they can do to prevent entry of the disease into the basin.

Recommendation - Private pond owners should follow established UDWR policies on pond stocking.

14.11.6 Tourism Impacts

Issue - The increasing human population and tourism are creating a larger demand for recreational facilities and activities and can impact resources.

Discussion - The West Colorado River Basin contains several national and state parks, Glen Canyon National Recreation Area and Lake Powell, three national forests, and large expanses of proposed wilderness. The basin is truly a destination recreational area. Tourism in the region has increased and will continue to do so along with a growing population. There will be increasing pressure on fish populations and demand for associated facilities. Increasing numbers of visitors and residents, and continued development, may destroy or disturb progressively areas of fish and wildlife habitat and reduce wildlife populations.

Planning should minimize environmental impacts, and improve recreational facilities and access management. Fish and wildlife regulations should be improved, and aquatic and terrestrial habitats should be created and restored where possible.

Recommendation - Coordination should occur between all interested groups to plan for future growth. The UDWR must become interested in financially participating in projects that provide benefits to fish and wildlife resources. ●

Section 15 - West Colorado River Basin
Water-Related Recreation

15.1	Introduction	15-1
15.2	Setting	15-1
15.3	Organizations and Regulations	15-2
15.4	Outdoor Recreation Facilities and Use	15-3
15.5	Recreation Activity Problems and Needs	15-5
15.6	Needed Recreation Opportunities	15-6
15-7	Issues and Recommendations	15-7

Tables

15-1	State Parks Visitation and Facilities	15-4
15-2	Federal Parks, Monuments and Recreation Areas	15-4
15-3	Lake Powell Air and Water Temperature	15-5

Section 15
West Colorado River Basin - Utah State Water Plan

Water-Related Recreation

15.1 Introduction

This section describes the water-related recreational aspects, facilities and resources found in the West Colorado River Basin. Data from the Utah State Comprehensive Outdoor Recreation Planning (SCORP) process are included. This process provided information for the preparation of a priority list of key water-related recreational and environmental issues to be addressed in the future. Information includes consumer or participant's expressions of outdoor recreation needs/demands, issues and alternative solutions.

The West Colorado River Basin contains world class desert and mountain recreation opportunities, some of which are enhanced by reservoirs, streams and wetlands.

15.2 Setting [41]

The reservoirs, clear streams, alpine scenery, and world-class red rock plateaus and canyon areas are prime attractions. The major public land

Water skiing on Lake Powell

managers are the Bureau of Land Management, U. S. Forest Service, National Park Service, Utah State Parks and Recreation, and the Utah School and Institutional Trust Lands Administration. These five agencies control about 92 percent of the basin area and most of the water-related recreational facilities. This gives them responsibility as well as control over much of the recreation in the basin. National parks in the basin include Capitol Reef and portions of Bryce Canyon and Canyonlands. The National Park Service also operates and maintains Glen Canyon National Monument (Lake Powell). The BLM will administer the new Grand Staircase-Escalante National Monument. A three-year monument management planning process was recently completed.

The Utah School and Institutional Trust Lands Administration has the responsibility for over 600,000 acres of school trust lands in the basin. Most of these lands are in scattered sections and are used primarily for livestock grazing and wildlife habitat. Recently the state traded its lands located in national parks and monuments for blocks of land potentially more valuable to the school children of Utah. There is the potential for recreational development on these new state lands.

The Utah Division of Parks and Recreation manages eight state parks: Huntington Lake, Goblin Valley, Green River, and Millsite in Emery County; Scofield in Carbon County; Anasazi Indian Village and Escalante in Garfield County; and Kodachrome Basin in Kane County.

The Utah Division of Wildlife Resources (DWR) administers the Desert Lake Waterfowl Management Area in Carbon County and located on the Pacific Flyway. This area is fed by springs supplying about 15,000 acre-feet of water annually. The DWR also administers the Parker Mountain Wildlife Area in western Wayne County, as well as fish hatcheries near Bicknell and Loa.

World-class water-related activities in the basin include boating and fishing on Lake Powell; rafting Cataract Canyon on the Colorado River; and canoeing Labyrinth, Stillwater, and Grey canyons on the Green River. The area has many parks, picnic areas and campgrounds, along with undeveloped areas where water-related outdoor activities can be enjoyed. Swimming pools and golf courses are located in some of the communities. Most of the perennial streams have fisheries, while the reservoirs and lakes provide fishing and flat-water activities.

Outdoor recreation and tourism are becoming major economic activities in Utah and in the West Colorado River Basin area. They impact lodging, transportation, food and retail sales, bringing much needed income into this rural area. Many jobs are related to tourism in the West Colorado River Basin, according to a recent outdoor recreation household survey. Projects have been assisted through the federal Land and Water Conservation Fund program administered by the National Park Service.

15.3 Organizations and Regulations

Management of recreational facilities and activities is usually by local, state or federal government agencies. Many of these facilities or activities are water-related.

15.3.1 Local

The basin is covered by three multi-county planning districts (MCDs): Central (MCD 4), Southwest (MCD 5) and Southeast (MCD 6). Each of the MCDs collects data to prepare brochures and guide material to attract and assist visitors to the area. These organizations are formed and staffed under the direction of the several county commissions. MCDs are also called “area associations of government” (AOGs). They often provide technical services, clearing houses for grant programs, and other advocacy roles for local government.

Other local organizations involved in promoting recreational activities include county and city/town governments and, to some degree, state and regional tourism organizations.

15.3.2 State [14]

The Division of Parks and Recreation has responsibility for conserving Utah’s rich natural resources heritage while making recreational opportunities available to all users. By statute, the division is the “recreation authority” for the state (see *Title 63-11-17.1, Utah Code Annotated*, as amended). Its mission is to “enhance the quality of life through parks, people and programs.” Within this context, the division manages eight state parks in the West Colorado River Basin. They also coordinate four grant funding programs, manage the OHV program, oversee the boating and trails programs, and prepare the *Statewide Comprehensive Outdoor Recreation Plan (SCORP)*.

The division operates under general guidelines of its 1996 system plan: *Frontiers 2000: A System Plan to Guide Utah State Parks and Recreation into the 21st Century* (pp.39). Statewide, 15 major issues have been identified by planning participants. These include boating, participating in the state water planning process, park planning, public safety on Utah’s waters, establishing carrying capacities on lakes and reservoirs, boating education, personal water craft training and certification, personal training, and enforcing the state boating laws.

15.3.3 Federal

Federal agencies with responsibilities to provide and conserve recreational opportunities include the Bureau of Land Management, Forest Service and National Park Service. Each operates under regulations unique to that agency.

15.4 Outdoor Recreational Facilities and Use

All levels of government and the private sector provide a broad spectrum of recreational opportunities, facilities, and uses. Some of the most used recreational facilities have water features.

15.4.1 City and County Recreational Facilities

City and county recreational facilities range from golf courses and ball diamonds to picnic areas, all using water for large grass areas or minor amounts for culinary needs. Three golf courses are located in the West Colorado River Basin. They are the Carbon Country Club in Helper, Green River State Park in Green River, and Millsite in Ferron. Nearly every town within the basin has large, grassy city center park.

Swimming pools are also large users of water. Price, Orangeville, Huntington, Bicknell, Green River and Escalante have city or high school swimming pools which are open for public recreation.

15.4.2 State Parks

All of the basin’s state parks have major water-related recreational facilities, except Goblin Valley, Anasazi Indian Village and Kodachrome state parks. All of the parks are popular and visitation has increased over the years. Visitation for each of the parks is listed in Table 15-1 along with the water-related facilities.

Escalante State Park

15.4.3 Federal Recreation Areas

Capitol Reef National Park, Canyonlands National Park (Maze District) and Glen Canyon National Recreation Area are the major developed federal facilities. The new Grand Staircase-Escalante National Monument is being developed into another outstanding recreation area. Table 15-2 shows information on the major national recreation areas and their water-related facilities.

Capitol Reef National Park - Capitol Reef National Park splashes color for 75 miles from its northern to southern boundaries. A geologic uplift of rainbow-hued sandstone; most of Capitol Reef is an inviting wilderness of spires, formations and cliffs. In the midst of Capitol Reef’s red rocks and ancient petroglyph panels are large orchards where

Table 15-1
State Parks Visitation and Facilities

Park	Visitation (1000)	Water Area (acres)	Water-related Recreational Opportunities
Anasazi Indian Village	99	0	None
Escalante	77	100	Flatwater fishing, boating and swimming
Goblin Valley	71	0	Camping
Green River	138	Staging area for river recreation.	River boat launching, golf course, and camping
Huntington Lake	63	250	Flatwater fishing, boating and swimming
Kodachrome	64	0	Camping
Millsite	47	530	Flatwater fishing, boating and swimming
Scofield	104	2,800	Flatwater fishing and boating

Table 15-2
Federal Parks, Monuments and Recreation Areas

Name	1998 Visitation (1000)	Type	Water-related Recreational Opportunities
Bryce Canyon National Park	1,649	Geologic	Camping
Canyonlands National Park (Maze District) (Horseshoe Canyon)	432	Geologic Pre-history	Rafting/canoeing Hiking and camping
Capitol Reef National Park		Geologic Historic	Orchards, hiking and camping
Glen Canyon National Recreation Area	2,400	Recreation	Boating, fishing, swimming, rafting, hiking and camping
Grand Staircase-Escalante National Monument - BLM	>120	Geologic Pre-history Biological	Hiking and camping

fruit may be picked in season, and the remnants of Fruita, an early pioneer settlement. The visitor center is open year-round. Several fairly easy hiking trails and the 25-mile Scenic Drive lead from the vicinity of the visitor center. Cathedral Valley and other back country areas may be reached via high-clearance dirt roads.

Canyonlands National Park - Views thousands of feet down to the Green and Colorado rivers, or thousands of feet up to red rock pinnacles, cliffs and spires create the incredible beauty of Utah's largest national park. The two rivers have sliced Canyonlands National Park into three districts, each named according to its distinctive landscape: Island in the Sky, Needles and The Maze. This rugged national park is world-renowned for its four-wheel driving, mountain biking, whitewater rafting and hiking.

Glen Canyon National Recreation Area - Lake Powell, the second largest reservoir in North America, is 186 miles long and has 1,960 miles of shoreline. Hundreds of side canyons, inlets and coves sheltering Indian ruins and natural wonders make Lake Powell a paradise for houseboating and photography. Relatively warm spring, summer and fall water temperatures make Lake Powell ideal for swimming (see Table 15-3).

Lake Powell is also known for its bass fishing. Five major marinas are located along its shores. Bullfrog Marina, 70 miles south of Hanksville, and Wahweap Marina, 7 miles north of Page, Arizona, have lodges for overnight accommodations. Campgrounds and housekeeping trailers are available at Hite, Halls Crossing and Bullfrog marinas. The John Atlantic Burr Ferry operates between Bullfrog Marina and Halls Crossing.

Grand Staircase-Escalante National Monument - In September 1996, President Clinton designated this new national monument. It is unique in that it is the first monument to be administered by the Bureau of Land Management. The monument is a geologic sampler, with a huge variety of formations and features, and world class paleontological sites. Through 2001, the BLM, Department of the Interior, White House Council on Environmental Quality, and Utah state and local officials are working together to design the monument's management plan and determine the best ways to enjoy the monument's resources. The EIS was completed recently.

Table 15-3
Lake Powell Air and Water Temperature

Month	Air Temp. (°F) High	Air Temp. (°F) Low	Water Temp. (°F)
January	45	24	47
February	53	31	46
March	61	36	52
April	72	46	54
May	82	53	62
June	90	62	70
July	97	71	76
August	64	69	80
September	88	60	76
October	77	46	69
November	59	36	62
December	45	25	53

National Forests - Many campgrounds and picnic areas are located in the Dixie, Fish Lake and Manti-LaSal national forests. All of these contain mountain lakes, reservoirs and streams. Major water-related opportunities within the national forests include: 1) Fishing and boating on Joes Valley, Electric Lake, Huntington, Cleveland, and Johnson Valley reservoirs; 2) fishing and boating on Fish Lake; and 3) fishing on Huntington Creek and the upper Fremont River system.

15.5 Recreation Activity Problems and Needs [14]

The Division of State Parks and Recreation is in the process of conducting a series of public opinion surveys associated with state parks and the Utah SCORP (Statewide Comprehensive Outdoor

Recreation Plan). The 1992 survey helped determine the recreational problems and needs in the West Colorado River Basin. Opinions expressed in this survey are listed below:

- Enhance winter outdoor recreation opportunities: access, facilities, programs.
- Need for Outdoor Recreation ethics--among OHVers, bikers, and littering campers and fishermen.
- Develop stable funding sources for acquiring lands and developing outdoor recreation and tourism facilities.
- Provide more water-based recreation opportunities: access to lakes, reservoirs, streams.
- Provide information facilities for travelers and tourists--get them off the freeways and into the area.
- Provide improved quality and accessible hunting and fishing opportunities: areas being closed off by private development and federal regulations.
- Provide recreation planning assistance to local government and businesses: grants, data base, programs.
- Complete reasonable development of existing parks: renovate where run down; provide at least a basic level for visitor services in local, state and federal park and recreation areas. (*Utah SCORP, 1992*, p. 93)

Reservoir user surveys were conducted by the Division of Parks and Recreation in 1996-1997. Each reservoir park site has different characteristics, but there are some common findings and concerns by reservoir park users:

- Respondent parties expend between $90 to $230 per visit on food, lodging, gas, recreation equipment and equipment rentals--usually in parties of two adults and more than two children.
- Location, facilities and affordability are primary attractions to park users.
- Major needs include maintenance of facilities (clean and green), trails, rentals (jet skis or boats), shade and water access-including beaches.
- Depending on the park, and its level of development--the provision and maintenance of beaches and rest rooms ranked very high.
- The most popular activities were camping, boating, waterskiing. This depends upon the quality and character of the resource in question.

15.6 Needed Recreation Opportunities

A 1995 and 1991 statewide survey revealed public attitudes and desires regarding state parks and outdoor recreation in general:

- Needs for the counties included developed camping opportunities; improved fishing (access, quality habitat); improved hunting (access, quality of big game and upland game); golf courses (varied between counties); primitive camping (only basic, if any development); picnicking facilities; trails; OHV staging areas and trails; mountain bike trails; equestrian facilities (corral, hitching, loading, watering staging areas); backways and byways (less developed roads for sightseeing, and paved roads with good signs, beautiful vistas and access to quality recreation areas).

Some problems that need to be reviewed include:

- Improve and update recreation facility and support facility infrastructure to encourage revenue generation from tourism.
- Improve the comprehensive planning process for the allocation of natural resources; i.e., look at all uses, conflicts, and opportunities for any water, highway or other resources development.
- Plan and construct a comprehensive localized and connecting trail system

linking key resource areas such as reservoirs; lakes; forests; national, state, and community parks; Great Western Trail; and American Discovery Trail.
- Improve government agency cooperation and coordination to reduce costly redundancies and resolve federal wilderness issues.

In 1991, as part of the *Utah SCORP* process, recreation-providing agencies were asked their major concerns or issues. These include:

- Need for interagency coordination.
- Assuring environmental quality.
- Public and private cooperation--partnerships, coordination.
- Need for recreation development and infrastructure improvement.
- Deteriorating facilities and systems.
- Overcrowding of existing recreation facilities and resources.
- Recreation water allocations--leaving enough for recreation and fisheries.
- Environmental education--reducing conflicts, damage and management costs.

More than 23 problems were identified by government agencies. These range from funding to wetland and cultural site protection, application of computer technology, greenways and trail development needs. It was understandably different from problems identified by resource users who had a few common concerns for funding, new facilities, wilderness, government coordination and access problems. Many of these problems can be realized or obviated by good design, adequate capitalization, public participation in the planning process, and coordination and good management of water resources development or river corridor protection.

15.7 Issues and Recommendations

Two major issues are outdoor ethics and comprehensive planning.

15.7.1 Outdoor Ethics

Issue - Many conflicts are exacerbated by unethical behavior in recreational settings.

Discussion - As the use of flat-water facilities increase, boating and water skiing accidents are becoming more commonplace. There often appears to be no concern by boaters for each other's safety or for respecting other's recreation experience, particularly when water-skiing is involved.

Some areas are so popular, especially on holiday weekends, facilities are over-crowded to the point security personnel are required to maintain a semblance of order. Problems arise when multiple ownership exists and coordination is lacking. Waste disposal facilities are especially over-loaded to the point it is dangerous to people's health and welfare.

Programs such as TREAD LIGHTLY, CAPTAIN SAFE'TE (boating safety), hunter education and off-highway vehicle training are helping make everyone aware of the problems. Education and enforcement programs need to be continued and even increased in the future.

Recommendation - The Division of Parks and Recreation should organize groups with a cross-section of recreators and managers to obtain ideas and support for recreational safety and to determine ways to reduce conflict.

15.7.2 Comprehensive Planning

Issue - Efficient allocation of resources can best be achieved through comprehensive planning.

Discussion - The Division of Parks and Recreation is in the process of preparing comprehensive management plans for all the areas it manages in the West Colorado River Basin. The objective is to make all state parks more attractive and better able to meet the needs of the recreating public.

Recommendation - The Division of Parks and Recreation should continue to prepare and update management plans to achieve and balance the use of water resources for recreation. ●

Section 16 - West Colorado River Basin

Federal Water Planning and Development

16.1	Introduction	16-1
16.2	Background	16-1
16.3	Federal Concerns	16-1
16.4	Federal Programs and Projected Planning and Development	16-1

Table

16-1	Threatened or Endangered Species	16-4

Section 16

West Colorado River Basin - Utah State Water Plan

Federal Water Planning and Development

16.1 Introduction

This section provides a brief description of each agency's programs and how they impact the resources of the West Colorado River Basin. Although the activities of federal agencies are changing, many programs are still available to the local people for their betterment and the enhancement of their resources. This section gives an insight to the program functions and how they can be accessed. This will also help improve the working relationships between the local entities, individuals and the federal government.

Federal involvement at the local level is becoming more oriented toward the management, conservation and preservation of natural resources with fewer programs promoting natural resources development

Glen Canyon Dam

16.2 Background

With the continual downsizing of the federal government in the natural resources fields, there are decreases in financial and technical assistance in most agency programs. This process is also passing the responsibility to local and state governments to carry out many of these programs without providing funding. Along with this, the federal standards for resources use are higher, adding to the total cost.

16.3 Federal Concerns

Four concerns of federal agencies were identified in the *1990 State Water Plan.* These concerns were: 1) Reserved water rights, 2) interrelated planning, 3) stream and riparian habitat loss, and 4) water rights filings. All of these apply to the West Colorado River Basin.

One other concern has been raised since the *State Water Plan* was published. This is the lack of coordination between federal, state and local officials during the planning and implementing of various programs and projects. This basin plan could be a mechanism to help with coordination.

16.4 Federal Programs and Projected Planning and Development

The various federal agencies and the programs they can provide are briefly described on the following pages. (Also see Section 8). Some projected planning and implementation being considered by various agencies are also discussed.

16.4.1 Bureau of Land Management

The Federal Land Policy and Management Act gives the Bureau of Land Management (BLM) authority for inventory and comprehensive planning for all public lands and resources under its jurisdiction. This includes water resources with the mandate to comply with applicable laws. They are also responsible for managing the existing and proposed wilderness areas, wild and scenic rivers, and all recreational uses associated with these rivers.

Water resources, in quantity and quality, are key factors in managing all terrestrial and aquatic resources on public lands. Water resources are often small and dispersed sources. Water sources on public lands are rapidly becoming a major determinant of resources management alternatives. The BLM manages riparian habitats of springs, seeps, streams, lakes, reservoirs and ponds to help provide high quality water resources for beneficial downstream uses.

Collection of water resources quantity and quality data is needed for all programs. The BLM is also responsible for planning the use of these resources on the public lands in coordination with state and other agencies. All of these data become a part of a draft "resource management plan" (RMP) for a given area. After public input, these become management plans for resources on BLM administered land. The published *Escalante Resource Management Plan* covers part of the West Colorado River Basin. The Bureau of Land Management will manage the Grand Staircase-Escalante National Monument and is currently working on a monument management plan.

16.4.2 Bureau of Reclamation

The Bureau of Reclamation built the Emery and Narrows (Scofield) projects in Emery and Carbon counties. Four broad categories of water resources programs administered by the Bureau of Reclamation are investigations, research, loans and service, all requiring close cooperation with the concerned entities.

Investigation Programs - General investigations are conducted for specific and

Joes Valley Reservoir in Emery County

multipurpose water resources projects. These include an environmental assessment.

Research Programs - Reclamation conducts research on water-related design; construction; materials; atmospheric management; and wind, geothermal and solar power. Most programs are conducted in cooperation with other entities.

Loan Programs - These programs provide federal loans and assistance to qualified organizations wishing to construct or improve smaller and generally less complex water resources development.

Service Programs - These are intergovernmental specialized technical service programs designed to provide data, technical knowledge and expertise to states and local government agencies to help avoid duplication of special service functions. Local governments pay for requested services.

16.4.3 Cooperative State Research, Education, and Extension Service

This agency will be assigned responsibility for all cooperative state and other research programs presently performed by the Cooperative State Research Service, all cooperative education and extension programs presently performed by the Extension Service, and such other functions related to cooperative research, education and extension as may be assigned.

16.4.4 Corps of Engineers

If local interests are unable to cope with a large water resources problem, they may petition the Corps or, for larger projects, petition their congressional representatives for assistance. Requests for assistance with smaller problems may be made directly to the Corps of Engineers. This allows the Corps to investigate the economic and technical feasibility and social and environmental acceptability of remedial measures. When the directive covers an entire river basin, it is studied as a unit and a comprehensive plan is developed. Close coordination is maintained with local interests, the state and other federal agencies.

The Corps of Engineers can also participate in environmental stream and river restorations. These can include the restoration of fish and wildlife habitat, wetland and meander restoration, restoration of riparian areas, and stabilization of riverbanks and riverbed. These projects are cost shared with a local sponsor. The Corps also has authority under its Flood Plain Management Services Program to delineate areas of potential flood and debris flow threats for local communities at no charge.

16.4.5 Environmental Protection Agency

Environmental Protection Agency programs dealing with water resources include the safe drinking water program under the Federal Safe Drinking Water Act and the water pollution control program under the Clean Water Act. Several noteworthy aspects of the Clean Water Act include the following:

National Pollutant Discharge Elimination System (NPDES) - The NPDES program (Clean Water Act, Section 402) regulates the discharge of point sources of pollutants to waters of the United States.

Construction Grants - This program originally provided grant funds for construction of needed municipal wastewater treatment facilities. It was phased out in 1990 and replaced with a revolving loan fund managed by the state.

Water Quality Management Planning and Non-point Source Pollution Control - Section 205(j) of the Clean Water Act provides funds to states to carry out water quality management planning. Section 319 of the act authorizes funding for implementation of non-point source pollution control measures under state leadership.

16.4.6 Farm Service Agency

The Farm Service Agency (FSA) administers farm commodity, crop insurance, and conservation programs for farmers and ranchers. As of October 1995, the FSA also administers the farm ownership and operating loans formerly provided by the Farmers Home Administration. The Agricultural Conservation Program (ACP) and the Emergency Conservation Program (ECP) have been replaced by other programs in other agencies. Elements of these programs have been transferred to the Natural Resources Conservation Service. Two programs administered by the FSA are water-related. They are the Conservation Reserve Program (CRP) and the Flood Risk Reduction Program (FRR).

The Conservation Reserve Program reduces soil erosion, protects the nation’s ability to produce food and fiber, reduces sedimentation in streams and lakes, improves water quality, establishes wildlife habitat, and enhances forest and wetland resources. It encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filterstrips, or riparian buffers. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the vegetative cover practices.

The Flood Risk Reduction Program was established to allow farmers who voluntarily enter into contracts to receive payments on lands with high flood potential. In return, participants agree to forego certain U.S. Department of Agriculture program benefits. These contract payments provide incentives to move farming operations from frequently flooded land.

16.4.7 Federal Emergency Management Agency

Federal Emergency Management Agency (FEMA) programs are related to disaster preparedness, assistance and mitigation. The agency provides technical assistance, loans and grants.

Presidential Declared Disaster - After a presidential declaration of a major disaster, usually after a state request, grants are available to state and local governments for mitigation of disaster related damage.

Assistance Grants - The FEMA can provide grants on a matching basis to help the state develop and improve disaster preparedness plans and develop effective state and local emergency management organizations. Also, grants are available to develop earthquake preparedness capabilities.

Flood Plain Management - The FEMA provides technical assistance to reduce potential flood losses through flood plain management. This includes flood hazard studies to delineate flood plains, advisory services to prepare and administer flood plain management ordinances, and assistance in enrolling in the National Flood Insurance Program. The FEMA can also assist with the acquisition of structures in the flood plain subject to continual flooding.

16.4.8 Fish and Wildlife Service

The U. S. Fish and Wildlife Service (USFWS) is responsible for achieving part or all of the mandates of the Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act and Migratory Bird Treaty Act. No land or water areas in the basin are directly managed by the USFWS.

Table 16-1 lists the species considered threatened or endangered and which occur in the West Colorado River Basin. This list can change over time as other species are added when they become threatened or species are removed when they recover. When any activity is planned that may impact a threatened or endangered species, it is the responsibility of the sponsor to take actions to protect them.

The USFWS compiles lists of animal and plant species native to the United States that are being reviewed for possible addition to the List of Endangered and Threatened Species. Such species are generally referred to as candidates. The West Colorado River Basin contains no candidate species.

Table 16-1 Threatened or Endangered Species
Humpback Chub
Bonytail Chub
Colorado Pikeminnow
Razorback Sucker
California Condor
Bald Eagle
Peregrine Falcon
Mexican Spotted Owl
Southwestern Willow Flycatcher
Utah Prairie Dog

Source: Utah Division of Wildlife Resources

When rights-of-way permits are required on federal lands, the consultation requirement under the Fish and Wildlife Coordination Act is actuated. If federal funds are involved, Section 7 consultation with the USFWS is required by the Federal Endangered Species Act (Also see Section 14). The Section 404 permitting process of the Clean Water Act administered by the Corps of Engineers calls for U.S. Fish and Wildlife Service response on impacts to wetlands as well as threatened or endangered species.

Under the Migratory Bird Treaty Act, all birds are protected with the exception of starlings, English sparrows and pigeons. Any unpermitted activity on any land that results in "take" of federally listed species constitutes violation of Section 9 of the Endangered Species Act. "Take" under the act is defined as "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect or to attempt to engage in any such conduct." This can include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering.

16.4.9 Forest Service

Water-related programs of the Forest Service include watershed management; special use authorization for water development projects; and coordination with local, state and federal agencies.

They also manage wilderness areas located on national forest lands.

Watershed Management - Watershed protection insures that activities do not cause undue soil erosion and stream sedimentation, reduce soil productivity or otherwise degrade water quality. Water yields may be affected primarily through snowpack management as a result of timber harvest using well-planned layout and design. Potential increases may approach one-half acre-foot per acre for some treated areas, but multiple-use considerations and specific on-site conditions may limit actual increases.

Special Use Authorization - Construction and operation of reservoirs, conveyance ditches, hydropower facilities and other water resources developments require special use authorization and usually an annual fee. Authorization contains conditions necessary to protect all other resources use. Coordination of water developments by others requires communication early in the planning process to guarantee environmental concerns are addressed.

The Forest Service has prepared draft EISs and land and resource management plans for the Dixie and Fishlake national forests. Final plans will be published after public comment.

16.4.10 Geological Survey

The U.S. Geological Survey (USGS), through its Water Resources Division (WRD), investigates the occurrence, quantity, distribution, and movement of surface water and groundwater and coordinates federal water data acquisition activities. This is accomplished through programs supported by the USGS, independent of or in cooperation with, other federal and non-federal agencies.

The USGS manages continuing programs in cooperation with various state agencies. These include water quality and water level changes in the West Colorado River Basin groundwater reservoirs. They also read and evaluate surface water stream gages.

16.4.11 National Park Service

The National Park Service (NPS) was established in 1916 to promote and regulate the use of national parks, monuments and similar reservations to "conserve the scenery and the natural historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (39 Stat. 535; 16 U.S. Code 1). The long-range objectives of the NPS are as follows.

1. Conserve and manage the parks for their highest purpose; the natural, historical and recreational resources.

2. Provide the highest quality of use and enjoyment by increased millions of visitors.

3. Develop the parks through inclusion of additional areas of scenic, scientific, historical and recreational value.

4. Communicate the cultural, natural, inspirational and recreational significance of the American heritage.

In fulfillment of these objectives, NPS performs the following functions.

- Manages Capitol Reef National Park and portions of Canyonlands National Park, Bryce Canyon National Park, and Glen Canyon National Recreation Area in the West Colorado River Basin.
- Conducts the recreational aspects of water project implementation studies.
- Conducts congressionally authorized Wild and Scenic River and National Historic and Scenic Trail studies.
- Through cooperative agreements, administers recreation on lands under the jurisdiction of other federal agencies.
- Provides professional and administrative support to the national, regional and park advisory boards.

In federal water resources project pre-authorization studies, the NPS may provide technical assistance in general development planning. In post-authorization studies, it may provide technical assistance in development planning; site planning; consultation pertaining to the development, interpretation and operation of recreations areas; management planning; negotiation of agreements for administration of reservoir recreation areas; and follow-up on the administration of such agreements.

Glen Canyon Adaptive Management Work Group - The Grand Canyon Protection Act (Act) of October 30, 1992, embodied in Public Law 102-575, directs the Secretary of the Interior, among others, to operate Glen Canyon Dam in accordance with the additional criteria and operating plans specified in Section 1804 of the act and to exercise other authorities under existing law in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and the Glen Canyon National Recreation Area were established, including but not limited to the natural and cultural resources and visitor use.

As part of long-term monitoring, the Secretary's Record of Decision (ROD) mandates development and initiation of an Adaptive Management Program (AMP). The AMP provides for monitoring the results of the operating criteria and plans adopted by the interior secretary and changes to those operating criteria and plans. The AMP includes an Adaptive Management Work Group (AMWG).

16.4.12 Natural Resources Conservation Service

The National Resources Conservation Service (NRCS) provides technical and financial assistance to conserve soil, water and related resources on non-federal land through local soil conservation districts. In addition to working with individual landowners and units of government, the NRCS administers programs to inventory existing soil and snow pack conditions, protect watersheds, and to plan for flooding and drought events.

Soil Surveys - Published soil surveys contain descriptions of an area's soils, their use and management, and maps depicting the extent of these soils. Several soil surveys have been completed in Carbon and Emery counties and in the eastern area of Wayne and Garfield counties.

Snow Surveys - Through the snow survey program, the NRCS measures snow water equivalent and precipitation at either a manually measured snow course station or at a SNOTEL site which can be accessed electronically. See Section 3, Table 3-4, for a listing of snow course and SNOWTEL sites in the West Colorado River Basin.

Environmental Quality Incentives Program (EQIP) - The Environmental Quality Incentives Program provides technical, educational and financial assistance to eligible farmers and ranchers to address soil, water and related natural resources concerns on their lands in an environmentally beneficial and cost-effective manner. The program provides assistance to farmers and ranchers in complying with federal, state and tribal environmental laws, and encourages environmental enhancement. The program is funded through the Commodity Credit Corporation. The purposes of the programs are achieved by cost-sharing the implementation of a conservation plan, which includes structural, vegetative and land management practices on eligible land. Fifty percent of the funding will be targeted at natural resources concerns relating to livestock production, primarily in priority areas.

Watershed and River Basin Planning and Installation - Technical and financial assistance is provided in cooperation with local sponsoring organizations, state and other public agencies to voluntarily plan and install watershed-based projects on private lands. The program empowers local people or decision makers, builds partnerships, and requires local and state funding contributions. The purposes of watershed projects include watershed protection; flood prevention; water quality improvements; soil erosion reduction; rural, municipal and industrial water supply; irrigation water management; sedimentation control; fish and wildlife habitat enhancement; and creation and restoration of wetlands and wetland functions.

Section 3 of Public Law 83-566 provides for assisting sponsoring local organizations to develop a plan on watershed not exceeding 250,000 acres. During planning, problems such as water quality, flooding, water and land management, and sedimentation are evaluated and works of improvement are proposed to alleviate problems. The resulting watershed plans estimate benefits, costs, cost-sharing rates, and arrange for operation and maintenance necessary to justify federal assistance to install works of improvement.

Section 6 of Public Law 83-566 provides for cooperation with federal, state and local agencies in making investigations and surveys of river basins as a basis for development of coordinated water resource programs. Reports of the investigations and surveys serve as guides for the development of water, land and related resources in agricultural, rural and urban areas within upstream watershed settings. They also serve as a basis for coordination with major river systems and other phases of water resource management and development. One project (Ferron) has been completed under the Watershed Protection and Flood Prevention Act (Public Law 83-566), as amended (See Section 9).

The Emergency Watershed Protection Program (EWP) was set up by Congress to respond to emergencies created by natural disasters. It is designed to relieve imminent hazards to life and property caused by floods, fires, windstorms and other natural occurrences. The purpose of EWP is to help groups of people with a common problem. It is generally not an individual assistance program. All projects undertaken must be sponsored by a political subdivision of the state, such as a city, county, general improvement district or conservation district.

Wetlands Reserve Program - The Wetlands Reserve Program is a voluntary program offering landowners the opportunity to protect, restore and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. The goal is to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. This program offers landowners an opportunity to establish lang-term conservation and wildlife practices and protection.

Resource Conservation and Development Program - The purpose of the Resources Conservation and Development (RC&D) Program is to accelerate the conservation, development and utilization of natural resources, improve the general level of economic activity, and enhance the environment and standard of living in authorized RC&D areas. It improves the capacity of state, tribal and local units of government, and local non-profit organizations in rural areas to plan, develop and accomplish programs for resource conservation and development. The program also establishes or improves coordination systems in rural areas. Current program objectives focus on improving the quality of life through natural resources conservation and community development which leads to sustainable communities, prudent use (development), and the management and conservation of natural resources. The NRCS can provide grants for land conservation, water management, community development and environmental needs in authorized RC&D areas. The West Colorado River Basin contains portions of the Color Country RC&D, Panoramaland RC&D and Castleland RC&D project areas.

16.4.13 Rural Development

Rural Development provides financial assistance for water and waste disposal facilities in rural areas and towns of up to 10,000 people. Priority is given to public entities in areas smaller than 5,500 people to restore, improve or enlarge a water supply or waste disposal facility. Eligibility for loans and grants requires water or waste disposal systems must be consistent with state and subdivisions development plans and regulations. Rural Development also makes loans for resource conservation and development projects. ●

Section 17 - West Colorado River Basin
Water Conservation

17.1	Introduction	17-1
17.2	Background	17-1
17.3	Water Conservation Opportunities	17-1
17.4	Issues and Recommendations	17-6

Tables

17-1	Monthly Water Rates For Selected Communities	17-5
17-2	Flat Rate	17-7
17-3	Increasing Block	17-8
17-4	Ascending Block	17-9

Section 17

West Colorado River Basin - Utah State Water Plan

Water Conservation

17.1 Introduction

This section of the West Colorado River Basin Plan discusses water conservation policies, practices, measures and ideas. The discussions and presentations generally focus on conservation in residential, commercial, industrial and agricultural water uses.

Water conservation programs and policies can result in a more efficient use of existing water supplies for most municipal, commercial, industrial and

17.2 Background

Whenever water is discussed in Utah, the term conservation will most likely be included. Water is a finite resource and the demands on its use are growing. However, future water shortages in this basin will more likely be the product of long-term drought and infrastructure problems than dramatic increases in municipal and industrial (M & I) water demands. The basin is currently experiencing a slight increase in population growth. No M & I shortages have occurred so far. Considering the data presented in Section 9, M & I water shortages are not expected to occur through the year 2020.

The basin has experienced several droughts where annual water supplies have been less than 50 percent of the average annual runoff. The most notable were the drought years of the 1930s, 1961, 1977 and the early 1990s when local reservoirs were drained to record low levels. Due to these events, agricultural water users generally suffer the greatest impacts. They have taken shortages so that M&I uses could continue.

17.3 Water Conservation Opportunities

The initial and major use of water was for irrigation of agricultural crops and to support various ranching operations. Currently municipal and industrial demands are increasing. Both of these types of water users have opportunities for conservation measures.

Public awareness programs should educate consumers and also provide the educational tools necessary for children to understand and respect the value of water. Education programs are a long-term investment in our state's natural resource future, providing the tools for children to become responsible adults with a water stewardship ethic.

A well-managed conservation program for all public water uses may postpone or eliminate the need for building new facilities and finding additional supplies. The most effective program combines incentives to conserve along with conservation measures designed into the construction and operation of water supply systems.

Effective conservation programs combine activities designed to reduce the demand for water with measures to improve efficient delivery systems. Demand reduction should include educating customers on improving cropland and residential irrigation practices and landscape design. Culinary water demand reduction is also helped with a pricing schedule that provides customers an incentive to find ways to use water more efficiently. Delivery efficiency can be improved by system audits and installing new meters and other facilities to reduce measurable losses.

Water quality is important in any conservation program. If the goal is to conserve high quality water for meeting culinary growth demand, then providing a separate irrigation pipe network to substitute untreated water for lawn and garden irrigation can be a logical solution. The total amount of water may be about the same, but this saves the high cost-high quality water for culinary purposes.

17.3.1 Water Conservation Advisory Board

The 1995 publication of various water conservation recommendations by the Utah Water Conservation Advisory Board offers a number of programs and means to effectively conserve a substantial percentage of M&I water. These recommendations include: 1) Development of water management and conservation plans by major water provider agencies, 2) reduction of secondary water by replacing high water consuming landscaping with xeriscaping or landscaping with reduced water needs, 3) better overall management of water intensive businesses and large conveyance systems, and 4) implementation of incentive pricing policies.

17.3.2 Agricultural Water

Agriculture remains the largest single water use in the West Colorado River Basin; current estimates indicate irrigated agriculture diverts over 295,000 acre-feet annually. As a result, conservation programs applied to irrigated agriculture have the highest potential to conserve water.

Agricultural water users have been implementing conservation measures and facilities over the last four decades. These measures include land leveling, on-farm and off-farm ditch and canal lining, sprinkler irrigation systems, and gated pipe.

Exchanging a low-efficiency irrigation system for a more efficient one may reduce the amount of water diverted while maintaining the amount of water depleted. This will leave more water in the stream for use downstream and improve water quality. However, if the more efficient system increases crop depletion by providing a full water supply, return flows will be reduced.

Water budgets prepared during 1997-98 indicate an overall irrigation efficiency of nearly 50 percent. Current irrigation practices allow room for improvement in distribution and application efficiencies. The most widespread and effective conservation practice is scheduling irrigation based on the crop's need. This includes determining the crop consumptive use and irrigating to replenish the root-zone supply before the plant is stressed. The Colorado River Salinity Control Program will improve irrigated and conveyance efficiencies on about 36,000 acres in the Price/San Rafael area over the next 10 years (See Section 6.6)

Agricultural water conservation measures are evaluated from two stand points: one to consider the overall conveyance of water supplies from various sources to individual farms, and a second to evaluate on-farm methods of applying irrigation water to crops.

Agricultural Water Conveyance Systems -

Distribution systems provide water to farms and ranches in addition to a variety of municipal, commercial and industrial water users. Open channels are the most common method of conveying water to irrigated agriculture, mostly because of low initial construction cost. Operation and maintenance costs are higher to remove weeds and debris. Excessive water loss can also be a problem resulting in poor overall water conveyance efficiencies. Seepage from open channels can be effectively managed by lining high loss sections with concrete or synthetic liners. The amount of water saved by lining may be considerable, but each case is different and must be evaluated on an individual basis.

On-Farm Irrigation Practices - Early settlers applied water to farm and ranch lands by flood irrigation or by using furrow or border irrigation. Recent studies have established the range of efficiency for all irrigation practices at a high of 90 percent to a low of near 40 percent. Irrigation efficiencies can be improved in some cases by optimizing the operation and layout of existing sprinkler or flood irrigation practices.

17.3.3 Municipal and Industrial Water

Municipal and industrial (M&I) water includes residential, commercial, institutional and industrial uses by various entities and individuals. All of these uses are supplied by culinary (potable) and secondary (non-potable) water at a current rate of about 55,000 acre-feet per year.

Culinary water use can be reduced by replacing old water using devices with new, more efficient ones; i.e., installing low flow shower heads, ultra low flow toilets, water efficient washing machines and aerators on faucets. Such devices may be able to reduce indoor water use by as much as 20 percent. More lawn sprinkling systems are being installed, but they are often operated for convenience rather than to save water. Ordinances requiring watering only between the hours of 6:00 p.m. and 10:00 a.m. have been effective in reducing water use. Reduced water use through the installation of low water-using landscapes is a good practice.

Some cities and towns have installed secondary systems to supply lawn and garden and some industrial uses with lesser quality water. Many of these systems are pipelines, but some are still open ditches.

An evaluation of water losses from municipal conveyance systems begins with an audit of existing pipelines, canals, ditches, and all related hydraulic structures and appurtenances. As field measurements have substantiated, leakage from piped distribution systems ranges from 5 percent, which is acceptable, to 20 percent where corrective action should be taken.

Water system audits effectively identify areas of excessive loss. These audits include: 1) An accounting of diversion and delivery records, 2) pressure testing of pipe systems, and 3) installation of groundwater observation wells to assess open channel seepage. This can assess overall system efficiencies, locate and determine severe losses, and provide information to develop short-and long-term system rehabilitation and water conservation programs. Annual examinations can update results of previous audits.

Xeriscape garden in Escalante

Additional conservation measures include audits of existing indoor and outdoor distribution systems, use of sprinkler and drip irrigation systems, and replacement of extensive landscaped areas with minimal water consuming shrubbery. Some areas can be graveled or hard surfaced to reduce water needs.

Institutional Water Uses - This use includes water for municipal and public recreational buildings and facilities such as schools, health care facilities, golf courses and major landscaped areas such as parks, cemeteries and athletic fields. Water consumption by these facilities accounts for about 10 percent of total M&I uses.

Irrigation of large areas such as parks, cemeteries and golf courses can be more efficient and conserve water through use of automated sprinkler systems with moisture probes. This can reduce over application of water as well as allow irrigation at night, thus reducing evaporation losses.

Residential Water - Residential uses include culinary (potable) and secondary (non-potable) water, indoor and outdoor, and are about 45 percent of total M&I uses. Potential residential water savings range from 5 percent to 50 percent in some cases.

Indoor water demand accounts for 30-40 percent of all residential uses. Indoor water use can be reduced by: 1) Conducting regular inspection of existing toilets, fixtures and plumbing; 2) replacing old high flow toilets with low flush units; 3) installing low flow showerheads; 4) taking shorter showers; and 5) shutting off faucets while brushing teeth, minimizing flows when using kitchen garbage disposers, and by washing all dishes and clothes in fully loaded machines.

Outdoor water use for landscape irrigation accounts for 60-70 percent of all residential demands. This is supplied from either culinary or secondary water. Secondary water should be used for outdoor uses whenever feasible. This will reduce the demand for the more expensive culinary water, but it should be metered and appropriately priced.

Flood irrigation of lawns, gardens and shrubbery is inefficient and results in water loss beyond established root zones. Use of more efficient methods such as sprinkler and drip irrigation systems should be considered. The total amount of water applied per irrigation depends on the time and rate of application. Most residential users are not aware of the amount required or how much is applied. As a result, efficiencies are often low. Evaporation losses can be minimized by irrigating between the hours of 6:00 p.m. and 10:00 a.m. An example of the water savings is shown by a study in Bountiful in northern Utah. Beginning in 1991, the Bountiful Sub-Conservancy District restricted the hours of secondary watering between 10:00 a.m. and 6:00 p.m. The Division of Water Resources studied the water use in Bountiful for the 10-year period before and five-year period after the restrictions and found a 17 percent average decrease in water used after restrictions were implemented.

A significant amount of water can be conserved by making changes in residential landscaping schemes. The Utah State University Extension Service has information on low water consuming plants and vegetation. Water can be conserved by reducing planted areas or replacing existing landscaping with “hardscapes” such as decks, patios, walkways and play areas for children. Grassed areas should be designed so they are easy to care for and can be irrigated efficiently.

Other common outdoor uses include washing of vehicles, driveways, sidewalks and exterior portions of the home. These practices should be reduced as much as possible. In times of drought, outdoor water uses are the first subjected to water restrictions.

Outdoor conservation measures include: 1) Inspection and repair of outdoor plumbing; 2) use of brooms to clean driveways, sidewalks and patios; 3) elimination of continuously flowing water hoses when washing vehicles; and 4) when children are prone to leave water running, remove handles from outside hose bibs.

Commercial Water - Commercial water uses include those by small retail businesses such as grocery stores and gas stations. The largest commercial water users are restaurants, laundries, linen suppliers, hotels, commercial office buildings and car washes. In the West Colorado River Basin, commercial water use is about 5 percent of total M&I uses. Conservation measures include water audits of existing distribution and handling systems, replacement of high volume fixtures with more efficient models, recycling where possible, and reduction of high use landscaped areas.

Industrial Water - Industrial uses are about 40 percent of total M&I uses in the basin. Each industrial business or facility has its own unique process characteristics and so must be evaluated individually. Water conservation measures currently used in similar situations should be put into practice to the extent possible. Many of the water conservation measures applicable for commercial businesses apply to industry. Water audits are effective in identifying losses and should be conducted on a regular basis. Specific improvements to conserve water should be identified and implemented as part of an overall program to improve manufacturing processes.

17.3.4 Municipal Water Rates [1, 2]

Water rates may provide a strong incentive to use municipal water more efficiently. Current rates for selected cities are shown in Table 17-1.

Setting water prices to encourage more efficient use requires consideration of several principles. They are as follows:

- **A conservation price structure encourages a lower water use rate without causing a shortfall in system revenues.** To avoid

Table 17-1
Monthly Water Rates For Selected Communities

Water Supplier	Use Rate (gpcd)	Base Rate ($)/gal	First Overage: Overage Charge ($)/gal	First Overage: Overage Amount (Gallons)	Second Overage: Overage Charge ($)/gal	Second Overage: Overage Amount (gallons)
Bicknell (Billed quarterly)	141	30/24k	1/k	10k	12/10k	All
East Carbon	270	12/5k	1.25/k	All		
Escalante	276	19/15k	1.50/k	10k	2/20k	
Green River	299	15/6k	2/k	All		
Helper Municipal	354	12/10k	1.45/k	All		
Lyman	151	10/10k	.80/k	All		
North Emery Water Users	136	20/10k	1/k	10k	.50/30k	All
Price City	307	29.50/6k	1.35/k	All		
Sunnyside	523	12/5k	1.25/k	All		
Teasdale SSD	399	15/40k	.50/k	20k	1/k	All
Torrey	700	10/30k	.50/k	20k	1/k	All

revenue shortages, the rate schedule should provide a base charge that is set to cover all fixed cost - those which do not vary with the amount of water delivered. It will cover all debt service, insurance, personnel, etc. which must be paid regardless of how much water is taken from the system. All customers pay this charge whether they use any water or not. Variable costs - those that do vary with the amount of water delivered - should be covered by the volume charge, or what is often called the overage rate. Revenue from this part of the rate will vary with the amount of water delivered to customers and should cover the costs of all energy, treatment chemicals, etc.

- **A conservation price structure provides for the identification of waste, rewards efficient use and penalizes excessive use**. In larger communities with more sophisticated billing and customer relations staffs, water use targets can become part of the conservation program with currently available weather station technologies, phone modems and computer billing programs. With targets in place for each customer, water over-use is readily identified, as are exemplary water efficient behaviors.

- **A conservation price structure produces excess revenues from penalty rates that can be used to fund needed water conservation programs.** Water conservation comes at a cost. This cost can be added to the commodity portion of the rate, raising the price of each gallon of water delivered to the customer's meter. Revenue generated by the conservation portion of the rate schedule should be placed in a dedicated account and used to pay the cost of water conservation programs.

- **A conservation price structure is supported by a water bill that clearly communicates the cost of wasted water to the responsible person.** The ideal water bill would present a target usage based on weather, landscaped area and other pertinent use factors; the amount of water delivered above (or below) the target use; and the price charged for the target usage and any excess. With this information, the customer is equipped with the information needed to make intelligent choices about such things as landscape changes, spraying the driveway, washing the car, filling the pool and allowing long showers.

- **A conservation price structure is supported by a person or staff who can respond to customer calls for help in reducing water usage** . Individual home owners who desire to stay within their targets and request assistance can be visited, given a soil probe and taught to properly irrigate their lawns and gardens. Water audits for golf courses, school grounds and other large areas can be provided by trained staff personnel or by private or extension service irrigation specialists.

Water rates can be structured in several ways, each of which uphold the above principles in whole or in part. The next of three tables are used to demonstrate two common rate structures and one that is relatively new to system managers and customers in Utah. All examples bring in approximately the same revenue.

Flat rate is very simple to administer and to understand. A base charge is paid every month regardless of water use. All water delivered through the water meter is charged at a flat rate. Table 17-2 shows how this rate structure works in a hypothetical family for one year.

Increasing block rate is more complex but simple to administer if the water supplier has the proper computer billing hardware and software. Table 17-3 shows how this rate structure works in a hypothetical family for one year.

The flat and increasing block rates can be constructed to encourage efficient water use without causing a shortfall in revenue. This can be done by setting the base charge to cover fixed costs and the commodity charge set to cover variable costs.

Neither has a specific feature to identify wasteful or efficient behaviors. Under both, a water bill could be devised to show how much water is being used. A charge for each overage may encourage more efficient use. Both rate structures can be supported by a staff that responds to customer calls for help in reducing water use.

Ascending block rate is more complex. It provides a water use target for each customer based on size of landscaped area, family size and current weather conditions as measured by evapo-transpiration. Irrigation application efficiency is also accounted for in setting the targets. Table 17-4 shows how this rate structure works in a hypothetical family for one year.

17.3.5 Wastewater Reuse

Since there is only one wastewater treatment plant (Price) in the West Colorado River Basin, water reuse is not a significant source for secondary irrigation. In other regions of the United States, wastewater is routinely utilized to irrigate golf courses, landscaped strips along state and federal highways, municipal parks, and other isolated public landscaped areas.

17.4 Issues and Recommendations

The overall M&I per capita water use (potable and non-potable) in this basin is greater than the state average which makes conservation an important component for meeting future needs. One policy issue dealing with pricing is discussed.

17.4.1 Water Pricing

Issue - Public water supplier pricing rate schedules can affect water use.

Discussion - A pricing strategy may be among the most powerful conservation tools at a water utility's disposal. Cities and water districts are finding certain rate schedules can help modify customer behavior and meet conservation goals (see Section 17.3.4). Those responsible for maintenance of large areas of turf should be billed for the cost of water, even if it is the municipality. This would bring about recognition of the cost of water.

Recommendation - The local water providers should adopt water-rate schedules that encourage water conservation. See Tables 17-2 through 17-4 for examples of water rate schedules. ●

Table 17-2
Flat Rate

Month	Usage (kgals)	Base Charge ($)	Commodity Charge ($1.10/kgal)	Total ($)
Jan	5	10.00	5.50	15.50
Feb	6	10.00	6.60	16.60
Mar	9	10.00	9.90	19.90
Apr	13	10.00	14.30	24.30
May	38	10.00	41.80	51.80
Jun	48	10.00	52.80	62.80
Jul	53	10.00	58.30	68.30
Aug	48	10.00	52.80	62.80
Sep	29	10.00	31.90	41.90
Oct	13	10.00	14.30	24.30
Nov	9	10.00	9.90	19.90
Dec	6	10.00	6.60	16.60
TOTALS	277	120.00	305.80	424.70

Table 17-3 **Increasing Block**						
Month	Usage (1,000 gal)	Base Charge ($)	Overage ($)			Total ($)
			0 gal to 10 kgal $0.90	10 gal to 20 kgal $1.00	Over 20 kgal $1.25	
Jan	5	10.00	4.50			14.50
Feb	6	10.00	5.40			15.40
Mar	9	10.00	8.10			18.10
Apr	13	10.00	9.00	3.00		23.00
May	38	10.00	9.00	10.00	22.50	51.50
Jun	48	10.00	9.00	10.00	35.00	64.00
Jul	53	10.00	9.00	10.00	41.25	70.25
Aug	48	10.00	9.00	10.00	35.00	64.00
Sep	29	10.00	9.00	10.00	11.25	40.25
Oct	13	10.00	9.00	3.00		22.00
Nov	9	10.00	8.10			18.10
Dec	6	10.00	5.40			15.40
TOTALS	277	120.00	94.50	58.00	145.00	416.50

Table 17-4
Ascending Block

Month	Usage (kgals)	Base Chg. ($)	Target use (kgals)	ET In.	Discount @ $.83/ Kgal	Conserve use @ $1.10/Kgal	Inefficient Use @ $2.20/Kgal	Wasteful Use @ $4.40/Kgal	Irres. Use @ $8.80/Kgal	Total ($)
Jan	5	10.00	11	0	4.13					14.13
Feb	6	10.00	11	0	4.95					14.95
Mar	9	10.00	11	0	7.43					17.43
Apr	13	10.00	26.0	4	10.73					20.73
May	38	10.00	35.84	6.67		41.80				51.80
Jun	48	10.00	41.85	8.30		46.04	13.52			69.56
July	53	10.00	45.17	9.20		49.69	17.22			76.91
Aug	48	10.00	41.85	8.30		46.04	13.52			69.56
Sep	29	10.00	29.69	5		32.65				42.65
Oct	13	10.00	26.00	4	10.73					20.73
Nov	9	10.00	11	0	7.43					17.43
Dec	6	10.00	11	0	4.95					14.95
TOTALS	277	120.00	301.40	45.47	50.35	216.22	44.26			430.88

Days in Billing Period = 30 Application Efficiency = .65 Indoor use = 75 gpcd
Irrigated Area = .21 ac. Family Size = 5

Section 18 - West Colorado River Basin
Industrial Water

18.1	Introduction	18-1
18.2	Industrial Water Use	18-1
18.3	Projected Industrial Water Development	18-3

Tables

18-1	Industrial Water Use by County	18-2
18-2	Projected Industrial Water Use by County	18-3
18-3	Potential Hydroelectric Sites	18-3

Section 18

West Colorado River Basin - Utah State Water Plan

Industrial Water

18.1 Introduction

The generation of electrical power has become an important part of our society. The current uses of water for power production are large and may increase in the future. Other industrial uses include mining and manufacturing. It is important to have suitable water available for these and additional industries that may come into the basin.

This section of the *West Colorado River Basin Plan* presents data and information taken from several studies on municipal and industrial (M&I) water use. Current and projected industrial water use is presented for public water systems and private self-supplied industries.

Self-supplied industries are among the major water users in Carbon and Emery counties.

Hunter Power Plant in Emery County

18.2 Industrial Water Use [16]

Table 18-1 shows a breakdown of estimated industrial water uses in 1996, totaling about 36,300 acre-feet. This includes potable and non-potable water supplies.

Water planners and managers need to provide for the future construction of treatment and distribution facilities to accommodate any increases in industrial water demand.

Projected industrial water use data are presented in Table 18-2. In contrast to residential and commercial water users, which grow in proportion with population, future industrial use in this basin is difficult to predict. Industrial water use will increase to an estimated 42,000 acre-feet by the year 2020.

18.2.1 Water Use By Major Industries

Utah Power is the major water user in the West Colorado River Basin with three coal-fired steam generation electrical power plants. The Carbon plant west of Price in Carbon County uses about 3,000 acre-feet of potable and non-potable water. This plant's water rights are diverse and include well sources and surface water from the Price River. Numerous agreements are in place with Helper city, Price City and the Price River Water Improvement

Table 18-1
Industrial Water Use by County

County	Potable	Non-Potable (acre-feet)	Total Industrial
Carbon			
Self-Supplied Industries	2,579	2,200	4,779
Public Community Systems	162	0	162
Emery			
Self-Supplied Industries	1,103	30,000	31,103
Public Community Systems	62	0	62
Wayne			
Self-Supplied Industries	0	0	0
Public Community Systems	133	0	133
Garfield			
Self-Supplied Industries	3	0	3
Public Community Systems	2	0	2
Kane			
Self-Supplied Industries	48	0	48
Public Community Systems	0	0	0
Totals	4,092	32,200	36,292

Source: Utah Division of Water Resources: M&I Water Supply Studies, West Colorado River Basin, 1998.

District for exchange of water supplies and use of each other's facilities. Some storage is provided in Scofield Reservoir

Utah Power and Light operates the Huntington and Hunter plants in Emery County. They use about 31,000 acre-feet of potable and non-potable water. The Huntington and Hunter plants have a water storage of about 84,000 acre-feet. About 54,000 acre-feet of water has been acquired from irrigation companies on Ferron, Cottonwood and Huntington creeks and includes about 8,600 acre-feet from the Joes Valley Project. The other 30,000 acre-foot supply was developed by Utah Power and Electric Lake Dam on Huntington Creek. These supplies provide holdover capability for use during extended drought cycles.

Sunnyside Cogeneration Associates in Carbon County uses about 800 acre-feet from Grassy Trail Reservoir at its coal-fire steam-generation electrical power plant in Sunnyside. Mining companies, including CO-Op Mining Co.; Genwal Resources, Inc.; Energy West; Canyon Fuel Co., Cypress Western Coal Co.; and White Oak Mining and Construction Co. in Carbon and Emery counties are other major water users. Total water use by these companies is about 1,000 acre-feet.

18.2.2 Non-Consumptive Industrial Water Use [31]

Hydroelectric power generation plants require operational hydraulic head and significant volumes of water. However, this is a non-consumptive use

Table 18-2 Projected Industrial Water Use by County [a]		
County	1996 (acre-feet)	2020
Carbon	4,941	6,000
Emery	31,165	35,000
Wayne	133	200
Garfield	5	10
Kane	48	100
Totals	36,292	41,310

[a]Includes potable and non-potable water use.

and the water can be used downstream. The one hydroelectric power generation facility is a small plant above Boulder operated by GarKane Power Association, Inc. Table 18-3 lists potential hydroelectric sites within the basin. Another non-consumptive industrial water use is fish production. Wayne County has two state fish hatcheries (Loa and Bicknell) and one privately run trout farm (Loa). The state also has a fish hatchery located near Big Water in Kane County that is used in the Recovery Implementation Program (RIP) for the endangered Colorado River fish. All of these facilities need large quantities of water to operate efficiently.

18.3 Projected Industrial Water Development

Industrial requirements for water are not expected to increase significantly. The coal mining operations in Carbon and Emery counties have reserves for up to 30 years. The West Colorado River Basin has been identified as a major source of tar sand. If mining tar sands were to become economically feasible, large amounts of water would be necessary. With the creation of the new Grand Staircase-Escalante National Monument, it is doubtful that the Kaparowitz Plateau coal will ever be mined. It is anticipated that any increase in industrial water needs will be from light industries that will probably use culinary water from existing public water suppliers. ●

Table 18-3
Potential Hydroelectric Sites

County/ Reservoir Name	River	Potential Capacity (kw)	Owner
Carbon			
Scofield	Price	1,347	DOI USBR
Electric Lake	Huntington Creek	868	Utah Power
Joes Valley Res.	Seely Creek	142	DOI USBR
Millsite	Ferron Creek	110	Ferron Canal & Res. Co.
Sevier			
Johnson	Seven Mile Creek	132	Fremont Irrigation Co.

Section 19 - West Colorado River Basin
Groundwater

19.1	Introduction	19-1
19.2	Aquifer Characteristics	19-1
19.3	Groundwater Basins	19-5
19.4	Case Histories	19-16
19.5	Policy Issues and Recommendations	19-19

Figures

19-1	Folding of the Navajo Sandstone	19-3
19-2	Stress Concentrations in Folded Rocks	19-4
19-3	Groundwater Basins	19-7
19-4	Geologic Cross Sections	19-8
19-5	Well Locations	19-11
19-6	Spring Locations	19-12
19-7	Lithologic Log - Tropic Culinary Well	19-17
19-8	Lithologic Log - Escalante Culinary Well	19-18
19-9	Hydrographic Profile	19-20

Tables

19-1	Characteristics of Selected Aquifers	19-2
19-2	Estimated Storage Characteristics of Navajo Sandstone	19-6
19-3	Springs and Wells by Basin	19-10
19-4	Groundwater Contribution to Municipal Supply	19-10
19-5	Groundwater Budget of the San Rafael Basin	19-13
19-6	Groundwater Budget of the Lower Dirty Devil River Basin	19-14
19-7	Groundwater Budget of the Kaiparowits Plateau Basin	19-16

Section 19

West Colorado River Basin - Utah State Water Plan

Groundwater

19.1 Introduction [24]

Surface water occurs in readily discernible drainage basins, while groundwater occurs in aquifers that are hidden from view. The boundaries of an aquifer may outcrop at the surface or be deeply buried. At any given location, the land surface may be underlain by several aquifers. Each aquifer may have a different chemical quality and different hydraulic potential. Each aquifer may be recharged in a different location and flow in a different direction. Groundwater divides do not necessarily coincide with surface water divides. For these reasons, the development and management of groundwater is more complicated than that of surface water.

Development of the groundwater resources in the West Colorado River Basin to date has been minor. This is due to several reasons: 1) The general absence throughout the basin of productive and easily developed alluvial aquifers; 2) the unfractured consolidated aquifers generally have hydraulic properties that are not conducive to large-scale groundwater development; 3) the quality of the groundwater in some parts of the area is unsuitable for domestic, municipal, and/or agricultural uses; and 4) the economics of drilling and pumping water from deeply buried consolidated aquifers is not economical for many uses.

In order to adequately address the highly diverse hydrogeology in the West Colorado River Basin, the discussion of groundwater and aquifers is divided into smaller basins. Each of these smaller basin subdivisions has unique aspects to its groundwater setting.19

19.2 Aquifer Characteristics [36, 37, 39,, 49, 50]

From Table 19-1 it is evident that the most productive aquifers within the basin consist of alluvium, basaltic lava flows, and Mesozoic and Paleozoic aged sedimentary formations of limestone and sandstone.

While groundwater is not a major source of water in the West Colorado River Basin, locally it is very important. In some communities it is the sole source of culinary-grade water.

Unconsolidated, valley-fill materials have traditionally been the best producers of groundwater in Utah. About 98 percent of the wells in Utah are completed in unconsolidated deposits. In the West Colorado River Basin, however, the occurrence of unconsolidated deposits is limited. The unconsolidated deposits, where present, are composed of alluvium and lacustrine deposits consisting of gravel, sand, clay and silt.

Alluvial aquifers are generally characterized by high transmissivities (up to 14,000 feet per year) and high storage coefficients (up to 20 percent). They are often thin and thus frequently connected to surface water sources and, therefore, subject to contamination. In most areas of the West Colorado River Basin the unconsolidated aquifers are thin and found in the bottoms of canyons, in stream valleys, and as discontinuous caps on terraces. These deposits are rarely more than 20 to 50 feet thick.

Due to the lack of alluvial aquifers in much of this basin, the only other groundwater that could be developed is from consolidated or bedrock aquifers. The best producing consolidated aquifers are volcanic basalt flows and sandstone formations.

Table 19-1 Characteristics of Selected Aquifers		
Formation	Permeability (ft/d)	Transmissivity $(ft/d)^2$
Alluvium	0.5 to 500	200 to 14,000
Basalt Flows	0.5 to 500	50 to 14,000
Flagstaff	0.5 to 500	nd
North Horn	0.5 to 5	nd
Price River	5 to 500	nd
Entrada	0.5 to 50	5 to 200
Navajo	0.5 to 50	1 to 14,000
Wingate	0.5 to 50	nd
Kaibab	0.5 to 50	nd
Coconino	0.5 to 50	10

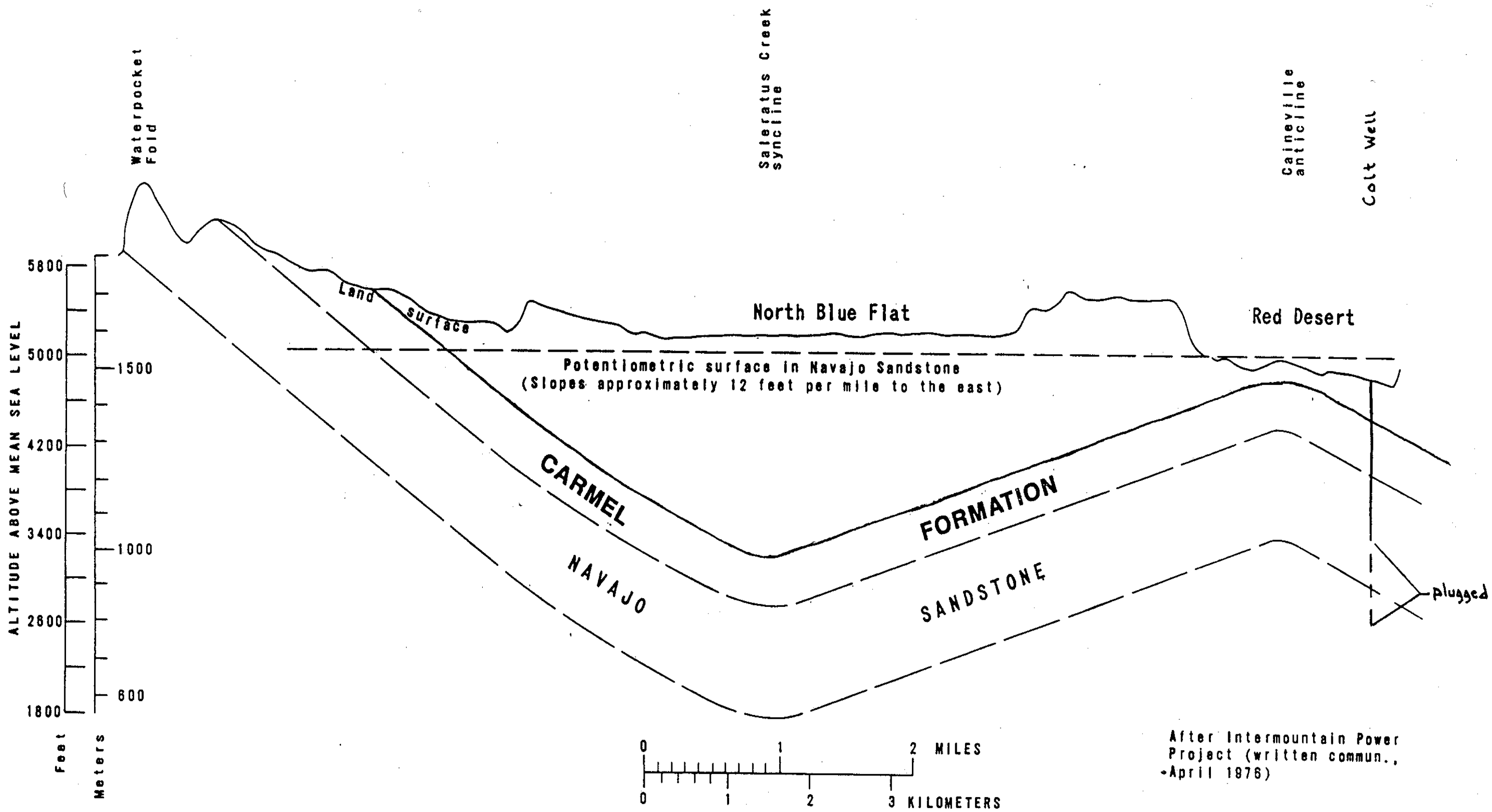
Source: Schlotthauer & others, Tables 9 & 10, 1981.

The Entrada Sandstone, the Navajo Sandstone, the Wingate Sandstone, and the Coconino Sandstone, including its equivalents in the Cutler Formation, have been found to yield water to springs or wells in sufficient quantity and quality to be useful. Of these, the Navajo Sandstone aquifer has been the most studied.

Groundwater in these consolidated formations is unconfined in locations nearest areas of recharge. Confined conditions, however, are the most common. It is estimated that confined conditions occur in about 90 percent of the area within the basin which is underlain by sedimentary rocks. Artesian conditions exist where the confined aquifers are pressurized, such as the Red Desert area north of Caineville (see Figure 19-1). In the Colt well, the top of the Navajo Sandstone was encountered at 710 feet below ground while the artesian water level stood at 178 feet above ground.

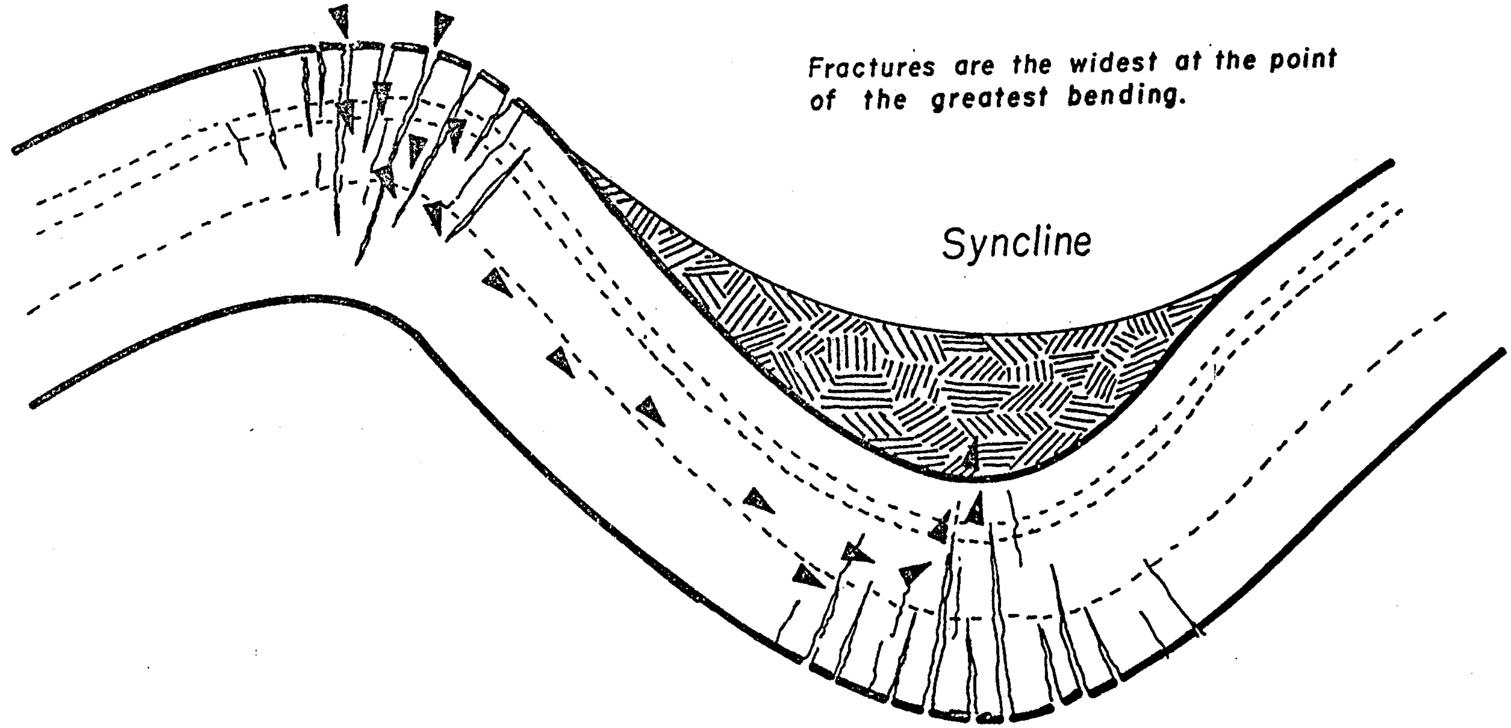
The circulation of groundwater in these consolidated aquifers is affected by folding and faulting, which locally will either enhance groundwater movement by fracturing (See Figure 19-2) or impair groundwater movement by offsetting aquifers, as across Joes Valley. Fracturing also, locally, enhances interformational leakage which affects water quality.

The Navajo Sandstone aquifer underlies most of the West Colorado River Basin and ranges from 400 to 1,600 feet in thickness. It is cross-bedded, massive, and made up of very fine to fine-grained, poorly to well-cemented sand. Between 1971 and 1974, extensive studies of the Navajo Sandstone aquifer were carried out by the Intermountain Consumers Power Association and then by the Intermountain Power Project. These studies were made during planning for the construction of a coal-fired electrical generation plant in the area north of Caineville. From these studies came the following characteristics of the Navajo Sandstone aquifer. The unfractured sandstone as an aquifer is characterized as homogeneous and isotropic. However, geologic mapping and the results of extensive well tests indicate that the Navajo Sandstone is frequently fractured so that the overall permeability is increased and the formation can be



Generalized east-west section showing folding of the Navajo Sandstone.

Figure 19-1



Graphic illustration of stress concentrations in folded rocks

Figure 19-2

considered heterogeneous and probably anisotropic on a regional scale. The average hydraulic conductivity is about 0.5 ft per day. Transmissivity, calculated from a 30-day pump test, averaged 1,500 feet per day. Under artesian conditions, a generalized value for Storage Coefficient is 0.001 and the value for Specific Yield is estimated to be between 5 and 10 percent.

Table 19-2 summarizes the storage characteristics of the Navajo Sandstone for those groundwater basins where studies by the U.S. Geological Survey have been conducted.

19.3 Groundwater Basins

As shown on Figure 19-3, the West Colorado River Basin consists of five groundwater basins which, although connected by surface flows, are geologically separate. Due to the sparse population and lack of industrial development, no detailed studies have been conducted in any of these basins, with the exception of the Intermountain Power Project study in the Red Desert north of Caineville. Only very general information needed to determine the simplest groundwater budgets has been gathered.

19.3.1 Castle Valley Groundwater Basin [13, 21, 33, 35, 42, 60]

Castle Valley has been eroded into the thick, Mesozoic aged Mancos Shale formation (see Figure 19-4-A). It is understood that geologic conditions in this area of Emery and Carbon counties are mostly unfavorable for producing groundwater from wells, especially of the quality and quantity that would be required for a municipal supply. The highest producing wells and springs which occur in this basin have been developed outside of Castle Valley in the neighboring Wasatch Plateau, where the sandstone and limestone beds of the Flagstaff (T_1 in Figure 19-4-A), North Horn (TK), and Price River (uppermost K_3) formations have yielded water. The main Jurassic/Triassic age aquifers (Entrada J_1, Navajo, and Wingate Sandstones JTR) are all too deeply buried to be considered as economically feasible groundwater targets.

Not enough data have been gathered in this groundwater basin to determine a groundwater budget. Table 19-3 indicates there are 488 wells (see Figure 19-5) and 2,930 springs (see Figure 19-6) whose water rights status is categorized as either perfected or approved. In this basin for the 15-year period 1979 through 1993, an average 10 percent of total municipal water supplies was groundwater (see Table 19-4). A total of 648 acre-feet was produced from springs, while 4,079 acre-feet was produced from wells during this time period.

Water quality has not be studied sufficiently in this groundwater basin to allow a detailed discussion. In general, the thick Mancos Shale (K_2) and other coal bearing bedrock units (Castlegate Sandstone, Blackhawk Formation, and Star Point Sandstone of K_3) have produced water of poor quality. Some concern has been expressed about coal mining activities and the effect it has on water quality. See Policy Issues and Recommendations, Section 19.5, for discussion of this issue. Better quality water is found in the overlying Tertiary and uppermost Cretaceous beds (Flagstaff, North Horn, and Price River formations).

19.3.2 San Rafael Swell Groundwater Basin [21, 35, 38]

The San Rafael Swell is a broad, asymmetrical upwarp which is about 70 miles long and 30 miles wide (see Figure 19-4-B). Its asymmetry comes in part from the fact that strata on the west side have a shallow westerly dip of 2 ° to 6 °, while strata on the east side, by contrast, dip steeply to the east from 45° to 85°. Mesozoic and Paleozoic rocks are exposed on the flanks of the swell where they can receive recharge (see Figure 19-4-B).

All the formations in the geologic section contain some water, but only five are considered to be major aquifers because of their large areal extent, their thickness, and their potential for locally large yields to individual wells. These five are the Entrada ($J_{1)}$, Navajo and Wingate Sandstones (JTR), the Coconino Sandstone P_1, and the limestone units of Mississippian age (M_1) (see Figure 19-4-B). Due to economic constraints of drilling deep bedrock wells, the most shallow and accessible sandstone units, the Entrada and the Navajo, have become the most common targets for groundwater development.

Table 19-2
Estimated Storage Characteristics of Navajo Sandstone[1]

Groundwater Basin	Average Thickness (feet)	Area (square miles)	Percent Saturated	Estimated Effective Porosity [3] (percent)	Volume of Groundwater in transient storage [4] (millions of acre-feet)	Assumed Specific Yield [5] (percent)	Water [2] in Transient Storage Assuming Complete Drainage (millions of acre-feet)	Water in Upper 100 Feet of Aquifer (millions of acre-feet)
San Rafael Swell	412	2,300	87	18	94	9	42 [2]	12
Lower Dirty Devil River	800	2,580	75	20	198	9	89 [2]	11
Kaiparowits Plateau	1,600	2,150	83	25	434	10	190 [2]	11

[1] Information gathered and published by the U. S. Geological Survey. (Technical Publication #s 78, 68, 81)
[2] The values stated for water recoverable from storage are calculated based on hydrologic theory. Actual recoverable amounts would be less because of various physical limitations, including depth to aquifer, well spacing and well yields, and various economic, legal and environmental constraints such as land ownership.
[3] Effective porosity is defined as the volume of void spaces through which water can travel in a rock or sediment divided by the total volume of the rock or sediment.
[4] Transient storage is the amount of water which is moving through an aquifer, analogous to the "active storage" of a surface reservoir and does not include isolated water or "dead storage".
[5] Specific yield is the ratio of the volume of water that will drain under the influence of gravity to the volume of saturated rock. This groundwater may not be economically or legally recoverable.

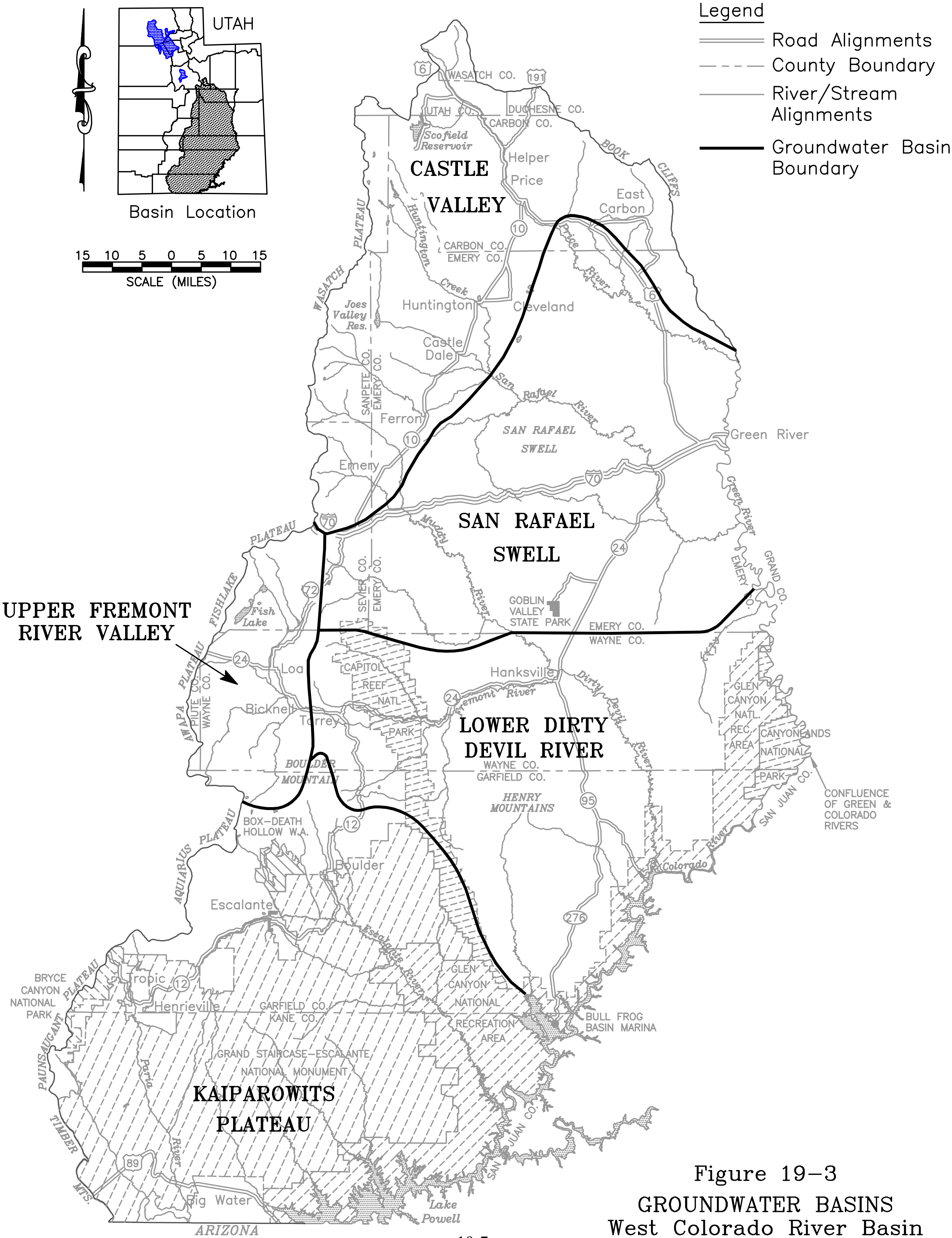


Figure 19-3
GROUNDWATER BASINS
West Colorado River Basin

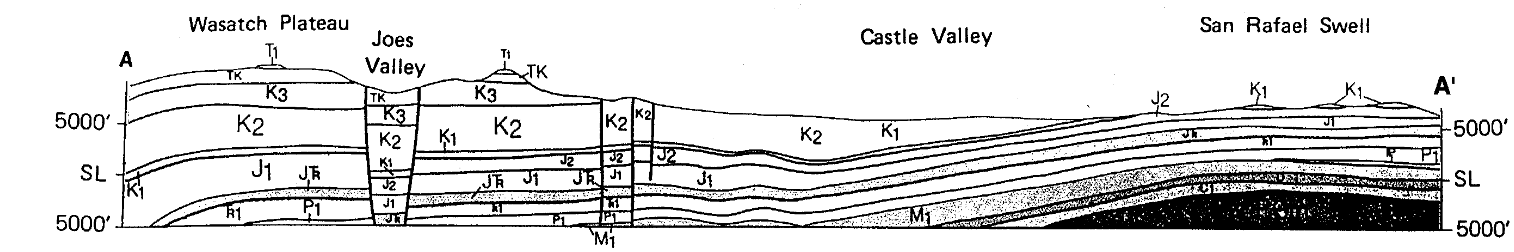


Figure 19- A

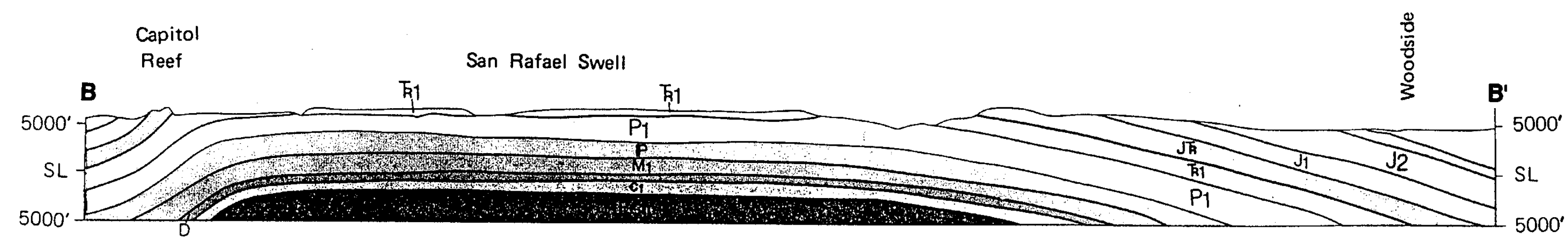


Figure 19- B

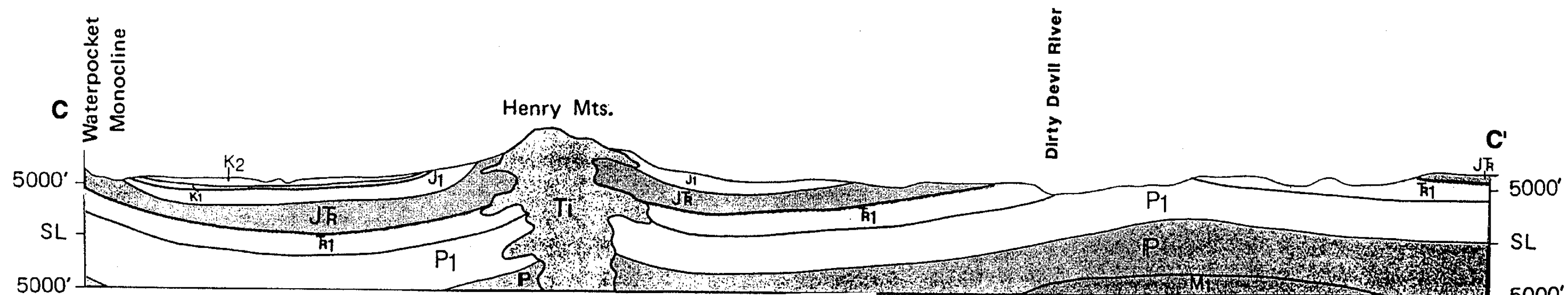


FIGURE 19-4
GEOLOGIC CROSS SECTIONS
(LOCATIONS ON FIGURE 19-3)

Figure 19– C

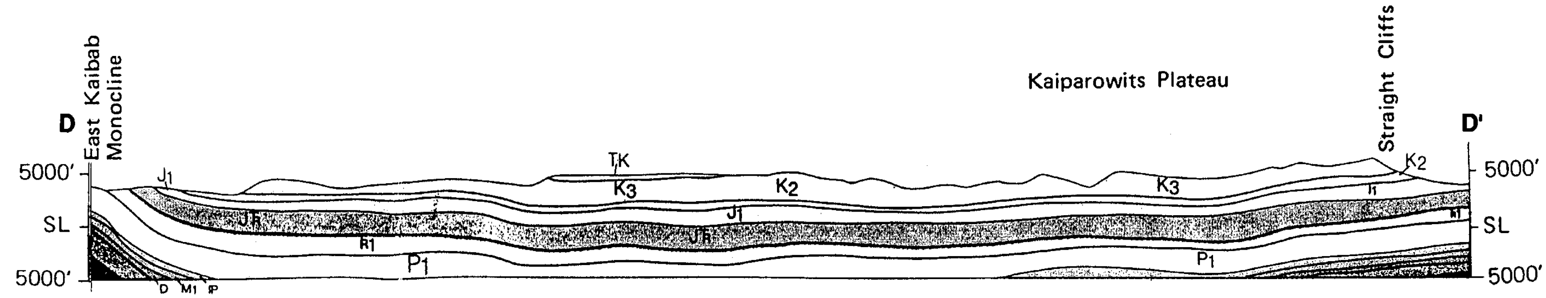


Figure 19 - D

Geologic Legend for Cross-sections

Tertiary
- T_1 - Flagstaff Formation
- TK - North Horn & Canaan Peak Formations

Cretaceous
- K_3 { Price River Fm., Castlegate Sandstone, Blackhawk Formation, Star Point Sandstone }
- K_2 - Mancos Shale
- Dakota Sandstone &
- K_1 - Cedar Mtn. or Burro Canyon Fm.

Jurassic
- J_2 - Morrison Formation
- Bluff Sandstone
- J_1 { Summerville Formation, Curtis Formation, Entrada Sandstone, Carmel Formation }
- JŦR { Navajo Sandstone, Kayenta Formation, Wingate Sandstone }

Triassic
- $Ŧ\!R_1$ - Moenkopi Formation

Permian
- P_1 - Cutler Group

Pennsylvanian
- P - Hermosa Group

Mississippian
- M_1 - Redwall Lms.

Devonian
- D { Ouray Lms., Elbert Fm., McCracken Ss., Aneth Fm. }

Cambrian
- C_1 - Tapeats Qtzt.

FIGURE 19-4
Continued

Table 19-3
Springs and Wells by Basin

Groundwater Basins	Springs	Wells
Castle Valley	2,930	488
San Rafael Swell	294	109
Upper Fremont River Valley	499	100
Lower Dirty Devil River	479	301
Kaiparowits Plateau	698	388
Total	4,900	1,386

Source: Division of Water Rights.

Table 19-4
Groundwater Contribution to Municipal Supply
1979-1993

Groundwater Basins	Total Municipal Supply 1979-1993 (ac-ft)	Groundwater Source		Groundwater Percentage of Total Municipal Supply
		Springs (ac-ft)	Wells (ac-ft)	
Castle Valley	7,000	648	80	10
San Rafael Swell	6,265	0	0	0
Upper Fremont River Valley	5,720	4,938	782	100
Lower Dirty Devil River	4,673	3,560	1,113	100
Kaiparowits Plateau	12,496	9,218	3,278	100
Total	36,404	18,364	5,253	310

Source: Division of Water Rights.

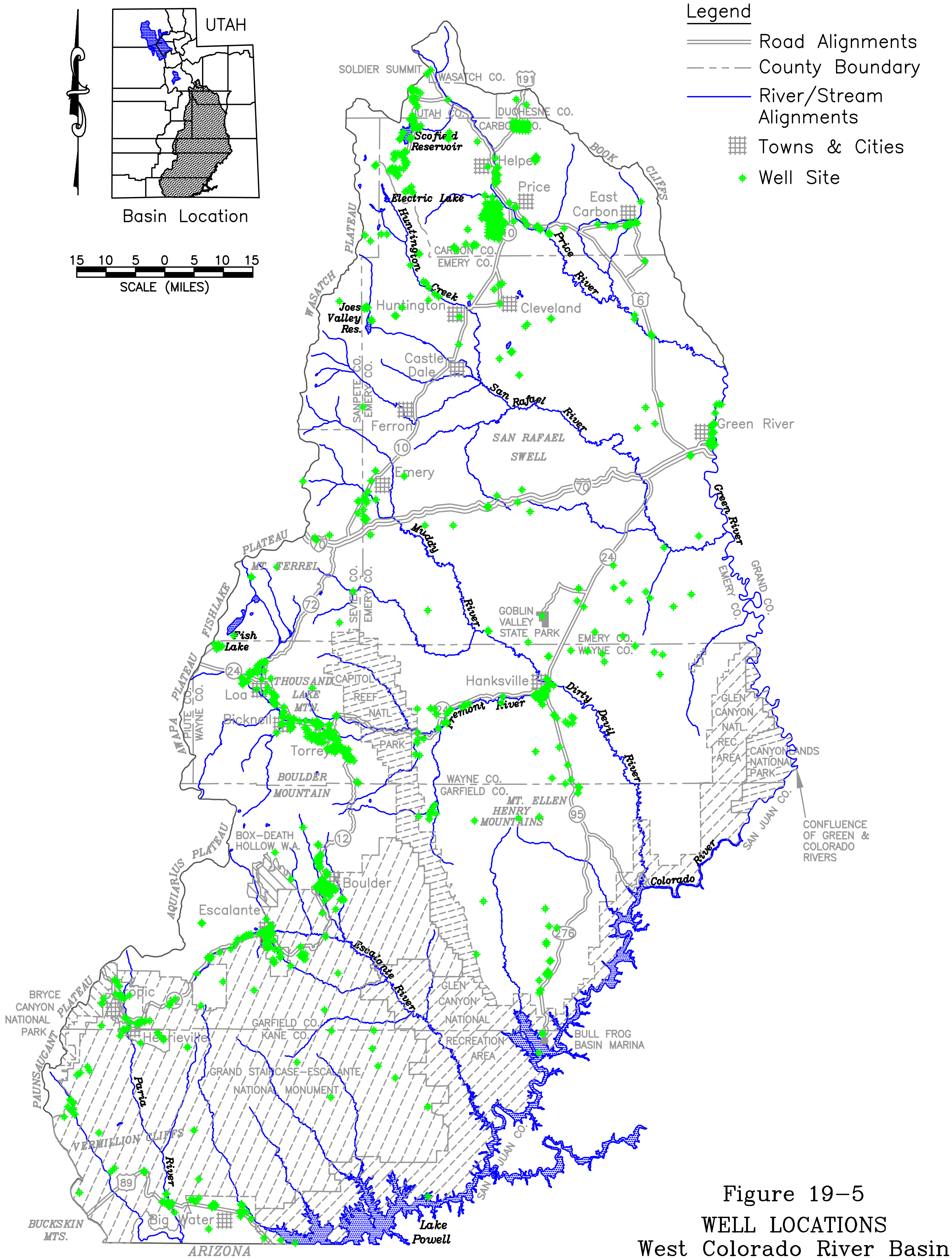


Figure 19-5
WELL LOCATIONS
West Colorado River Basin

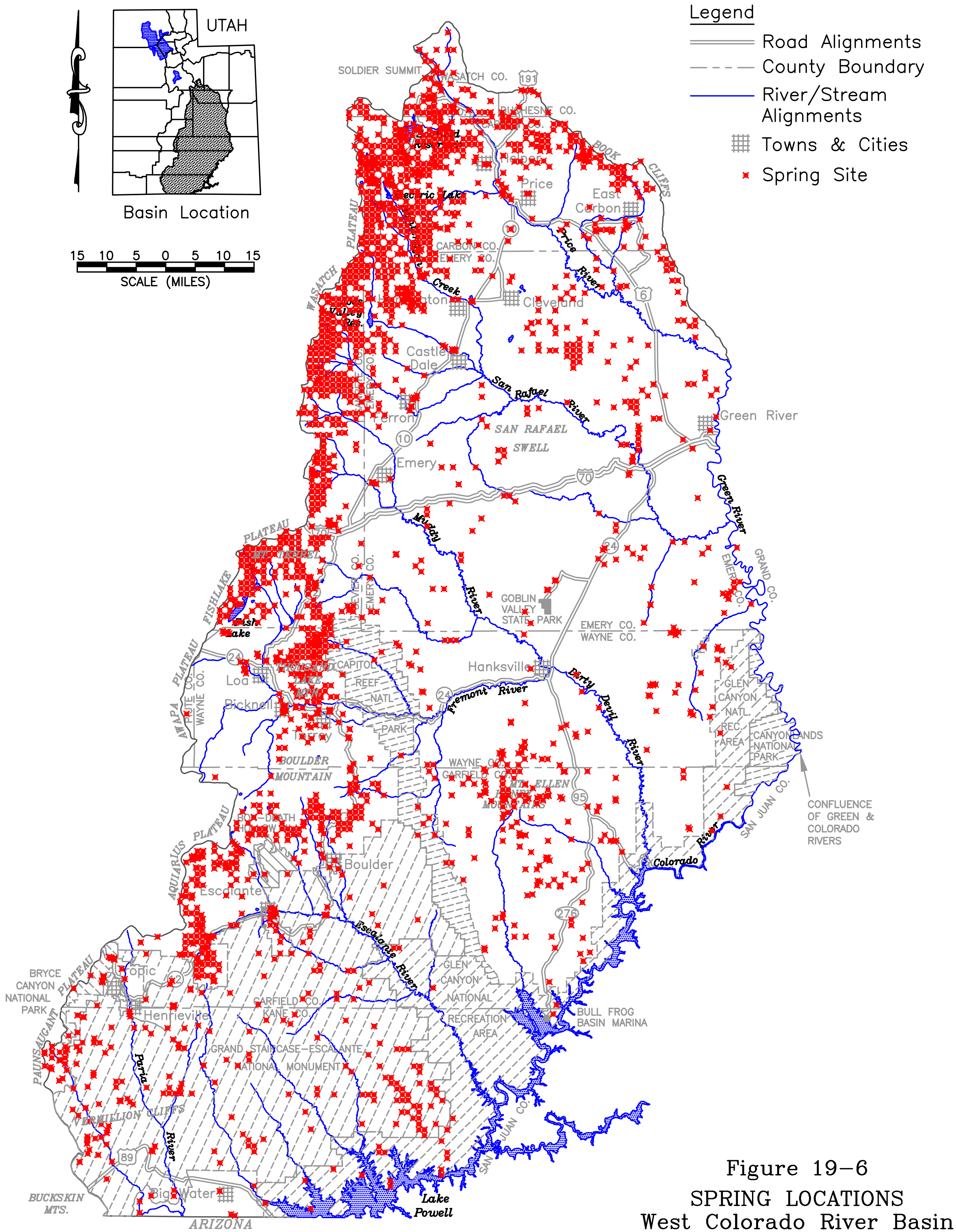


Figure 19-6
SPRING LOCATIONS
West Colorado River Basin

Table 19-5
Groundwater Budget of the San Rafael Basin

Component	Long-Term Average (ac-ft per year)	
	Navajo Sandstone	Basin Total
<u>Recharge</u>		
Precipitation	3,000	10,000
Recharge from Stream Loss (not known)	--	--
Subsurface Inflow (not known)	--	--
Total	3,000	10,000
<u>Discharge (figured for Navajo Sandstone only)</u>		
To Gaining Streams	2,000	Moderate Amount
Evapotranspiration + Springs	400	Majority
Subsurface Outflow	600	Minor Amount
Total	3,000	10,000

Table 19-5 shows the groundwater budget from the 1984 USGS study. Table 19-3 indicates that located within this basin are 109 wells (see Figure 19-5) and 294 springs (see Figure 19-6) whose water rights status is categorized as either perfected or approved. For the 15-year period from 1979 through 1993, none of the municipal supply was supplemented by groundwater (see Table 19-4), although there is a well at Goblin Valley State Park which supplies water from the Navajo Sandstone to park visitors. The average population during this time period was 1,136, all located in the town of Green River.

An estimated 87 percent of the Navajo Sandstone in this groundwater basin is saturated. Based on the figures in Table 19-2, there is 11.5 million acre-feet of water in the upper reaches of the Navajo Sandstone. It is not presently known how much of this resources is economically and legally recoverable.

The water budget shows the bedrock aquifers are full and overflowing. The water in storage is so large in comparison to recharge and discharge that substantial additional groundwater could be developed with a carefully planned system of wells without significantly affecting surface flow, spring discharge or existing water rights.

In this basin, consolidated bedrock aquifers are most likely to contain fresh water nearest their outcrop areas, where recharge takes place. Known occurrences of fresh water in the Navajo Sandstone include outcrop areas east and west of the San Rafael Swell, but also at depth in a broad area extending from the east edge of the Swell to the Green River. In most other areas, water in the Navajo shows some degradation by mixing with more saline water from overlying and/or underlying formations through interformational leakage.

19.3.3 Upper Fremont River Valley Groundwater Basin [11, 21]

The largest and most productive alluvial aquifers in the West Colorado River Basin are in the upper Fremont River Valley in the vicinity of Loa, northwestern Wayne County. Here the valley-fill material is as thick as 500 feet. Through well and spring development, groundwater from the unconsolidated aquifers in the upper Fremont Valley has been utilized for drinking water, irrigation, stock watering and fish culturing. Wells and springs in these deposits are found to yield from less than 10 gpm to greater than 1,000 gpm. The other productive aquifer in this basin is the volcanic basalt flows of Rabbit Valley in western Wayne County. Interconnecting columnar joints greatly add to the aquifer's ability to recharge, store, transmit and discharge groundwater. Numerous springs and wells are supplied by the basalt. Pine Creek Spring flows at 17.6 cfs, while some individual wells produce nearly 4.6 cfs. Springs at the head of Spring Creek flow at 10-12 cfs.

Not enough data have been gathered in this basin to determine a groundwater budget. Within this basin are 100 wells (see Figure 19-5) and 499 springs (see Figure 19-6). In this basin, all municipal water supplies come from groundwater (see Table 19-4), 85 percent of it from springs.

Water quality in this basin is generally very good. because the main aquifers are alluvium and basaltic lava flows, neither of which have many soluble minerals which would degrade water quality.

19.3.4 Lower Dirty Devil River Groundwater Basin [21, 35, 37]

The Henry Mountains set in the midst of a large structural basin (see Figure 19-4-C). Folding, faulting, and igneous intrusion are the principal factors that influence the permeability of consolidated rocks in this basin. While the Henry Mountain intrusions are themselves mostly impermeable, their emplacement resulted in extensive fracturing of intruded rocks, thus increasing the permeability of the enveloping sedimentary strata. The USGS studied this area in 1984 and developed a groundwater budget as shown in Table 19-6. There are 301 wells (see Figure

Table 19-6
Groundwater Budget of the Lower Dirty Devil River Basin

Component	Long-Term Average (ac-ft per year)	
	Navajo Sandstone	Basin Total
Recharge		
Precipitation	5,000	34,000
Recharge from Stream Loss (not known)	--	--
Subsurface Inflow (not known)	--	--
Total	5,000	34,000
Discharge		
To gaining streams	--	Moderate Amount
Springs and Wells	--	Very Minor Amount
Evapotranspiration	–	Majority
Subsurface Outflow	--	Minor Amount
Total	5,000	34,000

19-5) and 479 springs here (see Figure 19-6 and Table 19-3). In this basin, 100 percent of municipal water supplies comes from groundwater (see Table 19-4), more than two-thirds from springs. A total of 3,560 acre-feet was produced from springs, while 1,113 acre-feet was produced from wells.

An estimated 75 percent of the Navajo Sandstone in this groundwater basin is saturated. Based on the figures in Table 19-2, there is 11 million acre-feet of water in the upper 100 feet of the Navajo Sandstone. More work needs to be done to determine how much of this is economically and legally recoverable. As in the San Rafael groundwater basin, the water budget for this basin shows that the bedrock aquifers are full and overflowing.

From studies conducted and reported by the USGS, it has been determined that the Navajo Sandstone in this basin contains fresh water over large areas, but locally is degraded by interformational leakage to qualities ranging from slightly saline to briny.

19.3.5 The Kaiparowits Plateau Groundwater Basin [12, 21]

The Kaiparowits Plateau consists of nearly flat-lying sedimentary rocks and overlies the Kaiparowits structural basin, where the down-turned Navajo Sandstone reaches depths at or below sea level (see Figure 19-4-D). The plateau is bounded on the west by the Cockscomb Ridge which is a hogback formed on the East Kaibab Monocline. The monocline dips steeply eastward as much as 86 degrees. The Navajo Sandstone is intensely fractured along this fold. This secondary porosity enables a large percentage of the precipitation in the area to infiltrate as recharge. The Kaiparowits Plateau is bounded on the east by the Straight Cliffs, which is a cuesta formed along the west limb of the Circle Cliffs upwarp. Here the strata has a gentle westward dip.

In 1986 the USGS studied this area and came up with the very general groundwater budget shown in Table 19-7. Within this basin are 388 wells (see Figure 19-5) and 698 springs (see Figure 19-6 and Table 19-3). In this groundwater basin, most of the municipal water supplies come from groundwater (see Table 19-4). An estimated 83 percent of the Navajo Sandstone in this basin is saturated. Based on figures in Table 19-2, there is 10.9 million acre-feet of water in the upper 100 feet of the Navajo Sandstone aquifer. More work needs to be done to determine how much of this is economically and legally recoverable. Again, as in the San Rafael and Upper Fremont groundwater basins, the water budget of this basin shows bedrock aquifers are full and overflowing.

From studies conducted and reported by the USGS, it has been determined that groundwater in the Navajo Sandstone in this basin ranges from fresh to slightly saline. As expected it is freshest in the principal recharge areas (near Boulder Mountain, the Paria Plateau and the western side of the Kaiparowits Plateau) where unconfined conditions exist. In these areas, the Navajo is either at the surface or is overlain by alluvium or dune sand. The water is slightly saline in areas of deepest burial where the formation is completely saturated and is overlain by the Carmel Formation. Areas such as this, where the Navajo aquifer is confined, exist throughout the basin and were identified particularly near the Paria River where it is crossed by U.S. Highway 89 and in the Wahweap Bay area near Lake Powell. In areas dominated by unconfined conditions, the predominant water type is calcium magnesium bicarbonate. In areas of confined conditions, the water type is generally sodium sulfate.

Inundation of Glen Canyon and tributary canyons by Lake Powell has resulted in an increase in the level of the potentiometric surface near the lake. The groundwater system, put out of equilibrium by the lake, has been slow to re-establish the regional gradient back toward Glen Canyon and Lake Powell. A higher potentiometric surface and much flatter groundwater gradient will result from the attainment of equilibrium. Inundation has also caused changes in groundwater chemistry near the lake. This is particularly true where the potentiometric surface has risen above the contact between the Navajo Sandstone and the Carmel Formation. Most affected has been the

Table 19-7
Groundwater Budget of the Kaiparowits Plateau Basin

Component	Long-Term Average (acre-feet per year) Navajo Sandstone	Basin Total
<u>Recharge</u>		
Precipitation	8,300-16,900	44,000
Recharge from Stream Loss (not known)	--	--
Subsurface Inflow (not known)	--	--
Total	8,300-16,900	44,000
<u>Discharge (figured for Navajo Sandstone only)</u>		
To gaining streams (not known)	--	Moderate Amount
Spring and Seeps	6,600-15,200	Moderate Amount
Wells	1,500	Minor Amount
Evapotranspiration	200	Majority
Subsurface Outflow (not known)	--	Minor Amount
Total	8,300-16,900	44,000

increase in sulfate concentration and decrease in bicarbonate plus carbonate concentration of water in the Navajo Sandstone.

19.4 Case Histories [5, 39]

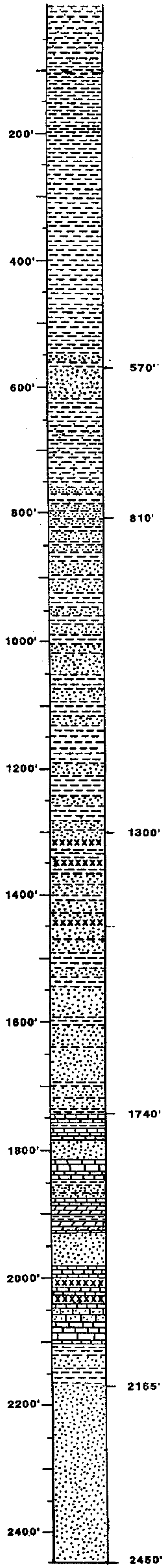
Two wells, both drilled in the time period of 1990 to 1991, are worthy of discussion. They are characteristic of the challenges faced by those who would develop water from the consolidated aquifers in this basin.

The first well, completed in April 1991, targeted the Navajo Sandstone and was drilled in the town of Tropic in Garfield County. The second well, likewise completed in 1991, also targeted the Navajo Sandstone and was drilled near the town of Escalante in Garfield County. Both wells exceeded 2,000 feet in total depth. It was anticipated that each would provide water to their respective communities as public supply wells, but currently only the Escalante well provides culinary water.

The Tropic well, located in the Paria Amphitheater, is collared in the Tropic Shale. The well encounters the following formations before entering the Navajo Sandstone: the Tropic Shale, Dakota Formation, Entrada Sandstone and the Carmel Formation (see Figure 19-7). The Navajo Sandstone was encountered at a depth of 2,165 feet and the well penetrated 285 feet of Navajo before reaching total depth at 2,450 feet. Static water level stood at 911 feet below the collar.

The Tropic well was test pumped at 320 gpm for 24 hours. The water has a total dissolved solids content of 448 mg/l. It exceeds state drinking water standards in arsenic, iron and turbidity (which is a consequence of dissolved iron), and at this time remains unused for culinary purposes.

The Escalante well, located near the western limb of the Escalante anticline, penetrates the Entrada Sandstone, Carmel Formation and Page Sandstone before reaching the Navajo Sandstone (see Figure 19-8).



TROPIC SHALE

Mudstone, sandy and carbonaceous, medium-grey to black, soft to hard, finely laminated, fissile, bentonitic, gypsiferous. Carbonaceous content varies. Weathered into sandy clay to clayey sand in the upper 90 feet.

Incomplete Thickness Tropic Shale--570'

DAKOTA FORMATION

Interbedded Sandstone, light-to medium-grey, friable, very-fine-grained, well-sorted;

Mudstone, medium-grey to black, soft to hard, finely laminated, fissile, carbonaceous, gypsiferous.

Total Thickness Dakota Fm.--240'

ENTRADA FORMATION

Interbedded Sandstone, light-to medium-brown, reddish-brown and light-grey, friable, very-fine-grained, well-sorted;

Mudstone, grey, brown, and reddish-brown, soft to hard, finely laminated.

Total Thickness Entrada Fm.--490'

CARMEL FORMATION

Interbedded Sandstone, light-to medium-brown and reddish-brown, friable, very-fine-grained, well-sorted;

Mudstone, light-to medium-reddish-brown and light-to medium-grey, soft, finely laminated;

Gypsum, mostly white, acicular selenite and massive fine-granular.

Interbedded Limestone, light-grey, hard, brittle, siliceous, medium-to fine-grained;

Dolomite, white to light-grey, hard, brittle, siliceous, fine-grained;

Sandstone, light-brown, friable, very-fine-grained, well-sorted;

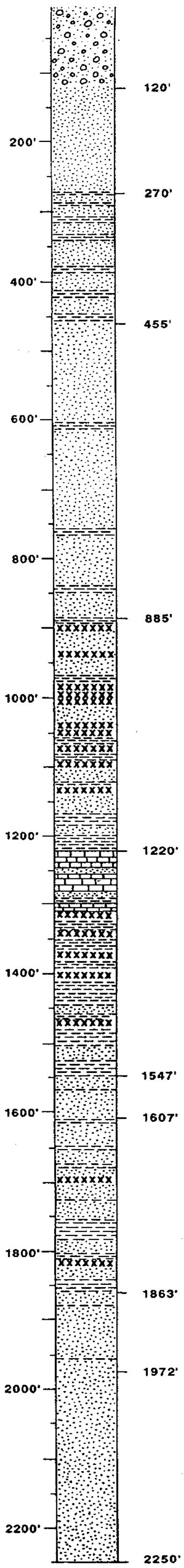
Gypsum, white and light-to medium-grey, massive, sugary textured.

Total Thickness Carmel Fm.--865'

NAVAJO SANDSTONE

Sandstone, white, friable, very-fine-grained and well-sorted.

Figure 19-7. **Lithologic log - Tropic culinary well**



ALLUVIUM/COLLUVIUM

Sand, generally white to light-brown, coarse-to fine-grained; and
Gravel, to cobble size, mostly well-rounded sandstone, quartzite, chert and siltstone.

ENTRADA FORMATIION

Sandstone, light-to medium-greenish-grey, friable, fine-to very-fine-grained, well-sorted.

Interbedded Sandstone, light-to medium-brown and reddish-brown, friable, fine-to very-fine-grained, well-sorted;
Mudstone and Siltstone, mostly reddish-brown and minor bluish-grey, soft, very-thin-bedded.

Sandstone, reddish-brown, harder, medium-to fine-grained, contains large, angular chips of yellow, orange, grey, and black chert; contains a few thin interbeds of
Mudstone, medium-to dark-reddish-brown, very-thin-bedded to laminated.

Incomplete Thickness Entrada Fm.--765'

CARMEL FORMATION

Interbedded Sandstone, brown to reddish-brown, fine-to very-fine-grained, well-sorted;
Mudstone, mostly reddish-brown with some greenish-grey, soft, very-thin-bedded;
Gypsum, white, grey, green, red, and brown, acicular selenite and massive fine granular.

Interbedded Limestone, light-to medium-grey, very-fine-grained, hard, siliceous;
Sandstone, light-to medium-brown and reddish-brown, friable, medium-to very-fine-grained;
Mudstone, reddish-brown and light-to medium-greenish-grey, soft, very-thin-bedded;
Gypsum, clear and white, acicular selenite and massive fine granular.

Total Thickness Carmel Fm.-Upper Member--662'

PAGE SANDSTONE - THOUSAND POCKETS TONGUE

Sandstone, light-to medium-brown, friable, medium-to very-fine-grained; with very minor Mudstone and Gypsum.

Total Thickness Page Ss.-Thousand Pockets Tongue--60'

CARMEL FORMATION - JUDD HOLLOW TONGUE

Interbedded Sandstone, light-to medium-brown, friable, fine-to very-fine-grained, well-sorted;
Mudstone, reddish-brown and light-to medium-grey and greenish-grey, soft, very-thin-bedded to laminated;
Gypsum, clear and white, acicular selenite.

Total Thickness Carmel Fm.-Judd Hollow Tongue--256'

PAGE SANDSTONE - HARRIS WASH TONGUE

Sandstone, light-to medium-brown, friable, fine-to very-fine-grained, well-sorted, contains angular chips of white, yellow, and orange chert; & minor
Mudstone, reddish-brown and bluish-grey to grey, soft, very-thin-bedded.

Total Thickness Page Ss.-Harris Wash Tongue--109'

NAVAJO SANDSTONE

Sandstone, light-to medium brown, friable, fine-to very-fine grained, well-sorted.

Figure 19-8. Lithologic log - Escalante culinary well

The Navajo Sandstone was encountered at a depth of 1,972 feet and the well penetrated 278 feet of Navajo before reaching total depth at 2,250 feet. Static water level stood at approximately 120 feet below the collar.

The Escalante well was pump-tested in 1998 as part of its resource protection plan. It showed a 575 feet. The water meets all the standards for a culinary source and has a total dissolved solids content of 288 mg/l.

The Escalante well continues to produce potable water, while the Tropic well produced a marginal quality in some categories and exceeded state standards in others. The Escalante well is located much nearer outcrops in recharge areas of the Navajo Sandstone, while the Tropic Well site is far from its recharge area. The Tropic Well is also near the Paunsagunt Fault zone, which may be allowing groundwater to mix and travel between several formations.

The following are accounts of other wells drilled within the West Colorado River Basin:

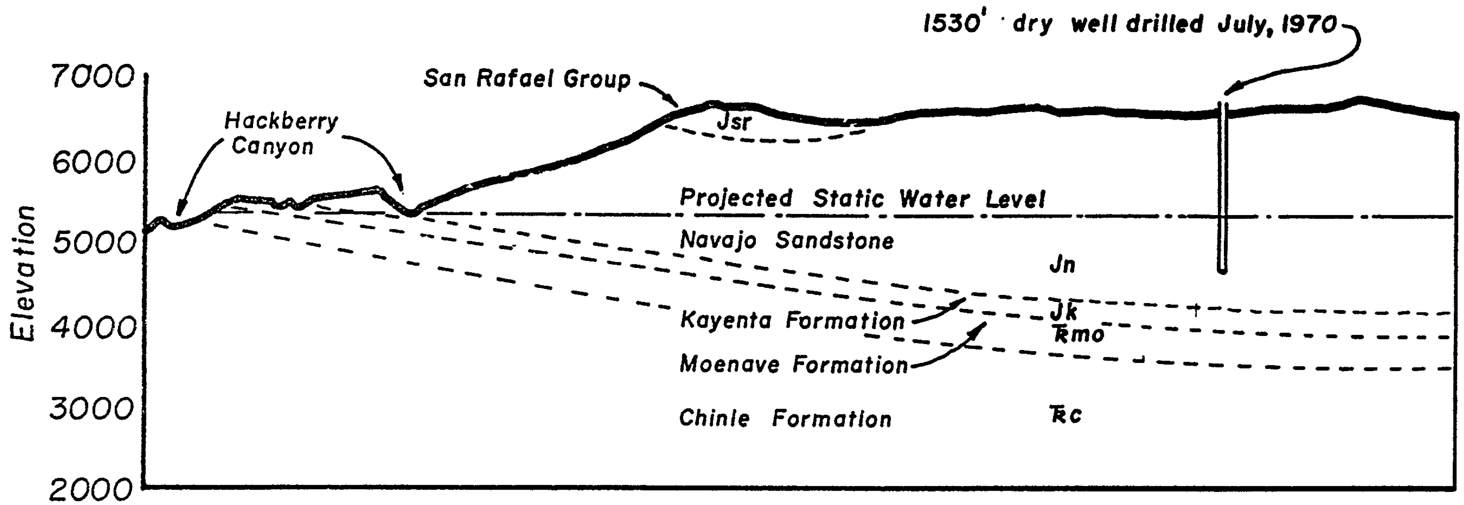
- During construction of Glen Canyon Dam, the Merrit-Chapman Construction Company drilled three wells into the Navajo Sandstone. These were located along the axis of the Kaiparowits Syncline, parallel to the Echo Monoclinal flexure. The wells produced an average of 3 cfs each. Recharge was considered to be from Wahweap Creek which flows along the flexure.
- Near Colton, in the Wasatch Plateau, two wells were drilled into fractured rock of the North Horn Formation. These wells were located for Utah Power and Light Company by Dr. Ray Marsell of the University of Utah. When pumped, these two wells produced a combined total of 5 cfs.
- In January 1971, an 803-foot 16-inch well was drilled approximately five miles upstream from Lake Powell on Wahweap Creek. This well was test pumped at 1,627 gpm for 48 hours with a draw down of 177 feet. The static water level stood at 20 feet below ground.

In sharp contrast to the wells just discussed are the following accounts:

- Five wells, all 10 inches in diameter and ranging from 537 to 675 feet deep, were drilled as municipal supply wells for town sites near Lake Powell. All five wells were drilled into the Navajo Sandstone along the general trend of the Echo Monoclinal flexure and are all within three miles of the well last mentioned above. These wells produced between 5 and 25 gpm, which is typical for wells in non-fractured sandstone aquifers in this region.
- Marathon Oil Company drilled a well in 1970 that was to be used as a water supply. The well was located between Hackberry Canyon and Cottonwood Creek east of the Paria River and about 13 miles southeast of Henrieville, Utah. It had been assumed that the fractured Navajo Sandstone was saturated to an elevation equal to that of several springs that flowed from fracture openings in the two canyons mentioned. It is customary and logical to assume that such springs represent the overflow of the groundwater reservoir. The Marathon well was drilled to a depth of 1,530 feet, which is 500 feet deeper than the previously estimated level of saturation in the area between the canyons (see Figure 19-9). From all indications, this well should have been a good producer of water, but it was abandoned as a dry hole. This clearly indicates the complexity of bedrock aquifers. It also indicates that due to this complexity the usual assumptions or customary procedures may not always be valid.

19.5 Policy Issues and Recommendations

Two issues previously discussed in sections 12 and 7 are presented here.



Hydrographic Profile

Figure 19-9

19.5.1 Monitoring Methane Concentrations in Shallow Groundwater near Price, Utah

Issue - Ongoing and future development of coal-bed methane resources in the vicinity of Price, Utah, could cause migration of methane into near-surface environments. (See Section 12.7.2)

19.5.2 Groundwater Interference from Mining Operations

Issue - Possible groundwater interference by mining operations in Emery County may be affecting local water entity supplies (see Section 7.8). ●

Section A
West Colorado River Basin - Utah State Water Plan

Acronyms, Abbreviations and Definitions

A.1 Acronyms and Abbreviations

Many names, titles, programs, organizations, legislative acts, measurements and activities are abbreviated to reduce the volume of words and to simplify communications. A few of the abbreviations and acronyms used in the West Colorado River Basin Plan are listed below.

A.1.1 State and Local Agencies and Organizations

CEM	Division of Comprehensive Emergency Management
DWQ	Division of Water Quality
DWR	Division of Wildlife Resources
DWRe	Division of Water Resources
DWRi	Division of Water Rights
DPR	Division of Parks and Recreation
DDW	Division of Drinking Water
DNR	Department of Natural Resources
DEQ	Department of Environmental Quality
GOPB	Governor's Office of Planning and Budget
MCD	Multi-County Planning District
SDCO	State Disaster Coordinating Office
SHMT	State Hazard Mitigation Team
UWQB	Utah Water Quality Board

A.1.2 Federal Agencies

BLM	Bureau of Land Management
BR	Bureau of Reclamation
COE(Corps)	Corps of Engineers
EPA	Environmental Protection Agency
FSA	Farm Service Agency
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FWS(USFWS)	Fish and Wildlife Service
GS(USGS)	Geological Survey
NRCS	Natural Resources Conservation Service
USDA	United States Department of Agriculture

A.1.3 Programs/Acts

ACP	Agricultural Conservation Program
CERCLA	Comprehensive Environmental Response and Comprehensive Liability Act
CFR	Code of Federal Regulations
CRP	Conservation Reserve Program
CWA	Clean Water Act
DWSPR	Drinking Water Source Protection Rule
ESA	Endangered Species Act
ECP	Emergency Conservation Program
NAWQA	National Water Quality Assessment
NFIP	National Flood Insurance Program
NPDES	National Pollution Discharge Elimination System
RPDWS	Rules for Public Drinking Water Systems
SCORP	State Comprehensive Outdoor Recreation Plan
SDWA	Safe Drinking Water Act
UPDES	Utah Pollution Discharge Elimination System
USDWA	Utah Safe Drinking Water Act
UWPCA	Utah Water Pollution Control Act
UWQA	Utah Water Quality Act

A.1.4 Measurements

ac-ft	Acre-feet
cfs	Cubic Feet Per Second
gpcd	Gallons Per Capita Day
gpm	Gallons Per Minute
MCL	Maximum Contaminant Level
mgd	Million Gallons Per Day
mg/l	Milligrams Per Liter
mw	Megawatt
PMP	Probable Maximum Precipitation
SMCL	Secondary Maximum Contaminant Level
TDs	Total Dissolved Solids

A.1.5 Miscellaneous

EAP	Emergency Action Plan
EOP	Emergency Operations Plan
FIRE	Finance, Insurance and Real Estate
I&D	Irrigation and Drainage
M&I	Municipal and Industrial
OHV	Off-Highway Vehicle
RC&D	Resource Conservation and Development
RIP	Recovery Implementation Program
RMP	Resource Management Plan

RPA	Reasonable and Prudent Alternative
TCPU	Transportation, Communications and Public Utilities
WWTP	Wastewater Treatment Plant

A.2 Water Resource Definitions

Many terms used in the water business have different meanings depending on the source, and are sometimes confusing. Some words are used interchangeably. A few commonly used water terms are defined for use in this document.

A.2.1 Water Use Terms

Water is often said to be *used* when it is diverted, withdrawn, depleted, or consumed. But it is also *used* in place for such things as fish and wildlife habitat, recreation and hydropower production.

Commercial Use - Uses normally associated with small business operations which may include drinking water, food preparation, personal sanitation, facility cleaning/maintenance and irrigation of landscapes.

Consumptive Use - Consumption of water for residential, commercial, institutional, industrial, agricultural, power generation and recreational purposes. Naturally occurring vegetation and wildlife also consumptively use water. Water consumed is not available for other uses within the system.

Depletion - Net loss of water through consumption, export and other uses to a given area, river system or basin. The terms *consumptive use* and *depletion*, often used interchangeably, are not always the same.

Diversion/Withdrawal - Water diverted from supply sources such as streams, lakes, reservoirs, springs or wells for a variety of uses, including cropland irrigation and residential, commercial, institutional and industrial purposes. The terms *diversion* and *withdrawal* are often used interchangeably.

Industrial Use - Use associated with the manufacturing or assembly of products which may include the same basic uses as commercial business. The volume of water used by industrial businesses, however, can be considerably greater than water use by commercial businesses.

Institutional Use - Uses normally associated with general operation of various public agencies and institutions, including drinking water; personal sanitation; facility cleaning and maintenance; and irrigation of parks, cemeteries, playgrounds, recreational areas and other facilities.

Irrigation Use - Water diverted and applied to cropland. Residential lawn and garden uses are not included.

Municipal Use - This term is commonly used to include residential, commercial and institutional uses. It is sometimes used interchangeably with the term *public water use*.

Municipal and Industrial (M&I) Use - This term is used to include residential, commercial, institutional and industrial uses.

Private-Domestic Use - Includes water from private wells or springs for use in individual homes, usually in rural areas not accessible to public water supply systems.

Residential Use - Water used for residential cooking; drinking; washing clothes; miscellaneous cleaning; personal grooming and sanitation; irrigation of lawns, gardens, and landscapes; and washing automobiles, driveways and other outside facilities.

A.2.2 Water Supply Terms

Water is supplied by a variety of systems for many uses. Most water supply systems are owned by an irrigation company or a municipality, but in some cases the owner/operator is a private company or a state or federal agency. Thus, a public water supply may be either publicly or privately owned. Systems may also supply treated or untreated water.

Municipal and Industrial (M&I) Water Supply - A supply that provides culinary/secondary water for residential, commercial, institutional and industrial uses.

Public Water Supply - Includes culinary water supplied by either privately or publicly owned community systems which serve at least 15 service connections or 25 individuals at least 60 days per year. Water from public supplies may be used for residential, commercial, institutional, and industrial purposes, including irrigation of publicly and privately owned open areas.

Secondary/Non-Potable Water Supply - Pressurized or open-ditch water supplies of untreated water for irrigation of privately or publicly owned lawns, gardens, parks, cemeteries, golf courses and other open areas. These are sometimes called dual water systems.

A.2.3 Groundwater Terms

Aquifer - A saturated body of rock or soil which will yield water to wells or springs.

Groundwater - Water which is contained in the saturated portions of soil or rock beneath the land surface. Excludes soil moisture which refers to water held by capillary action in the upper unsaturated zones of soil or rock.

Mining - Long-term groundwater overdraft in excess of recharge.

Phreatophyte - A plant species that extends its roots to the saturated zone under shallow water table conditions and transpires groundwater. These plants are high water users and include such species as tamarisk, greasewood, willows and cattails.

Recharge - Water added to the groundwater reservoir, or the process of adding water to the groundwater reservoir.

Recoverable Reserves - The amount of water which could be reasonably recovered from the groundwater reservoir with existing technology.

Safe Yield - The amount of water which can be withdrawn from an aquifer on a long-term basis without serious quality, environmental or social consequences, or seriously depleting the reservoir.
Total Water in Storage - A volume of water derived by estimating the total volume of saturated aquifer and multiplying by the porosity (intergranular space containing water).

A.2.4 Other Water Terms

The following water terms are peculiar to the water industry.

Call - The ability to order a quantity or flow of water at a given time and for a given period of time.

Carriage Water - Water needed for hydraulic operation of a delivery system.

Drinking Water - Water used for a potable/culinary supply.

Export Water - A man-made diversion of water from a river system or basin other than by the natural outflow of streams, rivers and groundwater. This is sometimes called a *transbasin diversion*.

Instream Flow - Water flow maintained in a stream for the preservation and propagation of wildlife or aquatic habitat and for aesthetic values.

Non-Point Source Pollution - Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, etc., carried to lakes and streams by surface runoff.

Point Source Pollution - Pollutants discharged from any identifiable point, including pipes, ditches, channels and containers.

Potable/Culinary - Water suitable for drinking or cooking purposes. The terms *culinary* and *potable* are often used interchangeably.

Reuse - The reclamation of water diverted from a municipal or industrial wastewater treatment system.

Riparian Areas - Land areas adjacent to rivers, streams, springs, bogs, lakes and ponds. They are ecosystems composed of plant and animal species highly dependent on water.

Watershed - The total area of land above a given point on a waterway that contributes runoff water to the flow at that point; a drainage basin or a major subdivision of a drainage basin.

Wet/*Open Water Areas* - Includes lakes, ponds, reservoirs, streams, mud flats and other wet areas.

Wetlands - Areas where vegetation is associated with open water, wet and/or high water table conditions.

Water Yield - The runoff from precipitation that reaches water courses and, therefore, may be available for man's use.

Section B

West Colorado River Basin - Utah State Water Plan

Bibliography

1. American Water Works Association, Long-Term Effects of Conservation Rates, 1997.

2. Ash, Tom, *Developing the Irvine Ranch Water District Ascending Block Rate Structure,* 1997.

3. Ashcroft, Gaylen L., Donald T. Jensen, and Jeffrey L. Brown, *Utah Climate,* Utah Climate Center, Utah State University, Logan, Utah, 1992.

4. Arnow, Ted and others, *Ground-Water Conditions in Utah, Cooperative Investigations Report No. 2-38*, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Resources (Utah Water and Power Board) and Division of Water Rights, Salt Lake City, Utah, 1964-97.

5. Aubrey, Daniel, E., *Stratigraphy of Escalante and Tropic Deep Culinary Wells, in Engineering and Environmental Geology of Southwestern Utah*, Kimm M. Harty, Editor, Utah Geological Association, Publication 21, pages 225-231, 1991.

6. Bancroft, Hubert Howe, *History of Utah*, Salt Lake City, Utah 1964.

7. Barnett, Don, *Reservoir Land Grant Fund - An Historical Update,* prepared for Utah Division of Water Resources, Salt Lake City, Utah, 1984.

8. Bartos, Dale L. and Robert B. Campbell, *Decline of Aspen in the Interior West*, presentation to the River Basin Coordinating Committee at Salt Lake City by USDA Forest Service, Intermountain Research Station, Logan, Utah and Fish Lake National Forest, Richfield, Utah, 1997.

9. Bartos, Dale L., and Robert B. Campbell, Jr., Rangelands, excerpted from American Water Resources Association, Water Resources Bulletin, Vol. 20, No. 1, February 1998.

10. Bartos, Dale L., and Robert B. Campbell, Jr., *Water Depletion and Other Ecosystem Values Forfeited When Conifer Forests Displace Aspen Communities*, proceedings of the AWRA Speciality Conference, Rangeland Management and Water Resources, sponsored by the American Water Resources Association in cooperation with the Society of Range Management and the Soil and Water Conservation Society of America, Reno, Nevada, May 1998.

11. Bjorklund, L.J., *Reconnaissance of the Ground-Water Resources of the Upper Fremont River Valley, Wayne County, Utah*, Technical Publication No. 22, 54 pages, 1969.

12. Blanchard, P.J., *Ground-Water Conditions in the Kaiparowits Plateau Area, Utah and Arizona, With Emphasis on the Navajo Sandstone*, Technical Publication No. 81, 87 pages, 1986.

13. Cordova, Robert, M., *Hydrogeologic Reconnaissance of Part of Headwaters Area of the Price River*, Utah Geological and Mineralogical Survey, Water Resources Bulletin 4, 26 pages, 1963.

14. Division of Parks and Recreation, Comprehensive Planning and Policy Section, *The 1997 Utah Comprehensive Outdoor Recreation Plan (SCORP)*, draft, unpublished data, Salt Lake City, Utah, 1997.

15. Division of Water Resources, *Inventory of Potential and Existing Reservoirs for the West Colorado River Basin, Utah*, unpublished, Salt Lake City, Utah, 1997.

16. Division of Water Resources, *Municipal and Industrial Water Supply and Uses in the West Colorado River Basin, 1996*, in-house draft, Salt Lake City, Utah, 1997.

17. Division of Water Resources, *Utah State Water Plan*, Salt Lake City, Utah, 1990.

18. Division of Water Resources, *Water-Related Land Use Inventory of the West Colorado River Basin, Utah*, Salt Lake City, Utah, 1990.

19. Division of Water Resources, *A Water-Related Land Use Summary Report of the State of Utah*, Salt Lake City, Utah, 1996.

20. Division of Water Rights, *Rules and Regulations Governing Dam Safety in Utah*, Salt Lake City, Utah, 1982.

21. Division of Water Rights, *Utah Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah*, Water Use Reports No. 1-11, prepared by the Utah Division of Water Rights in cooperation with the U.S. Geological Survey, Salt Lake City, Utah, 1980-97.

22. Dutton, C.E., *Report on the Geology of the High Plateaus of Utah*, U.S. Geographical and Geological Survey, Rocky Mountain Region Report, 1880.

23. Federal Emergency Management Agency, *Digest of Federal Disaster Assistance Programs*, FEMA Manual 8600.2 (ECS-2), Washington, D.C., 1987.

24. Fetter, C.W., *Applied Hydrogeology*, Merrill Publishing Company, 592 pages, 1988.

25. Forsling, C.L., *Erosion on Uncultivated Lands in the Intermountain Region*, Scientific Monthly, Vol. XXXIV, pages 311-321, 1932.

26. Freethey, G.S. and G.E. Cordy, United States Geological Survey Professional Paper 1411c, Geohydrology of Mesozoic rocks in the Upper Colorado River basin–excluding the San Juan Basin–in Arizona, Colorado, New Mexico, Utah, and Wyoming, United States Geological Survey, 1990, Appendix C 104.

27. Gates, Joseph S., and David V. Allen, *Ground-Water Development in Utah and Effects on Ground-Water Levels and Chemical Quality,* Cooperative Investigations Report No. 37, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1996.

28. Gellis, Allen, Richard Hereford, S.A. Schumm, and B.R. Hayes, *Channel Evolution and Hydrologic Variations in the Colorado River Basin: Factors Influencing Sediment and Salt Loads*, Jour. Hydrology 124, pages 317-344, 1991.

29. Gerner, S.J., J.I. Steiger, and others, *Ground-Water Conditions in Utah, Spring of 1997*, Cooperative Investigations Report Number 38, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Resources and Division of Water Rights, Salt Lake City, Utah, these reports have been published annually since 1964.

30. Gifford, Gerald F., William Humphries and Richard A. Jaynes, *A Preliminary Quantification of the Impacts of Aspen to Conifer Succession on Water Yield - II, Modeling Results,* American Water Resources Association, Water Resources Bulletin, Vol. 20, No. 2, Herndon, Virginia, May 1998.

31. Gillars, Kevin, *A Survey of Small Hydroelectric Potential at Existing Sites in Utah,* Utah Energy Office, Salt Lake City, Utah, 1981.

32. Graf, J.B., R.H. Webb, and Richard Hereford, *Relation of Sediment Load and Flood-Plain Formation to Climatic Variability, Paria River Drainage Basin, Utah and Arizona*, Geological Society of America Bulletin, Volume 103, pages 1405-1415, 1991.

33. Griswold, Daniel, H., and Gilbert, Creighton N., *Ground Water Resources of Price River Basin, Utah*, Soil Conservation Service Report, 7 pages, 1964.

34. Hem, John D., *Study and Interpretation of the Chemical Characteristics of Natural Water,* U.S. Geological Survey Water-Supply Paper 2254, Washington, D.C., 1985.

35. Hintze, Lehi, F., Geologic Map of Utah, Utah Geological and Mineral Survey, Scale - 1:500,000, 1980.

36. Hood, J.W., and Danielson, T.W., *Aquifer Tests of the Navajo Sandstone Near Caineville, Wayne County, Utah*, Technical Publication No. 66, 69 pages, 1979.

37. Hood, J.W., and others, *Bedrock Aquifers in the Lower Dirty Devil River Basin Area, Utah*, *With Special Emphasis on the Navajo Sandstone*, Technical Publication No. 68, 143 pages, 1981.

38. Hood, J.W. and others, *Bedrock Aquifers in the Northern San Rafael Swell Area, Utah, with Special Emphasis on the Navajo Sandstone*, Technical Publication No. 78, 128 pages, 1984.

39. Jensen, Ronald L., *Paria-San Rafael: A Reconnaissance of Ground Water Resources*, U. S. Bureau of Reclamation, 31 pages, May 1972.

40. Judd, Harry Lewis, *Utah's Lakes and Reservoirs*, prepared by the Utah Department of Environmental Quality, Division of Water Quality, in cooperation with the U.S. Environmental Protection Agency, Region VIII, Salt Lake City, Utah, 1997.

41. Kratz, Gregory P, *Tourism is Big Business in the Beehive State,* Deseret News, February 10, 1998, Salt Lake City, Utah.

42. Marsell, R.E., *Ground Water From Deep Wells near Colton, Utah*, Consulting Report, 8 pages, 1952.

43. Miller, Jerry, hydrologist, United States Bureau of Reclamation, Salt Lake City, UT, personal conversation, January 11, 1999.

44. Natural Resources Conservation Service, *Utah Cooperative Snow Survey Data of Federal-State-Private Cooperative Snow Surveys*, issued by Paul W. Johnson, Chief, Natural Resources Conservation Service, Washington, D.C., 1995.

45. Poll, Richard D., Gen. Ed., T.G. Alexander, E.E. Campbell, D.E. Miller, Assoc. Ed., *Utah's History,* Utah State University Press, Logan, Utah, 1977.

46. Powell, Allan Kent, Editor, *Utah History Encyclopedia*, University of Utah Press, Salt Lake City, Utah, 1994.

47. Price, Don and G.G. Plantz, Hydrologic Monitoring of Selected Stream in Coal Fields of Central and Southern Utah, Summary of Data Collected, August 1978-September 1984, Water-Resources Investigation Report 86-4017, pg 97, 1986.

48. Reetz, Gene R., PhD., et al, *Water Quality in the West,* Report to the Western Water Policy Review Advisory Commission by the U.S. Environmental Protection Agency, Denver, Colorado, 1998.

49. Schlotthauer, W.E., Nance, B.W., and Olds, J.D., *Identification and Characteristics of Aquifers in Utah*, Utah Division of Water Rights, 240 pages, 1981.

50. Steiger, J.I., and others, *Ground-Water Conditions in Utah*, Utah Division of Water Resources Cooperative Investigations Report No. 36, 89 pages, 1996.

51. Stokes, William Lee, *Geology of Utah*, Utah Museum of Natural History and Utah Geological and Mineral Survey, Salt Lake City, Utah, 1988.

52. U. S. Department of Interior, Bureau of Reclamation, Upper Colorado Region, *Draft Environmental Impact Statement, Narrows Project, March 1998,* Provo Area Office, 1998.

53. Utah Agricultural Statistics Service and Utah Department of Agriculture and Food, *Annual Report*, Salt Lake City, Utah, 1997.

54. Utah Code Annotated, 1953, amended.

55. Utah Department of Environmental Quality, Division of Water Quality, *Standards of Quality for Waters of the State*, R317-2, Utah Administrative Code, Salt Lake City, Utah, effective date: December 19, 1997.

56. Utah Department of Environmental Quality, Division of Water Quality, Utah's 1998 303(d) List of Waters, Salt Lake City, Utah, 1998.

57. Utah Department of Natural Resources, *Water Use Data For Public Water Suppliers in Utah 1979-1993*, Water Use Report No. 2-10, published yearly then bi-yearly 1981-1995.

58. Utah Division of Community Development, Department of Community and Economic Development, *Legislative Report of the Permanent Community Impact Fund*, Salt Lake City, Utah, 1996.

59. Verniew, William, hydrologist, Grand Canyon Monitoring and Research Center, Flagstaff, AZ, personal conversation January 11, 1999.

60. Ward, J.A., and Marsell, R.E., *Ground Water From Deep Wells On The Wasatch Plateau Near Kyune, Utah*, Consulting Report, 16 pages, 1953.

61. Whetstone, Helen, *Water Companies in Utah*, Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1990.

State Water Plan - West Colorado River Basin

Prepared by the State Water Plan Coordinating Committee

DEPARTMENT OF NATURAL RESOURCES
Kathleen Clarke, Executive Director
Marty Ott, Deputy Director

DIVISION OF WATER RESOURCES
D. Larry Anderson, Director
Paul L. Gillette, Deputy Director
Eric Millis,
Harold Brown
Eric Klotz
D. Gay Smith

DIVISION OF WATER RIGHTS
Robert L. Morgan, State Engineer
Jerry D. Olds
William Schlotthauer

DIVISION OF WILDLIFE RESOURCES
John F. Kimball, Jr., Director
William A. Bradwisch
Louis Berg
Stanley G. Beckstrom

DIVISION OF PARKS AND RECREATION
Courtland C. Nelson, Director
Tharold E. (Terry) Green

DEPARMENT OF ENVIRONMENTAL QUALITY
Dr. Dianne R. Nielson, Director

DIVISION OF DRINKING WATER
Michael Georgeson, Acting Director
Steve Onysko

DIVISION OF WATER QUALITY
Don A. Ostler, Director
Jay B. Pitkin
Michael K. Reichert
Harry Judd

GOVERNOR'S OFFICE OF PLANNING AND BUDGET
Lynne N. Ward, Director
Brad T. Barber
Natalie Gochnour
Pamela Perlich

DEPARTMENT OF AGRICULTURE AND FOOD
Cary G. Peterson, Commissioner
Randy N. Parker

DIVISION OF COMPREHENSIVE EMERGENCY MANAGEMENT
Earl Morris, Director
John Rokich
Nancy Barr
Judy Watanabe

UTAH WATER RESEARCH LABORATORY
Dr. Ronald C. Sims, Director
Dr. Upmanu Lall

Photo Credits: Utah Division of Water Resources.

Printed on recycled paper using vegetable-base inks. 400 8/00

TAKE Pride IN UTAH