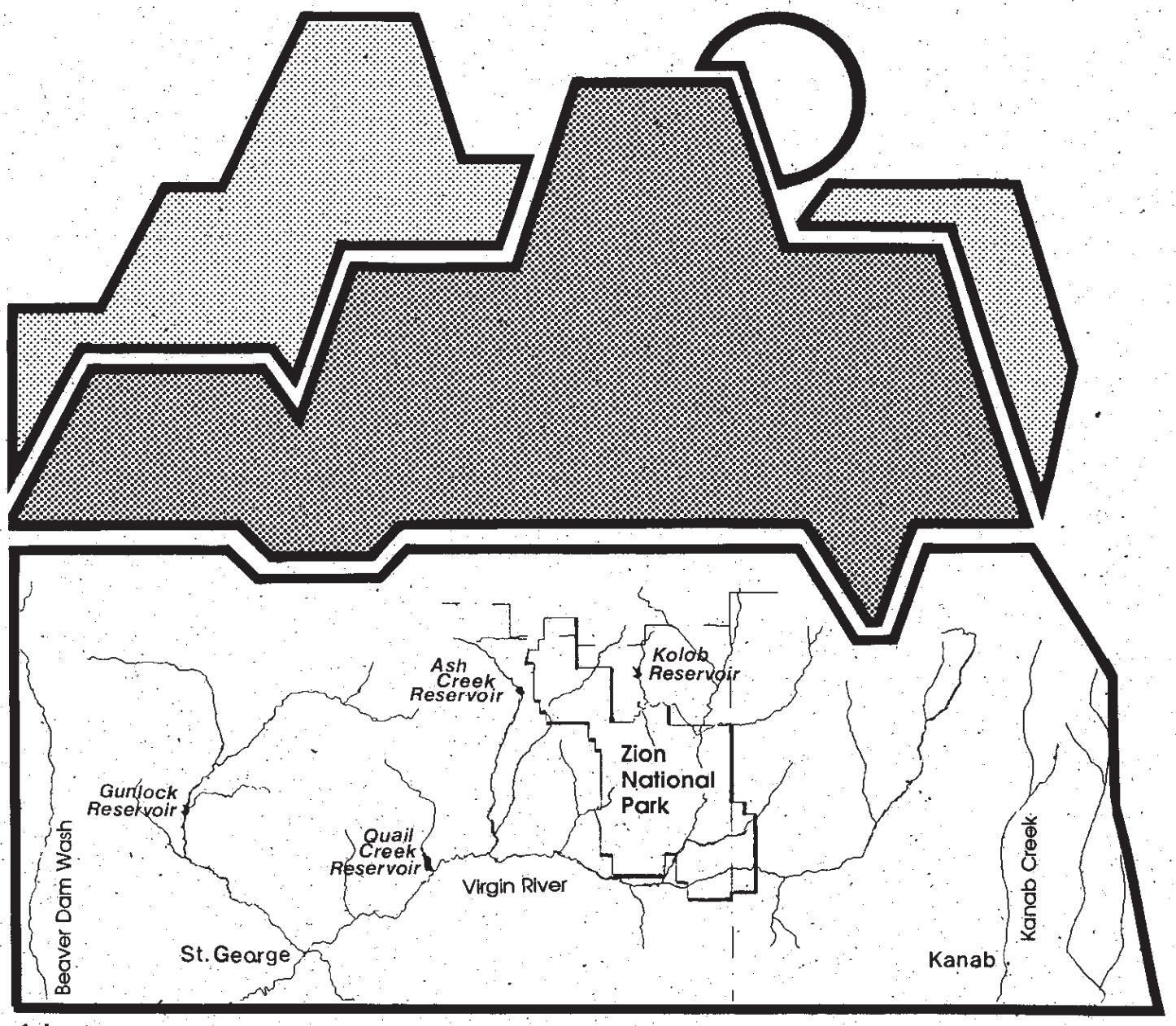
Utah
State Water Plan

Kanab Creek/Virgin River Basin

August 1993



■ **State Water Plan** - Kanab Creek/Virgin River Basin

Section

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State Water Plan
Kanab Creek/Virgin River Basin

Utah Board of Water Resources
1636 West North Temple
Salt Lake City, UT 84116

August 1993

Section 1 Foreword

1 Foreword

A *State Water Plan,* prepared and distributed in early 1990, provided the foundation and overall direction to establish and implement the state policy framework of water management.

As a part of the state water planning process, more detailed plans are prepared for each of the 11 hydrologic basins in the state. The Kanab Creek/Virgin River Basin is one of these plans. This hydrologic basin plan will identify potential conservation and development projects and describe alternatives to satisfy the problems, needs and demands. Final selection of alternatives will rest with local decision makers.

In earlier drafts, use of the name Lower Colorado River Basin caused some confusion. This name is construed by many to mean the Colorado River below Lee Ferry to its terminus. To avoid further confusion, the Johnson Wash, Kanab Creek and Virgin River drainages in Utah will be called the Kanab Creek/Virgin River Basin.

Planning needs the active participation of all concerned entities and their response to issues. The success of this planning process is enhanced through public involvement, resulting in broader support to implement recommendations.

Within the broad responsibility to enhance the quality of life and general welfare of its citizens, the state of Utah has a specific obligation to plan for and encourage the use of resources in a manner that best serves their physical, environmental and social needs.

1.1 Acknowledgement

The Board of Water Resources gratefully acknowledges the dedicated efforts of the State Water Plan Steering Committee and Coordinating Committee in preparing the Kanab Creek/Virgin River Basin Plan. This work was spearheaded by the planning staff in the Division of Water Resources, with valuable assistance from individual coordinating committee members representing state agencies with water-related missions. Their high standards of professionalism and dedication to improving Utah's natural resources base are essential ingredients of this basin plan.

We also appreciate input from representatives of state and federal

cooperating entities, the statewide local advisory group and the basin planning advisory group which brought expertise from a broad spectrum of Utah's population.

In addition, we extend sincere thanks to those who attended meetings and provided oral and written comments on the Kanab Creek/Virgin River Basin Plan. Public input in the water planning process is imperative to successful use of this resource.

In endorsing this plan, as was the case with the *January 1990 State Water Plan,* we reserve the right to consider water projects on their own merits. This basin plan is an important guide for water development in the Kanab Creek/Virgin River Basin. ■

Philip S. Knight, Chair

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1.2 Abbreviations/Acronyms

Many names, titles, programs, organizations, legislative acts, measurements and activities are abbreviated to reduce the volume of words and simplify communications. A few of the commonly used abbreviations in the Kanab Creek/Virgin River Basin Plan are shown in this section.

1.2.1 Federal Agencies

ASCS	Agricultural Stablization and Conservation Service
BLM	Bureau of Land Management
Corps	Corps of Engineers
EDA	Economic Development Administration
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FWS(USFWS)	Fish and Wildlife Service
GS(USGS)	Geological Survey
NPS(NP)	National Park Service
SCS	Soil Conservation Service
USDA	United States Department of Agriculture
WRD	Water Resources Division (Geological Survey)

1.2.2 State and Local Organizations

CEM	Comprehensive Emergency Management
KCWCD	Kane County Water Conservancy District
MCD(MCPD)	Multi-County Planning District
SCC	Soil Conservation Commission
UP&L	Utah Power and Light
UWQB	Utah Water Quality Board
WCWCD	Washington County Water Conservancy District

1.2.3 Programs/Acts

ACP	Agricultural Conservation Program
ARDL	Agricultural Resource Development Loan
CRP	Conservation Reserve Program
CRSC	Colorado River Salinity Control
CWA	Clean Water Act
ECP	Emergency Conservation Program
ISA	Instant Study Area (WSA Act)
LWCF	Land and Water Conservation Fund
NFIP	National Flood Insurance Program
NPDES	National Pollution Discharge Elimination System
NPS	Non-point Source Pollution

RC&D	Resource Conservation and Development
SCORP	State Comprehensive Outdoor Recreation Plan
SDWA	Safe Drinking Water Act
UCA	Utah Code Annotated
UWPCA	Utah Water Pollution Control Act
WSA	Wilderness Study Area Act

1.2.4 Measurements

Ac	Acre
Ac-Ft	Acre-feet
AUM	Animal Unit Months
cfs	Cubic Feet per Second
Ft	Feet
GPCD	Gallons Per Capita Day
mg/l	Milligram per Liter
pH	Acidity of soils
TDS	Total Dissolved Solids
Yd^3	Cubic Yards

1.2.5 Other

ATV	All-Terrain Vehicle
BMP	Best Management Practice(s)
FIRE	Finance, Insurance and Real Estate
M&I	Municipal and Industrial
RV	Recreation Vehicle
TCPU	Transportation, Communications and Public Utilities
W&S	Wage and Salary
UPED	Utah Process Economic and Demographics

Section 2 Executive Summary

2 Executive Summary

This section summarizes the *Kanab Creek/Virgin River Basin Plan*. Like the *State Water Plan*, this document contains 19 sections including this summary. In addition, the *State Water Plan* contains Section 20, "River Basin Summaries," and Section 21, "Annual Status Report."

The following headings are titles of each of the sections summarized. These sections should be studied for more detailed information.

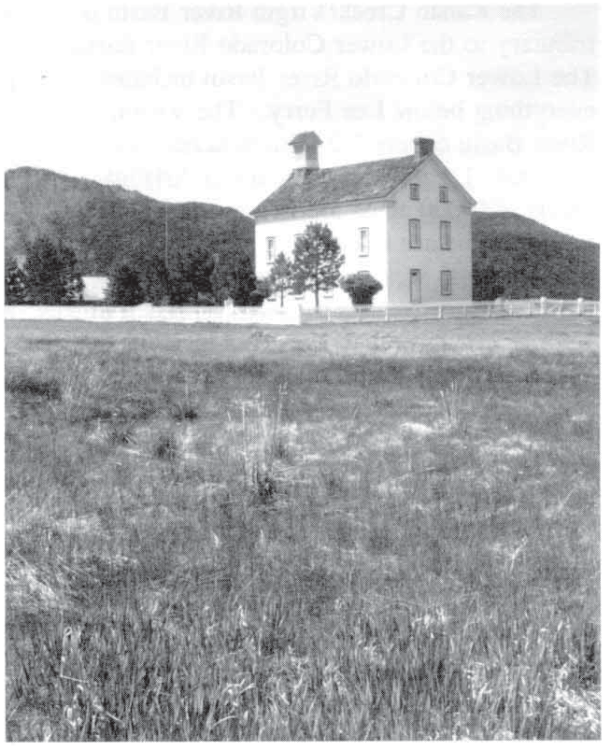
2.1 Foreword

Within the broad responsibility to enhance the quality of life and general welfare of its citizens, the state of Utah has the specific obligation to plan for and encourage the best use of its resources. The *State Water Plan* (1990) provides the statewide foundation and direction. More detailed plans are and will be prepared for the 11 hydrologic basins. The *Bear River Basin Plan* was published in January 1992. This plan for the Kanab Creek/Virgin River Basin is the second report to be completed.

The purpose of this plan is to identify potential conservation and development projects and describe alternatives to satisfy the problems, needs and demands. The final selection of alternatives will be made at the local level.

2.3 Introduction

Section 3 contains the general planning



guidelines used to insure continuity during basin plan preparation. The guidelines consist of guiding principles, purpose, organizational structure and review process. The organizational arrangements provide contribution and review opportunities for state and federal agencies, special interest groups and especially local entities, organizations and individuals. The planning process allows for review and approval at various stages of completion. This section also discusses the settlement, climate, general physical characteristics and land status of the Kanab Creek/Virgin River Basin. Since the first settlements in the early 1850s, many changes have occurred. The mild climate has contributed to much of this.

The Kanab Creek/Virgin River Basin is tributary to the Lower Colorado River Basin. The Lower Colorado River Basin includes everything below Lee Ferry. The Virgin River Basin covers 3.2 million acres. Of this total, 1.1 million acres are in Arizona, nearly 300,000 acres are in Nevada and 1.8 million acres are in Utah.

The total area of the Lower Colorado River (Kanab Creek/Virgin River) Basin in Utah is 2.2 million acres. This includes the Virgin River, 1.8 million acres; Johnson Wash, 211,000 acres and Kanab Creek, 189,000 acres.

Mean annual valley temperatures vary from 45° to 61° F. Summer temperatures over 110° F are not uncommon. Precipitation ranges from six inches in the desert areas to 35 inches in the high mountains. Elevations range from 2,297 feet to 10,375 feet above sea level.

The area is marked by colorful cliffs and plateaus on the east to broad valleys and mountains on the west. Pinyon/juniper and mountain shrubs are the primary vegetation. These cover nearly one-third of the area with rockland accounting for 15 percent. There are 25,600 acres of irrigated cropland.

The federal government administers over two-thirds of the total area and the state about eight percent. About 23 percent of the land is in private ownership and 1.3 percent is tribal lands.

2.4 Demographics and Economic Future

Population, employment and the economy are discussed in this section. This is an area of rapid growth. The 1990 and projected 2020 populations follow with the latter in parentheses. The basin population is 52,742 (158,381); 47,401 (147,438) in Washington County, 4,843 (10,553) in Kane County and 228 (410) in Iron County. At present, the largest cities are: St. George, 28,502; Washington, 4,198; Hurricane, 3,915 and Kanab, 3,289. The growth rate will be an estimated 3.4 percent per year compared to 1.7 percent for all of Utah.

The major growth sectors are transportation, communications, public utilities and service. All sectors except agriculture are expected to grow at about four percent annually. Agricultural employment is expected to continue its decline. Southwestern Utah will grow as an economic force. This will come through recreation, retirement living and tourism along with some industrial and manufacturing expansion.

2.5 Water Supply and Use

Section 5 discusses the historical water supplies and present uses. The surface water supplies are estimated primarily from three stream gages. They indicate the long-term

annual flows at Virgin River near Littlefield, 169,970 acre-feet; Virgin River near Virgin, 130,610 acre-feet and Kanab Creek near Kanab, 9,300 acre-feet. The highest year in the basin was 1922 with 337,000 acre-feet near Virgin. The long-term average annual groundwater discharge in the Virgin River basin is 155,000 acre-feet. The groundwater discharge in Kanab Creek and Johnson Wash drainage area is 22,000 acre-feet annually, with about 5,000 acre-feet of this being outflow into Arizona.

Total water diversions are culinary, 20,330 acre-feet; secondary, 15,960 acre-feet and irrigation, 123,300 acre-feet for a total of 159,590 acre-feet. Total depletions for these uses are 73,050 acre-feet. Wetland and riparian vegetation uses are not included.

2.6 Management

The water in the basin is generally well managed to serve the various uses. Two areas of concern, however, are instream flow requirements and potential storage reservoirs.

Nearly 70 percent of the total water supply is managed by a combination of 35 irrigation companies with an additional one-third of the irrigated area water supply under private systems. There are 78 drinking water systems, 35 of which are classified as "Public Community" suppliers.

Managers of water delivery systems are concerned with maintaining and/or improving facilities. Increasing water use efficiencies and maintaining water quality are always major concerns.

2.7 Regulation/Institutional Considerations

The responsibility for water regulation rests primarily with two state agencies. These are the Division of Water Rights and the Department of Environmental Quality.

Proposed determinations of water rights have been made for all areas in the basin. It is difficult to predict when decrees will be entered by the courts. In addition, claims for reserved water rights need to be resolved.

Water quality is always a concern. Constant vigilance is needed to maintain the quality of surface water and groundwater. An expanded monitoring program will help control water quality.

2.8 State, Federal and Local Water Resources Funding Programs

This section discusses the funding programs available. Funding can be either grants or loans at various interest rates. These funding resources are available for all kinds of water-related proposals.

The time periods reported by the agencies vary but the total funds expended are impressive. The state and federal grants are over $120 million and loans are nearly $59 million for a total of $179 million. Data from local sponsor funding including private financial institutions are not available.

2.9 Water Planning and Development

Section 9 discusses the water resources problems and needs. Development and management alternatives are described for surface water and groundwater.

Considerable controversy has developed over the proposed development and use of existing water resources. As a result, three policy issues are presented in the plan. These are concerned with potential reservoir sites, wilderness areas and long-range plans.

Because of the demand for water to meet the needs of projected population growth, new water storage and delivery facilities have been proposed. These proposals have invoked objections by special interest groups seeking to preserve and protect the area in its present state. This, coupled with proposed wilderness areas where no development is allowed, could severely restrict future development. The need for long-range plans is clear.

Based on population projections, the demand for culinary and secondary water supplies will increase over four times by 2040. This amounts to diversions of 82,710 acre-feet and 65,030 acre-feet, respectively, by 2040.

Agricultural water use has remained fairly constant. Future development will displace some presently irrigated farm land. This will make irrigation water available for other uses.

The demands and needs for water-based recreation and water for fish and wildlife will increase. Recreation activity should increase at about the same rates as population. Fish and wildlife needs will increase at a slower rate.

Only four areas are still open for groundwater development. These are Kanab Creek, Johnson Wash, an area southwest of Hurricane and Beaver Dam Wash. The primary aquifer is the Navajo sandstone with an estimated storage of several million acre-feet of recoverable water. Studies are needed to determine if additional water can be developed without mining taking place. There are some opportunities for artificially recharging this aquifer so groundwater use can be increased.

Another alternative is to upgrade the conveyance and delivery systems. Diversions for agricultural use can be reduced by increasing delivery efficiency. This can be accomplished by installing pipelines, canal lining, water control facilities and management methods. Deteriorated public water supply systems can be upgraded by replacing leaking pipes, constructing needed storage tanks and installing other required facilities.

Additional water storage reservoirs will be needed to meet the projected basin needs, primarily municipal and industrial supplies. Over 100 sites have been investigated at various levels of detail. Through a series of evaluations, about two-thirds of these were eliminated because they were not technically or economically feasible. There are also additional sites that could be evaluated in the future.

Water supply management strategies can also increase the available water supplies. One of the major management tools is

computer modeling. This can be used to simulate flow and effects of existing and proposed reservoirs. Another management tool to increase the water supply is cloud-seeding.

Depletions occur in five major categories. The current and projected depletions to the year 2040 in acre-feet are culinary, 10,570 and 51,280; secondary, 11,170 and 45,520; irrigation, 51,300 and 37,600; exports, 2,600 and 9,100 and reservoir evaporation, 5,300 and 8,400.

2.10 Agricultural Water Conservation and Development

This section discusses the agricultural aspects of the basin. Agricultural activities, although decreasing, are still an important part of the economy.

Total area of all agricultural lands is about two million acres. Less than two percent of the total land area is used as cropland, although six percent have soils suitable for cultivation. The balance is used for grazing. There are over 90,000 AUMs of livestock grazing with nearly 50,000 AUMs allocated for wildlife.

Irrigated cropland covers 25,600 acres and depletes 51,300 acre-feet of water annually, mostly for alfalfa and pastures. Most of the crop production is used to support the livestock industry although some alfalfa is exported. There are about 3,000 acres of irrigated cropland in Arizona and 4,000 acres in Nevada in the Kanab Creek and Virgin River drainages. Dry cropland covers about 21,300 acres.

There are critical erosion areas throughout the basin. These areas are eroding at over three times the background geologic rate, primarily because the watershed range condition is poor. Water deficits on irrigated cropland are 19,000 acre-feet or 37 percent of the average depletion. It is estimated about 7,000 acres of irrigated cropland will be lost to other uses by the year 2040.

There are various alternatives for solving problems including canal lining and pipelines, reservoir storage and rangeland improvement measures. Increasing resource use efficiencies is always a viable option.

2.11 Drinking Water Supplies Development and Management

Section 11 discusses the drinking water systems, their problems and the future needs. The systems are publicly or privately owned. Groundwater is the primary source. The basin-wide use is 350 gallons per capita per day (GPCD). This is higher than the state average of 284 GPCD. The GPCD use ranges from 147 in Virgin and 152 in Glendale to 389 in Washington City.

There are 78 drinking water systems in the basin; 35 of these are classified as public community systems. Of the 35 public community systems, 28 are approved, two are not approved and five are pending corrective action.

Most public water suppliers expect an increase in demand of 40-60 percent to over double the current use of 20,330 acre-feet annually in the next 30 years. Over 90 percent of the increased demand will occur in Washington County. If conservation is applied, the use would decrease.

Meeting the projected growth will require long-range planning and development. More surface water will be used requiring storage facilities and treatment plants. Groundwater development

still holds promise, particularly in the Navajo sandstone aquifer.

2.12 Water Pollution Control

Section 12 discusses the water quality of the basin along with the problems and needs. Most of the groundwater in the basin is of good quality. The Navajo sandstone is the major aquifer, supplying most of the municipal and industrial water supplies. Many of the recharge areas for this aquifer have been identified to aid local governments in preparing protection strategies. The alluvial aquifers are also vulnerable to pollution and need to be protected. Surface water quality is usually better in the upper reaches of the streams and gradually deteriorates downstream. Total dissolved solids are the primary pollutant. La Verkin (Pah Tempe) Springs produces flows containing about 9,000 mg/l total dissolved solids. This effects all downstream uses of the Virgin River.

In order to maintain or improve the water quality, ongoing planning and monitoring programs are needed. Protection of upper watershed areas is needed to reduce pollutant contributions to water supplies. Pollution can be controlled by local government entities being involved. They can work with state agencies to implement groundwater protection programs. Federal programs are also available to help reduce pollution.

2.13 Disaster and Emergency Response

Flood hazard mitigation and disaster response programs are discussed in Section 13. It also discusses associated problems and needs. Flooding and drought are the major water-related emergencies.

Some of the communities have hazard mitigation and disaster response plans. All of the local governments need those type plans in place. If disaster preparedness plans and staff are ready, damages can be reduced and lives can be saved. It is much easier to be ready before an event than to correct the problems after something happens.

Floods of various sizes have been recorded since the area was settled. The largest flow was in December 1966 on the Virgin River. The Kanab Creek peak flow was in September 1961.

Droughts are a frequent occurrence. These are aggravated because most of the basin is below 7,000 feet elevation making the winter snow packs small.

Flood control structures on tributary streams are effective for reducing damages from local cloud burst storms. Installation of non-structural flood prevention measures in the upper watershed areas can have the greatest long-term effects. Large water storage facilities can alleviate the effects of droughts as well as floods. There are potential sites, such as one on Quail Creek, that should be considered for flood control on many of the drainages. Weather modification and groundwater development are alternatives for drought relief.

Disaster response plans are the most effective way to prepare for emergency situations. This is true at the county and community level as well as for families and individuals.

2.14 Fisheries and Water-Related Wildlife

Section 14 discusses the fish and wildlife resources of the basin along with the problems, needs and some alternative solutions. The range in environments varies

from alpine to the Mojave Desert with wildlife species found accordingly. Several threatened and endangered species are found in the area. Because of the threatened and endangered fish, instream flows have become an item of considerable importance. The dry climate has also contributed to the impact of development on the wetlands and riparian habitat.

Many environmental problems are the result of the rapidly expanding population centers. This is going to increase the conflicting demands for water to support increasing numbers of people and maintaining fish and wildlife habitat.

Cold water fisheries are found in the upper reaches of the rivers and streams. Reservoirs in these reaches also provide trout fishing. The lower areas provide warm water fisheries in the streams and reservoirs. Several species of native fishes are found in the warm water fisheries. These include the endangered woundfin minnow and the Virgin River roundtail chub, found only in the Virgin River.

Mitigation is needed whenever changes are made in the fish and wildlife habitat. When reservoir storage projects are constructed, consideration should be given by those interested to purchase conservation pools or storage water to provide fish habitat. Rehabilitation or replacement of disturbed areas may also be needed. Preservation of riparian areas can be accomplished by providing other watering sources for wildlife and livestock. Streams supporting riparian habitat can also be enhanced by small structural measures.

2.15 Recreational Aspects of Water Development

The importance of recreation and related facilities are presented in Section 15 along with problems and needs. Recreation is becoming a major part of the basin's lifestyle. The area offers a diversity of outdoor recreational opportunities because of the variety of topography, climate and vegetation. The area contains four state parks, one each national park and national forest, two wilderness areas and many camping areas and RV sites There are several byways and backways for those wanting more solitude. Development of non-motorized trails and riverways is continuing. Over $2 million has been cost-shared on 14 projects in Washington County.

Within the Utah State Comprehensive Outdoor Recreation Planning (SCORP) process, surveys are conducted to determine the priority of recreational and environmental issues to be addressed. It was noted over 50 percent of all tourists visiting Utah pass by St. George and Cedar City on I-15. More of them need to be aware of the area's attractions. Many of the issues concerned funding. There is a need for more and stable funding sources. Key recreation areas need to be linked together to provide a wider array of opportunities. The natural environment plays an important part in the overall recreation scene. The most desirable recreational activities are either water-based or water-related.

The importance of recreation is evidenced by increasing use of developed state park areas with an increase of 16 percent visitation during the period 1984-91. Visitation increased in Zion National Park to over 2.5 million in 1991, up 48 percent

since 1985. Similar increases have occurred in other areas.

2.16 Federal Planning and Development

Section 16 describes the federal involvement in basin planning and development. The federal role is changing. Many of the past activities concerned development of the resources. Concerns now are more oriented around conservation and protection. The federal role has been and will continue to be a vital part of the basin's resources use and development.

The main concern is the part federal agencies should play compared to state and local involvement. There is a definite need for coordinated planning and use. With the large amount of land area administered by the federal government, local needs and desires become even more important.

The Dixie Project was the most extensive planning effort by the Bureau of Reclamation. Additional studies were carried out in Kanab Creek. The Corps of Engineers has completed flood studies in the Virgin River drainage. The largest construction project is the Warner Draw Watershed Project by the Soil Conservation Service in cooperation with local sponsors and state and other federal agencies. It is primarily for flood control and irrigation water management.

Other Department of Agriculture and Interior agencies administer large areas of land for multiple use of the resources with the exception of Zion National Park which is a single purpose use. The Department of Agriculture also furnishes financial and technical assistance through water-related programs. The Fish and Wildlife Service is actively involved carrying out the Endangered Species Act. The U.S. Geological Survey has and is continuing to carry out groundwater studies and water monitoring programs.

2.17 Water Conservation

The importance of water conservation along with the need for and ways of conserving this resource are discussed in Section 17. Water conservation can alleviate the effects of drought by stretching available supplies. A system-wide long-term conservation program can extend the need for developing additional water supplies and increasing the delivery capacities. Conservation can also carry communities through short-term water emergencies. Installing secondary systems for outside uses can reduce the need for increased high quality water supplies. In the long term, water education is the key to conservation through more efficient use.

The two major uses of water are for municipal and industrial (M&I) and agricultural purposes. Reducing M&I uses by 50 gallons per capita day could save 56 acre-feet per 1,000 population annually. In St. George alone, this would have saved 1,700 acre-feet in 1990.

Agricultural water can be conserved with efficient delivery systems and on-farm practices to reduce waste. If the overall irrigation efficiency could be increased one percent, it would save 2,500 acre-feet of water in the basin.

Water conservation will require the input and support of the public. Programs are best carried out under the auspices of water suppliers. If everyone believes in water conservation, it will happen.

2.18 Industrial Water Use

Section 18 discusses industrial water uses in the basin. There is relatively little water used for industrial uses other than light industry operations. These industries are supplied from existing municipal and industrial water supplies delivered through systems now in place.

Other industrial water users are the Tenneco Minerals Corporation, Helca Mining Company and seven hydroelectric power plants. The Tenneco Gold Strike Mine and the Helca Mine use water for leaching operations. Total use is less than 100 acre-feet annually. The hydroelectric power plants have an installed capacity of 6,610 kilowatts. Other power plants may be constructed in future. Industrial water use demands are not expected to increase significantly.

2.19 Groundwater

Groundwater supplies and use and related problems are discussed in Section 19. Groundwater is the primary source of municipal and industrial water. The principal aquifer is the Navajo sandstone. The long-term annual recharge in the Virgin River basin is estimated to be the same as the discharge of 155,000 acre-feet. Recharge and discharge for the Kanab Creek and Johnson Wash drainages is estimated at 31,000 acre-feet. Groundwater inflow from the Sevier River Basin is estimated at 16,500 acre-feet annually.

Discharge to streams is about 35,800-57,700 acre-feet. Discharge to springs is about 10 percent of these estimates. Long-term discharge from wells has been about 10,900 acre-feet in the Virgin River drainage, although this amount can vary considerably. The 1975-85 average for the Virgin River drainage was 19,400 acre-feet with 27,000 acre-feet in 1982. Most of the increase is for M&I water.

The Navajo sandstone is exposed or underlies about three-fourths of the basin. It contains several million acre-feet of recoverable water. The water is generally of excellent quality. Some tests in several wells have shown TDS values ranging from 200 to 1,495 mg/l. There are over 750 wells in the basin. All but two, one near Gunlock and one in Fort Pierce Wash, do not show any long-term rise or fall in the water levels. Wells in the Navajo sandstone yield from 400 to 1,500 gallons per minute. There are nearly 900 springs. The largest is Toquerville Springs with total flows over 30 cfs and 450 mg/l TDS. La Verkin Springs flows about 12 cfs of low quality warm water (9,000 mg/l TDS at 100° F).

Increased demands to meet the needs of an expanding population will require increased use from groundwater aquifers. To avoid mining, monitoring will be required. There is also a need to protect the recharge areas. Planners need to take steps to protect recharge areas from pollution by hazardous spills and by the general population. ■

Section 3 Introduction

3 Introduction

3.1 Background

Planning for the use of Utah's water resources has always been a part of the state's history. Specific legislation to direct state water planning was passed in 1963. The first 19 sections of the *State Water Plan*[16] provide the basis for the future of Utah's water resources. Section 20 is comprised of summaries of individual basin plans. These plans provide more detail on available resources. They also detail problems, needs and demands for the resources and alternatives for future actions. Final decisions in the alternative selection process should be made at the local level. Section 21 contains the annual status reports; they show major changes and progress made on resolving issues.

3.2 Planning Guidelines

The basic foundation for state water planning is described in detail in the *State Water Plan*. Guidelines in the plan help preserve continuity during basin planning and insure the individual plans are complementary to the state plan and to each other.

The *State Water Plan* covers all aspects of Utah's water resources. The plan is designed to be flexible, to change as future conditions require. It describes a process for planning, investigating, conserving and developing the water resources.

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:

1. All waters, whether above or below ground, are held in trust by the state as public property; their use is subject to rights administered by the State Engineer. Surface water and groundwater rights are governed under a common body of Utah statutes. The doctrine of prior appropriation, which has governed Utah water law since statehood, will continue to be used.
2. Water is essential to life. Future generations are entitled to ample, good quality water to meet their basic needs.
3. The diverse present and future interests of Utah's residents should be

protected through a balance of economic, social, aesthetic and ecological values.

4. Water uses that are difficult to identify and charge beneficiaries for, such as recreation and aesthetic, should be included in program evaluation.

5. Public input is vital to water resources planning.

6. All residents of the state are encouraged to exercise water conservation and implement wise use practices.

7. Water right owners are entitled to transfer their rights to others under free market conditions. The State Engineer should be informed of any transfers in order to keep records current.

8. Water resources projects should be technically, economically and environmentally sound.

9. Water planning and management activities of local, state and federal agencies should be coordinated.

10. Local governments, with state assistance as is appropriate, are responsible for protecting against emergency events such as floods and droughts.

11. Water quality should be improved or maintained unless there is evidence the loss of water quality is outweighed by other benefits. State water quality standards should not be violated and the designated uses should be maintained and protected.

12. 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

One main purpose of this basin plan is to 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 can be the vehicle to involve concerned parties.

3.2.3 Organization

State water planning is the responsibility of the Division of Water Resources under the auspices of the Board of Water Resources. Several other state agencies with major water-related missions are also involved in the water planning process. As a result, a state water plan coordinating committee was formed with representation from 12 state agencies. A steering committee provides policy, resolves issues and approves plans prior to acceptance by the Board of Water Resources. In addition, 19 state and federal agencies are participating as cooperating agencies. They have particular expertise in various fields to assist with plan development.

A statewide local advisory group has assisted with input to various aspects of planning and with plan review. This group represents various interests and geographic locations.

The membership on the steering committee, coordinating committee, the cooperating state and federal agencies and the statewide local advisory group are listed in Section 3.4 of the *State Water Plan*.[16] One change has been made to that list. The Utah Division of Comprehensive Emergency Management is now a member of the coordinating committee; it was listed as a cooperating state agency.

A local basin planning advisory group provides input by way of advice, review and decision-making. The group represents various local interests and provides geographical representation within the basin.

3.2.4 Process

During the review and approval process, four drafts of the Kanab Creek/Virgin River Basin Plan are prepared. These are: 1) In-House Review Draft, 2) Committee Review Draft, 3) Advisory Review Draft and 4) Public Review Draft. Revised drafts can occur at any point, if warranted. After this process, the final basin plan is distributed to the public. Although the final plan provides guidance for water use, conservation, preservation and development for state and federal agencies, it is primarily for local entities.

3.3 Basin Description

The Kanab Creek/Virgin River Basin is shown in Figure 3-1 and Figure 3-2. This basin plan includes the Utah part of the Virgin River and its tributaries and Kanab Creek and Johnson Wash. This area is a part of the Lower Colorado River Basin, which includes everything below Lee Ferry.

Johnson Wash discharges into Kanab Creek which discharges directly into the Colorado River in Arizona. Some Fort Pierce Wash tributaries originate in Utah, but most of the drainage is in Arizona. Fort Pierce Wash empties into the Virgin River just below St. George. Beaver Dam Wash originates in Utah, flows through Nevada and back into Utah and enters the Virgin River near Littlefield, Arizona. The Virgin River eventually empties into Lake Mead.

The Kanab Creek/Virgin River Basin, Utah, is bounded on the north by the Bull Valley Mountains, Harmony Mountains, Markagunt Plateau (Navajo Lake area) and the Paunsaugunt Plateau (Bryce Canyon area). The east boundary is Timber Mountain and the eastern hydrologic boundary of Johnson Wash. The southern and western boundaries are the Utah-Arizona and Utah-Nevada state lines, respectively.

Elevations vary from a high of 10,375 feet at Black Mountain in the Cedar Mountains and 10,365 feet at Signal Peak in the Pine Valley Mountains to 2,297 feet and 2,461 feet where the Beaver Dam Wash and Virgin River, respectively, cross the state line. In the eastern part of the basin, elevations range from 9,394 feet near Bryce Canyon National Park to 4,922 feet and 5,086 where Kanab Creek and Johnson

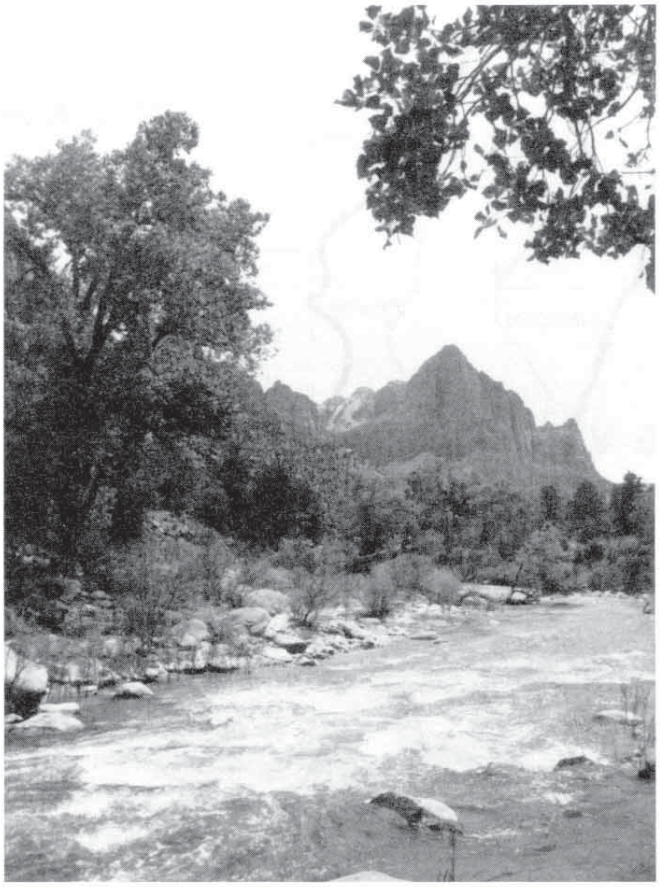


FIGURE 3-1
Regional Location Map
Kanab Creek/Virgin River Basin

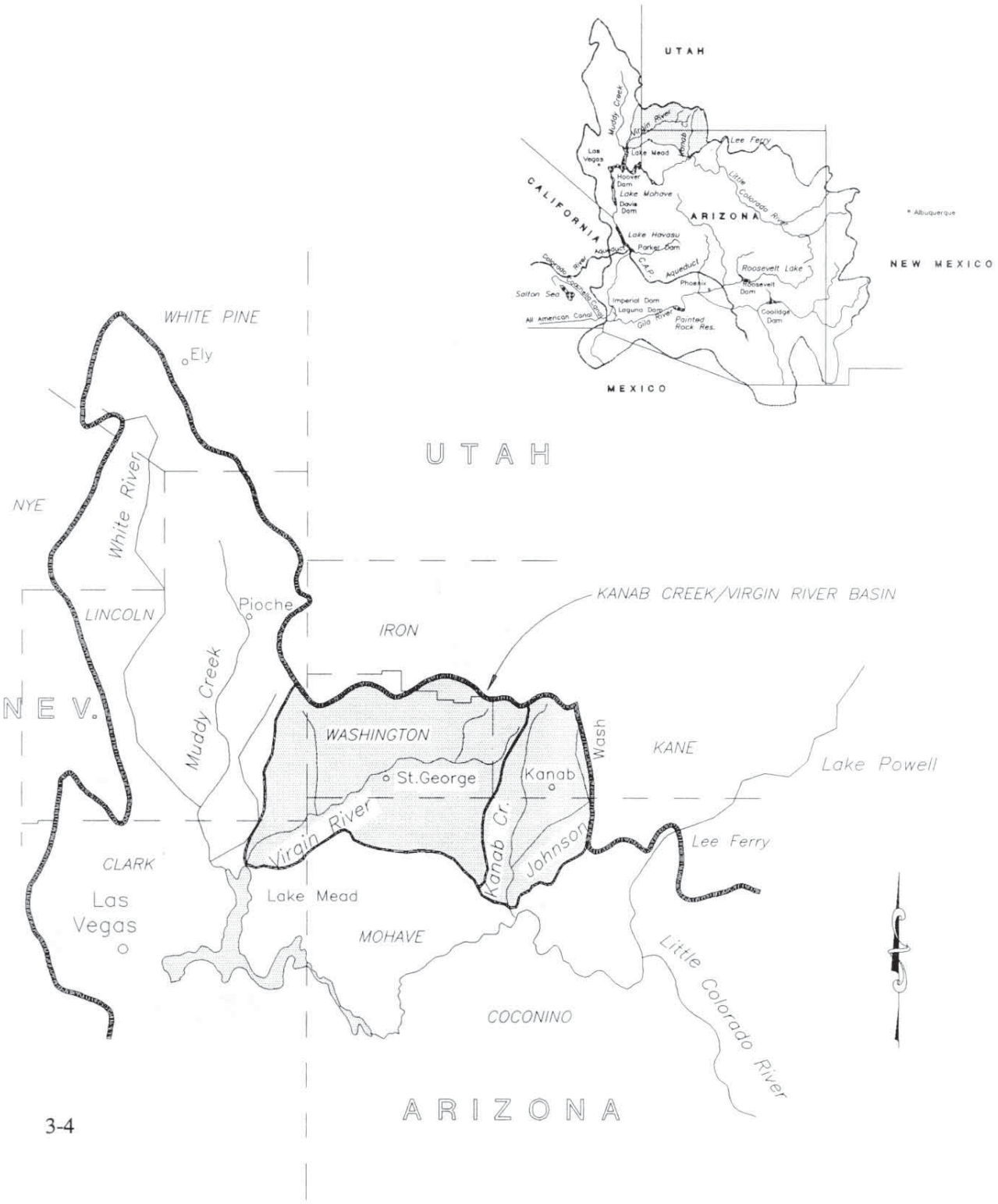
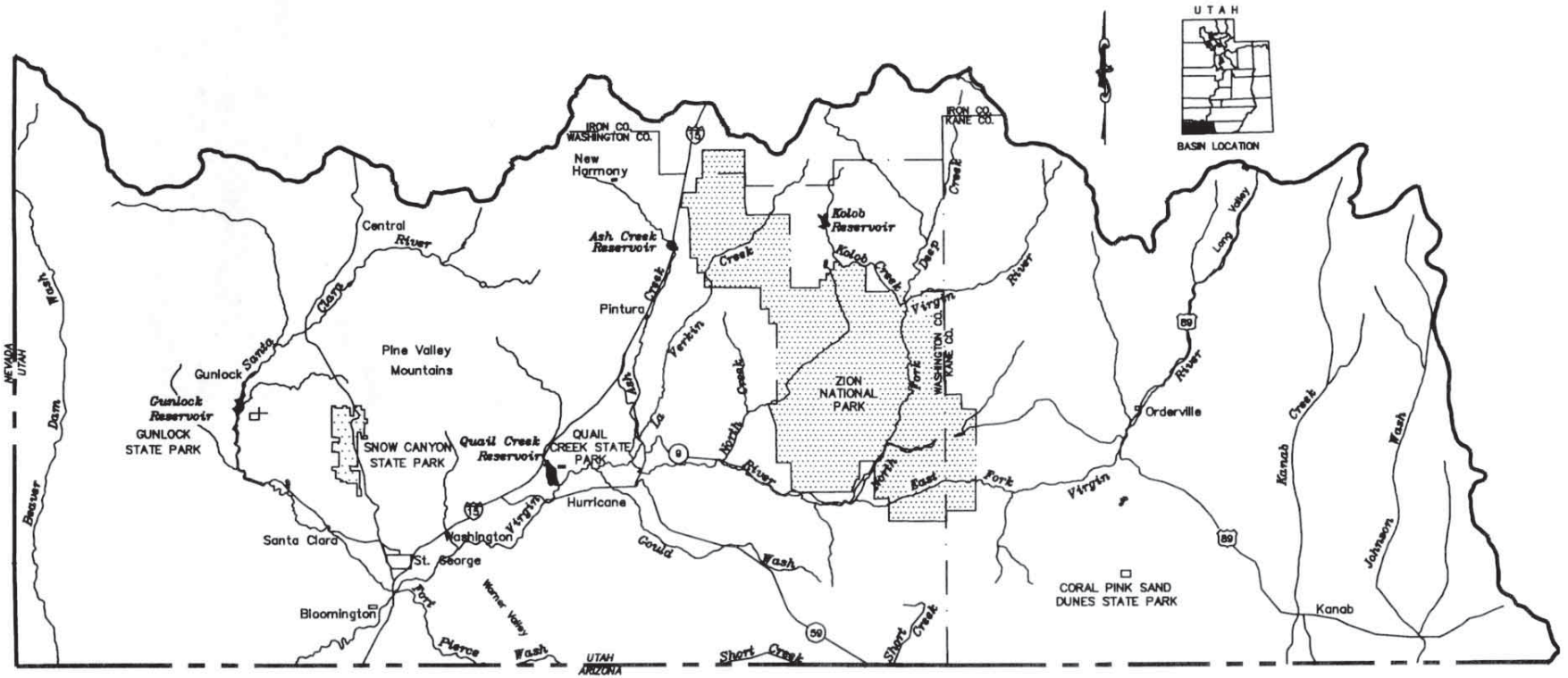


FIGURE 3-2
Location Map
Kanab Creek/Virgin River Basin



Wash, respectively, cross the state line.

Generally, only the hydrologic drainages within Utah are discussed in this report. In some instances, areas in Nevada and Arizona are discussed for clarity.

The basin includes most of Washington County and parts of Kane and Iron counties. The major population centers are St. George and Washington cities in Washington County and Kanab in Kane County.

3.3.1 History and Settlement[5,8]

The history and settlement of the Kanab Creek/Virgin River Basin provides an interesting backdrop for existing conditions. It can help explain some of the present problems as well as existing socioeconomic situations.

Prehistory - Evidence indicates the area was inhabitated 8,000 to 9,000 years ago by the Paleoindian complex of big-game hunters. Most of their artifacts have been destroyed over the years by the ravages of nature. At the end of the Pleistocene ice age, most of the big game animals disappeared. The Paleoindians had to find another way of survival, so they became mobile hunters and gathers known as the Archaic people.

The Archaic people wandered over the southwest for about 6,000 years in search of food. Their principal weapon was the dart-thrower or atlatl (a throwing stick). They made baskets and sandals from yucca and other fibers, and used rabbit skin and yucca fiber blankets to keep warm in their temporary shelters. Another slight climatic change about 2,000 years ago brought the emergence of people who lived in pithouses, grouped into small villages. They made beautiful baskets - hence the name Basketmakers. These people, probably the descendants of the Archaic people, are usually credited with the introduction of horticulture, hunting and gathering, the bow and arrow and crude pottery.

Over the next 900 years, the people gradually evolved into what today are called the Anasazi - the "Ancient Ones." These people were superb pottery makers, built large pueblos found all over the southwest and practiced sophisticated religions. They were excellent agriculturists, using every type of water control device to bring water to their fields where they grew corn, beans and squash.

The Anasazi in the Virgin River Basin evolved approximately 800 years ago. They abandoned this region and moved to areas like Black Mesa, Chaco Canyon, Hopi Mesas and along the Rio Grande River where their descendants live today. Some archaeologists attribute the move to a shift in rain patterns; others say it was continual warfare with the Uto-Aztecan speaking

groups from the west, and others claim it was a combination of both.

In the Kane County area, the Basketmakers were followed by the Puebloans. The Puebloans may be the same culture or related to the Anasazi. Early settlers in Kane County found the Kaibabits (Kaibab band of Paiutes) cultivating crops in the Kanab area and Johnson Wash.

The Uto-Aztecan hunters and gathers dominated the region for about 800 years. In this area they are called southern Paiutes. The Paiutes are noted for their basketry and well-made projectile points. Contact with Europeans spelled the end for the Paiutes. Those not killed by introduced diseases saw their farmlands and hunting and gathering areas gradually taken by the white man. The entire process took about 100 years and finally ended with the Paiutes being moved onto reservations around the turn of the century.

History - The first white man to pass through the area is believed to be Garcia Lopez de Cardenas, a lieutenant of the Spanish explorer Coronado, in about 1550. A party of eight, headed by Father Silvestre Valez de Escalante and Father Francisco Atanasio Dominques, two Franciscan monks, passed through the area in October 1776 trying to find a route from Santa Fe, New Mexico, to Monterey, California. Near Harrisburg, Washington County, they turned to the south and east, their mission a failure.

Fifty years later in 1826, Jedediah Strong Smith descended Ash Creek and the Virgin River enroute to California looking for new beaver country. It is possible Ewing Young, William Wolfskill, J.J. Warner and others followed Smith's route down the Virgin River toward California.

By the time Captain John C. Fremont came from California in 1844 by way of the Muddy River and Virgin River, across the Beaver Dam Mountains to the Santa Clara River and on to Mountain Meadows, the "Trail" was well defined.

Jefferson Hunt made the trip in 1847 to get seed for the settlers in Salt Lake Valley. He made the trip again in 1849, leading a

party of gold-seekers. Some who left the Hunt party for a shorter route did not make it past Death Valley, hence its name. The first wagon to travel the route was brought by the Mormon Battalion in 1848.

Parley P. Pratt led a group of 50 men sent by the Mormon church to explore the Virgin River area. They camped on Red Creek near present Paragonah in December 1849. Pratt and 20 of the men camped near the mouth of the Santa Clara River in early 1850.

Settlement - John D. Lee led a company in February 1852 to settle Harmony. The territorial legislature created Washington County on March 3, 1852. Harmony was the county seat until 1859. Later in 1852, Lee explored Ash Creek, Quail (Otter) Creek, Washington Field and the Santa Clara River. He then went over to Beaver Dam Creek and back by way of the Narrows and Parowan. Lee, accompanied by John Steele and others, also explored the East Fork of the Virgin River in 1852.

Jacob Hamblin and five others arrived in Santa Clara (Tonagaunt Station) in 1854 to learn about the Indians. Cotton was harvested in 1855 and the area became known as "Utah's Dixie." This was to be an experiment station to test crops in the area, particularly cotton.

Heberville (now Bloomington area) was settled in 1858. This settlement (also known as Seldom Sop, Lick Skillet, Never Sweat) was abandoned because of flood problems. Most of the towns now existing in Washington County had been settled by 1867. Central, Veyo and Ivins were settled much later. The early settlements included Harmony, Santa Clara, Tonaquint, Grafton (Wheeler), Gunlock, Toquerville, Washington, Heberville, Harrisburg (Harrisville), Virgin, Pocketville, Rockville (Adventure), Duncans Retreat, Mountain Dell, St. George, Kanarraville, Northrup, Shunesburg, Springdale, Dalton, Pintura (Ashton and Bellevue) and Leeds (Bennington). Some early settlements were later abandoned.

La Verkin and Hurricane were established at a later date. This area was recognized early as having potential fertile farmland and a good climate, but irrigation water was not easy to get for crop production. Irrigation was accomplished later after considerable effort. The first family moved to La Verkin Bench in 1889. The first people lived on Hurricane Bench in 1906, two years after the first water was delivered.

When John D. Lee first explored the Virgin River area in 1852, he found Indians diverting water from the Santa Clara River to irrigate small farms. The Indians were of the Shivwit tribe, a part of the Southern Paiutes. They were very friendly and helped the early settlers immeasurably. The United States Government gathered the Indians in 1891 to the reservation on the Santa Clara river. It was called the Jackson Farm, where 50 heads of families and a total of 194 Indians lived. The total tribal lands currently cover about 28,515 acres, primarily rangeland. About 305 acres of irrigated cropland are along the Santa Clara River within the reservation.

As stated earlier, John C. L. Smith, John Steele, John D. Lee and others explored Long Valley in what is now western Kane County. They continued down the East Fork of the Virgin River to Orderville Gulch where they had to turn back because of the precipitous terrain. In late 1858, Jacob Hamblin led a company of men from Washington County, through Kane County, and across the Colorado River to visit the Moquis Indians. A few scattered settlers were living in dugouts in the Kanab area and Long Valley. Successive trips were made in 1859 and 1860.

The Kane County boundaries were changed over the years until they were established in their present location by the territorial legislature in 1864. County seats included Grafton, Rockville and Toquerville. Kanab was named county seat in 1882.

Glendale (Berryville) and Mt. Carmel (Windsor) were settled in 1864. Some scattered settlers were in Long Valley (Berry Valley) in the 1860s. An advance contingent from the Muddy River settlement in Nevada arrived there in late 1870.

Others followed in early 1871. Orderville was settled in 1875 by part of the Mt. Carmel settlers to avoid contention in the United Order. Alton (an offspring of Upper Kanab) was settled in 1865.

Construction on Fort Kanab began during the winter of 1865-66. Kanab was permanently settled in 1870. Other settlements on the Kanab Creek drainage included Sink Valley, Skutumpah, Roundy's Station and Upper Kanab. These have since been abandoned.

Johnson, on Johnson Creek, was settled in 1871. The population eventually dwindled to a few ranching operations, but it is now increasing.

Pipe Springs (1863), Moccasin (about 1863) and Fredonia (1885) in Arizona have impacted the settlement and development around Kanab. They are in the Arizona Strip, a large area in northern Arizona and southern Utah, isolated by the Grand Canyon and Colorado River on the south and the cliffs of the Virgin River on the north.

3.3.2 Climate[7,11,15,17,18]

The climate of the Kanab Creek-Virgin River Basin varies from cold winters and short summers in the higher elevations to long, hot summers and mild winters in the lower basin areas. The valley temperature and precipitation are measured daily at eight climatological stations (Figure 3-3). Nine snow courses are in and near the basin. Eight of these are equipped with telemetry systems so data can be made available as often as needed (Figure 3-3).

A 30-year base period (1931-1960) is used in this report to analyze the climatic factors. The snow course data is taken from Soil Conservation Service snow course data for the period 1961-1990.

Temperature - Mean annual temperature varies from 61°F at St. George to 45°F at Alton. Average January temperatures range from 39°F at St. George to 26°F at Alton. July temperatures are 84°F and 66°F in the two communities. Temperatures at higher and lower elevations, where there are no stations, are likely to exceed these values.

Precipitation - The area has two separate precipitation seasons. The first is during winter and early spring when Pacific

storms move through the region more frequently than at other periods. A secondary precipitation maximum occurs in late summer when the area is occasionally subjected to thunderstorm activity associated with moist air moving in from the subtropics.

Mean annual precipitation at the valley stations varies from 17.3 inches at New Harmony to 8.0 inches at St. George. Basinwide precipitation varies from six inches on the lower desert to 35 inches in the high mountains near Navajo Lake. The monthly mean precipitation for the basin varies from 1.77 inches in January to 0.49 inches in June. The annual precipitation is shown in Figure 3-3. The October-April and May-September precipitation is shown in Figures 3-4 and 3-5, respectively.

Snow course records show accumulated water content collected during the winter months. Most stations can be accessed to determine daily, monthly or even single storm accumulations. The April 1st 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 course locations are shown on Figure 3-3. Most of the snow courses are outside the hydrologic boundary of the basin, but they are used to predict the annual water supply.

Six distinct climatic zones[10,17] are recognized in the Kanab Creek/Virgin River Basin area. The zones differ from each other in the amount of moisture received, temperature and the length of growing season.

The six zones are described below and shown on Figure 3-6.

1. High Mountain Climatic Zone - The average precipitation ranges from 22 to 35 inches, the average annual temperature is 35° to 45° F., the average freeze-free period is 40 to 90 days and elevations range from 8,000 to over 10,000 feet.

2. Mountain Climatic Zone - The average annual precipitation ranges from 16 to 22 inches, the average annual temperature is 42° to 50° F., the average freeze-free period is 70 to 170 days and elevations range from 6,000 to 8,200 feet.

3. Upland Climatic Zone - The average annual precipitation ranges from 12 to 16 inches, the average annual temperature is 45° to 59° F., the average freeze-free period is 120 to 170 days and elevations range from 4,500 to 6,900 feet.

4. Semidesert Climatic Zone - The average precipitation ranges from eight to 12 inches, the average annual temperature is 52° to 59° F., the average freeze-free period is 120 to 190 days and elevations range from 4,000 to 6,300 feet.

5. Semidesert (D 30) Climatic Zone - The average annual precipitation ranges from eight to 10 inches. The average annual temperature is 59 to 64 degrees. The average freeze-free period is 175 to 200 days and elevations range from 3,000 to 4,500 feet.

6. Desert (D 30) Climate Zone - The average annual precipitation ranges from six to eight inches, the average annual temperature is 59° to 67° F., the average freeze-free period is 175 to 205 days and elevations range from 2,400 to 4,000 feet.

Azonal Areas - The influence of water table, flooding or some other factor are strong enough to over-ride climate as a controlling factor in some azonal sites.

3.3.3 Physiography and Geology

Physiography - The Lower Colorado River Basin below Lee Ferry and above Lake Mead is located in three states: Utah, Nevada, and Arizona (Figure 3-1). This interesting area is marked by mesas and

FIGURE 3-3
Climatological Reporting Stations and Normal Annual Precipitation

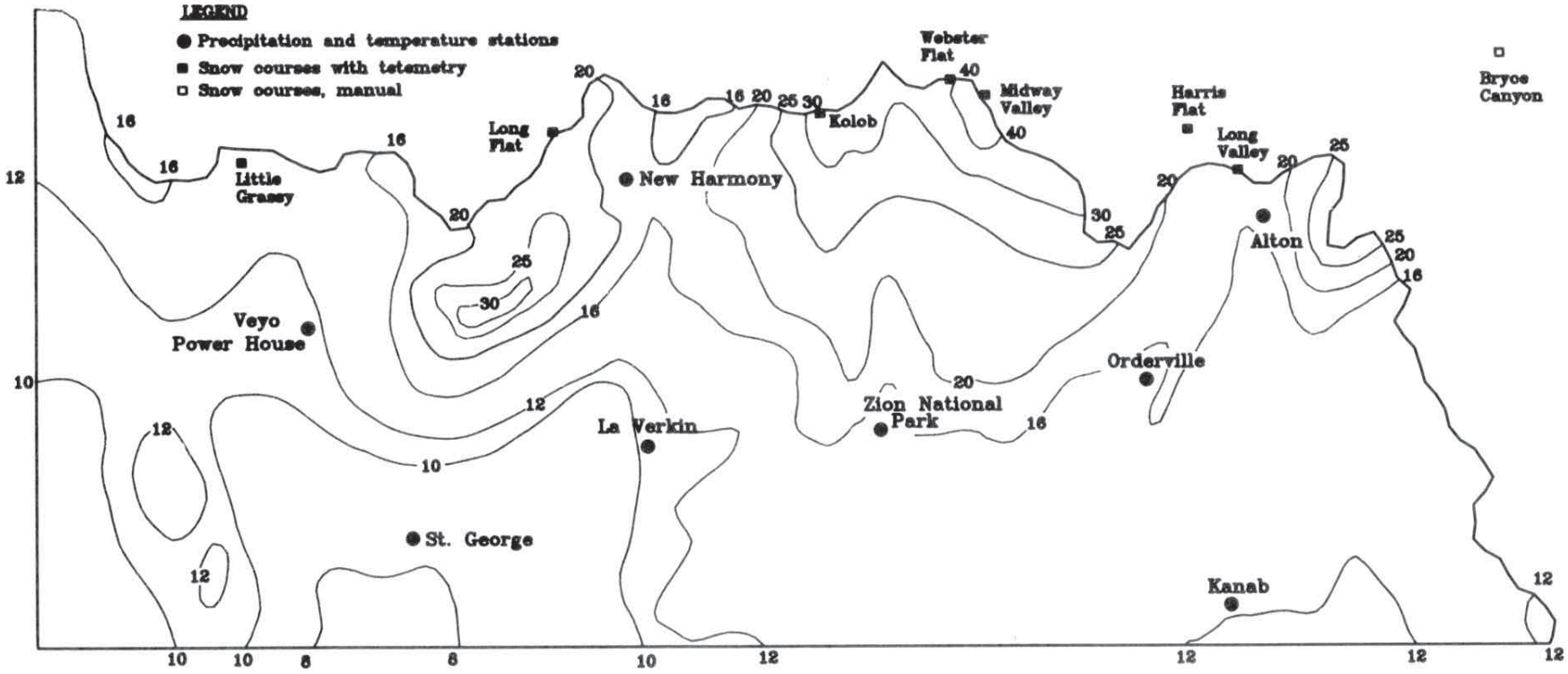


FIGURE 3-4
Normal Precipitation, October Through April[7]

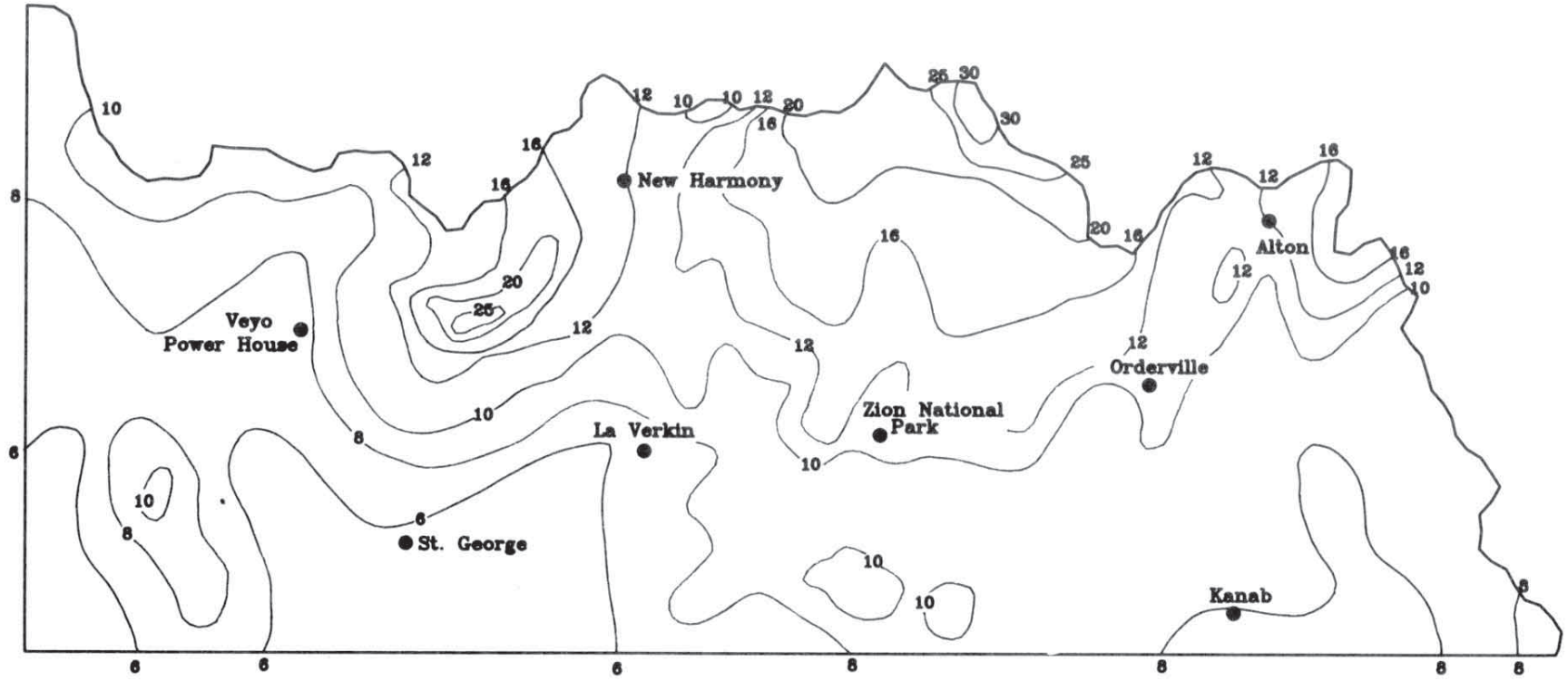


FIGURE 3-5
Normal Precipitation, May Through September[7]

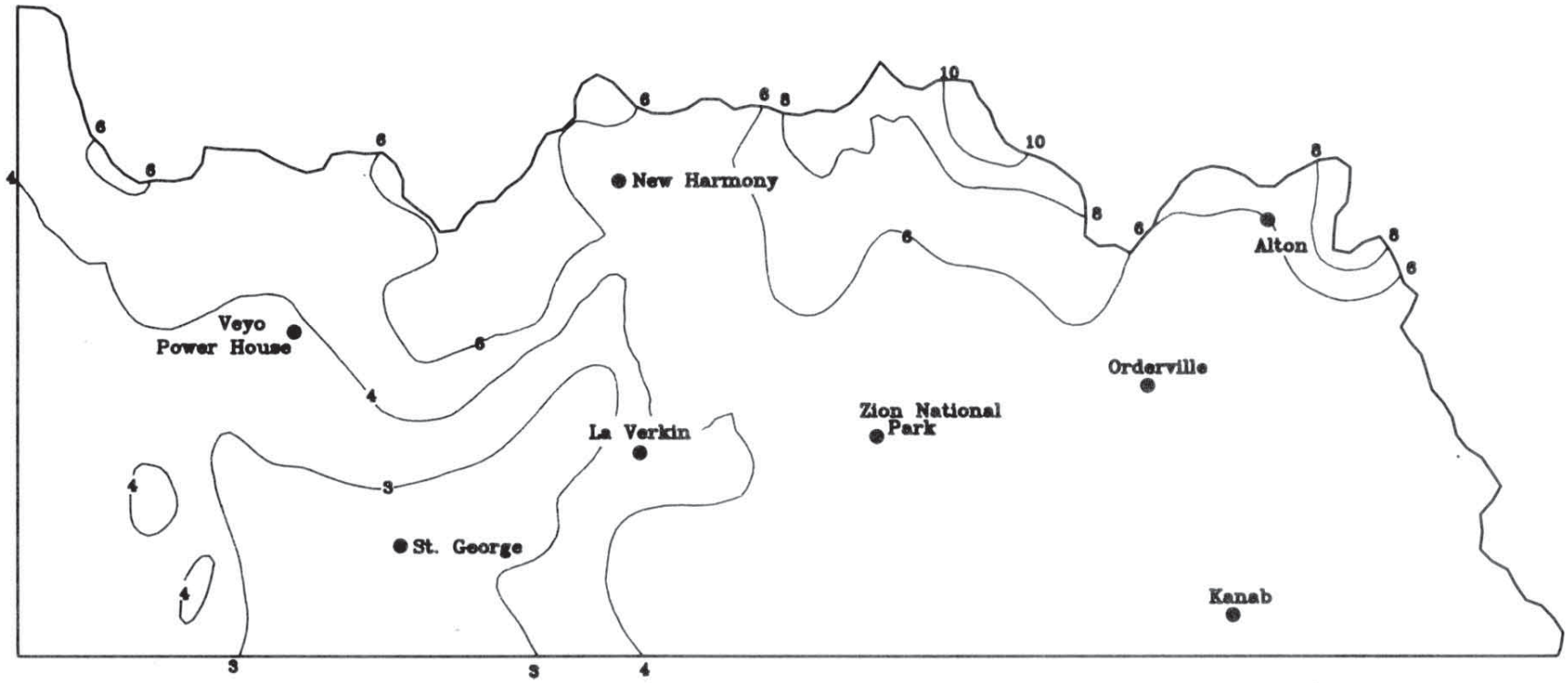


FIGURE 3-6
Climatic Zones

plateaus, escarpments, rugged peaks, broad flat-topped benches and basins. These all reflect the geology of the area.

The Utah portion (Kanab Creek/Virgin River Basin) is divided into two topographically different parts by the Hurricane Cliffs. The colorful mesas and plateaus of the Colorado Plateau Province rise to the east. Steep-walled narrow canyons and precipitous escarpments have been cut in the relatively soft sedimentary deposits by streams often carrying large volumes of abrasive sediments. The mesas and plateaus diminish in elevation to the south.

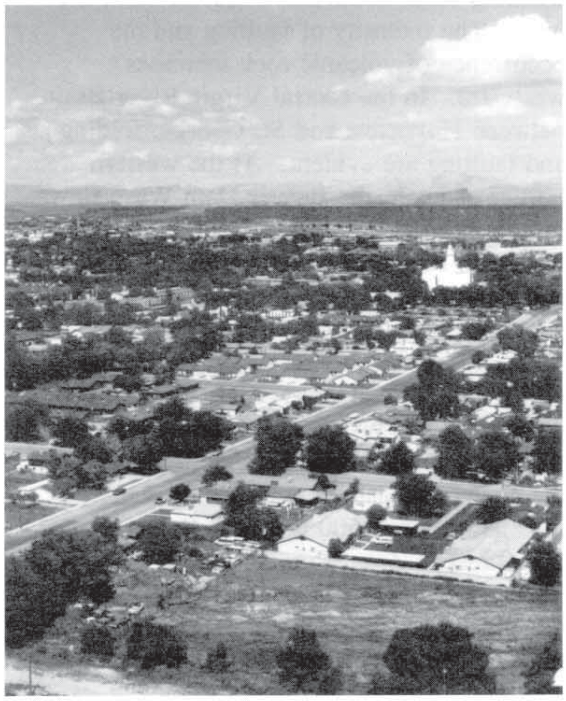
To the west of the Hurricane Cliffs, the landscape is more varied. St. George lies in a large valley, bounded on the north by the Pine Valley Mountains. Farther west, the Beaver Dam Mountains divide this basin from one stretching into Nevada. The northwest part of Washington County is marked by a jumble of low, irregular hills with only two or three prominent landmarks.

The eastern part of the basin is fed by drainages which head in the high plateaus above Johnson Wash and Kanab Creek. These rise on the escarpment of the Paunsaugunt Plateau and flow southerly before they join and empty into the Colorado River in northern Arizona.

The Virgin River flows southerly from the Markagunt Plateau, then turns west through Washington County. It then cuts across the northwest corner of Arizona before it empties into Lake Mead in Nevada.

The Santa Clara River originates on the north slopes of Pine Valley Mountains, flows west, then south to join the Virgin River near St. George. Beaver Dam Wash originates in Utah, flows southwest into Nevada, back into Utah, and joins the Virgin River in Arizona. The basin has been divided into watersheds to better identify some of the resources and resources problems. These will be shown in the sections where they apply. The basin has nine watersheds (Figure 10-1).

General Geology - The area lies on what geologists call the "transition zone" between the Colorado Plateau Province and the Basin and Range Province. In the east, the underlying rock consists of relatively undeformed beds of sedimentary rock which dip gently toward the north. Over geologic time, the erosion of the north-dipping beds



by south-flowing drainage has created a series of cliffs formed by the exposed edges of the more resistant formations, called the "Grand Staircase." It is the combination of north dipping rock and south-sloping topography that gives the region its characteristic groundwater hydrology as well as its distinctive topography.

The rocks east of the Hurricane Cliffs consist of interbedded shales, siltstones and sandstones of Mesozoic age, and the freshwater limestones and volcanic rocks of Cenozoic age. West of the Hurricane Cliffs, a greater variety of rock is exposed including older sedimentary rock, crystalline rock of pre-cambrian age in the Beaver Dam Mountains and intrusive and extrusive volcanic rock of Tertiary age in and around the Pine Valley Mountains.

Tectonic deformation in the eastern portion consists of widely spaced faults trending north-south and offset down to the west. The intensity of faulting and the occurrence of volcanic rock increases westward. In the central Virgin River Basin, between Hurricane and St. George, folding and faulting are evident. At the western border of Utah, the Beaver Dam Wash flows in a fault-bounded alluvial basin typical of the Basin-Range Province valleys of Nevada and Arizona. Figure 3-7 shows the general geology.

Aquifers[1,2,3,4] - East of the Hurricane Cliffs, the alluvial valley fill is thin. Most groundwater is provided by bedrock sandstone units. Principal among these is the Navajo sandstone, which ranges in thickness from 1,500 feet near Kanab to 2,200 feet in Zion National Park.

West of the Hurricane Cliffs, unconsolidated alluvial valley fills are thicker, and they constitute significant aquifers. Alluvial aquifers are in New Harmony Valley, Pine Valley, Santa Clara River Valley and the basin of Beaver Dam Wash.

3.3.4 Soils, Vegetation and Land Use

Resource data on the soils and vegetation varies in accuracy, particularly across land ownership and management boundaries. More data is available in the Virgin River drainage than in the Kanab Creek and Johnson Wash drainages.

Soils[10,12] - The basin has five broad, general landscapes. These landscapes can be used for interpretive purposes, and they are briefly described below. Each landscape generally has several soil associations. The soils in one association may occur in another, but in a different pattern. Other kinds of soil are present in each soil association, but they are not extensive enough to be included in the name.

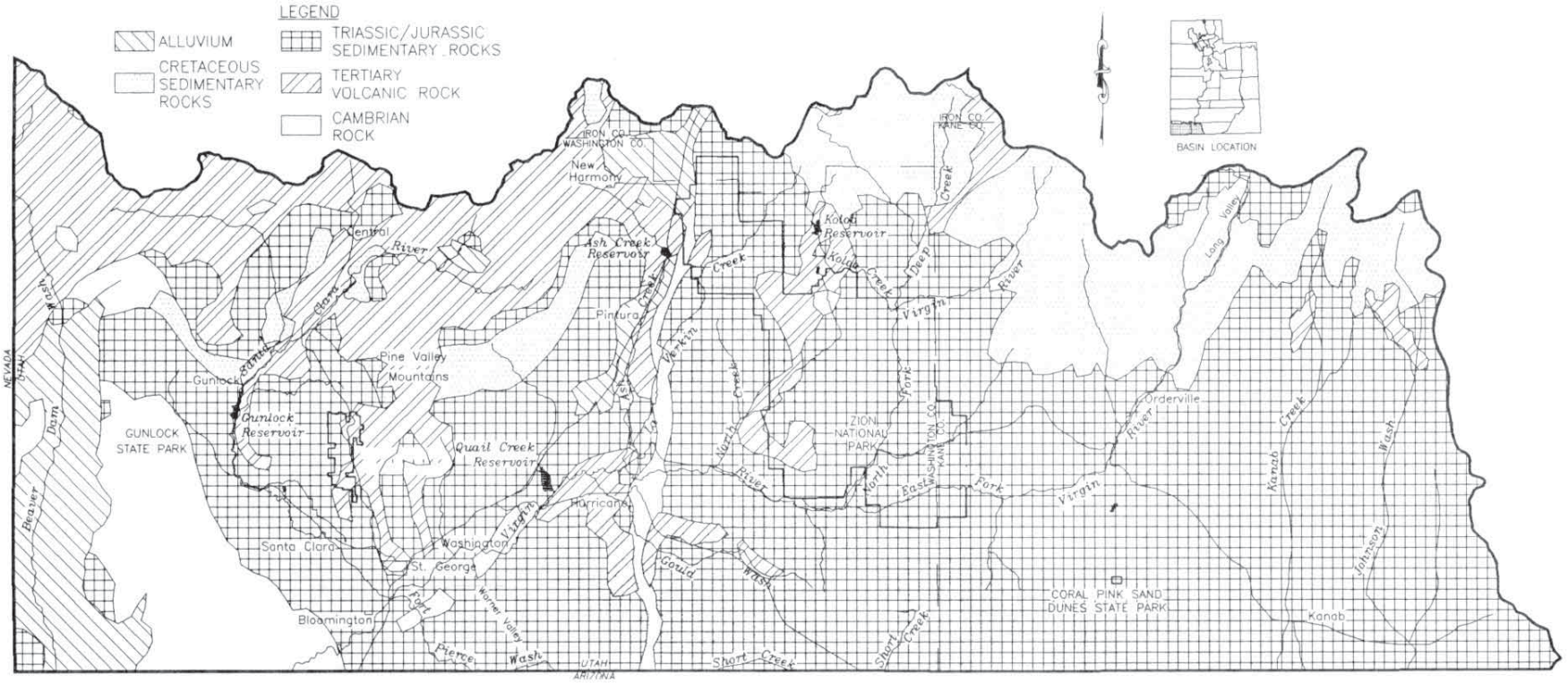
Soil associations are useful to people who want a general idea of the soils in an area, who want to compare different parts of an area or who want to know about large tracts suitable for a certain kind of land use. The soils in any one association ordinarily differ in slope, depth, stoniness, drainage and other characteristics affecting management.

- Dominantly well-drained and somewhat excessively-drained, nearly level to steep, shallow to deep soils; on alluvial fans, flood plains, mesas and mountains.

  Elevation ranges from 2,400 to 4,200 feet. Average annual precipitation ranges from six to 11 inches, average annual temperature ranges from 57° to 67° F and the frost-free period ranges from 190 to 205 days. The soils are used mainly for irrigated crops, range and wildlife habitat.

- Dominantly rock outcrop, rockland and badland and well-drained or somewhat excessively-drained, or

FIGURE 3-7
General Geology



gently sloping to very steep, shallow and moderately deep soils in desert basins and on uplands.

Elevation ranges from 2,600 to 7,000 feet. The average annual precipitation ranges from eight to 14 inches, average annual temperature ranges from 52° to 59° F and the frost-free period ranges from 160 to 195 days. These soils are used mainly for aesthetic purposes, range and wildlife habitat.

- Dominantly well-drained to excessively-drained, nearly level to steep, shallow to deep soils; on alluvial fans, mesas, plateaus and valley bottoms.

  Elevation ranges from 3,300 to 6,300 feet. Average annual precipitation ranges from 10 to 15 inches, average annual temperature ranges from 45° to 59° F and the frost-free period ranges from 120 to 170 days. The soils are used mainly for wildlife habitat, recreation, non-irrigated crops and range.

- Dominantly well-drained or somewhat excessively-drained, nearly level to very steep, shallow to deep soils; on mountains and fans.

  Elevation ranges from 3,700 to 8,000 feet. Average annual precipitation ranges from 12 to 18 inches, average annual temperature ranges from 42° to 56° F and the frost-free period ranges from 70 to 170 days. These soils are used mainly for range, recreation and wildlife habitat.

- Dominantly well-drained to excessively-drained, gently sloping to very steep, shallow to deep soils; on alluvial fans, mesas, plateaus and mountains.

  Elevation ranges from 3,500 to over 10,000 feet. Average annual precipitation varies from 12 to 40 inches, average annual temperature ranges from 35 to 55° F and the frost-free period ranges from 40 to 160 days. These soils are used mainly for watershed, wildlife habitat, range, recreation, esthetic purposes and some commercial forest products.

See Section 10, Agricultural Water Conservation and Development, for additional information on agricultural land use.

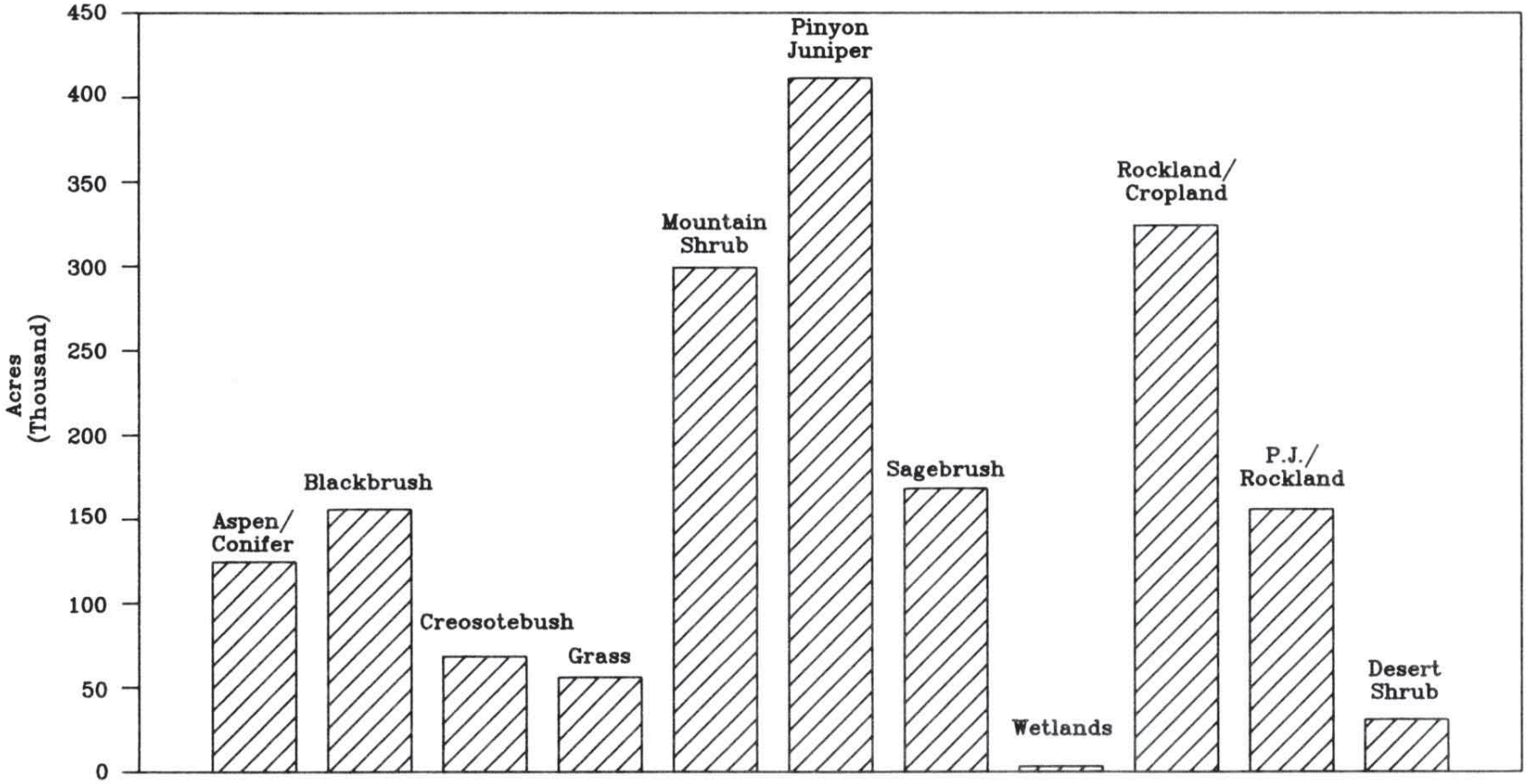
Vegetation[10] - Eleven landcover types have been categorized in the basin. Due to mapping intensities by various agencies, data detail will vary. Landcover data in the Virgin River drainage is adequate for the detail of this report. Information in the Kanab Creek and Johnson Wash drainages is still being collected and compiled.

The landcover types and areas of each for the Virgin River drainage are shown on Figure 3-8. These are broad delineations, shown to provide relative cover data.

Typically, the irrigated cropland areas are confined to the bottom lands along the stream channels. The bottom lands may also contain minor acreages of dry cropland but the non-irrigated areas are generally on the higher uplands where precipitation is greater. Cropland with the related agricultural types of land cover constitutes about 47,000 acres.

Land Use - The Soil Conservation Service capability groupings show, in a general way, the suitability of the soil for

FIGURE 3-8
Landcover Types



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 for agricultural cultivation. Other uses, such as for wildlife, may not be as restrictive.

Class 1 - Has few limitations that restrict use.

Class 2 - Has moderate limitations that reduce the choices of plants or requires moderate conservation practices.

Class 3 - Has severe limitations that reduce the choices of plants and requires very special conservation practices.

Class 4 - Has very severe limitations that reduce the choices of plants and requires very careful management.

Class 5 - Is subject to little or no erosion but has other limitations impractical to remove, limiting the use to pasture, rangeland or other permanent vegetation.

Class 6 - Has severe limitations that make it generally unsuitable for cultivation and limit its use largely to pasture, rangeland and other permanent vegetation.

Class 7 - Has very severe limitations that makes it unsuitable for cultivation and limit its use largely to pasture and rangeland or for wildlife.

Class 8 - Soils and land forms have limitations that preclude the use for cropland and restrict its use to recreation, wildlife, habitat or watershed.

Capability subclasses are soil groups within one class. They are designated by adding a small letter e, w, s or c.

e - Limitations due to a risk of erosion by wind and/or water.

w - Water in or on the soil interferes with plant growth.

s - Limitations due to shallowness, low water holding capacity or stony.

c - Limitations due to climate, too cold or too dry.

The majority of the soils (about 90 percent) in the basin are capability classes 5 thru 7. These soils, with moderate to severe limitations, are used primarily for pasture and rangeland.

Lands used for farming can also be defined according to their agricultural production capability and potential. Two categories, prime farmlands and farmland, are of statewide importance. About 17,000 acres of prime farmland and 26,000 acres of farmland have statewide importance. See Section 10.4 for detailed descriptions.

About 25,600 acres of irrigated cropland are in the Kanab Creek/Virgin River drainage in Utah (See Table 10-4). About 3,000 acres in Arizona and 4,000 acres in Nevada are irrigated cropland.

The balance of the area in Utah is primarily used for rangeland, although some rockland areas are unsuitable for grazing. Grazing is also prohibited in Zion National Park. Rangeland condition by percent of area is shown in Table 3-1.

Forest resources are produced in many areas in addition to the grazing resource. Six different forest types are pinyon-juniper, gambel oak, mountain mahogany, aspen, fir/spruce and pine.

The intensive management of commercial timber stands is not emphasized in the basin. Some commercial stands of aspen and ponderosa pine are on rimlands. Steep, dissected side slopes of the watersheds have mixed conifer.

The majority of the aspen is on private land. The numerous landowners involved with this resource make it difficult for

TABLE 3-1 RANGELAND CONDITION	
Condition	Area (percent)
Good	15
Fair	45
Poor	15
Not Rated	25

harvesters to obtain sufficient quantities to justify sales. Much of the conifer timber is located on or near mountain cabin lots discouraging harvesting. The ponderosa pine resource is mostly on the rims close to Zion National Park making harvesting to any scale very difficult and environmentally sensitive.

About 50 percent of the forest type is pinyon-juniper. Some fire wood, fence posts and pinenuts are commercially harvested. Recent interest has been shown in harvesting sap from pinyon and using juniper for fire starter, perfume and deodorizing bases. Interest has been increasing in transporting firewood (pinyon-juniper and gambel oak) to Nevada and California.

3.3.5 Land Status

The total area of the Lower Colorado River Basin in Utah is about 2.2 million acres. The area of the major drainages and their tributaries is: Virgin River, 1.8 million acres; Kanab Creek, 189,000 acres and Johnson Wash, 211,000 acres. The total area of the Virgin River is about 3.2 million acres. Of this total, 1.8 million acres are in Utah, 1.1 million acres in Arizona and nearly 300,000 acres in Nevada.

The federal government has the responsibility to administer about 68 percent of the basin lands in Utah. The state administers about eight percent and 23 percent is privately owned lands. The breakdown of land ownership and administration is shown in Table 3-2.

The federally administered land is under the jurisdiction of three agencies, one in the Department of Agriculture and two in the Department of Interior. They are the Forest Service, Bureau of Land Management and the National Park Service. In addition, the Bureau of Indian Affairs works with the Indian tribal lands. Table 3-3 shows these jurisdictions.■

TABLE 3-2
LAND OWNERSHIP AND ADMINISTRATION

Status	Virgin River		Kanab Creek and Johnson Wash		Total	
	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)
Private	433,500	23.7	80,800	20.2	514,300	23.0
Tribal	28,500	1.5	-0-	-0-	28,500	1.3
State	140,600	7.7	37,200	9.3	177,800	8.0
Federal	1,228,400	67.1	282,000	70.5	1,510,400	67.7
TOTAL	1,831,000	100.0	400,000	100.0	2,231,000	100.0

TABLE 3-3
FEDERAL LAND ADMINISTRATION

Agency	Virgin River		Kanab Creek and Johnson Wash		Total	
	(acres)	(percent)	(acres)	(percent)	(acres)	(percent)
Forest Service	291,000	23.7	8,200	2.9	299,200	19.8
Bureau of Land Manag.	795,100	64.7	273,800	97.1	1,068,900	70.8
National Park Service	142,300	11.6	-0-	-0-	142,300	9.4
Total	1,228,400	100.0	282,000	100.0	1,510,400	100.0

3.4 References

1. Clyde, Calvin G. *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Logan, Utah, 1987.

2. Doelling and Davis. *Geology of Kane County Utah.* Utah Geological and Mineral Survey Bulletin 124, p. 47, Salt Lake City, Utah, 1989.

3. Goode, Harry D. *Reconnaissance of Water Resources of a Part of Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 5, Salt Lake City, Utah, 1964.

4. Ibid. *Second Reconnaissance of Water Resources in Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 8, Salt Lake City, Utah, 1966.

5. Larson, Andrew Karl. *I Was Called To Dixie.* St. George, Utah, 1961.

6. Nevada Center for Water Resources Research and Utah Water Research Laboratory. *Virgin River Basin Study: A Regional Approach to Multiobjective Planning for Water and Related Resources.* Las Vegas, Nevada, 1977.

7. Peck, Eugene L. and E. Arlo Richardson. *Precipitation Maps for Utah, 1931-1960.* U.S. Weather Bureau, Washington, D.C., 1965.

8. Robinson, Adonis Findlay. *History of Kane County.* Kane County Daughters of Utah Pioneers, Kanab, Utah, 1970.

9. U.S. Department of Agriculture. *Water and Related Land Resources, Virgin River Unit.* Carson City, Nevada, 1977.

10. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin-Utah Cooperative Study.* Salt Lake City, Utah, 1990.

11. U.S. Department of Agriculture, Soil Conservation Service. *Utah Annual Data Summaries, Cooperative Snow Survey Data.* Salt Lake City, Utah, 1975-1990.

12. U.S. Department of Agriculture, Soil Conservation Service; U.S. Department of Interior, Bureau of Land Management and National Park Service; in cooperation with Utah Agricultural Experiment Station. *Soil Survey of Washington County Area, Utah.* Salt Lake City, Utah, 1977.

13. Utah Division of Water Resources. *A Water-Related Land Use Inventory Report of the Kanab Creek/Virgin River Basin.* Salt Lake City, Utah, 1993.

14. Ibid. *A Water-Related Land Use Inventory Report of the Virgin River Area.* Salt Lake City, Utah, 1990.

15. Ibid. *Hydrologic Inventory of the Virgin and Kanab Study Units.* Salt Lake City, Utah, 1983.

16. Ibid. *Utah State Water Plan.* Salt Lake City, Utah, 1990.

17. Weber State College. *Atlas of Utah.* Don C. Greer, Project Director. Brigham Young University Press, Provo, Utah, 1981.

18. Whaley, Bob L. and David C. McWhirter. *Summary of Snow Survey Measurements for Utah, 1924-1974 Inclusive.* U.S. Soil Conservation Service, Salt Lake City, Utah, 1975.

Section 4 Demographics and Economic Future

4 Demographics and Economic Future

The Kanab/Creek Virgin River Basin covers most of Washington County, western Kane County and a small part of southern Iron County. The major population center is St. George in Washington County. Kanab, located in the Kanab Creek drainage, has the largest population in Kane County.

4.1 Introduction

The economy of the basin is growing rapidly, especially in the St. George area. Gradual increases or stability are also noted in other communities. Washington County has experienced large population gains during the last two decades.

As the basin economy expands, planning at all levels of government will require reliable information on the supply and demand for water. This section will present information to help local leaders anticipate the need for timely water resources development. Combining this information with the latest technology for delivering, using and conserving available water should result in coordinated planning and manageable economic growth.

Employment increases have been substantial in Washington County with the trade and service sectors tending to dominate. Tourism and retirement have had a major impact. The economy of the area is expected to continue to expand, reducing the out-migration of the youthful labor force and providing conditions for growth in the manufacturing and professional services sectors.

4.2 Demographics

While Utah's overall growth rate is expected to be 1.7 percent through 2020, the Washington County rate is expected to be 3.44 percent annually. The 1990 population for the Utah portion of the Lower Colorado River Basin is 52,742. By 2020 the total is projected to be 158,381. This reflects an average annual growth rate of 3.38 percent per year. Population and projections shown in Table 4-1 and

Figure 4-1 are for cities in the Kanab Creek/Virgin River Basin in Utah. Hurricane and St. George divisions are the major growth areas; combined, they will triple by 2020. These projections were provided by the Utah Office of Planning and Budget. Divisions are a geographic grouping of communities for population planning purposes.

The Utah Governor's Office of Planning and Budget has developed procedures and criteria for making population projections. The Utah Process Economic and Demographic (UPED) model is part of this. The UPED projection model takes into account many variables regarding the demographics and industry mix of an area. The model incorporates historical employment growth rates into the future growth patterns, along with assumptions regarding labor force participation rates, non-employment related migration rates and constant age-specific fertility and survival rates. The transient and part-time population occupying the relatively large number of hotel rooms and condominiums in Washington County are not counted in the UPED, but the employment associated with serving this population is included.

Additional population projections were made to aid in estimating long-range municipal water requirements in the next 50 years. These projections assumed a constant annual growth rate beyond the year 2020 of 2.8 percent. This means by the year 2040, the population of Washington County would increase to about 261,000 and the basin population would increase to about 275,000.

Other population projections have been made locally. They show a larger rate of increase, and they will be used by local officials in their planning process.

4.3 Employment

Employment will likely continue the growth that began during the last decade when the service, transportation, communications and public utilities sectors registered 15 percent annual increases, respectively. Manufacturing, construction and trade showed annual increases of 6-10 percent, while agriculture, mining, government and finance, insurance and real estate increased less than six percent. This is derived from data shown in Table 4-2 and Figure 4-2. Agricultural on-farm employment is expected to continue to decline while agricultural services are expected to increase, but at a declining rate.[1]

Annual growth rates for all sectors in Washington County, except agriculture, are expected to increase at an average of almost

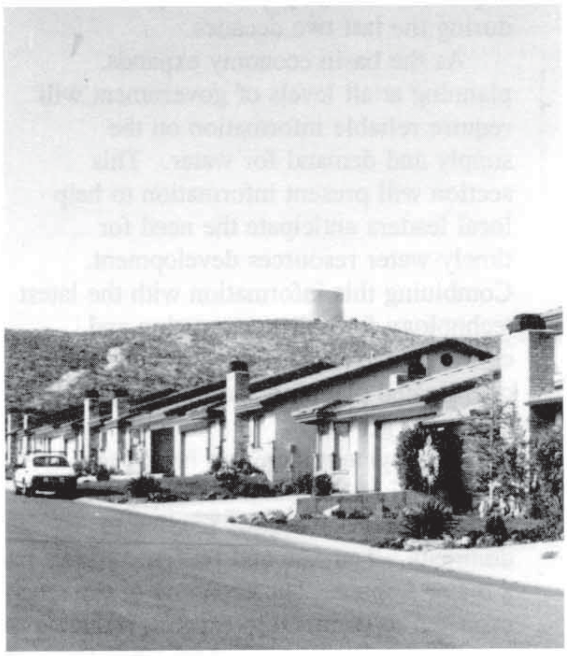


TABLE 4-1
POPULATION AND PROJECTIONS

City	1970	1980	1990	2000	2010	2020
Hurricane Division	**3,682**	**6,329**	**9,174**	**14,302**	**20.024**	**24,834**
Hildale	480	1,009	1,325	2,085	2,919	3,613
Hurricane	1,408	2,660	3,915	6,111	8,522	10,526
La Verkin	463	1,174	1,771	3,045	4,481	5,704
Leeds	151	218	254	352	467	566
New Harmony	78	117	101	134	176	213
Rockville	na	156	182	241	315	380
Springdale	182	258	275	373	492	595
Toquerville	185	277	488	750	1,038	1,278
Virgin	119	169	229	326	437	531
Unincorporated	616	291	634	885	1,177	1,428
St. George Division	**9,055**	**18,754**	**38,227**	**64,429**	**96,798**	**122,604**
Ivins	137	600	1,630	3,592	6,457	9,186
Santa Clara	271	1,091	2,322	4,107	6,139	7,720
St. George	7,097	13,146	28,502	46,444	68,176	84,986
Washington	750	3,092	4,198	8,050	12,901	16,869
Unincorporated	800	825	1,575	2,236	3,125	3,843
Enterprise Division*	**948**	**982**	**1,159**	**1,572**	**2,112**	**2,597**
Wash. County Total	13,685	26,065	48,560	80,303	118,934	150,035
Orderville Division	**738**	**833**	**902**	**1,073**	**1,365**	**1,602**
Glendale	200	237	282	348	450	531
Orderville	399	423	422	480	601	699
Unincorporated	139	173	198	245	314	372
Kanab Division	**1,683**	**3,191**	**4,267**	**5,916**	**8,029**	**9,677**
Kanab	1,381	2,148	3,289	4,565	6,199	7,474
Alton	62	75	93	115	149	176
Unincorp. (Johnson Wash)	240	814	559	781	1,062	1,281
Big Water*	NA	154	326	455	619	746
Kane County Total	2,421	4,024	5,169	6,989	9,394	11,279
Kanarraville	204	255	228	281	346	410
Basin Total	15,362	29,208	52,742	85,546	125,943	158,381

* Not in basin. Source: Utah Office of Planning and Budget

FIGURE 4-1
Population and Projections

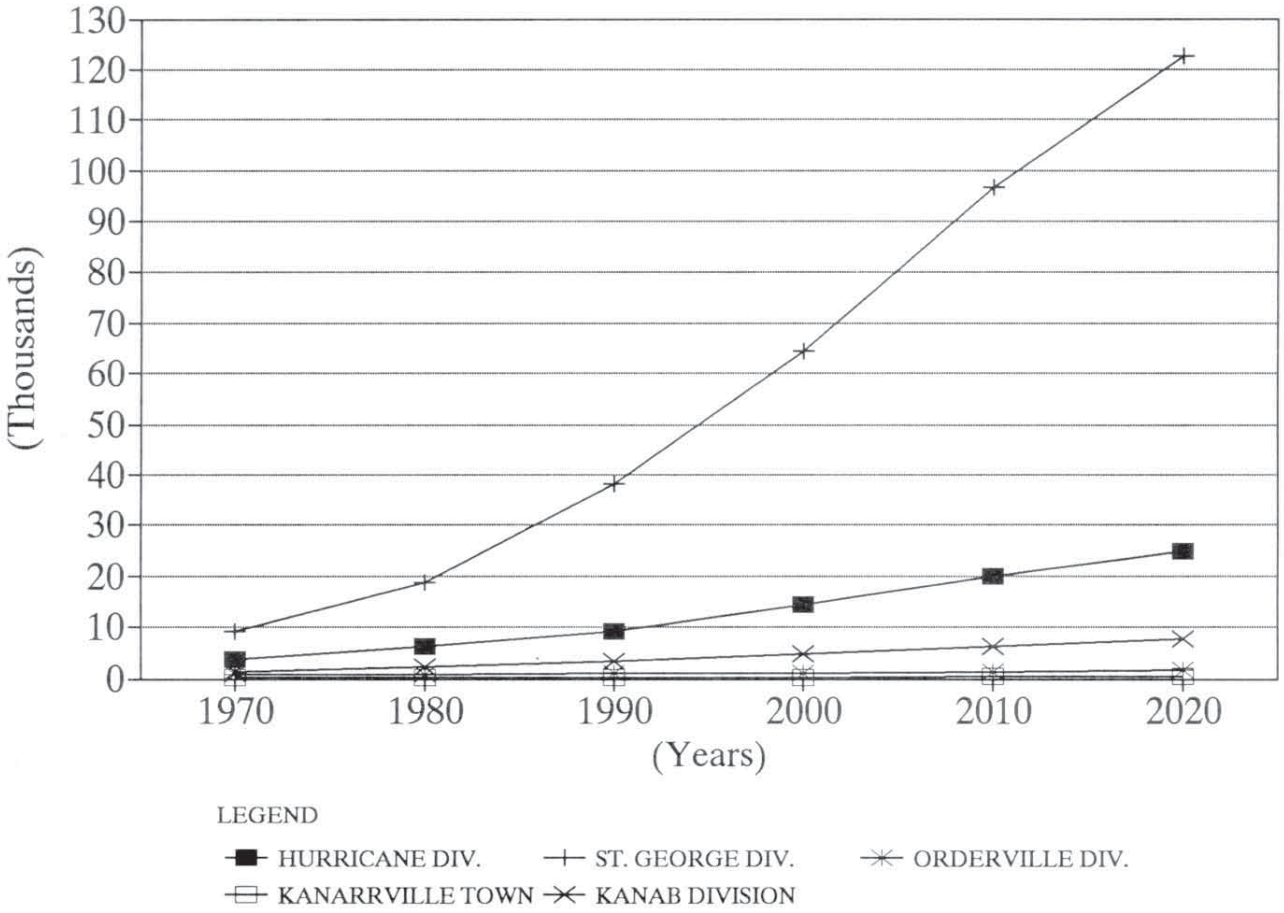


TABLE 4-2
WASHINGTON COUNTY EMPLOYMENT PROJECTIONS BY MAJOR INDUSTRY

Industry	1980	1990	2000	2010	2020
Agriculture[a]	480	491	587	668	746
Mining	70	106	117	158	202
Construction	540	917	1,918	2,586	3,199
Manufacturing	700	1,562	2,082	2,773	3,515
TCPU[b]	230	868	1,769	2,317	2,864
Trade	1,930	4,416	7,639	10,774	13,456
FIRE[c]	410	518	1,030	1,460	1,787
Services[d]	930	3,676	6,708	9,869	12,760
Government	1,680	2,677	4,112	6,308	8,044
Non-Farm Proprietors[e]	1,240	2,619	4,311	6,185	7,955
Total Employment	8,210	17,850	30,273	43,098	54,528
Non-Ag W&S Employment[a]	6,150	14,813	25,375	36,245	45,827

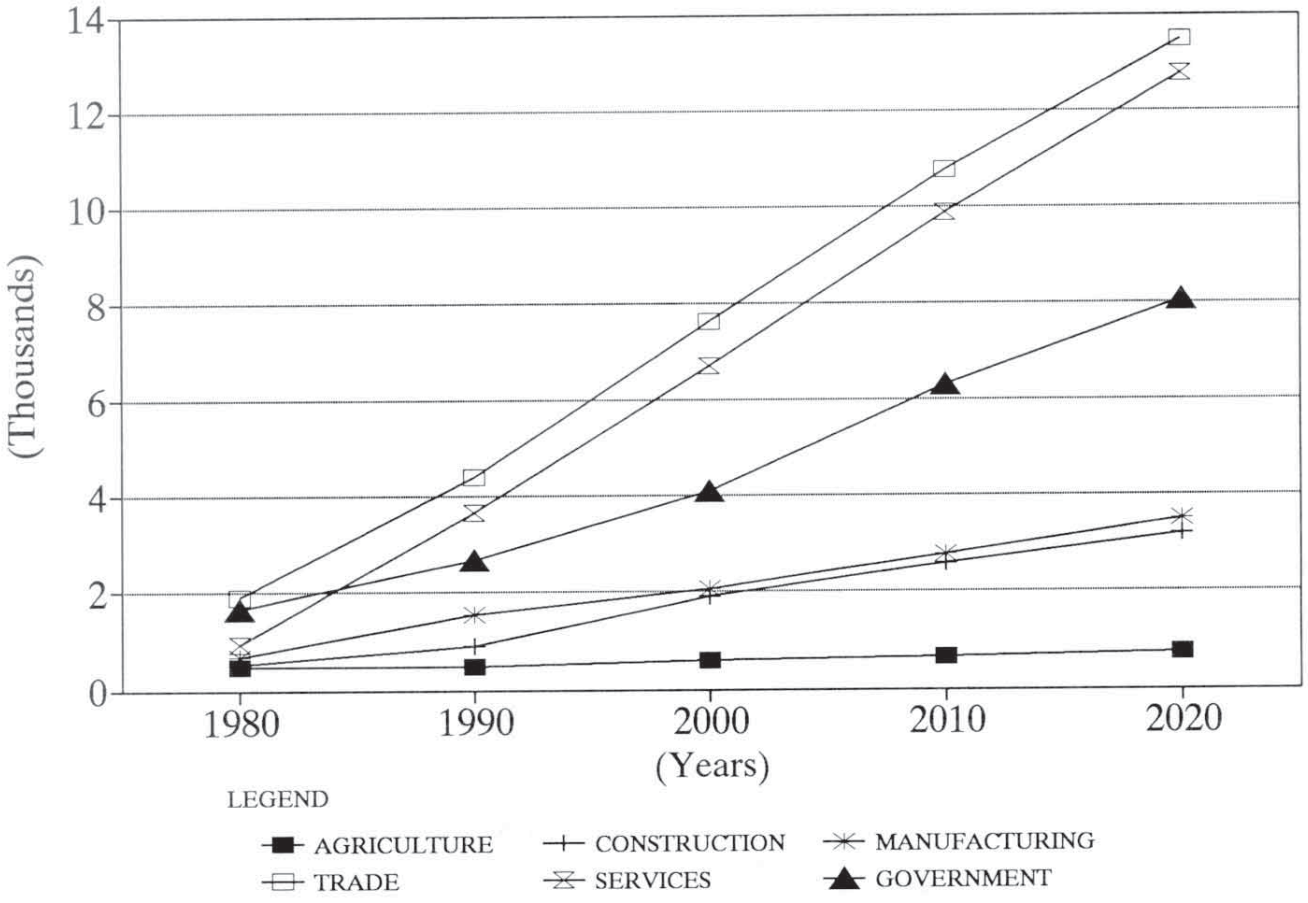
[a]Includes agriculture services.
[b]Transportation, communications and public utilities.
[c]Finance, insurance and real estate.
[d]Includes private household and agricultural services employment; excludes other agricultural and non-farm proprietors employment.
[e]Utah Department of Employment Security's definition.

four percent per year. This applies only to Washington County because data are not available for the communities in Kane County.

4.4 Economic Future

Southwestern Utah will grow as an economic force as recreation, retirement living, tourism and industrial expansion continue. Additional manufacturing firms are expected to locate in Washington and Kane counties to take advantage of the labor force, education, climate and other local resources. ■

FIGURE 4-2
Employment and Projections



Note: Washington County Only

4.5 References

1. Bureau of Economic and Business Research, Graduate School of Business, University of Utah. *1990 Statistical Abstract of Utah.* Salt Lake City, Utah, January 1990.

2. Utah Office of Planning and Budget. *State of Utah Economic and Demographic Projections, 1990.* Salt Lake City, Utah, December, 1989.

3. United States Department of Agriculture, Soil Conservation Service, Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study: Socioeconomic, Recreation, Visual, Historical, and Archaeological Resources Appendix.* Salt Lake City, Utah, August 1990.

Section 5 Water Supply and Use

5 Water Supply and Use

5.1 Introduction

This section discusses the present water supply and use. As some of the tributary drainages are outside Utah, it is necessary to define the hydrologic yield of the total area above the state line to properly understand the water resources. This includes surface water and groundwater supplies and use.

The rapidly increasing population has and will continue to demand more water. Expanding development of light industry and recreational facilities will also add to the water supply demand.

5.2 Background

The water supply in the basin is influenced by storm paths and topography. Storms from the Pacific Ocean produce the largest amounts of precipitation, mostly in the form of snow.

The base period for determining the water supply is water years 1941 through 1990. This 50-year period will be used for discussing surface water. Groundwater is discussed using various time periods. Discharge and recharge data vary depending on the time frame of studies and investigations.

Most of the water supply in the Kanab Creek/Virgin River Basin originates as precipitation on the surface hydrologic drainage within Utah. A small portion of the water supply comes as inflow from Nevada in the Beaver Dam Wash and from Arizona in the Fort Pierce Wash. Groundwater transbasin inflow from the Markagunt Plateau (Navajo Lake area) surfaces in the Virgin River drainage. The same is true of the Paunsaugunt Plateau (Bryce Canyon area) above Kanab Creek and Johnson Wash.

The largest water producing area is around the headwaters of the North Fork of the Virgin River and its tributaries. Other high and moderate producing areas include the Pine Valley Mountains, Paunsaugunt

Plateau and the Cougar Mountains in the upper Beaver Dam Wash drainage.

Many areas yield high volume-short duration flood flows produced by high intensity cloudburst storms. Most of these occur in lower elevation areas such as Johnson Wash, Fort Pierce Wash, Kanab Creek and lower Beaver Dam Wash. Rain on snow and early spring sustained high temperatures also occasionally produce high flows. These are generally longer duration snow-melt occurrences.

Water was being diverted by the Indians for irrigation when early explorations were conducted prior to establishment of the first white settlements. With the arrival of the white settlers in the 1850s, diversion of water for irrigation was top priority.

The first diversions and irrigation works were simple to build, but soon floods raised havoc with these systems. Stream channels deepened and banks eroded until they were often many times larger. Part of this occurred as a result of natural geologic processes and part was man-caused from overuse and abuse of the watersheds.

5.3 Water Supply

Water from melting snow makes up the largest percentage of streamflow and causes the high flows during the spring. The balance of the snowpack infiltrates into the ground and what is not used to support vegetation is the source for springs and groundwater recharge. Warm season rainstorms help augment streamflows.

5.3.1 Surface Water Supply

Most of the surface water comes from snow-melt during the months of March, April and May. Figure 5-1 is a graphical representation of the average annual streamflows and stream depletions for the period 1941-1990 for the Virgin River. The width of the flow line indicates the volume. Simulated river flows and diversions resulting from full use of the Quail Creek project are shown in Figure 5-2. By comparison, the flows in Kanab Creek and Johnson Wash are much smaller. These are shown in Figure 5-3. The volumes are derived from computed water budgets and from actual, correlated and estimated stream gage records.

One of the long-term U. S. Geological Survey (USGS) stream gages in the basin is located on the Virgin River near the town of Virgin (USGS gage 09406000). The Virgin gage has a period of record of 1909-1971, and then 1979 to the present. The missing years of daily flows for 1972 to 1978 have been estimated using a computer simulation and the daily flow record at the Hurricane gage. This provides a long-term water supply record at Virgin for the 1910 to 1991 period.

This gage is important because it has a long period of record, is located on the main stem of the river below many of the major tributaries, and is upstream from several major diversions. For these reasons, this gaging station is very useful in estimating and correlating streamflow records in other areas of the basin that are not gaged or have been gaged for a shorter time.

Figure 5-4 is a bar chart of the annual runoff at the Virgin gage for an 81-year period extending back to 1910. The highest year was 1922 with 337,000 acre-feet, and the lowest years were 1977 and 1990 with 69,000 acre-feet. Figure 5-5 shows the average monthly flows for the Virgin gage for the 1941 to 1990 50-year period. This

FIGURE 5-1
Virgin River System - Utah
Streamflow and Stream Depletion Chart (1941-1990 Base Period)

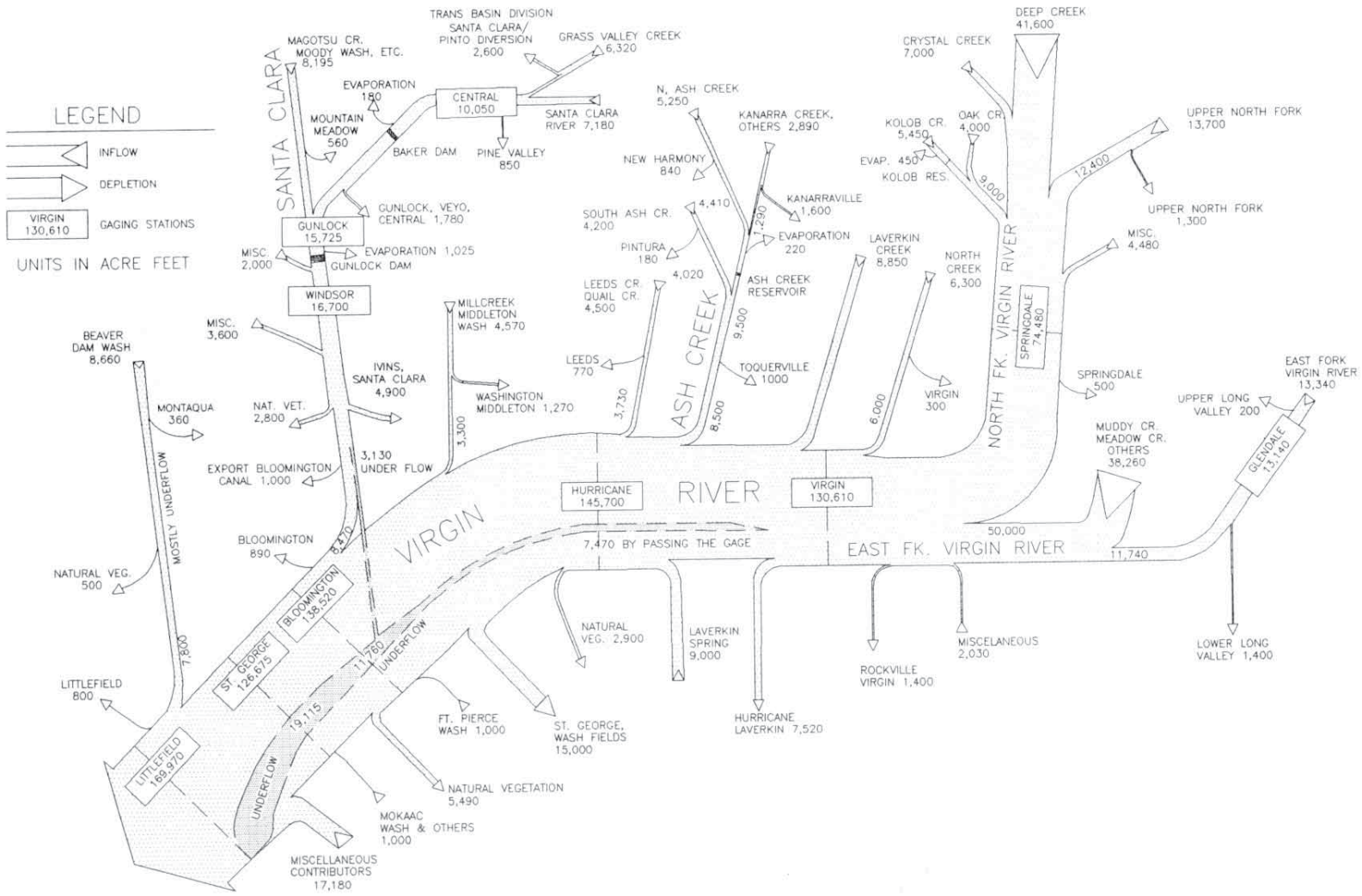


FIGURE 5-2
Virgin River
Simulated Quail Creek Project
Virgin Gage to Hurricane Gage (1941-1990 Base Period in Acre-feet)

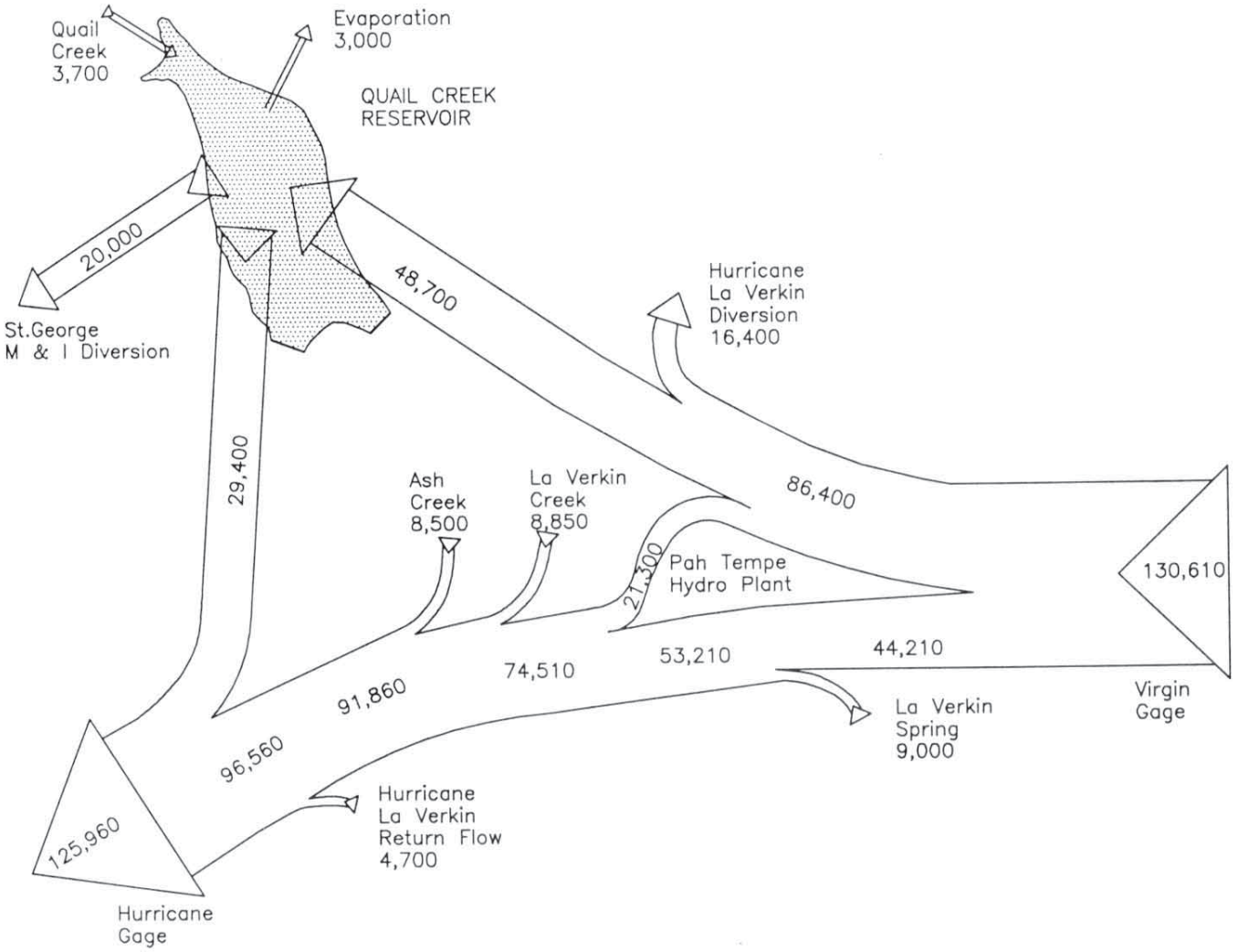


FIGURE 5-3
Kanab Creek and Johnson Wash
Streamflow and Stream Depletion Chart (1941-1990 Base Period)

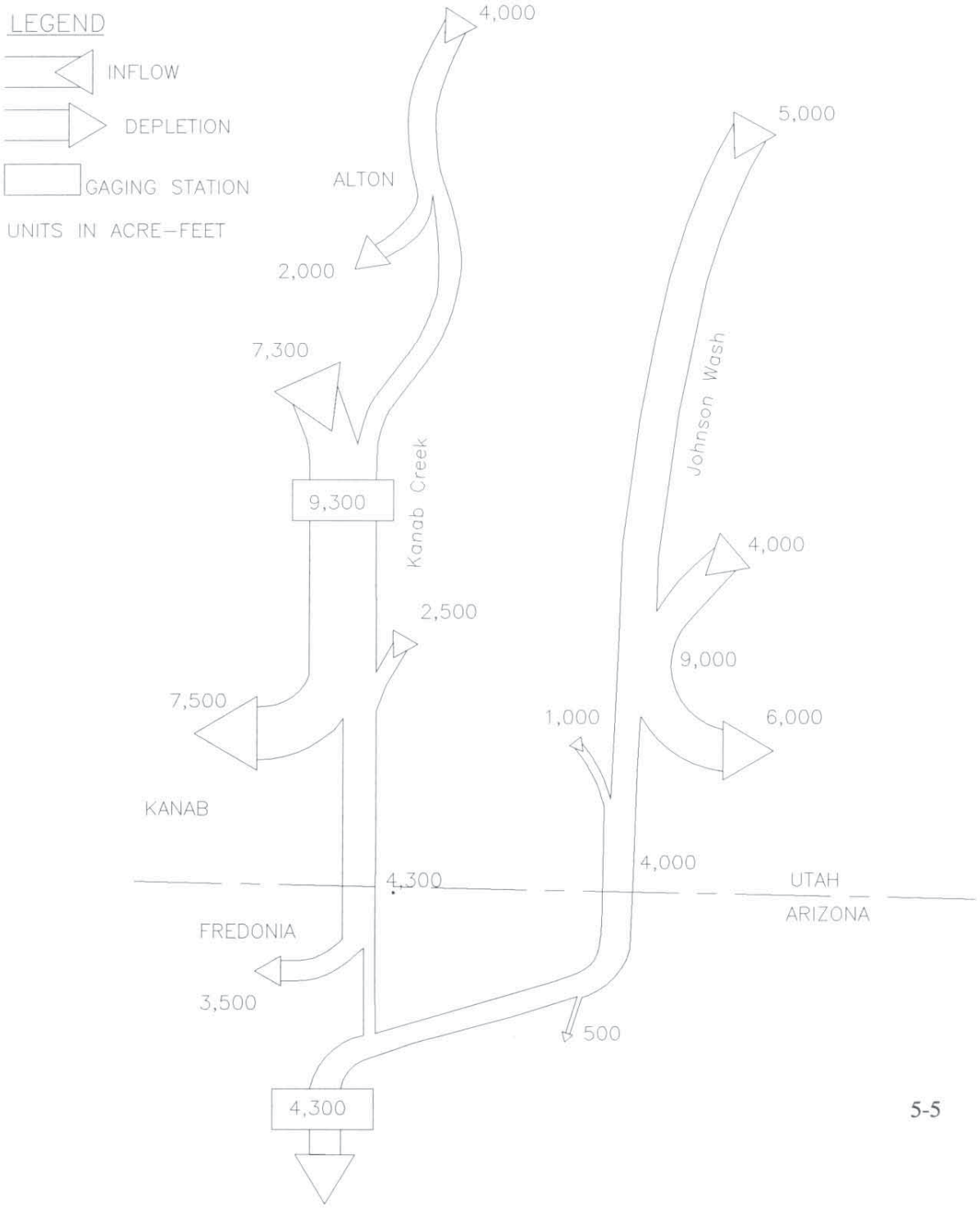


FIGURE 5-4
Annual Flows, Virgin River at Virgin

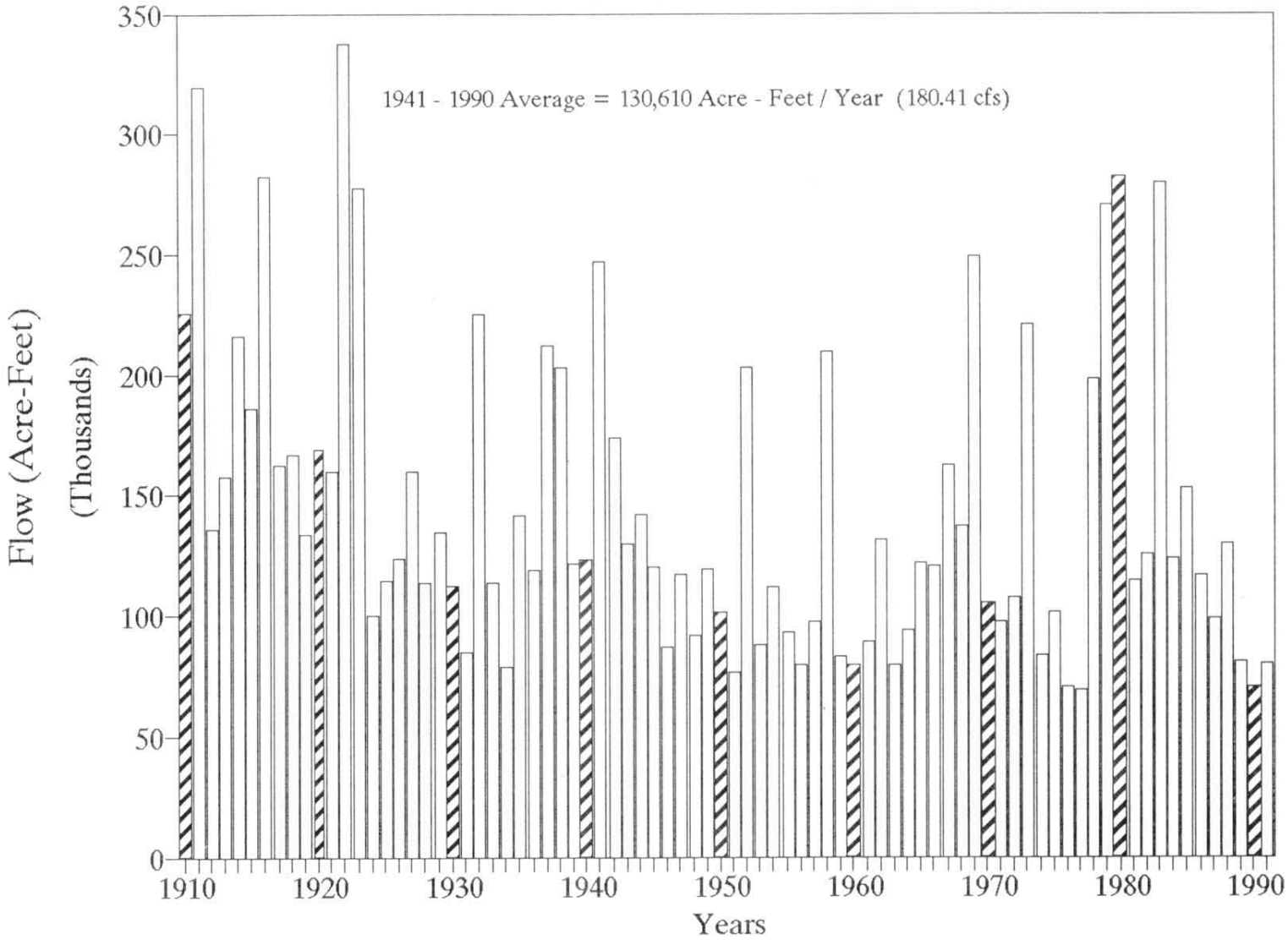
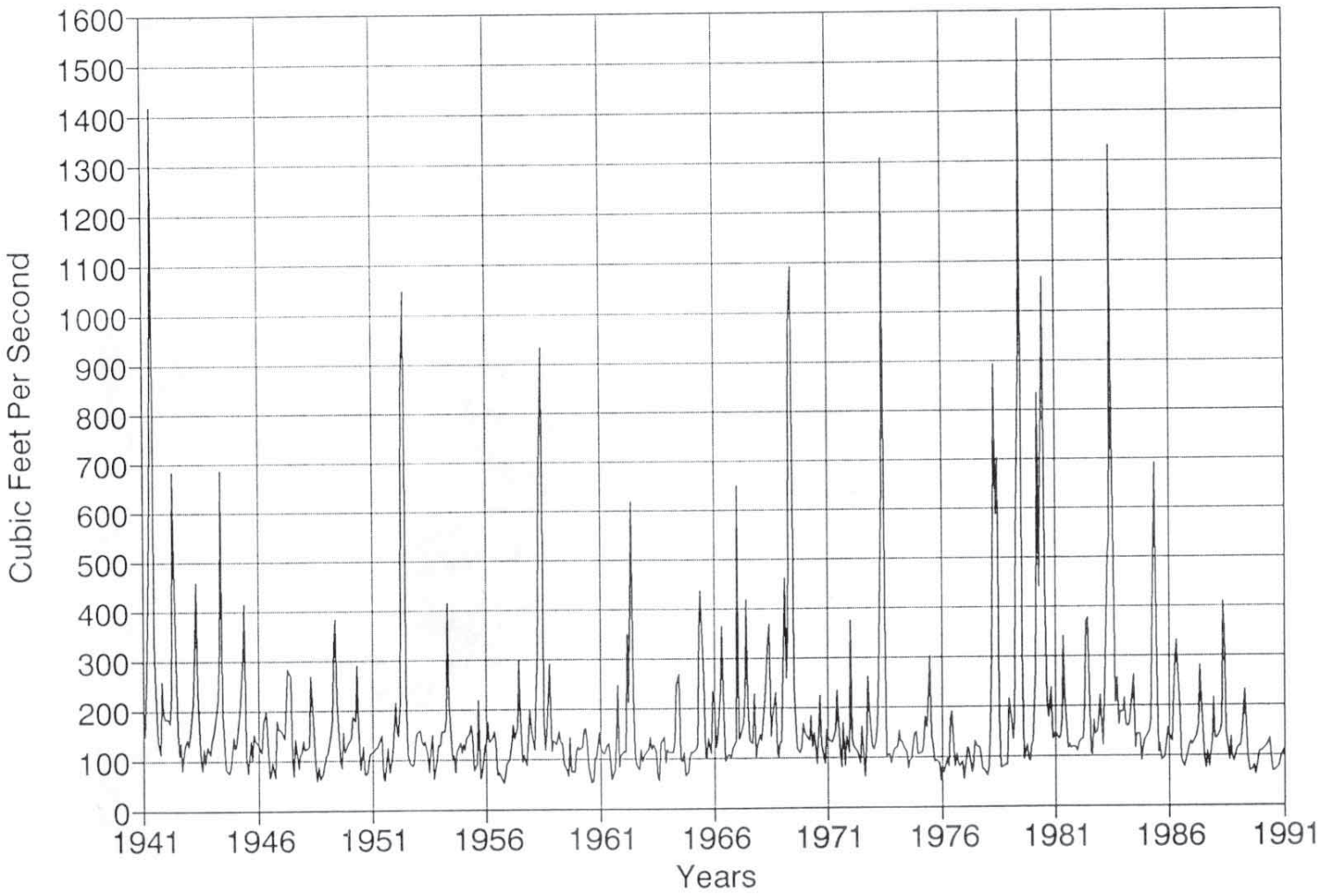


FIGURE 5-5
Monthly Mean Flows, Virgin River at Virgin

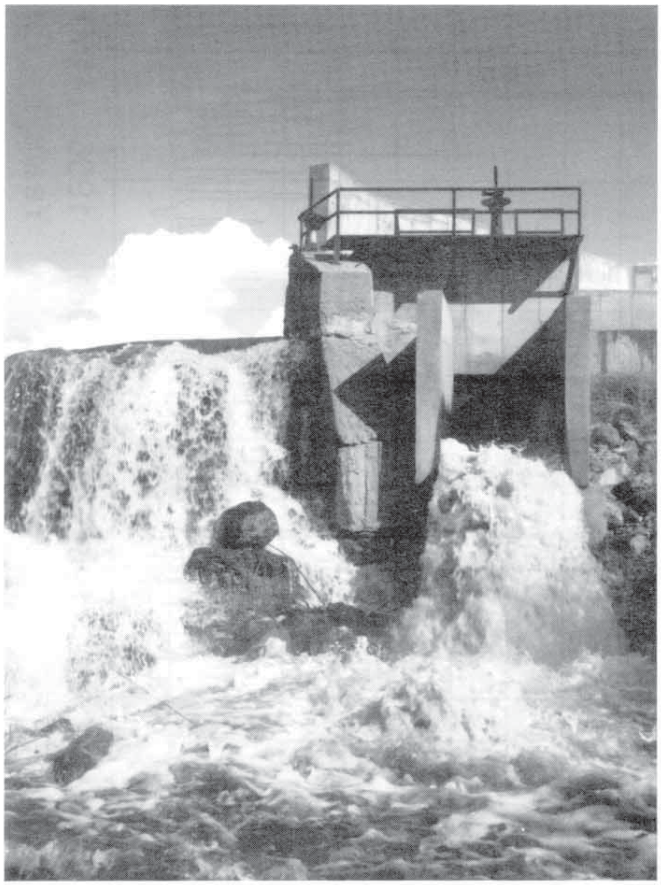


hydrograph shows the high variation of the flow of the Virgin River.

The flows at the Virgin gage at different probability levels are shown in Table 5-1. Similar data are shown for Kanab Creek in Table 5-2.

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 of monthly streamflows at the Virgin gage for water years 1910 through 1971, and also 1979 through 1990. Figure 5-6 shows this graphically. Figure 5-7 shows these data for Kanab Creek near Kanab.

Table 5-3 lists the stream gages in the Kanab Creek/Virgin River Basin. The station number, period of record and description are shown along with the mean monthly and annual flows in acre-feet. The values in this table are computed from rounded summary data; therefore, the values will be slightly different than if they had been computed from the actual daily flow records.



Most of the basin is prone to flash flooding from rainfall. The instantaneous peak flows from these flash floods can be very high and cause extreme erosion and property damage. For example, the highest peak flow ever recorded at the Virgin gage was 22,800 cubic feet per second (cfs) on December 6, 1966. As a comparison, the 50 percent probability flow in the month of May from Table 5-1 for the Virgin gage is 333 cfs. The peak flows during the spring are generally a result of snowmelt runoff. Late summer instantaneous peaks come from cloudburst floods. The highest peak flow for each year at the Virgin gage with the dates of occurrence is shown in Table 5-4. Flood frequencies at the Virgin gage are given in Table 5-5. Also refer to Figures 5-6 and 5-7.

The peak flow at the Kanab Creek gage for the period of record was 3,030 cfs on September 8,

TABLE 5-1
MONTHLY STREAMFLOW PROBABILITIES OF OCCURRENCE, VIRGIN RIVER AT VIRGIN, 1910-1971 AND 1979-1990.

Month	90%	80%	50%	20%	10%
	(acre-feet)				
January	6783	7189	7933	9236	9902
February	5867	6520	7332	9676	13215
March	7802	8265	11322	18478	26297
April	7616	9046	17027	36444	40212
May	6802	8291	14881	43156	68799
June	3897	4576	6218	12378	19276
July	4090	4591	5864	7901	10926
August	4776	5206	7225	9275	11191
September	3719	4332	5390	8300	13298
October	4722	5339	6600	8373	9531
November	6046	6286	7378	9105	11632
December	6784	7205	8195	10105	13172
Annual	56954	68429	94174	151309	228897

TABLE 5-2
MONTHLY STREAMFLOW PROBABILITIES OF OCCURRENCE OF KANAB CREEK NEAR KANAB, 1979-1990.

Month	90%	80%	50%	20%	10%
January	571	782	878	992	1020
February	666	717	760	1598	2296
March	676	784	1327	2939	4261
April	586	672	906	3597	7044
May	480	533	639	841	1565
June	354	377	453	552	690
July	325	378	490	608	820
August	416	497	635	740	978
September	375	441	536	927	1015
October	406	477	742	1053	1508
November	403	471	724	847	895
December	389	638	893	1144	1337
Annual	4691	5538	8557	12112	15927

TABLE 5-3
MEAN MONTHLY AND ANNUAL STREAMFLOWS IN ACRE-FEET

Number	Description	Years	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
09404450	East Fork Virgin River near Glendale	1967-90	879	969	1075	1082	1113	1502	2385	2064	973	784	764	705	14295
09405200	Deep Creek near Cedar City	1987-90	83	102	93	84	83	169	260	216	103	60	73	51	1377
09405250	East Fork Deep Creek near Cedar City	1987-90	143	221	169	167	150	247	467	372	153	73	77	65	2303
09405300	Crystal Creek near Cedar City	1957-61	71	76	68	77	68	112	663	3044	671	115	122	146	5233
09405400	North Fork Virgin River near Glendale	1973-78	255	257	219	181	187	283	350	558	544	352	287	240	3712
09405420	North Fork Virgin River below Bulloch Canyon near Glendale	1975-84	794	773	769	801	1046	1384	2139	2479	1433	1007	942	739	14306
09405450	North Fork Virgin River above Zion Narrows near Glendale	1979-84	1001	1000	1022	1005	1391	1758	2938	3440	1805	1192	1177	818	18546
09405499	Springdale Canal near Springdale	1969-88	409	299	275	291	216	276	471	531	575	522	476	471	4812
09405500	North Fork Virgin River near Springdale	1926-90	3492	3394	3677	3516	4175	5775	13593	18975	6728	3973	3857	3555	74712
09405900	North Creek near Virgin	1985-90	233	475	378	353	604	941	1097	246	64	155	178	115	4838
09406000	Virgin River at Virgin	1909-72 1979-90	8150	8797	10012	9962	10565	15221	23326	26773	9458	7603	8692	8510	145710
09406150	La Verkin Creek near La Verkin	1985-90	405	456	414	463	630	1009	1442	732	379	245	428	216	6817
09406300	Kanarra Creek at Kanarraville	1960-82	141	130	138	146	136	189	403	831	341	201	197	155	3008
09406500	Ash Creek near New Harmony	1939-47	635	506	318	240	570	1275	1715	1414	174	69	127	171	7051
09406700	South Ash Creek below Mill Creek near Pintura	1967-82	135	133	251	223	273	546	929	1097	658	380	233	142	4998
09407000	Ash Creek above Toquerville	1985-90	4	87	56	18	166	251	454	208	37	11	76	7	1351
09407200	Ash Creek below West Field Ditch at Toquerville	1973-82	785	843	830	826	1439	2368	2931	3539	1641	1067	916	846	18030
09407201	Ash Creek below below Diversion Dam, at Toquerville	1973-82	833	852	858	864	1510	2370	2923	3561	1658	1061	912	841	17901

TABLE 5-3 (continued)

Number	Description	Years	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Ann
09407600	Ash Creek near Toquerville	1956-58	306	432	575	370	976	2074	4073	3209	574	491	308	360	9284
09407800	Ash Creek near La Verkin	1956-58	193	395	495	356	946	2042	3107	2707	307	263	119	316	11242
09408000	Leeds Creek near Leeds	1965-90	243	245	304	273	369	538	534	639	789	645	446	275	5300
09408150	Virgin River near Hurricane	1967-88	7562	9233	12914	13486	14114	20690	25625	32431	12365	7342	8211	7720	166107
09408175	St George-Washington Canal near Washington	1988-90	3656	3103	2451	1015	1623	2892	4295	4393	4147	4276	4493	4900	41245
09408195	Fort Pierce Wash near St George	1985-89	32	6	2	2	2	2	5	6	21	28	70	9	186
09408400	Santa Clara River near Pine Valley	1960-90	223	241	251	174	182	359	1022	2080	1479	615	354	231	7212
09408500	Santa Clara-Pinto Diversion near Pinto	1954-90	32	59	12	6	16	151	824	1101	381	11	23	0	2616
09409000	Santa Clara River near Central	1909-61	795	670	643	681	653	1149	1652	2790	1523	721	593	497	12207
09409500	Moody Wash near Veyo	1955-69	5	42	276	138	347	484	519	115	35	5	26	35	1903
09409880	Santa Clara River at Gunlock	1970-90	711	932	964	1037	2061	2633	2433	2731	1937	702	598	502	17241
09410000	Santa Clara River above Winsor Dam near Santa Clara	1943-71	780	933	1382	1081	1265	1906	2291	2014	1291	803	808	669	15224
09410100	Santa Clara River below Winsor Dam near Santa Clara	1972-90	231	405	242	807	1970	2661	2785	2552	2186	1087	942	682	16516
09410400	Santa Clara River near Santa Clara	1966-74	338	491	1568	1427	1208	1441	1980	2509	1910	725	739	723	15059
09413000	Santa Clara River at St George	1951-90	177	293	419	442	330	689	1031	553	249	228	476	189	5075
09413200	Virgin River near Bloomington	1978-90	7948	10795	11959	16365	18907	25116	28437	33957	12474	6271	7389	6071	185691
09413500	Virgin River near St George	1951-57	2831	6405	9280	10795	7940	9435	18280	14900	2045	4108	10535	1738	86896
09415000	Virgin River at Littlefield, AZ	1930-90	8990	11414	14047	14231	17566	21194	24402	25858	8063	6632	11486	8843	172726
09403600	Kanab Creek near Kanab, Utah	1979-90	775	682	847	832	1118	1647	1883	702	456	478	607	599	10625
09403780	Kanab Creek near Fredonia, AZ	1964-80	109	132	448	363	558	1027	1252	44	3	214	470	287	4907

Note: Streamflows were computed from summary values for the period of record.

TABLE 5-4
PEAK FLOWS FOR THE VIRGIN RIVER AT VIRGIN
1910-1971 AND 1979-1990

Water Year	Date	Discharge (cfs)	Water Year	Date	Discharge (cfs)
1910	01-01-10	2,770	1947	10-29-46	2,080
1911	09-10-11	10,600	1948	09-16-48	1,400
1912	07-31-12	5,100	1949	09-08-49	1,010
1913	10-27-12	12,000	1950	07-08-50	6,620
1914	07-10-14	2,500	1951	08-29-51	2,800
1915	09-03-15	4,360	1952	12-30-51	4,840
1916	07-26-16	4,350	1953	08-01-53	12,900
1917	10-06-16	2,610	1954	09-12-54	4,690
1918	03-12-18	5,100	1955	08-25-55	10,600
1919	09-03-19	1,240	1956	01-27-56	2,260
1920	08-19-20	11,000	1957	06-10-57	1,430
1921	08-22-21	12,650	1958	09-03-58	7,410
1922	08-31-22	3,400	1959	08-03-59	4,420
1923	07-22-23	5,100	1960	09-01-60	2,190
1924	09-10-24	3,100	1961	09-17-61	13,500
1925	08-25-25	1,660	1962	02-12-62	3,100
1926	10-05-25	2,770	1963	09-18-63	4,550
1927	09-13-27	4,300	1964	08-12-64	4,630
1928	10-31-27	2,600	1965	09-05-65	6,890
1929	07-31-29	4,200	1966	11-23-65	3,930
1930	08-04-30	3,000	1967	12-06-66	22,800
1931	11-17-30	3,550	1968	08-07-68	6,840
1932	02-09-32	9,000	1969	01-25-69	13,660
1933	09-08-33	2,350	1970	08-18-70	2,660
1934	07-28-34	1,550	1971	08-21-71	2,880
1935	04-08-35	1,760	1979	03-28-79	7,600
1936	07-31-36	6,300	1980	09-10-80	10,830
1937	05-08-37	1,920	1981	07-15-81	3,650
1938	03-03-38	13,500	1982	08-23-82	9,700
1939	09-06-39	10,000	1983	11-30-82	4,740
1940	09-17-40	4,370	1984	09-10-84	4,580
1941	05-06-41	2,980	1985	07-19-85	2,920
1942	10-13-42	3,150	1986	03-08-86	1,620
1943	03-09-43	920	1987	07-20-87	7,200
1944	05-12-44	1,070	1988	11-05-88	2,690
1945	05-03-45	840	1989	07-28-89	1,500
1946	08-12-46	1,700	1990	08-15-90	3,200

Note: Values are for water years.

TABLE 5-5
FLOOD FREQUENCY FOR THE VIRGIN RIVER NEAR VIRGIN
1910-1971 AND 1979-1990

Return Period	Probability[a]	Value (cfs)
2 Years	50	3898.2
5 Years	20	7306.3
10 Years	10	10145.6
25 Years	4	14396.3
50 Years	2	18048.2
100 Years	1	22109.1
200 Years	0.5	26642.9
500 Years	0.2	33376.5

[a]Computed by Log Normal Distribution

TABLE 5-6
PEAK FLOWS FOR KANAB CREEK NEAR KANAB
1960-1968 AND 1979-1990

Water Year	Date	Discharge (cfs)	Water Year	Date	Discharge (cfs)
1960	09-06-60	2100	1981	07-16-81	200
1961	09-08-61	3030	1982	09-14-82	327
1962	02-12-62	1400	1983	03-12-83	148
1963	08-31-63	1310	1984	09-20-84	1130
1964	08-12-64	600	1985	07-19-85	376
1965	03-13-65	640	1986	02-19-86	350
1966	08-02-66	360	1987	10-11-86	55
1967	12-06-66	1230	1988	08-01-88	511
1968	07-07-68	1300	1989	09-08-89	340
1979	03-28-79	190	1990	02-03-90	49
1980	04-06-80	1060			

FIGURE 5-6
Monthly Streamflow Probabilities.
Virgin River at Virgin

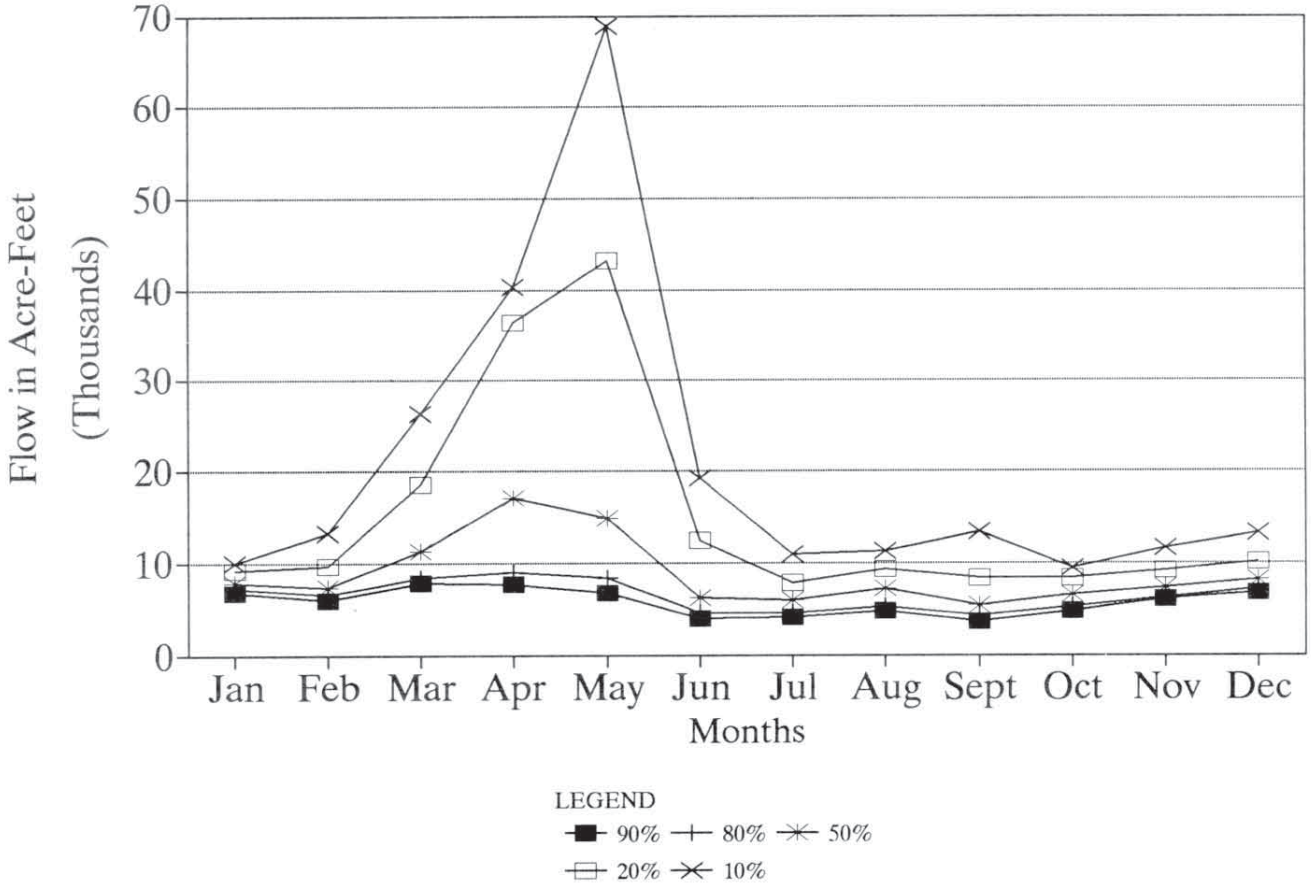


FIGURE 5-7
Monthly Streamflow Probabilities,
Kanab Creek Near Kanab

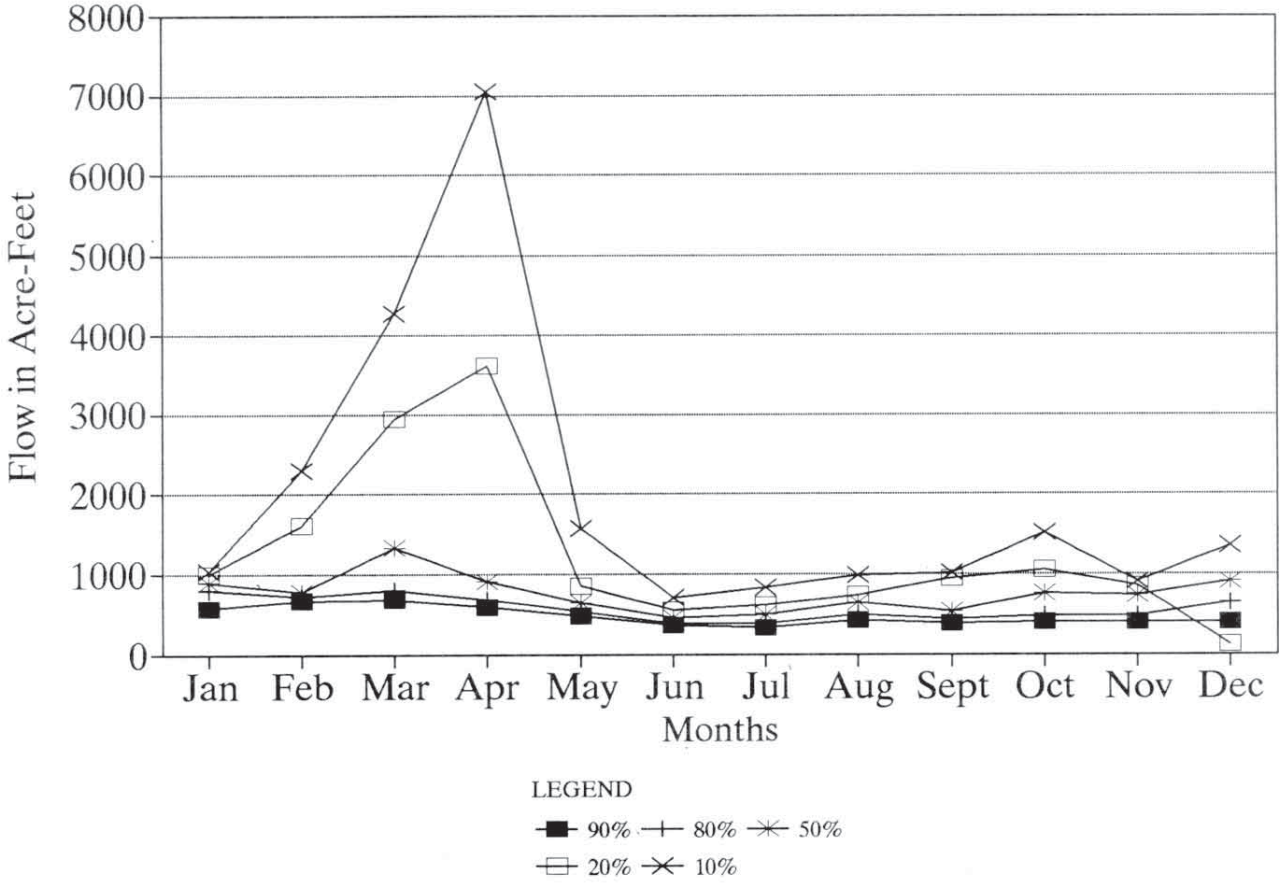


TABLE 5-7
FLOOD FREQUENCY FOR KANAB CREEK NEAR KANAB
1960-1968 AND 1979-1990

Return Period	Probability[a]	Value (cfs)
2 Years	50	541.2
5 Years	20	1271.0
10 Years	10	1889.4
25 Years	4	2778.7
50 Years	2	3498.1
100 Years	1	4250.6
200 Years	0.5	5024.6
500 Years	0.2	6082.2

[a]Computed by Log Pearson Type III Distribution

1961. The peak flows on Kanab Creek and the dates of occurrence are shown in Table 5-6 with flood frequencies shown in Table 5-7.

5.3.2. Groundwater Supply

A groundwater system is a storage reservoir. The amount of water in storage depends on both recharge and discharge. On the average, groundwater discharge must be limited to recharge. Discharging more water than is recharged over a long time will deplete the amount in storage. This will cause well water levels to drop and some springs and wells will begin to dry up.

Most of the springs receive their supply from deep percolation of precipitation that falls on adjacent higher areas within the local watershed. Many springs in the cliffs close to the topographic divide between the northward flowing Sevier River drainage and southward flowing lower Colorado River drainage probably are fed in part by water that falls on the higher Markagunt and Paunsaugunt plateaus to the north. In these areas, the surface drainage is tributary to the Sevier River. Movement of groundwater from a higher surface drainage area to a lower surface drainage is a natural phenomenon that can occur wherever the water table is high enough to intersect the land surface.

In western Kane County, the water table is high under the Markagunt and Paunsaugunt plateaus because both areas receive good quantities of precipitation, and both are underlain largely by the jointed and water-receptive Claron formation. Here also much of the spring water in the south-facing cliffs is derived by groundwater capture

from the natural surface drainage of the Sevier River to the north. A good example is Cascade Spring near Navajo Lake. The water supply to this spring comes from the topographic drainage of the Sevier River Basin. This source has been measured and is well documented.

Groundwater supplies come from unconsolidated and consolidated aquifers. Natural recharge to the groundwater in the Virgin River area and Kanab Creek is mostly by infiltration of precipitation as well as seepage from streams passing over recharge areas of the aquifer outcrops. Some recharge also occurs from subsurface inflow, mostly in areas east of the Hurricane Cliffs.

Withdrawal or discharge of groundwater is through wells used for public water supply, irrigation, domestic supply and stock watering. Besides this man-made discharge through wells, there is natural discharge through springs, drains, seepage into streams, evapotranspiration by plants and subsurface outflow from the basin. The long-term average annual groundwater discharge from the Virgin River is estimated to be the same as the average annual recharge value of 155,000 acre-feet.[3]

Groundwater discharge estimates for the central Virgin River basin have been made for two years.[5] These estimates are: 76,000 acre-feet, 1968; and 88,000 acre-feet, 1970. The average groundwater discharge for these two years is 82,000 acre-feet.

Estimated groundwater discharge for the upper Virgin River basin is 49,000 based on the year 1977.[4] Figure 5-8 shows the central and upper Virgin River, the Hurricane fault and the upper Kanab Creek and Johnson Wash area.

The discharge of groundwater for 1977 in the Kanab Creek and Johnson Wash drainages is estimated at 22,000 acre-feet annually.[4] About 5,000 acre-feet of this is subsurface outflow into Arizona.

Existing wells are good indicators of extent, location and amount of groundwater development. There are over 750 wells in the Kanab Creek/Virgin River Basin developed for various uses. Since most wells are developed as near as possible to the point of use, their location tends to indicate where groundwater is used. The exception is where some municipal wells are located at a distance from the actual place of use of the water. Most of the growth in irrigation well development occurred after 1950. See Section 19 for more discussion on groundwater.

5.4 Water Resouces 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.

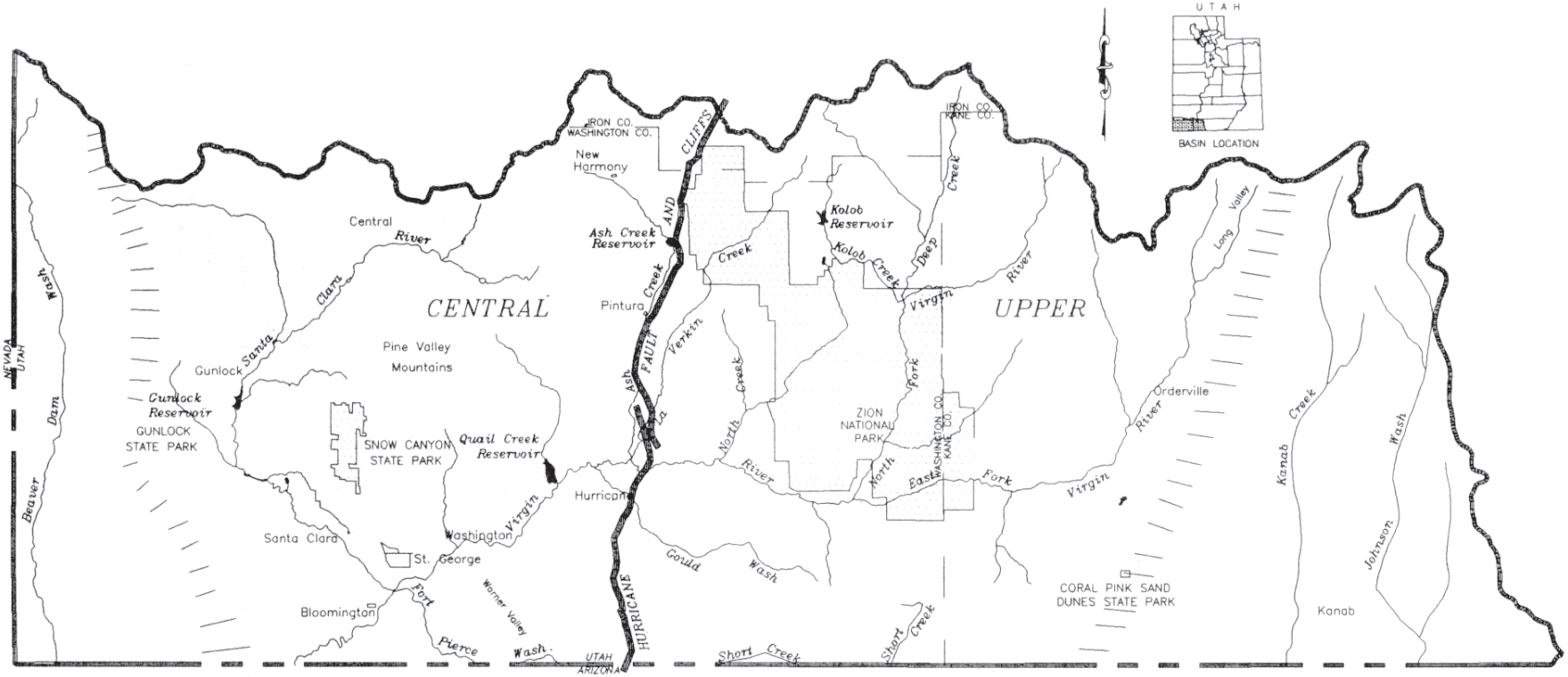
5.4.1 Water Use Terms

Water is used in a variety of ways and for many purposes. 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.

Cropland Irrigation Use - Water used for irrigation of cropland as identified in the "Water-Related Land Use Inventory of the Kanab Creek/Virgin River Basin" (see Table 10-3). Residential lawn and garden uses are not included.

Residential Use - Water use associated with residential cooking; drinking water;

FIGURE 5-8
Groundwater Study Area



Note: Hash marks indicate the groundwater areas discussed.
The Hurricane fault is the dividing line.

washing clothes; miscellaneous cleaning; personal grooming and sanitation; irrigation of lawns, gardens and landscapes and washing automobiles, driveways and other outside facilities.

Commercial Use - Uses normally associated with small business operations which may include drinking water, food preparation, personal sanitation, facility cleaning and maintenance and irrigation of facility landscapes.

Municipal 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, play grounds, recreational areas and other facilities. This term is commonly used to include residential, commercial and municipal uses.

Industrial Use - Use associated with the manufacturing or assembly of products which may include the same basic uses as commercial business. However, the volume of water used by industrial businesses can be considerably greater than water used by commercial businesses.

Municipal and Industrial (M&I) Use - This term is commonly used to include residential, commercial, municipal and industrial uses. It is sometimes used interchangeably with the term "public water use."

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.

Diversion - Water diverted from supply sources such as streams, lakes, reservoirs or groundwater for a variety of uses including cropland irrigation, residential, commercial, municipal and industrial. The terms diversion and withdrawal are often used interchangeably.

Withdrawal - Water withdrawn from supply sources such as lakes, streams, reservoirs or groundwater. This term is normally used in association with groundwater withdrawal.

Depletion - Water lost or made unavailable for return to a given designated area, river system or basin. It is intended to represent the net loss to a system. The terms consumption and depletion are often used interchangeably but are not the same. For example, water exported from a basin is a depletion to the basin system, but is not consumed in the basin. Therefore the exported water is available for use in another system.

Consumption - Water evaporated, transpired or irreversibly bound in either a physical, chemical or biological process.

Consumptive Use - Consumption of water brought about by human endeavors, i.e. use of water for residential, commercial, municipal, industrial, agricultural, power generation, recreation, fish and wildlife and other purposes along with the associated losses incidental to these uses.

5.4.2 Water Supply Terms

Water is supplied by a variety of systems for many users. Most water supply systems are owned by a municipality, but in some cases the owner/operator is a private company, or is a state or federal agency. Thus, a "public" water supply may be either publicly or privately owned. Also, systems may supply treated or untreated water.

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, municipal and industrial purposes, including irrigation of publicly and privately owned open areas.

Culinary Water Supply - Water meeting all applicable safe drinking water requirements for residential, commercial and municipal uses.

Municipal Water Supply - A supply that provides culinary water for residential, commercial, municipal and light industrial uses. The terms municipal, community and city are often used interchangeably.

Secondary Water Supply - Pressurized or open ditch water supply systems that supply untreated water for irrigation of privately and publicly owned lawns, gardens, parks, cemeteries, golf courses and other open areas. These systems, sometimes called "dual" water systems, are installed to provide a water supply in addition to the culinary supply.

5.4.3 Other Water Terms

Some water terms, peculiar to the water industry, are briefly defined in order to better understand the information presented.

Open Water Areas - Include lakes, ponds, reservoirs, streams and areas inundated or partially inundated adjacent to open water areas.

Carriage Water - Water needed for the hydraulic operation of a delivery system is referred to as carriage water.

Drinking Water - Water that is used or available for use as a culinary supply. The quality is typically the highest available in the locality.

Instream Flow - Water flow that is maintained in a stream for the purpose of preservation and propagation of fish.

Wetland and Riparian Areas - Land areas adjacent to rivers, streams, springs, bogs, lakes and ponds. These are ecosystems composed of plant and animal species highly dependent on water.

Export Water - Water leaving a river system or basin other than by the natural outflow in streams, rivers and groundwater.

5.5 Water Use

Water is used for municipal and industrial (M&I) use, agricultural purposes, wetlands and riparian areas, instream flows and for livestock watering. Agricultural water is primarily diverted from surface water sources. The majority comes from the Virgin and Santa Clara rivers. Groundwater is also used for irrigation, but to a much lesser degree than surface water. Water used for livestock watering facilities are generally small wells around ranches and in rangeland areas along with some surface water use.

Historically, groundwater has supplied most of the M&I water for a rapidly expanding population because treatment is usually not needed. In the past, about two-thirds of the groundwater came from wells and one-third from springs.

The diversion and use of water requires a water right (See Section 7.5, Water Rights Regulation). Water is also non-consumptively used for instream flows and power generation.

5.5.1 Municipal and Industrial Water Use

Municipal and industrial (M&I) water use, also called public use, refers to culinary quality supplies primarily used in homes, businesses and industry. It also includes culinary water used to irrigate lawns and gardens. Since a heavy industrial base does

not exist in the basin, population is the main factor controlling the M&I water demand.

Surface water supplies are brought up to culinary standards in treatment plants. The town of Virgin has a small plant that treats North Creek water. During 1992, nearly 15.2 million gallons (46.6 acre-feet) were treated by this plant. The St. George water treatment plant, completed in 1989, treats Virgin River water. Over 976.8 million gallons (3,006 acre-feet) were treated in 1991. There is also a small treatment plant serving Springdale and Zion National Park. This plant is being updated to treat 14.1 million gallons (43.1 acre-feet) annually.

Daily water use per capita (GPCD) can vary substantially depending on how much culinary water is used to irrigate lawns and gardens, parks, golf courses and other outdoor facilities. Another factor in the basin municipal water use is the mobile tourist and part-time resident population. This use varies considerably on any given day, week or other time period.

Much of the basin is located where temperatures are generally 10°F to 15°F warmer than the rest of the state. Due in part to this fact, some areas of the basin have experienced rapid population growth as a recreation and retirement location during the last 15 to 20 years (Refer to Section 4, Demographics and Economic Future, for population data). The percentage of M&I water use compared to total use is expected to increase.

The per capita use for each city is calculated by using current annual public water supply diversions reported to the Utah Division of Water Rights, and dividing by 365. This gives the average water use in each city per day. This result is then divided by the 1990 census population to give daily use per capita. Each city's use is taken into account in calculating a basin average. The results are shown in Table 5-8.

For comparison, the average per capita use for the state is also shown. As can be seen, the per capita use is highly variable. Much of the variability between cities can be attributed to how much culinary water is used to irrigate lawns and gardens. This is partly because of the difference in lifestyles between rural agricultural areas such as Glendale and retirement communities such as St. George.

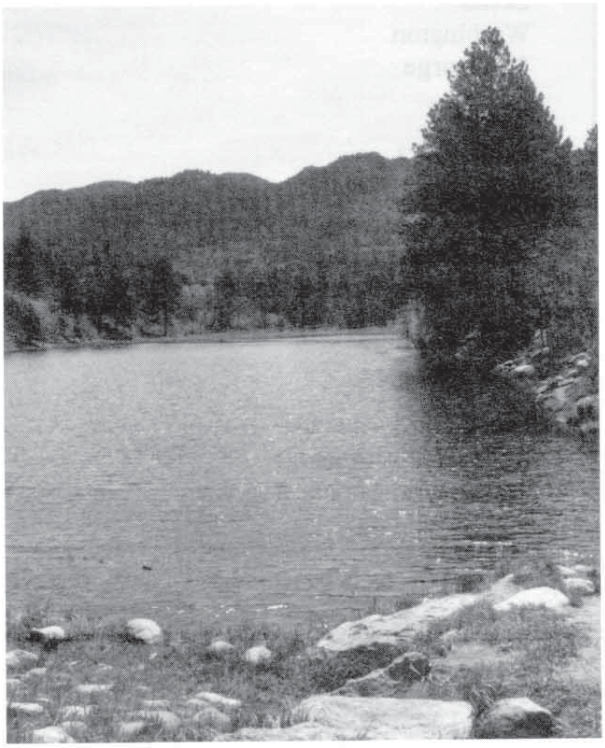


TABLE 5-8
CULINARY WATER DIVERTED PER CAPITA DAY

City	Population (1990)	Per Capita (gallons)
Alton	93	176
Kanab	3,289	359
Glendale	282	152
Orderville	422	211
Springdale	275	361
Rockville	182	199
Virgin	229	147
Kanarraville	228	337
New Harmony	101	381
Toquerville	488	158
La Verkin	1,771	245
Hurricane	3,915	366
Leeds	254	371
Washington	4,198	389
St. George	28,502	374
Ivins	1,630	197
Santa Clara	2,322	314
Hildale	1,325	153
Kane County Unicorp,	757	199
Washington County Unicorp.	2,209	364
Basin Average		347
State average		284
Iron County Average		337
Kane County Average		321
Washington County Average		350

Note: Does not include secondary (dual) systems.

Even in communities like St. George, water use varies at different times of the year. This is partly because of part-time residents and the fluctuating motel occupancy rate. Also, a mean annual July temperature variation of nearly 20°F. from the cooler to

TABLE 5-9
ESTIMATED CURRENT CULINARY WATER USE

County	Diversions[a] (acre-feet)	Depletions (acre-feet)
Washington	18,570	9,660
Iron	90	50
Kane	1,670	870
Basin Total	20,330	10,580

[a]Includes only treated water use supplied by municipal systems.

hotter areas effects water use. Diversions and depletions for current culinary water use are summarized by county in Table 5-9. Diversions are from the Division of Water Rights Reports on public water suppliers.[19] Depletions are calculated as a percentage of the water diverted which does not return to the river system.

There are seven hydroelectric power plants in the basin. There is one near Gunlock, two near Veyo on the Santa Clara River and one each on La Verkin Creek and Cottonwood Creek. Two plants are part of the Quail Creek project (See Section 18).

5.5.2 Secondary Systems Water Use

Water from secondary systems (also called dual systems) is used in municipal areas to irrigate various landscapes such as lawns, gardens, parks, cemeteries and golf courses. The systems supply untreated water and may be owned and operated by municipalities, irrigation companies, special service districts and other entities. Most of the golf courses and many parks in the St. George area use water from secondary systems. Estimates of current diversions and depletions are summarized in Table 5-10.

5.5.3 Agricultural Water Use

The majority of the agricultural water is diverted from the Virgin and Santa Clara rivers, Kanab Creek, Johnson Wash and their tributaries. Groundwater is usually used as supplemental irrigation water and only makes up about 10 percent of the total agricultural diversions.

Surface irrigation water is obtained from direct flows in the rivers and streams and also from storage reservoirs. The areas with only direct flow rights often experience water shortages in the summer during times of low flows. Those areas where storage water is available are usually better off but also experience shortages in dry years.

Water quality effects the water requirements for agricultural crops. For data on water quality, refer to Sections 10 and 12.

Storage reservoirs make it possible to store water during high flows and have it available in times of low flows. Without storage reservoirs, this water would not be available for irrigation. Table 5-11 shows

TABLE 5-10
ESTIMATED CURRENT SECONDARY WATER USE

County	Diversions (acre-feet)	Depletions (acre-feet)
Washington	14,710	10,300
Iron	0	0
Kane	1,250	820
Basin Total	15,960	11,120

TABLE 5-11
EXISTING IRRIGATION WATER STORAGE RESERVOIRS[16]

Name	Stream	Location (S. Tp. R.)	Capacity (acre-feet)
Ash Creek	Ash Creek	7 39S 12W	3,175
Baker	Santa Clara	22 39S 16W	1,160
Gubler(Harris)	Reservoir Wash	4 38S 12W	31
Gunlock	Santa Clara	5 41S 17W	10,884
Ivins(offstream)	Santa Clara	36 41S 17W	475
Johnson Lake	Johnson Lake Canyon	5 43S 4½W	30
Kolob	Kolob Creek	36 38S 11W	5,586
McDonald Lake	E.F. Virgin	16 39S 6W	75
Quail Creek	Quail Creek[a]	36 41S 14W	40,325
South Creek	South Creek	9 42S 10W	1,580
Stratton	Virgin River (off-stream)	36 41S 14W	135
Total			64,027

[a]Primary inflow diverted from Virgin River.

the reservoirs with capacities greater than 30 acre-feet. The reservoirs in the table may also be used for other purposes. Quail Creek Reservoir, for example, provides municipal and industrial water for St. George, but also recreation as well as irrigation water.

Land use surveys were completed in the Kanab Creek/Virgin River Basin in 1991.[18] Most of the irrigated lands are near the Virgin River, North and East forks of the Virgin River, Santa Clara River, Kanab Creek and Johnson Wash. The areas of irrigated land, diversions and depletions are shown in Table 5-12. See Section 10 for more data.

TABLE 5-12
ESTIMATED CURRENT IRRIGATION WATER USE[15]

County	Area[a] (acres)	Diversion (acre-feet)	Depletions (acre-feet)
Washington	16,680	87,800	39,320
Iron	1,520	7,860	1,490
Kane	7,400	27,640	10,490
Total	25,600	123,300	51,300

[a]Includes idle cropland

Where records are available, water diverted is obtained from the Division of Water Rights or the irrigation companies. Diversion records are available for 13 of the 35 irrigation companies. A period of field monitoring would be required to obtain diversion data for those companies not keeping records.

5.5.4 Wetland and Riparian Water Use

Riparian areas are directly influenced by the availability of water. These areas include land and vegetation adjacent to rivers, streams, springs, bogs, wet meadows, lakes and ponds. Riparian areas display a great diversity of vegetation and wildlife species. In general, over 80 percent of the overall wildlife diversity is associated with riparian areas, although this zone accounts for less than five percent of the total land mass. Typical riparian vegetation consists of cottonwood trees, willows, salt cedar, arrowhead and seepwillow; grasslike plants such as rushes and sedges and aquatics such as watercress and cattails.

Good riparian habitat is important to support the fisheries and wildlife resources. The character and quality of the riparian zone will directly impact the fisheries resources in several ways. The riparian vegetation moderates the thermal input of the sun. The water temperature dictates species composition, population size and available nutrients. Riparian vegetation provides the majority of biomass input for an aquatic environment. For further information regarding wildlife, see Section 14.

The Virgin River, Santa Clara River and West Fork of the Beaver Dam Wash are all important habitat for migrating bald eagles,

waterfowl and other raptors during the winter months. These areas are also important as year-long habitat for a wide variety of other wildlife species. The Virgin River from Shinob Kibe to La Verkin Springs and from the City of Virgin through Zion National Park are important for nesting and year-round peregrine falcon habitation. Riparian vegetation is found along the North and the East forks of the Virgin River, the Santa Clara River, Ft. Pierce Wash and the West Fork of Beaver Dam Wash as well as several smaller perennial streams. This provides habitat for amphibians and mammals.

5.5.5 Instream Flow Requirements

Instream flows are one form of use where water is not depleted. Water for instream flows is required in the reach of the Virgin River from the Quail Creek Reservoir diversion to the St. George and Washington Canal diversion for the protection of endangered species. This instream flow requirement is tied to the operation of Quail Creek Reservoir, and states that the lessor of either 86 cfs or the natural flow must be in the river during all months of the year. This was one of the requirements set forth by the U.S. Fish and Wildlife Service (USFWS) when the Quail Creek Project was built. The flow of 86 cfs is the water right for St. George and Washington Fields Canal Company at their diversion below Quail Creek Reservoir.

5.6 Interbasin Diversions

There is only one interbasin diversion of surface water in the basin. This is the diversion from the Santa Clara River (Grass Valley Creek) into Pinto Creek in the Cedar/Beaver River Basin (Stream gage 09408500). This diversion has historically averaged about 2,600 acre-feet annually. Groundwater inflow from the Sevier River Basin into the Kanab Creek/Virgin River Basin has been estimated at 16,500 acre-feet annually in a study of the water and related land resources of the Sevier River Basin.[11,12]

5.7 Water Quality

Streams in the Kanab Creek/Virgin River Basin flow from areas that are considerably different from each other in geology, land use, vegetation, altitude and climate. Water quality is measurably affected by these differences. Mineralized solutions are determined by rock and soil composition, climate, biological effects of plants and animals and water management and use as the water flows downstream.

Outcropping geologic formations affecting water quality include fine-grained clastic and carbonate rocks of Mesozoic age. Much of the water quality problems are the result of erosion. Natural erosion levels are high because of low vegetative densities, steep gradients and unstable substrates. Erosion contributes to increased salinity and to a higher concentration of trace elements.

The water quality problems are caused by point discharges as well as natural and non-point sources. The water quality in the mountain areas is good compared to the lower elevation stream reaches. Refer to Section 12, Water Pollution Control, for more detailed data. ■

5.8 References

1. Bingham Engineering. *Navajo Aquifer Investigation in Portions of Kane and Garfield Counties, Utah.* Alton Coal Project, Utah International, Inc., Salt Lake City, Utah, 1987.

2. Clyde, Calvin G. *Groundwater Development and Potential of the Beaver Dam Wash Aquifers.* Prepared for the City of St. George, 1990.

3. Ibid. *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Logan, Utah, 1987.

4. Cordova, R.M. *Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basin Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70 prepared by the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

5. Cordova, R.M., G.W. Sandberg, and Wilson McConkie. *Ground-Water Conditions in the Central Virgin River Basin, Utah.* Technical Publication No. 40, prepared by the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1972.

6. Goode, Harry D. *Reconnaissance of Water Resources of a Part of Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 5, Salt lake City, Utah, 1964.

7. Ibid. *Second Reconnaissance of Water Resources in Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 8, Salt Lake City, Utah, 1966.

8. Hardy, Thomas B., Brent Bartz, and Wendy Carter. *Population Dynamics of the Fishes in the Virgin River from 1984 through 1987 and Impact Analysis of the Quail Creek and North Creek Reservoir System.* Utah State University, Logan, Utah, 1989.

9. Leslie and Associates. *Hydrological Study of Beaver Dam Wash Aquifers in Mohave County, Arizona.* Cedar City, Utah, 1990.

10. U. S. Department of Agriculture in cooperation with the Utah Department of Natural Resources and U.S. Department of Interior. *Water and Related Land Resources, Beaver River Basin, Utah-Nevada.* Salt Lake City, Utah, 1973.

11. U. S. Department of Agriculture in cooperation with the Utah Department of Natural Resources. *Water and Related Land Resources, Sevier River Basin, Utah.* Salt Lake City, Utah, 1969.

12. Ibid. *Water Supply - Sevier River Basin, Utah.* Appendix II. Salt Lake City, Utah, 1991.

13. U. S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study.* Salt Lake City, Utah, 1990.

14. Utah Division of Water Resources. *A Water-Related Land Use Inventory Report of the Virgin River Area.* Salt Lake City, Utah, 1990.

15. Ibid. *Hydrologic Inventory of the Virgin and Kanab Study Units.* Salt Lake City, Utah, 1983.

16. Ibid. *Inventory of Reservoirs and Potential Damsites in the Virgin River Basin.* Salt Lake City, Utah, 1988.

17. Ibid. *Municipal and Industrial Water Diversion and Depletion for the Virgin River and Kanab Creek Drainage Basins.* Salt Lake City, Utah, (In preparation).

18. Ibid. *Water Related Land Use Inventory of the Kanab Creek/Virgin River Basin.* Salt Lake City, Utah, 1993.

19. Utah Division of Water Rights. *Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah.* Reports 1-8, 1960-89 and 1990-91 (unpublished). Salt Lake City, Utah.

20. Utah Energy Office. *A Survey of Small Hydroelectric Potential at Existing Sites in Utah.* Salt Lake City, Utah, 1980.

Section 6 Management

6 Management

6.1 Introduction

This section describes the management of water resources in the basin. Many entities have rights to use and regulate the available water. Demands for water are changing. As new users compete for water, conflicts may arise.

Management of the Kanab Creek/Virgin River Basin water resources is one of the primary concerns of the local water providers and users. This is particularly true because the area is subject to frequent periods of drought. The increasing demand for water further complicates the situation.

6.2 Setting

The Paiute Indians developed the first water in the area to irrigate crops along the Santa Clara River. Another band of Indians, the Kaibabits, also cultivated crops in the Kanab Creek and Johnson Wash areas.

The first white settlers diverted water in 1855 to raise crops. Continued attempts to establish and maintain irrigation were plagued by floods and other problems.

Since these early efforts, more permanent structures have been installed to develop the water resources for the benefit of the local water users. These include diversion structures, storage reservoirs and delivery systems for irrigation. Systems have also been developed to supply water for domestic, municipal and industrial use. The available water supply is now administered according to state water law by the various entities with rights to use and distribute this resource. These entities include mutual irrigation companies, municipalities, water conservancy districts and individuals.

6.3 Policy Issues and Recommendations

Two policy issues discussed to help improve the management of water resources are a Virgin River minimum flow requirement and water storage reservoirs.

6.3.1 Virgin River Flow Requirements

Issue - Instream flow requirements below La Verkin Springs for protection of the endangered woundfin minnow and Virgin River roundtail chub are competing with future water development alternatives and increasing management problems. Requirements for instream flow need to be resolved.

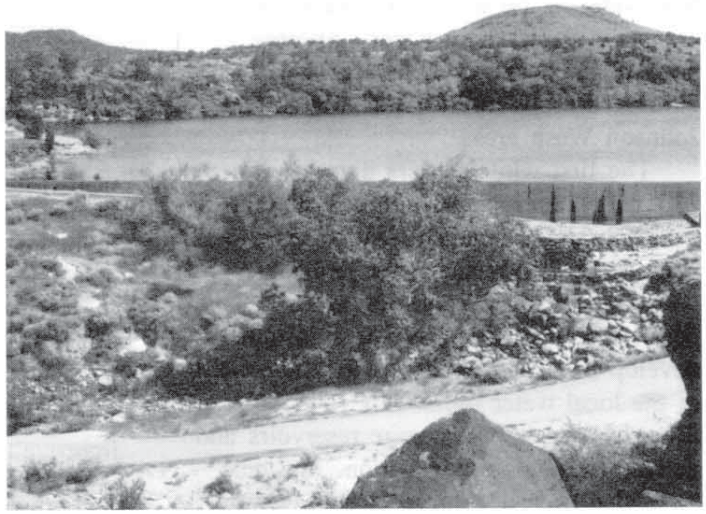
Discussion - There are reaches below diversions in the Virgin River where instream flows are not required. The only current instream flow requirement in the Virgin River is tied to the construction and operation of Quail Creek Reservoir. This requirement states the lessor of either 86 cfs or the natural flow must be in the river below Quail Creek Reservoir down to the St. George and Washington Canal diversion during all months of the year. This is one of the requirements set forth by the U.S. Fish and Wildlife Service (USFWS) to protect the endangered woundfin minnow when the Quail Creek Project was built until studies were made to determine the minimum flow. The 86 cfs was based on the water right at the St. George and Washington Canal Company diversion below Quail Creek Reservoir, not on a minimum flow determination.

Experts disagree about flows required for the protection of the woundfin minnow. Over the years, minimum required flow recommendations have ranged from 30 to 110 cfs. A recent five-year study sponsored by the Washington County Water Conservancy District suggests a minimum of 50 cfs during the winter months and 86 cfs during the irrigation season will adequately protect the woundfin minnow. Additional data may be needed to make a final determination.

Recommendation - The Washington County Water Conservancy District, in conjunction with the Utah Department of Natural Resources and the U. S. Department of Interior, should initiate negotiations or additional studies to resolve the quantity of flow required to allow recovery of the endangered fish.

6.3.2 Storage Reservoirs for Management

Issue - Surface water storage reservoirs can provide dependable water supplies for use during the time of need. Reservoirs can also reduce peak flood flows and trap sediment. Some people maintain that flooding and low flows are needed to preserve the pristine habitat.



Discussion - Water storage is needed to meet the increasing municipal and industrial demands of a fast-growing population. Winter flows and snowmelt runoff can be captured and saved for use when natural streamflows are inadequate to supply all the needs. Instream flows can be enhanced in designated river sections by timing the release from reservoirs to meet consumptive and non-consumptive needs. Riparian vegetation can be improved by preventing destruction from high flood flows. Even with some reservoir construction, flood flows will still carry sediment. This will maintain a semblance of historic flow regimes and still provide development opportunities to meet future demands.

Recommendation - Several potential storage reservoir sites are located on the tributary streams of the Virgin River and on Kanab Creek and Johnson Wash. The Division of Water Resources should continue to assist local entities in their investigation to identify water storage projects that are feasible.

6.4 Irrigation Systems

Incorporated mutual irrigation companies serve the majority of the irrigated land in the basin. Private irrigation systems serve about one-third of the irrigated area. Thirty-three irrigation companies are in the Virgin River drainage and two in the Kanab Creek drainage. These irrigation companies and systems are responsible for managing nearly 70 percent of the total water supply. Table 6-1 lists these irrigation companies and the areas they serve.

6.5 Municipal and Industrial Systems

The basin has 78 drinking water systems. Thirty-five are classified as "Public Community" suppliers. All of the systems use groundwater as their sole supply source, except Virgin, St. George and Springdale. These three cities treat surface water as well as use groundwater from springs and wells. The major public water suppliers are listed in Table 5-8 along with the per capita day use.

Some light industries use minor amounts of water that are delivered through the public water supply systems. Heavy industries have not been established in the basin. There are, however, two mining operations; one is located in the Beaver Dam Wash drainage and the other is in the Santa Clara River drainage. These operations use self-supplied water (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.

6.6 Problems and Needs

One of the biggest problems is delivering the water needed to the right place at the right time. Another problem is providing water for all needs and uses.

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 fill with sediment, reducing conservation pools and active storage capacity. Eventually, replacement capacity may be

TABLE 6-1
IRRIGATION COMPANIES[1]

Central Virgin River	Acres Served
Bench Lake	1,100
High Line Ditch	60
Hurricane Canal	1,220
Kanarraville	990
La Verkin Bench and Canal	270
Lee - Spendlove	110
Leeds Water Company	280
New Harmony Reservoir and Irrigation	90
Pintura	120
South Fields	30
St. George and Washington Canal	3,410
St. George and Washington Canal & Wells	360
St. George Valley	330
Tanner Ditch	130
Toquerville	260
Virgin Canal	120
Virgin	80
Total	8,960
East Fork Virgin River	
Glendale	400
Mt. Carmel	380
Orderville	240
Muddy	170
Total	1,190

TABLE 6-1 (continued)
IRRIGATION COMPANIES

North Fork Virgin River	Acres Served
Hall-Grafton	170
Rockville	60
Springdale	120
Total	350
Santa Clara River	
Bloomington Canal	200
Central Canal and Irrigation	620
Gunlock	190
Ivins	560
New Santa Clara Fields	330
Pine Valley	590
St. George - Clara Fields Canal, Seep Ditch	690
Town Ditch	50
Veyo	400
Total	3,630
Kanab Creek	
Alton Farmers Association	580
Kanab	1,500
Total	2,080
Private Irrigation Systems	9,390
Total	25,600

needed. Dredging existing reservoirs is expensive and can be environmentally offensive. New reservoirs may be required.

6.6.1 Irrigation Companies

Irrigation companies have experienced many problems over the years with diversion facilities and delivery systems. From the days of early settlement, floods have been a particular problem, often washing out diversion structures two or three times a year. Canals and ditches still wash out occasionally. In some smaller systems, seepage rates may reduce deliveries to less than half of the water diverted. Delivery system efficiencies for selected systems are shown in Table 6-2.

Considerable improvement has been made over the years in delivery systems and onfarm application, but additional work is needed to improve water use. This is especially true as increased demands for water accelerate. Most of the irrigation companies shown in Table 6-2 with a delivery efficiency over 90 percent have an improved system such as a lined-canal or pipeline. Remaining systems need to be upgraded where it is economically and technically feasible.

Most of the major irrigation company diversion structures are in good condition. Some need better maintenance to avoid more costly repairs or replacement later. Some structures could be improved with minor construction or renovation.

In general, irrigation water needs exceed the supply. In areas where agricultural land is converted to residential development, the irrigation water could become available for other uses.

Even if considerable progress is made toward improving irrigation systems, there will not be enough water to meet the agriculture needs. This accents the need for wise management and conservation of water used by the agricultural industry.

Improved onfarm water application efficiencies are needed in some areas. Improvements could reduce required diversions or reduce late season shortages. Much has been done to increase onfarm efficiencies of water use, including implementing best management practices. Refer to Section 17.2 for additional water savings information.

6.6.2 Municipal and Industrial Water Concerns

Two concerns regarding municipal and industrial water are water quantity and water quality. Most public water suppliers have adequate quantities of water to meet current needs, except during extended periods of extreme drought. Suppliers using groundwater from wells generally have good quality water.

Municipal and industrial water for future demands could be developed by using surface water flows or groundwater. Developing additional wells could increase the use of groundwater in some areas, particularly where the Navajo sandstone aquifer exists at feasible depths. Monitoring of groundwater storage would be imperative to prevent mining or infringement on other rights. Additional surface water could be developed or converted from agricultural uses and treated in conventional water treatment plants. Protection of aquifer recharge zones and conservation and wise water use would also be beneficial to maintain quality and stretch existing supplies.

TABLE 6-2
IRRIGATION DELIVERY EFFICIENCIES[1]

Irrigation Companies	Efficiency (percent)
Bench Lake Canal	70
Hurricane Canal	70
St. George and Washington Canal	70
La Verkin Bench Canal	97
Virgin	88
Glendale	90
Mt. Carmel	50
Orderville	75
Bloomington	90
Central Canal	96
Gunlock	96
Ivins	94
New Santa Clara Fields	75
Pine Valley Irrigation	85
St. George/Clara Fields	95
Veyo Irrigation	96
Kanab	80

6.7 Colorado River Salinity Control Program

Congress enacted the Colorado River Basin Salinity Control Act in 1974, (Public Law 93-320). This act directed the Secretary of the Interior to enhance and protect the quality of water available in the Colorado River system for use in the U.S. and the Republic of Mexico. Public Law 96-375 further authorized the Bureau of Reclamation to conduct a feasibility study of the Lower Virgin River unit. Later amendments to the act (Public Law 98-569) gave the Secretary of Agriculture the authority to identify other areas with salt loading resulting from irrigation and watershed practices, and to develop and implement practices to reduce salt loading.

The planning report on the La Verkin Springs salinity control unit (authorized by the 1974 act) was completed in December 1981. Although a salinity control project based on membrane desalting and solar evaporation ponds was technically and environmentally feasible, the Bureau of Reclamation concluded efforts to remove salt contributed by La Verkin Springs would not be cost effective, and might well be negated by the hydrogeology of Virgin River canyon. Alternative methods of brine disposal were examined later and determined to be economically infeasible.

Studies for the Allen-Warner Valley Energy System were carried out to determine the feasibility of using water in the Kanab Creek drainage to slurry coal in a pipeline from the Alton coal fields to southern Utah and Nevada. Studies were terminated because of uncertainties associated with scheduling construction of a proposed power plant near Las Vegas. The Bureau of Reclamation is presently working with the Las Vegas Valley Water District on a feasibility study of a 70,000 acre-foot joint salinity control/water supply project on the lower Virgin River. The study is scheduled for completion in 1995.

The U.S. Department of Agriculture has investigated the potential for agricultural-related salinity control in the lower Virgin River Basin. The department released a draft environmental impact statement in July 1992 on the Moapa Valley Unit in Nevada. Preliminary estimates indicate good cost-effectiveness. ■

6.8 References

1. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study*. Salt Lake City, Utah, 1990.

2. Utah Division of Water Resources. *Hydrologic Inventory of the Virgin and Kanab Study Units*. Salt Lake City, Utah, 1983.

3. Utah Division of Water Rights. *Water Companies in Utah*. Salt Lake City, Utah, 1990.

4. Ibid. *Water Use Data For Public Water Supplies and Self-Supplied Industry in Utah*. Reports 1-8. Salt Lake City, Utah, 1960-1989. (Also 1990-1991 unpublished).

Section 7 Regulation/Institutional Considerations

7 Regulation/ Institutional Considerations

Regulation of water resources use is necessary to manage conflicts and to provide for orderly future planning and development. This includes consideration of water rights, water quality and environmental concerns.

7.1 Introduction

This section discusses the various entities responsible for water regulation in the Kanab Creek/Virgin River Basin. It also discusses the major related problems and issues.

Two state agencies are primarily responsible for water regulation. They are the Division of Water Rights and the Department of Environmental Quality. The Division of Water Rights, under the direction of the State Engineer, regulates water allocation and distribution according to state water law. Water quality is regulated at the state level by the Department of Environmental Quality through two agencies, the Division of Water Quality and the Division of Drinking Water. These agencies operate in accordance with the Utah Water Quality Act and the Utah Safe Drinking Water Act. Water quality is also regulated by provisions of various federal acts. The Division of Water Resources regulates the cloud seeding program (See Section 9 for details).

The functions of these agencies are described in the *State Water Plan,* Sections 7, Regulation/Institutional Considerations; 11, Drinking Water Supplies Development and Management and 12, Water Pollution Control.[9]

7.2 Setting

Water regulation is generally performed under the direction of state agencies. Local public and private institutions and entities usually manage and operate the water systems at the basin level.

7.2.1 Regulation

Water distribution is based on the doctrine of prior appropriation under Utah water law. Water law is administered by the State Engineer who has a representative, the regional engineer, located in Cedar City, Utah.

The court order mandating the adjudication of the water rights in the Virgin River Basin was signed on April 18, 1980. Since that time, mapping of the area for water use is nearly complete and thousands of water user's claims have been taken. The Proposed Determination of Water Rights for the Santa Clara River-Beaver Dam Wash Division, Area 81, Book No.1, was distributed in the summer of 1989. A similar document for the East Fork Virgin River Division, Area 81, Book No. 2, was distributed in 1992. The Proposed Determination of Water Rights for the Kanab Creek and Johnson Creek Division, Code No.85, Book No. 1, was distributed in 1974. The Utah Division of Water Rights has indicated, given the nature and number of claims in the Virgin River adjudication, it is difficult to predict when a decree will be entered by the court.

The quality of water is determined under standards for allowable contaminant levels according to the use designations. The use designations and the standards are published by 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. This is carried out through the Division of Water Quality.

The Utah Safe 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. This may be publicly or privately owned. The Safe Drinking Water Board has adopted State of Utah Public Drinking Water Regulations to help assure pure drinking water. There is also a Drinking Water's Source Protection Program. This includes monitoring delivered drinking water quality as well as water source protection. These responsibilities are carried out by the Division of Drinking Water.

7.2.2 Local Institutions and Organizations

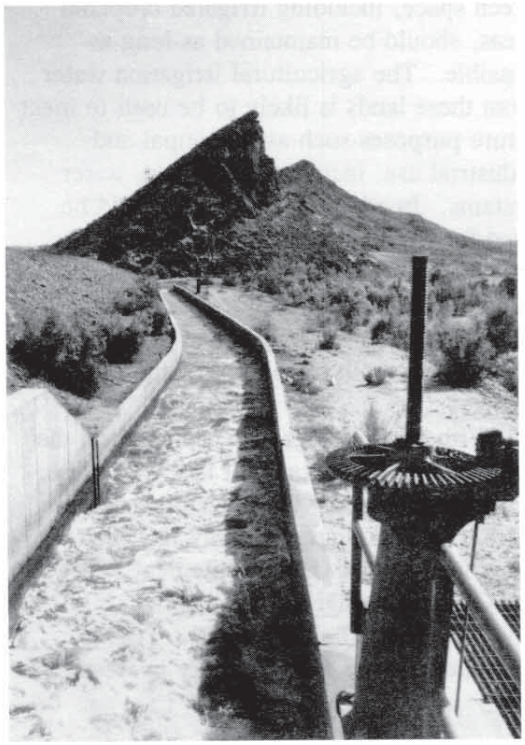
Most of the water development in Utah has been completed under the auspices of local institutions, entities and organizations. These entities are all formed under specific enabling legislation. Types of these entities are described below.

Water Conservancy Districts - These are created under Title 17A-2-1401 of the Utah Code. 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. Water conservancy districts have very broad powers, including that of constructing and operating water systems, levying taxes and contracting with government entities. These districts may include incorporated and unincorporated areas. The districts in the basin are the Kane County Water Conservancy District and the Washington County Water Conservancy District with offices in Kanab and St. George, respectively. These districts cover all of Kane and Washington counties.

Mutual Irrigation Companies - These are the most common water development and management entities in the basin. They are formed under the corporation code, and the majority of them are non-profit. 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. Over 33 mutual

irrigation companies are in the Virgin River drainage; two are in the Kanab Creek drainage.

Water Companies - These are entities formed by cities, towns and other groups 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 and local ordinances provide the legal framework for water company operation. There are about 30 water companies in the basin. Local entities may pass ordinances regulating water use.[2] Some organizations, such as special service districts, have authority to levy taxes. Private water companies operated for profit are regulated by the Division of Public Utilities.



Water User Associations - These organizations are groups formed to deliver water for various purposes. They are often informal groups that can also be incorporated under Utah law. There are nearly 20 such groups in the basin.

Other - Three other entities deliver water to specific areas. They are 1) the Shivwits Band of Paiute Indian Tribe used for domestic use and cropland irrigation, 2) the Utah Division of Parks and Recreation at Gunlock, Coral Pink Sand Dunes, and Snow Canyon State Parks for drinking water and miscellaneous use and 3) the National Park Service at Zions National Park for culinary and other miscellaneous uses.

7.3 Policy Issues and Recommendations

Two issues regarding water regulations and related institutional considerations that need resolution are water quality monitoring and reserved water rights.

7.3.1 Water Quality Monitoring

Issue - Additional water quality data is needed.

Discussion- Future demands for conversion of water use from one purpose to another requires accurate knowledge of water quality. Monitoring is already carried out by the Division of Water Quality, Bureau of Land Management, Forest Service and U. S. Geological Survey. More emphasis should be placed on seasonal and episodic event sampling. The impact of non-point source pollution needs to be better evaluated. There is a continued need to measure the water quality at strategic locations throughout the basin.

Recommendation - The U.S. Geological Survey; Utah Departments of Natural Resources, Agriculture and

Environmental Quality and local government entities should establish water quality monitoring stations at strategic locations to develop a better understanding of water quality. Event monitoring should also be carried out where appropriate.

7.3.2 Reserved Water Rights

Issue - The United States has filed claims for reserved water rights based on the date of creation of the federal reservation for an undetermined amount of water. These need to be resolved.

Discussion - The United States has filed claims on behalf of the Bureau of Land Management (BLM), the Forest Service, Zion National Park and the Shivwits Band of the Paiute Indian Tribe. The Solicitor of the Department of Interior and the U.S. Attorney General have jointly taken the position that reserved rights will not be claimed for existing wilderness areas.[6]

The claims filed by the BLM are primarily based on state water rights; however, the majority of the claims filed by the Forest Service, Park Service and the Shivwits Indians are reserved rights claims. Among the reserved water claims are 1) instream channel maintenance and fisheries maintenance flows by the Forest Service, 2) all surface and groundwater within Zion National Park which is necessary to fulfill the purposes of the national park and 3) a claim for 11,355 acre-feet annually to fulfill the purposes of the Shivwits Indian Reservation.

Recommendation - The Division of Water Rights should continue to actively negotiate with the appropriate parties to resolve these claims under state water law. If agreement cannot be reached, the United States should be served and their claims resolved through the legal framework provided under adjudication procedures.

7.4 Problems and Needs

More information is needed in the Beaver Dam Wash drainage to determine the quantity and quality of the water resources in this area. With the increasing demand for water in this drainage, from within the state and out-of-state, it is imperative to obtain data on the surface water and groundwater supplies.

As future growth continues in the basin, some of the new development from urbanization is likely to displace presently irrigated farm land. Efforts should be made to maintain presently irrigated land by recommending future urban development in non-irrigated areas. Preservation of open green space, including irrigated cropland areas, should be maintained as long as possible. The agricultural irrigation water from these lands is likely to be used to meet future purposes such as municipal and industrial use, including secondary water systems. In addition, the water could be used for instream flows, supplemental irrigation in other water short areas and irrigation of new agricultural cropland. There is a need for long-range planning to provide a smooth transition for these use changes.

With continued growth, demand on the groundwater resources will likely increase. A recharge map for the Navajo sandstone aquifer in Washington County has been developed by the U. S. Geological Survey (USGS) and the Department of Environmental Quality (DEQ). This is shown on Figure 9-2. A study in western

Kane County investigated groundwater aquifers. This was a cooperative study by USGS, DEQ and local organizations including Kane County, Kanab City, Garkane Power Association, Inc. and Five County Association of Governments. Local protection planning for this zone is essential if both future water quantity and quality are to be ensured.

Knowing how much and where groundwater can be developed is a problem. Additional studies are needed to make this determination, particularly in the Beaver Dam Wash drainage. Study needs in other areas should be assessed and carried out where warranted.

7.5 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) if 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 purposes of speculation or monopoly. The State Engineer shall withhold action on an application if the application is determined to interfere with a more beneficial use of water or prove detrimental to the public welfare or the natural stream environment.

Utah water law allows changes in the point of diversion, place of use and/or nature of use of an existing water 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.

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 his regulatory authority, the State Engineer influences water management by establishing diversion

requirements for various uses and policies on water administration for surface water and groundwater supplies.

The Division of Water Rights is responsible for a number of other 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 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.

7.6 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*.[10]

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 including, but not limited to, the construction or operation of facilities 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, that any such discharge will comply with applicable state water quality standards and 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 block 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) to prevent groundwater contamination rather than cleanup after the fact and 3) to provide protection based on the different existing groundwater quality. 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 provision 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). However, these operations 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, EPA retains the oversight role necessary to insure compliance with all rules, regulations and policies.

7.7 Drinking Water Regulation

The Safe 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*. 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 Division of Drinking Water serves as staff for the Safe Drinking Water Board to assure compliance with the standards. At the local level, considerable reliance is placed on public water supply operators. Those operating systems serving over 800 people are currently required to have state certification. Water systems serving fewer than 800 people will need to have a certified operator if the water system has some sort of treatment facility in place.

7.8 Environmental Considerations

Water is often viewed as a commodity for people's use with little thought given to other purposes of the hydrologic cycle. Many recreational opportunities in Utah involve water. Adequate quantity and quality of water is crucial to maintaining healthy wildlife habitats and populations. This includes providing instream flows where prudent and possible and maintaining critical wetlands areas.

Providing instream flow as a beneficial use to maintain fish and wildlife populations, riparian vegetation and stream channels is widely recognized as important. The Utah legislature recognized this through recent legislation allowing purchase of instream flow water rights. Adequate water resources planning allows consideration of instream flow needs early in the design process so problems can be resolved before construction or operation of the project.

Wetlands are extremely important for groundwater recharge and discharge, flood storage and desynchronization, shoreline stabilization, sediment trapping, water purification and pollution control, food chain support, habitat for fish and wildlife and active and passive recreation. Stream channelization and draining and filling of wet areas can all impact wetlands.

Numerous potential sources of pollution may adversely affect the quality of groundwater. These sources include agriculture, on-site waste treatment systems, solid wastes, hazardous wastes, oil and gas exploration and production, mining, surface impoundments and urban runoff. The importance of groundwater as a resource should always be considered. Any activities should emphasize prevention, protection of recharge areas of the major aquifers and management of existing supplies to prevent degradation.

The Kanab Creek/Virgin River Basin has several environmentally sensitive areas. These areas are shown and discussed in the Resource Management Plans prepared by the Bureau of Land Managment. These should be considered for protection and/or mitigation when water development is contemplated. For information on how communities can set up and carry out a "Local Aquifer Protection Management Plan" contact the Division of Water Quality.

7.9 Dam Safety

All dams in Utah, which store in excess of 20 acre-feet of water or may cause loss of life, are assigned a hazard rating. Hazard ratings are either high, moderate or low, thus determining the frequency of the inspection. High-hazard dams are inspected yearly; moderate, every other year and low, every fifth year.

Following the inspection, a letter from the State Engineer suggests maintenance needs and requests specific repairs. The State Engineer may declare the dam unsafe and order it breached or drained. Efforts are always made to work with dam owners to schedule necessary actions.

The State Engineer has design standards which are outlined in a publication entitled *Rules and Regulations Governing Dam Safety in Utah*. Plans and specifications must be consistent with these standards. Dam safety personnel monitor construction to insure compliance with plans, specifications and design reports. Any problems are resolved before final approval is given. ■

7.10 References

1. Barnes, Robert P., Mack G. Croft. *Ground Water Protection Strategy for the State of Utah*. Utah Department of Health, Salt Lake City, Utah, 1986.

2. City of St. George. Ordinance No. 5.2. 1987, an ordinance making it unlawful to dispose of water apart from the land which it has historically benefitted or where it is found; prohibiting subsequent development where violation has occurred; requiring a permit for resale of water at a profit; imposing penalties. St. George, Utah, 1987.

3. Division of Water Resources. *State of Utah Water-1982*. Salt Lake City, Utah, 1982.

4. Division of Water Rights. *Rules and Regulations Governing Dam Safety in Utah*. Salt Lake City, Utah, 1982.

5. Federal Water Pollution Control Act. Public Law 92-500, 1972, as amended. Commonly referred to as the Clean Water Act.

6. Office of Attorney General. Letter of Opinion from Attorney General Edwin Meese III to Donald P. Hodel, Secretary, Department of the Interior, concerning reserved water rights for wilderness areas. Washington, D. C., July 28, 1988.

7. Safe Drinking Water Committee. *State of Utah Public Drinking Water Regulations, Part 1-Administrative Rules*. 5th Revision adopted February 1, 1986.

8. United States Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin-Utah Cooperative Study*. Salt Lake City, Utah, 1990.

9. *Utah Code Annotated. 1953, amended.*

10. Utah Division of Water Resources. *Utah State Water Plan*. Salt Lake City, Utah, 1990.

11. Utah Wastewater Disposal Regulations, Parts I through VIII. Salt Lake City, Utah, 1988.

12. Utah Water Pollution Control Act. Title 26, Chapter 11, UCA, 1953, amend. Salt Lake City, Utah.

13. Utah Water Quality Board. *Utah Wastewater Disposal Regulations, Part 6 - Ground Water Quality Protection Regulations*. Salt Lake City, Utah, Adopted May 26, 1989.

Section 8 State, Federal and Local Water Resources Funding Programs

Tables

8 State, Federal and Local Water Resources Funding Programs

8.1 Introduction

This section briefly describes some of the state, federal and local funding programs available to plan and implement water resources projects in the Kanab Creek/Virgin River Basin. Additional information can be found in the *State Water Plan* (1990), Section 3, Introduction, and Section 8, State and Federal Water Resources Funding Programs. Additional information can be found in other sections of the *State Water Plan* regarding specific agency programs.

Funding water resources development and conservation requires cooperation, persistence and ingenuity. This was especially true in the early days of settlement in the basin. It is even more real today. Reduced federal funding is making financial assistance availability increasingly scarce.

8.2 Background

Prior to 1970, most of the water-related projects were agriculturally related. During the last two decades, however, more of the projects are for multiple purposes with increasing emphasis on municipal and industrial water supplies.

One of the largest water projects was construction of Quail Creek Reservoir and related facilities. Total cost for the reservoir and diversion facilities was about $32 million, including repairs to a failed dike. The water treatment plant part of the project cost about $8 million to construct for a total of about $40 million. Other related purposes include hydropower, recreation, fishing facilities, irrigation water delivery systems, some flood control and instream flow enhancement for endangered fish.

One other multipurpose project provided flood control and agricultural water-related facilities of considerable magnitude. The Warner Draw Watershed Project was sponsored by several local, state and federal entities. The Soil Conservation Service provided most of the cost-share funding grants. This project, in the St. George-Washington-Hurricane area, was started in the early 1970s. Various aspects are still being implemented. Total cost at present

exceeds $46 million, including local and state input.

Total funds expended for planning and implementation of water and water-related projects is impractical to determine. They are probably in the hundreds of millions of dollars. It is certain that local entities and individuals provided the vast majority of the financing from their own resources or by other payback arrangements. Tables 8-1 and 8-2 show recent funding provided by state and federal agencies for water-related projects.

TABLE 8-1
STATE WATER-RELATED FUNDING EXPENDITURES

Funding Agency Program	Grants ($1,000)	Loans ($1,000)	Period
Board of Parks & Recreation			
Land & Water Consv. Fund	$2,000		1971-91
Riverway Enhancement Program	30		1986-91
Board of Water Resources			
Cities Water Loan Fund		$ 2,804	1976-88
Constr. & Dev. Fund		37,507	1982-90
Revolving Constr. Fund		4,283	1984-91
Community Development			
Comm. Dev. Block Grants	1,029		1982-92
Permanent Comm.Impact Board			
Perm. Comm. Impact Fund	686[a]	203[a]	1988-92
Disaster Relief Board Fund	4,280		1989
Safe Drinking Water Board			
Financial Assistance Program	182	1,437	1983-92
Soil Conservation Comm.			
Agri. Resource Dev. Loan		1,456	1976-91
Priority Watershed Program	b	b	
Utah Wildlife Board			
Dingle-Johnson Act	b	b	
Water Quality Board			
State Loan Program		2,545	1984-91
State Revolving Loan Program		-0-	1988-91
Federal Const. Grants	11,126		1972-90

[a]Includes other types of development
[b]Data is not available

TABLE 8-2
FEDERAL WATER-RELATED FUNDING EXPENDITURES

Funding Agency Program	Grants ($1,000)	Loans ($1,000)	Period
Agric. Consv. & Stab. Service			
Agric. Consv. Program	$2,434[a]		1982-92
Consv. Reserve Program			
Emerg. Consv. Program			
Bureau of Reclamation			
Investigations Program[b]	None		1973-92
Loan Program	None		1973-92
Corps of Engineers			
Civil Works	None		1982-92
Continuing Auth. Program	None		
Emergency Activities	None		
Economic Dev. Adm.			
Public Works & Econ. Dev.	c		
Farmers Home Administration			
Rural Development	4,446	8,520	
Res. Consv. & Dev.		None	
Fed. Emergency Mgt. Agency			
Presidential Declared Disaster	60,000		1983-89
Flood Plain Management	601 per year		1991-92
Soil Conservation Service			
Watershed Prot. & Flood Prev.	33,000		1970-92
Resource Consv. & Dev.	60		1974-92
Emergency Watershed Program	0		
Environmental Protection Agency	c		

[a]Includes Agriculture Conservation Program, Emergency Conservation Program and Conservation Reserve Program.
[b]Does not include planning and investigation for the Dixie Project
[c]Data are not available

8.3 State, Federal and Local Funding Programs and Resources

Tables 8-3, 8-4 and 8-5 indicate some of the funding programs (grants and loans) available through state, federal and local agencies and entities. These can accelerate water resources development. ■

TABLE 8-3
STATE FUNDING PROGRAMS

Entity/Program	Contact	Purpose	Type
Board of Parks and Recreation			
Land and Water Consv. Fund	Div. of Parks and Rec.	Recreational Facilities	Cost-share
Riverway Enhancement Program			Grants
Board of Water Resources			
Revolving Construction Fund	Div. of Water Resources	Small irr. and culinary projects	Loans
Cities Water Loan Fund		Municipal culinary systems	Loans
Consv. and Development Fund		Large water projects	Loans
Community Dev. Block Grants			
Block Grants	Div. of Community Dev.	Rural living envir. imp.	Grants
Permanent Comm. Impact Board			
Permanent Comm. Impact Fund	Div. of Community Dev.	Rural public facilities	Grants and loans
Disaster Relief Board Fund		Disaster repair	Grants
Safe Drinking Water Board			
Financial Assistance Program	Div. of Drinking Water	Drinking water systems	Loans
Soil Conservation Commission			
Agri. Resources Development Loan	Dept. of Agriculture	Improve private agri. land	Loans
Priority Watershed Program		Watershed improvement	Grants
Utah Wildlife Board			
Dingle Johnson Act	Div. of Wildlife Resources	Fish habitat restoration/dev.	Grants
Water Quality Board			
Revolving Const. Loan Program	Div. of Water Quality	Wastewater treatment facilities	Loans
Federal Construction Grants		Wastewater treatment facilities	Grants
State Loan Programs			Loans

TABLE 8-4
FEDERAL FUNDING PROGRAMS

Agency	Program	Purpose	Type
Department of Agriculture			
Agricultural Stablization and Conservation Service	Agri. Conservation Program	Soil, water, energy consv.	Grants
	Emergency Const. Program	Rehab. of farmland damaged by disasters	Grants
	Consv. Reserve Program	Reduce erosion, main. wetlands	Grants
Farmers Home Administration	Rural Development	Water supply, wastewater disposal	Grants, Loans
	Resource Consv. and Development	Multi-purpose water, land construction facilities	Loans
Soil Conservation Service	Watershed Protect. and Flood Prev.	Flood control and water-related development	Grants
	Resource Consv. and Development		Cost-share
	Resource Consv. and Development	Multi-purpose water and related facilities	Grants
	Emergency Watershed Program	Reduce sedimentation and flooding	Cost-share
Department of the Army			
Corps of Engineers	Civil Works	Flood control, water supply, recreation	Grants
	Continuing Auth. Program	Flood control and protection	Grants
	Emergency Activities	Flood control and protection	Grants
Environmental Protection Agency		Water quality	Grants

TABLE 8-4 (continued)
FEDERAL FUNDING PROGRAMS

Agency	Program	Purpose	Type
Department of the Interior Bureau of Reclamation	Investigation Program Loan Program	Water storage, delivery Small multi-purpose projects	Loans Loans
Economic Dev. Administration	Public Works and Economic Dev.	Water development	Grants Loans
Federal Emergency Mgmt. Agency	Presidential Declared Disaster Flood Plain Management	Damage mitigation Structure acquisition-flood plains	Grants Grants

TABLE 8-5
LOCAL FUNDING PROGRAMS

Entity	Purpose	Type
Private financial institutions	Any approved water-related project	Loan
Washington County Water Conservancy District	Group water projects	Loans, Cost-share
Kane County Water Conservancy District	Group water projects	Loans, Cost-share
Western Farm Credit Bank	Water-related projects	Loan

8.4 References

1. Peterson, Sheila G., *Catalog of Funding Agency Information.* Division of Community Development, Salt Lake City, Utah, 1983.

Section 9 Water Planning and Development

9 Water Planning and Development

Wise planning for water conservation and development is essential to properly meet the needs and demands of a growing population in the Kanab Creek/Virgin River Basin. This will require cooperation of all government and local groups.

9.1 Introduction

This section describes the existing and proposed water planning and development activities in the basin. State and federal agencies and other interested parties should recognize water as a resource to provide for the needs of local communities and citizens while keeping in mind the aesthetic and environmental values. Considerable water-related activity is already under way, particularly in Washington County where population and employment are increasing at the highest rate in the state.

The goal of the Division of Water Resources and other water-related agencies is to assist in the coordination needed to make future planning and development as effective as possible. However, the decision-making process is still the responsibility of the local entities. This plan is intended to provide local decision makers with data to help them solve existing problems and provide for future needs with the most viable alternative.

9.2 Background

As stated in earlier sections, considerable planning and development has been accomplished in the area. Early activities were by groups of individuals with a common cause. Later, these became formal incorporated irrigation companies and cities. Since then, water conservancy districts have been formed in Kane and Washington counties. On occasion, several irrigation companies and/or groups have joined to pursue development of a common water project. A variety of other entities, such as special service districts, have been formed to develop needed water. Some of the sponsors and developments assisted by the Board of Water Resources are shown in Table 9-1.

TABLE 9-1
WATER DEVELOPMENT PROJECTS

Sponsor	Type[a]	Year
Iron County		
Kanarraville Town	CL, Well	1948
Spring Cr. & La Verkin Cr. Irr. Co.	Res., Dam	1983
Kane County		
Glendale Irr. Co.	Pond, Spk.	1984
Kanab City	CL, PL, Well	1983-88
Kanab Irr. Co.	Div., PL	1983
Mt. Carmel Irr. Co.	Div., CNL	1956-61
Mt. Carmel Pipe Line Co.	CL, Well, PL	1979
Mt. Carmel SSD	CL, PL, Tank	1982
Orderville Irr. Co.	Div., PL	1956-69
Washington County		
Ash Creek Irr. Co.	Res. Dam	1958-87
Baker Reservoir Association	Res. Dam	1950
Bench Lake Irr. Co.	Res. Dam, CNL, PL	1957-76
Black Canyon Irr. Co.	Div., PL	1984
Central Canal & Irr. Co.	Div., CNL, Pond, Spk.	1972-82
Central Culinary Water Assoc.	CL, Tank, PL	1984
Hall & Grafton Irr. Co.	PL	1986
Hurricane Canal Co.	PL, CNL	1960-91
Hurricane City	CL, Tank, PL, Ds	1978-92
Ivins Irr. Co.	CNL, PL	1976
Ivins Town	CL, PL	1979
Kolob Res. & Storage Assoc.	Res. Dam	1956
La Verkin City	CL, Pump, Tank, PL	1976-82
Leeds Domestic Water Users Assoc.	CL, Tank, Well	1976-90

TABLE 9-1 (continued)
WATER DEVELOPMENT PROJECTS

Leeds Water Co.	Div., CNL	1972
Lower Gunlock Res. Corp.	Res. Dam	1970
New Harmony Res. Irr. Co.	PL, CNL	1963-85
Pine Valley Irr. Co.	CL, PL, Spring Div.	1975-82
Pine Valley Mtn. Farms Irr. Co.	CL	1990
Rockville Pipeline Co.	CL, Well	1975
Rockville Town Ditch Co.	Div., PL, Spk.	1968-90
Santa Clara City	CL, Well, Tank, Pipe	1979
Silver Reef SSD	CL, Tank, PL, Spk	1980
South New Harmony Canal Co.	Div., Spk.	1975
Springdale Consolidated Irr. Co.	Dual Sys.	1988
St. George & Washington Canal Co.	Div., CNL	1974-89
St. George City	CL, Treat.	1990
Trees Ranch Ltd.	Res. Dam	1988
Veyo Irr. Co.	CNL	1961
Virgin Canal Co.	Spk.	1972
Virgin Town	Well, Tank, Treat.	1978-84
Washington City	Tank, PL, Well	1976-82
Washington County Water Con. Dist.	Div., Res. Dam	1983-90

Note: Projects assisted by the Board of Water Resources

[a]CL - Culinary line
Res. - Reservoir
Spk. - Sprinkler
PL - Pipeline
Div. - Diversion
CNL - Canal lining
Treat.- Treatment plant
Ds - Dual system

Also refer to Tables 8-1 and 8-2 for state and federal expenditures.

As the demands for municipal and industrial (M&I) water increase, the supplies will come primarily from water right transfers, new water development and conservation. Additional supplies can be developed primarily from Virgin River surface water or from groundwater in the basinwide Navajo sandstone aquifers. Water conservation can meet a part of future needs. Of the total water depleted for all uses, not including riparian and wetland, about 63 percent is for agricultural purposes. This will decrease to 25 percent as other demands increase. The current depletion for M&I water is 13 percent, but it will increase to 34 percent by 2040.

Water conservation can reduce the M&I water diversion in several ways. This can be accomplished by installing water saving fixtures inside the home and by reducing outside water use. Xeriscaping and use of secondary systems are the best ways to conserve culinary water used outside.

Increasing irrigation water use efficiencies is the most effective way to conserve agricultural supplies. This can be accomplished by installing canal lining, pipelines, and sprinkler irrigation systems. Also see Section 17, Water Conservation.

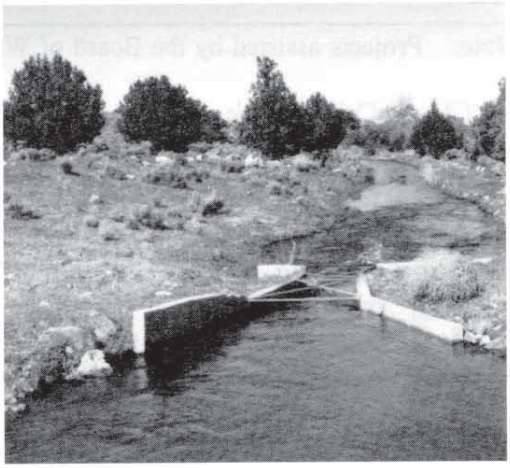
The M&I and agricultural water needs in the states of Arizona and Nevada are other demands on the Virgin River system. This is particularly true in the Las Vegas area where the M&I demands are accelerating at a high rate.

9.2.1 Dixie Project

After the passage of the Federal Reclamation Act of 1902, many studies and investigations relating to the Dixie Project were conducted between 1902 and 1937. Most important of these early investigations is one made by H. H. Kleinschmidt for the state of Utah and reported in the *Seventh Biennial Report of the State Engineer of Utah, 1909 and 1910.* The Bureau of Reclamation published a report in 1937 entitled *Report on Dixie Project Investigations, Utah*, which summarized many technical investigations as well as general investigations conducted by the State of Utah, Bureau of Reclamation, the Mormon Church and the Utah Power and Development Company (Utah Power & Light Company).

Subsequent re-study and updating resulted in the Dixie Project being submitted to Congress for authorization. The project was finally authorized for construction September 2, 1964, and a *Definite Plan Report* was published in June 1967.

After project authorization, detailed studies of the Virgin City Reservoir, a key feature of the project, revealed the probability of excessive reservoir leakage at the site selected. This would require costly subsurface treatment to correct.



This required a search for another dam and reservoir site, resulting in the selection of a new site about 15 miles downstream. This change required considerable modification of project facilities, including the elimination of power development as a project feature. With this change, the project's financial status changed from one which could pay for itself to one requiring other financial assistance. The financial status also was aggravated by rising construction and operation costs, and the elimination of some lands from the project because of inherent drainage problems.

On September 30, 1968, the project was re-authorized for construction at a site determined feasible by the Secretary of the Interior. It also provided financial integration into the Lower Colorado River Basin Development Fund and an increase in the appropriation ceiling. The 1968 plan of development contained essentially all of the multipurpose functions of the originally authorized project. However, the construction of Lower Gunlock Reservoir on the Santa Clara River was eliminated. The Lower Gunlock Reservoir was constructed in 1970 by the Lower Gunlock Reservoir Corporation.

Between 1969 and 1972, the Dixie Project again underwent major changes. Also, as a result of the Environmental Protection Act of 1969, a search began for a project with less impact on the environment. The reformulation studies resulted in a project deemed better suited to the needs of the people of southwestern Utah and more adaptable to the statewide water plan. It would provide higher quality water and would be better environmentally. The reformulated project replaced the Virgin River Dam and Reservoir with an offstream storage site in Warner Valley located about eight miles east of St. George, Utah.

In February 1973, the directors of the Washington County Water Conservancy District met and elected to accept the offer of the Allen-Warner Valley Energy System sponsors and to reject the alternative of the Dixie Project proposed by the Bureau of Reclamation. This ended efforts to work with the Bureau of Reclamation.

The Allen-Warner Valley Energy System Project experienced many problems with the environmental review and permitting process. The energy system was delayed and, eventually, work on the Warner Valley Water Project was stopped.

9.2.2 Recent Water Development

The effort to develop the water resources continues. The Washington County Water Conservancy District, with assistance from the Board of Water Resources, completed the Quail Creek Project in 1985. Quail Creek Reservoir has a total capacity of 40,325 acre-feet. The primary water supply is diverted from the Virgin River above Hurricane via a diversion dam and pipeline.

Four projects, Pine Valley, Baker, Lower Gunlock and Ivins reservoirs, provide approximately 13,000 acre-feet of storage on the Santa Clara River system. Two projects, Kolob and Ash Creek reservoirs, have been built on tributaries in the upper part of the Virgin River. Kolob Reservoir, located in the head waters of the North Fork of the Virgin River, has an active storage of 5,586 acre-feet. Ash Creek Reservoir has experienced leakage since the time it was constructed. Storage is now 3,175 acre-feet. There are three other small reservoirs: Blue Springs on North Creek, Aspen Lake on Deep Creek and Stratton Reservoir

(offstream) below Quail Creek dam.

Glendale Irrigation Company has installed a pond and sprinkler irrigation system. Orderville Irrigation Company and Mt. Carmel Irrigation Company have installed diversions, a pipeline and canal lining. A culinary well and storage tank were installed by Mt. Carmel Pipeline Company and Special Service District. Canal lining, pipelines and a well have been constructed in the Kanab area. Several sprinkler irrigation systems have been installed in Johnson Wash.

9.2.3 Current Water Development

Projects currently in various stages of development are Springdale Water Treatment Plant Improvements, Kanab City Culinary Well, and the Hurricane Secondary (Dual) Water System. Other unknown projects may be underway.

9.3 Policy Issues and Recommendations

Three policy issues are discussed. These are 1) preservation of potential reservoir sites, 2) development in proposed wilderness areas and wild and scenic river segments and 3) long-range conservation and development plans.

9.3.1 Preservation of Potential Reservoir Sites

Issue - Feasible reservoir sites are becoming harder to find.

Discussion - Construction of additional water storage facilities is 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, more than 100 potential reservoir sites have been investigated. Investigation detail varies from cursory on-site evaluations to minor 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.

Reservoir site protection proposals should have public input. The Forest Service and Bureau of Land Management should identify

and evaluate potential reservoir storage sites in their planning processes. See Section 9.7.3 and Tables 9-5 thru 7.

Recommendation - The Washington and Kane counties water conservancy districts and other appropriate entities should act to protect potential water storage sites.

9.3.2 Development in Proposed Wilderness Study Areas and Wild and Scenic River Segments

Issue - Designation of proposed wilderness areas and wild and scenic river segments may restrict or prohibit future development, use and maintenance of needed water supplies and facilities.

Discussion - Two wilderness areas exist in the Kanab Creek/Virgin River Basin. These are 1) Beaver Dam Mountain, 3,788 acres and 2) Pine Valley Mountain, 50,000 acres. There are several wilderness study areas with a total area of over 152,000 acres. Several of the proposed wilderness study areas contain potential sites for wells and sources of surface water which could be used to meet future municipal and industrial (M&I) water needs. There are potential reservoir sites in some of the wilderness study areas and wild and scenic river segments where high flows could be stored for multiple purposes, including M&I, irrigation, recreation, flood control and instream flow water uses. Existing water developments could still be used, but future access for operation and maintenance may be more difficult. After wilderness study areas and wild and scenic river segments are designated, new development cannot take place.

The wilderness areas proposed by the Bureau of Land Management are listed in Table 9-2 and shown on Figure 9-1. In-holding areas are not included in the acreage. The wild and scenic river segments are shown on Figure 9-1.

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 by excluding these areas when making wilderness and wild and scenic river segment designations.

9.3.3 Long-Range Management Plans

Issue - There is a need for long-range coordinated planning for the management of the water resources at all levels of government.

Discussion - Water use in the basin will increase in the future. A rapidly expanding population, especially in Washington County which encompasses much of the basin, will increase the M&I use of water. The place of use of agricultural water will also change in the future. Some agricultural lands will be taken out of production and the water converted to M&I uses and some new lands may be developed. Water supplies for

TABLE 9-2
WILDERNESS STUDY AREAS

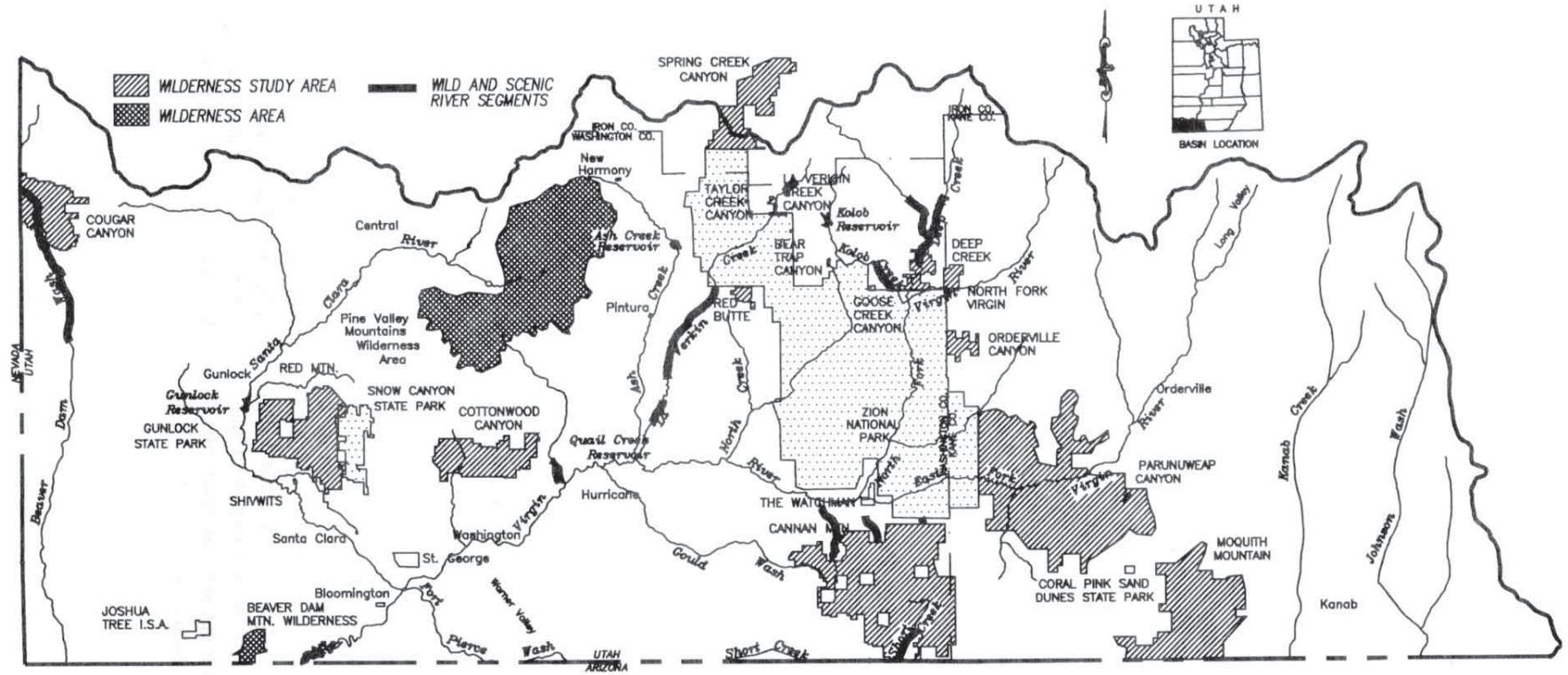
WSA Name	Acreage
Cougar Canyon	15,968
Red Mountain	18,290
Cottonwood Canyon	11,330
La Verkin Creek Canyon	567
Deep Creek	3,320
Canaan Mountain	47,170
Red Butte	804
Spring Creek Canyon	4,433
The Watchman	600
Taylor Creek Canyon	35
Goose Creek Canyon	89
Bear Trap Canyon	40
(Joshua Tree ISA)[a]	1,040
North Fork Virgin River	1,040
Orderville Canyon	1,750
Parunuweap Canyon	30,800
Moquith Mountain	14,830
TOTAL	152,106

[a]Instant Study Area
Source: Bureau of Land Management

agricultural lands that experience frequent shortages could be firmed up.
Other important factors affecting future water availability are federal reserve claims, instream flow requirements and designation of critical habitat and wild and scenic river segments. Also, areas of critical environmental concern, special recreation management areas and Visual Resource Management Class I and II will impact future water availability.

Long-range plans will be required in order to best develop and conserve the water

FIGURE 9-1
Wilderness Study Areas and Wild and Scenic River Segments



resources to meet all the demands. These plans should include buildout studies as appropriate. These plans should also include the quantity and quality of water available from presently developed sources as well as institutional, physical and hydrologic limits. Separate plans are needed for the Virgin River basin and the Kanab Creek/Johnson Wash drainages.

Recommendation - The Washington and Kane counties water conservancy districts should take the lead to inventory existing resources and prepare specific long-range management plans. The Division of Water Resources and other appropriate state and federal agencies should provide assistance.

9.4 Water Resources Problems

The major water resources problem is providing adequate supplies at the location and time needed. Often, sufficient annual supplies are available but the peak supply is at a different time than the peak need. Also, there is generally a problem of conveying water from one location to another because of water rights, cost and environment concerns. The variation in flows is shown by gaged records of the Virgin River near the town of Virgin. See Figure 5-4 and 5-5. This variability can be caused by snow-melt runoff, cloudburst floods and wet and dry periods.

Certain parts of the basin are prone to flash flooding from rainfall. The instantaneous peak flows from these flash floods can be high and cause erosion and property damage. Sediment transport in the basin, that can also be a significant problem, is compounded by high peak flows and flash flooding. The sediment is transported and then deposited in areas such as reservoirs and stream channels and in front of diversion dam structures. When on-stream reservoirs are built, such as Gunlock Reservoir, a portion of the original storage volume is required for the sediment trapped in the reservoir. Sediment accumulation reduces the effective water storage capacity of reservoirs.

In the Kanab Creek/Virgin River Basin, usable quantities of groundwater occur in consolidated and unconsolidated rock. Presently, the unconsolidated aquifers produce more water than consolidated rock formations such as the Navajo sandstone; however, total groundwater storage is greater in the consolidated formations. Water quality in both aquifers tends to be better at higher elevations in the tributaries, but good and poor quality may be found in many areas. The unconsolidated aquifers generally have poorer quality water in the lower elevations of the basin due to discharge from some geological formations containing soluble minerals. Additional discussion on groundwater is given in Sections 9.7.1 and 19.

Providing adequate, high quality water for municipal and industrial (M&I) use will be one of the most challenging problems for years to come.

9.5 Water Resources Demands and Needs

Demands for water to satisfy various users will continue to increase. Because of economic status, 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 future M&I water needs. Agricultural uses are likely to decrease as the area urbanizes. Reserved

TABLE 9-3
CURRENT AND PROJECTED CULINARY WATER USE

Year	County			Total	
	Iron	Kane	Washington	Diversion	Depletion
			(acre-feet)		
1990	90	1,670	18,570	20,330	10,570
2000	100	2,390	30,000	32,490	17,540
2010	110	2,880	39,800	42,790	23,960
2020	130	3,300	47,700	51,130	29,660
2040	210	4,500	78,000	82,710	51,280

water claims and instream flows are discussed in Section 7 and 6, respectively.

9.5.1 Culinary Water

Table 9-3 shows the current and projected culinary water diversions and depletions. It is estimated the culinary water use will increase about two and one-half times by the year 2020 and increase over four times by 2040.

If agricultural water is used for municipal purposes, it will require adequate treatment. Water in the Santa Clara River and the Virgin River above La Verkin Springs (Pah Tempe Hot Springs) is suitable for treatment for municipal use; however, water in the Virgin River below La Verkin Springs is too high in total dissolved solids (TDS) for drinking use unless it is treated by desalinization.

9.5.2 Secondary Systems

Secondary (dual) systems provide irrigation water for residential and municipal areas. Secondary systems allow the use of lower quality waters for landscape and turf irrigation. Parks, golf courses and other large grass areas are ideal candidates for secondary systems. Currently, most golf courses in the St. George area use unmetered secondary system water to supply most or all of their outside uses. Secondary systems are projected to serve future parks and golf courses in a manner similar to current practices. Projected diversions and depletions for secondary systems are shown in Table 9-4.

9.5.3 Irrigation Water

Agriculture has remained fairly constant over the past 20 years. As future population growth continues, some of the new development will displace presently irrigated farmland. The displaced agricultural irrigation water from this urbanization could be used for 1) irrigation of new lands or supplemental water supply of existing land experiencing a shortage, 2) conversion to municipal and industrial uses including secondary (dual) water systems and/or 3) remain in the streams or reservoirs for aesthetics, conservation pools for recreation and wildlife values. Projected irrigation water use is shown in Table 10-6.

TABLE 9-4
CURRENT AND PROJECTED SECONDARY WATER USE

Year	County			Total	
	Iron	Kane	Washington	Diversion	Depletion
		(acre-feet)			
1990	0	1,250	14,710	15,960	11,170
2000	0	1,720	23,670	25,390	17,770
2010	0	2,080	31,550	33,360	23,540
2020	0	2,370	37,810	40,180	28,130
2040	0	3,240	61,790	65,030	45,520

The major source of water for most of the presently irrigated lands is surface water. About 10 percent comes from wells.

If irrigation water from Washington Fields is transferred for use on new croplands, one location could be in Warner Valley. This would require a pump lift of about 500 feet from the St. George-Washington Fields Canal diversion to Warner Valley. This amount of pumping would substantially increase the cost of crop production. Lands just above the existing canal could be irrigated with only small pump lifts.

Because of the high total dissolved solids (TDS) of La Verkin Springs, the most likely use for the Washington Fields displaced water would be secondary (dual) water systems for parks and golf courses.

If irrigation water from displaced cropland in the Hurricane and La Verkin areas is not applied to new or existing lands, it could be treated for municipal use or used in secondary systems. This is currently being done in part of the Hurricane area where there is a new secondary system.

Displaced irrigation water from the Santa Clara River could be used in a secondary system or be treated for culinary use. The water could be purchased for a larger conservation pool in Gunlock Reservoir and/or used for aesthetic and recreational values.

As agricultural lands in the Kanab area are taken out of production for subdivision developments, the water can be put to other uses. Again, water is needed for secondary water systems, supplemental irrigation water and municipal and industrial water.

9.5.4 Recreational Water Demands

Recreation offers diverse leisure opportunities. The basin contains four state parks, one national park, one national forest and two wilderness areas. The recreational activities range from camping, hiking, nature study, hunting, golfing and water sports in the summer to cross-country skiing, snowmobiling, hunting and sledding in the winter. Sightseeing is aesthetical at any time of the year with majestic rock formations at Zion National Park and Snow Canyon, beautiful lakes at Gunlock and Quail Creek reservoirs, dense green forest with beautiful fall colors in Dixie National Forest, drifting sand dunes and cliffs at Coral Pink Sand

Dunes and mile after mile of backcountry administered by the Bureau of Land Management.

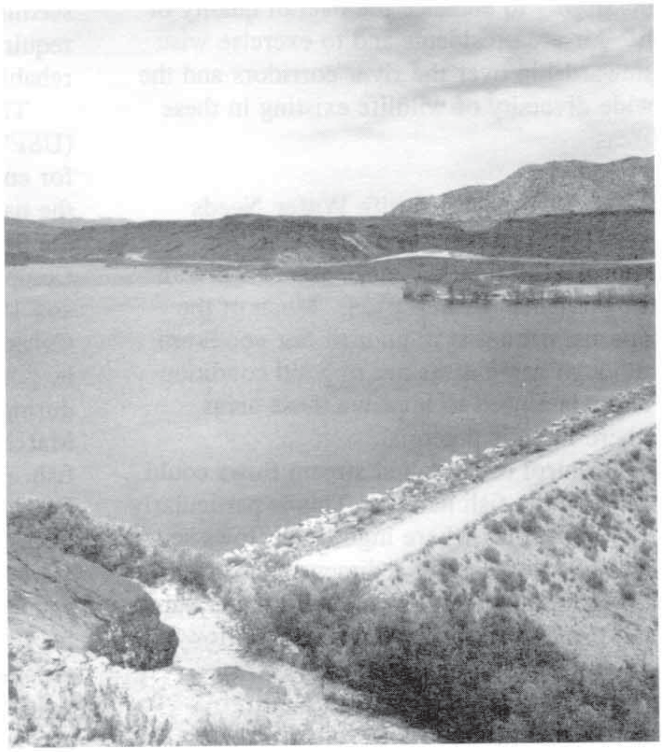
Gunlock State Park at Gunlock Reservoir is located on a paved secondary road between the small communities of Veyo and Santa Clara. The park is within 30 minutes of St. George, 90 minutes from Cedar City and two hours from Las Vegas, with the majority of the park's visitation coming from these areas.

Gunlock Reservoir and dam were built on the Santa Clara River in 1970 by the Lower Gunlock Reservoir Corporation. The dam is 117 feet in height, creating the reservoir's storage capacity of nearly 11,000 acre feet. The maximum surface acreage of the reservoir is 266 acres, with a mean depth of 77 feet and 5.1 miles of shoreline. This provides, along with other uses, recreational opportunities for several water-based activities. Demands for more and better facilities will increase.

Quail Creek Reservoir has a capacity of 40,325 acre-feet of water, a surface area of 625 acres and a water depth of 85 feet from conservation pool to the spillway. The dam spans Quail Creek at the notch where it flows through the colorful geological fold known as the Virgin Anticline.

Aside from its primary water storage purposes, Quail Creek Reservoir offers water-based recreational opportunities. As sponsor of the project, the Washington County Water Conservancy District provided $1.2 million for development of recreational facilities at the reservoir. Additional recreational facilities will be needed as time progresses.

The Virgin River Corridor Greenways Project goal is to designate a corridor along the Virgin and Santa Clara rivers, and to implement a trail system within the corridor. The system is proposed to run from Zion National Park to St. George along the Virgin River, and along the Santa Clara River to Gunlock State Park. Tributaries of these rivers and linear parks within the adjacent communities may also be included in the network. Eventually, the trail system may be connected with the Great Western Trail



which, when completed, will stretch from Canada to Mexico.

The Virgin River/Santa Clara River trail system will be comprised primarily of walkways. Equestrian and bicycle paths will also be included where possible. The optimum corridor width is 100 feet in order to allow for the accommodation of different trail types. The estimated length of the corridor is 76 miles. The location of the corridor will be determined in cooperation with property owners and government agencies.

The purpose of the project is to provide greater opportunities for the enjoyment of the natural amenities of the area to residents and visitors alike. It also offers the possibility to enhance the overall quality of life for area residents and to exercise wise stewardship over the river corridors and the wide diversity of wildlife existing in these areas.

9.5.5 Fish and Wildlife Water Needs

There is a need to maintain and/or improve the riparian zones associated with the permanent water areas. Much of the riparian habitat is in poor to fair condition, although some areas are in good condition. There is a need to improve those areas where there is potential.

Control of river and stream flows could improve the fish habitat. This is particularly true in reaches where high flood flows scour channels and deposit sediment. This could also help maintain better water temperature and provide instream flows. Some flow fluctuations can be beneficial to stream channels. This can occur through management practices for other purposes. Even with regulation, flood water flows will still occur.

An additional demand for the water in the Virgin River, from La Verkin Springs to the Washington Fields Diversion, is the instream flow requirement for endangered species. To meet the requirement, water used for irrigation in Washington Fields must be diverted at or below their present diversion dam (See Section 6.3.1).

9.6 Water Supply Enhancement

There are several ways to enhance the water supply. These include constructing additional reservoir storage to reduce and conserve high flows for use during low flow periods, adopting water conservation and increased use efficiency, conjunctive use of groundwater and surface water, cloud-seeding, refining instream flow requirements, implementing watershed rehabilitation or a combination of these.

The U.S. Fish and Wildlife Service (USFWS) requires a minimum instream flow for endangered fish of the lessor of 86 cfs or the natural flow all months of the year above the St. George and Washington Fields Canal Company diversion. Studies between 1980 and 1985 by the Washington County Water Conservancy District have indicated it may be possible to reduce the flow to 50 cfs during the months of November through March without impacting the endangered fish. This could provide about 7,000 acre-feet of additional water yield from Quail Creek Reservoir.

Making more efficient use of existing water supplies can increase the availability for future demands. This can be accomplished by continuing to increase irrigation water use efficiencies, install secondary systems and better control of municipal and industrial water use. See Section 17.

9.7 Water Development and Management Alternatives

The Kanab Creek/Virgin River Basin has the most rapid population growth in the state. Population is projected to more than double by the year 2020. This will require wise planning and prudent use of the resources to meet future demands and anticipated needs in the basin.

9.7.1 Groundwater

The State Engineer considers the groundwater supplies fully appropriated with the exception of four areas. These are 1) Johnson Wash, 2) Kanab Creek, 3) west of Hurricane and south of the Virgin River, and 4) Beaver Dam Wash. Applications for appropriation in these areas are considered on their own merits. However, in the closed areas, a liberal change application policy has been adopted to alleviate the need for water in areas where there is merit.

There is increasing interest in the Beaver Dam Wash area as demands for water in the basin increase. Water planning is complicated by interstate interests in Utah, Arizona and Nevada. The three states, in cooperation with USGS, have initiated a joint hydrologic study of the Beaver Dam Wash area.

The area closed to new appropriation in the Virgin River basin includes most of the area underlain by the Navajo aquifer, perhaps the most dependable long-term supply and estimated to contain several million acre-feet of recoverable water.[2] Production from this source in excess of present withdrawals is considered groundwater mining, and is being discouraged by the State Engineer under current policy. Water is stored in other consolidated aquifers and the alluvium, but the volume has not been determined.

A possibility for additional groundwater use in presently developed areas is to control the recharge and/or discharge of the groundwater. Artificially increasing recharge to the groundwater reservoir from melting snow and during periods of heavy precipitation may be another productive means for increasing available groundwater. While this may be a viable option, downstream users will object if their water supply is adversely affected.

The supply of high quality water in the Navajo sandstone aquifer is especially vulnerable to pollution by the activities of people. This is because so much of the uncovered, potential recharge area of the aquifer outcrop has highly pervious sandy soil or lava flow surface layers and is located close to the populated areas in and near St. George. Public use of the outcrop areas should be controlled. Some areas, such as Snow Canyon State Park, are already protected. Other areas, such as City Creek, Middleton Wash and Mill Creek, are vulnerable and should be protected. Figure 9-2 shows the recharge zone to the Navajo sandstone aquifer in Washington County. More information on groundwater resources is given in Section 19.

9.7.2 Water Conveyance and Delivery Systems

Agricultural Water - Many of the irrigation companies in the Kanab Creek/Virgin River Basin have improved their water conveyance and delivery systems during the last number of years. These system improvements have consisted primarily of concrete canal lining and pipelines. Pipelines have been installed in

recent years to provide gravity/pump pressure for irrigation sprinkler systems.

Some irrigation companies have replaced or improved other facilities used to deliver irrigation water. These include diversion structures, canal improvements, pipelines, measuring devices, water control structures and other management facilities. More detail is given in Sections 10 and 17.

Municipal and Industrial Water - Many communities have been upgrading their culinary water supply systems. Nine have built new or additional storage tanks. Ten have replaced or developed additional sources of water. Fifteen have replaced and/or added distribution systems and made other improvements (See Table 9-1).

There are still communities where systems need to be upgraded. This includes new or additional water storage tanks and new or upgrading of distribution systems. This is required because of additional population growth and for fire protection. More detail is given in Section 11.

9.7.3 Water Storage Facilities

New water storage facilities will be needed to meet future water demands throughout the Kanab Creek/Virgin River Basin. Storage reservoirs not only increase the total supply available but make more efficient use of the existing water.

The Division of Water Resources completed an inventory in 1988 of 92 potential reservoir sites located in the Virgin River drainage. This report documents past investigations. In January 1992, the division completed an evaluation of the initial 92 sites plus 6 additional sites identified in the process.[10,12] Through a series of evaluations, which included geologic concerns, location problems and small capacity (less than 3,000 acre-feet), the list of potential sites was narrowed to 16.

In February 1993, the division re-evaluated 27 sites eliminated in the 1992 evaluation because their capacities were less than 3,000 acre-feet. Also, an additional site on Tobin Wash was evaluated. After an in-house geologic review, 16 of these smaller sites were considered feasible for additional investigation. Sponsors pursuing additional water should consider all 32 sites in their investigation of water supply alternatives. Detailed field investigations will likely eliminate some of these sites from further study. There may also be other sites not presently identified that could be evaluated in the future. These potential sites for the Virgin River drainage are summarized in Tables 9-5 and 9-6. Locations are shown on Figure 9-3.

Other reservoir sites have been proposed in the Kanab Creek and Johnson Wash drainages during various investigations. These potential sites are summarized in Table 9-7 and shown on Figure 9-3.

Other management alternatives, including potential storage reservoirs, are currently being studied. These are discussed in Section 9.7.5. Reservoir locations are shown on Figure 9-3.

9.7.4 Virgin River/Cedar City Transfer

During the early 1950s, a discussion between Iron County and Dixie Project officials was held to explore diverting Virgin River water into Cedar City. Because of potential delays, nothing was done. The Utah Water and Power Board then appointed a committee to consider the needs of Washington and Iron counties. After the Navajo Lake diversion was eliminated because of water rights issues, Cedar City

FIGURE 9-2
Potential Recharge Area, Navajo Sandstone Aquifer, Washington County, Utah

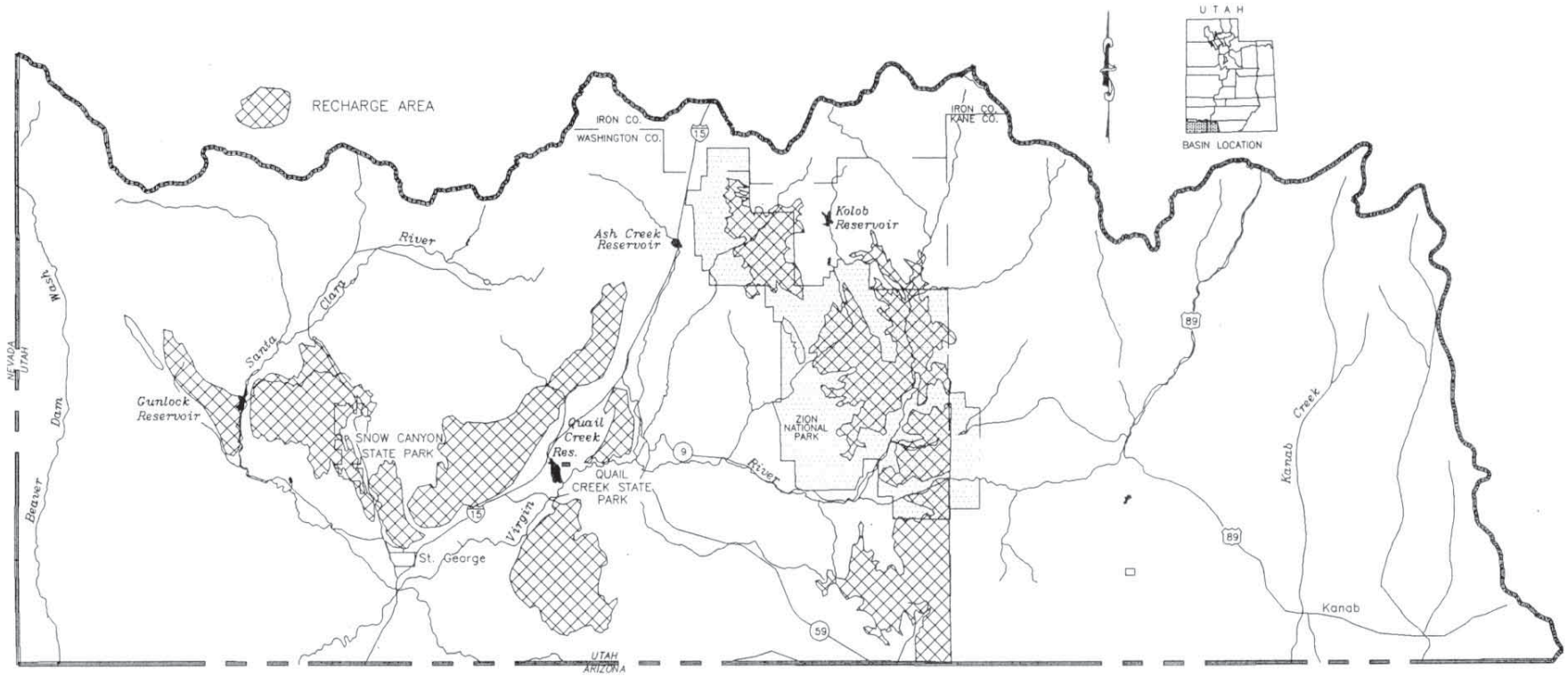


TABLE 9-5
POTENTIAL RESERVOIRS OVER 3,0000 ACRE-FEET[10,12]
VIRGIN RIVER DRAINAGE

No.	Site Name	Location			Dam Height (ft.)	Dam Crest Length (ft.)	Dam Crest Width (ft.)	Dam Embankment Volume ($yd.^3$)	Reservoir Storage Capacity (ac-ft.)	Max. Water Surface Elevation (ft.)	Reservoir Surface Area (ac.)	Land Ownership
		Tp.	Range	Sec.								
93	Stout Creek	39S	7W	35,36	170	840	39	1,660,000	6,000	6,440	94	BLM, Private
3	Lydia's Canyon	40S	7W	11	210	1,600	40	2,700,000	12,000	6,140	177	Private
94	Muddy Creek	41S	7W,8W	7,12	130	1,700	31	1,440,000	12,500	5,500	277	BLM, State
6	Long Valley	41S	8W	36	115	750	25	150,000[c]	19,000	5,180	170	BLM, State
90	East Fork	42S	8W	7	150	300	25	80,000[c]	12,000	4,960	262	BLM, (W.S.A.)[d]
15	Seth Canyon	38S	8W	31	150	1,300	35	1,860,000	5,000	7,280	81	Private
19	Hay Canyon	39S	8W	18	150	850	35	1,270,000	3,000	6,800	52	Private
22	Bullock[a]	39S	9W	32	144	650	34	860,000	8,500	5,700	154	BLM, State
32	North Creek[e]	41S	12W	14,23	125	1,400	30	1,012,000	13,500	3,660	225	BLM, Private
95	La Verkin	40S	12W	19	155	800	36	1,160,000	5,000	3,820	112	BLM, State
62	Warner Valley	42S	14W	28,29	240	3,250	53	9,240,000	55,000	2,940	264	BLM, Private
63	Fort Pierce	43S	14W	34	110	700	27	570,000	16,000	3,000	54	BLM
96	Gunlock Enlargement[b]	41S	17W	5	142	1,550	33	200,000	16,800	3,609	375	State
80	Santa Clara (Shem)	41S	17W	28	150	800	35	1,280,000	22,000	3,360	401	BIA
83	Lower Santa Clara	42S	16W	18	190	700	25	340,000[c]	18,000	3,000	294	BLM, State
97	Beaver Dam1	38S	20W	25	190	450	25	120,000[c]	18,000	4,800	302	BLM, Private

[a]Additional geotechnical and design data is available
[b]Gunlock Dam is currently 117 ft. high, 1,400 ft. long, and holds 10,884 Ac-Ft.
[c]Roller Compacted Concrete Dam Embankment Quantities
[d]Wilderness study area
[e]Site rejected by Bureau of Land Management in June 1993

TABLE 9-6
POTENTIAL RESERVOIRS UNDER 3,000 ACRE-FEET
VIRGIN RIVER DRAINAGE[10,12]

No. Site Name	Location			Dam Height (ft.)	Reservoir Storage Capacity (acre-feet)	Land Ownership
	Township	Range	Section			
2 Lower Swapp	39S	6W	16	*	*	State, Private
26 Deep Creek (Shopman Hollow)	38S	9W		*	*	State, Private
37 Meadow Hollow	38S	11W	16	*	*	State, Private
38 Willow Creek	38S	11W	15	*	*	State, Private
39 Big Water	38S	14W	11	36	234	Forest Service
40 Deep Flat Canyon	38S	14W	13	*	*	Forest Service
48 Mill Creek	39S	13W	29	*	*	Forest Service
49 Mill Harmon	39S	13W	32	*	*	Forest Service
52 Grape Vine Wash	40S	13W	31	*	*	State, Private
53 Jones Creek	40S	14W	26	*	*	Forest Service
54 Quail Creek (Leeds)	40S	14W	36	51	200	Forest Service
61 Washington	42S	15W	15	67	270	State, Private
71 Pilot Creek	38S	17W	29	*	*	Forest Service
72 Moody Creek	38S	17W	33,34	100	2,000	State, Private
84 Dry Wash	42S	16W	8	57	280	BLM
100 Tobin Wash	40S	17W	9	*	*	BLM, State

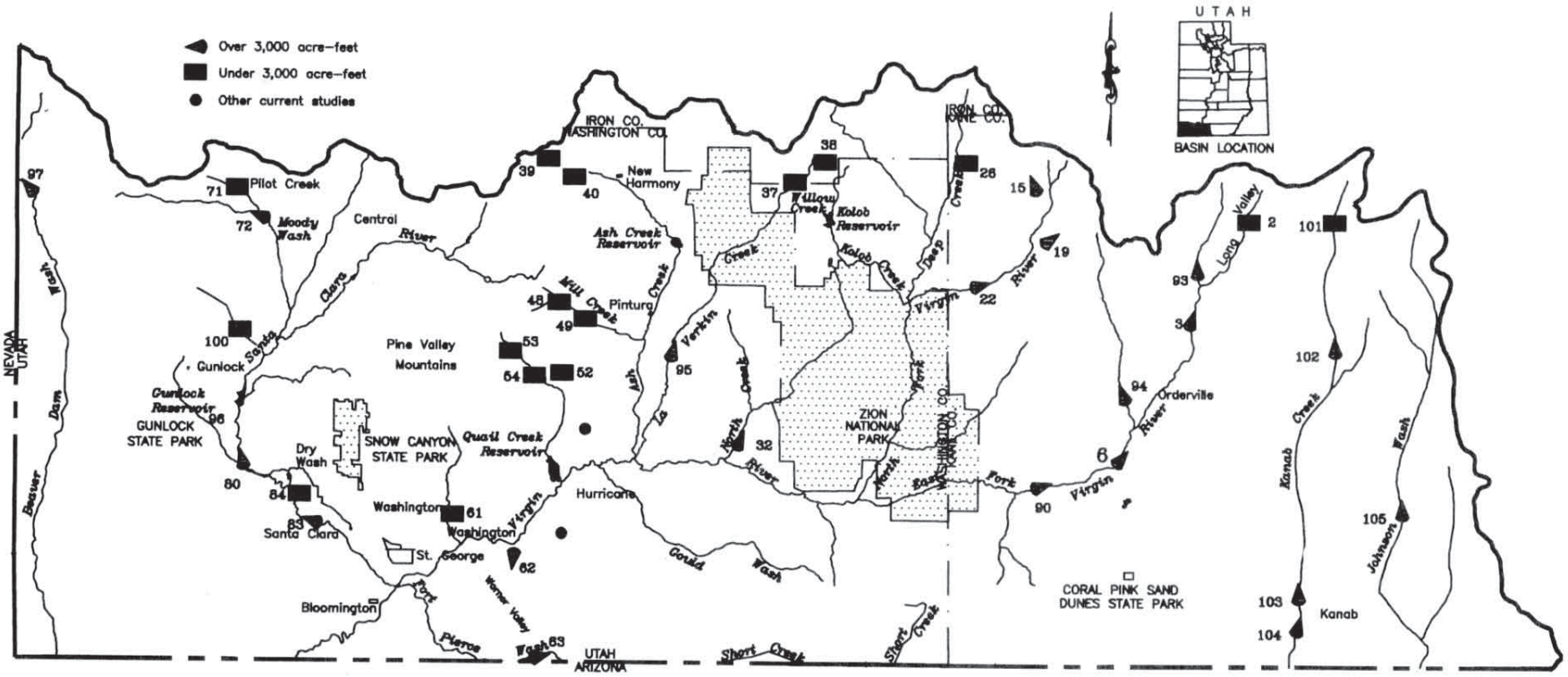
* No information is available. Additional evaluations are needed.

TABLE 9-7
POTENTIAL RESERVOIRS
KANAB CREEK/JOHNSON WASH DRAINAGE[1,7]

No.	Site Name	Location			Dam Height (ft)	Reservoir Capacity (ac-ft)	Land Ownership
		Twnship	Range	Section			
101	Alton	38S	5W	32	25	200	Private
102	Elbow	40S	6W	35	52	5,500[a]	BLM, Private
103	John R. Brown	42	6	29	115	7,000[a]	BLM, State, Priv.
104	Bridge	43	6	5	110	9,000	BLM, Private
105	Johnson Creek Wash	42S	5W	15	103	9,000[a]	BLM, State

[a] Other larger capacities investigated

FIGURE 9-3
Potential Reservoir Sites [1,7,9,10,12]
Kanab Creek/Virgin River Basin



looked at Kolob Creek in the Virgin River basin. In August 1953, Cedar City entered into an agreement with Washington County and the newly formed Kolob Reservoir and Storage Association (water users from Hurricane and Washington Fields). The agreement was to construct the Kolob Dam and Reservoir (capacity 5,500 acre-feet) with Cedar City repaying two-fifths of the cost of construction. This allowed Cedar City to acquire the entire water storage and supply in Kolob Reservoir when the Dixie Project was completed. When the Dixie Project was abandoned in the early 1960s, a substitute reservoir was needed.

A study was completed in 1982 by the Utah Division of Water Resources for conveying water from Kolob Reservoir to Cedar City and considering Bullock Dam for use by Washington County water users as a replacement supply for Kolob water. The project was presented to the Board of Water Resources in May 1982, but funding was never authorized.

In 1984, an agreement between Cedar City and Washington County Water Conservancy District (WCWCD) outlined opportunities for Cedar City to develop water in the Virgin River basin. A short summary of the agreement follows: Cedar City is repaying a portion of the costs of constructing Quail Creek Dam and Reservoir in exchange for the right to divert water from the upper Virgin River drainage for transbasin conveyance to Cedar City. Cedar City is thereby purchasing storage in Quail Creek Reservoir from WCWCD to provide 3,340 acre-feet annually to the Hurricane Canal Company and St. George and Washington Fields Canal Company. In exchange, Cedar City would have the right to divert the water developed and stored in Kolob Reservoir, as well as 1,600 acre-feet annually of Crystal Creek primary water and any high water right in Crystal Creek they can acquire. This agreement recognizes the first 600 acre-feet annually stored in Kolob Reservoir is reserved for prior downstream rights.

If transbasin conveyance is economically or environmentally infeasible, then Cedar City can divert up to 6,100 acre-feet annually from springs in the upper Virgin River basin. One restriction is not more than 533 acre-feet can be diverted per month during July, August and September. If Cedar City decides not to construct facilities for transbasin diversion of water from the upper Virgin River drainage, the WCWCD will reimburse Cedar City for the amount paid plus interest towards the cost of construction of the Quail Creek project. The WCWCD will then purchase Cedar City's two-fifths interest in Kolob Reservoir along with associated water rights and property.

This 1984 agreement is important to Cedar City because it allows full development of its water rights in the upper Virgin River basin. The agreement is important to the WCWCD because it specifies conditions and the time frame Cedar City must meet.

Cedar City and the Division of Water Resources completed a study in March 1993 to evaluate water supply, demand and development opportunities for Cedar City. The report includes an update evaluation of several transbasin diversion alternatives, some of which have been previously studied.

9.7.5 Water Supply Management

Even though much has been accomplished, there are additional opportunities to improve the management of

water resources. This applies to uses ranging from municipal, industrial and agricultural to instream flows.

Management includes increased delivery efficiency, reduced wasteful uses and prudent application of water for aesthetic purposes. Water managers should always be searching for ways to increase the available supply for all uses.

Computer modeling is one of the tools used in the planning and design of water projects. It is used to simulate river systems to determine reservoir yields, hydroelectric power production, water shortages and the affect on the river systems as new reservoirs become operational. Reservoir operation procedures can be developed to maximize the available water for use and minimize any problems associated with changing flow regimes.

Five management alternatives are under consideration or investigation. These are briefly discussed below.

The Kane County Water Conservancy District is investigating a reservoir for construction where U.S. Highway 89 crosses Kanab Creek. The estimated capacity is 9,000 acre-feet.

Three projects are being investigated by the Washington County Water Conservancy District. One is a proposal to divert La Verkin (Pah Tempe) Springs into a pipeline and return it to the Virgin River below the St. George and Washington Fields Canal Company diversion. This would improve the water quality for agriculture and provide for future conversion of Virgin River water for municipal purposes with conventional treatment.

The second is construction of an offstream storage reservoir in Sand Hollow west of Bench Lake Reservoir. This would maximize the potential of Bench Lake Reservoir and meet existing environmental requirements.

The third proposal is to pipe Ash Creek Reservoir, Leap Creek, South Ash Creek and Wet Sandy Creek to an offstream site near Anderson Junction with a capacity of about 10,000 acre-feet. This water could provide secondary water for Toquerville and La Verkin releasing Toquerville Springs for municipal and industrial uses. An alternate to the Anderson Junction site is one in Grapevine Wash with a storage capacity of 34,000 acre-feet.

The Soil Conservation Service is considering a debris basin in Gould Wash above Hurricane. This structure would capture flood flows in Gould Wash and release them at a lower rate. The only storage would be temporary flood water flows. This is a part of the Warner Draw Watershed Project.

9.8 Projected Basin Water Depletions

Kanab Creek and the Virgin River are interstate stream systems which pass through portions of Arizona, Nevada, and Utah prior to entering the Colorado River. The streams currently serve water users in the three states. Not only is it important to assess the available water resources and document current water demands, it is also important to project future long-range depletions to the river systems. Depletions are water losses to a basin or system other than by naturally occurring depletions for wetland and riparian vegetation, and surface water or groundwater outflow. These depletions occur in five major categories: irrigation of crops, M&I use from public systems, secondary use in municipal areas, water surface evaporation and exports.

TABLE 9-8
CURRENT AND PROJECTED WATER DEPLETIONS

Use	1990 (acre-feet)	2040
Culinary	10,580	51,280
Secondary	11,170	45,520
Irrigation	51,300	37,600
Exports	2,600	9,100
Reservoir Evaporation	5,300	8,400
Shivwits Paiute Indian Band	300	[a]
Total depletion	81,250	151,900

[a]Unknown. Depends upon ruling on reserve water rights.

Current and projected water depletions for the Virgin River Basin in Utah are shown in Table 9-8. Values are estimated for the year 2040. Irrigation uses are expected to gradually reduce as existing agricultural land is converted to new residential development. The converted irrigation water may be available to meet the future M&I water supply. The increase in exports includes the potential delivery of 6,500 acre-feet of water to Cedar City. (See Section 9.7.4).

Two separate activities are currently underway which may modify the diversion and depletion values shown in this section. Washington County Water Conservancy District is cooperating with local communities, Washington County and Five County Association of governments on a study to determine Washington County's ultimate population based on a total buildout concept. A similar study may be undertaken in Kane County. The Division of Water Resources is conducting a detailed study in cooperation with local communities to better determine M&I water diversions and depletions for the basin. As these activities/studies are completed, they will be evaluated and the basin plan updated as appropriate.

9.9 Cloud Seeding

Cloud-seeding is an acknowledged method of increasing the water supply within a selected area. It requires the right conditions to be the most effective. During prolonged dry conditions, this program may not produce significant increases in precipitation. Recognizing the need for development of additional water resources, the state, through the Division of Water Resources, has participated in a cost-sharing winter cloud-seeding project. The Utah Water Resources Development Corporation initiated the program in 1973. The development corporation represents participating counties and conservancy

districts (Beaver, Carbon, Emery, Garfield, Grand, Iron, Juab, Millard, Piute, Sanpete, Sevier, San Juan, Tooele, Wayne and Washington). Participating entities pay a large part of the funds needed to operate the cloud-seeding program.

The winter cloud-seeding project was designed to produce additional snowpack in the mountains and increase the subsequent spring runoff. By comparing the amount of precipitation in a seeded area (target) to that in a nearby unseeded area (control), it is possible to estimate the seeding effects. An overall increase of about 11 percent has been indicated. This difference, with a 95 percent probability, is due to cloud-seeding. These results compare favorably with other winter cloud-seeding programs. A conservative economic evaluation of this increase indicates water is being developed for about one dollar per acre-foot. ■

9.10 References

1. Bureau of Reclamation. *Reconnaissance Report, Kanab Creek Basin, Arizona-Utah.* Boulder City, Nevada, 1971.

2. Clyde, Calvin G., *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Salt Lake City, Utah, 1987.

3. Cordova, R.M., *Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

4. Cordova, R.M., G.W. Sandberg, and Wilson McConkie. *Ground-Water Conditions in the Central Virgin River Basin, Utah,* Technical Publication No. 40, prepared by the U.S. Geological Survey in cooperation with the Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1972.

5. Hardy, Thomas B., Brent Bartz, and Wendy Carter. *Population Dynamics of the Fishes in the Virgin River from 1984 through 1987 and Impact analysis of the Quail Creek and North Creek Reservoir System.* Utah State University, Logan, Utah, 1989.

6. Leslie and Associates. *Hydrological Study of Beaver Dam Wash Aquifers in Mohave County, Arizona.* Cedar City, Utah, 1990.

7. State Engineer, *Twenty-Second Biennial Report.* For the Biennium July 1, 1938 to June 30, 1940, Salt Lake City, Utah, 1940.

8. U.S. Department of Commerce, Weather Modification Advisory Board. *The Management of Weather Resources*. Washington, D.C., 1978.

9. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study*. Salt Lake City, Utah, 1990.

10. Utah Division of Water Resources. *Inventory of Reservoirs and Potential Damsites in the Virgin River Basin as Supplemented*. Salt Lake City, Utah, 1988, 1993.

11. Ibid. *Municipal and Industrial Water Diversion and Depletion for the Virgin River and Kanab Creek Drainage Basins*. Salt Lake City, Utah, (In preparation).

12. Ibid. *Preliminary Analysis of Potential Damsites in the Virgin River Basin*. Salt Lake City, Utah, 1992.

13. Utah Division of Water Rights, *Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah*. Reports 1-8, Salt Lake City, Utah, 1960-1989 (also 1990-1991 unpublished).

14. Utah Office of Planning and Budget, Demographic and Economic Analysis. *Utah Data Guide*. Vol. 10, No. 1, Salt Lake City, Utah, 1991.

15. Ibid. *State of Utah Economic and Demographic Projections - 1990*. Salt Lake City, Utah, December 1989.

Section 10 Agricultural Water Conservation and Development

10 Agricultural Water Conservation and Development

10.1 Introduction

This section describes the agricultural industry in this hydrologic basin. It also discusses the problems and needs and areas of potential development.

Even though this is one of the fastest growing areas in the state, agriculture continues to be an important part of the economy. Spinoff from agriculture helps support employment and production in other industries and maintains economic diversity.

Agriculture is a unique industry in the Kanab Creek/Virgin River Basin of Utah. The climate is milder and the diversity of crop production is greater than other areas of the state. Double cropping is also possible. About the only thing in common with most of the state are the chronic water shortages.

10.2 Background

Less than two percent of the total land area is used as cropland primarily because of topographic restrictions; arable areas are not irrigated because of water limitations. See Section 5.3 for data on water supply. Nearly all of the land area is suitable for grazing, although not all of it is utilized. Typically, the irrigated cropland is confined to the bottom land areas along the rivers and streams. Much of the non-irrigated, dry cropland areas are located in the higher mountain valleys and benches where arable land and adequate precipitation occurs. See Section 3.3.2 for a discussion on climate. Rangeland is found from the low lying desert areas to the high mountain forest lands (See Section 3.3.4).

The number of farms has tended to increase over the last 10-15 years. This has been accompanied by a decrease in the average farm size. The total land acreage in farms increased between 1982 and 1987.[2] The irrigated cropland acreages have increased in Iron and Kane counties but decreased in Washington County. The total irrigated area has increased, especially in the last 15 years. These trends reflect the change from full-time farming to part-time operator with an outside job and an

increasing number of hobby farms or ranchettes. These changes will continue as more people move into the basin to spend their retirement years.

Each year, some cropland is converted to non-agricultural uses. This will continue. Boundaries of incorporated cities will continue to expand, infringing on present agricultural areas. Some new cropland in scattered tracts has been recently developed. However, water supplies are limited, so it is not likely many more new areas will be brought into production.

Cattle is the major farming industry. This industry consists of cow-calf operations with some beef production and dairies. Most of the crops grown are used to support these activities as are pasture and range lands.

There is some increase in water use per unit (tons, bushels, AUMs) of production in the warmer climates. The production per unit of resources utilized also increases because of the climate. For instance, five or more crops of alfalfa can be grown in the St. George area. At the same time, only three crops can be produced in the Orderville area. In the case of small grains, the same amount of water is required to grow a mature crop regardless of location.

10.3 Policy Issues and Recommendations

The policy issues revolving around the agricultural industry include maintaining the land base, reducing irrigation water supply shortages and watershed protection.

10.3.1 Agricultural Land Base

Issue - Agricultural lands are subject to conversion for other uses.

Discussion - The possibility of losing considerable agricultural land base could impact the rural economy. It is estimated about 7,000 acres will be lost to other uses. The rapidly increasing population requires more land for new residential developments. These developments are sometimes located in agricultural cropland areas and on a random basis. This isolates other tracts of agricultural land. As city corporate boundaries are expanded, they often include some of these tracts, complicating the operation of the cities and agriculture.

Consideration should be given to making federal and state administered lands available to ease this pressure. This can be accomplished by exchange or purchase. Many higher elevation fringe areas around the agricultural cropland are more suited to housing developments. Foundations are more stable and views are more enjoyable.

Another consideration is the right of land owners to make decisions regarding their property. Consideration should be given to farmland easement leases and development right purchases giving farmers alternative choices. This would allow the land to remain in agricultural production and provide open green space along with financial incentives.

Recommendation - City and county planners should prepare long-range plans to control sprawling development, particularly avoiding agricultural areas when possible. Zoning committees should avoid allowing indiscriminate variations where the viability of farmland operations would be affected.

10.3.2 Agricultural Water Supply Shortages

Issue - Irrigation companies depending on direct flow water rights from rivers and

streams are susceptible to late season shortages.

Discussion - The Kane and Washington counties water conservancy districts and irrigation companies need to pursue development of multipurpose projects to provide a more stable supply for late season irrigation use. Increased water storage volumes can also dampen year to year effects of dry and wet cycles.

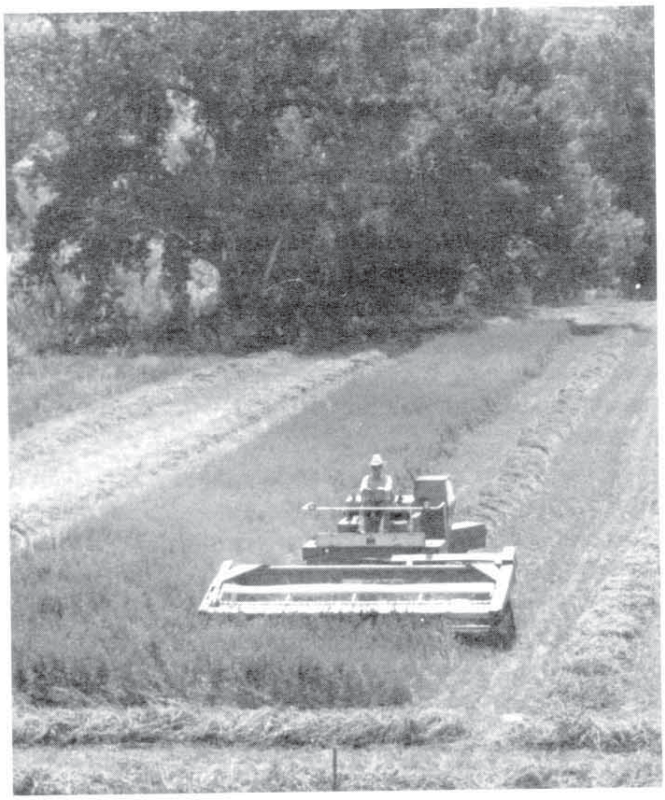
Improved use efficiencies can increase the irrigation water supply available by reducing deep percolation and excess tailwater. This can also be accomplished by improvement and timely maintenance and repair of diversion and conveyance facilities to reduce the loss of water available to individual irrigation companies. Onfarm irrigation best management practices can be a boon to efficient water conservation goals as well as increasing profits to farmers. See Table 10-6 for irrigation water use. Water users should encourage partnerships between irrigation companies and municipal and industrial organizations to improve off-farm and onfarm efficiencies for possible water exchanges. See Section 17 for further conservation discussions.

Recommendation - Irrigation companies, with assistance from Kane and Washington counties water conservancy districts and state and federal agencies, should move to protect and improve their water supplies by implementing water conservation programs and multipurpose projects when possible. Local soil conservation districts should assist by implementing and actively promoting these options.

10.3.3 Watershed Management

Issue - Many areas of severe and critical erosion exist in watersheds of the basin.

Discussion - Excessive sediment yield from both natural source areas and man's activities result in lower value wildlife habitat, degraded fishery values, less rangeland forage for grazing and higher treatment costs for M&I water. It indicates some lands are out of ecological balance, particularly in sensitive areas of the upland, desert and riparian zones of the watersheds.



The potential exists to improve the watershed conditions of these lands, reduce erosion and sediment and at the same time increase forage available for wildlife and livestock. Technical, educational and financial help is available through the Soil Conservation Commission's (SCC) Agricultural Resource Development Loan (ARDL) program. It assists ranchers and farmers and other private land owners to improve rangeland, cropland, wetlands and riparian zones.

Close coordination among agencies and organizations operating existing reservoirs or proposing to build new storage facilities is needed. Improvement of the watershed above these structures could be carried out to maximize use of available resources.

Recommendation - The Utah Soil Conservation Commission and its local soil conservation districts, working closely with the Soil Conservation Service, Forest Service, Bureau of Land Management and private land owners, should evaluate all lands of the watersheds for improvement projects. The Soil Conservation Service should vigorously pursue the current PL-566 Orderville-Muddy Creek Watershed Project and the Toms Canyon Flood Hazard Analysis.

10.4 Agricultural Lands

Lands used for agriculture cover a major portion of the Kanab Creek/Virgin River Basin. These lands are in all kinds of ownership and administration categories: private, tribal, state and federal. Table 10-1 shows the land areas owned and administered by the various entities with estimated acres of agricultural use. Only six percent of the total lands have soils suitable for cultivation. The balance is suitable for grazing only. See Tables 3-1 and 3-2 for basinwide land status data.

Lands used for farming can also be defined according to their agricultural production ability and potential. There are two categories: prime farmlands and farmland of statewide importance. The definitions for farmland of statewide importance have been modified for application to the state of Utah. Land designated as prime may not be the most productive in the county. It will, however, have the best combination of physical and chemical characteristics for producing food, feed, forage and fiber crops. To insure long-term production, these lands must be managed according to their inherent capabilities. There are about 17,000 acres of prime farmland and 26,000 acres of farmland of statewide importance.[4,5]

Prime farmlands have:

1. An adequate and dependable water supply from precipitation or irrigation, a favorable temperature and growing season, acceptable acidity and alkalinity, acceptable salt and sodium content and few or no rocks. A dependable water supply is one in which enough water is available eight out of 10 years.

2. A mean annual temperature higher than 32° F at a depth of 20 inches. Summer temperature of the soil is warmer than 59° F at a depth of 20 inches.

3. A pH value between 4.5 and 8.4 above a depth of 40 inches.

4. A water table that is maintained at a sufficient depth during the cropping season to allow cultivated crops common to the area to be grown.

5. A salt content of less than 4 mmhos in the upper 40 inches of soil. Also, an

TABLE 10-1
AGRICULTURAL LAND OWNERSHIP AND ADMINISTRATION[5,8]

Status	Virgin River (acres)	(percent)	Kanab Creek and Johnson Wash (acres)	(percent)
Private	400,000	24.4	80,000	20.3
Tribal	28,000	1.7	-0-	-0-
State	140,000	8.6	37,000	9.4
Federal				
Forest Service	280,000	17.1	7,000	1.8
Bureau of Land Management	790,000	48.2	270,000	68.5
National Park Service	-0-	-0-	-0-	-0-
Total	1,638,000	00.0	394,000	100.0

exchangeable sodium percentage of less than 15 percent.

6. No flood hazard, or flooding less often than once in two years.

7. Minimal erosion danger; K (erodibility factor) times percent slope is less than 2.0 and I (soil erodibility) times C (climatic factor) does not exceed 60.

8. A permeability rate of at least 0.06 inches per hour in the upper 20 inches.

9. Less than 10 percent of the surface layer consisting of rock fragments coarser than three inches.

Farmland of statewide importance has:

1. A water supply sufficient to permit economic crop production in five out of 10 years.

2. Summer temperature of the soils warmer than 59° F at a depth of 20 inches.

3. A pH value between 4.5 and 8.6 above a depth of 20 inches and an exchangeable sodium percentage of less than 15 percent.

4. A water table that does not prevent the production of food, feed and forage crops.

5. No significant salt content (less than 4 mmhos, in the upper 20 inches of soil).

6. No flood hazard nor flooding more than once in two years.

7. The product of K (erodibility factor) times percent slope is 5 or less.

These lands do not qualify as prime farmland because they do not have adequate irrigation water, are on relatively steep slopes with moderate to high erosion hazards, have a high water table and /or have salt or alkali problems. In general, these soils require more management than prime farmlands if they are to achieve satisfactory and sustained economic production. Prime farmlands are included in lands of statewide importance.

Some statewide important soils, now used for partially irrigated crops, could become prime farmland with full irrigation. Certainly the inherent soil texture, slope and salinity levels indicate excellent agricultural potential.

10.4.1 Rangeland

Currently, approximately 15 percent of the rangeland is in good condition, 45 percent in fair condition, 15 percent in poor condition and 25 percent not rated. Present range productivity was computed from reconnaissance level inventory data, existing data from conservation plans of individual private ranches and data furnished by the Forest Service and Bureau of Land Management.

At the present level of range management, range condition and utilization efficiency, rangelands in the Virgin River drainage are producing approximately 75,000 Animal Unit Months (AUMs) of grazing for livestock and wildlife. The Kanab Creek and Johnson Wash areas are producing about 17,000 AUMs. Wildlife forage allocation values are about 32,100 AUMs for Washington County, including the Enterprise area, and about 15,000 AUMs for western Kane County. An AUM is the amount of forage needed to sustain one 1,000 pound cow and a calf for one month, in this case, 800 pounds. Observed utilization efficiencies were used to compute the estimated AUMs of grazing being produced. The estimated number of AUMs presently produced and potential AUMs with improvements in each watershed are shown in Table 10-2 (approximately 200,000 acres were not surveyed).

There are six distinct climatic zones in the area. These zones differ by amount of precipitation, temperature and growing season. These are the high mountain, mountain, upland, semidesert, semidesert (30) and desert climate zones. There are four azonal sites within these zones where the influence of water table, flooding or some other factor is strong enough to override climate (See Section 3.3.2, Climate).

Available AUMs vary from as low as 25 acres or more per AUM in the desert areas to two AUMs per acre in the high

TABLE 10-2
AUMS BY WATERSHED[5]

Watershed	Present (AUMs)	Potential (AUMs)
Beaver Dam Wash	14,100	16,000
Central Virgin River	25,900	33,000
East Fork Virgin River	400	700
Muddy Creek Watershed	1,100	7,000
Fort Pierce Wash	2,800	8,000
Gould Wash	2,600	5,500
North Fork Virgin River	14,900	22,000
Santa Clara River	13,300	18,000
Virgin River Basin Totals	75,100	110,200
Kanab Creek	15,000	a
Johnson Wash	b	a
Basin Total	90,100	110,200

[a]Data not available
[b]Included in Kanab Creek

mountains, and three to five AUMs per acre in wet pastures. The AUMs permitted depend on the range condition. There is potential to increase the use with improved watershed condition, although there are areas where increased forage production is not possible.

10.4.2 Irrigated Cropland

There are 25,600 acres of irrigated cropland in the basin. Irrigated crops grown are alfalfa and grass hay, 31 percent; small grains and corn silage, four percent; orchards and row crops, six percent; pasture and turf, 34 percent and idle land, 25 percent. Most of the crop production is used to support the livestock industry, although some alfalfa is shipped out of the area. Table 10-3 shows a more detailed breakdown. Table 10-4 shows the irrigated cropland acreage changes over time. Also see Table 5-12 for the current use of water by county for irrigated cropland.

There are about 3,000 acres of irrigated cropland in Arizona and 4,000 acres in Nevada. These are all in the Virgin River and Kanab Creek drainages. There is no irrigated cropland on Johnson Wash in Arizona.

TABLE 10-3
IRRIGATED LAND BY CROP[8]
(acres by county)

Crop	Washington	Iron	Kane	Total
Fruit/Nuts/Vineyards	730	0	71	801
Grain	826	0	126	952
Corn	60	0	9	69
Other row crops	725	0	0	725
Alfalfa	4,725	255	2,195	7,718
Grass hay	462	0	268	730
Pasture	4,863	659	2,639	8,161
Turf	125	3	0	128
Idle plowed	662	72	101	835
Idle overgrown	3,202	518	1,696	5,416
Pasture, surf. & sub. irr.	200	15	146	361
Surface Subtotal	16,623	1,522	7,251	25,396
Sub. Irr. Pasture	60	0	147	207
Total	16,683	1,522	7,398	25,603

10.4.3 Dry Cropland

Dry cropland covers about 21,300 acres. These lands are generally located at higher elevations where the precipitation is greater. The primary crop is small grain. Some areas are planted to exotic grasses to provide grazing for livestock.

10.5 Watershed Management

Watershed management is the protection, conservation and use of all the natural resources of a specific watershed to keep the soil mantle productive and in place; and to assure that water yield and water quality meet the existing and potential uses. If not properly protected, watershed lands are readily damaged from erosion, flood, sediment and fire. Following are some watershed treatment measures:

- Livestock and wildlife grazing management.
- Vegetation improvement of the cropland, rangeland, pastures, forest land, wetlands, riparian zones and other areas. Also, conservation tillage protection on cropland coordinated with grazing management. Improved cropping sequences,

TABLE 10-4[1,5,6,7] IRRIGATED CROPLAND CHANGES			
County/Drainage	1955	1978 (acres)	1991
Ash Creek	1,390	1,370	1,520
Iron County Total	**1,390**	**1,370**	**1,520**
Virgin River	2,380	1,730	2,430
Kanab Creek	1,350	11,550	2,300
Johnson Wash	1,130	1,370	2,670
Kane County Total	**4,860**	**4,650**	**7,400**
Virgin River	14,880	13,230	12,430
Santa Clara River	3,520	3,700	4,250
Washington County Total	**18,400**	**16,930**	**16,680**
Total	**24,650**	**22,950**	**25,600**

pasture and hayland management and improved irrigation systems and management are important.

- Structural measures, such as contour trenching, debris basins, gully control and stream channel stabilization, in conjunction with vegetation improvement and grazing management.

For the purpose of this plan, the basin has been divided into nine watershed units as shown in Figure 10-1. Table 10-5 gives the areas and describes their condition.

The basin is an area with a high degree of soil and rock erosion activity. The sediment yield conditions for the river basin can be viewed in relationship to percent of total surface area versus percent of total estimated sediment yield as follows:

CLASS 2 (high yield) - 12 percent of the total area is yielding 35 percent of the sediment;

CLASS 3 (moderate high yield) - 48 percent of the total area is yielding 51 percent of the sediment;

CLASS 4 (moderate yield) - 24 percent of the total area is yielding 12 percent of the sediment; and

CLASS 5 (low yield) - 16 percent of the total area is yielding two percent of the sediment.

Sediment and salt yields from the CLASS 2 (Critical Erosion) areas are at least three times the background geologic rate. This is due to man's activities, mostly grazing, along with wildlife use. This

FIGURE 10-1
Watershed Map

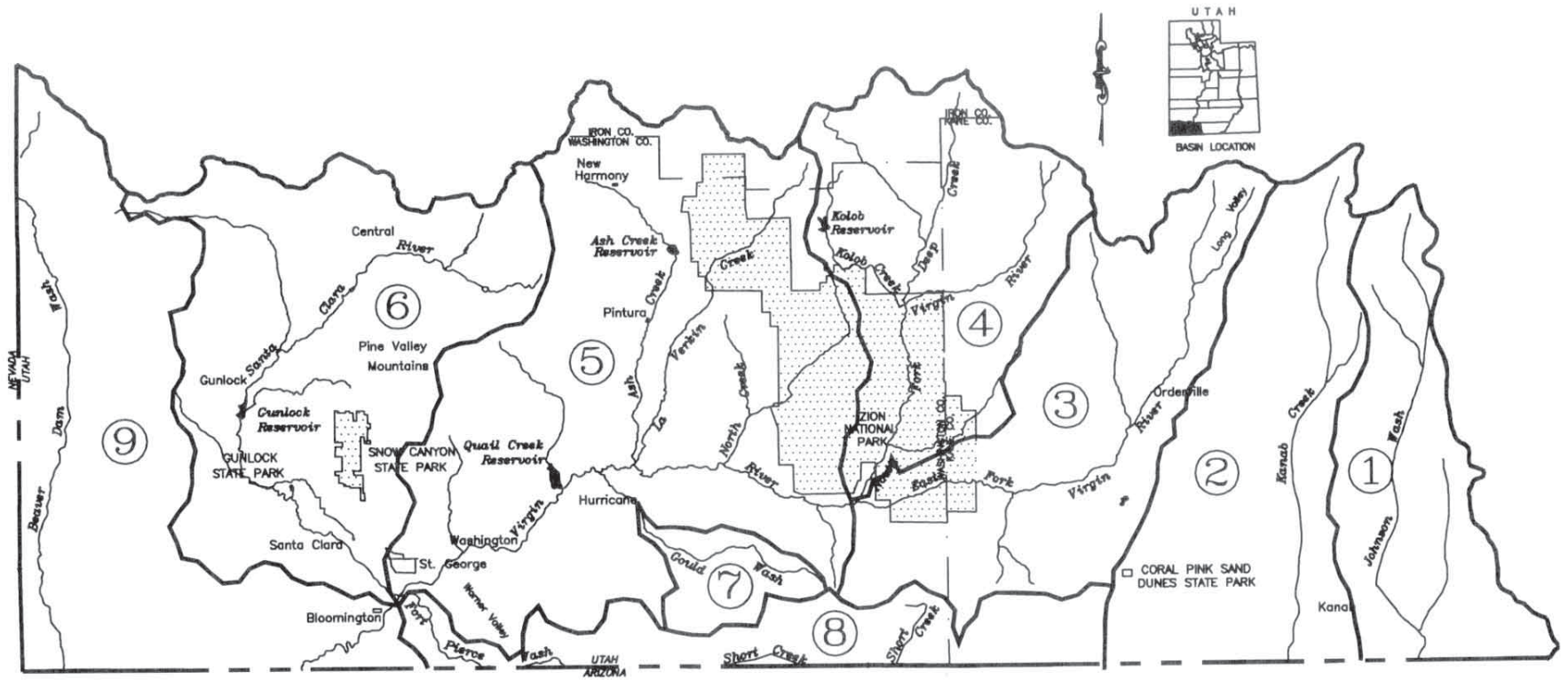


TABLE 10-5
WATERSHED CONDITION

Map No.	Name	Total Area (acres)	Range Condition (acres)		
			Good	Fair	Poor
1	Johnson Wash	210,000	a	a	a
2	Kanab Creek	190,000	a	a	a
3	East Fork Virgin River	258,000	500	183,000	43,800
4	North Fork Virgin River	229,300	18,400	138,700	13,800
5	Central Virgin River	524,200	63,100	170,600	61,700
6	Santa Clara River	349,600	51,200	139,000	46,600
7	Gould Wash	38,700	12,100	7,300	11,500
8	Fort Pierce Wash	130,000	9,200	57,000	24,200
9	Beaver Dam Wash	301,200	110,500	122,300	25,200
	Total	2,231,000	265,000	817,900	226,800

[a]Data not available

Note: Rock outcrops, urbanized and other miscellaneous areas and unsurveyed areas not included.

excessive sediment is depleting the watershed values. It is reducing wildlife habitat, degrading fishery values, lowering water quality in the Colorado River Basin, increasing sediment and salt loading to the Colorado River and degrading the value of rangeland grazing.

The critical erosion areas for each of the watersheds are shown on Figure 10-2 and described below in general terms:

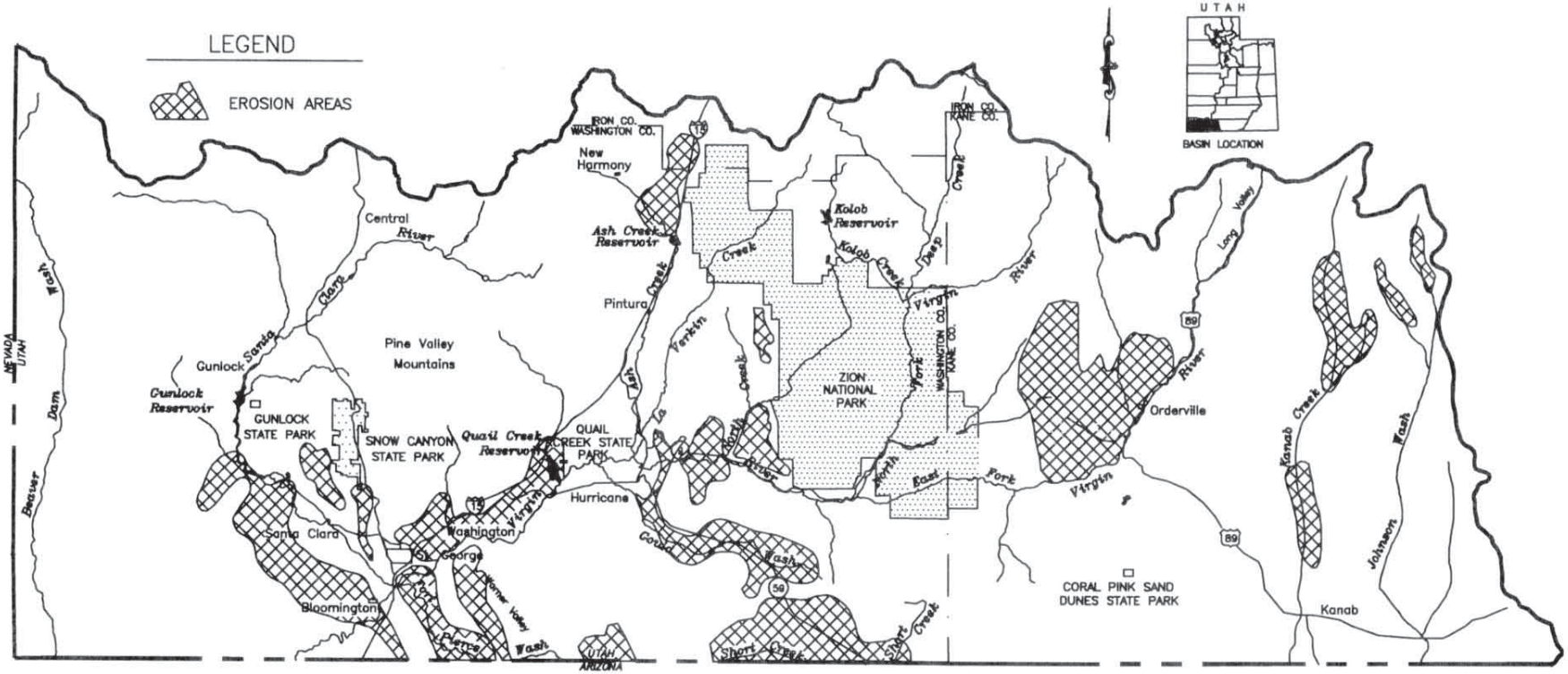
Kanab Creek and Johnson Wash - Data is not available, but there are critically eroding areas in both watersheds.

East Fork Virgin River - Critical erosion. Designated a priority watershed for non-point source pollution control. It also contains a Soil Conservation Service PL-566, small watershed protection project (the Orderville-Muddy Creek Watershed Erosion and Flood Control Project).

North Fork Virgin River - Contains many small areas of poor ecological condition lands.

Central Virgin River - Critical erosion, primarily in the lower reaches. Gypsum affects soils in the St. George/Bloomington area where there is an extremely sparse and

FIGURE 10-2
Critical Eroding Areas Map



fragile vegetative community. These are soils with severe erosion.

There is wind erosion in the New Harmony and Smith Mesa area on dry/arid areas.

Kolob Terrace has high natural erosion, but specific locations may have accelerated erosion from man-caused activities. These can be corrected.

Santa Clara River - Critical erosion in downstream locations. Western area of the upper watershed in poor ecological condition. Designated as a priority watershed for a non-point source pollution project.

Gould Wash - Critical erosion and excessive wind erosion in the Big Plains area where there is abandoned cropland.

Fort Pierce Wash - Critical erosion with high sediment yields and sand dunes in the Sand Mountain area.

Beaver Dam Wash - Critical erosion on the Virgin River drainage southwest of Bloomington.

10.6 Agricultural Water Problems and Needs

Currently, irrigation of crops depletes 51,300 acre-feet of water annually. Water budget and other background information has indicated there is an existing agricultural water deficit in the basin. For example, if all of the existing irrigated cropland (including idle land) with a valid water right were to receive a full water supply, an additional 19,000 acre-feet would be depleted. The water deficit can be reduced in many cases by reducing seepage and evaporation and improving irrigation efficiencies. It is not possible to salvage enough water from improved irrigation practices to meet the needs of all acres if they were planted to crops.

Many of the irrigation companies in the basin have already completed or have planned projects to improve overall irrigation efficiencies. The projects include reducing seepage losses by improving system management, lining canals and putting some canal sections in pipe. Projects to reduce onfarm losses include selecting a different irrigation method or improving an existing method. Operation and maintenance procedures have been recommended through conservation plans to many of the irrigation companies.

The agricultural use of water will change in the future. Some agricultural lands will be taken out of production and new replacement lands may be developed. It is estimated about 3,000 acres net of irrigated cropland will be converted to other uses by the year 2040. Projected irrigated areas, diversions and depletions for irrigated cropland are shown in Table 10-6.

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

10.7 Agricultural Water Conservation and Development Alternatives

There are irrigation pipeline projects being planned to conserve water such as those in the Santa Clara and Bench Lake areas. Even if other projects are pursued, it is assumed the cropland acres will decrease. The crop types most likely to be converted to non-agricultural uses are alfalfa, pasture and grains.

TABLE 10-6
CURRENT AND PROJECTED IRRIGATED CROPLAND WATER USE

Year	Area[a] (Acres)	Diversions (acre-feet)	Depletions (acre-feet)
1990	25,600	123,300	51,300
2020	21,400	96,300	43,300
2040	18,600	80,000	37,600

aIncludes some idle land.

The improvement of conveyance system and onfarm irrigation efficiencies has been identified as some of the actions to conserve water. Three irrigation companies have the possibility of converting to pressure sprinkler irrigation systems. These are Pintura, Leeds and New Santa Clara.

A major project on the Fort Pierce Wash could provide storage for up to 16,000 acre-feet if water were available through importation from the Virgin River. This project would reduce the danger of flooding, provide water based recreation and create the possibility of moving cropland acres from the St. George area to the Warner Valley area. There are arable soils in Warner Valley that could be converted to irrigated agriculture uses. This project would include diverting water from the Virgin River, eight miles of canal, 14 miles of pipeline, and a dam on Fort Pierce Wash.

Bench Lake could be more efficient by completing distribution system improvements as could the St. George-Washington Canal by providing irrigation water on demand.

Pintura and Leeds should look towards pressure irrigation pipelines.

The Mt. Carmel and Toquerville systems currently have open ditches for irrigation water and should look into installing pipelines.

Orderville needs to improve its irrigation system and also provide flood control devices for the town.

New Santa Clara Irrigation Company should look into sprinkler systems, providing a new diversion and installing eight miles of irrigation water pipeline.

St. George - Santa Clara Irrigation Company should replace its open ditches with 13 miles of irrigation pipeline. Veyo also needs to replace three miles of irrigation ditches with pipeline.

There are several practices to increase the rangeland carrying capacity. These include watering troughs and fencing for better livestock distribution, vegetation improvement through pinon-juniper and brush removal followed by reseeding and mechanical erosion control. Erosion control measures include contour terracing and trenching, gully plugs and water spreading techniques. ■

10.8 References

1. Bagley, Jay, Wayne D. Criddle, and Keith Higginson. *Survey of Utah Portion of Lower Colorado River Basin, 1955-1957.* Utah Agricultural Experiment Station.

2. Bureau of Economic and Business Research, Graduate School of Business. *1990 Statistical Abstract of Utah.* University of Utah, Salt Lake City, Utah, January 1990.

3. Bureau of Reclamation. *Reconnaissance Report, Kanab Creek Basin, Arizona-Utah.* Boulder City, Nevada, 1971.

4. Holt, Francis T. for Soil Conservation Service, Miles "Cap" Ferry for Department of Agriculture, and Dr. Doyle Matthews for Utah State University. *Memorandum of Understanding, Prime and Unique Farmlands.* Salt Lake City, Utah, 1985.

5. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study.* Salt Lake City, Utah, 1990.

6. Utah Division of Water Resources. *Hydrologic Inventory of the Virgin and Kanab Study Units.* Salt Lake City, Utah, 1983.

7. Ibid. *Water-Related Land Use Inventory of the Virgin River Area.* Salt Lake City, Utah, 1990.

8. Ibid. *Water-Related Land Use Inventory of the Kanab Creek/Virgin River Basin.* Salt Lake City, Utah, 1993.

Section 11 Drinking Water Supplies Development and Management

11 Drinking Water Supplies Development and Management

Adequate water for culinary use is required for the area's rapidly growing population. If growth is to continue, additional high quality water supplies will be required.

11.1 Introduction

This section discusses systems providing water for human consumption in the Kanab Creek/Virgin River Basin. Even though public and private water suppliers provide water for other uses, the primary purpose is for the benefit of people.

Public water supply systems are addressed whether they are publicly or privately owned. A public water supply system is one serving at least 15 connections or 25 people 60 days per year.

11.2 Setting

Until recent years, the water supply for public systems came from groundwater (wells and springs). Surface water is now being used more extensively as the population increases, especially in the St. George area where a new 10 mgd water treatment plant was constructed in 1989.

Culinary use (sometimes called municipal and industrial), refers to the water primarily used in homes, businesses and industry. It also includes the water used to irrigate lawns and gardens. (See Section 5.4 for definition).

Because the area does not have a heavy industrial base, population is the main factor controlling culinary water demand. Daily water use per capita (GPCD) can vary substantially depending on how much culinary water is used to irrigate lawns and gardens.

The state of Utah began a cooperative effort in 1977 with the U.S. Geological Survey to quantify water use data from public water suppliers and major self-supplied industries. The data are collected by the Utah Division of Water Rights through questionnaires mailed each year to public water suppliers. The data for 1979 through 1989 are summarized in published reports.[4] The 1990-92 data have not been published.

The current basinwide average culinary water use per capita day (GPCD) is about 350 gallons, which is higher than the state average of 284 gallons. The GPCD use ranges from 147 in Virgin and 152 in

Glendale to 389 in Washington (See Table 5-8).

Much of the variability between cities can be attributed to the amount of culinary water used for outside irrigation. This is partly because of the difference in lifestyle between rural agricultural areas such as Glendale and retirement communities such as St. George. Another major factor for the variability in per capita use is the large number of tourists and part-time residents in the St. George area who use water, but are not included in the census population. A mean annual July temperature variation of nearly 20°F. from the cooler to hotter areas also affects water use.

11.3 Policy Issues and Recommendations

Drinking water supplies are most important to the health and welfare of the local population. Issues and recommendations concerning drinking water are discussed below.

11.3.1 Drinking Water Quality

Issue - Drinking water quality needs to be continually monitored to assure a safe supply.

Discussion - Public water systems are managed to provide a safe, dependable supply to its users. The smaller private systems are more at risk because they lack staff to operate and maintain them. Some work has been started by the Five-County Association of Governments to help the smaller systems obtain adequate technical assistance. As more surface water is used, these problems will tend to increase.

Recommendation - State and local health authorities should review their monitoring programs and procedures to assure ample oversight - including monitoring, education and public awareness - is given to drinking water supplies.

11.3.2 Drinking Water Quantity

Issue - The high rate of population growth will increase the demand for municipal and industrial water.

Discussion - Because of the favorable climate in most of the basin, increasing numbers of people are moving into the area. A large increase in visitor-days of recreationists coming into the area also has been noted. These factors will increase the need for more high quality water than now exists. Even treatable lower quality water, including supplies converted from agricultural use, will become more scarce. Conservation of agricultural, municipal and industrial water can postpone the need in some locations.

Recommendation - Water suppliers need to project future demands and make plans to fill the potential needs by protecting and utilizing aquifer recharge areas, by developing more supplies and by implementing conservation.

11.4 Local Regulatory Organizations

All public drinking water supplies are subject to the Utah Safe Drinking Water Act and the Utah Public Drinking Water Regulations. These laws and regulations are administered by the State Department of Environmental Quality, Division of Drinking Water. The department has a district engineer stationed in St. George.

Towns, cities and counties have primary responsibilities for drinking water control within their respective entities. These responsibilities and authorities are contained in Sections 10, 11, 17, 19, and 73 of the *Utah Code Annotated, 1953, amended*. Private water suppliers (i.e. those serving fewer than 15 conections or 25 people) are not regulated.

In addition, the Board of Health, Southwest Utah Public Health Department, has responsibilities for controlling drinking

water and individual water well installation and construction. These responsibilities and duties are carried out through their staff. They work closely with the Utah Department of Environmental Quality on related regulations.

When private water systems are proposed to serve new developments, local planning commissions often ask the local health department to evaluate the feasibility of the water supply. Specific design and construction standards for these private systems are not assured once planning commission approval is received.

11.5 Drinking Water Problems

Increasing population will increase the demand for high quality water and the potential for contamination of drinking water supplies. Of the 78 drinking water systems in the basin, 35 are classified "Public Community" systems. Official ratings of public community water systems by the Division of Drinking Water are summarized in Table 11-1.

Problems can originate from several sources. They include poor water quality caused by geologic (natural) conditions, refuse from human sources such as landfills, chemical contamination from agricultural activities, land use abuse, mineral exploration, mining, construction and accidental hazardous waste spills. Sediment and salt loading from severely eroding rangeland also contribute to poor water quality.

As more surface water is used for culinary purposes, the possibility of contamination will increase. The increase in population and outdoor recreation activities will also increase potential problems.

Increased development of groundwater will affect existing water quality. This is particularly true as withdrawals from Navajo sandstone aquifers are increased. Contamination will come from overlying and underlying formations as hydraulic gradients increase. The recharge areas for the Navajo sandstone aquifer have been mapped (See Figure 9-2 for areas in Washington County). The protection of this area by local entities is essential if reliable underground water resources quality and quantity are to maintained (Also see sections 12.5 and 12.6).

11.6 Municipal and Industrial Water Needs and Demands

Estimates of future population growth are used to project future culinary water needs.

TABLE 11-1
RATINGS OF PUBLIC COMMUNITY WATER SYSTEMS

Rating	Iron	Kane	Washington	Total
Approved	1	4	23	28
Not Approved	0	0	2	2
Corrective Action Required	0	1	4	5
Total	1	5	29	35

Population projections for the cities and towns in Washington, Kane and Iron counties were made by the State Office of Planning and Budget. Table 4-1 and Figure 4-1 show their projections. Most public water suppliers expect an increased demand in the next 20 to 30 years. Some of these increases are in the 40 to 60 percent range. Several suppliers expect an increase approaching 100 percent or nearly double the current use. This will require continued long-range planning and development.

Projected annual water use for cities and towns is shown in Table 11-2. The projected water use for the basin is based on the assumption conservation is applied and the per capita use is reduced one percent per year from 1995 until 2010, one-half percent per year until 2020 and one-fourth percent per year until 2040. This value will vary considerably from community to community.

Conservation of culinary water could be accomplished with installation of household water saving appliances such as low-flow fixtures and low-flush toilets. Xeriscaping and proper lawn watering could also reduce demands. See Section 17 for further discussion on water conservation issues.

These water use projections can be used to help determine when new water supplies will be needed to meet future culinary demands. All systems should be evaluated for their ability to meet the future culinary demands by four dimensions: source capacity, storage capacity, legal capacity and distribution system capacity. The water sources, physically and legally (water rights), must be able to meet the peak daily flow as well as the yearly flow volume.

Storage facilities must have sufficient capacity to meet indoor water demands, irrigation and fire flow. The water distribution system capacity must be adequate to meet demands at the point of use. Even if adequate water is available at the supply source and storage is sufficient to meet peak demands, the distribution system must be adequate.

11.7 Alternative Solutions

Future culinary water development will mainly revolve around providing water for the area's rapidly expanding population. The water development required to meet future needs will come by way of several sources. These include developing surface water and groundwater rights, operating existing reservoirs to produce the highest possible yield, building new reservoirs, converting agricultural water to municipal

TABLE 11-2
CURRENT AND PROJECTED CULINARY WATER DIVERSION

City	Year			
	1990	2000	2010	2020
	(acre-feet)			
Alton	20	22	27	30
Kanab	1,330	1,740	2,130	2,440
Glendale	50	60	70	80
Orderville	100	110	130	140
Kane Co. Unicorp	170	220	280	325
TOTAL (Kane Co.)	**1,670**	**2,152**	**2,637**	**3,015**
Kanarraville (Iron Co.)	90	100	110	125
Springdale	110	140	170	200
Rockville	40	50	65	75
Virgin	40	50	70	90
New Harmony	40	50	65	75
Toquerville	90	130	175	215
LaVerkin	490	800	1,110	1,340
Hurricane	1,600	2,380	2,990	3,500
Leeds	110	140	165	190
Washington	1,830	3,340	4,810	5,970
Hildale	230	350	490	610
St. George	11,910	18,470	24,440	28,940
Ivins	360	770	1,320	1,790
Santa Clara	820	1,370	1,840	2,200
Washington Co. Unicorp	900	1,210	1,500	1,750
TOTAL (Wash. Co.)	**18,570**	**29,250**	**39,210**	**46,945**
BASIN TOTAL	**20,330**	**31,502**	**41,957**	**50,085**

Note: Refer to Table 4-1 for population projections.

and industrial uses and conservation programs. Seeking modification of instream flow requirements also has possibilities.

Further development of the Navajo sandstone groundwater aquifer should be investigated. This is particularly true in the St. George area where considerable use is currently from groundwater. Potential development from this aquifer in the Kanab Creek drainage seems to have promise. Development of the Navajo sandstone groundwater aquifer should be carefully planned to prevent long-term mining (Also see Section 19).

Surface water will probably provide an increasing proportion of the culinary water supply. In order to use developed and undeveloped surface water efficiently, new storage facilities will be required. Several potential reservoir sites have been investigated; potential sites are discussed in Section 9.7.3.

All alternatives should be evaluated based on current and future conditions. This process is outlined in Section 3.2.1. ■

11.8 References

1. Clyde, Calvin G., *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Salt Lake City, Utah, 1987.

2. Cordova, R.M. *Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70, Prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

3. Ibid, G.W. Sandberg, and Wilson McConkie. *Ground-water Conditions in the Central Virgin River Basin, Utah,* Technical Publication No. 40, Prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1972.

4. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources, *Virgin River Basin - Utah Cooperative Study.* Salt Lake City, Utah, 1990.

5. Utah Division of Water Rights. *Water Use Data for Public Water Suppliers and Self-Supplied Industry in Utah.* Reports 1-8, Salt Lake City, Utah, 1960-1989 (also 1990-1991 unpublished).

Section 12 Water Pollution Control

Tables

12 Water Pollution Control

Water quality is very important and often fragile. While natural environmental processes and controls provide a means, to some extent, for removing pollutants from water, there are definite limits on how much pollution can be assimilated in this manner. It is up to society to provide safeguards to protect and maintain water quality. This may require increased coordination of water quality and water quantity management.

12.1 Introduction

Water is polluted from two sources: natural pollution from geologic contributions and man-caused pollution. Man-caused pollution is from either point or non-point sources.

Point sources contribute pollution from such things as pipe discharges from industrial processes or wastewater treatment plants. Non-point pollution comes from diffuse sources via overland flow and gully erosion. These include pollution from activities such as agricultural related operations, rangeland uses, mining, construction and urban runoff.

12.2 Setting

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. These are enforced statewide.

Significant progress has been made since 1972 on improving water quality, including the Kanab Creek/Virgin River Basin. However, much more must be accomplished. Existing discharge permittees are shown in Table 12-1.

TABLE 12-1
MUNICIPAL AND INDUSTRIAL WASTEWATER DISCHARGES AND RESPECTIVE RECEIVING STREAMS

Community/Industry	Receiving Stream
Ash Creek (near Hurricane)	Total Containment
Long Valley	Total Containment
Kanab	Total Containment
Springdale[a]	Total Containment
St. George	Virgin River
Interstate Rock Products	Total Containment
Virgin Town Culinary	Total Containment

[a]Includes Zion National Park and town of Rockville.

The Utah Department of Environmental Quality has implemented a plan for the protection of groundwater. This plan is based on an Executive Order issued in 1984 by the governor of Utah. As a result, the *Ground Water Quality Protection Strategy for the State of Utah* was published.

During the process of preparing this strategy, many potential sources of groundwater pollution were examined. These included sources from agricultural operations, various types and methods of waste disposal, various operations such as mining and oil and gas exploration and other potential pollution sources.

The Department of Environmental Quality is in the process of putting this strategy in place. It includes such things as management, regulations, public information and education, legislation and technical assistance. In an effort to protect the groundwater, recharge areas of the Navajo sandstone aquifer have been identified. The delineation of the recharge area, physical extent and quality of groundwater will aid local governments in the planning of future developments and present use impacts on groundwater resources. This still requires the cooperation of local entities, businesses and individuals to make the strategy a success.

Where streams are deeply incised into consolidated rock formations, groundwater flows out of the rock directly into the streams or into unconsolidated material along the watercourse and then into the streams. Some aquifers where high quality water is now found are vulnerable to pollution by the activities of people. The Navajo sandstone aquifer is vulnerable because much of the outcrop area is in highly pervious sandy soil or lava flows. It is also located near populated areas. In these potential recharge areas, the aquifer is exposed to contaminants in precipitation and streamflow and to contaminants left in or on the land. The outcrop areas must be protected if the quality of the Navajo sandstone aquifer water is to

be preserved. Some areas, such as Snow Canyon State Park, are already protected. Other areas, such as City Creek, Middleton Wash, Mill Creek and Kanab Creek, are vulnerable.

Alluvial aquifers are also vulnerable to pollution; in some cases, they have already been adversely affected by the activities of people. These shallow aquifers must also be protected. Recharge areas for the Navajo sandstone have been mapped in Kane and Washington counties by the U.S. Geological Survey in cooperation with the Division of Water Quality (See Figure 9-2). The study was also funded cooperatively by the Kanab Area Water Association, Kane County, Kanab City and Garkane Power Association, Inc. The Five County Association of Governments pledged technical assistance for contract coordination and for planning and zoning.

As a result of this study, the following steps could be taken:

- classify groundwater and aquifers,
- revise land use in the county master plan to protect recharge areas,
- incorporate water quality and watershed protection in the Bureau of Land Management resource management plans,
- consider "sole source aquifer" designation.

12.3 Policy Issues and Recommendations

Two issues are involved in water pollution. The following are discussions and recommendations.

12.3.1 Water Quality Management Plan

Issue - The areawide water quality management plan for southwestern Utah, prepared a number of years ago, is now outdated.

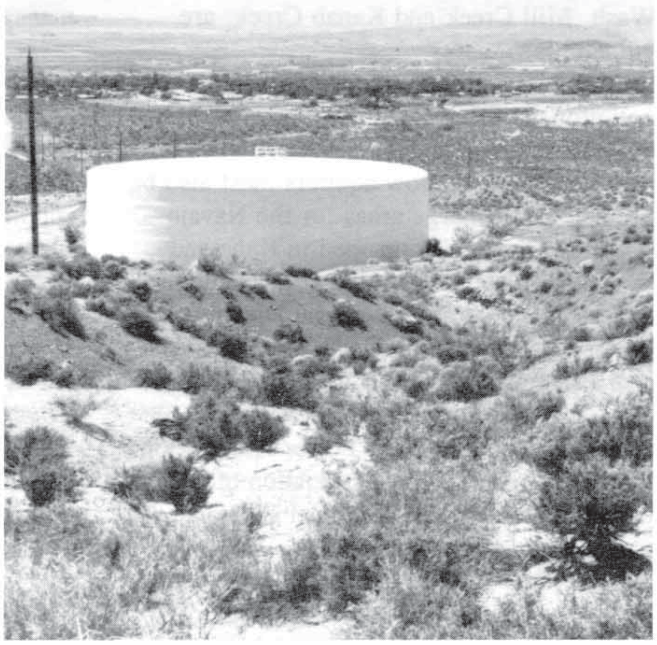
Discussion - As the population increases, so does the demand for high quality water . This is particularly true for culinary water supplies. The demand for water-based recreation will also increase. Agricultural water use should also be protected.

Recommendation - The Division of Water Quality, with assistance from other entities as needed, should update the *Five-County Areawide Water Quality Management Plan* to reflect current problems and solutions.

12.3.2 Local Aquifer Water Quality Protection and Management Plans

Issue - Preparation and implementation of "Local Aquifer Protection and Management Plans" is needed.

Discussion - Most groundwater use is currently diverted to meet municipal and industrial requirements. This use is expected to increase in the future. This could result in large overdrafts from groundwater aquifers, particularly in the Navajo sandstone formation. As a result, water quality could deteriorate at an increasing rate. Measures should be taken to prevent this.



State programs are not comprehensive enough to cover all activities which can be sources of groundwater contamination. The many activities leading to pollution of groundwater suggest it will be difficult in the future to maintain the high quality of water most of the people enjoy unless more care is taken by each municipality to protect its aquifers, wells and springs. Recharge areas in the Navajo sandstone aquifer should be designated as environmentally sensitive. Recharge areas for the Navajo sandstone aquifer were mapped by the Division of Water Quality in cooperation with the U.S. Geological Survey for Kane and Washington counties. These areas for Washington County are shown in Figure 9-2.

Recommendation - The Division of Water Quality and other appropriate entities should continue to study the groundwater resources to determine existing conditions. The Five County Association of Governments and local government agencies should work with the Division of Water Quality and other appropriate agencies to develop and implement local groundwater management and protection programs.

12.4 Local Regulatory Organizations

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

In addition, the Board of Health, Southwest Utah Public Health Department, has responsibilities for controlling public waste water, water pollution, septic tank

installation and construction and vector, i.e. mosquito control. These responsibilities and duties are carried out through their staff. They work closely with the Utah Department of Environmental Quality on related regulations.

12.5 Water Quality Problems

The Five County Association of Governments and others have reports and data on the areas' water quality. These should be studied by those interested for more detailed information than is presented in this report.

Historically, water quality and water quantity have been under separate jurisdictions. Changing conditions will impact this relationship. Increasing populations will require more high quality water to meet their needs. There will also be more water quality problems associated with increased recreational activities. This will require those concerned with water quality to work more closely with administrators of water rights. Eventually, close coordination will be required as one will directly influence the other.

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. Minerals dissolved in water are determined by rock and soil composition, climate, biological effects of plants and animals and water management and use as the water flows downstream.

Geologic pollution of surface water comes from areas where sediments are eroded from the land surface and washed into streams and rivers. These contain various chemicals depending on the source. Contamination of groundwater occurs as it moves through bedrock aquifers leaching out chemicals. This type of pollution is difficult to control. Natural erosion levels are high because of low vegetative densities, steep gradients and unstable substrates. Erosion contributes to increased salinity, concentration of trace elements, turbidity, sediment loading and biological oxygen demand.

Basin water quality problems are caused primarily by natural geologic and specific non-point sources. The water quality in the mountains is good compared to the lower elevation stream reaches.

Streams and lakes in the state of Utah are assigned water quality standards for maximum contaminant levels according to their established beneficial use designations. These standards are compared against the available water quality data to determine which parameters are exceeding the standards.

Virgin River[1,2,3,4,5] - Soluble salts are the main component of total dissolved solids (TDS) in streams. The highest TDS values on the East Fork of the Virgin River occur at a station south of Mt. Carmel Junction. The values there range from 396 to 1,986 mg/l and average 702 mg/l. The TDS values on the North Fork of the Virgin River and North, Ash and La Verkin creeks are below the standard of 1,200 mg/l for agricultural waters. The TDS values on the Santa Clara River at the station above the confluence with the Virgin River range from 302 to 2,138 mg/l. At that station, the average TDS value is 1,347 mg/l. The average TDS values on the Virgin River exceed the state standards at all stations downstream from and including La Verkin

Springs. The average values at those stations range from 1,459 to 1,898 mg/l. La Verkin Springs contributes water to the Virgin River with a TDS of about 9,000 mg/l.

La Verkin Springs presents a rather peculiar problem. The 9,000 mg/l of total dissolved solids produces downstream effects on agricultural, municipal and industrial and fish habitat uses.[1,2,7] These springs yield nearly 15 percent of the St. George and Washington Fields Canal Company diversion right. This salty water, when applied to irrigated cropland, requires leaching to keep the land in production. It also reduces crop yields.

The salty water reduces the woundfin minnow habitat. Conversely, the water is needed to maintain the instream flow. The high saline content makes it prohibitive to treat the water for culinary uses. Uses for industrial purposes are also unrealistic. Studies have investigated several alternatives to solve this saline water problem. So far, none of the alternatives studied has been cost effective. A new study has been proposed, but little progress has been made. See Section 9.7.5.

Samples collected from 19 springs and one well in the drainage of the East Fork of the Virgin River have a range in total dissolved solids from 145 to 2,703 mg/l and a range in hardness of 124 to 1,819 mg/l. The median values of these 20 samples (10 had less, 10 had more) were 450 mg/l for total dissolved solids and 350 mg/l for hardness.

The best water in the East Fork of the Virgin River drainage comes from springs in the Cretaceous sandstones and from a spring in the Claron Wasatch formation. Nine of the 15 samples collected from springs issuing from the Cretaceous sandstones have less than 425 mg/l total dissolved solids, although seven are very hard and two are hard. These nine samples probably come from the Kaiparowits or Wahweap sandstones and are low in all constituents except calcium and magnesium carbonate. Two of the samples, one from Big Springs in Lydias Canyon and one from the campground spring on US 89 which respectively contain 180 and 145 mg/l total solids, are of water as good or better than the water from the Navajo sandstone aquifer. The only sample from the Claron Formation contains 287 mg/l total solids and has a hardness of 278 mg/l. Five of the other six samples, probably from the Wahweap or Straight Cliffs sandstones, contain between 511 and 690 mg/l total solids. One of these samples, possibly due to surface contamination, contains more than 2,700 mg/l total solids. In addition to being very hard, the five samples contain 116 to 196 mg/l sulfates, appreciably more than the nine samples from the Kaiparowits and Wahweap sandstones.

One sample was collected from a spring, probably in the Tropic shale, in Dry Wash. It contained 527 mg/l total solids, was very hard and had 132 mg/l sulfate.

Two samples of poor quality water were collected from the Carmel formation in Spring Hollow and Red Hollow. These samples contained 809 and 1,017 mg/l total solids and sulfates of 258 and 458 mg/l. These waters are satisfactory for their present use of stock watering.

The only sample collected from a well in this drainage represents some of the poorest water of the area, yet the water used for municipal supplies in Mt. Carmel. This sample contained 1,825 mg/l total solids and

One other sample from a well in this drainage was collected by Nevada Power Company. This water, probably from alluvium, contained 750 mg/l total solids and is harder than most spring water in the vicinity. With adequate treatment it would be satisfactory for domestic use.

Iron readings occasionally exceed the state standard of 1.0 mg/l at two locations on the North Fork of the Virgin River. The readings reach 8.7 mg/l with an average of 1.01 mg/l on the North Fork of the Virgin River at the station above the confluence with the West Fork of the North Fork. Iron readings on Ash Creek near Toquerville range from 0.03 to 4.9 mg/l with an average value of 0.77 mg/l.

Kanab Creek and Johnson Wash[1,3,4] - According to H.D. Goode, all waters sampled in the upper and lower Kanab Creek areas were hard to very hard, but contained less than 500 mg/l total solids. None of these waters contained excessive quantities of silica, sulfate, chloride or iron. However, the excessive hardness of all but the sample from the Navajo sandstone in the lower Kanab drainage suggests that this water should be treated before being used for domestic, public and most industrial needs.

The groundwater from the Navajo sandstone in lower Kanab Creek is comparable to the water sampled from the Kanab City well in Three Lakes Canyon. This water is acceptable for culinary use.

The two samples from the Tropic shale near Alton are harder than any other surface samples from this drainage, and both contain more than 400 mg/l total solids. The evident similarity of the two samples in all constituents except sulfate supports the idea they have a common source.

The other four samples near Alton probably all come from Cretaceous sandstone; their range in total solids, 277 to 462 mg/l, and in other constituents can probably be attributed to the differences in the kinds and thickness of rocks through which the waters percolated before appearing as springs.

The high total dissolved solids in the samples collected by Nevada Power Company from wells 1 and 2 near Alton indicate three of the four samples came from formations containing large quantities of sulfate, presumably the Curtis or Winsor formations which contain gypsum. The fourth sample, although also containing appreciable sulfate, came from a source of better water, presumably the upper part of the Navajo sandstone. Water from this source lower in the Navajo sandstone, as indicated by the water from the Kanab City well and from the spring near lower Kanab Creek, is of better quality. See Section 11.7.

Samples from wells in Johnson Wash contained 1,227 and 790 mg/l total solids and both were high in sulfate. These waters are satisfactory for their present use, irrigation and stock watering.

A one time sampling event at several locations on streams in the basin shows the concentration of trace elements to be above standards in some locations. These include concentrations of lead, cadmium, mercury, chromium, copper and silver. More data is needed to evaluate trace elements in the basin.

12.6 Water Quality Needs

Naturally occurring processes in the Kanab Creek/Virgin River Basin affect water quality. In addition to this, recent and future

growth and development will create changes in water use and water quality. To adequately analyze water in the basin, the following ongoing water quality planning and monitoring programs are needed.

1) Routine and intensive monitoring should be continued. More emphasis should be placed on seasonal and episodic event sampling since data is deficient in that area. Additional monitoring is needed where there are no precisely identified sources of pollution.

2) 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 such as the Muddy Creek Watershed. The impact of management practices should be refined as additional data become available. Testing on surface water as well as groundwater is needed to determine if nutrient (fertilizer) and/or pesticide contamination has occurred, especially in vulnerable areas such as Washington Fields.

3) Further studies and sampling are required on lakes and reservoirs, of water quality near mines and geothermal wells and on contribution of TDS from groundwater movement in local aquifers. St. George basin urban runoff problems will need to be more extensively studied if anticipated population increases occur.

4) Monitoring can help determine contamination due to faulty septic tanks and the extent of contamination and sources due to leaking underground storage tanks.

5) Riparian vegetation needs to be re-established along portions of the river corridors where recreational impacts and grazing have destroyed the vegetation and compacted the soils. These impacts increase runoff that in turn increases salt and suspended solid yields in the streams.

12.7 Alternative Solutions

In the Kanab Creek/Virgin River Basin, non-point sources are the biggest contributor to water pollution. These sources are primarily geologic, but many are man-caused. Also, local government entities should work with state agencies to implement local groundwater protection programs.

Pollution caused by man's activities can be controlled or at least reduced. Landfills should be controlled by elected officials and located in areas where runoff or leaching will not contaminate water supplies. Controls on construction and other land surface disturbances will reduce pollution.

Where land cover has been depleted, (for example, from domestic livestock or wild animals) practices to re-establish vegetation will reduce erosion and the resulting pollution.

The Colorado River Basin Salinity Control Act was passed to provide financial and technical assistance to reduce salinity levels in the Colorado River Basin. Most of the current activities are directed toward agricultural non-point pollution problems. A more detailed discussion is found in Section 6.7. ■

12.8 References

1. Cordova, R.M. *Ground-Water Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70, Prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

2. Damery, Wm. E. *Local Ground Water Protection.* Division of Water Quality, GW Brochure #3, Salt Lake City, Utah, 1991.

3. Goode, Harry D. *Reconnaissance of Water Resources of a Part of Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 5, Salt Lake City, Utah, 1964.

4. Ibid. *Second Reconnaissance of Water Resources in Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water-Resources Bulletin 8, Salt Lake City, Utah, 1966.

5. Sandberg, George W. and LaVerne G. Sultz. *Reconnaissance of the Quality of Surface Water in the Upper Virgin River Basin, Utah, Arizona, and Nevada, 1981-82.* Technical Publication No. 83, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1985.

6. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study.* Salt Lake City, Utah, 1990.

7. U. S. Department of Interior, Bureau of Reclamation. *La Verkin Springs Unit, Utah, Concluding Report.* Boulder City, Nevada, 1981.

Section 13 Disaster and Emergency Response

13 Disaster and Emergency Response

13.1 Introduction

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

Reacting to a disaster or emergency after it has occurred is generally inefficient. This wastes time, money and other resources. Loss of life and threats to health and welfare are also possible. Pre-disaster activities such as floodplain management, hazard mitigation and mitigation planning are the preferred approaches.

Disasters are always traumatic experiences for those affected. Any emergency must be alleviated, but there is always a drain on resources.

13.2 Background

Statutory authority to carry out disaster related programs, including pre- and post-disaster hazards, exists at all levels of government. No entity, however, has all of the necessary authority to implement actions to mitigate a specific hazard or disaster. Agencies with specific authorities and assistance programs are discussed in the *Utah State Water Plan, 1990*; Section 3, Introduction; Section 13, Disaster and Emergency Response and Section 16, Federal Water Planning and Development.[4]

The Division of Comprehensive Emergency Management is responsible for disaster and emergency response at the state level.

13.3 Policy Issues and Recommendations

Policy issues regarding hazards, disasters and emergencies are discussed below. The prime responsibilities for most of these rest with local units of government. Also see Section 13, *State Water Plan, 1990.*

13.3.1 Hazard Mitigation Plans

Issue - Local governments should prepare hazard mitigation plans to protect life and property.

Discussion - A hazard mitigation plan is a joint effort requiring input from each involved office or agency to list many of the hazards facing a jurisdiction, to identify mitigation recommendations, to define implementation strategies with time frames,

to estimate costs and prioritize each recommendation. The objective is to save money over the long run and to protect life and property.

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 to reduce flood losses. Hazard mitigation plans can be implemented by communities to deal with identified hazards in the region such as flooding.

The Division of Comprehensive Emergency Management performs functions relating to hazard mitigation plans at the state level. They are responsible to prepare, implement and maintain mitigation plans and programs.

Recommendation - Local towns, cities and counties should prepare hazard mitigation plans with assistance from the Division of Comprehensive Emergency Management.

13.3.2 Floodplain Management

Issue - Local governments need to become aware of their responsibilities as it relates to floodplain management in order to qualify for the National Flood Insurance Program.

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.

Approximately 16 communities in the basin area are participating in the NFIP. The general area has approximately 56 policies in force and total coverage of approximately $3,741,000. A community agrees to enact and enforce minimum floodplain management requirements as stated in the Code of Federal Regulations, found in Part 60.3. In exchange for enforcing these regulations, flood insurance is made available to those who want coverage. Regulations apply to new construction and substantial improvements.

The Division of Comprehensive Emergency Management is the State Coordinating Agency for NFIP. The office can assist local participating communities in the implementation of the floodplain management objectives as defined by the NFIP.

Recommendation - Local entities should conduct an educational program to make residents aware of the benefits under the National Flood Insurance Program. The Division of Comprehensive Emergency Management should assist as needed.

13.3.3 Disaster Response Plans

Issue - All communities and counties in the basin should have a disaster response plan.

Discussion - Local governments need to increase their ability to respond to natural disasters and emergencies. Response plans need to be prepared ahead of time. Counties, cities and towns can coordinate efforts and responsibilities. Decisions should be made on leadership positions and activation of response activities. Disruption, contamination or exceptional shortfall in water supplies can occur during emergency situations and may result in a temporary

limitation of available water. When this happens, water deliveries may need to be prioritized in order to ensure critical needs are met first.

Kane and Washington counties have emergency operations plans in place. Emergency action plans have been prepared for Gunlock, Quail Creek, Ash Creek and Kolob reservoirs. These response plans address potential flood disasters.

The Division of Comprehensive Emergency Management has the statewide responsibility of planning for, responding to, recovering from and mitigating emergencies. They have developed statewide plans for disaster response. This agency can assist local entities prepare response plans for emergency situations.

Recommendation - Local entities should develop disaster response plans with assistance from the Division of Comprehensive Emergency Management.

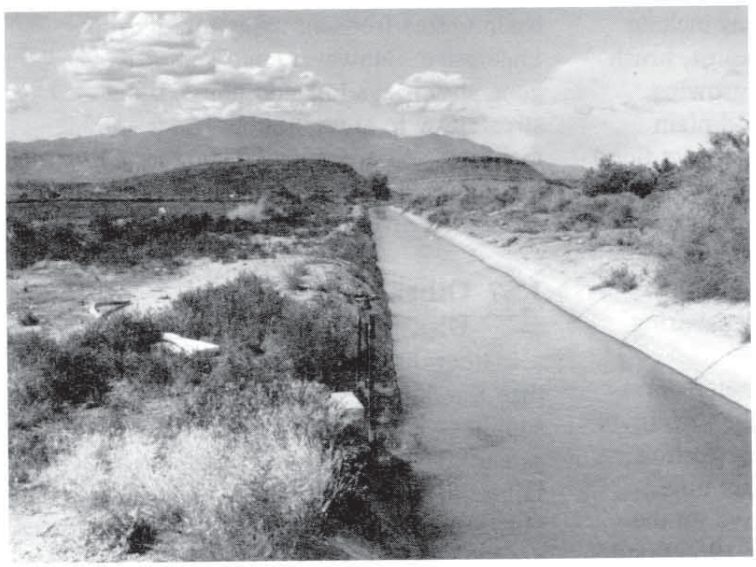
13.3.4 Flood Prevention and Floodwater and Sediment Control

Issue - Flooding is a problem throughout the basin. Measures need to be taken to prevent future damages.

Discussion - Records show floods have occurred since the earliest settlements in the basin. These floods have mostly damaged agricultural developments and facilities, but lately they have caused increased damage to residential areas. Construction of water storage reservoirs should include space for floodwater and sediment storage. The design should also provide for passing peak flows safely. Various other measures for controlling flood water and sediment are available. These include structural and non-structural measures as well as management activities in the watershed areas.

Several state and federal agencies have programs and funding for floodwater control. These agencies can assist local entities in many instances.

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



13.4 Local Organizational Structure

The cities and counties have primary responsibility for disaster response. Most entities have delegated responsibilities to specific individuals in their respective organizations. This was apparent after the

September 1992 Springdale earthquake where water and power interruptions were quickly restored.

13.5 Flooding Problems

Three types of storms produce flooding in the area. These are the general winter storms occurring between November and April which produce the watershed snowpack, the general summer storms occurring between May and October and the summer thunderstorms which normally occur between July and October.

Major flooding along the Virgin River is typically a result of the large general storms. Thunderstorms cover comparatively small areas and are usually a major factor in the flooding of the smaller tributaries to the Virgin River.

The same is true in the Kanab Creek and Johnson Wash drainages. Because of the smaller drainage areas, they are more susceptible to localized storms and cloudbursts.

Natural and man-made obstructions also affect flooding. Such obstructions include bridges across the rivers and streams, brush, large trees and other vegetation growing along the streambanks in the flood plain areas. 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 velocity of flow immediately downstream thereby scouring the stream channel.

Damaging floods on major watercourses are known to have occurred in the vicinity of St. George as early as 1858. See Section 5.3 for peak flow data. Since that time, several major floods have occurred on the Virgin River with the December 1966 flood having the highest recorded peak discharge. The flood of August 1971 had the highest recorded peak discharge on Fort Pierce Wash. The highest recorded peak discharge on Kanab Creek occurred during the flood of September 8, 1961.

Floods of the same or larger magnitude as those occurring in the past could take place in the future. Larger floods have been experienced in the past on other streams with geographical and physiographical characteristics similar to those found in the study area.

13.6 Drought Problems

Drought is a continuing problem because most of the basin is below 7,000 feet in elevation. As a result, winter snowpack accumulation is limited. This limits annual water yield rates and corresponding streamflow volumes and groundwater aquifer recharge. Refer to Section 5, Water Supply and Use, for streamflow data and Section 19, Groundwater, for aquifer data.

The hot, summer climate of most of the basin makes frequent irrigation of crops imperative. However, mid-summer generally brings low and non-existent streamflow in areas without water storage facilities. As a result, crops suffer. Even in the higher elevations, rangeland production of feed for livestock is reduced.

13.7 Other Water-Related Disaster Problems

Other disasters, generally more localized than flooding or drought, can impact water supplies. These disasters include such things as earthquakes, landslides and structural failure of water supply facilities. The Hurricane fault and Sevier Valley fault zones are high risk areas.

13.8 Flood Prevention and Drought Reduction Alternatives

In connection with the *Virgin River Basin Cooperative Study* report, a reconnaissance level hydrologic examination of the incidental flood control of two proposed water supply reservoirs was undertaken. The two sites are Shem, on the Santa Clara River (maximum water supply capacity of 25,000 acre-feet), and North Creek above the Virgin River confluence (maximum water supply capacity of 22,000 acre-feet). The damage centers are located at Green Valley on the Santa Clara River, the Virgin River above Fort Pierce Wash and the Virgin River at Bloomington below the Santa Clara River confluence.

To establish "without project" base conditions, the Virgin River basin was modeled without the proposed reservoirs. The Shem and North Creek sites were then each included in the model as water conservation reservoirs with no dedicated flood control pool. The 10-year and 100-year peak discharges were determined with and without the proposed reservoirs, based on computer modeling results, and plotted on log-frequency paper. Discharge frequency results from with and without project conditions indicate a reservoir on North Creek above the Virgin River confluence would have no significant effect on downstream peak discharges.

A reservoir at the Shem site also would have no significant reduction of peak discharges for the Virgin River. However, peak discharges on the Santa Clara River at Green Valley above the Virgin River confluence are very sensitive to the amount of water supply during a flood event at the Shem location. For a more detailed explanation of the evaluation for flood control of these proposed water supply reservoirs, see the Corps of Engineers draft report on the subject[1].

Similar studies should also be made of other potential sites to determine flood control possibilities. A potential debris basin site exists on Quail Creek to protect Quail Creek Reservoir. Efforts on the Muddy Creek upper watershed above Mt. Carmel are good examples of management and non-structural flood prevention measures. Flood Plain Management studies are underway in and northeast of Kanab.

Drought is probably the most perennial problem in the basin, due to the low precipitation rate. Lack of water storage facilities also contributes to the problem.

Weather modification is a method for increasing the precipitation rate. Cloud-seeding requires the right conditions to be most effective. Significant increases in precipitation may not be possible during prolonged dry conditions. Generally, this is a viable alternative available on a continuing basis.

Another alternative is increased use of water storage facilities. Several reservoir sites have been identified where water could be stored to supplement supplies during drier periods on a seasonal or holdover basis.

Groundwater development is another alternative for consideration. This may entail mining during prolonged dry periods. See Section 9.7, Water Development and Management Alternatives, and Section 19, Groundwater.

13.9 Disaster Response Recommendations

Several actions deserve consideration to alleviate disaster situations. Having plans or

facilities in place prior to disaster response requirements is always more effective.

Suggested actions include 1) development of disaster response plans by individual communities and counties, 2) investigation and construction of water storage and floodwater prevention projects, 3) continuation of weather modification programs and 4) family emergency plans. The Utah State Division of Comprehensive Emergency Management suggests all residents prepare a 72-hour emergency survival kit, which experts say is adequate time for relief efforts to reach most residents.Along with preparing a 72-hour 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 the safety of each.

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 to reduce flood losses. Hazard mitigation plans can be implemented by communities to deal with identified hazards in the region, such as flooding. ■

13.10 References

1. Corps of Engineers. *Hydrology for Evaluation of Proposed Water Supply Reservoirs*. Los Angeles, California, 1988.

2. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study*. Salt Lake City, Utah, 1990.

3. Utah Division of Water Resources. *Utah Drought Response Plan*. Salt Lake City, Utah, 1990.

4. Ibid. *Utah State Water Plan*. Salt Lake City, Utah, 1990.

Section 14 Fisheries and Water-Related Wildlife

14 Fisheries and Water-Related Wildlife

The Kanab Creek/Virgin River Basin supports a diverse and abundant wildlife fauna. Physiographically, the basin varies from alpine environments as high as 10,325 feet to 2,297 feet elevation in the Mojave Desert ecosystem of Beaver Dam Wash. The types of wildlife found in the basin also vary accordingly. The basin is home to several threatened and endangered species. The protection and recovery of those species will play a major role in determining the course of water resources use and development in the future.

14.1 Introduction

This section describes the fisheries and other water-related wildlife in the basin. Multifaceted recreational opportunities provided by wildlife and fishing can be enjoyed by all ages regardless of their situation. All forms of wildlife depend on water at some point in their lives. Water is being developed and associated riparian communities are being impacted. For these reasons, it is important to understand the relationship of fisheries and wildlife to other water-related resources. Some of this area has unique ecosystems supporting a diversity of rare species.

14.2 Setting

The Division of Wildlife Resources has the responsibility for management, protection, propagation and conservation of the state's wildlife resources. Some federal agencies have limited authority for wildlife management on lands they administer. Threatened and endangered species are primarily the responsibility of the U.S. Fish and Wildlife Service.

Planning for wildlife habitat needs is recognized as an integral part of basin water planning. Fishing, hunting and non-game wildlife activities contribute financially to the economy and these need to be considered in water development plans. The Division of

Wildlife Resources will assume the lead role in determining potential impacts (positive and negative) to wildlife resources from water development projects. The role of the Division of Wildlife Resources in water planning is:

1. Assess water development plans and specifically:
   a. Identify potential benefits to wildlife and their habitats.
   b. Identify potential adverse impacts to wildlife and their habitats.
   c. Recommend a course of action to mitigate project impacts to preservewildlife and their habitat for the public interest.
   d. Recommend termination if mitigation is not feasible or possible.
2. Provide factual information to decision makers regarding consequences of unmitigated and mitigated impacts to wildlife resources.

14.3 Policy Issues and Recommendations

This section addresses three policy issues. They deal with instream flows, wetland and riparian habitat and endangered species.

14.3.1 Instream Flows

Issue - Quantification of instream flow requirements in the basin is controversial.

Discussion - Instream flow is defined as water flow maintained in a stream channel. Instream flows are required to support fish populations, maintain riparian vegetation and streambank stability, achieve favorable conditions of flow in stream channels, provide aesthetic enjoyment and recreational use and supply normal daily requirements of birds and animals.

The Utah Code Annotated allows the Division of Wildlife Resources or Division of Parks and Recreation to file changes on perfected water rights in order to provide instream flows in designated reaches of streams. These flows may be acquired for preservation and enhancement of fisheries, the natural stream environment or public recreation. Flow releases from dams for other downstream uses often provide the necessary fluctuation as well as accommodate instream flow requirements along the way.

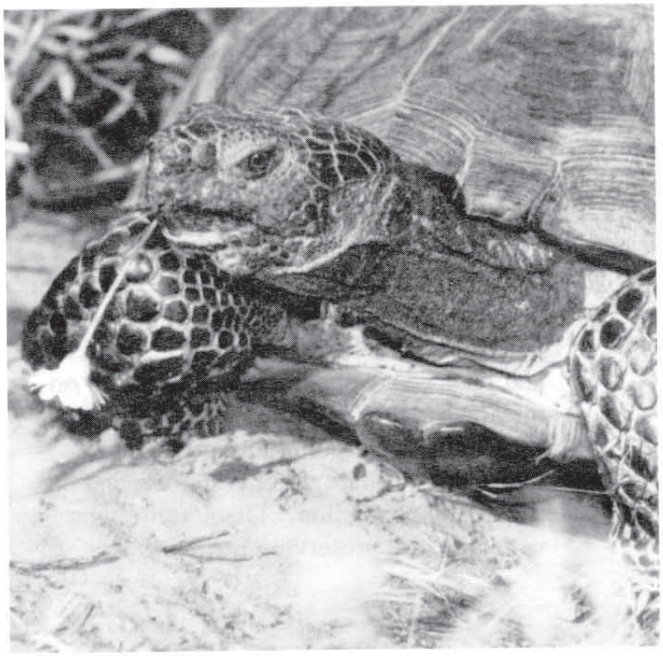
Instream flow decisions may affect some water development projects including reservoir operation, hydroelectric power generation, spring source development, irrigation and municipal uses. The *Utah Code Annotated* authorizes the State Engineer to reject an application to appropriate water or change use of a water right if, in the State Engineer's judgment, approval of the application would unreasonably affect public recreation or the natural environment. The U.S. Fish and Wildlife Service may also require instream flows in certain reaches of a stream if a particular segment is declared critical habitat for an endangered species. The Bureau of Land Management is conducting an instream flow inventory in the Virgin River Basin in connection with the Dixie Resource Management Plan.

Recommendation - Planning for water projects should incorporate instream flow considerations as part of project operating criteria.

14.3.2 Wetland and Riparian Habitat

Issue - Over the years, wetlands and riparian areas have been reduced in extent and quality.

Discussion - There are relatively few wetland areas in the basin. Waterfowl habitat areas are limited to a few "potholes" and marshes created by seepage from farm ponds, reservoirs and other water sources including springs and lakes. These are used primarily as resting areas for migrating birds, although some species live in these areas year-round. Some of the ponds are used for brood rearing as is evidenced by broods reared on a BLM reservoir on Little Creek Mountain and several other small reservoirs in the basin. Terrestrial wildlife also use these areas. Wetlands should be protected due to their importance to wildlife and human populations.



Riparian areas include land directly influenced by sufficient water to sustain growth. In general, over 80 percent of all wildlife species are associated with riparian areas at some point in their life cycle, although this zone accounts for less than five percent of the total land mass in the basin. This makes these areas important to wildlife.

Riparian communities in good condition exhibit an abundant and diverse assortment of plants. Healthy communities show good age distribution and the soil is mostly covered with vegetation. This provides streambank stability, maintains channel contours, regulates water flows and enhances water quality.

Kanab Creek, Johnson Wash, Virgin River, Santa Clara River and West Fork of the Beaver Dam Wash are all important habitat for terrestrial species. Present wildlife species include amphibians, 10; birds, 216; mammals, 63; reptiles, 29 and fishes, 35. Also see Section 16.4.8. Riparian vegetation is well developed along Kanab Creek, Johnson Wash, both forks of the Virgin River, the Santa Clara River, Fort Pierce Wash and the West Fork of the Beaver Dam Wash as well as several smaller perennial streams and around many springs.

Recommendation - Wetlands and riparian communities with significant values should be identified. The Division of Wildlife Resources should be contacted during project planning to provide input and suggest mitigation practices.

14.3.3 Endangered Species

Issue - Several species in the basin are now on the threatened and endangered species list or could be placed on the list. These should be considered where there are planned projects.

Discussion - The basin contains several federally threatened and endangered species (T&E). These species have full protection under the Endangered Species Act. See Section 16.4.8 for the definition of "take" for T&E species. In addition, some species are federally classified as Category 1 or Category 2. Category 1 species are up for listing as soon as funding is available. Category 2 species are those of which the U. S. Fish and Wildlife Service (USFWS) currently does not have adequate data to list as a T&E species. While species in these categories do not have federal protection, the USFWS encourages their consideration in long-range environmental planning. Planning and management for these species now may prevent them from being listed as threatened or endangered at a later date.

A list of the federally classified T&E species occurring in the basin area is shown in Section 16.4.8. Not all these species are physically found in water, but water development that includes upland or riparian habitats may still impact them. The USFWS or the Utah Department of Natural Resources Natural Heritage Program should be contacted for further information regarding plants.

The USFWS has jurisdiction over all T&E species. Any activities which may affect these species must be coordinated with USFWS. They are also responsible for recovery teams which address the T&E species. Recovery plans for some T&E species identify guidelines and stipulations for new development.

If T&E species are believed to occur in the proposed project area, USFWS must be contacted before starting the project. If federal funds are involved, this is usually automatically done. The USFWS will normally ask for a biological assessment to be completed if T&E species may be affected by the project. This assessment will look at the potential impacts of the proposed project. The USFWS will subsequently review the assessment and issue a biological opinion. This opinion may indicate the project cannot continue due to adverse impacts to the species or it may suggest a combination of mitigation alternatives which will allow the project to continue while reducing impacts to the species. Every situation is different.

Recommendation - Project sponsors should contact USFWS during the planning phase of any project to consider T&E and Category 1 & 2 species to alleviate potential problems. Consideration should be given to tradeoffs in public values during the listing and habitat management plans process.

14.4 Environmental Problems

Many environmental problems in the basin are the result of expanding population centers. Because of the mild winter climate, people are attracted from other areas to live and play. This puts increased pressure on the area's water resources.

Conflicts are going to increase in the future due to finite water resources and an expanding population. There are groups who advocate preserving resources by

instream flow protection while other groups depend on these resources for their livelihood. These conflicting demands will increase in the future.

14.5 Fish, Wildlife and Habitat Needs

Streams and lakes in the southwest part of Utah are on the northeastern edge of the Mojavian Desert region. The stream courses are generally associated with desert willow and Fremont cottonwood trees. The stream channels are usually wide to accommodate flash floods which occur periodically during the year. The streams usually have high water temperatures and sandy channel bottoms. There are few perennial streams in the region, and only a few of them accommodate sport fishing. The sport fisheries for the area congregate around Baker, Gunlock, Quail Creek and Kolob reservoirs and tributaries on the Dixie National Forest.

The Beaver Dam Wash drainage on the western edge of Utah is influenced some by the irrigation demands in the area. The flows are decreased the most during the summer when water demands for irrigation are high. The water channels are wide from frequent floods that scour the stream bottom. Native fish species that occur in this drainage include the Virgin spinedace. The West Fork of Beaver Dam Wash supports a natural habitat for rainbow trout reproduction, but there is limited access for fishermen. There are concerns the rainbow trout prey on the Virgin spinedace. No other sport fisheries exist in this drainage in Utah.

The Santa Clara River drainage is the most important to the fishermen because there are brown trout and rainbow trout in the upper parts and largemouth bass just above and in Gunlock Reservoir. There are also two reservoirs, Baker and Gunlock, that provide lake fishing. Baker Reservoir

contains rainbow and brown trout and is stocked periodically by the Utah Division of Wildlife Resources. Gunlock Reservoir is managed as a warm water fishery and contains largemouth bass, bluegill, black crappie, channel catfish and green sunfish. Two smaller reservoirs, the Upper and Lower Sand Coves, are located just northeast of Gunlock and contain largemouth bass, black crappie, bluegill and brown trout. The streams in this area are heavily used for irrigation. Portions of the Santa Clara are dewatered at various places for these practices. Many native fish species, including the Virgin spinedace, occur in this drainage.

The Virgin River drainage, the largest in this area, has the most water. This drainage has several fish associated with it. The Virgin River contains some brown trout above the Zion National Park boundary. Rainbow trout, cutthroat trout and brown trout can be found in several of the tributaries as well as the upper reaches on National Forest land. Brown trout are found throughout Zion National Park. Flash floods are common in some of the lower tributaries and may periodically almost eliminate the trout populations. Endangered fishes, the woundfin minnow and Virgin River roundtail chub, are found only in the Virgin River. The U. S. Fish and Wildlife Service has proposed the river be designated critical habitat for these species. The Virgin River also provides habitat for other native species including the Virgin spinedace, flannel mouth sucker, desert sucker, and speckled dace. The Virgin spinedace has been listed in the Federal Register as a proposed threatened and endangered species. The drainage has conditions common to desert streams where siltation, widely fluctuating flows and high water temperatures are occurring along the stream.

Kanab Creek and Johnson Wash drainages do not provide much in the way of sport fisheries. Flows are generally too small to provide adequate habitat for fish although terrestrial wildlife benefit from the water and riparian community. There may be limited aquatic habitat in the upper stream reaches. Flows in the lower reaches in Arizona support some native fish species.

Instream flows could provide more and better fish habitat and support riparian communities where perennial water is available. This may infringe on existing water rights in some areas. As a side benefit, reservoir storage releases could provide more adequate instream flows. The most desirable instream flows for native fish species may only be represented by the unregulated regime.

Riparian areas are important wildlife habitat for many species. Such areas generally offer all four major habitat components: food, water, cover and living space. The available water and deeper soils increase production of plant and animal biomass. The contrast with surrounding vegetation increases habitat diversity and the linear shape of a riparian area increases the "edge" between the contrasting vegetation types. Differing combinations of increased humidity, transpiration, vegetation height, shading and air drainages produce varied 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.

Some riparian areas have been degraded by livestock grazing and trampling. Degraded riparian areas can also reduce the water quality. Other areas have been

damaged by ATV travel and other recreational uses, as well as dewatering of streams. These can cause loss of some vegetation and associated wildlife values, loss of streambank stability and siltation.

14.6 Mitigation Policy

Where possible, it is easier and better to plan development projects to avoid the necessity for mitigation. In some cases, mitigation becomes necessary and it will become part of project plans. Mitigation alternatives to consider include maintenance of native fish communities and habitat and the associated ecological requirements.

The Bureau of Land Management has a riparian demonstration project where best management practices and instream habitat improvement work has been implemented. The North Creek demonstration project in Washington County began in 1979 in an area where most of the negative impacts were due to recreationists and livestock grazing. Sixty acres were fenced to prohibit use and to allow vegetation to re-establish. This site is still in the rejuvenation stage with vegetation becoming established.

Habitat can be classified according to value. Four categories of habitat are used in Utah. They are critical, high-priority, substantial-value and limited-value. Mitigation goals vary with habitat value, wildlife species and project plans. For example, the Virgin River Fishes Recovery Plan could be useful to help determine habitat value.

There are several approaches to mitigation. In order of importance, they are:

1. Avoiding the impact altogether by not taking a certain action or parts of the action.
2. Minimizing impacts by limiting the degree or magnitude of the action and its implementation.
3. Rectifying the impact by repairing, rehabilitating or restoring the affected environment.
4. Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.
5. Compensating for the impact by replacing or providing substitute resources or environment within the same drainage when possible.

14.7 Alternative Solutions

There are several alternatives to solving fisheries and water-related wildlife habitat problems. These need to be continually evaluated and updated.

Whenever reservoir storage projects are constructed, consideration should be given by interested groups and the Utah Division of Wildlife Resources to purchase conservation pools or storage water. This may enhance the fish and wildlife values, provide holdover storage during dry periods, and enhance instream flows for sport fisheries. Purchase of conservation pools and storage should also be considered in existing reservoirs. Rehabilitation of disturbed areas should also be a part of projects.

One way to defer use of riparian areas by livestock grazing is by providing water upland from stream banks. Options include upstream ponds, horizontal wells and wind power or solar energy to pump water to upland areas. Other ways to defer livestock uses of riparian habitat include fencing the area and managing it as a pasture or changing the season of use.

Another technique to assist with acceleration of re-growth on riparian areas is construction of instream structures. These include low head check dams, rock weirs, streambank protection, sediment traps, building up water tables, vegetation planting and/or anchoring trees or rocks to streambanks to prevent further erosion. ■

14.8 References

1. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study*. Salt Lake City, Utah, 1990.

2. Utah Division of Wildlife Resources. *File Data on Wildlife*. Salt Lake City, Utah.

3. U.S. Fish and Wildlife Service. *Virgin River Fishes Recovery Plan, Public Review Draft*. Prepared by Virgin River Fishes Recovery Team, Salt Lake City, Utah, 1992.

Section 15 Recreational Aspects Of Water Development

15 Recreational Aspects of Water Development

Outdoor recreation is one of several leisure uses of water: others are water and environmental education, scientific inquiry, recreation programs, active and passive outdoor recreation activities and skill training outdoor recreation activity. More specifically, water development uses include fishing, hunting, swimming, power boating, sailing, wind surfing, scuba diving, personal water craft uses, jet skiing, remote controlled model boats and aesthetic enjoyment. Many other activity facilities are favored on a water-related setting; e.g., camping, picnicking, trail uses including hiking, bicycle riding, mountain bike riding, ATV use and touring.

Water development generally contributes to the local, regional and statewide leisure and outdoor recreational estate or resource inventory. Free-flowing water is also an important part of the area resource.

15.1 Introduction

This section presents recent findings from the 1990-91 Statewide Household Recreation Survey conducted for the Utah State Comprehensive Outdoor Recreation Planning (SCORP) process.[5] Findings from a series of local public meetings are presented. These meetings resulted in the preparation of a priority list of key recreation and environmental issues to be addressed in the future. Some of the issues relate to facility development, including water developments in Utah. This section describes water-related aspects of outdoor recreation in the Kanab Creek/Virgin River Basin. This includes consumer or participant's expressions of outdoor recreation needs/demands, issues and alternative solutions.

15.2 Setting

While this area includes the lowest geographical elevation in the state of Utah (Mojave Desert-Beaver Dam Wash), it is also one of the driest with some of the highest and growing demands for water use. The major public land managers are the Bureau of Land Management, U.S. Forest Service, National Park Service and the Utah Division of State Lands and Forestry. They

control over 80 percent of the basin study area.[2]

The availability of and accessibility to water is a concern: "...many cities and towns throughout the country lament lost opportunities to conserve and provide public access to their river corridors..to integrate these corridors into the fabric of their communities..providing greenways and walkways..linking key recreational and community functions."[3] This concept is appropriate for access to lakes, wetlands and reservoirs as well.

Most of the study area is experiencing dramatic population growth and demographic change. The Washington County population has increased from 26,065 in 1980 to 48,560 in 1990, an increase of over 86 percent. Much of the increase is due to immigration of retirees. Youth and mature populations are heavy users of recreation facilities and programs. Much of the mature or retirement community is seasonal; i.e., November through April.

The area offers an interesting and diverse topography - high alpine and montane forests, open woodlands and desert shrub lands - each offering a range of temperatures, vegetation and climate throughout the year that can accommodate a variety of outdoor recreation activities. As anticipated, sites associated with water are most often preferred.

The State Division of Parks and Recreation manages over 10,000 acres of state parks in the basin. These data are shown in Figure 15-1.

The Bureau of Land Management (BLM) administers approximately 1.07 million acres. This is about five percent of their total 22.1 million acres in Utah. Developed and protected recreation areas are Baker Dam Campground, 20 miles north of St. George; Piute/Beaver Dam Mountain Wilderness Area, 15 miles southwest of St. George; Red Cliffs Campground, 4.5 miles southwest of Leeds on the I-15 frontage road and Ponderosa Grove Campground, seven miles west of US-89 on Hancock road. This represents less than 30 campgrounds and about 10 developed camp sites.

The U.S. Forest Service manages about 299,200 acres, or 13 percent of the study area; the National Park Service manages about 142,000 acres, or 6.4 percent and the BLM manages about 1,068,900 acres, or about 48 percent. This represents about 1,510,400 acres or about 68 percent of the basin area. In terms of potential availability and accessibility, federal or public lands have one of the highest potentials for outdoor recreation use. The availability of relatively remote public lands is particularly attractive to southern California population centers where citizens enjoy escaping to

Utah's high quality open space; and for the +700,000 foreign guests, many of which visit southern Utah parks and open space and spend over $700 million dollars in Utah. Tourism now represents over $2.1 billion of economic activity in Utah (lodging, transportation, food and retail sales). Over 2,800 jobs are related to tourism in the Southwest Multi-County District (MCD).[4]

Zion National Park has 381 developed campsites, six primitive sites, and 12 river sites. The Dixie National Forest has about 48 RV campsites and 46 formalized tenting sites. The Utah Division of Parks and Recreation has 59 RV campsites and about 57 tenting sites. Private providers have about 1,468 RV campsites, and about 192 tenting sites. The BLM reported 20 RV campsites (10 at Red Cliffs and 10 at Baker Dam Reservoir) and 20 tenting sites. Washington County also has 41 miles of Scenic Byways: Highway 9 from I-15 to the county's east boundary (36 miles) and a five-mile route at a turnoff from I-15 to Kolob Canyon (NP). The county enjoys 62 miles of Backways: the Kolob Reservoir road from Virgin on U-9 north to Cedar Breaks (30 miles in the county), the Smithsonian Butte Road connecting Hildale on U-59 and Rockville adjacent to U-9 (9 miles), the Mojave Desert/Joshua Tree Road beginning on US-91 and ending at US-91 totalling some 16 miles and Snow Canyon road (Route 300) beginning in Ivins and traveling through Snow Canyon State Park to U-18 (7 miles)[5].

Kane County has about 147 miles of Scenic Byways: Highway 14 from U.S. 89 to the Iron County line, Highway 9 from Mt. Carmel Junction to the Washington County line and U.S. 89 from the north to the south county boundary. Backways are also designated.

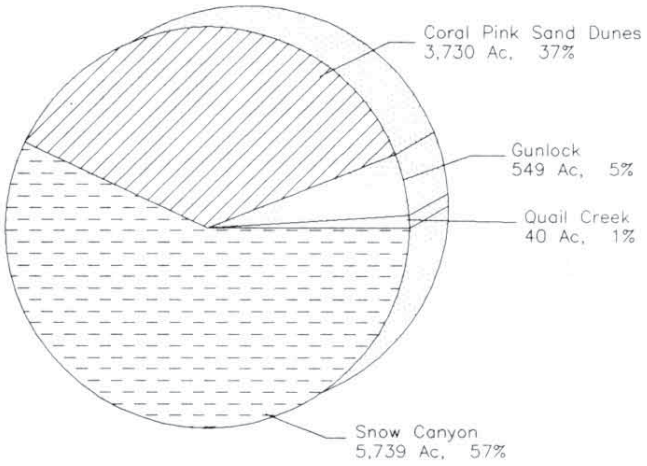
15.2.1. Federal Land and Water Conservation Fund Projects

Fourteen Federal Land and Water Conservation Fund (LWCF) Projects have been match-funded in Washington County since 1971 (See Figure 15-2). The projects, including 50 percent LWCF match, exceed $2 million in cost. They include three swimming pools, development in one state park and park projects in Bloomington, Santa Clara, St. George, Washington, Hildale, Ivins, Virgin and Hurricane. No projects have been submitted for reservoir or lake recreation facilities at this time; i.e., outdoor recreation on water developments.

15.2.2 Utah Recreational Trails Grants

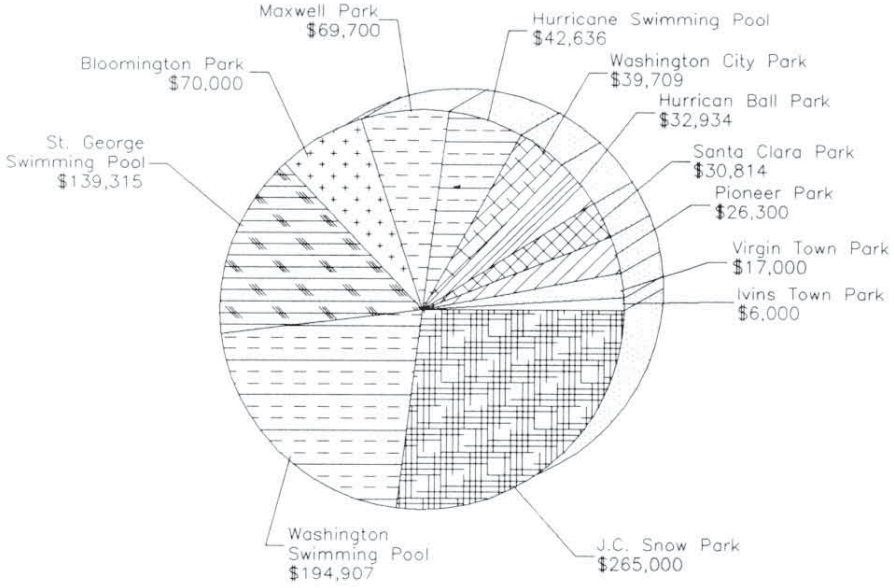
Under the Utah Senate Bill 52 (1991) Statewide Trails Program, several important non-motorized trails projects have been funded in the study area. Two of them are the Virgin River Rim Trail in the Dixie National Forest ($7,000 match for a plus $25,000 trail project) and the Virgin/Santa Clara River Greenway in Washington County, sponsored by "Walkways West Utah" ($20,000 match for a plus $50,000 project). These projects are important because they are intended to link communities, special use areas, parks and other public facilities as part of a statewide non-motorized trail system. Other projects on these drainages are proposed in the future.

FIGURE 15-1
State Park Acreage in Multi-County Planning District



Source: State Park Real Estate Inventory, 1992

FIGURE 15-2
Land and Water Conservation Funds, 1971-1991, Washington County



Source: Utah SCORP, 1992
Note: Total cost, $2+Million
Snow Canyon State Park,
additional $65,790

15.2.3 State Riverway Enhancement Program

In addition, (Senate Bill 143, 1986) a major park has been funded on the Santa Clara River near Green Valley in association with a linear trail along the Santa Clara River. The project will provide a major staging area and day use facility. Construction is currently underway on this +$30,000 project. This program was established subsequent to the success of the Provo-Jordan River Parkway program to reduce flood damage, enhance water quality, provide outdoor recreation, provide fishery and wildlife habitat, aid in water reclamation, protect cultural resources and provide a non-consumptive amenity in terms of functional open space along important river corridors throughout the state. This program is intended to protect river corridors and provide public access, which is a major statewide issue and need according to the Utah SCORP planning process and public surveys.[5]

15.3 Major Issues Identified

The following major issues surfaced in a public meeting held in Cedar City in late September 1990. The issues were prioritized by those present:

- The need for improved highway and site signage - better directions to facilities, public and private

- A critical need to provide stable and/or new recreation funding sources

- The need to improve and update recreation facility and support facility infrastructure to encourage revenue generation from tourism

- Provide more winter recreation opportunities - longer season for tourism and leisure service businesses

- Improve the comprehensive planning process for the allocation of the natural resources; i.e., look at all uses/conflicts/opportunities for any water development, highway and resource development

- A need for a comprehensive localized and connecting trail system linking key resource areas such as reservoirs, lakes, forests, national and state parks, community parks, Great Western Trail and American Discovery Trail

- Improve government agency cooperation and coordination--reduce costly redundancies; come to a disposition of "federal wilderness issues" - one way or another...get on with it!

Some of the participants noted that over 50 percent of all tourists visiting the state of Utah pass by St. George and Cedar City on I-15. They want to attract more of those visitors at well designed and accommodated facilities in the study area.[5]

A similar request, again as part of the Utah SCORP process, was made to recreation-providing agencies in Utah early in 1991. They were asked their major concerns or issues. These are listed below:

- Inadequate funding of their respective agencies
- Need for interagency coordination

- Assuring environmental quality
- Public and private cooperation - partnerships, coordination
- Vandalism is a major concern
- Need for recreation development and infrastructure improvement
- Rising costs of liability insurance
- Deteriorating facilities and systems
- Securing volunteers - importance of volunteerism
- Communicating and justifying the economic significance of recreation
- Overcrowding of existing recreation facilities and resources
- Law enforcement
- Access to public lands - closures by private land owners
- Recreation water allocations - leaving enough for recreation and fisheries
- Environmental education - reducing conflicts, damage and management costs.

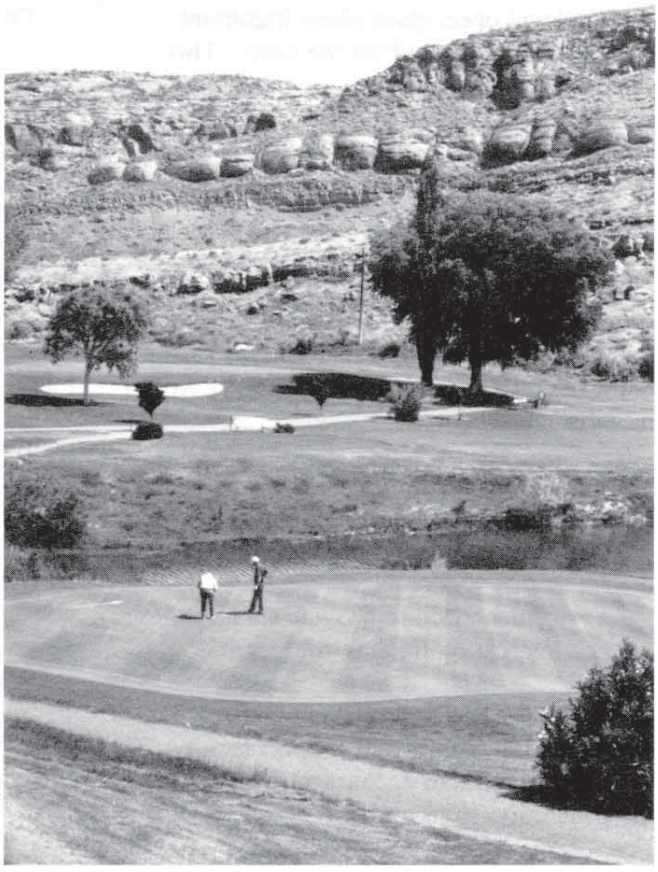
Over 23 issues were identified by government agencies. These range from funding to wetland and cultural site protection, application of computer technology, greenways and trail development needs. It was understandably different from the issues identified by resource users - with a few common concerns for funding, new facilities, wilderness, government coordination and access problems. Many of these issues can be realized or obviated by good design, adequate capitalization, public participation in the planning process and good coordination and management of water resource development or river corridor protection.[5]

15.4 Outdoor Recreational Use

The use of recreation areas has been rapidly increasing during the past number of years. This use is expected to increase even faster in the future.

15.4.1 Utah State Parks

Four parks are within the study area: Coral Pink Sand Dunes (110,417 visitation, 1991); Gunlock (34,190 visitation, 1991); Snow Canyon (192,000 visitation, 1991, plus an estimated 262,341 counted on Route 300



(through the park for the first time) and Quail Creek Reservoir (visitation unavailable). Discounting the first ever highway count through Snow Canyon, visitation to these study area parks increased 16.3 percent. This is delineated in Figure 15-3.

15.4.2 Zion National Park

Park visitation increased over 48 percent from 1985 to 1991; i.e., from 1.69 million to over 2.5 million in 1991. From 1990 to 1991, visitation grew about 6.4 percent (+134,592) in one year to 2.23 million.[7]

15.4.3 Economic Development Administration Tourism Study

This study has developed an inventory of tourism support facilities. The Southwest Multi-County District has 12 airports (nine have no services), 12 roadside rest areas, 118 campgrounds, 123 cultural/recreational sites and over 5,500 rooms in 200 motels. Several general conclusions about the 1992 Tourism Study include:

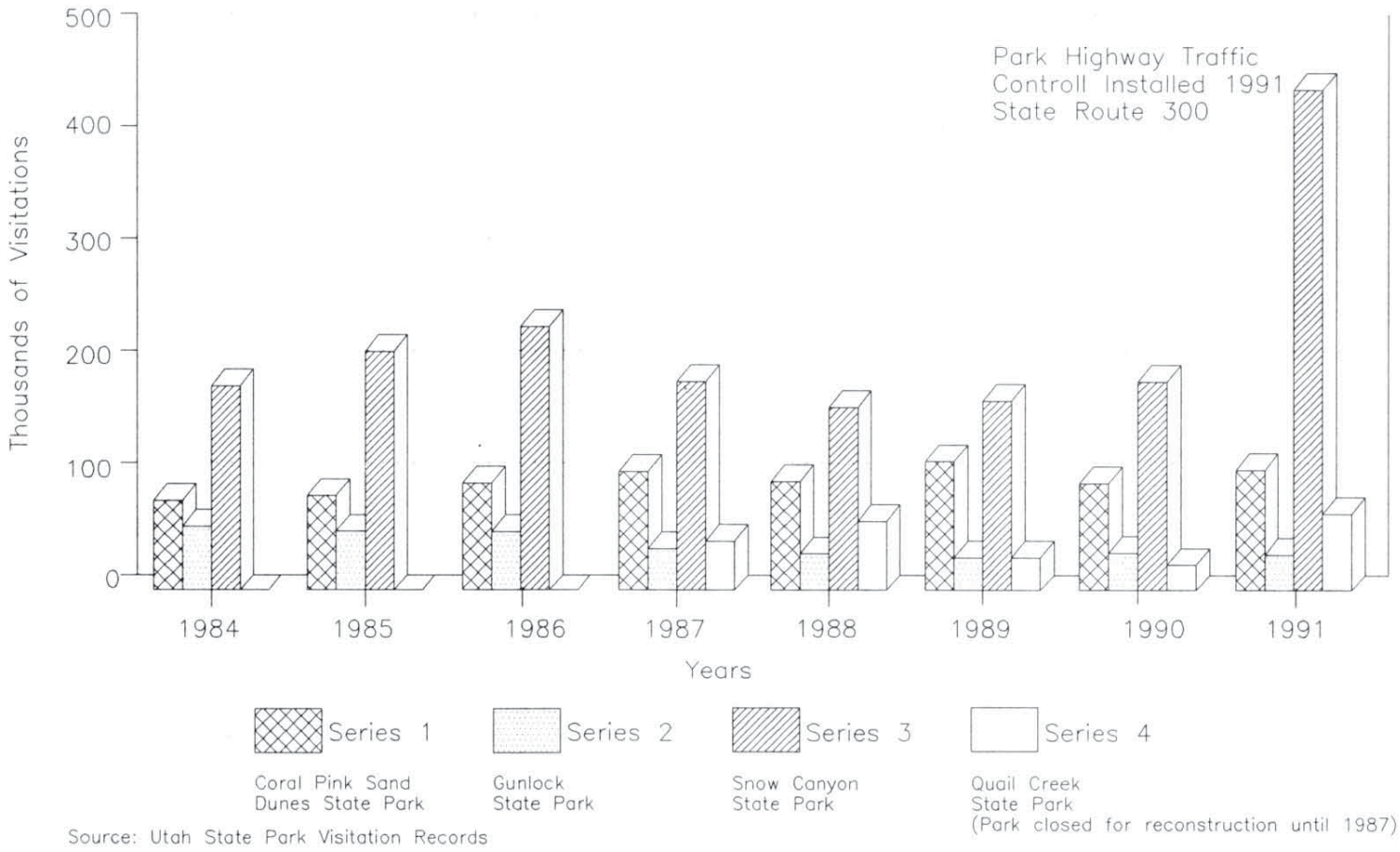
- Tourism represents one of the most important activities in the Utah economy
- Prospects for continued growth in the industry are favorable
- Impacts on state and local revenues are generally positive
- Tourism can help stabilize and diversify the economic base without displacing other industries
- Although the infrastructure to support tourism is substantial, improvements and/or additions are needed, particularly in state and federal parks/recreation areas
- Many sources exist to finance tourism infrastructure improvements.[4]

The study concludes with the importance of resident and non-resident tourism. Most data are related to non-resident tourism. High quality recreation facilities are critical to the success of tourism and marketing in the state of Utah. Major funding and the discovery and utilization of new sources of revenue continue to be of the highest priority. Water development should incorporate adequate infrastructure for leisure services and facilities and provide continued support for operation and maintenance.

15.5 Outdoor Recreation Activity and Needs

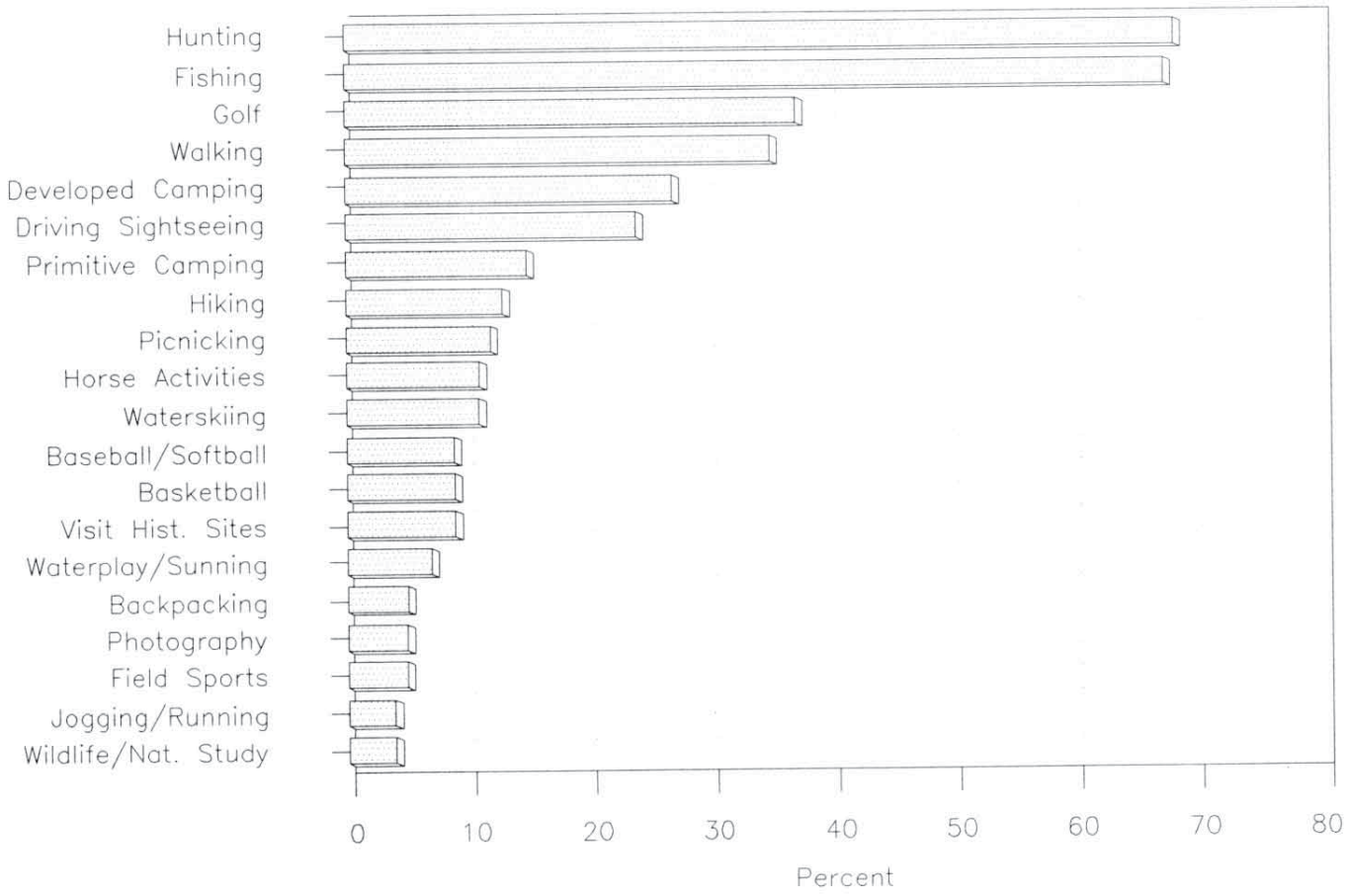
The following series, Figures 15-4 thru 15-8, are from the 1990-91 Utah SCORP Household Survey[4] of over 2,400 homes in Utah. The figures describe the top favored "individual" outdoor recreation activities, the top 20 favorite "family" activities (we do different things in a group or with family), new "community facilities that are needed", "statewide facilities needing improvement" and new "statewide facilities needed." These probably relate more to water developments. Also broken out are Washington County's favorite "individual" and "family" activities. Obviously, many activities and facilities are preferred near water, while a few, like fishing and boating, are clearly dependent on water or water developments (reservoirs). ■

FIGURE 15-3
State Park Visitation: 1984-1991



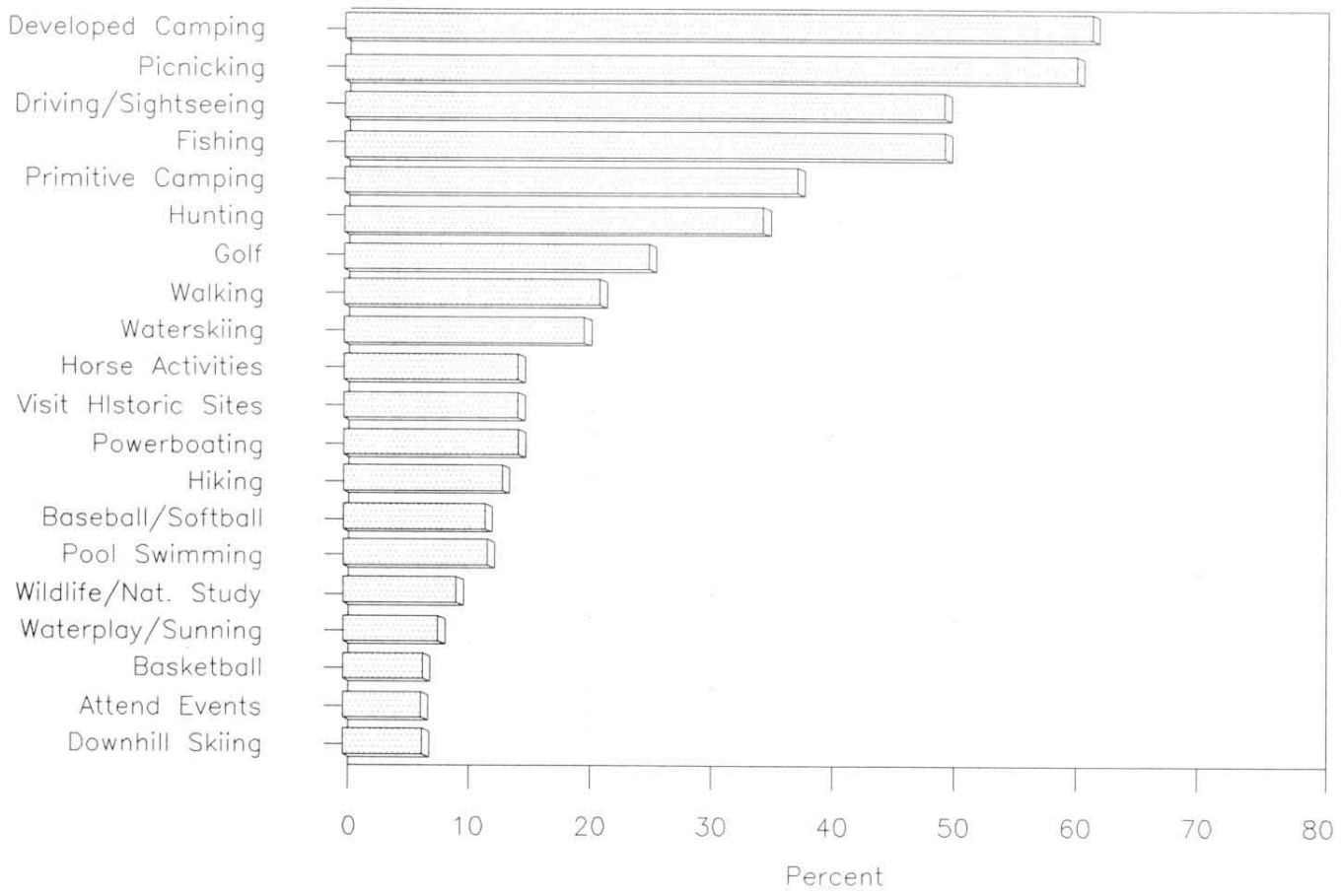
Source: Utah State Park Visitation Records

FIGURE 15-4
Top 20 Favorite Individual Activities



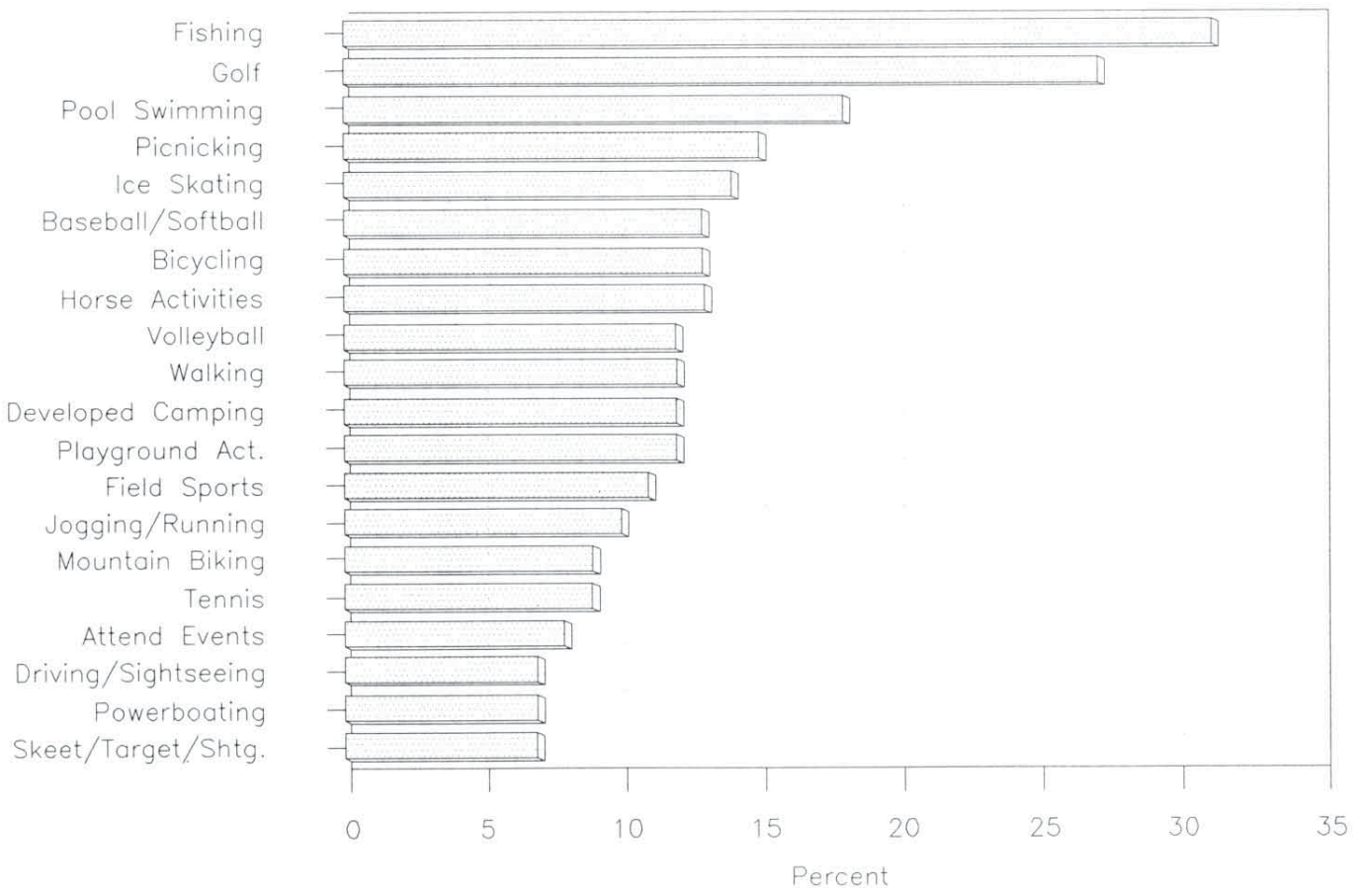
Note: Includes all of the Southwest Multi-County District
435 Resondents

FIGURE 15-5
Top 20 Favorite Family Activities



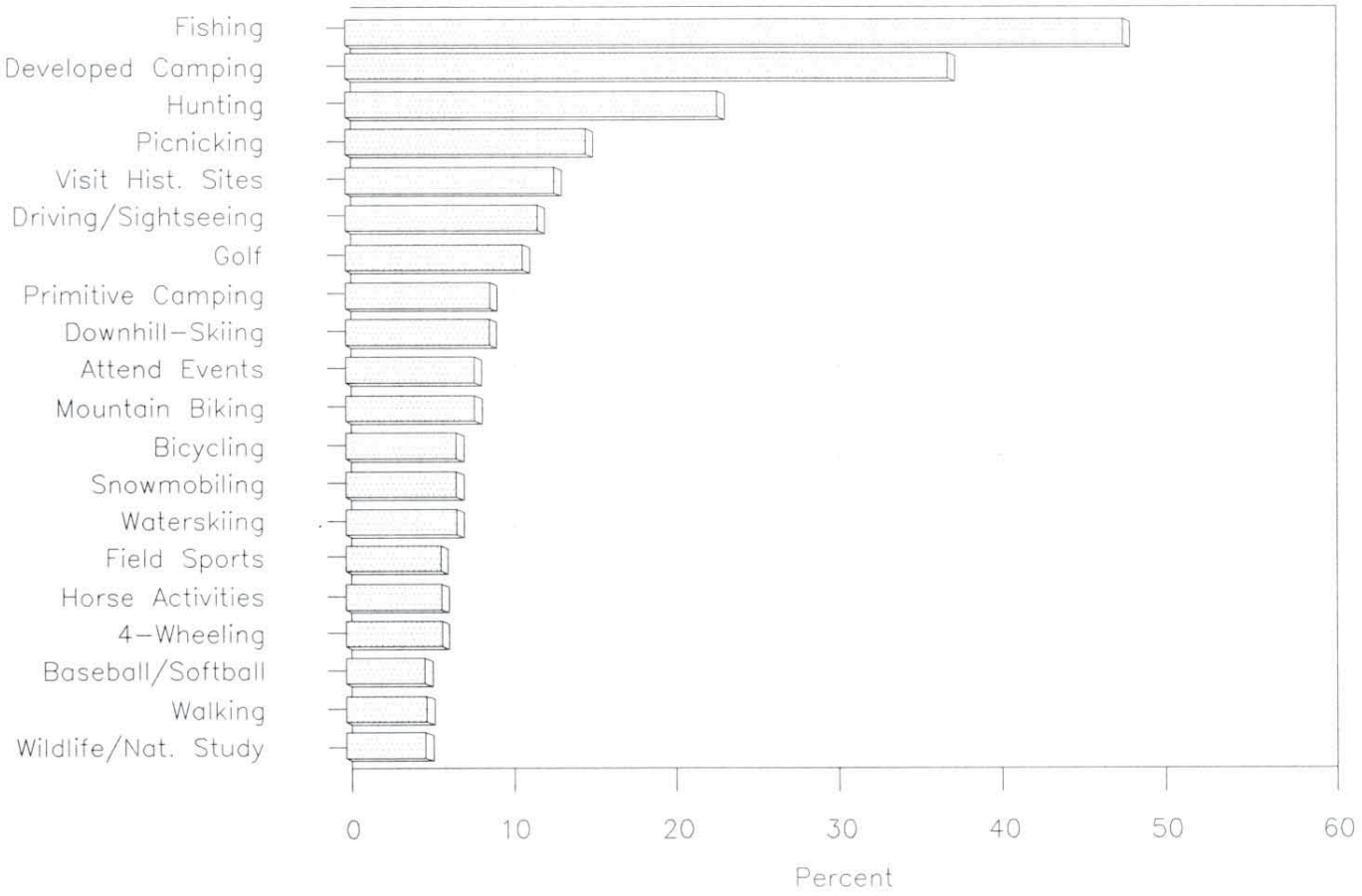
Note: Includes all of the Southwest Multi–County District
435 Resondents

FIGURE 15-6
New Community Facilities Needed



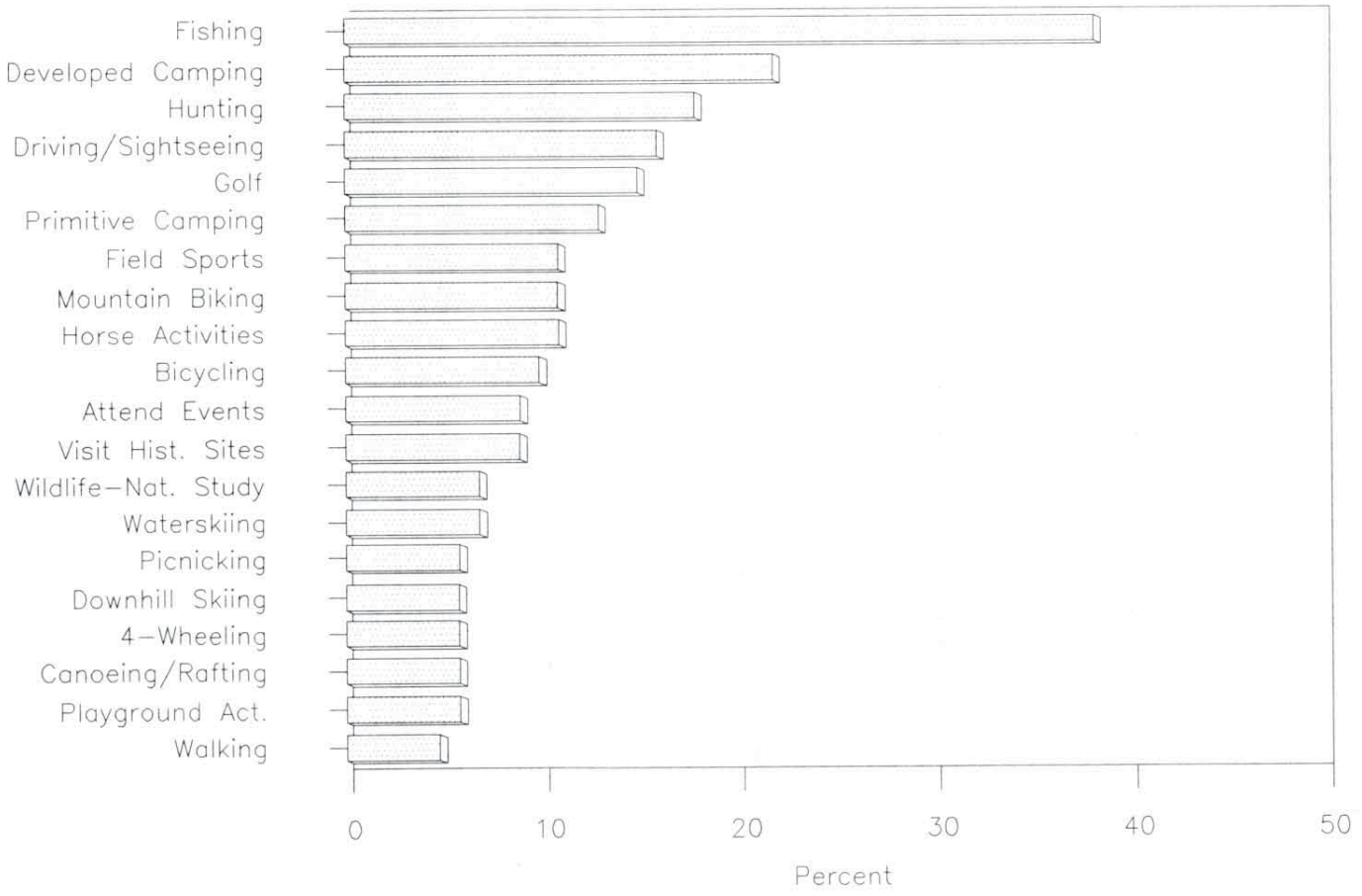
Note: Includes all of the Southwest Multi-County District

FIGURE 15-7
Statewide Facilities Needing Improvement



Note: Includes all of the Southwest Multi–County District

FIGURE 15-8
Statewide New Facilities Needed



Note: Includes all of the Southwest Multi–County District

15.6 References

1. Spangler, Jerry. *Tourists Still Flocking to Utah's Scenic Sites.* Deseret News, No. 267, Deseret News Press, Salt Lake City, Utah, Section M.

2. U.S. Department of the Interior, Bureau of Land Management. *BLM Facts and Figures, 1988.* U.S. Printing Office, Washington, D.C., 1989.

3. U.S. Department of the Interior, Rocky Mountain Regional Office, National Park Service. *Table 14: Detailed Listing of Grants by County, 1/16/92.* p. 202-203. Denver, Colorado, 1992.

4. Utah Division of Parks and Recreation, Comprehensive Planning and Policy Section. *1990-91 Utah Outdoor Recreation Household Survey.* Unpublished/SAS Computer Formatted. Salt Lake City, Utah, 1992.

5. Utah Division of Parks and Recreation, Comprehensive Planning and Policy Section, DPR. *The 1992 Utah State Comprehensive Outdoor Recreation Plan (SCORP), draft, unpublished data.* Salt Lake City, Utah.

6. Utah Office of Planning and Budget, Utah Department of Community and Economic Development and the University of Utah, Bureau of Economics and Business Research. *Working Draft: EDA Tourism Study.* Salt Lake City, Utah, March 9, 1992.

7. Walkways West. *The Virgin and Santa Clara River Greenways Project, Recreational Trial Project Proposal.* St. George, Utah, 1991.

Section 16 Federal Water Planning and Development

16 Federal Water Planning and Development

Twelve federal agencies have water resources planning and development missions. Some of these agencies have increased their roles in the Kanab Creek/Virgin River Basin area; other agency roles have decreased.

16.1 Introduction

Federal water planning and development activities have changed considerably over the years. This section discusses many of the federal programs available to assist with water resources development and planning. With this information, it is possible to develop better interagency and local working relationships.

16.2 Background

Federal water use, planning, development and regulation are an integral part of the basin plan. The federal role in funding water resources programs is decreasing while its regulatory role is increasing. As a result, the state is being called on to fill the void, particularly when financial assistance is required. Added costs are also required of the state to carry out federally mandated programs. Federal mandates may influence the ability of the state to respond to local requests.

16.3 Federal Concerns

Four concerns were identified in the *State Water Plan* by federal agencies. These were 1) reserved water rights, 2) interrelated planning and development, 3) stream and riparian habitat loss and 4) water rights filings.

Progress has been made on most of the concerns. Most notable is the completion of the Virgin River Cooperative Study with the cooperation of every agency and entity in the area with water resources related interests.

16.3.1 Policy Issues and Recommendations

Recently, the issue of interrelated planning and development surfaced.

16.3.2 State, Federal and Local Coordinated Planning

Issue - There is a need for representatives of state and federal agencies and local entities to coordinate their water and water-related planning, particularly those having management authority over land and water resources.

Discussion - The natural resources of this basin are vitally important to every individual, agency or organization involved in their development and use. Consequently, plans for development and use of available resources should be carefully evaluated and coordinated among all appropriate entities.

Land owners, state and federal land managers and administrators of other federal, state and local agencies should strive for acceptable compromises and work toward a common goal.

The needs of an expanding population should be the major consideration, including water to drink and land to develop. Other important water-related considerations should include preserving areas for recreation and leisure activities and water-related wildlife and habitat for the enjoyment of present and future generations.

Recommendation - Form a coordinating council composed of state cabinet level officials, state and regional heads of federal agencies and selected local officials; the executive director of the Department of Natural Resources would be its chairman. This council should coordinate all major activities concerning the basin's natural resources.

16.4 Federal Programs and Projected Planning and Development

The various federal agencies and their programs available are briefly described below. Projected planning and implementation are also discussed.

16.4.1 Agricultural Stabilization and Conservation Service

To assure effective solutions to local conservation problems, the Agricultural Stabilization and Conservation (ASC) committees in Kane and Washington counties periodically meet with their respective County Program Development groups to identify the problems and develop conservation practices to solve them.

Agricultural Conservation Program (ACP) - The ACP is designed to help reduce soil erosion and water pollution, protect and improve productive farm and ranch land, conserve water used in agriculture, preserve and develop wildlife habitat and encourage energy conservation measures.

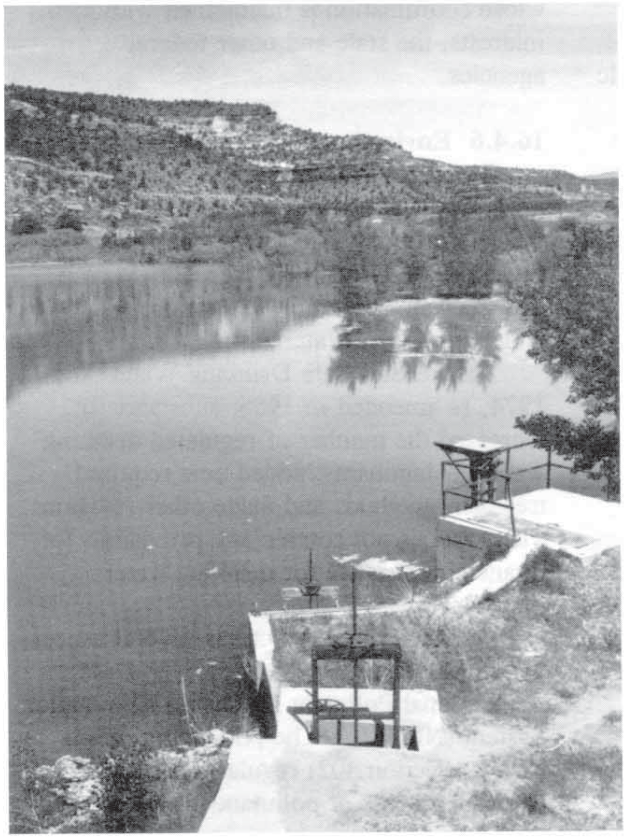
Only those practices that significantly contribute to these objectives, and are not required as a condition of receiving assistance through other federal programs, are eligible for cost-share assistance.

The ACP is administered by state and county committees working under the general direction of the Agricultural Stabilization and Conservation Service. The Soil Conservation Service, Forest Service and Utah Division of State Lands and Forestry are responsible for providing technical program guidance. The County Cooperative Extension Service provides educational support.

Emergency Conservation Program (ECP) - The ECP provides emergency cost-share funds to rehabilitate farmland damaged by wind erosion, floods or other natural disasters and for carrying out emergency water conservation measures during periods of severe drought.

Colorado River Salinity Control (CRSC) - The CRSC program applies to an eligible project area identified in a published U.S. Department of Agriculture salinity control report. The Moapa Valley Project in Nevada is currently included in the implementation.

Conservation Reserve Program (CRP) - The CRP was created in the Food Security Act. This program provides for removing highly erodible lands from production to protect them. It also promotes maintaining wetlands for wildlife habitat and water quality.



16.4.2 Bureau of Indian Affairs

The Bureau of Indian Affairs, under the trusteeship exercised by the Secretary of the Interior, works cooperatively with the Indian people and their tribal leaders toward assuring the most effective and productive use and development of their resources. Accordingly, the bureau is interested in development of water resources.

16.4.3 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 quality considerations, with the mandate to comply with applicable laws. This agency is also responsible for managing the existing and proposed wilderness areas.

The quantity and quality of water resources are key factors in managing all terrestrial and aquatic resources on public lands in the Cedar City District. Water resources are rapidly becoming a major determinant of resources management alternatives. BLM manages riparian habitats of streams, lakes, reservoirs and ponds to provide high-quality water resources for beneficial downstream uses.

Collection of water resources and water quality data is needed for all resources programs. The BLM is also responsible for planning the use of these resources on the public lands in coordination with the state and other agencies.

All of these data become a part of a resource management plan for a given area. Public input is requested at points in the process. This finally becomes the management plans for the resources on BLM administered land.

16.4.4 Bureau of Reclamation

Bureau of Reclamation programs for water resources can be placed into four broad categories: investigations, research, loans and service. All require close cooperation with the concerned entities.

Investigations Programs - General investigations, including an environmental assessment, are conducted for specific and multipurpose water resources projects. Water quality improvement programs (Public Law 93-320) are special investigations to control salinity levels in the Colorado River. The criteria for determining feasibility are set by the Colorado River Basin Salinity Control Forum, a committee composed of basin state representatives.

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 in areas where opportunities exist for demonstrating future feasibility.

Loan Programs - Loan programs provide federal loans and assistance to qualified organizations wishing to construct or improve smaller and generally less complex water resources developments.

Service Programs - Intergovernmental service programs are 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.

16.4.5 Corps of Engineers

If local interests are unable to cope with a water resources problem, they may petition their representatives in Congress for assistance. This allows the Corps of Engineers (Corps) to investigate the economic and technical feasibility and environmental and social 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.

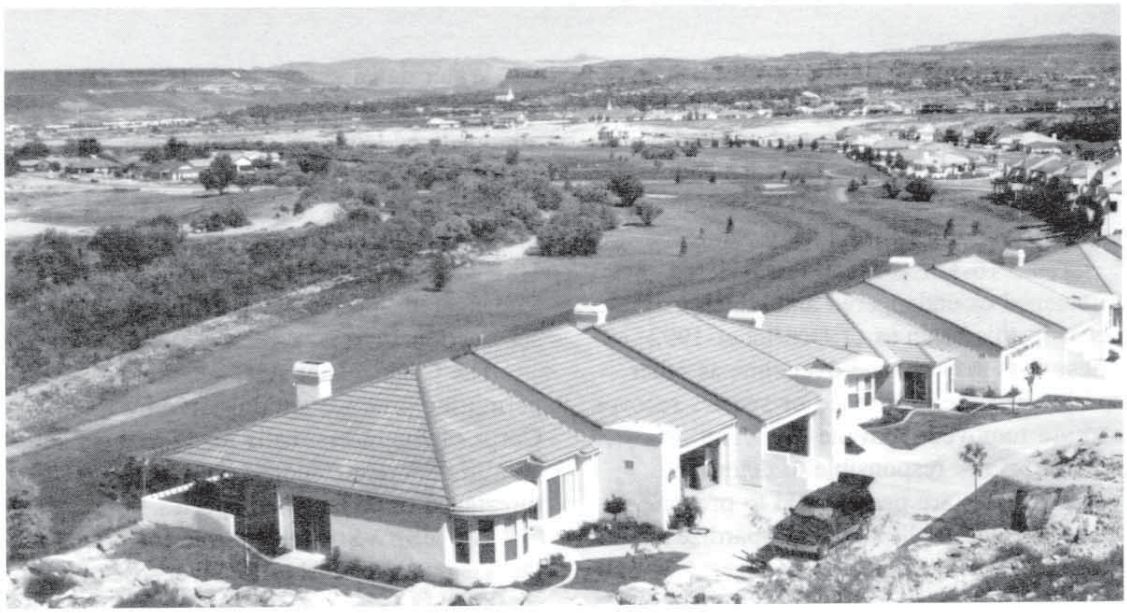
16.4.6 Environmental Protection Agency

Environmental Protection Agency (EPA) programs dealing with water resources are the safe drinking water program under the Federal Safe Drinking Water Act (SDWA) and the water pollution control program under the Clean Water Act (CWA).

The Federal Safe Drinking Water Act, 1974, as amended in 1986, substantially increased the number of regulated drinking water contaminants, added new required treatment methods and made other revisions. The act does not contain any provisions for financial assistance for drinking water systems.

The Clean Water Act has several aspects including:

National Pollutant Discharge Elimination System (NPDES) - The NPDES program (CWA, Section 402) regulates the discharge of point sources of pollutants to waters of the United States.



Construction Grants - This program provides grant funds for construction of needed municipal wastewater treatment facilities. This program 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 CWA provides funds to states to carry out water quality management planning. Section 319 of the CWA authorizes funding for implementation of non-point source pollution control measures under state leadership.

16.4.7 Federal Emergency Management Agency

Programs administered by the Federal Emergency Management Agency (FEMA) are related to disaster preparedness, assistance and mitigation. They can provide 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 to 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 Insurance Program. The FEMA can also assist with the acquisition of structures subject to continual flooding.

16.4.8 Fish and Wildlife Service

Activities of the U.S. Fish and Wildlife Service (USFWS) are those connected with the Endangered Species Act, Fish and Wildlife Coordination Act, Clean Water Act and the Migratory Bird Treaty Act.

Table 16-1 lists species considered threatened or endangered and which may occur in this basin as of December 1992. These lists may change over time as other species become threatened or species recover and are removed from the list. The developers are responsible to determine which species are present and to prevent activities that might further jeopardize a given species or its habitat.

Water development projects requiring rights-of-way permits for federal administered lands actuate the consultation requirement under the Fish and Wildlife Coordination Act. When federal funds are involved, Section 7 consultation with the USFWS as required by the federal Endangered Species Act is required (Also see Section 14).

The Clean Water Act, Section 404 permitting process, administered by the Corps of Engineers, calls for U.S. Fish and Wildlife Service response on impacts to threatened or endangered species.

The USFWS is responsible for preparing the Virgin River Fishes Recovery Plan. A draft was published in October 1992. It was prepared by the Virgin River Fishes Recovery Team. This plan should be consulted prior to project development.

TABLE 16-1[6,7]
THREATENED OR ENDANGERED SPECIES

Bald eagle	Kanab ambersnail
Peregrine falcon	Welsh's milkweed
Woundfin minnow	Siler pincushion cactus
Virgin River chub	Dwarf bear-claw poppy
Desert tortoise	

There are no Category 1 species in the basin. Over 62 species are listed as Category 2. These lists are constantly changing to reflect existing conditions. Although some of these species are not aquatic in origin, water availability in southwestern Utah is important to them. That availability also affects the extent of human population growth that may encroach on the habitat of terrestrial species.

The Fish and Wildlife Service has the primary authority for enforcement of the protective elements of the Migratory Bird Treaty Act. The act prohibits the "take" of covered bird species. All birds (with the

exception of starlings, English sparrows and a few others) are protected under the Migratory Bird Treaty Act. The Endangered Species Act also prohibits "the taking" of a protected species.

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." In addition, "'harm' in the definition of 'take' in the act means actually killing or injuring wildlife. Such action may 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 developments and other water resources developments require special use authorization and usually require 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.

16.4.10 Geological Survey

The Geological Survey, 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 Geological Survey independent of, or in cooperation with, other federal and non-federal agencies.

The Geological Survey has recently completed a groundwater condition study in the upper Virgin River and Kanab Creek basins. Earlier, a similar study was completed in the central Virgin River area. A more comprehensive study is planned in the near future in Washington County. A reconnaissance groundwater study in the Beaver Dam Wash is underway. This study is sponsored by Arizona, Nevada and Utah and should be completed in 1995.

16.4.11 National Park Service

The National Park Service 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 National Park Service are as follows:

1. To conserve and manage the parks for their highest purpose; the natural, historical and recreational resources.

2. To provide the highest quality of use and enjoyment by increased millions of visitors.

3. To develop the parks through inclusion of additional areas of scenic, scientific, historical and recreational value.

4. To communicate the cultural, natural, inspirational and recreational significance of the America heritage.

In fulfillment of these objectives, the National Park Service performs the following functions:

1. Manages the 142,300 acres in Zion National Park.

2. Conducts the recreation aspects of water project implementation studies.

3. Conducts Wild and Scenic River and National Historic and Scenic Trail studies authorized by Congress.

4. Through cooperative agreements, administers recreation on lands under the jurisdiction of other federal agencies.

5. Provides professional and administrative support to the national, regional and park advisory boards.

In federal water resources project pre-authorization studies, the National Park Service 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 recreation areas; management planning; negotiation of agreements for administration of reservoir recreation areas and follow-up on the administration of such agreements.

16.4.12 Soil Conservation Service

Soil Conservation Service (SCS) authorities and programs are provided in the Soil and Domestic Allotment Act of 1935. This act calls for the development and implementation of a continuing program of soil and water conservation on all lands, regardless of ownership, when so requested. Over the years, additional programs have been added.

A soil survey has been completed in Washington County. One is currently underway in western Kane County.

The SCS snow survey program in the Kanab Creek/Virgin River Basin area makes and coordinates surveys and prepares forecasts of seasonal water supplies. This is a cooperative program with state and other federal agencies for the benefit of water users.

The Watershed Protection and Flood Prevention Act (Public Law 83-566), as amended, gives primary responsibility to SCS for small, upstream watershed activities. Construction on the Warner Draw

Watershed Project around St. George is almost complete. Before the project closes, two added features will be assessed. Planning is underway on the Muddy Creek Watershed near Orderville.

The Resource Conservation and Development (RC&D) program began with the Food and Agriculture Act of 1962 (Public Law 87-703), as amended. It provides assistance to government and non-profit organizations in multiple-jurisdictional areas. The Kanab Creek/Virgin River Basin in located within the Color Country RC&D Project area.

The Emergency Watershed Program provides technical and financial assistance to relieve eminent hazards to life and property. These hazards include floods and products of erosion created by natural disasters causing sudden impairments. ■

16.5 References

1. Agricultural Stabilization and Conservation Service, Bureau of Land Management, Bureau of Reclamation, Corps of Engineers, Fish and Wildlife Service, Forest Service, and Geological Survey. Background Papers, Salt Lake City, Utah, 1987.

2. *Bureau of Land Management Manual* 1601, 1620, 1621, and 1622.

3. Federal Emergency Management Agency. *Digest of Federal Disaster Assistance Programs*. FEMA Manual 8600.2 (ECS-2). Washington, D.C., 1982.

4. Ibid. *Disaster Assistance Programs, A Guide to Federal Aid in Disasters*. Washington, D.C., 1987.

5. Federal Land Policy and Management Act of 1976 (43 USC 1711-1712), Sections 102, 201, & 202.

6. Jensen, F. Clair, by Pam C. Hill. Letter transmitting *Native Utah Wildlife Species of Special Concern, Revised*. Utah Division of Wildlife Resources, Cedar City, Utah, December 1990 (letter dated May 21, 1992).

7. Provan, Timothy H. Letter transmitting *Utah Endangered, Threatened, and Candidate Species* list. Utah Division of Wildlife Resources, Salt Lake City, Utah, September 1992 (letter dated January 14, 1993).

8. U.S.D.A., Soil Conservation Service. *Statutory Authorities for the Activities of the Soil Conservation Service*. Under the direction of the Office of the General Counsel. Washington, D.C., 1981.

9. U.S. Water Resources Council. *Water Resources Coordination Directory*. Washington, D.C., 1980.

Section 17 Water Conservation

17 Water Conservation

This section defines water conservation, discusses current programs, addresses prominent issues and makes recommendations to resolve the issues.

17.1 Introduction

Water conservation in the *State Water Plan* is defined as "wise use" which is broader in scope than many definitions. It includes strategies for reducing water demand, and for increasing water supply. Structural measures and non-structural means can be used to accomplish water conservation under both strategies. The resulting well-managed water conservation program may postpone the need for building new facilities. Water purveyors should implement three measures in an effective water conservation program. First, the systems should be designed and operated efficiently. Second, users should use water saving devices and practices to reduce usage. Third, the water purveyors should implement programs (incentives/penalties) to encourage people to use water wisely.

To understand water use and conservation, there is a need to distinguish the difference between depletions and diversions. Depletions consist of water put to desired end uses, consumed and unavailable for return to the system. Diversions consist of the depleted water as well as the carriage water needed for delivery. If diversions and depletions were the same, then theoretically, the system would be 100 percent efficient. However, anything close to this is not realistically obtainable under any but laboratory conditions.

Conservation of water through decreasing depletions can be accomplished to a limited degree through changes in economic activity, the environment and/or lifestyle. Conservation of water through decreasing diversions requires an increase in efficiency and is generally more effective than decreasing depletions.

Another factor to be considered in implementing water conservation measures is water quality. High quality water (suitable for potable or culinary use) is of greater value to municipalities than lower quality water (which is adequate for irrigation) due

to the difference in treatment costs and social acceptance by customers. Replacement of high quality water for outside uses with lower quality water will not reduce diversions or depletions. The higher quality water could be applied to other uses meeting Safe Drinking Water Act standards.

Temporary water shortages and growing demand place continuing stress on the available water supplies. Construction of additional projects is usually considered to develop additional water supplies and deliver water to demand areas. The size and cost of all of these projects will be reduced by water conservation measures.

In the long term, education is the major key to water conservation through more efficient use. The public will respond when convinced of the need for water conservation and given reasonable and practical means to conserve water. The water conservation process may require legal mandates and regulations to stimulate and encourage public acceptance.

17.2 Water Conservation Opportunities

Water use in the Kanab Creek/Virgin River Basin falls into two basic categories; municipal and industrial (M&I) and agricultural.

17.2.1 Municipal and Industrial Water

The basin M&I water diversions for culinary use average 347 gallons per capita day (gpcd), 63 gpcd higher than the state average of 284 gpcd. (See Section 5 for more detailed information). A large portion of this difference may be attributed to the basin climate which is hotter and drier than the rest of the state. The M&I use is the fastest growing demand. Effective conservation to reduce present use should be concentrated upon reducing residential per capita demand. As an example, reducing M&I water diversions by 50 gallons per capita day could save 56 acre-feet per year per 1,000 population. In 1990, this would have saved 14 percent of the M&I water reported delivered.

Residential Water Conservation Measures - A basic residential water conservation program might include providing flow restrictors for showers and faucets, toilet dams, leak detection kits and lawn watering guides to consumers. Estimates, using techniques developed by the State of California,[1] show the cost of water conserved in St. George City would be about $130 per acre-foot. (This cost includes the foregone revenues from decreased water sales as well as the cost of providing the conservation materials.) Some other typical residential conservation programs and estimated costs and savings were developed

TABLE 17-1
ESTIMATED RESIDENTIAL WATER CONSERVATION COSTS AND RESULTS FOR ST. GEORGE, UTAH

Item	Program Description	Annual Estimated Water Conservation (acre-feet)	Annualized Cost Per Acre-Foot Conserved
A	Minimal Kit Program (Deliver toilet dams, flow restrictors and leak detection kits, 4,000 kits per year for two years)	25	$ 190
B	Moderate Kit Program (Provide and install toilet dams, flow restrictors and leak detection kits and follow-up with customer contacts, 1,000 kits per year for eight years)	165	$ 125
C	Residential Water Conservation and Education Program (4,000 kits per year for two years repeated four times for eight years total)	110	$ 140
D	Toilet replacement with ultra low-flow toilets provided by St. George with customer installation (500 per year for eight years)	50	$ 350
E	Provide lawn watering guides to customers (8,000 per year every year)	15	$ 200
F	Requiring new residential construction to meet model landscape or Xeriscape ordinances (based on 100 new landscapes per year for eight years)	280	$ 85
	Combination of items B, C, D, E, & F listed above (eight-year program)	620	$ 130

using the California techniques. These are shown in Table 17-1.

Secondary Systems - Basin water purveyors are investigating the feasibility of installing secondary (dual) systems to supply landscape and garden irrigators plus some industry with water of lesser quality while the culinary system delivers more costly, higher quality water. Several communities are investigating the feasibility of pressurized

secondary systems. High quality water for culinary use is in short supply. The anticipated demand will constitute the largest segment of future water needs.

Currently, six golf courses in the St. George area divert 4,438 acre-feet of water annually[2]. The water supplies for the golf courses are a mix of lower quality irrigation canal water, well water, river water and city supplied M&I water. Since golf course watering is such a prominent and high profile use of water in the St. George area, water conservation measures and careful irrigation water management will have a wider scope of impact than just the saving of water on the golf course itself. This is an opportunity for public education and influence. The potential publicity and goodwill generated could provide a sound launching point for water conservation in the area.

17.2.2 Irrigation

Farmers have been installing sprinkler irrigation systems at an increasing rate over the last decade and finding them to be especially cost effective where gravity pressure can be used. The sprinkler irrigation systems in Gunlock and Glendale, for example, serve lawns and gardens as well as agricultural land. Other communities could also save acceptable high quality water for future culinary use by following their example.

Current irrigation practices allow room for improvement in distribution and irrigation efficiency. Recent data given in Sections 5 and 10 of this report show the following:

Irrigation Depletions = 51,300 AF
Irrigation Diversions = 123,300 AF
Overall Efficiency = 42 percent

Typically a flood irrigation system operates at less than 50 percent efficiency and sprinkler irrigation systems operate at about 65 percent efficiency. Some allowance is required for leaching of salts due to salinity problems associated with diverting irrigation water from the Virgin River below La Verkin Springs. This limits the amount of irrigation efficiency improvements possible in some areas. A one percent overall increase in irrigation efficiency basinwide would result in the conservation (reduced diversion) of approximately 2,500 acre-feet of water.

17.3 Policy Issues and Recommendations

The basin is experiencing rapid population growth and water conservation will be a vital component in the overall plan for meeting future water demands.

17.3.1 Residential Water Conservation Plans

Issue - Residential water conservation can stretch existing supplies to help meet future growth demands.

Discussion - Residential water use is the fastest growing component of water demands. Future demands for additional water will be to meet increasing residential uses. Developing additional sources of water for residential use is increasingly costly as most inexpensive sources of high quality water are currently developed. Stretching currently developed high quality sources by conservation to serve portions of

future growth is and will be increasingly cost competitive with the development of new sources.

As additional sources of water are needed, residential water conservation is a valid component to meet the growing M&I demand. Water suppliers need to identify conservation goals in relation to supplies and demands. A conservation plan can identify alternatives to provide water to meet projected demands. The plan should contain an inventory of present water supplies developed for use and water demand projections with recommendations to meet future water needs.

Recommendation - A water management and conservation plan should be developed by each water purveyor. Conservation measures should be among the alternatives investigated.

17.3.2 Cropland Irrigation Efficiency Improvement

Issue - Improvement of irrigation efficiencies on cropland is the most effective water conservation measure in terms of the quantity of water conserved.

Discussion - Irrigation is the largest use of water in the basin. Improvement of irrigation efficiencies can result in the largest amount of water conservation. The technology for improvement of irrigation efficiencies is well proven and accepted. The biggest hurdle in improving irrigation efficiencies is the capital costs of improvements. Funding programs that aid irrigators in defraying these costs hold potential of increasing water conservation efforts in the basin. See Section 8 for a description of funding programs.

Recommendation - The Utah Department of Agriculture, the Cooperative Extension Service, the Soil Conservation Service and the Division of Water Resources need to continue providing technical and financial assistance to agricultural water users to upgrade and improve conveyance and delivery systems as well as provide on-farm irrigation management information and assistance for irrigators.

17.3.3 Secondary Water Systems

Issue - Secondary (dual) water systems can reduce the demand for high quality treated water.

Discussion - Water treatment is costly, and municipal water system managers can save considerable money by delivering lower quality waters for uses such as landscaping. A large portion of the municipal supplies are used for landscape irrigation where there is no need for water treated to culinary standards.

The installation of secondary systems can divert water supplies that were previously used by agriculture. This could eliminate the need to find more distant sources of higher quality water. This practice can delay, or in the case of smaller and slower growing communities, could eliminate the need for municipal system expansion and thus bring substantial financial benefits. The Division of Water Resources provides financial and technical assistance to communities considering the installation or upgrading of secondary systems. Additional help is also available from the Color Country Resource Conservation & Development (RC&D) program.

Communities may want to require developers to cooperate (cost share) in studies of the comparative costs of secondary systems versus a single culinary system as part of the permitting process.

Recommendation - Communities should undertake studies to determine the feasibility of installing and/or improving secondary (dual) systems.

17.3.4 Water Conservation Education

Issue - Public education on water conservation is the most effective way to insure that long-term goals are met.

Discussion - Ultimately, regardless of the conservation technology employed by water agencies, public acceptance of water conservation and correct use of water supplies by consumers is the foundation of water conservation. Water conservation education is relatively inexpensive, but it requires a long-term commitment to the program. Unless the public understands and accepts the need for water conservation, efforts will not be fully effective. The public needs to understand the full costs and consequences of their water use decisions.

Programs in public school systems can teach the upcoming generations about wise use of water. These can be implemented as part of the school curriculum. Currently the state of Utah has an active program for instructing teachers in the use of water education materials.

Purveyors need to keep the public informed concerning water issues so that the consumer will be cognizant of the results of use decisions. With this knowledge, the public will be able to provide valuable input in the decision making process concerning water resources.

Recommendation - Water agencies should support the state's water education efforts in the local schools by giving technical and financial support.

Water purveyors should ensure that information is provided for consumer education through mail inserts, water use information sessions, conservation information opportunities and other avenues.

17.3.5 Water Reuse

Issue - Reuse of sewage effluent for limited agricultural, parks and golf course irrigation may help meet some future water supply needs.

Discussion - As population increases, the quantity of water available for reuse will increase. Currently, the major source of

water for reuse is the effluent from the St. George sewage treatment plant.

The principal accepted use in other areas of the country for reuse of effluent is in large landscape irrigation such as golf courses. (These are large water users in the St. George area). However, use of sewage effluent can pose a health risk unless precautions are taken. Social acceptance may hinder water reuse.

Opportunities to reuse agricultural water for new uses are limited because most of the return flows from agriculture are incorporated in downstream users' water rights.

Recommendation - City officials should explore reuse possibilities for golf courses and other large landscapes and promote reuse where it appears feasible. The Department of Environmental Quality and the Division of Water Resources should provide technical assistance.

17.3.6 Xeriscape

Issue - The use of water conserving landscapes can reduce the amount of water necessary to meet the increase in demand.

Discussion - Landscapes use a major portion of the water in the larger communities. Xeriscape type landscapes use a combination of native plants, low water use plants, mulched flower beds, hardscaping (decks, patios and rock gardens) and turf areas to achieve a pleasing mix in the landscape design. They can also meet the needs for recreation and entertainment areas as well as beautification. This type of landscape can consume up to 50 percent less water (depending on the mix of features selected) than the typical monoculture of turf grass.

While retrofitting an existing landscape from the traditional expansive grass areas to an aesthetic Xeriscape can be costly and time consuming (as most landscape projects are), new residential construction lends itself to more choices. Costs of installing an aesthetic, functional Xeriscape from scratch are comparable with normal landscape installation cost and will result in significant water and cost savings over the life of the landscape.

Recommendation - Communities should prepare and adopt model landscape ordinances for new construction which require water conservation and encourage Xeriscape landscaping.

17.3.7 Water Pricing

Issue - Water pricing rate structures can lead to high water use.

Discussion - Current water pricing practices of low, level rates for all water use or declining block rates for increasing use provide little, if any, incentive for the consumer to conserve water. The financial reward for water conservation is small while the effort involved can be significant.

Currently, revenues for water purveyors are linked or "coupled" to the quantity of water delivered. Enough water has to be delivered to recoup costs associated with water development and system operation. With this type of rate structure, water conservation decreases the water utilities revenues by decreasing the amount of water delivered and paid for by customers without proportionate decreases in fixed costs. This serves as a strong disincentive for water conservation.

Decoupling water purveyor revenues from the amount of water delivered and linking revenues to the number of customers

served at base rate levels, would provide protection of necessary water utility revenues while giving incentive for water conservation to decrease the marginal costs of additional water delivery. Allowances could be made by the purveyors to cover low income households similar to what other utility programs currently use to provide lifeline level services.

If base water rates covered the fixed costs of a water system and marginal rates reflected the cost of water delivery above the base amount, water conservation would provide financial incentives for the consumer and supplier. The supplier's revenue stream would be protected to cover fixed costs while the marginal price of water above the base amount would cover the additional costs of securing more expensive water sources to meet growing demands. As demand increased, prices would increase and this would provide the financial incentive for the consumer to reduce use.

Recommendation - Water purveyors in the basin should establish base rates to cover fixed costs and set increasing block rates for M&I water use above the minimum.

17.4 Conservation Implementation

Water conservation is best carried out under the auspices of the management of the local water purveyors with support from governmental agencies with needed special expertise. Political support is also needed from citizen groups interested in supporting the conservation programs. Establishing water conservation policies will require the input and support of the public. If the public feels that the policies are reasonable and reflect their input, then implementation will be facilitated. ■

17.5 References

1. Department of Water Resources, State of California, *Water Plan™ Version 1.00 Benefit/Cost Analysis Software for Water Management Planning*. Sacramento, California, October 1989.

2. Utah Division of Water Resources, *Municipal and Industrial Water Diversions and Depletions for the Virgin River and Kanab Creek Drainage Basins*. Salt Lake City, Utah, (In preparation).

3. USDA Soil Conservation Service and Utah Division of Water Resources. *Virgin River Basin-Utah Cooperative Study*. Salt Lake City, Utah, 1990.

Section 18 Industrial Water Use

18 Industrial Water Use

18.1 Introduction

This section discusses the present and future uses of water for industrial purposes. Current industrial uses are relatively minor, although they could increase. All anticipated situations must be considered to assure long-range water demands and needs can be met.

Industry uses water for many purposes. These include uses as solvents, for temperature control, to carry away wastes, for human needs and for aesthetic purposes.

18.2 Background

The major uses of water for industrial purposes are for mining operations in the Beaver Dam Wash area, for tailings leaching on the Shivwits Indian Reservation and for seven hydroelectric power plants in Washington County. The power plants are described in Table 18-1.

Tenneco Minerals Corporation consumes about 70 acre-feet of water annually at its Goldstrike Mine operation. Most of this water is purchased from the DI Ranch on the East Fork of Beaver Dam Wash. Catchment basins for precipitation are utilized when possible. The Helca Mining Company leaches mine tailings to recover gallium on the Shivwits Indian Reservation. The mine is near the "Utah Hill" on U.S. 91. Water uses are low, only about 100 gallons per day from underground sources.

Other uses are primarily for light industrial purposes in the St.George area. These purposes, mostly for employee use and outside landscaping irrigation, are supplied primarily through existing municipal systems.

18.3 Policy Issues and Recommendations

Very little industrial water is used in the basin. The water supply is delivered through the municipal systems, except for the self-supplied use for a mining operation in Beaver Dam Wash. As a result, there are no policy issues or recommendations.

TABLE 18-1
HYDROELECTRIC POWER PLANTS

Name	River	Installed Capacity (kw)
Cedar No. 1 (Gunlock)	Santa Clara	750
Cedar No. 2 (Veyo)	Santa Clara	500
Cedar No. 3 (Veyo)	Santa Clara	1,000
Cedar No. 4 (La Verkin)	Virgin	1,000
St. George	Cottonwood Creek	420
Pah Tempe	Virgin	600
Quail Creek No. 1	Virgin	2,340
TOTAL		6,610

18.4 Projected Industrial Water Development

Heavy industrial development will probably not increase at a very high rate. Increases will occur in the light industry, service and trade sectors. One hydroelectric power plant is planned below Quail Creek Reservoir. The design capacity is two megawatts.

In the future, water for industrial water uses will probably be delivered through existing municipal systems. Future water demands for industry are not anticipated to be very high. Existing supplies should cover these needs. ■

18.5 References

1. State Economic Coordinating Committee. *Economic Report To The Governor, 1992.* Salt Lake City, Utah, 1991.

Section 19 Groundwater

19 Groundwater

19.1 Introduction and Setting

Groundwater is not visually discernable and, as a result, it is difficult to quantify. This section describes the areal extent and volume of groundwater in the basin. It also describes groundwater quality along with present use and some development alternatives. Groundwater is used for public water supply, irrigation, domestic supply and for stock watering. Springs have always been the first to be developed by the early settlers. Later, after 1900, wells were developed. The climatic and geologic settings are described in subsection 3.3.

Groundwater is a particularly valuable source of water in the Kanab Creek/Virgin River Basin. It has had a major influence on the economic development and growth of the area. More data is needed from this area, however, to evaluate the extent of this water resource.

19.2 Groundwater Budget

Consolidated and unconsolidated aquifers store water used in the basin. These aquifers are supplied by precipitation infiltrating to the zone of saturation. Some water comes indirectly as streams cross aquifer recharge areas and by groundwater inflow into the basin.

The Navajo sandstone is the principal aquifer in the basin. Recharge to this groundwater aquifer is mostly by infiltration of precipitation and streamflow in outcrop areas. In some outcrop areas, highly permeable basalt enhances infiltration into the aquifer.

19.2.1 Precipitation

Much of the recharge takes place at higher elevations in the Pine Valley Mountains north of St. George, the Kolob Plateau above Zion National Park and the Markagunt Plateau around and east of Navajo Lake where the precipitation averages between 30 and 40 inches annually. Precipitation on the Paunsaugunt Plateau around Bryce Canyon National Park is somewhat less at about 20 to 25 inches

annually. See Figure 3-3 for annual precipitation.

19.2.2 Recharge and Discharge[2]

A groundwater system is a storage reservoir. The amount of water in storage depends on recharge and discharge. On the average, the amount of groundwater discharge must be limited to the amount recharged back into the system. Discharging more water than is recharged over a long time will deplete the amount in storage. This may cause groundwater levels to drop and some springs and wells may begin to dry up.

Lowering water levels in the Navajo sandstone aquifer may reduce flow from springs along the outcrop near St. George. Unseen groundwater outflow may also be reduced. Reduction of spring outflow can impact water rights and may be a transfer of spring flow to well flow. This may be desirable in some respects, however, because the well flows are more convenient as they are available when needed. Reducing subsurface outflow is likely a net increase in available water, depending on if and where the groundwater outflow surfaces. Reducing the available water from springs may also have a negative impact on wildlife. Continuous monitoring would be needed to assure undesirable impacts do not result.

Artificial recharge may be a viable option, especially for the Navajo sandstone aquifer. Many streams cross the outcrop area. A few flow continuously, but most are ephemeral. To make more water available, recharge could be increased by building check dams and ponds and by spreading facilities in the stream courses to capture more of the unused high flows through infiltration. This could also have negative impacts on fish and wildlife.

The long-term average annual recharge in the Virgin River Basin is estimated to be the same as the discharge of 155,000 acre-feet. [2,3,4] In the central Virgin River Basin, the estimated average annual recharge of 105,000 acre-feet per year is greater than the discharge of 82,000 acre-feet per year for the years 1968-1970.[4] Similarly, the average annual discharge in the upper Virgin River Basin of 55,000 acre-feet per year is greater than the discharge of 49,000 acre-feet per year in 1977.[3] Recharge and discharge estimates generally will not balance unless the same base period is used. Time lag can also effect these estimates. Most groundwater not pumped from wells or used as evapotranspiration will eventually appear as streamflow.

Groundwater recharge and discharge in the upper Kanab Creek Basin (includes Johnson Wash) follow a similar pattern except at a smaller annual volume. The groundwater recharge from the Paunsaugunt Plateau and the East Fork of the Sevier River drainage north of the topographic divide of Kanab Creek is estimated at 6,000 acre-feet per year.[10] The groundwater recharge in upper Johnson Wash from these sources is much less. Sink Valley, lower Kanab Creek and Johnson Wash depend on infiltration of local direct precipitation and streamflow infiltration for groundwater recharge. An estimate of the groundwater recharge is shown in Table 19-1. Man-made withdrawal of groundwater is through wells used for public water supply, irrigation, domestic supply and for stock watering. Besides the use by wells, there is natural discharge through springs, seepage into streams, evapotranspiration by plants and subsurface outflow from the basin. The average annual discharge from

TABLE 19-1
ESTIMATED AVERAGE ANNUAL GROUNDWATER RECHARGE[1,3,4,6,10]

Source	Virgin River Central (acre-feet)	Virgin River Upper (acre-feet)	Kanab Creek & Johnson Wash (acre-feet)
Precipitation infiltration[a,b]	70,000	55,000[c]	25,500[c]
Streamflow infiltration	15,000	NA	NA
Subsurface inflow	20,000	10,500[d]	6,000[d]
Total	105,000	65,500	31,000

[a]Includes precipitation and streamflow infiltration. Data is incomplete.

[b]Current estimates for the upper Virgin River, Kanab Creek, Johnson Wash and Paria River range from 5,500 to 110,000 acre-feet.[6]

[c]Estimated for year 1977.

[d]Brown, H. T. Hydrogeology of the Markagunt Plateau, Sevier River Basin Summary Report and appendices, USDA.

Note: Recharge varies depending on time periods used for estimates.

TABLE 19-2
ESTIMATED AVERAGE ANNUAL GROUNDWATER DISCHARGE[2,3,4]

Source	Virgin River		Kanab Creek & Johnson Wash[b]
	Central[a]	Upper[b]	
	(acre-feet)		(acre-feet)
Seepage into streams	23,500	42,000	8,000
Flow from springs and drains	36,000	10,500[c]	800
Well withdrawal	7,600	1,300	2,000
Evapotranspiration	13,000	4,000	6,000
Subsurface outflow	2,000	unknown	5,000
Total	82,100	57,800	21,800

[a]Average for 1968 and 1970

[b]1977

[c]Includes La Verkin (Pah Tempe) Spring

Note: Discharge varies depending on time periods used for estimates.

the Virgin River Basin depends on the years averaged. The supply for municipal and industrial uses coming directly from groundwater were estimated at 13,000 acre-feet in 1983[2]. Studies are underway to update the data.

The base flow of the East Fork of the Virgin River and of the upper and lower Kanab Creek comes from springs and seepage into the riverbed. These springs are in many formations throughout the whole geologic section; they begin at the Lamb Point Tongue of the Navajo sandstone and continue with interruptions up to the Brian Head formation in the Sevier River drainage.

Table 19-2 shows available estimates of annual groundwater discharge for specific years in the Virgin River Basin. The values shown are broken down into the central Virgin River area west of the Hurricane Fault and the upper Virgin River area east of the Hurricane Fault. The values would be different for different years or time series. For example, Table 19-2 shows the 1968 and 1970 average for withdrawal from wells in the central Virgin River area to be 7,600 acre-feet.[4] The volume has increased substantially since then. The 1975-85 average is 19,400 acre-feet.[2] During 1982, which was a high year, 27,000 acre-feet were withdrawn.

Discharge to streams is estimated as follows: North Fork Virgin River, 14,500-28,000 acre-feet; East Fork Virgin River, 23,700-26,000 acre-feet; and Kanab Creek, 1,600-3,700 acre-feet. Discharge to springs

is about 10 percent of these values (Heilweil and Freethey[6]). The creek in Johnson Wash is ephemeral in those stretches flowing on outcrops of the Lamb Point Tongue of the Navajo sandstone about six miles north of its mouth.

Other estimates for Kanab Creek and Johnson Wash indicate the following: seepage, 2,500 acre-feet; springs, 5,100 acre-feet; wells, 1,000 acre-feet; evapotranspiration, 1,500 acre-feet and subsurface outflow, 4,000 acre-feet.[6] This re-emphasizes the variability depending on the time period used.

19.2.3 Transbasin Groundwater Inflow

Much of the northern divide of the Kanab Creek-Virgin River Basin in the Markagunt and Paunsaugunt plateaus is formed by south-facing cliffs of pink limestone of the Claron Formation. Springs issue from the base of these cliffs in many places, draining groundwater which is recharged north of the topographic divide. The best documented case is that of Cascade Spring, south of Navajo Lake (Wilson and Thomas, 1964). Therefore, much of the groundwater divide between the Kanab Creek/Virgin River Basin and the Sevier River Basin lies somewhat north of the topographic divide. This is the source of over 16,000 acre-feet of groundwater inflow.

19.2.4 Groundwater Storage

The unconsolidated aquifers presently produce more water than the consolidated rock formation such as the Navajo sandstone; however, total groundwater storage is greater in the consolidated formations. The volume of relict water is unknown.

The Navajo sandstone is the largest consolidated aquifer in the basin. This is a fossil dune sand and is up to 2,200 feet thick in some places. It has a permeability ranging from 0.5 to 50 feet per day, depending on the intensity of fracturing. Its storage coefficient ranges from 0.001 to 0.10^{8}. The Navajo sandstone is exposed in or underlies about three-fourths of the area of the basin and is estimated to contain several million acre-feet of recoverable water. Other consolidated formations that contain water in recoverable quanities are the Claron Formation, the Straight Cliffs and Wahweap sandstone[3], the Carmel, Kayenta, Moenave, Chinle (Shinarump member) and Moenkopi formations, the Kaibab limestone and the Tropic and Dakota shale. Any groundwater used from these aquifers is restricted by several factors. These include legal, environmental, technological and economic restraints. Water quality is marginal to poor in some of these formations.

Virgin River - It appears most of the recoverable groundwater in the central and upper Virgin River basin is in the Navajo sandstone. Since the thicknesses and areas of the aquifers are similar in the two basins, the larger difference in recoverable groundwater must be explained by other aquifer characteristics.

The explanation lies in the different shape and depth of the aquifer east and west of the Hurricane fault. West of the fault, the Navajo sandstone aquifer has a distinctive saucer shape with the lip or high edge of the saucer corresponding to the southern and eastern edges of the aquifer outcrop. The bottom of the aquifer plunges deeper to near sea level or below as it dips northward under the Pine Valley Mountains.

East of the Hurricane fault, the Navajo sandstone aquifer is more nearly horizontal, especially to the north of the Virgin River, and is exposed or close to the surface in many areas. Recovery of the groundwater is probably more feasible than in the deeply buried Navajo sandstone west of the fault, but little development has taken place because of its location in and above Zion National Park.

Kanab Creek and Johnson Wash - The greatest potential source of water in the Kanab Creek and Johnson Wash drainages is the Navajo sandstone. Within the Navajo sandstone, the two most favorable water bearers are the base of the massive upper member, probably about 1,200 to 1,500 feet below the top of the Navajo sandstone in Johnson Wash, and the base of the Lamb Point Tongue, which is about 400 to 500 feet thick and separated from the upper member in the vicinity of Johnson Wash by about 100 feet of the Tenney Canyon Tongue of the Kayenta formation. The Navajo sandstone may approach 2,000 feet as a single unit near Alton.

The water in both units of the Navajo sandstone is generally of excellent quality, generally of better quality than available surface water. Analyses of water from 11 test wells in the Navajo sandstone range from 200 to 1,495 mg/l in total dissolved solids (TDS), with an average of 460 mg/l (Bingham Engineering, 1987, Table B-1). Analyses of 75 springs in the upper member of the Navajo range in TDS from 62 to 1,135 mg/l, with an average of 275 mg/l (op.cit., Table B-7). Analyses of 35 springs in the Lamb Point Tongue of the Navajo range from 80 to 1,030 mg/l and average 320 mg/l (op. cit. Table B-8).

The greatest depths to the base of the Lamb Point Tongue are a little more than 3,000 feet, and the shallowest depths are in the vicinity of Johnson Wash where the Lamb Point Tongue crops out and forms the surface over large areas. If the bottom 200 feet of either the massive upper member or the Lamb Point Tongue is saturated, then the Navajo sandstone in this area could contain several million acre-feet of water in the 300-square mile area. See Figure 19-1.

Water quality in both formations tends to be better higher in the tributaries, but good and poor water quality may be found in many areas. Water from the Navajo sandstone aquifer is generally good; however, there are exceptions. The unconsolidated aquifers generally have poorer quality water in the lower elevations of the basin due to discharge from some geological formations that contain soluble minerals.

19.2.5 Wells

Existing wells in the Kanab Creek/Virgin River Basin are good indicators of extent, location and amount of groundwater development. Over 750 wells are located within the basin.[2] Since most wells are developed as near as possible to the point of use, the wells show where groundwater is used. Some municipal wells are located at a distance from the actual use of the water. Well locations are shown in Figure 19-2.

Most wells in the basin do not show any long-term rise or fall in the water levels. Two, however, do show declines in response to increased pumping.[2] The first well, located in the Navajo sandstone aquifer near Gunlock, has dropped 22 feet since 1971. The second well, in unconsolidated rock in

FIGURE 19-1
Schematic Geologic Section, Kanab Block, Kane County

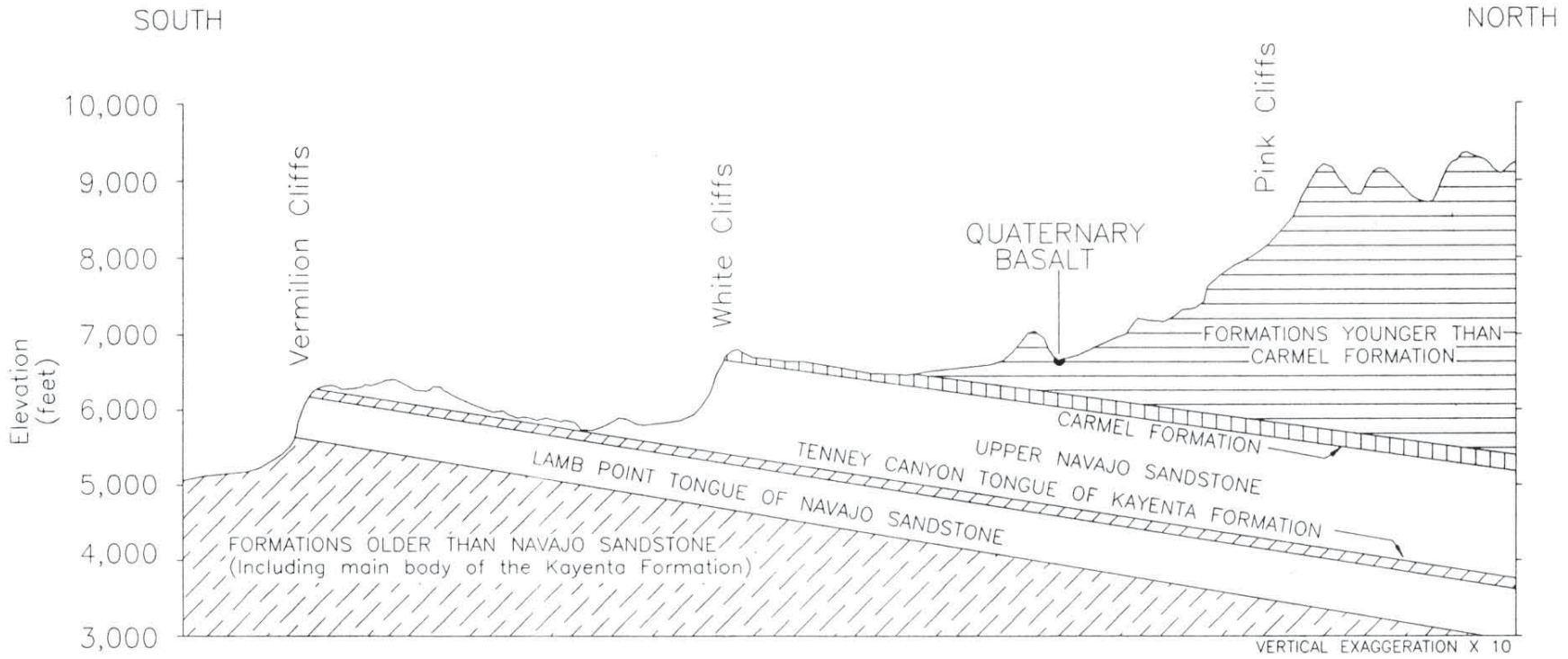
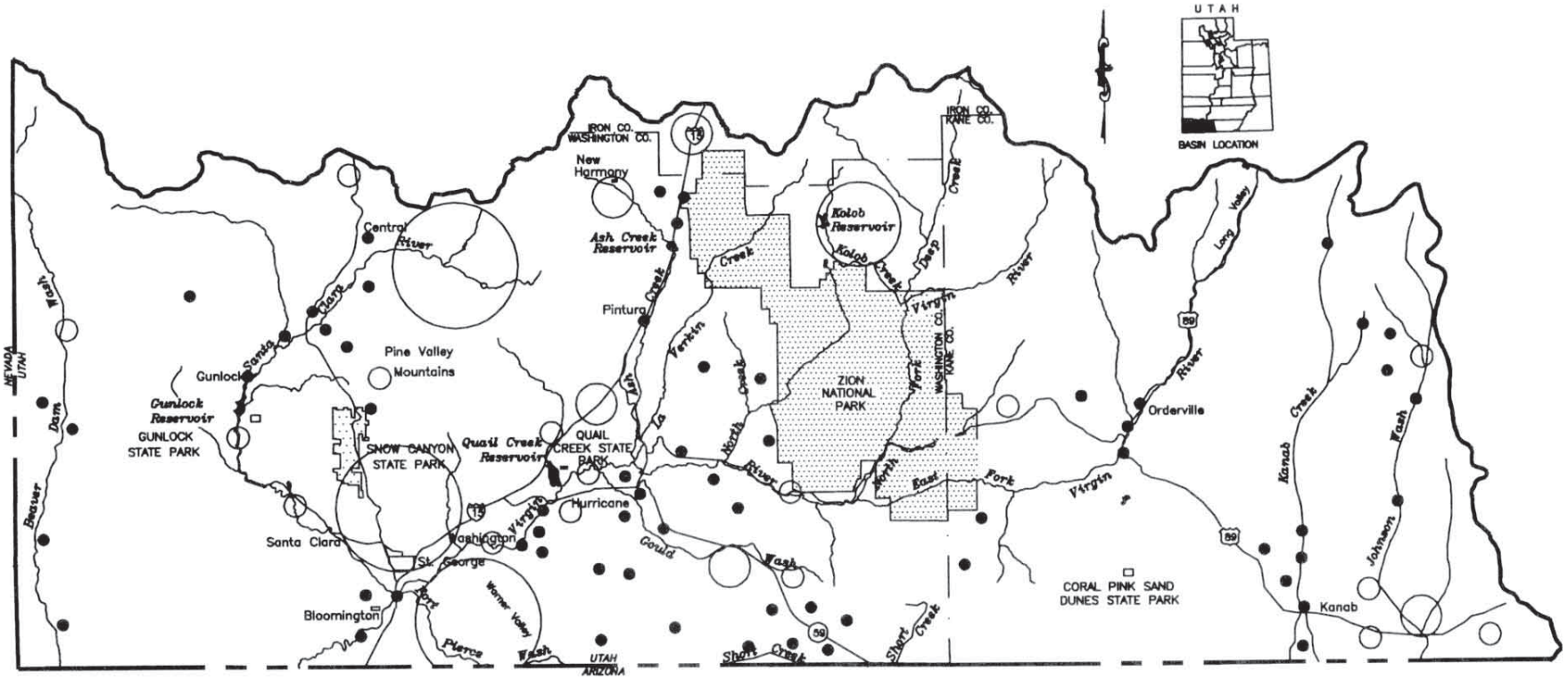


FIGURE 19-2
Well Locations



Source: Groundwater Resources of the Virgin River Basin; Clyde
Ground–Water Conditions in the Upper Virgin River and Kanab Creek Area, Utah; Cordova

LEGEND: Number of wells in vicinity.

1–5 ● 6–10 ○ 11–15 ◯ 16–25 ◯ +25 ◯

Fort Pierce Wash near the Arizona border, has dropped 45 feet since 1961. There is no evidence of long-term draw down in any wells in the East Fork of the Virgin River, Kanab Creek or Johnson Wash drainages. Even though available data do not show any widespread downward trend in well water levels, the downward trend in the two wells and the lack of data in other areas should motivate the collection of additional water level and pumpage data.

Most of the growth in irrigation well development occurred after 1950. The irrigation, domestic and stock wells are scattered around the basin while public water supply wells are clustered near cities. Most of the big public water supply wells are found at Gunlock, Snow Canyon and Mill Creek Canyon in and around St. George City. Kanab City has developed wells in Kanab Canyon. There are a total of 13 wells in the Kanab and Cottonwood canyons.

Potential exists for development of additional water by drilling wells at favorable locations. Wells drilled to penetrate the Navajo sandstone will yield from 400 to 1,500 gallons per minute. Yield depends on the thickness of the saturated zone and the extent of jointing and fracturing in the rock. About one-half of the wells yield water with dissolved-solids concentrations of less than 500 mg/l.

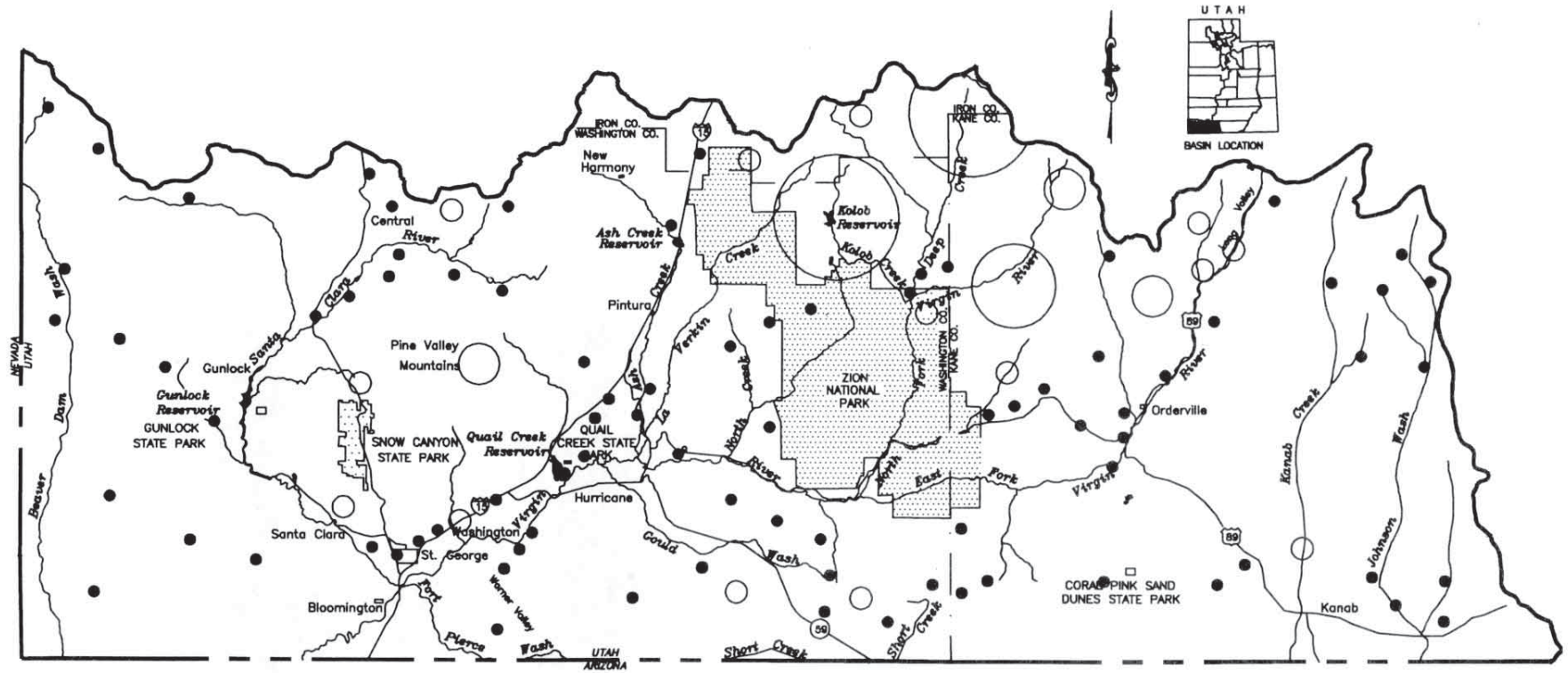
19.2.6 Springs

Springs are places where water spills from full groundwater reservoirs. Flows from the springs in the basin range from seeps to 10s of cubic feet per second (cfs). The basin has nearly 900 springs.[2] Toquerville Springs are the largest. The upper spring has been measured at greater than 21.7 cfs. If the lower springs are added in, the flows have exceeded 30 cfs. Total dissolved solids are about 450 mg/l.

La Verkin Springs (Pah Tempe) also produce a substantial amount of water, but it has poor quality. The total dissolved solids exceed 9,000 mg/l. About 12 cfs flows from these springs into the bed of the Virgin River just east of the Hurricane Fault near the town of La Verkin.

Most springs are located at higher elevations in steeper terrain. Location of the springs is shown in Figure 19-3. In some cases, wells and springs are near each other and draw on the same aquifer. An example is the springs near the edge or lip of the Navajo sandstone near St. George, in Pine Valley and in Kanab Creek and Johnson Wash. In general, spring flows are determined by long-term precipitation

FIGURE 19-3
Spring Locations



Source: Groundwater Resources of the Virgin River Basin; Clyde
Ground–Water Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah; Cordova

LEGEND: Number of springs in vicinity.

1–5 ● 6–10 ○ 11–15 ◯ 16–25 ◯ +25 ◯

patterns reflecting wet and dry cycles. About 50 percent of the springs yield water with less than 500 mg/l total dissolved solids.

19.3 Policy Issues and Recommendations

Two policy issues are discussed. These concern alternatives for groundwater development.

19.3.1 Groundwater Development

Issue - Future water needs will increase pressure on developing additional groundwater resources.

Discussion - Large volumes of high quality water are stored in the groundwater aquifers, particularly in the Navajo sandstone. More and more of this water resource is being developed. The recharge to this aquifer is slow, so care will be necessary to control groundwater mining. Use of groundwater should be tempered by its effect on water quality. Limited opportunities exist for artificially enhancing aquifer recharges. The recent study completed in Kane County through the coordinated efforts of federal, state and local entities indicates future possibilities.

Recommendation - The Utah Department of Natural Resources, U.S. Geological Survey and local government entities should conduct the necessary groundwater studies to determine the available resources and extent of use possible.

19.3.2 Protection of Recharge Areas

Issue - Groundwater recharge areas to the Navajo sandstone aquifer will become more susceptible to pollution as man's activities increase.

Discussion - Recharge maps have been developed by the U.S. Geological Survey in cooperation with the Division of Water Quality. A map of part of the area is shown in Figure 9-2. The recharge areas are environmentally sensitive and essentially the gateways to a valuable drinking water source. Any pollution spill onto these areas has a potential to contaminate drinking water taken from the Navajo sandstone and other aquifers. Recharge areas should be protected from degradation in accordance with the Utah groundwater protection regulations. County commissioners and planners should work to protect recharge areas, including ordinances if needed.

Recommendation - The Navajo sandstone recharge areas should be identified in local master plans. Local government entities should investigate management approaches in protecting these areas from potential sources of groundwater pollution. ■

19.4 References

1. Bingham Engineering. *Navajo Aquifer Investigation in Portions of Kane and Garfield Counties, Utah.* Alton Coal Project, Utah International, Inc., Salt Lake City, Utah, 1987.

2. Clyde, Calvin G. *Groundwater Resources of the Virgin River Basin in Utah.* Utah Water Research Laboratory for the Utah Division of Water Resources, Salt Lake City, Utah, 1987.

3. Cordova, R.M. *Groundwater Conditions in the Upper Virgin River and Kanab Creek Basins Area, Utah, with Emphasis on the Navajo Sandstone.* Technical Publication No. 70, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1981.

4. Ibid, G. W. Sandberg, and Wilson McConkie. *Groundwater Conditions in the Central Virgin River Basin, Utah*, Technical Publication No. 40, prepared by the U.S. Geological Survey in cooperation with the Utah Department of Natural Resources, Division of Water Rights, Salt Lake City, Utah, 1972.

5. Damery, Wm. E. *Local Ground Water Protection.* Division of Water Quality, GW Brochure #3, Salt Lake City, Utah, 1991.

6. Heilweil, Victor M., and Geoffrey W. Freethey. *Simulation of Ground-Water Flow and Water-Level Decline That Could Be Caused By Proposed Withdrawals, Navajo Sandstone, Southwestern Utah and Northwestern Arizona.* Water-Resources Investigations Report 90-4105, prepared by U.S. Geological Survey in cooperation with the Department of the Interior, National Park Service, Salt Lake City, Utah, 1992.

7. Goode, Harry D. *Reconnaissance of Water Resources of a part of Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water Resources Bulletin 5, Salt Lake City, Utah, 1964.

8. Ibid. *Second Reconnaissance of Water Resources in Western Kane County, Utah.* Utah Geological and Mineralogical Survey Water Resources Bulletin 8, Salt Lake City, Utah, 1966.

9. Schlotthauer, William E., Boyd W. Nance, and Jerry D. Olds. *Identification and Characteristics of Aquifers in Utah.* Utah Division of Water Rights, Salt Lake City, Utah, 1981, adapted from Feltis, R.D., Water from Bedrock in the Colorado Plateau of Utah; Utah State Engineer, Salt Lake City, Utah, 1966.

10. U.S. Department of Agriculture, *Water and Related Land Resources of the Sevier River Basin.* Salt Lake City, Utah, 1969.

11. U.S. Department of Agriculture, Soil Conservation Service and Utah Department of Natural Resources, Division of Water Resources. *Virgin River Basin - Utah Cooperative Study*. Salt Lake City, Utah, 1990.

12. Wilson, M.T., and H.E. Thomas, *Hydrology and Hydrogeology of Navajo Lake, Kane County, Utah,* U.S. Geological Survey Professional Paper 417-C, 26 pp. Salt Lake City, Utah, 1964.

■ **State Water Plan** - Kanab Creek/Virgin River Basin

Prepared by the State Water Plan Coordinating Committee

DEPARTMENT OF NATURAL RESOURCES
Ted Stewart, Executive Director
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