Uintah Basin
Planning for the Future

UTAH STATE WATER PLAN

November 2016

UINTAH BASIN
PLANNING FOR THE FUTURE

November 2016

By:

Utah Division of Water Resources

With input from other State of Utah water agencies
(See inside-back cover for participating agencies)

U T A H   S T A T E   W A T E R   P L A N

This document and other state water plans are available online at: www.water.utah.gov

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PREFACE

One of the major responsibilities of the Utah Division of Water Resources is comprehensive water planning. Over the past 26 years, the division has prepared a series of documents under the title "Utah State Water Plan." This includes two statewide water plans, an individual water plan for each of the state's eleven major hydrologic river basins, and five special studies on the important topics of water reuse, conjunctive management, drought, reservoir sedimentation, and leak detection. The preparation of these plans involved several major data collection programs as well as extensive inter-agency and public outreach efforts. Much was learned through this process; state, local, and federal water planners and managers obtained valuable information for use in their programs and activities, and the public received the opportunity to provide meaningful input in improving the state's water resources stewardship.

This document is the latest in the "Utah State Water Plan" series and is intended to guide and inform water-related planning and management in the Uintah Basin over the coming years. It summarizes key data obtained through the previous water planning documents, introduces new data where available, and addresses issues of importance to all future water planning efforts. Where possible, it identifies water use trends and makes projections of water use. The document also explores various means of meeting future water needs. Water managers and planners within the basin will find the data, insights and direction provided by this document valuable in their efforts. The general public will discover many useful facts and information helpful in understanding the basin's water resources. Both audiences should appreciate the real-life examples highlighted in the text and photographs. Although the use of technical words is avoided wherever possible, an extensive glossary illuminates exact usage of terminology that may be unfamiliar.

In addition to the printed form of this document, the Utah Division of Water Resources has made a digital "pdf" version available on the Internet. This can be accessed through the division's home page at: www.water.utah.gov. This web page allows this document and other water planning documents to be viewed by the largest audience possible, thus facilitating better planning and management at the state and local level.

<u>Editorial Note</u>*: The Utah Division of Water Resources recognizes that new statewide population projections are due to be published in mid-2017. These new projections will cause the future water demands to be different than the estimates contained in this report. The division will prepare updated water demands for the entire state once the new projections are available and encourages the reader to consult with the division to understand what if any impact these changes will have on the conclusions of this report. Additionally, the division is updating its data analysis processes and obtaining third-party verification of the 2015 water use numbers. This report utilizes 2010 water use numbers.*

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EXECUTIVE SUMMARY

The water resources of the Uintah Basin play an important part in the lives of basin residents. Supplying adequate water to meet the needs of the population is a responsibility shared by local water suppliers as well as federal, state and local governments.

The purpose of this document is to describe the current status of the water resources in the Uintah Basin and estimate future demands that will be placed upon them. It also identifies ways to manage and enhance existing supplies and develop new supplies to satisfy future needs. A main goal is to help water managers and others formulate the management strategies and policies that will ensure a bright future for the basin. The following pages summarize the main points of each chapter.

CHAPTER 1
INTRODUCTION:
WATERS OF THE UINTAH BASIN

The Uintah Basin receives an average of 15.6 inches of precipitation annually and contains many of Utah's largest water supply reservoirs. While much of the water stored in these reservoirs is used in the basin, a significant amount is transferred out of the basin to satisfy water needs along the Wasatch Front.

The principal drainage in the basin is the Green River with the Duchesne and White rivers being major tributaries. Vernal, Roosevelt and Duchesne are the largest communities in the basin. Approximately 57 percent of the basin is owned and managed by the federal government with a little more than half of that being managed by the Bureau of Land Management. Land ownership in the basin is as follows: Bureau of Land Management 30 percent, National Forest 19 percent, private 18 percent and Tribal Lands 15 percent.

Native inhabitants of the basin traversed the area as early as 12,000 years ago. The Fremont culture was the first to establish settlements and irrigate crops. Since about 1300 AD to today the Ute tribe has resided in the basin.

In 1861 president Abraham Lincoln established the Uintah Valley Indian Reservation that encompassed the drainage of the present day Duchesne River in the northwest quadrant of the basin. By 1864 most of the Utah Utes were relocated to this reservation. In 1881 the Uncompahgre band of Utes located in Colorado were forced to join the neighboring Ute tribe on the reservation. Soon thereafter the Uncompahgre Indian Reservation was formed in the more arid southeast quadrant of the basin. Today these lands are collectively referred to as Uintah and Ouray Tribal Lands.

With the assistance of irrigation, the first white settlers established successful farming and ranching communities in Ashley Valley. This raised the pressure on federal officials to open up portions of the original Uintah and Ouray Indian Reservation for settlement. Cooperation among the whites and Native Americans resulted in the completion of an extensive network of canals and laterals that benefitted both tribal members and white settlers.

Around the turn of the century, farmers in southern Utah Valley began to work on a project to divert water from the Uintah Basin to their farms. This ambitious dream became a reality when the federal government entered the water development business in the West. Eventually, in 1915, the Strawberry Valley Project was completed. This included the basin's first large dam at Soldier Creek and a major tunnel to divert water through the mountains to the Wasatch Front. In subsequent years, many additional water development projects were constructed, including the Moon Lake Project in 1941. In 1953, another diversion from the basin to the Wasatch Front occurred with the completion of the Duchesne Tunnel, a feature of the Provo River project.

The ultimate water development project constructed in the basin is the Central Utah Project (CUP). The final components of this project for the Uintah Basin have been completed. Although some components of the project were never completed, including those intended for the Ute Tribe, the tribe receives $2.1 million per year from the Bonneville Unit M&I revenues and to date has received $240 million for economic development. Key CUP facilities located in the Uintah Basin include: Strawberry Aqueduct, Strawberry Reservoir, Upper Stillwater Reservoir, Currant Creek

Reservoir, Starvation Reservoir, Bottle Hollow Reservoir, Steinaker Reservoir and Red Fleet Reservoir.

The Utah Division of Water Resources strives to gather information to include in its planning documents that is both accurate and useful for local water managers. Occasionally these managers may disagree with certain data and decide it is necessary to gather their own data or conduct their own analysis. The division recognizes the importance of local planning and encourages managers to conduct research and analysis to meet local water needs. Nothing published in the division's planning documents should be interpreted as intending to limit or control projects that are deemed necessary by local managers.

CHAPTER 2
WATER SUPPLY

The bulk of the Uintah Basin's water supplies come from surface water sources. The Green River is the largest river in the basin and receives significant flow from the Yampa, White and Duchesne rivers. Groundwater is developed primarily for municipal and industrial uses and makes up only a minor component of the overall water supply.

It is estimated that approximately 9,113,000 acre-feet precipitation falls on the Uintah Basin each year. Of this, the vast majority (7,939,400 acre-feet) is consumed by natural systems. The basin's total yield, or available supply is approximately 1,173,600 acre-feet. Uses in the basin include irrigation depletions of 340,000 acre-feet, municipal and industrial (M&I) depletions of 18,000 acre-feet, and surface evaporation from reservoirs of 124,000 acre-feet. Water exported from the basin is about 167,000 acre-feet per year. Approximately 3,463,000 acre-feet per year flows out of the basin via the Green River.

Drought is a significant variable to the water supply. Using the Palmer Drought Severity Index and the Surface Water Supply Index, six significant drought periods were identified during the last 117 years. Climate change is another variable in the water supply. Research shows that mean temperatures in parts of the Colorado River basin have been steadily increasing and have warmed more than any other region in the United States. Consequences of temperature increases include a growing season that begins earlier and lasts longer, increased evapotranspiration, a smaller snowpack with earlier melting, decreased summer precipitation with fall and winter precipitation coming as rain rather than snow and decreased streamflow in the Colorado River and its tributaries.

Water rights are an integral component of water management in Utah. In the Uintah Basin, the unresolved issue of reserved water rights for the Ute Tribe greatly impacts existing water management and planning for the future. In 1992, as part of the Central Utah Project Completion Act (CUPCA), the State of Utah and the federal government ratified the proposed 1990 Ute Indian Water Compact. This is subject to re-ratification by the State and the Tribe, neither of which has occurred as of October, 2016. A central purpose of this compact was to quantify the Tribe's reserved water rights. According to the Compact, the Tribe is entitled to 248,943 acre-feet of depletion per year with a related gross diversion of 470,594 acre-feet per year from all sources. An additional 10,000 acre-feet of depletion for M&I uses was authorized to be taken from the Green River. Depending on the type and location of proposed use, the priority date of the water right is either October 3, 1861 or January 5, 1882.

The Compact further indicates that, "the State of Utah, through the State Engineer, shall use its best efforts to see that the reserved water rights of the Ute Tribe secured in this Compact are protected from impairment." The Utah Division of Water Rights has estimated the amount of diversions that have been taking place so far. When these estimated amounts are subtracted from the total 258,943 acre-feet, there is left remaining approximately 106,000 acre-feet per year of depletions yet to be developed.

CHAPTER 3
POPULATION AND WATER USE TRENDS AND PROJECTIONS

The 2010 U.S. Census put the population of the Uintah Basin at just over 52,000 persons. Over 60 percent live in rural areas. The Governor's Office of Management and Budget estimates the basin's 2030 population will increase modestly to just over 67,000 people. The 2060 population is projected to grow to just over 81,000 residents. The distribution is 1,678 in Daggett County, 29,275 in Duchesne County and 50,174 in Uintah County. While much of this growth is in the several cities, over half of it is projected to occur in rural areas. In most areas of Utah, irrigated agricultural ground has been converted to residential, commercial or industrial uses as the population grows. However, in the Uintah Basin this is not the trend; instead, agricultural land areas have increased about six percent over the last 20 years.

Municipal and industrial water use in the basin totals approximately 25,566 acre-feet per year with 23,120 acre-feet for potable uses and 2,441 acre-feet for non-potable or secondary uses. The 2010 water uses in Daggett, Duchesne and Uintah counties are substantially lower than available reliable water supplies. The Uintah Basin's total public use of 288 gallons per capita per day is about 20 percent higher than the statewide average of 240 gpcd.

Industrial water use in the oil and gas industries is unique to the Uintah Basin. Crude oil production has had a series of "boom and bust" scenarios from 1956 to 2016. Water is produced by oil and by gas drilling; this water is disposed of by injecting it into deep wells, storage and evaporation and re-use of produced water. Isolated water shortages still occur and those shortages are expected to continue.

Recreation is a major water use in the Uintah Basin. Included in the basin are Dinosaur National Monument, Flaming Gorge Reservoir and Recreational area, four state parks, the Uinta Mountains, wilderness areas, three National Forests (Ashley, Uinta and Wasatch), Nine-mile Canyon, the Green River, Strawberry Reservoir, along with numerous other lakes, reservoirs, mountain streams and campgrounds. While Utah's population increased four times over the last four decades, boat registration increased nine times and the number of fishing licenses increased three times; clearly recreation is playing an increasing important role in the lives of Utah citizens.

CHAPTER 4
OIL SHALE AND TAR SANDS WATER NEEDS

Extracting oil from oil shale requires water. Given the large quantities of oil shale in the Uintah Basin, there is understandable concern that such recovery could deplete existing water supplies.

While oil shale is found in 33 countries worldwide, the Green River Formation deposits in Utah, Colorado and Wyoming are the largest. About 52 percent of the world's estimated oil shale is contained in these deposits. About 72 percent of this oil shale is located beneath federal lands, making the federal government a key player in its potential development.

The U. S. Geological Survey (USGS) estimates that the Green River Formation contains about three trillion barrels of oil, and about half of this may be recoverable. This is an amount about equal to the entire world's proven oil reserves. However, it's important to note some distinctions (italics and bold added); these *in-place resource numbers* should not be compared to *conventional oil reserves,* as is often the case (a **resource** is the total amount of a particular commodity *available in the ground,* a recoverable **reserve** is the amount of that commodity *that can be economically recovered*). No commercial technology is currently available in the United States to extract oil from oil shale; therefore, accurate reserve numbers cannot be calculated.

In 2008 the Utah Geological Survey published a report taking into account five reasonable *constraints* to oil shale mining and estimated the potential **resource** of shale oil in the ground in Utah. Using these constraints, the Uintah Basin's potential economic oil shale resource was estimated to be about 77 billion barrels. This is a more realistic estimate of potential resource. However, this number should not be used as an estimate of recoverable **reserves**, which cannot be calculated until a proven commercial technology is developed. The 77 billion barrel resource number represents a very large and very significant amount of oil. *However, it is only about 5 percent of the USGS estimate quoted by GAO of 1.5 trillion barrels and the recoverable **reserve** amount will be less than the resource amount.* This strongly suggests the size of the oil shale industry in the Uintah Basin will be much smaller than previous estimates and less water than originally estimated will be needed.

2010 estimates of how much water is needed to extract oil from shale varied widely depending on the process used. Estimates ranged from one to 12 barrels of water for each barrel of oil, with an average of about five barrels. 2015 estimates from companies exploring specific projects are in the range of 0.5 to 2 barrels of water needed per barrel of oil.

There are more than 50 identified tar sand deposits in Utah, which contain an estimated **resource** total of 19 to 29.2 billion barrels of oil in place. About 80 to 90 percent of Utah's total tar sand resource is found in the Uintah Basin. As previously defined, a **resource** is the total amount of a particular commodity *available in the ground*; a **reserve** is the amount of that commodity *that can be economically recovered*. There is no commercial technology currently available to extract oil from Utah tar sands. For comparison, the **resource** estimate of about 24 billion barrels in the tar sands is 31 percent of the 77 billion barrel **resource** number for oil shale. Without a commercial technology to extract oil from Utah tar sands, little is known about potential impacts to the water resources in the Uintah Basin.

Of the three companies extracting oil from tar sands, one company's process uses no water while the second will get water from nearby surface water sources. The third will use water from nearby wells; in addition, the technology recycles 95 percent of the water. It appears that, at least for the foreseeable future, none of the three tar sand extraction companies expects to get water from water suppliers in the basin. Of the three companies extracting oil from shale, one expects to get water from wells on the mining property. In addition, the extraction process produces water. The second oil shale company uses the same process as the first; however, the water source is unknown. The third shale oil company expects to pump water from the Green River. It appears that, at least for the foreseeable future, none of the three shale extraction companies expects to get water from water suppliers in the basin.

Since the oil shale and tar sand industries will start small and likely expand in the future, it is prudent for water suppliers to plan for some water demand for these industries. The higher water use estimates developed in 2006 were used as a basis to estimate water needs for producing oil from shale and from tar sands in 2015. Present day and future oil production rates from the respective companies were also used. Then the number of barrels of water needed per barrel of oil was indexed from past estimates to present day estimates. The result is an estimated amount of water needed in 2015 for extracting oil from shale from 8,640 acre-feet to 43,200 acre-feet, depending on oil production rates. The estimated amount of water needed in 2015 for extracting oil from tar sands varies from 13,500 acre-feet to 40,500 acre-feet, depending on oil production rates.

It is possible that the price of water could be driven high enough by the energy industry that it becomes advantageous to sell one's water rights and no longer be involved in agriculture. If this occurs, the agriculture industry would be impacted by oil shale mining. However, such a voluntary transfer of demand from agriculture to M&I would not affect the total demand. Such willing buyers to willing seller transfers are common throughout Utah.

CHAPTER 5
M&I WATER CONSERVATION AND OTHER WATER MANAGEMENT STRATEGIES

The State of Utah has developed a specific goal to conserve municipal and industrial (M&I) water supplies. This goal is to reduce the per person, or "per capita" water demand from public community water systems by at least 25 percent before 2025. The base year for measuring the decrease is 2000. Specifically, statewide per capita demand will need to decline from 295 gallons per person per day (gpcd) to a sustained 221 gpcd or less. A 25 percent reduction in the Uintah Basin would decrease water demand from 305 gpcd in 2000 to 229 gpcd in 2025.

In 2010 statewide per capita water use had declined 18 percent in ten years or about 1.8 percent per year. This is almost twice the state goal. Per capita water use in the Uintah Basin declined 5.2 percent in the same 10-year period or about 0.5 percent per year. This is half the state goal. Statewide, industrial water use is about two percent of the total public community system use. However, some systems in the Uintah Basin have unusually high industrial water demands of 53 and 73 percent. Moreover, the percentage of industrial water use is increasing with time.

Because of the significance of oil, gas and mining to the future of the basin's economy, the Utah Division of Water Resources does not anticipate water demands in the industrial sector declining (on a per capita basis) in the future. Consequently, in calculating its public water supplier demand projections, the division held the *per capita industrial water use* constant. The result is an overall conservation goal in the Uintah Basin of 21 percent by 2060.

Without water conservation, it is estimated that by the year 2060 public community water systems in the Uintah Basin would experience a water demand of about 25,216 acre-feet per year. With conservation, this demand can be reduced to approximately 21,237 acre-feet per year, roughly 4,000 acre-feet per year more than is presently being used. This could save millions of dollars in infrastructure costs. Especially since the current reliable supply would be able to adequately supply the 2060 demand.

The Water Conservation Plan Act requires any water retailer with more than 500 connections and all water conservancy districts to prepare water conservation plans and submit them to the Division of Water Resources. As of October, 2016, 100 percent of the water retailers and conservancy districts in the Uintah Basin who are required to submit a plan or update have done so.

In the state's more urban basins, agricultural water is being converted to M&I use with increasing regularity. The Uintah Basin is the sole exception to this norm. So far, municipal and industrial water supplies have been more than adequate to meet the basin population growth. Consequently there has not been any pressure from the demand side to convert agricultural water to M&I use. Additionally, the basin's slow population growth has not caused much agricultural land to be converted to municipal, commercial or industrial uses. While current water supplies for the oil shale and tar sands industries are adequate, it is possible that future expansion of those industries will require commercial water suppliers to provide water. Moreover, those future needs may compete with other uses, primarily agriculture, for water that is available in the basin. It may end up that some agricultural water use will be converted to industrial use simply based on competition between water users. These would be market-based transfers between a willing buyer and a willing seller.

Salinity control projects throughout the Colorado River Basin have had a large impact on water development. In addition to reducing salt concentrations for downstream water users, these efforts have resulted in a significant reduction of water losses in canals and ditches and improved irrigation system efficiency. The result is more water being available for delivery to the farm field and greatly increased crop yields from the same irrigated acreage.

In 1973 the Colorado River Basin states formed the Colorado River Basin Salinity Control Forum to control salinity increases in the river in order to comply with Section 303 (a) and (b) of the Clean Water Act. Salt contributions from the Uintah Basin have been reduced by 179,000 tons per year or about 15 percent of the total reduction. It is estimated that an additional overall reduction of 1,362,000 tons per year can be achieved on the Colorado River. Of that, about an additional 108,000 tons per year (or eight percent) reduction may come from the Uintah Basin.

CHAPTER 6
WATER DEVELOPMENT

In 2003, the Central Utah Water Conservancy District undertook the Uintah Basin Replacement Project. The Big Sand Wash Reservoir capacity was increased by enlarging the dam. This allowed water that had been stored in high mountain lakes to be stored in the reservoir. The Big Sand Wash Feeder Diversion Structure was built on the Lake Fork River. Water is then taken through the Big Sand Wash Feeder Pipeline to the enlarged Big Sand Wash Reservoir and used for irrigation, as well as municipal and industrial purposes. Thirteen mountain lakes in the Uinta Mountains were stabilized. Taken together, this entire project, 1) increased irrigation water supplies by 1,963 acre-feet per year, 2) increased M&I water supply by 3,000 acre-feet per year for the city of Roosevelt, 3) stabilized 13 high mountain lakes, 4) stabilized instream flows on the Lake Fork and Yellowstone river resulting in more constant and extended water flows, 5) improved high mountain lake and stream habitat and 6) provided an estimated total annual benefit of about $2.4 million.

In 2009 the Mosby Irrigation Company completed construction of a diversion structure on Deep Creek, a feeder canal, an offstream earthfill dam and dike (Redwash Dam), and an emergency spillway. The project stores about 2,523 acre-feet of water for late season irrigation. Costing about $9.5 million, the project enables irrigation of an additional 2,173 acres of land resulting in an estimated annual benefit of $60,000 per year for the irrigators.

By constructing the Green River Pumping Project the Uintah Water Conservancy District developed and used about 8,500 acre-feet of its 51,800 acre-feet of the Flaming Gorge Water Right. In addition to preventing about 3,000 tons of salt from entering the Colorado River, there is a net annual benefit of $975,000 to the irrigators.

In 2007, a collaborative study was undertaken by the Central Utah, Duchesne County and Uintah water conservancy districts. The purpose of this study was to show how the districts intend to use the Flaming Gorge water rights that the Board of Water Resources awarded them. The study developed near future and total likely future water demand in the agricultural, municipal and industrial categories. The study identified ways to develop water to satisfy those demands. They include construction of four new reservoirs, enlargement of two reservoirs, extension of the Yellowstone Feeder Canal, pumping water from the Green River and multiple water right exchanges. Individually and collectively these represent substantial capital investments. A scheme to prioritize the projects and to combine projects was developed; included were estimates of water yield for each scenario. Finally, ranking criteria were developed.

CHAPTER 7
WATER QUALITY

In recent decades more attention has been given to minimizing negative impacts while putting water to beneficial use. Considerable effort and expense has been made mitigating past mistakes and repairing damaged ecosystems. In many instances it has been found that working in this manner is more beneficial in the long run. More than ever, today's water planners and managers are aware of the potential impacts water development can have and are working to create plans and strategies that minimize impacts.

The State Water Plan identifies the following water quality programs or concerns that are of particular importance to the future of the state's water resources: 1) Total Maximum Daily Load (TMDL), 2) Storm Water Discharge, 3) Concentrated Animal Feedlot Operations and 4) Septic Tank Densities.

Every waterbody in Utah is classified by beneficial use and assigned water quality standards necessary to protect that use. Waterbodies not meeting the standards are designated as impaired and a plan must be prepared to correct the impairment. There are 15 water bodies identified so far in the Uintah Basin needing work to meet TMDL conditions.

Currently there are no communities in the Uintah Basin large enough to require storm water discharge permits. Vernal will likely meet that threshold by 2020 and will require compliance thereafter. While there are nearly 3,000 concentrated animal feedlot operations statewide, there is only one in the Uintah Basin and it is in compliance with its management plan. There is currently only one problem area in the Uintah Basin due to septic tank densities. That is in Hancock Cove west of Roosevelt.

There is considerable concern that a proposed phosphate mine that would be immediately adjacent to and surrounding Ashley Springs may impede flows to the spring and cause pollution of the waters. The spring provides culinary water to over 18,000 people, over 50 percent of the population of Uintah County. The proposed mine is located on both sides of Ashley Creek (location of Ashley Springs) within one-quarter mile of the springs.

Phosphate mines in the United States are large contributors of selenium to surrounding waters. This element is bio-accumulating and poisons animals eating plants that absorb selenium. The phosphate fertilizer itself is a risk to animal and human health. Phosphate rock contains radioactive materials that are 10 to 100 times more concentrated than found in most natural materials. With the mining and processing operations going on in such immediate proximity to the springs (for years) there is concern that surface waters percolating down through the site can pollute the surface waters of Ashley Creek and the groundwater of Ashley Springs.

The U. S. Geological Survey has been engaged to do a comprehensive study of the south slope of the Uintah Mountains west, north and east of Ashley Springs in order to ascertain the risk of the proposed mine to Ashley Springs.

CHAPTER 8
THE ENVIRONMENT & OTHER MATTERS

In 1973, the federal Endangered Species Act (ESA) was passed by Congress to prevent plant and animal species from becoming extinct. Although the ESA has had some success, it has been widely criticized because of negative impacts on the communities located near threatened and endangered species. Once a species is federally listed as either threatened or endangered, the ESA restricts development, land management and other activities that may impair recovery of the species. As a preemptive measure, species in

Utah under consideration for federal listing are given a special designation and are managed by the state in an effort to preclude their listing. These species are listed as “candidate” species (CS). In addition, the state also has studied other “species of concern” (SPC) that may be covered by a conservation agreement if sufficient evidence supports such a listing.

Seven candidate species and 21 species of concern have been identified in the Uintah Basin. In 1988 the Upper Colorado River Endangered Fish Recovery Program was established to help bring four species of endangered fish back from the brink of extinction: the Humpback Chub, Bonytail, Colorado Pikeminnow and Razorback Sucker. Timelines for downlisting/delisting the individual species have been established that extend no later than 2023.

Due to human encroachment, wetland and riparian environments in the Uintah Basin have been impacted. While wetland and riparian corridors cover only a small portion of the landscape, these habitats harbor a large variety of wildlife, provide flood protection, and perform many ecological functions that maintain the integrity of stream channels and the quality of the water passing through them. In some areas of the Uintah Basin, diminished water flows have substantially reduced periodic flooding and the overall supply of water wetland and riparian areas depend on, diminishing their overall area and reducing the effectiveness of those areas that remain.

Four major wetland and riparian restoration projects have been identified; they are: 1) the Lower Duchesne River Wetlands Mitigation Project, 2) Montes Creek Mitigation Site, 3) Stewart Lake Waterfowl Management Area and 4) High Mountain Reservoir Stabilization.

An instream flow is often defined as “free flowing water left in a stream in quantity and quality appropriate to provide for a specific purpose.” In general, the purpose of such flow is to provide habitat for fish and other aquatic wildlife; however, an instream flow may also provide water for terrestrial wildlife and livestock watering, maintain critical riparian vegetation, accommodate recreational purposes, or simply enhance the aesthetics of the natural environment. The quantity and timing of instream flows vary with each purpose and are not necessarily the same as a minimum flow. There are six Minimum Instream Flow Agreements in the Uintah Basin located on Current Creek, Strawberry River (two reaches), Duchesne River, Rock Creek and the Green River.

The Wild and Scenic Rivers Act of 1968 states that, “certain selected rivers of the nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations." Only Congress has the authority to designate a stream or river segment as “Wild and Scenic.” In most cases, such designation would prevent construction of flow modifying structures or other facilities on designated river segments. The area for which development is limited along a wild and scenic river varies, but includes at least the area within one-quarter mile of the ordinary high water mark on either side of a designated river segment.

Currently there are only a handful of rivers in Utah with the Wild and Scenic River designation, mostly located in or near national parks. The recent completion of reviews by the U.S. Forest Service for wild and scenic suitability as well as the BLM Resource Management Plans for Utah, however, have identified river segments within the Uintah Basin that could be included in the national inventory. These proposed segments total 166 river miles, of which all but 40 are on various segments of the Green River.

There are currently 10 areas within the Uintah Basin designated as Wilderness and Wilderness Study Areas. Similar to Wild and Scenic Rivers, these areas are protected from development activities that would disturb or compromise the wild character of these lands. Dam hazard ratings reflect high, moderate or low damage potential if the dam were to fail. Hazard ratings do not reflect the condition or reliability of the dam, but rather the potential for loss of life or property damage in the event the dam failed. There are currently 26 high hazard dams in the Uintah Basin.

There is considerable discussion regarding the practice of “fracking” shale deposits in order to enhance the release of natural gas. Due to the unique geology of the Uintah Basin, fracking is unlikely to present significant problems.

1

INTRODUCTION: WATERS OF THE UINTAH BASIN

The Uintah Basin, located in the northeast corner of Utah along the border with Wyoming and Colorado, receives an average of 15.6 inches of precipitation annually — only slightly more than the statewide average of 13 inches — and contains many of Utah's largest water supply reservoirs. While much of the water stored in these reservoirs is used in the basin, a significant amount is transferred out of the basin to satisfy water needs along the Wasatch Front.

The Uintah Basin is predominantly a rural agricultural area with farms distributed throughout the basin. The basin is not densely populated like other Utah basins, and thus not subject to the same magnitude of problems associated with providing water for a growing population. However, the basin is incredibly rich in energy resources and thus subject to the ebb and flow of the oil and gas industry. The potential for large scale oil shale and tar sands extraction within the basin presents a particular challenge for future water planning.

In addition to uncertainties surrounding future energy development, not all streams and other water bodies in the basin meet Utah's water quality standards. Increasing environmental and recreational demands bring greater competition for the water in the basin and will require more emphasis on wise management and efficient use of the basin's water resources.

FUTURE VISION

In order to meet future water demands in the Uintah Basin, water suppliers will need to work together to efficiently use existing water supplies and develop new water sources. State and local leaders need to work closely with water suppliers in the basin to promote water conservation measures and to promote innovative water management technologies where needed. While there are generally sufficient water supplies available to meet the basin's growing demands, there is a need for additional local infrastructure to deliver the water to each community as growth occurs. Further, oil shale and tar sand energy development will likely stimulate additional water demand.

In addition to constructing adequate infrastructure for the future, water planners and managers need to expand efforts to effectively address water quality, environmental and other concerns. Water agencies and institutions must fully integrate strategies and policies into operations that address these issues. An important aspect of this endeavor will be to coordinate federal, tribal and state water resources efforts with localized needs, especially as the water needs of energy development interests become better defined. This coordination will allow solutions to be tailored to local conditions and help maintain a constructive and open dialog among all water resources stakeholders.

Keys to assuring a productive future for the water resources of the Uintah Basin include the following:

- Strong cooperation between all water resources stakeholders;
- Continued investment in water infrastructure and water development;
- Concerted effort to improve water conservation measures and practices;
- Continued investment in water quality programs; and

- Conscious effort to address environmental, recreational and other needs.

PURPOSE OF THIS PLAN

The purpose of this document is to describe the current status of the water resources in the Uintah Basin and estimate future demands that will be placed upon the basin's water suppliers. This involves quantifying the available water supply, measuring current uses, estimating future uses, and identifying ways to manage and enhance existing supplies and develop new supplies to satisfy future needs. A main goal of this document is to help water managers and others formulate the management strategies and policies that will ensure adequate future water supplies for the basin. In addition to presenting basic water-related data, this document will be a valuable resource for those who live in the basin or who are otherwise interested in contributing to water-related decisions.

The Utah Division of Water Resources makes a concerted effort to gather information to include in its planning documents that is both accurate and useful for local water managers. Occasionally these managers dispute the accuracy of certain data and decide it is necessary to gather their own data or conduct their own analysis. The division recognizes the importance of local planning and encourages managers to conduct research and analysis to meet local water needs. Nothing published in the division's planning documents should be interpreted as intending to limit or control projects that are deemed necessary by local managers.

DESCRIPTION OF BASIN

The Uintah Basin, as defined by the Utah Division of Water Resources, comprises all of Daggett and Uintah counties, most of Duchesne County, and a small portion of Grand, Emery, Carbon, Summit, Utah and Wasatch counties. See Figure 1. The basin is bounded on the north by the Utah-Wyoming boundary, on the west by the Wasatch Mountains, on the southwest by the West Tavaputs Plateau, on the southeast by the East Tavaputs Plateau and on the east by the Utah-Colorado boundary. The principal drainage in the basin is the Green River, with the Duchesne and White Rivers as major tributaries. Vernal, Roosevelt and Duchesne are the largest communities in the basin.

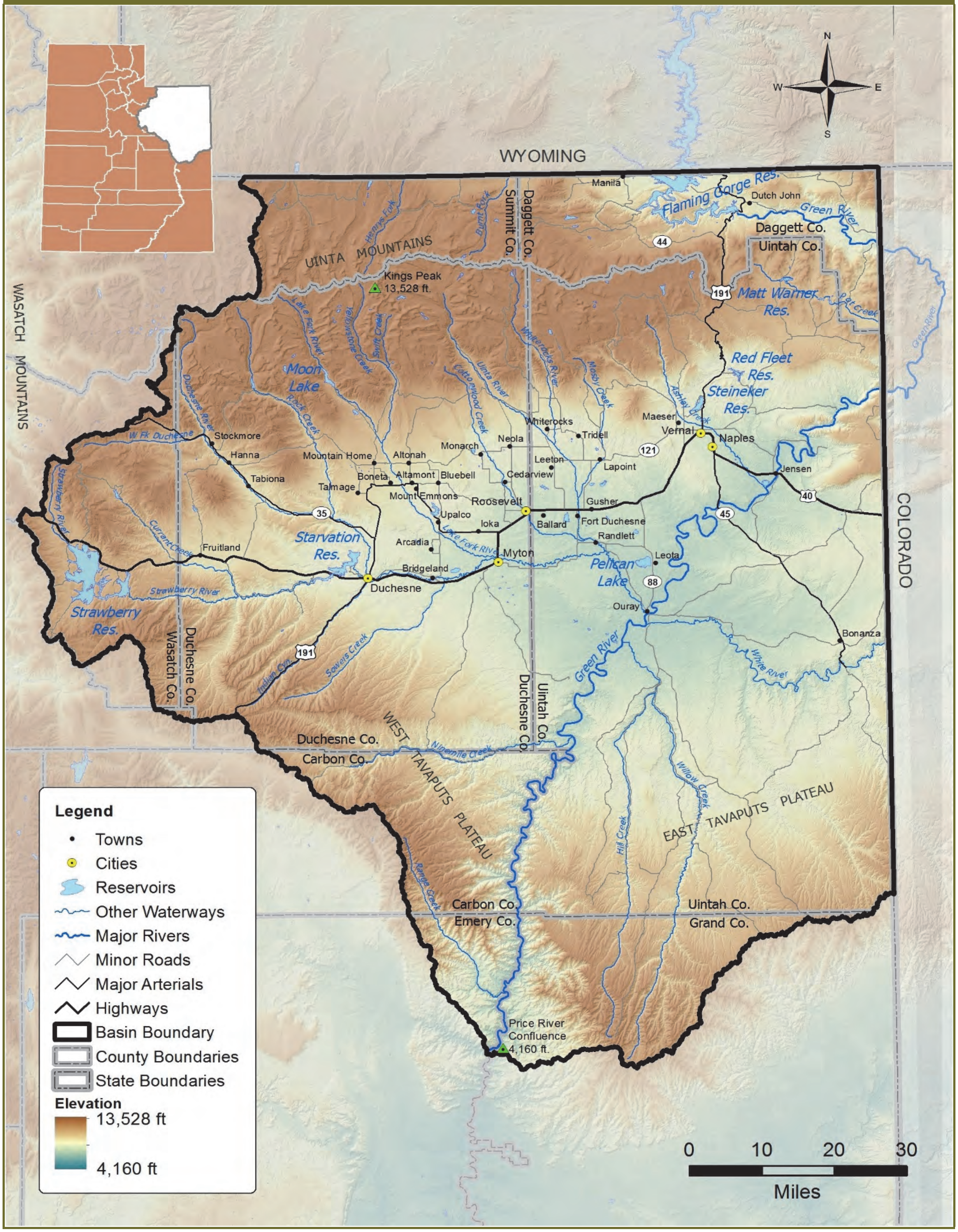
The Uintah Basin is one of the 11 planning areas that the division uses for water planning purposes. As such, the division's Uintah Basin should not be confused with the Uinta Basin, a natural hydrologic drainage that includes the majority of the Uintah Basin planning area (from the Uinta Mountains ridgeline south), but also extends into northwestern Colorado. In naming this planning area the Uintah Basin, the division follows the tradition of adding an "h" to the name Uinta to designate a human-defined boundary. Natural features include the Uinta Mountains and Uinta Basin.

Drainage Area and Topography

The Uintah Basin is divided into two primary drainages — the north slope and the south slope of the Uinta Mountains. The north slope is bounded by the Uinta Mountains to the south, the Wyoming border to the north, the Colorado border to the east, and the Bear River Basin to the west. The south slope is bounded by the Uinta Mountains to the north, the East and West Tavaputs Plateaus to the south, Diamond Mountain and the Utah-Colorado border to the east, and the Wasatch Range to the west. Elevations range from 13,528 feet at Kings Peak (the highest point in Utah) in the Uinta Mountains to 4,160 feet where the Green River exits the basin, just above the confluence with the Price River. While the mean elevation of the basin is 7,213 feet, most of the population lives between the elevations of 5,518 (Duchesne) and 5,095 feet (Roosevelt).

The Green River drains the north slope of the Uinta Mountains, while the Duchesne River, its primary tributary, drains the south slope. The White River, also a tributary, drains the eastern Utah border area, and part of Colorado. The north slope of the Uinta Mountains has many small streams, such as Blacks Fork, Smiths Fork, Henrys Fork, Beaver Creek, Burnt Fork and Sheep Creek. These streams flow north into Wyoming on the way to the Green River. Some of this water is used for irrigation and municipal and industrial purposes in Wyoming and Utah. The major south slope streams are Currant Creek, Red Creek, Rock Creek, Yellowstone[1] Creek, Lake Fork River, Uinta River, Whiterocks River and Strawberry River which drain into the Duchesne River, and eventually to the Green River. The Vernal area is drained by Dry Fork, Ashley and Brush creeks.

FIGURE 1
Uintah Basin Map



LAND OWNERSHIP

Approximately 55 percent of the basin (about 3.8 million acres) is owned and managed by the federal government. More than half of that federal land is managed by the Bureau of Land Management (2.1 million acres). There are 1.3 million acres of national forest land in the basin. See Table 1 and Figure 2.

There is approximately 1.3 million acres of private land in the basin, representing approximately 18 percent of the basin's total land. Private lands are located primarily in the valleys and lowlands in the central portion of the basin. There are also over a million acres of Tribal lands in the basin, just over 15 percent. About half of the basin's Tribal lands are located alongside the private land located in the lowlands in the central valley portion of the basin. Half of the basin's Tribal lands are located in the mountainous region of the Tavaputs Plateau east of the Green River in the southern portion of the basin.

The state owns approximately 668,000 acres of land in the basin, amounting to nearly 10 percent of the basin's lands. The majority of this is approximately 484,000 acres of state trust lands.

SIGNIFICANCE OF WATER RESOURCES TO THE BASIN

Water is a central feature of the Uintah Basin's landscapes. Originating primarily from high in the Uinta Mountains, numerous rivers and streams flow through mountain valleys and rugged canyons on the way to the Green River and subsequently to the Colorado River – one of the western United States' most significant sources of fresh water. Native inhabitants and early trappers of the Uintah Basin depended upon water resources and associated habitat and wildlife to sustain life. Later, with the establishment of two reservations for Native Americans and an influx of settlers, the waters of the basin were increasingly utilized.

Today the waters of the Uintah Basin support a significant agricultural industry and growing energy extraction activities. Outdoor activities available in the Uinta Mountains, area reservoirs and other natural features of the basin also help support a strong recreation and tourism industry. For these and other reasons, the basin's population is expected to continue growing, increasing approximately 55 percent from 2010 to 2060.

BRIEF HISTORY OF WATER USE AND DEVELOPMENT

For thousands of years the water resources in the Uintah Basin have sustained an abundant fish and wildlife population. Native Americans, as well as more modern immigrants to the basin, relied heavily on these resources for sustenance. Today, the water resources of the basin are primarily used for agricultural irrigation and export to the Wasatch Front; water also sustains local communities and farms and a growing energy extraction industry.

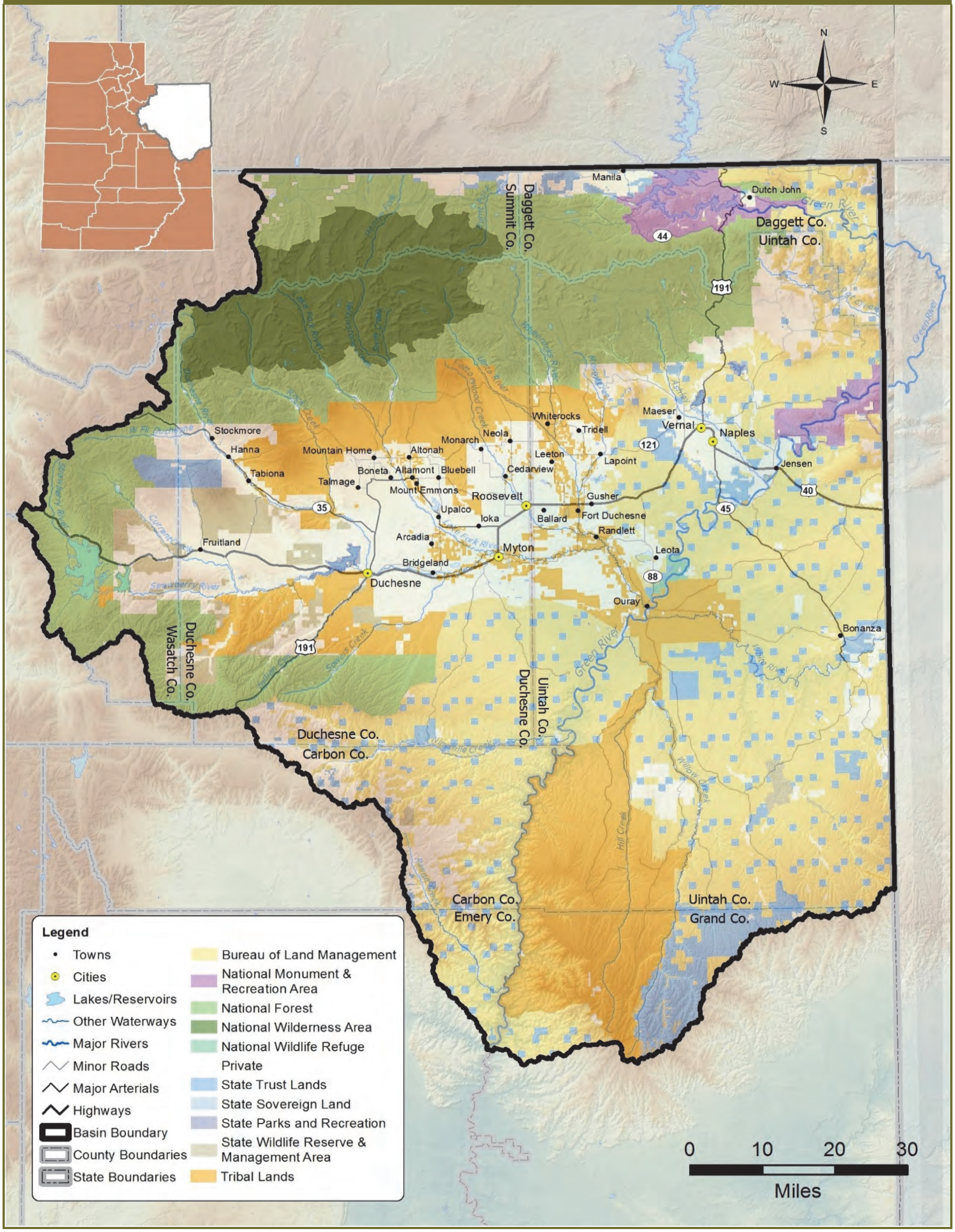
Water development has played a key role in the history of the Uintah Basin. While the sequence of events in the basin's water use and development history are numerous and quite fascinating, only a brief summary is given here.

TABLE 1
Land Ownership

Land Owner	Acres	Percent
Bureau of Land Management	2,078,800	29.8%
National Forest	1,306,600	18.8%
National Parks, Monuments and Historic Areas	51,900	0.7%
National Recreation Areas	91,600	1.3%
National Wilderness Areas	426,800	6.1%
National Wildlife Refuge	7,700	0.1%
Private	1,272,700	18.2%
State Parks and Recreation	11,300	0.2%
State Sovereign Lands	9,300	0.1%
State Trust Lands	483,700	6.9%
State Wildlife Reserve/Management Area	163,200	2.3%
Tribal Lands	1,067,200	15.3%
TOTAL	**6,970,000**	**100.0%**

Source: Utah Division of Water Resources, September, 2015.

FIGURE 2
Land Ownership



Native Inhabitants and Early Visitors (Before 1861)

Archeological evidence of ancient inhabitation of the Uintah Basin is sparse, but it is generally assumed that the area was at least visited, if not directly inhabited, about 12,000 years ago.[2] These Paleo-Indians, and the subsequent archaic culture, inhabited surrounding areas and certainly traversed the area, utilizing the many resources. More extensive evidence of the region's inhabitants exists for the Fremont people which are known to have inhabited the area as early as A.D. 600. The Fremont were a more settled people that at different times and different places practiced basic horticulture — growing corn, squash and beans on small plots of land or gardens. In some places ancient irrigation ditches were discovered by settlers that appear to have been several miles long, portions of which were "chiseled through hardpan and even sandstone."[3] These would likely have been constructed by the Fremont.

The native inhabitants of the Uintah Basin (circa A.D. 1300-present) are known as the Utes. Originally, this tribe occupied a vast territory extending from Utah and Sevier lakes in the west all the way to the Front Range of the Rocky Mountains in Colorado to the east. From north to south, the Utes occupied the territory from the Uinta Mountains to roughly the present day Colorado-New Mexico border. The Ute tribe was divided up into numerous smaller tribes, bands and family groupings. The band occupying the Uinta Basin was known as the Uintah.[4] The Uintah were largely a nomadic people hunting wildlife and gathering food, traveling by foot for sustenance. While spending the summer in the Uinta Basin, the band typically migrated to Utah Valley to spend the winter with the Ute band known as the Timpanogats.[5] In the mid-1500s, the Uintah and several other Ute bands acquired horses and became skilled at hunting big game, including bison.

Photo of Ute dwelling in Uintah Valley by Hillers, of the John Wesley Powell Expedition, circa 1873. (Smithsonian Office of Anthropology.)

The first known white men to explore the basin were part of the Dominguez-Escalante Expedition of 1776. Led by New Mexico-based Catholic priests, the expedition's purpose was to find a new route from Santa Fe to California. In September 1776, the group reached the present site of Duchesne City and later camped to the west on the Strawberry River. Escalante's journal described at least three sites that, with the assistance of irrigation, would make good settlements.[6]

Approximately 50 years after the Dominguez-Escalante Expedition entered the area, the Uinta Basin became an important part of the western fur trade. With the assistance of the Utes, William H. Ashley, Jedidiah Smith, Etienne Provost, Kit Carson and Antoine Robidoux, among others, took advantage of the abundant wildlife resources of the area. Antoine Robidoux was the dominant trader in the basin. He established a fort at the confluence of the Duchesne and Green Rivers in 1832 and utilized this fort as the central hub of trapping activities.[7] In addition to trapping animals for fur, these early adventurers also established trade with the Native Americans. However, because some of these traders exploited the Native Americans, the Utes drove out of the basin in 1844.[8]

Tribal Lands and Anglo-American Settlement (1861-1904)

Uintah Valley Indian Reservation

1861 is an important year in the history of the Uintah Basin. In that year an overland stagecoach route was proposed that would traverse the basin. Fearing that such a development could potentially result in outsider control of the area, Brigham Young sought to preempt this by establishing settlements. Accord-

Chief Ouray, Ute Chieftain, and sub-chiefs: Warets, Shavano, Ankatosh, and Guero (Ouray in center front). Photo taken by William Henry Jackson while on a peace mission to Washington, D.C.

ingly, a group was called in April of that year to explore, build a road, and determine the best locations for development.[9] Despite positive reports from earlier explorers who said the area held promise for settlement, the exploration returned home after only a few weeks (in September 1861) to report that "the area was one vast contiguity of waste, and measurably valueless, excepting for nomadic purposes, hunting grounds for Indians (Native Americans) and to hold the world together."[10]

Although the exploration failed, the newly appointed agent for the Native Americans was aware of Brigham Young's plans and, seeking to find a refuge for the Utes, proposed that all the land within the Duchesne River drainage be set aside as a reservation. President Abraham Lincoln agreed and the Uintah Valley Indian Reservation was established by executive order on October 3, 1861.[11] A few years later in 1864, Congress voted to approve this action and provided funding to manage the reservation. Soon thereafter, most of the Utes in Utah were relocated to the reservation.

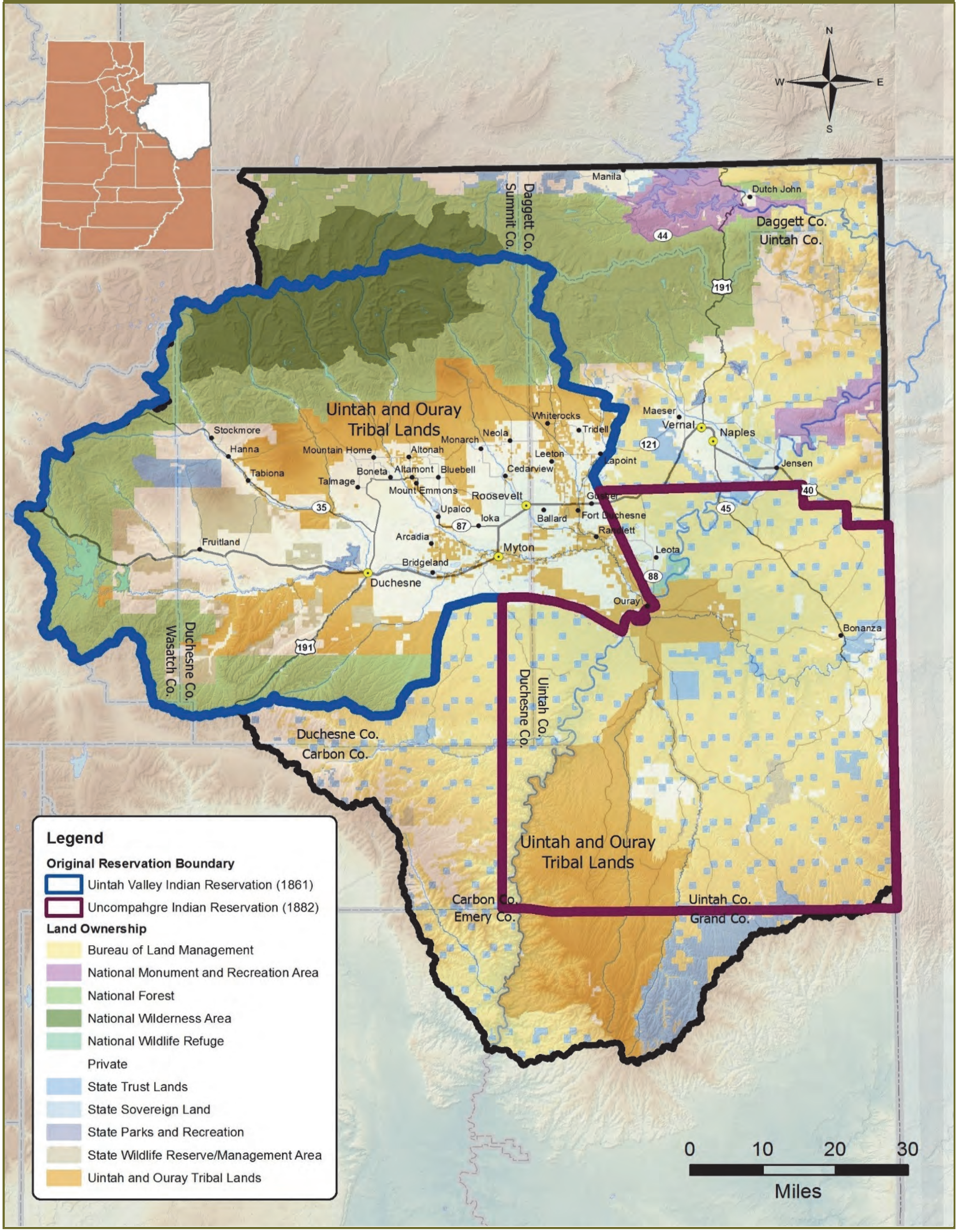
Uncompahgre Indian Reservation

In 1881 the Uncompahgre band of Utes located in Colorado were forced to join the neighboring Utes on the reservation. Soon thereafter, the Uncompahgre Indian Reservation was formed, and the band once again moved to a new home. The name of the reservation was later changed to Ouray, after Chief Ouray, a prominent leader of the Uncompahgre during the tribe's residence in Colorado.[12] Figure 3 shows the original boundaries of the Uintah Valley and Uncompahgre Indian reservations as well as the current extent of reservation lands, now known as the Uintah and Ouray Tribal Lands. Today approximately 2,970 Ute Tribe members[13] reside primarily on these tribal lands.

Native American Irrigation Projects

As part of the agreement the Utes made with the U.S. Government to relinquish Tribal lands and relocate to the Uintah Valley Indian Reservation, the government agreed to provide financial assistance to develop farms. It was hoped that the adoption of agriculture by the Utes would help establish a new and stable existence on the reservation.[14] Soon after the establishment of the reservation, it became apparent that in order for farming to be successful, irrigation would be required. Thus began a series of well-intended projects and efforts to irrigate lands for the benefit of the Utes. At that time the Native Americans found it difficult to adapt from long-established customs to a farming lifestyle. Nevertheless, these and subsequent efforts to help the Utes establish viable farms played a central role in the settlement of the basin.

FIGURE 3
Original Reservation Boundaries and Current Land Ownership



The Bureau of Indian Affairs helped the Utes construct approximately 14 canals of various lengths between 1865 and 1899.[15] Unfortunately, some of these early irrigation systems were not well designed, were not adequately maintained and many quickly fell into disrepair. Furthermore, the Utes found it difficult to adjust to the new lifestyle and as a result, farming success by the Native Americans was inconsistent. Despite the challenges, reservation agents were persistent and the U.S. Congress continued efforts to improve and expand irrigation on the reservation, ultimately culminating in the formation of the U.S. Indian Irrigation Service in 1906.[16]

Construction of Strawberry Dam, June 1912. The dam was a central feature of the original Strawberry Valley Project, Duchesne County. (Photo courtesy of U.S. Bureau of Reclamation.)

<u>*Anglo-American Settlements*</u>

The first Anglo-American settlement within the Uintah Basin (not related directly to the reservation agency and employees) was Ashley, east of the reservation in Ashley Valley in 1873. This settlement was established by Pardon Dodds and Morris Evans. Dodds was a former agent to the Native Americans who recognized the potential for agriculture in the area. After leaving the post at the reservation, Dobbs and Evans gathered their cattle from off the reservation and drove the herd to Ashley Valley. Soon thereafter, John Blakenship helped build the first home, which also doubled as a trading post for trappers and Native Americans.[17]

Dodds was the first white person in the basin to irrigate crops, building a ditch to divert water from Ashley Creek. By 1878 irrigation ditches began to proliferate, including additional ditches on Ashley Creek and new ditches on Brush Creek and Dry Fork.[18] Thus began the agricultural tradition on non-tribal lands that continues to today within the Uintah Basin.

Opening of the Reservations to Settlement and Early Water Developments (1905-1930)

The success early settlers of various communities had with irrigation, farming and ranching in Ashley Valley raised the pressure on federal officials to open up portions of the Uintah and Ouray Indian Reservation for settlement. Mining interests also exerted pressure to open the reservation in order to mine Gilsonite and Lederite. These pressures coincided with a national push to better assimilate Native Americans into white society, and by the end of the century, plans were underway to provide the Utes with individual farm tracts that could be cultivated and open up the remaining reservation lands for homesteading and other purposes. This took place in 1905 and attracted homesteaders from throughout Utah, the nation and even abroad.

With the sudden arrival of numerous settlers, the demand for effective irrigation systems rapidly increased. These settlers quickly recognized that the irrigation systems constructed for the Utes held great potential to assist the settlers if operated in a cooperative fashion. Progress was made on this front as settlers contracted with the Indian Irrigation Service to construct, rehabilitate and maintain the Uintah Indian Irrigation Project facilities.[19] This work was completed in 1920 and included 21 canals and laterals. Eventually, the good will created through these efforts resulted in white settlers being allowed to utilize these facilities to divert water and irrigate farms alongside Native Americans.

Strawberry Valley Project

Although not a project that directly benefited residents within the Uintah Basin, the Strawberry Valley Project (SVP) was the first large-scale water development project constructed with major facilities located in the basin. The SVP, which exports water from the Uintah Basin to the Utah Lake Basin, was the second federal reclamation project built in the United States. Continuing the work that was begun by Utah Valley farmers, the U.S. Bureau of Reclamation (USBR) began construction in 1906. Within a few years, Strawberry Dam was completed and water began to fill the reservoir, which had an active capacity of 270,000 acre-feet. Other major features of the project that are located in the Uintah Basin included Indian Creek Dike, Currant Creek Feeder Canal and Strawberry Tunnel. In 1915, the project was completed and water was delivered to eager farmers in southern Utah County, from Spanish Fork all the way to Spring Lake.

High Mountain Lakes and Other Reservoirs[20]

Construction of high mountain dams began in the spring of 1917 in the Brown Duck drainage with construction of Brown Duck, Island and Kidney Lake dams by the Farnsworth Canal and Reservoir Company. The Dry Gulch Irrigation Company later constructed Clement Dam in Clement Basin. During the 1910s and 1920s, 10 more dams were constructed in the Yellowstone (Garfield) and Swift Creek basins by Farmers Irrigation Company and a private dam (Milk Lake) by Chester Hartman. A total of 14 dams were completed with a total storage capacity of nearly 8,000 acre-feet. These dams were constructed on existing high mountain lakes in order to create additional storage.

A 1923 federal court decree (Dockets 4427 and 4418) gave the Uintah Indian Irrigation Project lands the first priority to water. Thus the percolating waters feeding the streams could not be diminished because the Uintah Indian Irrigation Project had first water rights. Three acre-feet per year of irrigation water was apportioned for each acre of Native American-owned irrigated land. Secondary water rights also received three acre-feet of water for each acre of irrigated land, as long as there was water in the stream.

Large Scale Water Developments and Exportation (1931-Present)

Moon Lake Project

Native American inhabitants of the Uinta River and Duchesne River basins had established early priority water rights for the irrigation of Tribal lands.[21] Non-native inhabitants began to arrive in the basin about 1905. As irrigation began, it became evident that there was insufficient water to satisfy Native American rights and irrigate an additional acreage of about 75,256 acres owned by the settlers. After investigation by local interests, the Utah Water Storage Commission entered into a contract with the U.S. Bureau of Reclamation for the investigation and planning of the Moon Lake Project.[22] Construction of the project by the Bureau began in May 1935, and was completed in May 1941. In order to serve the water needs of both Native American and non-native lands, the project is somewhat complex. It consists of the following:[23]

- Moon Lake Reservoir, on the West Fork of the Lake Fork of the Duchesne River. When combined with the original lake, it has a total capacity of 49,500 acre-feet.
- The Yellowstone Feeder Canal, which conveys water from the East Fork of the Lake Fork to the west branch of Cottonwood Creek.
- Midview Dam and Dike, which form a 5,800 acre-foot capacity, off-stream reservoir.
- Duchesne Feeder Canal which conveys surplus water from the Duchesne River to Midview Reservoir and to lands along the Lake Fork River.
- Midview Lateral, which conveys water released from Midview Reservoir to the Dry Gulch (U.S. Bureau of Indian Affairs) Canal for exchange purposes.

The project provides a late season supply of irrigation water enabling production of numerous crops that are primarily used to feed livestock.[24] Additionally, adjustment of reservoir outflow provides flood protection downstream. Moon Lake Reservoir is now a popular recreation destination with cabins, camping, picnicking and boating.[25]

Panoramic view of Upper Stillwater Dam and majestic spillway. The dam is located on Rock Creek in the Ashley National Forest, Duchesne County.

Provo River Project

Similar to the Strawberry Valley Project, the Provo River Project exports water from the Uintah Basin to satisfy demands along the Wasatch Front. Water is diverted out of the basin and into the Provo River via the Duchesne Tunnel, which diverts water from the North Fork of the Duchesne River. The tunnel, completed in 1953, is six miles long and has a capacity of 600 cfs. Water from the tunnel (primarily spring runoff) discharges into the main stem of the Provo River upstream of Woodland and is stored in Deer Creek Reservoir.[26]

Central Utah Project[27]

The Central Utah Project (CUP) was originally organized into six separate units: Bonneville, Jensen, Uintah, Upalco, Ute Indian and Vernal units. The Bonneville, Jensen, Upalco and Vernal units were authorized for construction in 1956 by the Colorado River Storage Project Act. The Uintah Unit and feasibility investigations for the Ute Indian Unit were authorized in 1968 by the Colorado River Basin Project Act.

The Jensen and Vernal units have been completed and the Bonneville Unit is still currently under construction. The Uintah, Upalco, and Ute Indian units were never constructed. The Ute Indian Unit was formally de-authorized in the Central Utah Project Completion Act (CUPCA) of 1992. This act also settled outstanding water rights claims by the Tribe against the United States arising out of the construction of the Central Utah Project.

The Bonneville Unit is a large trans-basin water development project that diverts water from the Uintah Basin to the Utah Lake Basin. In order to provide water for the Bonneville Unit, the United States, Central Utah Water Conservancy District, and Ute Tribe entered into The Deferral Agreement of 1965. In this the Tribe agreed to defer development of a portion of Reservation land in order to allow the associated water supply to be diverted from the Uintah Basin to the Wasatch Front for the Bonneville Unit. In exchange, the United States agreed to develop additional projects to provide water to the irrigable lands of the Reservation. By 2002, the major Uintah Basin water development projects which were intended to assist the Ute Indian Tribe and fulfill the 1965 Deferral Agreement remained unbuilt. The CUPCA legislation provided for a cash settlement to the Ute Tribe in lieu of the projects contemplated by the 1965 Deferral Agreement. The settlement included a portion of Bonneville Unit M&I revenues, an economic development fund, Secretarial assistance to enhance Tribal Farming operations and other activities specifically intended to improve natural resources and provide economic opportunities on the reservation. The portion of Bonneville Unit M&I revenues paid to the Tribe currently amounts to over $2.1 million per year. Funding provided for above activities was approximately $240 million.[28]

The Jensen and Vernal units are located entirely within the Uintah Basin and develop irrigation water for both Tribal and non-Tribal lands and for municipal and industrial use. The Bonneville Unit is broken up into two primary components: (1) the Starvation Collection System, which collects and distributes water in the Uintah Basin; and (2) the Strawberry Aqueduct and Collection System, which collects water for distribution in the Wasatch Front portion of the Bonneville Basin.[29]

Key CUP facilities located in the Uintah Basin include: Strawberry Aqueduct, Strawberry Reservoir, Upper Stillwater Reservoir, Currant Creek Reservoir, Starvation Reservoir, Bottle Hollow Reservoir, Steinaker Reservoir, and Red Fleet Reservoir.

State Water Planning

One of the main responsibilities of the Division of Water Resources is to conduct comprehensive water planning in Utah. Over the past several decades, the division has conducted several studies and prepared many reports for the Uintah Basin. An important document resulting from these studies was the *Utah State Water Plan: Uintah Basin*, published in 1999.

1999 Uintah Basin Plan

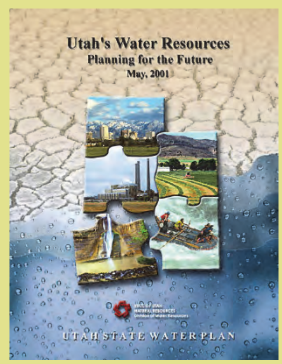
Although this 2016 document, *Uintah Basin—Planning for the Future*, touches upon many of the same topics presented in the 1999 Uintah Basin Plan, there is a valuable collection of pertinent data and useful information contained in the original plan that will not be revisited here. Some of the topics that will not be repeated, but may be valuable to the reader, are listed below:

- *Section 7 – Regulation/Institutional Considerations:* A discussion of water-related laws and regulations and the responsibilities of various state and federal agencies with regard to carrying out these laws.
- *Section 8 – Water Funding Programs*: A description of significant state and federal water funding programs.
- *Section 13 – Disaster and Emergency Response:* A description of the various types of disasters and emergencies that could disrupt the supply of water and the organizations and regulations that deal with them.

2001 Utah State Water Plan:
Utah's Water Resources—
Planning for the Future

Managing water resources in Utah is not an easy task. Supply is limited and competition between various uses continues to intensify. Add to that the unpredictable nature of wet vs. dry periods, and one gets an idea of the complex challenges facing Utah's water planners and managers.

Utah's Water Resources—Planning for the Future attempts to bring all the issues to light and to put the many pieces together that are required to obtain balanced and efficient water management. It discusses the major issues facing Utah's water resources and provides valuable data and guidance that will help in the important effort to efficiently manage one of the state's most precious resources.



- *Section 16 – Federal Water Planning and Development:* A list of all the federal agencies involved directly or indirectly with water planning and development within the basin and description of respective responsibilities.

A copy of the entire 1999 Uintah Basin Plan can be obtained by contacting the Division of Water Resources, or online at the division's web site: www.water.utah.gov.

The 2001 Utah State Water Plan and Subsequent Special Studies

In May of 2001, the Division of Water Resources updated the Utah State Water Plan with the publication of *Utah's Water Resources—Planning for the Future*. This plan addressed a host of issues important to

Utah's future (see sidebar). After publication of the Utah State Water Plan, the Division of Water Resources realized that investigation of other topics would greatly benefit the water supply community. Subsequently, the division published the following special studies:

- *Utah's M&I Water Conservation Plan* (2003)
- *Conjunctive Management of Surface and Ground Water* (2005)
- *Water Reuse in Utah* (2005)
- *Drought in Utah—Learning from the Past, Preparing for the Future* (2007)
- *Drought Management Toolkit* (2008)
- *Residential Water Use* (2009)
- *The Cost of Water in Utah* (2010)
- *Managing Sediment in Utah's Reservoirs* (2010)
- *Municipal and Industrial Water Use in Utah* (2010)
- *The Water-Energy Nexus in Utah* (2012)
- *Detecting Leaks in Utah's Municipal Water Systems* (2013)

All of these are available at www.water.utah.gov. While the Utah State Water Plan and special studies are valuable documents for water planners, managers and others interested in contributing to water-related decisions throughout the state, none address specific details and needs of the state's individual river basins.

The Current Plan

This 2016 document, *Uintah Basin—Planning for the Future,* is modeled in large part after the 2001 State Water Plan and provides the reader with more detail and perspective concerning issues of importance to the Uintah Basin. It takes a new look at the water resources of the basin. With increasing water demands caused by unique resource challenges, water is becoming a more precious resource. The waters of the basin will continue to play an important role in meeting some of Utah's future needs. Protecting the quality of this water and the ability to sustain the increased population is of utmost concern. The Division of Water Resources intends that this plan establishes a framework that will assist local and state policy makers and guide and influence water-related decisions within the basin.

NOTES

[1] In this report, Yellowstone River and Yellowstone Creek are used to designate the same stream, which is located due north of Mountain Home, Utah. Whether river or creek is used depends on how it was used in the reference source.

[2] Barton, John D., *A History of Duchesne County,* (Salt Lake City: Utah State Historical Society, 1996), Page 12.

[3] Ibid., Pages 12-15. See also, page 36, note 21, which reads: "Lester Maxfield, an old-time resident of Altonah who came with his family into the county to settle, claimed that some of the canals in Altonah and Talmage were already in place and only needed cleaning out and headgates installed to be serviceable to modern farmers."

[4] Ibid., Pages 39-40.

[5] Barton, John D., *Buckskin Entrepreneur: Antoine Robidoux and the Fur Trade of the Uinta Basin, 1824-1844,* (Roosevelt, Utah: Uintah Basin Standard Inc., 1996), Pages 16-17.

[6] Warner, Ted J., ed., *Dominguez-Escalante Journal,* Page 48.

[7] Barton, John D., *Buckskin Entrepreneur…*, Page 45.

[8] Burton, Doris, *A History of Uintah County--Scratching the Surface,* (Salt Lake City: Utah State Historical Society, 1996), Pages 57-61 and 67.

[9] Ibid., Pages 82-83.

[10] Deseret News, "Uinta Not What Was Represented," September 25, 1861.

[11] Burton, Page 83.

[12] "A History of Utah's American Indians." Retrieved from the Utah State Historical Society's Internet web page: http://historytogo.utah.gov/people/ethnic_cultures/the_history_of_utahs_american_indians/, January 2011. The details of the Uncompahgre Indian Reservation noted here come from Chapter 5, entitled "The Northern Utes of Utah," written by Clifford Duncan.

[13] Retrieved from the Internet website: http://www.utetribe.com/ April 4, 2016.

[14] Kendrick, Gregory D. ed., *Beyond the Wasatch: The History of Irrigation in the Uinta Basin and Upper Provo River Area of Utah,* (Washington D.C.: U.S. Government Printing Office, 1989), Page 17.

[15] Babb, Cyrus Cates, "The Water Supply of the Uintah Indian Reservation," (Washington D.C.: U.S. House

of Representatives, 1902), Doc. 671, 57th Cong., 1st Sess., Page 22.

[16] Kendrick, Page 20.

[17] Burton, Pages 84-85.

[18] Ibid., Page 295.

[19] Kendrick, Page 20.

[20] Utah Division of Water Resources, *Utah State Water Plan: Uintah Basin*, (Salt Lake City: Dept. of Natural Resources, 1999), Pages 3-17.

[21] U. S. Bureau of Reclamation, "Moon Lake Project." Retrieved from the Bureau's Internet web page: http://www.usbr.gov/projects/Project.jsp?proj_Name=Moon+Lake+Project, June 30, 2015.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Ibid.

[26] Utah Division of Water Resources, *Utah State Water Plan: Utah Lake*, (Salt Lake City: Dept. of Natural Resources, 1997), Pages 3-14.

[27] From a summary of the Central Utah Project, retrieved from the U.S. Bureau of Reclamation's Internet web page: http://www.usbr.gov/projects/Project.jsp?proj_Name=Central+Utah+Project, January 2011.

[28] Ibid.

[29] The Bonneville Basin includes all the drainages that anciently flowed into Lake Bonneville. For planning purposes the Utah Division of Water Resources has divided this large basin into six smaller basins: Bear River Basin, Weber River Basin, Jordan River Basin, Utah Lake Basin, Sevier River Basin and West Desert Basin.

2

WATER SUPPLY

This chapter provides an overview of the water supply in the Uintah Basin. It begins with a discussion of climate and precipitation. Surface water and groundwater supplies are then discussed, followed by a water budget for the basin and a section on developed water supplies. The final section is on water rights, since they play a key role in water management.

CLIMATOLOGICAL INFLUENCES

Climate in the Uintah Basin is typical of mountainous areas in the west, with wide ranges in temperature between summer and winter, and between day and night. The high mountain regions experience long, cold winters and short, cool summers. The lower valleys are more moderate with less variance between maximum and minimum temperatures. As part of the high plains of the Colorado Plateau, the Uintah Basin is classified as semi-arid.

The basin experiences four distinct seasons with a major portion of the precipitation occurring as snow in the mountain regions during the winter months and producing high runoff during the spring snowmelt period. The basin receives an average 15.6 inches of precipitation annually. This precipitation is distributed as shown in Figure 4 and ranges from a low of around 5 inches in the central valley portion of the basin to around 40 inches in the mountain peaks of the Uinta Mountains.

Mean temperatures in the valleys range from 44° to 47° F. Average monthly maximum temperatures reach as high as 94.6° F in July, and the average monthly minimum falls as low as 1.5° F in January. Table 2 displays the climatological data for selected sites throughout the basin.

AVAILABLE WATER SUPPLY

The Green River is the largest river in the Uintah Basin. With headwaters in western slopes of the Wind River Mountains of western Wyoming, the Green River flows into the northeastern corner of Utah at Flaming Gorge Reservoir. The Green River then flows east into Colorado where it is joined by the Yampa River before returning to Utah within Dinosaur National Monument. As the Green River flows south through the Uintah Basin on the way to merging with the Colorado River, it is joined by two large tributaries, the Duchesne River from the west and the White River from the east, and several smaller tributaries, most notably Ashley Creek and Brush Creek. Within Utah, the Duchesne and White rivers are the largest tributaries flowing into the Green River.

The Uintah Basin's present water supplies come almost exclusively from surface water sources. There is a very small amount of water imported into the basin and, for reasons that will be explained in the groundwater section, there has been very little groundwater developed in the basin. A portion of the basin's surface water is exported to the Wasatch Front via the Central Utah Project.

Surface Water

The portion of precipitation that is not initially evaporated or transpired by vegetation, eventually flows into streams and other surface water-bodies, or percolates into the ground. Surface water can be quantified

FIGURE 4
Average Annual Precipitation

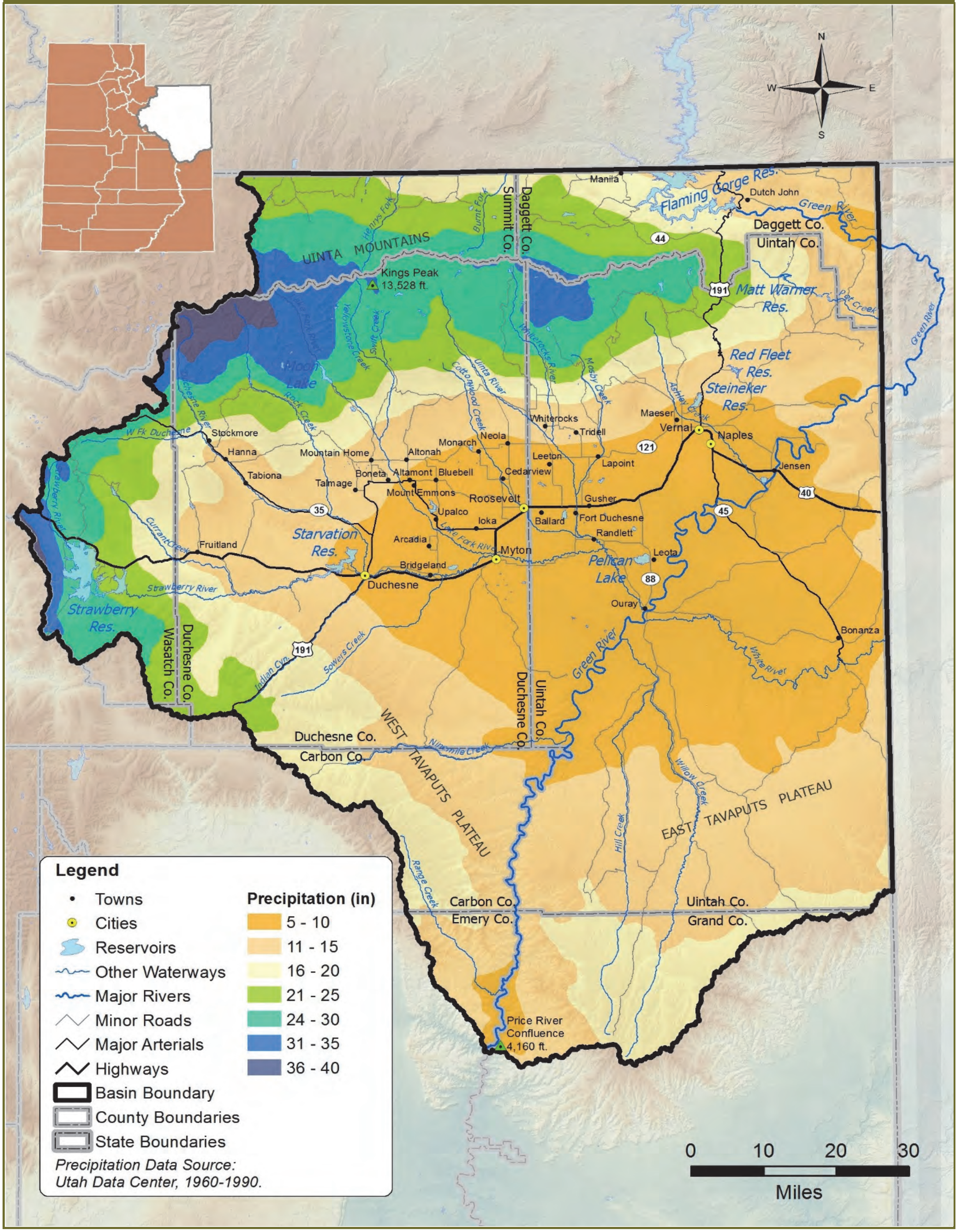


TABLE 2
Climatological Data

Weather Station	Period of Record	Temperature (Average Max. Min. and Mean in °F)								Precipitation	
		January			July			Record		Snow (in.)	Avg. Ann. (in.)
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.		
Allen's Ranch	1962-2001	38.2	11.6	24.9	90.4	51.6	71.0	105	-35	17.5	8.97
Altamont	1953-2015	31.4	7.2	19.3	83.9	52.4	68.1	97	-32	38.4	9.12
Bonanza	1938-1993	30.7	7.1	18.9	92.5	57.1	74.8	106	-32	24.9	8.85
Bonanza Pumping Station	1960-1966	31.5	10.7	21.1	91.0	61.9	76.5	98	-13	15.6	7.94
Currant Creek Junction	1985-1996	37.4	12.6	25.0	83.0	48.2	65.6	94	-8	77.9	15.08
Dinosaur Quarry	1915-2014	30.7	4.3	17.5	95.0	55.6	75.3	110	-40	20.2	8.47
Duchesne	1906-2015	31.0	4.7	17.8	87.0	52.7	69.9	101	-43	26.4	9.45
Duchesne Airport	1974-1980	29.4	7.3	18.4	88.0	55.9	72.0	97	-11	18.0	7.57
Flaming Gorge	1957-2015	35.7	9.6	22.6	86.2	50.4	68.3	102	-38	52.0	12.03
Fort Duchesne	1952-1994	28.2	1.5	14.9	90.5	52.4	71.5	106	-40	11.1	6.39
Hanna	1952-1994	34.3	7.8	21.0	82.7	47.8	65.2	96	-32	46.3	11.83
Jensen	1925-2015	29.5	2.7	16.1	92.1	52.8	72.5	106	-40	21.1	8.15
Maeser 9 NW	1983-2009	33.2	9.2	21.2	85.6	55.4	70.5	100	-33	61.3	14.05
Manila	1910-2012	35.7	10.2	23.1	84.5	52.1	68.4	102	-33	37.9	8.98
Moon Lake	1935-1969	30.0	3.2	16.6	76.2	44.7	60.5	84	-34	104.4	17.64
Myton	1915-2012	29.6	2.2	15.7	90.1	54.5	72.3	104	-39	14.0	6.83
Neola	1956-2012	30.8	7.9	19.4	84.9	54.5	69.7	99	-27	25.4	8.85
Nutter's Ranch	1963-1986	35.3	6.4	20.9	87.7	46.4	67.1	100	-25	45.6	11.57
Ouray	1941-2014	28.8	2.3	15.6	94.6	56.3	75.5	108	-43	15.3	6.79
Roosevelt	1948-2012	29.7	3.6	16.7	91.7	54.0	72.9	105	-47	20.8	7.26
Vernal	1984-2012	29.3	5.0	17.2	89.1	52.3	70.7	103	-38	18.5	8.44

Source: Western Regional Climate Center http://www.wrcc.dri.edu/summary/Climsmut.html. Data current as of September, 2015.

at gauging stations on stream segments. The U.S. Geological Survey, in cooperation with other federal and state entities, monitors an extensive network of gauging stations throughout Utah. Table 3 shows the average annual flow volume for streams in the Uintah Basin.

Figure 5 is a graphic representation of the present average annual streamflow of the Uintah Basin's primary streams. The Green River, along with Henrys Fork, brings an average annual flow of about 1.3 million acre-feet into the basin at Flaming Gorge Reservoir. The Yampa River and Vermillion Creek add another 1.5 million acre-feet per year from the northwestern corner of Colorado. The White River contributes a little less than half a million acre-feet annually also draining from western Colorado and the southeastern region of the basin. The Uintah Basin's other streams, the Duchesne River, Ashley Creek, Brush Creek and other minor tributaries contribute just under half a million acre-feet per year to the Green River. The average annual flow of the Green River out of the basin is roughly 3.5 million acre-feet per year. The band widths shown in Figure 5 represent the flows and are proportional to the average annual flow in acre-feet. Selected major diversions and tributary inflows are also shown.

Numerous lakes are located in the upper elevations of the Uinta Mountains. Forty-seven of these small, natural lakes were fitted with dams and outlet works and have functioned for many years as storage reservoirs. The original combined regulated capacity of these lakes was about 17,000 acre-feet. Most of these res-

TABLE 3
Average Annual Streamflow at Gauging Stations

Gauge Number	Description	Years of Record	Average Annual Flow (ac-ft)
09232000	Sheep Creek near Manila[1]	1944-61	8,723
09233000	Carter Creek near Manila	1949-54	6,753
09234000	Carter Creek at mouth near Manila	1947-55	43,491
09235600	Pot Creek above diversion near Vernal	1958-93	2,738
09260500	Jones Hole near Jensen	1950-61	26,310
09261500	Brush Creek above cave near Vernal[2]	1946-55	7,175
09261700	Big Brush Creek above Red Fleet Reservoir	1980-2015	41,764
09262000	Brush Creek near Vernal	1939-80	24,415
09262500	Little Brush Creek below East Park Res near Vernal	1949-55	9,620
09263000	Little Brush Creek near Vernal	1946-52	14,265
09264000	Ashley Creek below Trout Creek near Vernal	1944-54	17,446
09264500	South Fork Ashley Creek near Vernal	1944-55	14,410
09265300	Ashley Creek above Red Pine Creek near Vernal	1965-76	48,617
09265500	Ashley Creek above Springs near Vernal	1941-2015	43,930
09266500	Ashley Creek near Vernal[3]	1915-2014	69,147
09268000	Dry Fork above Sinks near Dry Fork	1939-1976	26,062
09268500	North Fork Dry Fork near Dry Fork	1946-90	4,867
09268900	Browns Canyon above Sinks near Dry Fork, UT	1961-90	9,478
09269000	East Fork of Dry Fork near Dry Fork	1946-63	5,775
09270000	Dry Fork below Springs near Dry Fork	1941-69	24,023
09270500	Dry Fork at mouth near Dry Fork	1954-89	19,779
09273000	Duchesne River at Provo River Trail near Hanna	1929-54	38,059
09273200	Duchesne River below Little Deer Creek near Hanna	1965-68	23,581
09273500	Hades Creek near Hanna	1949-68	6,546
09274000	Duchesne River near Hanna	1921-63	58,962
09274900	W Fork Duchesne River below Vat Diversion near Hanna	1990-94	8,861
09275500	West Fork Duchesne River near Hanna	1921-94	14,063
09276000	Wolf Creek at Rhodes Canyon near Hanna	1946-84	5,711
09278000	South Fork Rock Creek near Hanna	1953-93	3,510
09278500	Rock Creek near Hanna	1949-88	112,433
09279000	Rock Creek near Mountain Home	1938-2015	63,077
09280400	Hobble Creek at Daniels Summit near Wallsburg	1964-84	2,201
09285500	Willow Creek near Soldier Springs, UT	1943,47	3,858
09287500	Water Hollow near Fruitland	1946-84	3,477

TABLE 3 (Continued)
Average Annual Streamflow at Gauging Stations

Gauge Number	Description	Years of Record	Average Annual Flow (ac-ft)
09230300	Birch Spring Draw at FGNRA Boundary near Manila	2007-2013	6,074
09234500	Green River near Greendale	1951-2015	1,422,231
09261000	Green River near Jensen	1947-2015	3,029,267
09272400	Green River at Ouray	2009-2015	2,926,540
09277500	Duchesne River near Tabiona	1919-2015	131,824
09279000	Rock Creek near Mountain Home	1938-2015	63,079
09285900	Strawberry River at Pinnacles near Fruitland	1990-2015	43,546
09288000	Currant Creek near Fruitland	1936-2015	30,411
09288180	Strawberry River near Duchesne	1968-2015	104,934
09289500	Lake Fork River Above Moon Lake, near Mountain Home	1933-2015	82,325
09291000	Lake Fork River Below Moon Lake, near Mountain Home	1942-2015	90,632
09292000	Yellowstone Creek at Bridge campground near Altonah	1996-2015	68,969
09292500	Yellowstone Creek near Altonah	1945-2015	98,785
09295000	Duchesne River at Myton	1910-2015	317,792
09295100	Duchesne River above Uinta River, near Randlett	1998-2015	166,462
09296800	Uintah River below powerplant diversion near Neola	1991-2015	103,465
09299500	Whiterocks River near Whiterocks	1910-2015	80,799
09301500	Uinta River near Randlett	1976-2015	64,591
09302000	Duchesne River near Randlett	1943-2015	369,159
09306500	White River near Watson	1923-2015	496,722

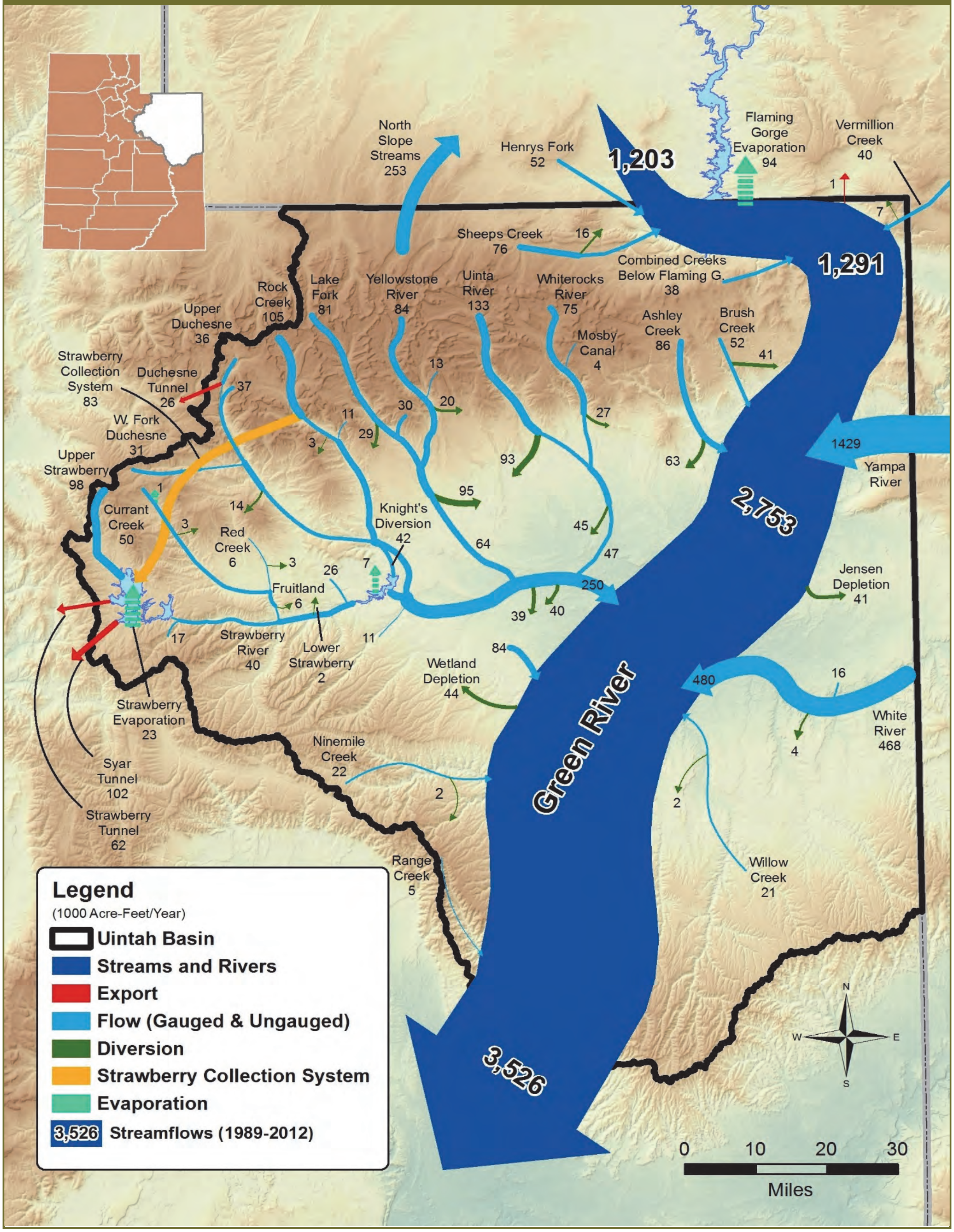
Source: From the USGS internet web page: http://waterdata.usgs.gov/ut/nwis/dv. Data current as of September, 2015.
[1] Canal diversion to Sheep Creek.
[2] Oaks Park Canal diversion to Ashley.
[3] Contains water from Oaks Park Canal since 1941.

reservoirs were constructed in the early 1900s by local irrigation companies. Thirteen of the lakes have been stabilized (outlet works permanently closed or removed) as part of the Central Utah Project Completion Act. With the water levels constant, these lakes no longer function as storage reservoirs, but are used for fish, wildlife and other recreational purposes.

Flaming Gorge Reservoir, constructed by the Bureau of Reclamation in 1964, provides water storage, power generation and recreation. Strawberry, Starvation, Currant Creek, Upper Stillwater, Steinaker, Bottle Hollow and Red Fleet reservoirs are Central Utah Project (CUP) reservoirs that provide storage for municipal, industrial, agricultural and recreational water uses.

Municipal and industrial (M&I) water for the Bonneville Unit of the CUP is exported to the Wasatch Front from Strawberry Reservoir through the Strawberry and Syar tunnels. It is released to Utah Lake and exchanged to Jordanelle Reservoir for use in Wasatch County, northern Utah County and Salt Lake County. Strawberry Valley Project water from Strawberry Reservoir is used for irrigation in southern Utah County. One component of the Provo River Project

FIGURE 5
Estimated Average Basin-wide Water Budget



exports water from the Duchesne River Drainage to the Provo River through the Duchesne Tunnel. This water is stored in Deer Creek Reservoir for use in Wasatch, Utah and Salt Lake counties.

Groundwater

Groundwater in the Uintah Basin has been developed primarily for municipal and industrial uses. Springs were the first method of accessing groundwater, followed by wells. Unconsolidated valley-fill aquifers have traditionally been the best producers of groundwater in Utah. About 98 percent of the wells in Utah are completed in unconsolidated deposits. In the Uintah Basin, however, the occurrence of unconsolidated deposits is limited. The unconsolidated deposits, where present, are composed of alluvium, colluviums and glacial deposits of moraine and outwash origin. The most extensive unconsolidated aquifers are found in the Duchesne-Myton-Pleasant Valley[1] area and the plain east of Neola.[2]

Unconsolidated aquifers are typically found in the bottoms of mountain canyons, in streams valleys and as discontinuous caps on terraces. These deposits are rarely more than 50 to 70 feet thick. Wells and springs in these deposits are found to have widely varying yields from less than 10 gpm to greater than 1,000 gpm, with relatively few wells yielding more than 500 gpm.

Due to the lack of unconsolidated aquifers in the Uintah Basin, many wells have been developed from consolidated or bedrock aquifers. While these geologic formations have limited water supplies, those in the Uintah Basin which have been identified as being the best groundwater sources are Browns Park, Duchesne River, Uinta Current Creek and Morgan Formations. Groundwater in these consolidated formations is unconfined in locations nearest areas of recharge. Confined conditions, however, are the most common, and occur in about 90 percent of the area within the basin underlain by sedimentary rocks.

The circulation of groundwater in these consolidated aquifers is affected by folding and faulting, which locally will either enhance groundwater movement by fracturing consolidated rock or impair groundwater movement by offsetting aquifers. Local fracturing also enhances inter-formational leakage, which affects water quality.

The average annual volume of precipitation falling within the basin is 9,113,000 acre-feet. Previous studies have shown that an estimated 600,000 acre-feet of that water infiltrates the ground, recharging the basin's aquifers. An additional 30,000 acre-feet of groundwater recharge comes from irrigation water and return flows from springs and wells, providing an average annual groundwater recharge of 630,000 acre-feet.[3]

To date the development of groundwater resources in the Uintah Basin has been relatively minor. This is due to the following reasons: (1) Existing surface water sources have been adequate to meet the demands imposed for irrigation and M&I needs; (2) the consolidated aquifers, generally have hydraulic properties that preclude large-scale groundwater development; (3) the quality of the groundwater in some parts of the basin is unsuitable for domestic, municipal, or agricultural use; and (4) the economics of drilling and pumping water from deep aquifers is prohibitive.

As can be seen from Table 4, municipal use accounts for the largest groundwater withdrawals, an estimated 10,290 acre-feet per year. Surface water development is much less costly than groundwater development. Mining uses take an estimated 3,000 acre-feet of groundwater annually. Oil production requires an estimated 770 acre-feet/year of groundwater. Power production uses 7,000 acre-feet of groundwater each year. Total groundwater withdrawals in the basin are an estimated 21,060 acre-feet per year. Groundwater withdrawals for irrigation have been negligible since surface water sources, coupled with surface water storage, have been sufficient to meet the majority basin irrigation demands.

TABLE 4
Summary of Groundwater Withdrawals

Use	Withdrawals (ac-ft)
Municipal	10,290
Mining	3,000
Oil Production	770
Power Production	7,000
TOTAL	**21,060**

Source: Utah Division of Water Resources, *State Water Plan, Uintah Basin*, 1999, Page 19-6.

Trans-basin Diversions

Trans-basin diversions, or exports, represent water leaving the Uintah Basin. See Table 5 for a summary of these exports and Figure 5 for a visual representation.

The Duchesne Tunnel, a part of the Provo River Project, diverts water from the North Fork of the Duchesne River, into the Utah Lake Basin. The tunnel intake is 21 miles east of Woodland. This tunnel, located under the spur of the Uinta Mountains, has a capacity of 600 cfs, is six miles long and discharges into the main stem of the Provo River upstream of Woodland. Completed in 1953, the tunnel began delivering water for the 1954 irrigation season. Because it has a 1936 water right and there are many prior rights on the Duchesne River, flow is dependent upon the availability of surplus water for diversion. More than 70 percent of average annual flow diverted through the Duchesne tunnel occurs during spring runoff months of May and June. Water diversions have ranged from 0 to 57,750 acre-feet per year, averaging 26,400 acre-feet per year.

The Strawberry Valley Project, operated by the Strawberry Water Users Association was the first Bureau of Reclamation project in Utah. The construction of the Strawberry Dam and reservoir commenced in 1906 and was completed a decade later. The initial project included the diversion of water from Strawberry Reservoir to Spanish Fork River and the Utah Lake Basin. The project did not include the diversion of water from the Duchesne River or Currant Creek to Strawberry Reservoir, although such strategies had been considered at the time. Historically, the Strawberry Valley Project has exported an average of 61,500 acre-feet of water annually, through the Strawberry Tunnel, into the Utah Lake Basin.

With the completion of the Bonneville Unit of the CUP, the Strawberry Collection System now exports about 101,900 acre-feet per year to the Utah Lake Basin through the Syar Tunnel.

There are two minor exports from the basin into Wyoming. One is an irrigation diversion of 370 acre-feet per year. The other is from the Simplot phosphate mine which uses water to carry phosphate slurry; this is about 260 acre-feet per year.

Central Utah Project[4]

The Central Utah Project (CUP), constructed by the U.S. Bureau of Reclamation and the Central Utah Water Conservancy District (CUWCD), is the largest water development project undertaken in Utah. The project provides the state with the opportunity to beneficially use a sizable portion of the allotted share of the Colorado River water. Project irrigation water is provided to Utah's rural areas in the Uintah and Utah Lake basins. Water is also provided to meet the municipal and industrial requirements of the most highly developed portion of the state along the Wasatch Front. Water developed by the CUP has been, and will be, used for municipal, industrial, irrigation, hydroelectric power, fish and wildlife conservation, and

TABLE 5
Trans-Basin Diversions

Source Stream	Conveyance	Receiving Stream	Owner	Developed Supply (ac-ft/yr)
Duchesne River	Duchesne Tunnel	Provo River (Utah Lake Basin)	Provo River Water Users	26,400
Strawberry River	Strawberry Tunnel	Sixth Water (Utah Lake Basin)	Strawberry Water Users	61,500
Duchesne Tributaries	Syar Tunnel	Diamond Fork (Utah Lake Basin)	CUWCD	101,900
Sheep Creek	Wyoming Canal	Wyoming Canal	unknown	370
Brush Creek	Pipeline	Phosphate Factory	Simplot	260
			TOTAL	**166,670**

recreation. The project also improves flood control capability and aids in water quality management.

Bonneville Unit

The Bonneville Unit is the largest and most complex of the authorized units of the Central Utah Project. It includes 10 reservoirs, more than 200 miles of aqueducts, tunnels, and canals; a powerplant, pumping plants, and 300 miles of drains. A key feature, Soldier Creek Dam, has nearly quadrupled the capacity of Strawberry Reservoir from 283,000 to 1,106,500 acre-feet.

Crossing the south flank of the Uinta Mountains, the 37 mile long Strawberry Aqueduct collects flows from Rock Creek and eight other tributaries of the Duchesne River and delivers the water to Strawberry Reservoir. The Upper Stillwater and Currant Creek Reservoirs serve as regulating reservoirs along the aqueduct.

Starvation Reservoir, constructed on the Strawberry River about three miles upstream of Duchesne, has a capacity of 167,000 acre-feet. It stores high flows of the Duchesne and Strawberry rivers to irrigate 26,000 acres of land along the Duchesne River and replace the water that is diverted by the Strawberry Aqueduct from the upper watershed and then exported to the Bonneville Basin.

The Duchesne River Area Canal Rehabilitation Program rehabilitated about 41 miles of existing canals near the Duchesne River, conserving about 14,000 acre-feet of water per year formerly lost through seepage.

To compensate the Ute Indian Tribe for economic losses associated with stream fishing, Bottle Hollow Reservoir, located near Fort Duchesne, Utah, was constructed in 1970 to provide recreation, fishing, and wildlife activities.

Vernal Unit

The Vernal Unit, completed in 1962, provides supplemental irrigation water to about 15,000 acres of land in Ashley Valley by storing the high spring flows of Ashley Creek for late season use. Flows from Ashley Creek are diverted at Fort Thornburgh Diversion Dam through the three-mile long Steinaker Feeder Canal for storage in Steinaker Reservoir. This off-stream reservoir, 3.5 miles north of Vernal, has a total capacity of 38,000 acre-feet. Storage water from the reservoir is distributed through the Steinaker Service Canal. The Vernal Unit also furnishes municipal water for the communities of Vernal, Naples and Maeser. Recreation and fishing facilities are also availabe at Steinaker Reservoir.

Jensen Unit

The Jensen Unit provides water for Ashley Valley and the area extending east of the valley to the Green River. The Jensen Unit, located in Uintah County, provides 18,000 acre-feet of municipal and industrial water in the Ashley Valley area and 4,600 acre-feet of irrigation water to lands in the vicinity of Jensen. Red Fleet Reservoir on Big Brush Creek, the Unit's major feature, has a total capacity of 26,000 acre-feet. The reservoir stores early spring runoff and surplus flows on Big Brush Creek for municipal, industrial, and irrigation use. Recreation, fish and wildlife, and flood control benefits are also part of the project. During operation, municipal and industrial water is conveyed from Red Fleet Reservoir by the Tyzak Pumping Plant to Tyzack Aqueduct. The Burns Pumping Plant pumps water from Green River for irrigation in the Jensen area. Water is also provided to enhance the Stewart Lake Water Fowl Management Area.

Upalco Unit and Uintah Unit

The Upalco and Uintah units were only studied and not constructed. These units were de-authorized by federal Public Law 107-366 on December 19, 2002. Facilities of the Uinta Basin Replacement Project (UBRP), a part of the Bonneville Unit authorized under the Central Utah Project Completion Act, were able to be constructed within the geographic area of the Upalco Unit, but not within the Uintah Unit.[5]

Uinta Basin Replacement Project

The UBRP consists of numerous projects on the Lake Fork and Yellowstone River drainages. The projects include: 1) stabilizing 13 high-mountain lakes; 2) modifying the Moon Lake Dam outlet works for winter releases; 3) constructing the Big Sand Wash Feeder Diversion (BSWFD) on the Lake Fork River; 4) constructing a pipeline from the BSWFD to the enlarged Big Sand Wash Reservoir (BSWR); 5) replacing the existing dam at the BSWR and enlarging the off-stream storage from approximately 12,000 acre-feet to 25,838 acre-feet; 6) constructing a pipeline from the BSWR to Roosevelt City to deliver M&I and project irrigation water; 7) providing for several fish and wildlife mitigation and enhancement locations along these two drainages; and 8) modifying two diversions, the Farnsworth Canal on the Lake Fork River and the Yellowstone Feeder Canal on the Yellowstone River.[6]

TABLE 6
Estimated Water Budget

Category	Water Supply (ac-ft/yr)
Supply	
Total Precipitation[1]	9,113,000
Estimated use by vegetation and natural systems	7,939,400
Available Supply (Water Yield)	**1,173,600**
Outflow to Wyoming	
North Slope Streams	**253,000**
Inflow to the Basin	
Green River	1,203,000
Henrys Fork	52,000
Vermillion Creek	40,000
Yampa River	1,429,000
White River	468,000
Total Inflow to the Basin	**3,192,000**
TOTAL SUPPLY[2]	**4,112,600**
Uses	
Irrigation Depletions	340,000
M&I Depletions	18,000
Surface Water Evaporation from Reservoirs	124,000
Exported Water to Utah Lake Basin[3]	167,000
Exported Water to Wyoming[3]	600
Total Uses	**649,600**
Outflow from the Basin @ Confl. w/Price River[4]	**3,463,000**

[1] Mass balance evaluation of Figure 4 (roughly 15.6 inches over 6,965,857 acres).
[2] Available Supply minus Outflow to WY plus Inflow to the Basin.
[3] See Table 5 Trans-basin diversions.
[4] Total Supply minus Total Uses.

Total Available Supply

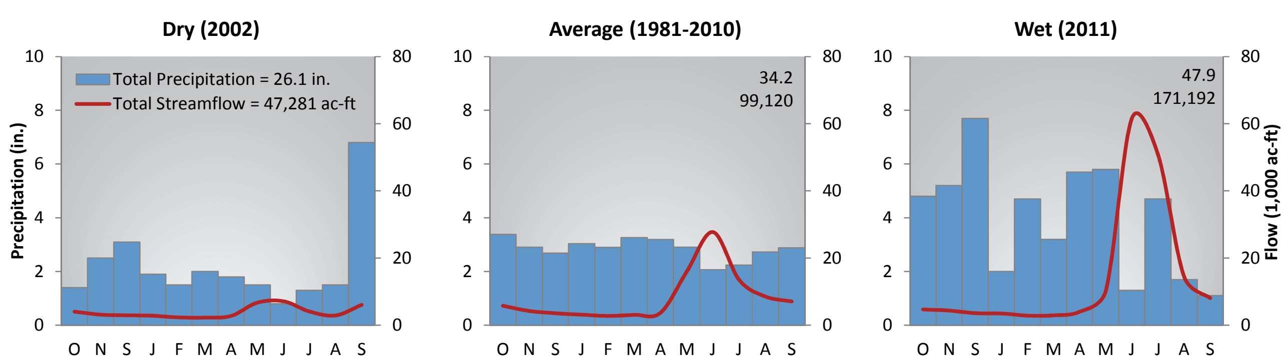
Capitalized terms in the following discussion match terms in Table 6. The Total Precipitation within the Uintah Basin is about 9,113,000 acre-feet per year. This number was arrived at by performing a mass-balance evaluation of the data presented in Figure 4, and represents an average of 15.6 inches of precipitation over the Basin's 6,965,857 acres. Streams on the north slope of the Uinta Mountains direct about 253,000 acre-feet per year Outflow to Wyoming. Inflow to the Basin from the Green River, Henrys Fork, Vermillion Creek, the Yampa River and the White River all add about 3,192,000 acre-feet per year to the basin resulting in an a Total Supply of 4,112,600 acre-feet per year.

Water uses within the basin, as well as imports and exports from the basin include Irrigation Depletions (340,000 ac-ft), M&I Depletions (18,000 ac-ft), Surface Water Evaporation from Reservoirs (124,000 ac-ft), Exported Water to the Utah Lake Basin (167,000 ac ft) and Exported Water to Wyoming (600 ac-ft). These Total Uses are about 649,600 acre-feet per year. When subtracted from the Total Supply there is about 3,463,000 acre-feet per year of Outflow from the Basin at the Confluence of the Price River. See Figure 5 for a visual representation of these flows in and out of the basin.

Variability of Supply

For the sake of convenience, the discussion to this point has focused on the basin's average annual water supply. Actual water supply conditions rarely match averages. In fact, it is not unusual to experience water supply conditions that are much drier or wetter than average. Figure 6 illustrates this point with a comparison of a dry, an average and a wet year. The blue bars show monthly precipitation in inches received at the basin's Snotel sites in the Yellowstone Creek sub-basin area. The red line shows monthly gauged streamflow of the Yellowstone Creek in acre-feet.

FIGURE 6
Water Year Scenarios



Precipitation at Five Points Lake SNOTEL site and streamflow at Yellowstone R near Altonah.
Source: NRCS, National Water and Climate Center (www.wcc.nrcs.usda.gov), September 2016.

The many reservoirs and diversion structures throughout the basin have significantly altered the hydrology of most of the basin's streams. The stream gauge on the Yellowstone River was selected because the upper drainage is relatively free of stream diversions thus making it a good site to illustrate the naturally occurring variability of supply. Figure 6 shows that the actual water supply can vary substantially from the average. On average (1981-2010), the Yellowstone River delivered 99,120 acre-feet near the town of Altonah. During the drought year of 2002, the total flow of the Yellowstone River at this same location was only 47,281 acre-feet, approximately half of the thirty-year average. In the wet year of 2011, 171,192 acre-feet flowed past this same location, an increase of about 70 percent.

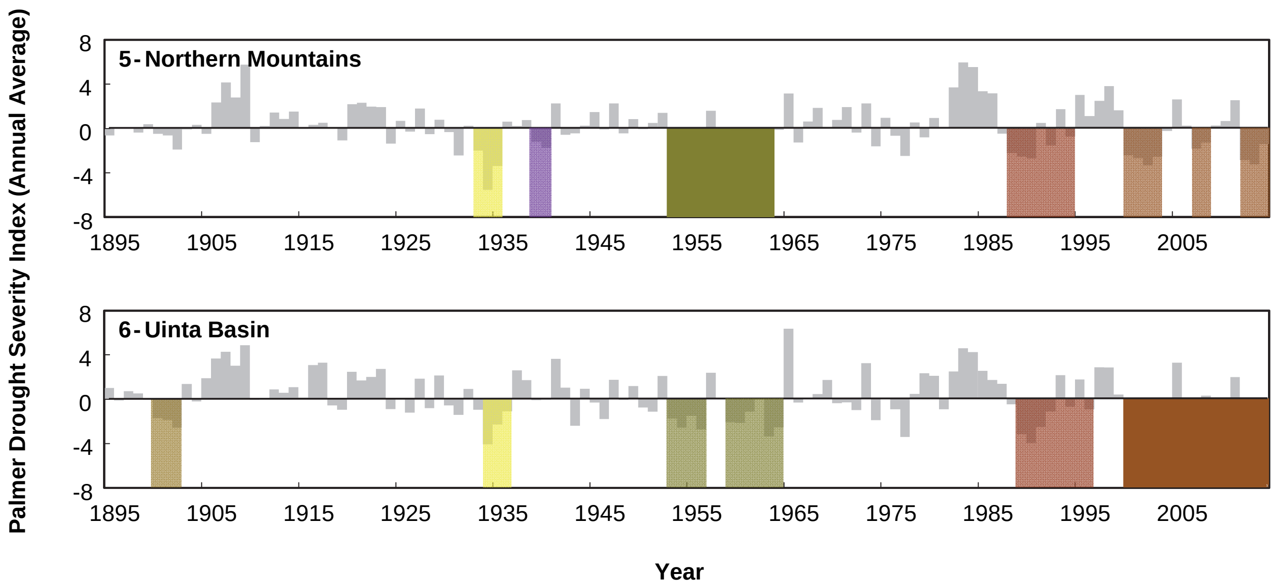
The variability of water supply illustrates the need for water storage. Without the benefits of storage, the effects of poor water years, such as prolonged drought, would be severely felt, as would the effects of flooding during wet periods. Instead, surface storage allows much of the excess flows available during wet years to be captured and held for use in drier years. However, storage on the Lake Fork and Yellowstone system only holds the equivalent of one year's use, so there is little mitigation provided in a long term drought scenario.

Drought

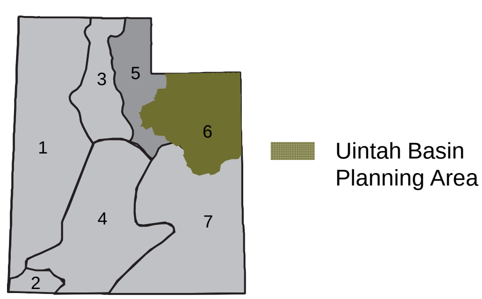
For planning purposes, it would be useful to be able to predict the duration and intensity of drought. Meteorologists have attempted to make such predictions and are continually fine-tuning the models as understanding of climate-influencing factors expands. There has been limited success to date. Drought prediction or other "early warning" systems could provide the needed stimulus during wet periods for implementing conservation measures and for investing in infrastructures such as reservoirs, aquifer storage and recovery projects, and water reuse. All of these would foster a more proactive approach to managing drought. Currently, officials use one or more of several indices to measure the relative severity of droughts. The State of Utah uses both the Palmer Drought Severity Index (PDSI), based upon precipitation and temperature, and the Surface Water Supply Index (SWSI) based upon precipitation, stream flow, snowpack and reservoir storage, when declaring drought status. Figure 7 shows the PDSI record (119 years record) for Utah's Climatic Division 5, which encompasses the mountains to the north and west where the majority of the basin's moisture is delivered, and Division 6 which includes the majority of the basin. Positive PDSI values are indicative of wet conditions whereas negative values represent dry or drought conditions.

Six droughts have been identified during the 119 year period of record using the PDSI and established drought criteria (see note on Figure 7 for drought criteria). Each drought is distinctly colored to allow comparison between the climatic regions. For example, the dust bowl years, the drought which started in the early 1930s in these regions, is identified by the yellow shading on the figure. The width correlates with the duration and the gray shading (or negative

FIGURE 7
Palmer Drought Severity Indexfor Utah's Climate Regions 5 and 6



Climatic Regions



Palmer Drought Severity Index Climatic Regions which influence and/or are within the Uintah Basin are highlighted in dark gray.

Droughts:

Six significant droughts (colored areas on graphs) were identified using the PDSI and developed drought criteria.

Drought Criteria:

A drought was considered to have started with two consecutive years of annual average PDSI values less than or equal to –1.0.

A drought was terminated when there were two consecutive years of near normal or above normal conditions (annual average PDSI above –0.5).

Source: Based on Figure 2-1 from *Drought in Utah: Learning from the Past—Preparing for the Future,* Utah Division of Water Resources, 2007, Page 15. Underlying data has been updated and extended to 2014 and is from: www.ncdc.noaa.gov.

PDSI values contained within the yellow shading) can be used to determine the drought's severity. See Table 7 for drought severity — average PDSI over the duration of the drought in each region.

Looking at Figure 7, a couple of items can be noted: (1) wet periods generally follow dry periods (and vice versa), and (2) droughts, longer and with similar or greater severity than the statewide drought of 1999, have occurred several times in the last 120 years. As can be seen, each drought varied between the two regions shown in Figure 7, with some similarities in intensity and duration. Impacts of each of these droughts are also varied due to the development of water supplies, economic conditions, population growth, water demand and other regional and local characteristics.

The impacts of the most recent drought (2000-2014, Region 6 – Uinta Basin), for example, were amplified by population increases that have occurred over the past fifty years. Some communities instituted outdoor watering ordinances, such as time-of-day restrictions, to lessen the strain on the water supply. To further investigate drought and possible mitigation

TABLE 7
Drought Duration and Severity

Climatic Region	Drought	Duration (years)	PDSI Average
5	1933-1935	3	-3.67
	1939-1940	2	-1.47
	1953-1963	11	-1.37
	1988-1994	7	-1.08
	2000-2003	4	-2.75
	2007-2008	2	-1.55
	2012-2014	3	-2.51
6	1900-1902	3	-2.06
	1934-1936	3	-2.49
	1953-1956	4	-2.17
	1959-1964	6	-1.89
	1989-1996	8	-1.07
	2000-2014	15	-1.44

Source: NOAA, National Climatic Data Center (www.ncdc.noaa.gov), 2015.

strategies, refer to the Utah Division of Water Resources' report on drought titled, *Drought in Utah: Learning from the Past—Preparing for the Future*, accessible online at: www.water.utah.gov.

Climate Change[7]

It is clear that the climate has been changing throughout all of history - it is a natural phenomenon. Today, the influence of human activities on climate change is more pronounced than at any time in the Earth's past. Even with regulation of greenhouse gases, it appears that climate change will continue and humankind will have to adapt to whatever the resultant climate may be.[8] Much credible work has been done for decades and serves to illuminate the subject and it is in the interest of Utah water suppliers to gain some knowledge of the matter. A report focusing on the Colorado River Basin states that mean temperatures in the basin have been increasing and that, "there is no evidence that this warming trend will dissipate in the coming decades; many different climate model projections point to a warmer future for the Colorado River region." The report further states that in recent years, "the Colorado River basin has warmed more than any other region of the United States."[9]

The overall implications of a warmer environment are many and varied and are not yet completely understood. A consensus has not yet been reached pertaining to the affect climate change will have on precipitation in Utah. Currently there is no significant annual precipitation trend in Utah that has been projected or detected. Although there is no consensus that climate change will significantly alter precipitation in the mountain west, the following is a list of consequences that will likely result from the temperature increases predicted by current climate change models:[10]

- The growing season will likely begin earlier and last longer.
- Evapotranspiration[11] will likely increase.
- Snowpack will likely be less (largely due to higher evaporation rates) and melt earlier.
- Summer precipitation could decrease and a greater percentage of fall and winter precipitation could come as rain rather than snow.
- Future Colorado River and tributary streamflows will likely decrease and "contribute to increasing severity, frequency, and duration of future droughts."[12]

These changes will impact management of water resources. Reservoirs will become more important and efforts to preserve storage capacity should be pursued. See, *Managing Sediment in Utah's Reservoirs*, at www.water.utah.gov.

DEVELOPED SUPPLY

Historically, surface water sources were first developed for irrigation, while groundwater was used for domestic and culinary needs. In more recent years, high quality surface water sources have been added to the public drinking water supply. The 2010 data (Utah Division of Water Resources, *Municipal and Industrial Water Supply Studies*, 2012) shows that 843,500 acre-feet/year, approximately 98 percent of the basin's developed water supply, comes from surface water sources (see Table 8). Roughly 97 percent of the basin's developed surface water is used for irrigation (822,000 acre-feet/year). Irrigation accounts for about 96 percent of all developed water use in the basin. Irrigation diversions vary from year to year with the changing stream flows, but the average annual irrigation diversion for the basin is estimated to

TABLE 8
Presently Developed Water Supplies (2010)

Source/Description	Average Annual (ac-ft/yr)
Surface Water	
Irrigation (Diversions)	822,000
Public Supply (Reliable Potable Supply)	19,100
Public Supply Secondary Water	2,400
Total Surface Water	**843,500**
Groundwater (Wells and Springs)	
Public Supply Wells and Springs	7,600
Industrial and Stock Watering	6,600
Total Groundwater	**14,200**
TOTAL SUPPLY	**857,700**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

be 822,000 acre-feet per year. This number was determined by applying the state engineer's irrigation duty to the inventoried irrigation lands. Some of the lands within the basin have a 4 acre-foot per acre duty and some have a 3 acre-foot per acre duty.

Table 9 lists the basin's maximum and reliable potable water supplies for public community systems. This 2010 data is taken from the Division's *State of Utah Municipal and Industrial Water Supply and Use Study Summary*. That document also provides water use data that is summarized in Tables 13 through 17 in Chapter 3. As can be seen from Table 9, the basin's total reliable potable water supply from all sources (springs, wells and surface) is just below 35,800 acre-feet per year.

WATER RIGHTS

Under Utah water law, the distribution and use of water is based upon the doctrine of prior appropriation. The Division of Water Rights, under the direction of the State Engineer, regulates water allocation and distribution. To facilitate the administration and management of water rights, the Uintah Basin has been divided into six management areas each designated by number. See Figure 8, and Table 10. The north slope of the Uinta Mountains is designated as Area 41; this area is in Summit County and Daggett County. The Ashley Creek Drainage and Brush Creek Drainage, in Uintah County, are designated as Area 45. The Pleasant Valley and Pariette Draw area, in Duchesne and Uintah counties, is designated as Area 47. The southeast portion of the Uintah County is designated as Area 49. The Duchesne and Strawberry River drainages are designated as Area 43. Area 43 drains portions of Wasatch, Duchesne and Uintah Counties. The Nine Mile Creek drainage, in Carbon and Emery counties, is designated as Area 90.

The surface waters of each of these areas are considered fully appropriated except for isolated springs. New surface water diversions and consumptive uses can be accomplished through change applications filed on owned or acquired rights. In areas 41, 45, 47, and 49, a large block of water under the Flaming Gorge Project has been transferred to the State of Utah and subsequently distributed by the Board of Water Resources to water users in the state for their use. In Area 90 some water is available for appropriation on a temporary (one-year) or fixed timed period. In each of the areas non-consumptive use applications, such as hydroelectric power generation, will be considered on the merits of each application.

In each of these areas there are limited groundwater resources available. Appropriations from isolated springs and underground water are generally limited to sufficient amounts to serve the domestic needs of one family, irrigation of a small parcel of land or a limited amount of livestock. In the lower reaches of the Duchesne and Strawberry River drainages (Area 43) there is groundwater available for large projects on a temporary or fixed–time basis. See Table 10 for details.

Native American Reserved Water Rights

The 1908 Winters v. United States Supreme Court decision established the doctrine of Native American reserved water rights. The court held that such rights existed whether or not the tribes were using the water. The decision was reaffirmed by the 1963 Arizona v. California decision that awarded water rights to five tribes in the Lower Colorado River Basin. The court determined the only feasible way the tribes' reserved water rights could be measured was based upon the amount of "practicably irrigated acreage" within the reservations. The court also ruled a tribe's quantified

TABLE 9
Potable Water Supplies for Public Community Systems (2010)

County	Reliable Potable Supply (ac-ft/yr)				Non-Potable Supply (ac-ft/yr)	GRAND TOTAL (ac-ft/yr)
	Springs	Wells	Surface	Total		
Daggett	308	1,142	645	**2,095**	**95**	**2,190**
Duchesne	1,218	3,698	8,961	**13,877**	**1,273**	**15,150**
Uintah	5,796	2,040	9,524	**17,359**	**1,073**	**18,433**
BASIN TOTAL	**7,322**	**6,880**	**19,130**	**33,332**	**2,441**	**35,773**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

reserved rights must be taken from and charged against the apportionment of water of the state in which the tribe's land is located.

Title V of Public Law 102-575, October 30, 1992 (CUPCA) provided congressional ratification of the proposed 1990 Ute Indian Water Compact with the Ute Indian Tribe of the Uintah and Ouray Reservation. This is subject to re-ratification by the State and the Tribe, neither of which has occurred as of September, 2016. A central purpose of this compact was to quantify the Tribe's reserved water rights.[13] According to the 1990 version of the Compact, the Tribe is entitled to 248,943 acre-feet of depletion per year with a related gross diversion of 470,594 acre-feet per year from all sources.[14] There is a "Tabulation of Ute Indian Water Rights" attached to the Compact which enumerates seven land groups where the water is to be diverted and how much depletion is entitled for each land group. Depending on the land group, the priority date of the water right is either October 3, 1861 or January 5, 1882.[15] An additional 10,000 acre-feet of depletion for M&I uses was authorized to be taken from the Green River. This has a priority date of October 3, 1861.[16] Thus, the total entitlement of the Tribe is 258,943 acre-feet of depletion per year (248,943 plus 10,000). This includes waters that have already been developed in the past and those that can be developed in the future.

The Compact further indicates that, "the State of Utah, through the State Engineer, shall use its best efforts to see that the reserved water rights of the Ute Tribe secured in this Compact are protected from impairment."[17] The Utah Division of Water Rights (State Engineer's Office) has estimated the amount of diversions that have been taking place in each of the seven land groups and for M&I. When these estimated amounts are subtracted from the total 258,943 acre-feet, there is left remaining approximately 106,000 acre-feet per year of depletions yet to be developed.[18]

Colorado River Compact[19]

In 1922 the seven states that contain land in the Colorado River Basin negotiated an agreement on how to allocate the undeveloped waters of the Colorado River. The states are Colorado, Wyoming, Utah, New Mexico, Nevada and California. The Federal Government later ratified the agreement formalizing it into an interstate compact. It is known as the Colorado River Compact and is the basis of the "Law of the River." While the Colorado River Compact of 1922 was the first of a long process of negotiation and litigation, it was not the last. In the 93 years since the Colorado River Compact was established, there have been a number of acts, treaties, court cases, agreements and guidelines that have added to and increased the complexity of the "Law of the River." In addition to the Colorado River Compact, the principle documents that govern the use of Colorado River water include:

- Boulder Canyon Project Act of 1928
- Mexican Treaty of 1944
- Upper Colorado River Basin Compact of 1948
- Colorado River Storage Project Act of 1956
- 1963 U.S. Supreme Court decision, *Arizona v. California*
- Colorado River Basin Storage Project Act of 1968
- 1970 Criteria for Coordination Long-range Operation of Colorado River Reservoirs

FIGURE 8
Water Rights Areas

- Minute 242 of the 1973 International Boundary and Water Commission
- Minute 391 of the 1973 International Boundary and Water Commission
- Colorado River Basin Salinity Control Act of 1974
- Grand Canyon Protection Act of 1992
- 2001 Colorado River Interim Surplus Guidelines
- 2007 Colorado River Shortage Guidelines and Coordinated Reservoir Operations

The natural flow of the Colorado River varies from year to year. Therefore, as part of the Colorado River Compact, upper Colorado River basin states agreed to not deplete a rolling average of 75 million acre-feet over 10 years to the lower Colorado River basin states. Thus, during any 10-year period deliveries to

TABLE 10
General Status of Water Rights

<table>
<tr><th>Area</th><th>Name</th><th>County(s)</th><th>General Policy</th></tr>
<tr><td>41</td><td>North Slope of the Uinta Mountains</td><td>Summit
Daggett</td><td rowspan="4"><u>Surface Water</u> – Surface waters are considered to be fully appropriated, except for isolated springs. New diversions and consumptive uses in these sources must be accomplished by change applications filed on owned or acquired rights. A large block of water under the Flaming Gorge Project has been transferred to the State of Utah and is available for some of these changes. Non-consumptive use applications, such as hydroelectric power generation, will be considered on individual merits.
<u>Groundwater</u> – There is a limited groundwater resource available. Appropriations from isolated springs and underground water are generally limited to sufficient acre-feet amounts to serve the domestic needs of one family, irrigation of 1.0 acres, and a reasonable amount of livestock. Water is available for larger projects on a temporary or fixed-time basis, which are generally limited to five years. Changes from surface to underground sources, and vice versa, are also considered on individual merits, with emphasis on the existence of a hydrologic tie between the two sources, the potential for interference with existing rights, and to ensure that there is no enlargement of underlying rights.</td></tr>
<tr><td>45</td><td>Ashley Creek
Brush Creek</td><td>Uintah</td></tr>
<tr><td>47</td><td>Pleasant Valley
Pariette Draw</td><td>Duchesne
Uintah</td></tr>
<tr><td>49</td><td>Southeast Uinta Basin</td><td>Uintah</td></tr>
<tr><td>43</td><td>Duchesne and Strawberry rivers</td><td>Wasatch
Duchesne
Uintah</td><td><u>Surface Water</u> – Surface waters are considered to be fully appropriated, except for isolated springs. New diversions and consumptive uses in these sources must be accomplished by change applications filed on owned or acquired rights. Non-consumptive use applications, such as hydroelectric power generation, will be considered on individual merits.
<u>Groundwater</u> – There is a limited groundwater resource available. Appropriations from isolated springs and underground water are generally limited to sufficient acre-feet amounts to serve the domestic needs of one family, irrigation of 0.25 acres, and 10 head of livestock. In the Strawberry River drainage above Soldier Creek dam and the Red Creek drainage above Red Creek dam applications are limited to in-house use only. Water is available for larger projects on a temporary or fixed-time basis, in the lower reaches of the drainage. Changes from surface to underground sources, and vice versa, are also considered on individual merits, with emphasis on the existence of a hydrologic tie between the two sources, the potential for interference with existing rights, and to ensure that there is no enlargement of underlying rights.</td></tr>
<tr><td>90</td><td>Nine Mile Creek</td><td>Carbon
Emery</td><td><u>Surface Water</u> – Surface waters are considered to be fully appropriated, except for isolated springs. New diversions and consumptive uses in these sources must be accomplished by change applications filed on valid existing water rights owned or acquired by the applicant. However, some water is available for larger appropriation on a temporary (One-year) or fixed time period basis. Non-consumptive use applications, such as hydroelectric power generation, will be considered on the merits of each application.
<u>Groundwater</u> – There is a limited groundwater resource available. Isolated springs in the Argyle Canyon area must meet the criteria outlined in the 2007 policy declaration. Permanent applications for isolated springs and underground water are generally limited to sufficient acre-feet amounts to serve the domestic purposes of one family, the irrigation of one acre, and ten head of livestock (or equivalent livestock units).</td></tr>
</table>

Source: Utah State Engineer website: http://nrwrt1.nr.state.ut.us/.

the Lower Colorado River basin states would average 7.5 million acre-feet per year. As a result of the Mexican treaty of 1944, the United States is obligated to deliver to Mexico 1.5 million acre-feet per year (increase in years of surplus to 1.7 million acre-feet).

One major problem with the "Law of the River" is the assumed quantity of water in the Colorado River upon which the 1922 compact was negotiated. At the time of the compact, the river's average annual flow (1896-1921) at Lee Ferry was believed to be about 17 million acre-feet per year. Now the basin states agree that the compact was negotiated during a period of high water supply. Recent estimates reveal that the river's average annual flow at that location to be 15 million acre-feet per year. Subtracting out the compact's and treaty's annual apportionments to the Lower Basin of 7.5 million acre-feet per year and Mexico's 1.5 million acre-feet per year leaves the upper Colorado River Basin with an estimated dependable supply of 6.0 million acre-feet per year. As a result Utah's allocated share has been reduced to approximately 1.4 million acre-feet per year. Consequentially, although Table 6 identified 1,173,600 acre-feet of water as the annual net basin yield, a significant portion of that water is not available; it is needed to meet Native American reserved water rights, international treaty and Colorado River compact obligations.

NOTES

[1] Price, Don and Louise L Miller, *Hydrologic Reconnaissance of the Southern Uinta Basin, Utah and Colorado*. Technical Publication 49, 1975.

[2] Hood, J. W., *Characteristics of Aquifers in the Northern Uintah Basin Area, Utah and Colorado*. Technical Publication 53, 1976.

[3] Holmes, W. F., *Water Budget and Ground-Water Occurrence in the Uinta Basin of Utah*, 1985, Pages 271 to 275. Retrieved from the Internet website: http://archives.datapages.com/data/uga/data/055/055001/271_ugs550271.htm, September, 18, 2015.

[4] The following description of the CUP is adapted (with a few edits and deletions) from a general description of the project and facilities found on the Bureau of Reclamation's web site at: www.usbr.gov/projects/Project.jsp?proj_Name=Central+Utah+Project.

[5] This information was provided to the Utah Division of Water Resources by Tom Bruton of the Central Utah Water Conservancy District in July 2015.

[6] Ibid.

[7] The discussion on Climate Change is taken from the Utah Division of Water Resources' report *Drought in Utah: Learning From the Past – Preparing for the Future,* published in April, 2007. The reader can access this report online at: www.water.utah.gov.

[8] Bob Holmes, "Ocean heat store makes climate change inevitable." Retrieved from the New Scientist's Internet web page: http://www.newscientist.com/channel/earth/climate-change/dn7161, September 2006.

[9] Committee on the Scientific Basis of Colorado River Basin Management, National Research Council, *Colorado River Basin Water Management: Evaluating and Adjusting to Hydroclimatic Variability*, Pages 4 & 83.

[10] Utah Division of Water Resources, *Drought in Utah: learning from the past – Preparing for the Future,* published in April, 2007, Page 50.

[11] Evapotranspiration: the process by which water is transferred from the land to the atmosphere by evaporation from the soil and other surfaces and by transpiration from plants.

[12] Committee on the Scientific Basis of Colorado River, Page 4.

[13] This information was provided to the Utah Division of Water Resources by Lee Baxter, Program Coordinator, Central Utah Project Completion Act Office, U. S. Department of Interior on July 20, 2015.

[14] "Ute Indian Water Compact," 1990 edition, Pages 1 to 3, as retrieved from the State Engineer's website: http://www.waterrights.utah.gov/cgi-bin/docview.exe?Folder=COMPACT000001, September, 2015

[15] Ibid.

[16] Ibid.

[17] Ibid., Page 8.

[18] Personal communication with Boyd Clayton, Utah Division of Water Rights, October 6, 2015.

[19] Anderson, D. Larry, "Útah's Perspective: The Colorado River," Second Edition, (Utah Dept. of Natural Resources: Salt Lake City, May 2002).

3

POPULATION AND WATER USE TRENDS AND PROJECTIONS

BACKGROUND

The Uintah Basin's population is distributed in a mixture of small rural farming communities, primarily nestled around the larger communities of Duchesne, Roosevelt, Vernal and Manila. In the past, the basin's economy has experienced several "boom and bust" periods, due in large part to the fluctuating economics associated with the basin's oil, natural gas and mining industries. The basin's rich oil shale and tar sands deposits have been identified as a natural resource of national, if not world-wide significance. Over the past several years, the basin's mining activities have helped to insulate the basin from the economic downturn experienced throughout much of the rest of the country.

Despite past performance and future potential, the Governor's Office of Management and Budget has projected only modest population growth for the basin over the next few decades. These low population projections indicate that the basin's existing municipal and industrial water supplies should be adequate through the planning year 2060.

Owing in part to the basin's adequate supply of municipal and industrial (M&I) water the Uintah Basin has actually experienced a slight increase in irrigated agricultural ground during the past two decades. This is in contrast to the state's more urban areas where increasing M&I demands have significantly reduced irrigated acreage, as irrigation water has been converted to M&I use. There is, however, the potential for industrial water demand to increase in coming decades. If oil shale mining becomes a reality, it is possible that industrial water demand could increase by voluntary market-based conversion from agricultural water demand. That is, a willing buyer cooperating with a willing seller. Of course, this would be a conversion and not an increase in total demand.

This chapter looks at the population, employment and economic future of the Uintah Basin. In addition, it attempts to quantify the amount of water that will be needed to meet future needs. As the basin's economy grows with time, planning at all levels of government will depend on reliable and consistent data detailing the demand for water. This section presents data to help local leaders anticipate the need for timely water resources development. This data along with the latest technology for delivery, use and conservation of water should provide planners and managers with tools to help manage water resources.

POPULATION TRENDS AND PROJECTIONS

The Governor's Office of Management and Budget (GOMB) has the responsibility to develop population forecasts for all regions of the State of Utah. That agency has the expertise and tools to fulfill that responsibility. Data generated by GOMB is used by state agencies as well as private industry. It would not make sense for every state agency and private company to make its own forecasts. There would be tremendous duplication of effort, a lot of variation and no way to validate any of the results.

In order to make forecasts as accurate as possible in the Uintah Basin, GOMB contacted the Uintah Basin Association of Governments. The association includes county commissioners from Duchesne, Uintah and Daggett counties; it also includes the mayors of the towns in those counties.[1] Thus, political leaders in the basin have had an opportunity to provide input to GOMB and offer justification for adjusting population projections. They may, or may not have done so, but the opportunity was provided. GOMB has indicated that the Uintah Basin Association of Governments approved the population forecasts for the basin that are used in this report.

Being a state agency, the Utah Division of Water Resources is constrained to use population projection figures provided by the GOMB. This is true for all 11 basin plans produced by the division.

Uintah Basin Population

The 2010 U.S. Census put the population of Uintah Basin at just over 52,000 persons. The Governor's Office of Management and Budget estimates the basin's 2030 population will increase to just over 67,000 people. The 2060 population is projected to grow to just over 81,000 residents. These numbers represent a population growth of slightly more than one percent per year. Table 11 shows 2000 and 2010 census populations and projections[2] for the basin's incorporated communities.

In 2010, Uintah County was home to 62 percent of the basin's population, approximately 32,600 people. Uintah County's population is projected to increase to 41,099 persons by 2030, and then to 50,174 inhabitants by 2060. This is a projected growth of 54 percent over the 50 years from 2010 to 2060 (approximately 1.1 percent per year).

Duchesne County had about 18,600 residents at the time of the 2010 census, approximately 36 percent of the basin's population. Duchesne County is projected to grow to 24,836 residents by 2030 and 29,275 residents by 2060. This is a projected growth of 57 percent over the 50 years from 2010 to 2060 (approximately 1.1 percent per year). Daggett County is the state's least populous county with only 1,059 residents in 2010. Daggett County's population is projected to increase to 1,377 by 2030 and then to 1,678 by 2060. This is a projected growth of 58 percent over the 50 years from 2010 to 2060 (approximately 1.2 percent per year).

Figure 9 presents the current population and projections for Daggett County. Manila, located approximately four miles west of Flaming Gorge Reservoir and immediately south of the Wyoming state line, is Daggett County's largest community. The 2010 census revealed Manila's population to be 310 residents. Between 2000 and 2010 Manila's population increased less than 1 percent, while Daggett County's population increased nearly 15 percent, from 921 to 1,059.

Clearly, a significant portion of the county's population resides in rural settings outside the boundaries of

TABLE 11
Population Projections

City/Community	2000	2010	2030	2060
Daggett County				
Manila	308	310	403	491
Balance of County	613	749	974	1,187
County Total	**921**	**1,059**	**1,377**	**1,678**
Duchesne County				
Altamont	178	225	300	354
Duchesne	1,408	1,690	2,256	2,659
Myton	539	569	759	895
Roosevelt	4,299	6,046	8,070	9,152
Tabiona	149	171	228	269
Balance of County	7,798	9,906	13,222	15,585
County Total	**14,371**	**18,607**	**24,836**	**29,275**
Uintah County				
Ballard	566	801	1,010	1,233
Naples	1,300	1,755	2,213	2,702
Vernal	7,714	9,089	11,463	13,994
Balance of County	15,644	20,943	26,413	32,245
County Total	**25,224**	**32,588**	**41,099**	**50,174**
BASIN TOTAL	**40,516**	**52,254**	**67,312**	**81,127**

Source: Governor's Office of Management and Budget, 2012.

FIGURE 9
Current Population and Projections: Daggett County

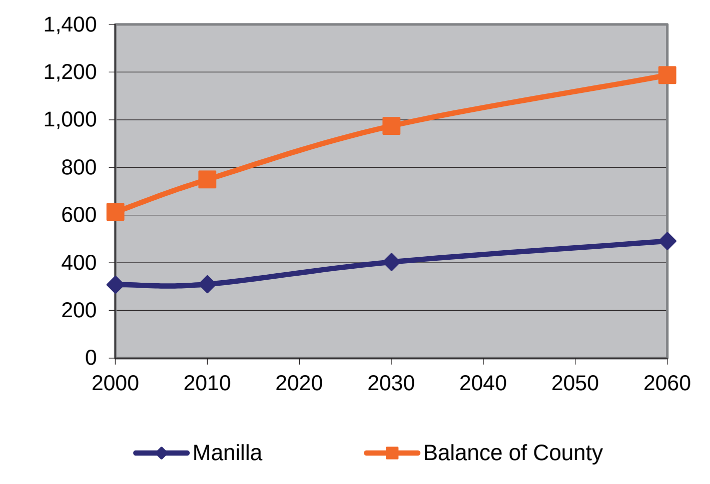


FIGURE 10
Current Population and Projections: Duchesne County

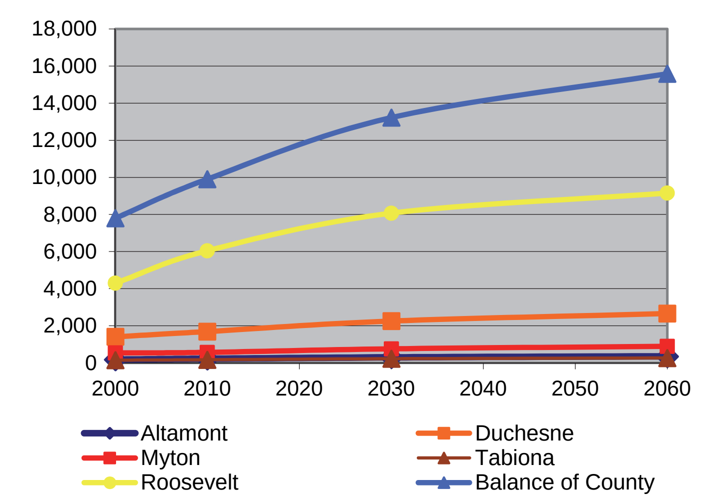
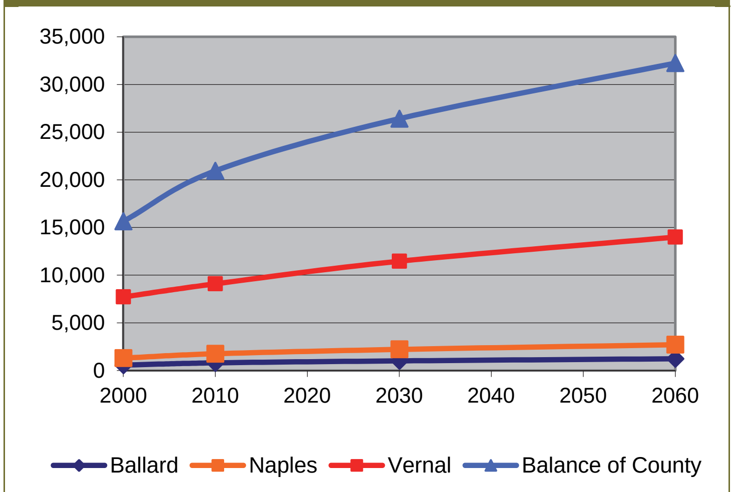


FIGURE 11
Current Population and Projections: Uintah County



Source: Governor's Office of Management and Budget, 2012.

these two communities. The Governor's Office of Management and Budget projects the Manila population to increase to 403 by 2030, and then 491 by 2060. Meanwhile the balance of county population is projected to increase to 1,187 by 2060.

Figure 10 presents the current population and projections for Duchesne County. Roosevelt, located near the very center of the Uintah Basin and at the eastern edge of Duchesne County, is the county's largest community with 6,046 residents in 2010. Roosevelt is projected to increase to 9,152 residents by 2060. The second largest community in the county is the town of Duchesne, located in south central portion of the county approximately 24 miles southwest of Roosevelt. Duchesne is projected to increase from the 2010 population of almost 1,700 residents to nearly 2,700 residents by 2060. Three other communities: Altamont, Myton and Tabiona are also shown. These communities are projected to experience moderate growth over the next fifty years. A little more than half of the county's residents reside outside the urban communities in rural settings. The Governor's Office of Management and Budget population projections reflect this fact with much of the county's growth falling in the "balance of county" category.

Figure 11 presents the current population and projections for Uintah County. Vernal is the largest community in Uintah County and the Uintah basin. Located in the north central portion of the county, Vernal's 2010 population of 9,089 is projected to increase to 11,463 by 2030 and about 13,994 by 2060. The county's next two largest communities, Ballard and Naples are also shown with rather modest projected growth. Nearly two-thirds of the county's population is located outside of the urban communities in rural settings. The Governor's Office of Management and Budget's population projections reflect this fact with more than half of the county's population growth falling into the "Balance of County" category.

Other population data suggests the basin is experiencing population growth faster than projected by the Governor's Office of Management and Budget. The U. S. Census indicates that between 2010 and 2014 Duchesne County experienced an estimated growth of 9.5 percent while Uintah County experienced an estimated growth of 13.1 percent.[3] Daggett County was estimated to have grown by 5.3 percent over the same time period.[4] The 2010 populations were the same as indicated in Table 11 and the 2014 populations were estimated. Overall, Utah experienced and estimated growth rate of 6.5 percent.

WATER USE TRENDS AND PROJECTIONS

Agriculture

Although there has been moderate growth in the basin's communities, the Uintah Basin has remained very rural. The Uintah Basin has a diversified economy, with jobs in mining, construction, service, transportation, trade and many other sectors. However, agriculture continues to be an important part of the basin economy. While agricultural ground has been decreasing throughout much of the state, irrigated lands in the Uintah Basin have increased slightly over the past two decades.

The Division of Water Resources conducted water-related land use surveys in the Uintah Basin in 1992, 2000, 2006 and 2012. The data show that, overall, the irrigated lands within the basin have increased about six percent during the 30 year interval from 1992 to 2012 (see Table 12). Total irrigated land increased about nine percent during the 14 year period from 1992 to 2006. Then again, total irrigated land decreased about three percent in the six years between 2006 and 2012. Such opposite changes make it difficult to predict whether the amount of irrigated land will increase or decrease in the future.

TABLE 12
Acres of Irrigated Land in the Uintah Basin by Year

Year	Surface Irrigated	Sub-Irrigated	Total Irrigated
1992	198,284	2,867	201,151
2000	207,491	4,461	211,952
2006	212,539	7,374	219,913
2012	204,933	7,762	212,695

Source: Utah Division of Water Resources, various water-related land use studies, 1992-2012.

Figure 12 presents the basin's irrigated lands at the time of the 2012 survey. The lands depicted in green were surface irrigated. Lands depicted in yellow were non-irrigated agricultural land. Included in this category are dry-cropland, idle and fallow ground. Although rangeland can be considered non-irrigated agricultural ground, it was not included in the surveys. The surveys were done primarily to identify irrigated lands.

Municipal and Industrial Water Use

The Municipal and Industrial (M&I) water use data provided in Tables 13 through 19 is taken from the Division of Water Resource's Municipal and Industrial Water Use Studies, 2012. This data reflects water use information from 2010.

As shown in Table 13, the basin's potable (meeting drinking water quality standards) water-use amounted to 23,120 acre-feet per year. The basin's potable water use represents 90 percent of the total M&I water use in the basin. In addition, an annual 2,441 acre-feet of secondary water use, delivered primarily by secondary irrigation companies, is also used within public water systems.

The basin's public community water systems delivered approximately 59 percent of the basin's potable water use, 13,674 acre-feet per year. Self-supplied industrial water accounted for approximately 38 percent of the basin's potable water supply (8,867 acre-feet per year). This water is used within the basin for oil and power production, and mining. See Table 13. Although this water is not treated to meet drinking water standards, the sources are groundwater wells which are believed to deliver water of sufficient quality to meet the drinking water standard. Consequently, the basin's self-supplied industrial water is included in the potable water use category. Only about 0.5 percent of the basin's potable water use comes from public non-community water systems (156 acre-feet/year), and about 2 percent comes from private domestic systems (423 acre-feet/year).

FIGURE 12
Irrigated Land-Use (2012)

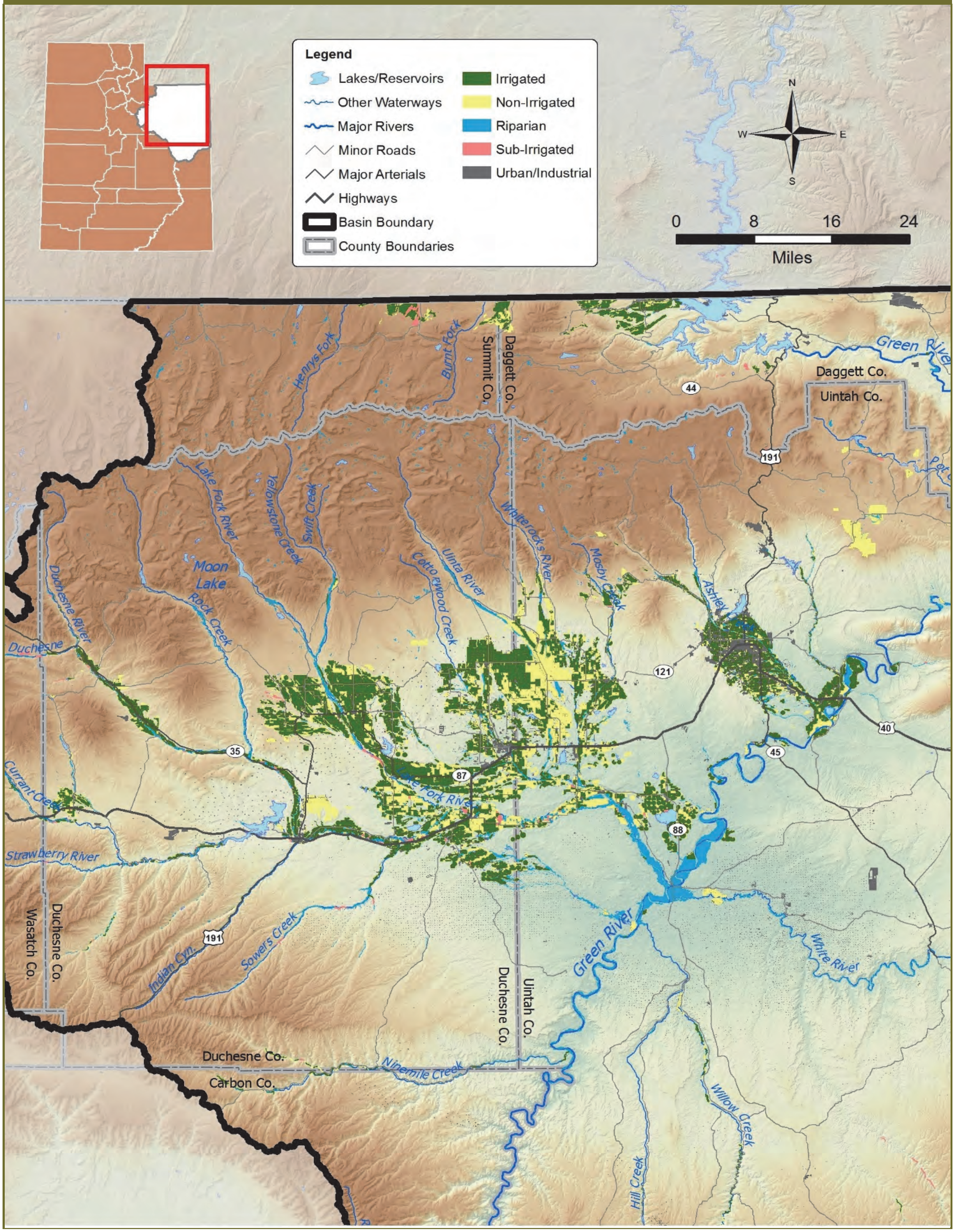


TABLE 13
Total M&I Water Use (2010)

Use Category	Water Use (ac-ft/yr)					
	Daggett	Duchesne	Uintah	Summit	Wasatch	Total
Potable Use						
Public Community Systems	313	5,289	8,071	0	0	13,674
Public Non-Community Systems	17	29	6	3	101	156
Self-Supplied Industries	0	0	8,867	0	0	8,867
Private Domestic	5	365	50	3	0	423
Potable Total	**335**	**5,684**	**16,994**	**6**	**101**	**23,120**
Non-Potable (Secondary) Use						
Secondary Irrigation Companies	95	1,273	1,073	0	0	2,441
Public Non-Community Systems	0	0	5	0	0	5
Self-Supplied Industries	0	0	0	0	0	0
Non-Potable Total	**95**	**1,273**	**1,078**	**0**	**0**	**2,446**
TOTAL	**430**	**6,957**	**18,072**	**6**	**101**	**25,566**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

Table 14 presents the potable and non-potable (secondary) water use for Daggett County. The county's total M&I water use for 2010 was 430 acre-feet. Approximately 73 percent (313 acre-feet) of that was potable water delivered by the county's public community water systems. About 21 percent (95 acre-feet/year) of the county's supply was non-potable secondary water. Only about 5 percent (17 acre-feet/year) of the county's water supply came from public non-community water systems including less than one percent from private domestic water systems.

Table 15 identifies the potable and non-potable water use in Duchesne County. Total M&I water use for Duchesne County was 6,957 acre-feet in 2010. Approximately 76 percent of that was potable water (5,289 acre-feet) delivered by public community water systems. Non-potable secondary water use (1,273 acre-feet) accounted for roughly 18 percent of the total M&I water use. Public non-community water systems provided almost 6 percent of the county's total M&I water supply.

Statewide, industrial water use is about two percent of the total public community system use. However, some systems in the Uintah Basin have unusually high industrial water demands. Of the total amount

TABLE 14
Daggett County
Potable and Non-Potable (Secondary) Water Use (2010)

Water Systems	Water Use (ac-ft/yr)		
	Potable	Non-Potable	TOTAL
Public Community Water Systems			
Dutch John	44	0	44
Greendale Water Company	61	50	111
Manila Municipal Water System	200	45	245
Questar Pipeline Company	7	0	7
Subtotal	**313**	**95**	**408**
Public Non-Community Water Systems			
Flaming Gorge NRA* Systems	5	0	5
Forest Service Systems	12	0	12
Bureau of Land Management Systems	0	0	0
Private Domestic Systems	5	0	5
Subtotal	**22**	**0**	**22**
TOTAL	**335**	**95**	**430**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.
*National Recreation Area

TABLE 15
Duchesne County
Potable and Non-Potable (Secondary) Water Use (2010)

Water Systems	Water Use (ac-ft/yr) Potable	Non-Potable	TOTAL
Public Community Water Systems			
Central Utah Water Conservancy District			
Starvation Water Users			
Duchesne Water Systems	440	88	528
Myton Municipal Water System	196	0	196
Johnson Water District	1,396	0	1,396
East Duchesne Improvement District	441	15	456
South Duchesne Improvement District	48	0	48
Duchesne Upper County WID	398	260	658
Fruitland Water SSD	127	0	127
Roosevelt Municipal Water System	2,077	101	2,178
Neola Water District	107	692	799
Tabiona Water System	40	95	136
Hanna W&SID	20	21	40
Subtotal	**5,289**	**1,273**	**6,562**
Public Non-Community Water Systems			
Forest Service Systems	1	0	1
State Parks	4	0	4
Private Commercial Systems	24	0	24
Private Domestic Systems	365	0	365
Subtotal	**394**	**0**	**394**
TOTAL	**5,684**	**1,273**	**6,957**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

of water delivered by Johnson Water District in 2010, about 53 percent went to industrial users. Of the total amount of water delivered by Johnson Water District in 2014, about 73 percent went to industrial users. Over that four year period, the amount of industrial water supplied increased by 84 percent while the percentage of total water supplied increased by 32 percent.[5] This increase was partially due to Roosevelt City being unable to supply industrial water for four months in 2014.[6] Similarly, in 2014, East Duchesne Improvement District supplied 84 percent of its water to commercial and industrial customers and only 16 percent to residential customers.[7]

Industrial water use in the Uintah Basin is typically for oil, gas and mining companies. Because of the processes used to produce these products, it may not be possible to reduce water use through conservation for these industries. Thus, the Utah Division of Water Resources does not anticipate industrial water demands in the Uintah Basin to decrease in order to help meet water conservation goals. Consequently, in calculating its public water supplier demand projections (shown in Table 20), the division held the per capita industrial water use constant.

Table 16 presents the M&I water use for Uintah County. Uintah County is home to about 60 percent of the basin's inhabitants. The county's 2010 total M&I water use of 18,072 acre-feet, accounted for approximately 71 percent of the basin's total M&I water use. This is a result of the 8,867 acre-feet of self-supplied industrial water use in 2010. This water is used in oil production, power production and mining. If this self-supplied water use is taken from the evaluation then per capita M&I water use in Uintah County is on par with per capita water use throughout the rest of the basin. The potable water supply delivered by public community water systems was 8,071 acre-feet. Use of secondary water in Uintah County was 1,073 acre-feet per year.

Table 17 presents the estimated M&I water use for the portions of Summit and Wasatch Counties that lie within the Uintah Basin. Only small portions of those two counties lie within the Uintah Basin, and it is not believed that there are any fulltime residents within those areas. There are, however, a number of summer homes, cabins, lodges, campgrounds and recreational facilities in those areas that use water on a seasonal basis. The total M&I water use for Summit County is approximately three acre-feet per year, two-thirds of which is used at forest service campgrounds. The total M&I water use for the Wasatch county portion of the Uintah Basin was 101 acre-feet in 2010.

TABLE 16
Uintah County
Potable and Non-Potable (Secondary) Water Use (2010)

Water Systems	Water Use (ac-ft/yr)		
	Potable	Non-Potable	TOTAL
Public Community Water Systems			
Central Utah Water Conservancy District			
Vernal Municipal Water System	2,986	0	2,986
Ashley Valley Water and Sewer	2,570	602	3,172
Jensen Water Improvement	436	0	436
Maeser Water Improvement District	592	352	944
Tridell-Lapoint Water Improvement District	319	0	319
Ute Indian Tribe Water System	845	0	845
Ballard Water Improvement District	242	96	338
Ouray Water Improvement District	82	23	105
Subtotal	**8,071**	**1,073**	**9,144**
Public Non-Community Water Systems			
Forest Service Systems*	0	0	0
Boy Scouts of America Systems*	0	0	0
State Parks Systems	6	5	11
Self-Supplied Industries	8,867	0	8,867
Private Domestic Systems	50	0	50
Subtotal	**8,923**	**5**	**8,928**
TOTAL	**16,994**	**1,078**	**18,072**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014. * Less than one ac-ft per year.

The previous chapter identified the basin's developed water supply. Table 9 in that chapter listed the basin's reliable potable water supplies for public community systems taken from the Utah Division of Water Resources, Municipal and Industrial Water Supply Studies, 2014. Figure 14 compares those reliable water supplies with the 2010 water use data listed in Tables 14, 15 and 16. The total potable water use in Daggett County for 2010 was 335 acre-feet per year. This is only about 16 percent of Daggett County's reliable potable supply of 2,095 acre-feet/year (see Table 9). The total potable water use in Duchesne County for 2010 was 5,684 acre-feet/year. This is about 41 percent of the county's reliable potable supply of 13,877 acre-feet/year. The total potable water use of public community systems in Uintah County for 2010 was 8,071 acre-feet/year. This is 46 percent of the county's 17,359 acre-feet/year of reliable potable supply.

Figure 13 provides a breakdown of the water use delivered by public community water systems including secondary water. In 2010, 67 percent of the water delivered by the basin's public community water systems went to residential use. That was a per capita use of 193 gallons per capita per day (gpcd). Of that 193 gpcd, 68 percent or 132 gpcd was used outdoors to water lawns and gardens. Indoor use was 61 gpcd amounting to 32 percent of the residential water use.

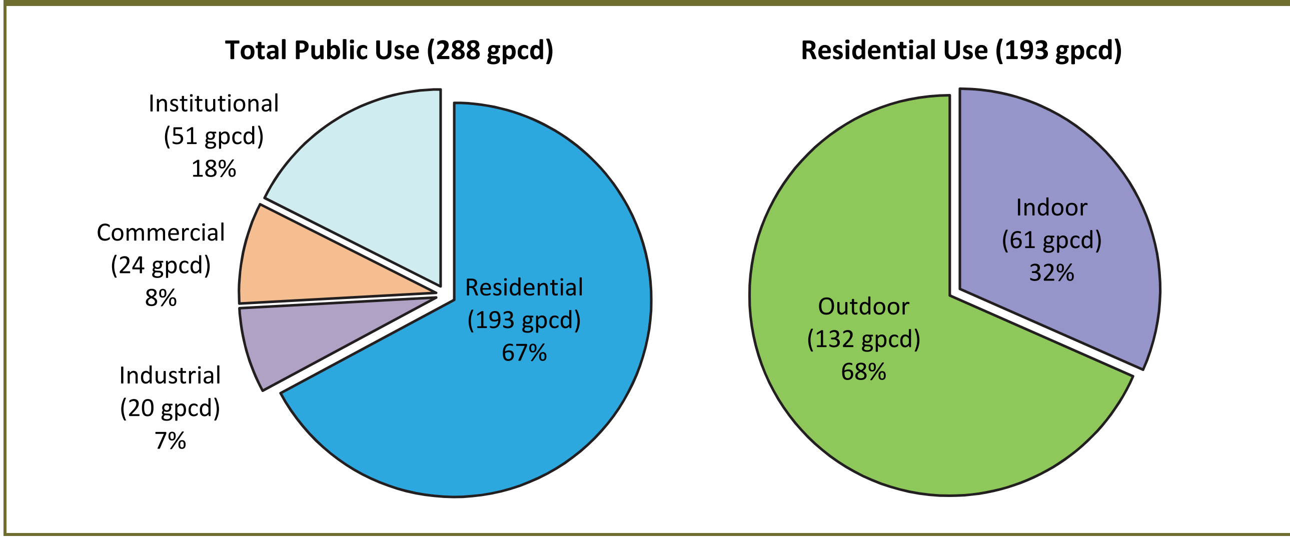
Seven percent of the water delivered by public community water systems went to industrial use. This amounted to 20 gpcd. Commercial uses took eight percent of public community water systems deliveries or 24 gpcd. Institutional uses were 51 gpcd or 18 percent. Institutional

TABLE 17
Summit and Wasatch Counties
Potable and Non-Potable (Secondary) Water Use (2010)

Water Systems	Water Use (ac-ft/yr)		
	Potable	Non-Potable	TOTAL
Summit County			
Public Non-Comm. Water Systems			
Forest Service Systems	1	0	1
Private Commercial Systems	2	0	2
Subtotal	**3**	**0**	**3**
Wasatch County			
Public Non-Comm. Water Systems			
Forest Service Systems	63	0	63
Private Commercial Systems	38	0	38
Windy Ridge Water Company	2	0	2
Subtotal	**101**	**0**	**101**
TOTAL	**104**	**0**	**104**

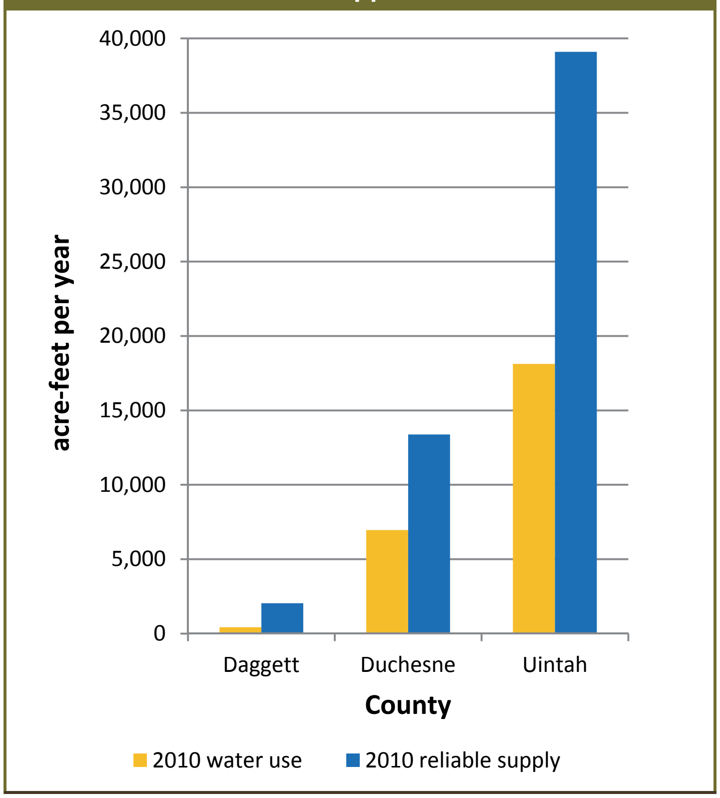
Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

FIGURE 13
Breakdown of Public Community Water Use Including Secondary Water Use (2010)



Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

FIGURE 14
Reliable Public Water Supplies vs. 2010 Water Use



Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

uses include water delivered to public facilities including courthouses, town halls, churches, parks, public landscapes, fire hydrants, and similar facilities.

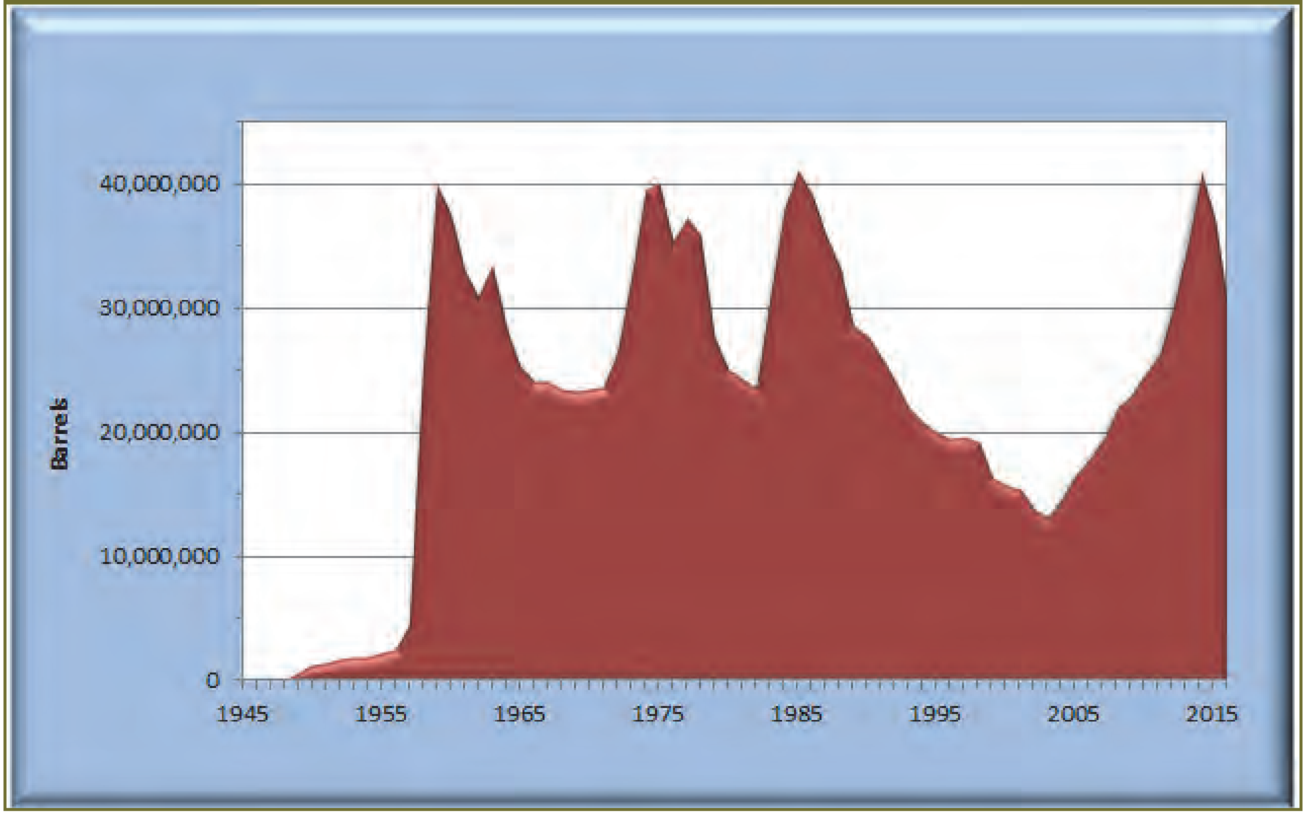
The Uintah Basin's total public use of 288 gallons per capita per day is high when compared to the statewide average of 240 gpcd (20 percent higher).

Industrial Water Use in the Oil and Gas Industries

Neither the Utah Division of Oil, Gas and Mining[8] nor the Utah Geological Survey[9] publishes studies attempting to define future energy development in the Uintah Basin. The following paragraphs provide insight to why this is so. They also provide some quantification of the M&I water needs of the oil industry.

The Uintah Basin is generally acknowledged to have had a long history of, "boom and bust" cycles due to the oil, gas and mining industries. This is confirmed and exemplified by looking at the record of crude oil production over the 71 years from 1945 to 2016 as shown

FIGURE 15
Crude Oil Production in Utah (1945 to 2016)



Source: Utah Geological Survey, Michael D. Vanden Berg, Petroleum Section Manager, 2016 data is estimated.

in Figure 15. Oil production influences population (which uses water) and the amount of water needed by that industry. As technology changes, the amount of water needed also changes; the recent advent of fracking wells is an example.

The price of crude oil determines how much oil is produced. This price is determined by the actions of many nations throughout the world; the term, "geopolitics" is sometimes applied. This is to say that the price of crude oil is set well beyond the borders of Utah and varies according to powerful forces that change through time. Notice the variations shown in Figure 15 do not follow any regular pattern; the only consistent feature of the graph is the total number of barrels[10] produced peaks at about 40 million. The gas industry has a similar record of sharp ups and downs over the period from 1960 to 2015.[11]

The shift from low oil prices (and resulting low production) to high prices and high production often takes place over relatively short time frames. See Figure 15. Thus, oil producing companies have consistently adopted a policy of submitting applications for new oil wells long before they are needed. That way the wells can be brought on line in the shortest time possible to take advantage of increased prices.[12] The fact that these applications are in place does not necessarily indicate the companies will be able to develop them immediately.

The most recent slope of the curve in Figure 15 indicates a recent down-turn in oil production. As of May 2016 the price of Brent Crude[13] oil is below $40 per barrel.[14] The U. S. Energy Information Administration forecast indicates the price of Brent Crude oil will remain below $80 per barrel through 2020 and below $100 per barrel through 2028.[15] This trend of gradually increasing prices suggests crude oil production in Utah might also gradually increase during the next decade. Increased sales of electric cars and increased use of solar and wind power are also expected to reduce the demand for oil in the long term.[16]

Due to a number of variables that are difficult to evaluate, the water demand of the oil and gas industry is difficult to determine. In response to this situation, in 2008 the Utah Geological Survey instituted a program titled, *"Water-Related Issues Affecting Conventional Oil and Gas Recovery and Potential Oil Shale Development in the Uinta Basin, Utah."*[17] Some of the matters that have been identified so far include:

- Water is produced by both oil well drilling and gas well drilling. Water produced from well drilling is commonly disposed of by
  - Injecting it into deep wells the bases of which are below the moderately saline aquifer,
  - Storage and evaporation in lined disposal ponds and (in the case of oil wells)
  - Used in Enhanced Oil Recovery (EOR).[18] EOR is a re-use of produced water.[19]
- A 2012 Uintah Basin Estimated Produced Water Balance was developed. It indicates that, of the 98 million barrels of produced water, 63 million barrels were injected into disposal wells, 17 million barrels were sent to holding ponds, 14 million barrels were used in EOR and 4 million barrels were evaporated.[20]
- Hydrologic fracking water volumes in Duchesne County increased from about 3.1 million gallons in 2012 to about 4.3 million gallons in 2013. This was an increase of 39 percent in one year. Fracking water volumes in Uintah County increased from about 6.3 million gallons in 2012 to about 6.5 million gallons in 2013.[21] This was an increase of three percent in one year. Fracking water is derived from produced water and fresh makeup water; the relative amounts are unknown.[22]

When the amount of water produced by a well is not sufficient to supply the needs for EOR, the shortage is made up with fresh water supplies. Often this water is obtained from wells drilled in the alluvium of nearby streams.[23] Table 18 shows the record of shortages which is an indication of the industrial water needs of the oil industry. The general trend of the amount of water needed increasing through time is expected to continue.[24] Overall, there was a 55 percent increase in water shortage volumes during the six years from 2008 to 2014.

TABLE 18
Enhanced Oil Recovery
Water Shortage Volumes

Year	Shortage (ac-ft)
2008	1,611
2009	1,170
2010	1,348
2011	1,408
2012	2,244
2013	2,492
2014	2,498

Source: Utah Geological Survey, Dave Tabet, Program Manager Energy and Minerals Program, March 2015.

Recreation

The Uintah Basin is heavily used for recreation, particularly in the summer months. Included in the Uintah Basin are Dinosaur National Monument, Flaming Gorge Reservoir and Recreation Area, four state parks, the Uinta Mountains, wilderness areas, three National Forests (Ashley, Uinta and Wasatch), Nine-mile Canyon, the Green River, Strawberry Reservoir, along with numerous other lakes, reservoirs, mountain streams and campgrounds. Water plays an important role in the recreational experience associated with each of these destinations. Recreational water use in Utah has grown significantly over the past few decades. While the state's population increased 2.5 times over the last four decades of the 20th century, the number of registered boats in Utah increased nine fold. The number of fishing licenses increased three-fold over the same period.[25] Much of the growing use of water-related recreational facilities is taking place in the Uintah Basin.

Although recreational water use is largely non-consumptive, its growing importance in people's lives will likely play an increasing role in the planning, development and management of Utah waters. As water is released from reservoirs and diverted from streams to meet agricultural and M&I demands, water levels in reservoirs decline and streams become de-watered, impacting recreational water uses. As this occurs, recreationists often become vocal advocates for environmental issues that often go hand in hand with recreational values. It has become increasingly important to address recreational values as well as environmental issues when managing Utah's waters.

People from the Wasatch Front frequent the basin's many parks and reservoirs. People from throughout the country and even from other countries come to visit Dinosaur National Monument and Flaming Gorge National Recreation Area. The influx of dollars into the basin as a result of this tourism is a significant portion of the basin's economy.

Dinosaur National Monument is located in the northeast corner of the basin, and extends into Colorado. The portion of the monument that attracts the largest number of visitors, including the park's visitor center, is in Utah. Because of paved roads and visitor interest, it is not uncommon for summer visitations at the Dinosaur Quarry to exceed 1,000 people a day.[26] The monument also has camping facilities, white water rafting opportunities, and scenic vistas that attract additional visitors daily.

Flaming Gorge National Recreation Area, is also located in the Northeast corner of the basin, and extends into the state of Wyoming. Similar to the monument, the major facilities within the recreation area and the majority of visitor days occur in the Utah portion. The Flaming Gorge National Recreation Area provides an outstanding opportunity for boating, fishing, jet skiing, house-boating, camping, and many other water related activities.

Within the boundaries of the basin's three national forests are more than 70 campgrounds. Many of these are full service campgrounds with approved drinking water systems. Many are situated near lakes and streams for fishing and other water related activities. These campgrounds provide hundreds of individual campsites, accommodating thousands of visitors nightly throughout the summer camping season. The Uinta Mountains Wilderness area attracts many thousands of campers, hikers, fishermen, hunters and nature enthusiasts. Many of the natural lakes throughout the Uinta Mountains were enhanced with dams in the late 1800s and early 1900s to provide storage capacity for irrigation water. As part of the Central Utah Project and the construction of larger reservoirs lower in the drainage, most of these lakes have been "decommissioned" as storage reservoirs and water elevations stabilized to better serve the recreational uses.

There are four state parks in the basin. Three are located at Starvation Reservoir, Red Fleet Reservoir and Steinaker Reservoir. The fourth is the Utah Field House of Natural History State Park in Vernal, Utah. Steinaker State Park receives 91,000 visitors a year. Starvation Reservoir gets 70,000 visitors each year. Red Fleet receives just less than 38,000 visitors each year while the Utah Field House of Natural History has just over 44,000 visitors each year.[27]

Fishing and boating are major activities on Flaming Gorge, Strawberry, Current Creek, Upper Stillwater, Steinaker, Starvation and Red Fleet reservoirs. These activities along with other water related activities are enjoyed at the basin's many other reservoirs and lakes as well.

Environment

More concern is being expressed about the environment than ever before and with it an awareness of society's effects on ecosystems. It is estimated that, of the 9 million acre-feet of water that falls upon the Uintah Basin in the form of snow and rain, people deplete only about six percent or 586,600 acre-feet per year. See Table 6. This includes 124,000 acre-feet per year of surface water evaporation from reservoirs. Approximately 87 percent of the natural supply remains in the natural system. While agricultural and M&I withdrawals and usages are relatively small compared to the amount of water that is left in the natural system, the depletion of 358,000 acre-feet per year can have an impact upon the environment in the basin. These impacts have become more apparent with the passage of time and have resulted in an increased awareness of the environment and the impacts that society's uses have on ecosystems.

Reduced stream flows due to diversions and drought have made it difficult to maintain fisheries in some locations. The instream flow agreement of 1980 and 1990 amendments have provided 44,400 acre-feet of water made available by the Central Utah Project to maintain minimum stream flows in Rock Creek, West Fork Duchesne River, Currant Creek and Strawberry River.

In the past, heavy recreational use and over-grazing in the watersheds has impacted riparian corridors, contributed to bank instability, reduced vegetation and increased silt loads in streams. Management practices have been put in place to reduce these impacts and improve the health of the watershed, but there is still room for improvement.

Some of the basin's wetlands have been impacted by urban growth and farming practices. Drainage from urban areas and farms also impacts water quality in the wetlands and in streams. All of these issues are currently being addressed through various federal, state and local agencies. These and other environmental issues are discussed in greater detail in Chapter 8.

MEETING FUTURE WATER NEEDS

The Uintah Basin has a complex and unique set of water needs that are unlike other basins in the state. Municipal systems appear to have more than enough water to meet current needs, as well as needs projected 50 years into the future. This is unique when compared to the rest of Utah. Another thing that distinguishes the basin from others in Utah is that water needs in the agricultural sector have been growing while in the rest of the state that sector has been declining. Finally, potential water needs for the development of the oil shale and tar sands industry are unique to this basin. This section provides an assessment of future water needs and presents a general strategy for how water suppliers in the basin plan to satisfy these needs.

Agricultural Water Needs

The division made land-use inventories in the basin in 1992, 2000, 2006 and 2012. See Table 12 and related narrative. While the total acreage increased slightly in the 20 years from 1992 to 2012, there was a 14 year period of increase followed by six years of decrease. Those in the agriculture business make independent decisions based on available options. One of those options might be selling water that is currently used for irrigation to the oil shale and tar sands industry. Another option might be to sell agricultural water for new M&I uses. This is what is happening in the rest of the state. It depends whether or not such options materialize and on how much those different industries are willing to pay for water. It may be that all of the aforementioned industries are able to develop independent water supplies. All of this makes forecasting future agricultural water needs in the basin quite difficult.

Municipal Water Needs

The following analysis is based on population increases as determined by the Utah Governor's Office of Management and Budget as shown in Table 11. Table 19 summarizes community water system supplies and future demands in the basin. In its public water supplier demand projections, the Utah Division of Water Resources held the per capita industrial water use constant. The result is an overall conservation goal in the Uintah Basin of 21 percent by 2060. This conservation goal is taken into consideration in the numbers presented in Table 19. Water systems that are indented mean water is supplied to them by the above water supplier that is not indented.

As is evident, all three counties overall and the basin overall are expected to have surplus water available in 2030 as well as 2060. In Daggett County, the Greendale Water Company is expected to have a small deficit in 2060. However, the company is surrounded by the Ashley National Forest which limits the opportunity for growth. Therefore, this small deficit may never materialize. The remaining systems in Daggett County have surplus water projected out to 2060.

In Duchesne County, the East Duchesne Improvement District, Johnson Water District, Myton Municipal Water System and the South Duchesne Culinary Water system are all projected to have deficits in 2030 and 2060. However, Central Utah Water Conservancy District (CUWCD) supplies wholesale water to all of these systems and has substantial supplies to meet those needs in 2030 and 2060.

The Neola Water and Sewer District is expected to have a substantial deficit in both 2030 and 2060. However, the Roosevelt Municipal Water System provides water to Neola Water and Sewer District and there are sufficient water supplies to cover the deficit in 2030. Unfortunately, both systems have deficits in 2060. The Duchesne County Upper Country WID and the Tabiona Water System are both projected to have deficits in 2060. There are no indications of how the 2060 deficits of these four systems will be met.

TABLE 19
Current Public Community System Water Supplies vs. Future Demands

Water System	2010 Demand (ac-ft)	2010 Supply (ac-ft)	Water Use Projections w/ Water Conservation† (ac-ft)		Water Supply Deficits/Surpluses‡ (ac-ft)	
			2030	2060	2030	2060
Daggett County						
Dutch John	44	645	46	59	599	588
Manila Municipal Water System	245	1,330	268	327	1,063	1,003
Questar Pipeline Co. (Clay Basin)	7	49	6	6	43	43
Greendale Water Company	111	166	138	171	28	(5)
Daggett County Total	**407**	**2,190**	**458**	**563**	**1,733**	**1,629**
Duchesne County						
Central Utah WCD	0	4,994	0	0	4,994	4,994
Duchesne Water System	528	3,708	588	694	3,120	3,014
East Duchesne Improvement Dist	441	198	491	597	(293)	(399)
Johnson Water District	1,396	484	1,554	1,890	(1,070)	(1,406)
Myton Municipal Water System	211	165	225	266	(60)	(101)
South Duchesne Culinary Water	48	0	53	65	(53)	(65)
Duchesne Co. Upper Country WID	658	990	861	1,050	129	(60)
Fruitland Water Special Service Dist.	127	188	142	172	46	15
Hanna Water & Sewer ID	41	331	56	68	275	263
Roosevelt Municipal Water System	2,769	3,724	3,186	3,764	538	(40)
Neola Water and Sewer District	208	178	282	344	(104)	(166)
Tabiona Water System	136	192	184	218	8	(26)
Duchesne County Total	**6,563**	**15,152**	**7,622**	**9,128**	**7,530**	**6,023**
Uintah County						
Central Utah WCD	0	2,000	0	0	2,000	2,000
Vernal Municipal Water System	2,986	2,139	2,924	3,572	(785)	(1,433)
Ashley Valley Water & Sewer ID	3,172	9,312	3,366	4,117	5,946	5,195
Jensen Water Improve District	436	0	429	526	(429)	(526)
Maeser Water Improve District	944	1,550	1,082	1,331	467	219
Ute Indian Tribe Water System	845	2,440	831	1,020	1,608	1,419
Ballard Water Improvement Dist.	338	96	373	456	(276)	(360)
Ouray Park Water Improve Dist.	105	173	114	139	59	34
Tridell-Lapoint WID	319	724	314	385	410	339
Uintah County Total	**9,145**	**18,434**	**9,433**	**11,546**	**9,000**	**6,887**
TOTAL	**16,115**	**35,776**	**17,513**	**21,237**	**18,263**	**14,539**

† All water use projections come from the Utah Water Demand/Supply Model and include incremental estimates of water conservation, with a total of 21% by 2060.
‡ Positive number indicates surpluses; red numbers in parentheses are deficits.
Note: Values have been rounded to the nearest whole number.

The remaining systems in Duchesne County, Duchesne Water System, Fruitland Water Special Service District and Hanna Water and Sewer Improvement District, have surplus M&I water projected for 2030 and 2060.

In Uintah County, the Vernal Municipal Water System shows deficits in 2030 and 2060. However, this is more than adequately covered by supplies from CUWCD, from whom wholesale water is purchased. The Jensen Water Improvement District shows deficits in 2030 and 2060; however, wholesale water from the Ashley Valley Water and Sewer Improvement District is more than sufficient to cover the deficits. The Ballard Water Improvement District shows deficits in 2030 and 2060. However, that system is supplied from wholesale water from the Ute Indian Tribe Water System which has sufficient supplies. The remaining systems have surplus water projected for 2030 and 2060.

The Uintah Basin as a whole is expected to have a surplus supply of community systems water of 18,263 acre-feet per year in 2030 and 14,539 acre-feet per year of surplus in 2060. The basin's water supply is over 95 percent from surface sources and less than five percent from groundwater.[28]

Flaming Gorge Water Rights

Originally, the U.S. Bureau of Reclamation (USBR) had an approved water right application that allowed the storage of 500,000 acre-feet of water in Flaming Gorge Reservoir and the use of that water for various purposes. The primary consumptive use included in the application was for the ultimate phase of the Central Utah Project, otherwise known as the Ute Indian Unit. In 1996, after the decision to not build that phase, USBR transferred most of the consumptive use portion of the application (447,500 acre-feet of diversion and 158,800 acre-feet of depletion) to the Utah Board of Water Resources (Board).[29] The Board refers to this segregated portion of the application as the Flaming Gorge Water Right.

The Board made this water available to Utah water users within the Colorado River Basin. The Board received applications for the water, approved some, and transferred portions of the water right to those applicants. In 1999, the Uintah Water Conservancy District was allocated 51,800 acre-feet of diversion (24,745 acre-feet of depletion) from the Green River. The Duchesne County Water Conservancy District was allocated 47,600 acre-feet of diversion (31,160 acre-feet of depletion), also from the Green River.[30]

The Board agreed to subordinate the Flaming Gorge Water Rights to USBR's water right for the Central Utah Project, and to the portions of the Flaming Gorge Water Rights that were transferred to the Uintah Water Conservancy District and the Duchesne County Water Conservancy District for use in the Uintah Basin. This is subject to those districts also subordinating their rights to USBR's water right for the Central Utah Project. To subordinate means to acknowledge that the organization's water rights are secondary to, or of lower rank, than those of the USBR.

NOTES

[1] Per telephone conversation between the Utah Division of Water Resources and the Uintah Basin Association of Governments, March 26, 2015.

[2] Retrieved from Internet web page: http://gomb.utah.gov/budget-policy/demographic-economic-analysis/, March, 2015. See *2012 Baseline Projections*, *Sub-County Population Projections* spreadsheet. This is the latest data available from the Governor's Office of Management and Budget.

[3] Retrieved from Internet web page: http://quickfacts.census.gov/qfd/states/49/49047.html, September, 2015.

[4] Ibid.

[5] Retrieved from Internet web page: http://www.waterrights.utah.gov/cgi-bin/wuseview.exe?Modinfo=Pwsview&SYSTEM_ID=1021, March, 2015.

[6] Personal communication with Ryan Clayburn, Water Technician, Roosevelt City, April, 2015.

[7] Personal communication with Lee Moon, Director East Duchesne Improvement District, April 9, 2015.

[8] Personal communication with John Rogers, Associate Director Oil and Gas, March 26, 2015.

[9] Personal communication with Michael Vanden Berg, Petroleum Section Manager, Utah Geological Survey, March 26, 2015.

[10] One barrel equals 42 gallons.

[11] Chidsey, Thomas C., *Oil and Gas in the Uinta Basin, Utah – What to Do with the Produced Water?* Slide 7. , Senior Scientist, Utah Geological Survey, November 10, 2014. Retrieved from the Internet web page: http://geology.utah.gov/resources/energy/oil-gas/produced-water/#tab-id-4, March, 2015.

[12] Personal communication with Michael Vanden Berg, Petroleum Section Manager, Utah Geological Survey, March 26, 2015.

[13] Brent Crude is a major trading classification of sweet light crude oil that serves as a major benchmark price for purchases of oil worldwide. This grade is described as light because of its relatively low density, and sweet because of its low sulfur content. Retrieved from Internet web page: https://en.wikipedia.org/wiki/Brent_Crude September 6, 2015.

[14] Retrieved from the Internet web page: http://oil-price.net/dashboard.php?lang=en#brent_crude_price_large, May 5, 2015.

[15] U.S. Energy Information Administration, *Annual Energy Outlook 2015 with Projections to 2040*, April 2015, page ES-2.

[16] Retrieved from the Internet web page: http://www.bloomberg.com/features/2016-ev-oil-crisis/, May 5, 2016.

[17] Retrieved from Internet web page: http://files.geology.utah.gov/emp/UBwater_study/pdf/projectsum.pdf, March, 2015.

[18] Chisdey.

[19] Ibid., Slide 25.

[20] Ibid., Slide 48.

[21] Ibid., Slide 27.

[22] Personal communication with Dave Tabet, Program Manager Energy and Minerals Program, Utah Geological Survey, March 30, 2015

[23] Ibid.

[24] Ibid.

[25] Utah Division of Parks and Recreation, *State of Utah: Strategic Boating Plan*, (Salt Lake City: Utah Department of Natural Resources, 2000) and license sales records.

[26] Retrieved from Internet web page: www.coloradovacation.com/parks/dino.html, May 2013.

[27] Retrieved from Internet web page: http://stateparks.utah.gov/about/visitation, May 2013.

[28] Utah Division of Water Resources, *Preliminary Assessment of the Potential for Managed Aquifer Recharge in the Uintah Basin, Utah*, (Unpublished Report, 2011), Figure 6, Generalized Geology, Upper Green River Basin, Utah, Page 18.

[29] Utah Division of Water Resources, “Board Decision in re: Flaming Gorge Water, Utah Water Right #41-3479 (A30414d),” (Salt Lake City: Utah Department of Natural Resources, April 30, 1999), Page 1.

[30] Ibid., Appendices D & E. These numbers are the total of the initial allocation plus allocations made after staff recommendations.

4

OIL SHALE AND TAR SANDS WATER NEEDS

The Uintah Basin is the only place in the state where oil shale is found. The basin also contains the majority of the tar sands in the state. The amount of water necessary to extract and process these deposits has been a topic that has prompted much discussion and debate over the years. This chapter explores the various factors involved in this complex issue and provides an estimate of the potential annual water demand for the industries.

ECONOMICS DRIVE OIL SHALE AND TAR SAND DEVELOPMENT

Extraction of oil shale and tar sands is currently more expensive than extraction of crude oil. As petroleum prices increase, mining these resources becomes more competitive. The United States is the world's largest petroleum consumer.[1] In April 2015 the U. S. Energy Information Administration (EIA) issued the Annual Energy Outlook. Net U.S. imports of energy declined from 30 percent of total energy consumption in 2005 to 13 percent in 2013. This is attributed to strong growth in domestic oil and natural gas production and slow growth of total energy consumption.[2] The decline in net energy imports is projected to continue at a slower rate, with energy imports and exports becoming balanced about 2028. From 2035 to 2040, energy exports are estimated to account for about 23 percent of total annual U. S. energy production.[3] These trends influence the development of Uintah Basin petroleum, natural gas and other energy sources. They are shown in Figure 16.

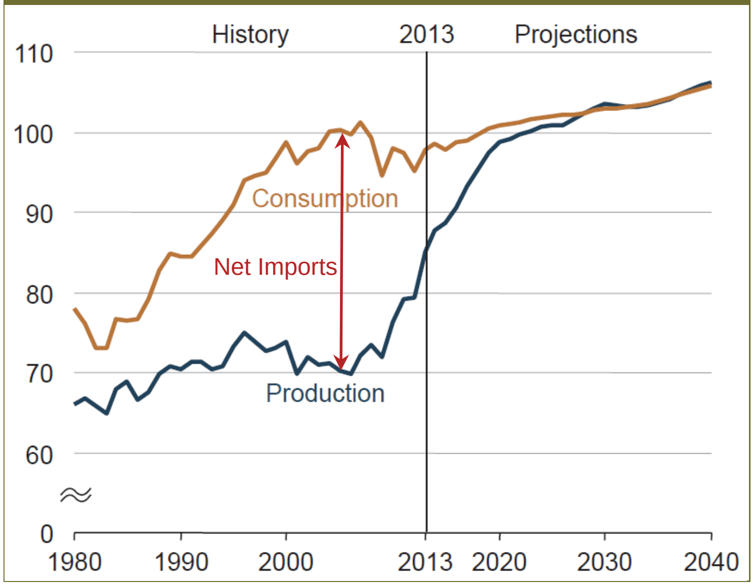
OIL SHALE DEVELOPMENT PROCESSES

Extracting oil from oil shale requires water. Given the large quantities of oil shale in the Uintah Basin, there is understandable concern that such recovery could deplete existing water supplies. This section provides background and relevant information about oil shale development and how it could impact the basin's water resources. Much of this section is derived from an October 2010 publication by the U. S. Government Accounting Office (GAO) titled, *Energy-Water Nexus, A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development*. This report "focuses on oil shale resources within the Green River Formation in the Piceance Basin of northwest Colorado and in the Uintah Basin of northeast Utah because these are the areas in the United States in which the industry is most interested in pursuing oil shale development due to the great thickness and richness of the deposits."[4] This publication attempted to define:[5]

1. What is known about the potential impacts of oil shale development on surface water and groundwater.
2. What is known about the amount of water that may be needed for commercial oil shale development.
3. The extent to which water will likely be available for commercial oil shale development and the sources.
4. Federal research efforts to address impacts to water resources from commercial oil shale development.

The investigation collected information and data from federal agencies including the Department of the Interior, Bureau of Land Management, and the U.S. Geological Survey, numerous state government agencies in Utah and Colorado, Internet searches, periodical

FIGURE 16
Total U.S. Energy Production & Consumption, 1980-2040 (Reference Case, quadrillion BTU)



Source: *Annual Energy Outlook 2015 with Projections to 2040*, U. S. Energy Information Administration, Page 17.

searches, numerous research studies from universities and industry, and discussions with companies involved in oil shale work.[6]

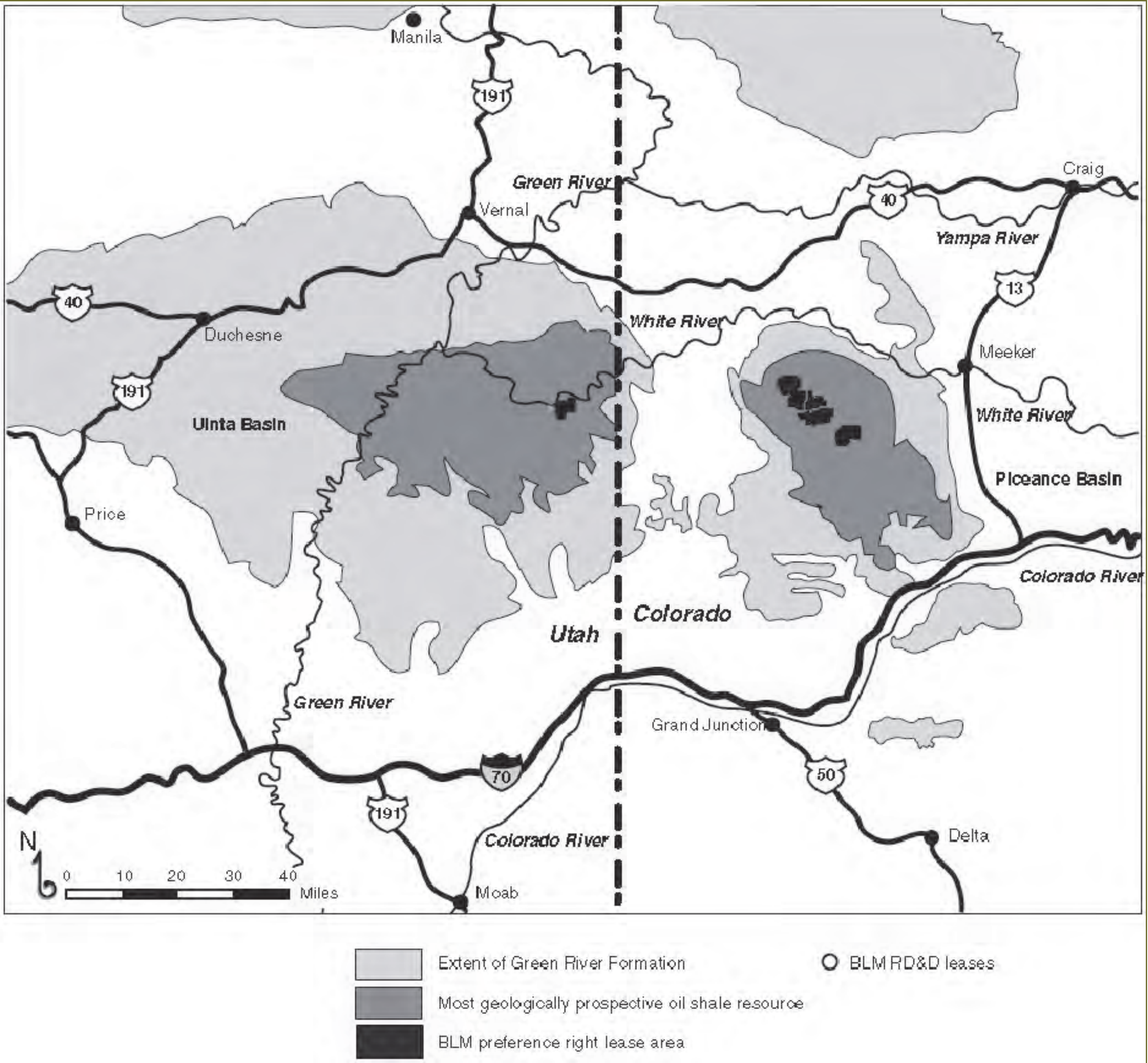
Oil shale is a fine-grained sedimentary rock containing large amounts of organic material called kerogen. When heated, the kerogen chemically transforms into crude oil and natural gas. The shale is considered a source rock for conventional crude resources in the deeper parts of the Uintah Basin.[7] While oil shale is found in 33 countries around the globe, the Green River Formation deposits in Utah, Colorado and Wyoming are the largest in the world.[8] About 52 percent of the world's estimated oil shale is contained in these deposits.[9] "About 72 percent of this oil shale is located beneath federal lands, making the federal government a key player in its potential development."[10] See Figure 17 for the location of oil shale resources in Utah and Colorado and Figure 18 for locations in the Uintah Basin.

Interest in Utah's oil shale as an energy source has waxed and waned many times since 1912 when President Taft set aside three oil shale locations, "to ensure an emergency domestic supply of oil."[11] Oil shale is in competition with other energy sources. Since a primary energy source in the United States is crude oil, interest in oil shale production follows the price of oil. As oil prices rise, interest in oil shale also rises. Readers are encouraged to read the *Industrial Water Use in the Oil and Gas Industry* section in Chapter 3 for a discussion of changes in crude oil production in the basin in the 71 years from 1945 to 2016. As mentioned in that section, as of April 2016 the price of Brent Crude[12] oil is below $40 per barrel.[13] The U. S. Energy Information Administration forecast indicates the price of Brent Crude oil will remain below $80 per barrel through 2020 and below $100 per barrel through 2028.[14] This trend of gradually increasing prices suggests crude oil production in Utah might also gradually increase during the next decade. This, in turn, suggests how interest in oil from shale and tar sands might follow crude oil prices.

The Energy Policy Act of 2005 directed the Bureau of Land Management (BLM) to lease land for oil shale research and development. Subsequently, BLM awarded several 10-year research, development and demonstration (RD&D) leases which are intended to allow businesses to develop commercially viable technologies to produce oil from the shale. Should the technologies prove successful, the lease size can be significantly expanded into commercial production.[15] The current status of the leases[16] as well as a summary of the two rounds of leasing[17] can be found on the Internet sites shown in the endnotes. Three areas comprising over 550,000 acres (859 square miles) in Utah, with a total resource estimate of greater than 31 billion barrels of oil, have been classified as leasing areas.[18] As of September, 2015 there is one active RD&D lease in Utah. It is held by Enefit America, covers 160 acres and will expire July, 2017; extensions can be applied for. This lease is adjacent to private land also held by Enefit.[19] See Figure 17 for the location of this lease.

Extracting the oil from the shale requires that it be heated to about 650 to 1,000 degrees Fahrenheit in a process called retorting. This is accomplished primarily by one of two methods. One involves mining the shale and bringing it to the surface where it is heated in retorts. The other, "known as an in-situ process, involves drilling holes into the shale formation, inserting heaters to heat the rock, and then collecting the oil as it is freed from the rock."[20] Some believe the future of oil shale development lies in the in-situ

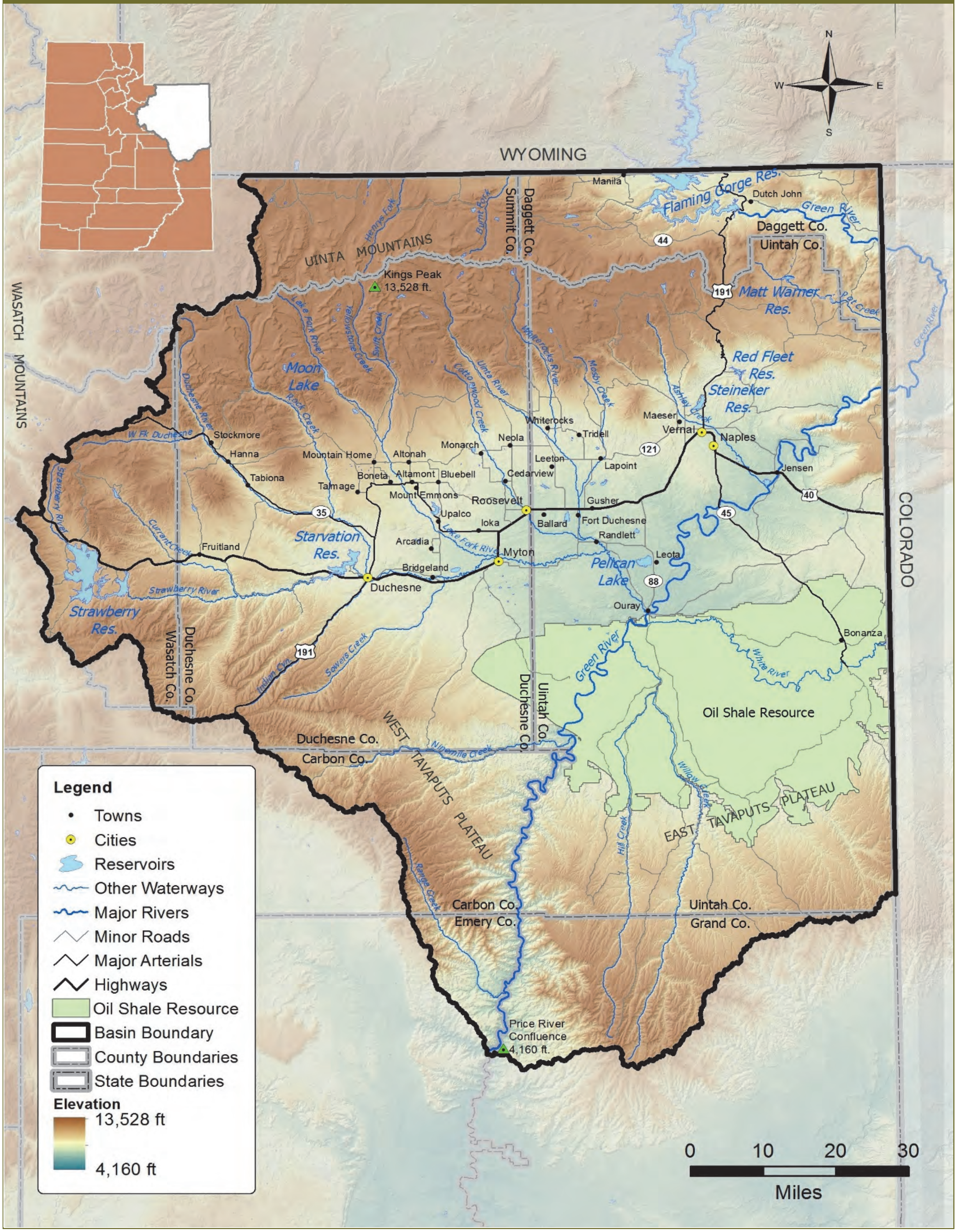
FIGURE 17
Location of Oil Shale Resources



Source: U. S. Government Accountability Office, "Energy-Water Nexus - A Better and Coordinated Understanding of Water Resources Could Help Mitigate the Impacts of Potential Oil Shale Development," (Government Accountability Office, 2010), Page 29.

method since the deposits are buried at great depth, making mining difficult or impossible.[21] However, this depends on the individual deposits. In Colorado, the better oil shale deposits are located at greater depth than in Utah making the in-situ process more attractive than mining. Many deposits in the Uintah Basin are available on the surface and are thus more accessible for mining.[22] Oil shale deposits are situated in remote locations. See Figure 18. Generally speaking, this means there are little or no infrastructure such as highways, pipelines and electrical power lines. Utah has more existing infrastructure in the state's oil shale regions than does Colorado thus making development more attractive and potentially less costly.[23] Still, the remoteness creates several challenges such as building electrical generators to heat the ground and extract the oil, as well as transporting the oil to market once it is obtained.[24]

FIGURE 18
Location of Oil Shale Deposits in Utah



Source of Oil Shale Resource location: Bureau of Land Management, Vernal, UT office, 2014.

One company has developed a process that could be described as a "modified in-situ" method. It appears to have advantages over the other two methods, and seems to be viable for use with the outcropping deposits found in Utah.[25] The process involves heating mined shale in a closed surface impoundment, or capsule. To begin, a large pit is excavated and lined with clay. The pit is then filled with mined shale; gas-fired heating pipes are run through lower portions of the shale. Natural gas is recovered using pipes in the upper portions of the shale while oil is recovered from the bottom of the pit.[26] The last step in constructing the capsule is covering it with sloped earthen materials which make reclamation part of the initial process. It's estimated that for every unit of energy used in the process, 10 units of energy are produced, making it comparable to the extraction of conventional oil. Produced gas could be used for power and heating requirements.[27]

AMOUNT OF SHALE-DERIVED OIL AVAILABLE

The GAO report notes that, "The U.S. Geological Survey (USGS) estimates that the Green River Formation contains about three trillion barrels of oil, and about half of this may be recoverable. This is an amount about equal to the entire world's proven oil **reserves**."[28] However, it's important to note some distinctions (italics and bold added); "these *in-place resource numbers* should not be compared to *conventional oil* ***reserves***, as is often the case (a resource is the total amount of a particular commodity *available in the ground*, a recoverable **reserve** is the amount of that commodity *that can be economically recovered*). No commercial technology is currently available in the United States to extract oil from oil shale; therefore, accurate recoverable **reserve** numbers cannot be calculated."[29]

In order to facilitate communications, the following definitions are provided. CFR means Code of Federal Regulations. According to 10 CFR 609.2, when used by the U. S. Department of Energy (DOE) *Commercial Technology* means "a technology in general use in the commercial marketplace in the United States. A technology is in general use if it has been installed in and is being used in three or more commercial projects in the United States in the same general application as in the proposed project, and has been in operation in each such commercial project for a period of at least five years. The five-year period shall be measured, for each project, starting on the in service date of the project or facility employing that particular technology."[30]

According to 7 CFR 4280.103, Definitions, "*Commercially Available* means a system that has a proven operating history specific to the proposed application. Such a system is based on established design, and installation procedures and practices. Professional service providers, trades, large construction equipment providers, and labor are familiar with installation procedures and practices. Proprietary and balance of system equipment and spare parts are readily available. Service is readily available to properly maintain and operate the system. An established warranty exists for parts, labor, and performance"[31]

In 2008 the Utah Geological Survey published a report taking the following factors into account and estimated the potential resource of shale oil in the ground in Utah.[32]

1. Deposits having a richness of at least 25 gallons per ton.
2. Deposits that are at least five feet thick.
3. Deposits under less than 3,000 feet of cover.
4. Deposits that are not in direct conflict with current conventional oil and gas operations, and
5. Deposits located only on BLM, state trust, private and tribal lands.

Using these constraints, the Uintah Basin's potential economic oil shale resource was estimated to be about 77 billion barrels. This "is a more realistic estimate of potential resource. However, this number should not be used as an estimate of recoverable **reserves**, which cannot be calculated until a proven commercial technology is developed."[33] The 77 billion barrel resource number represents a large and very significant amount of oil.[34] *However, it is only about 5 percent of the USGS estimate quoted by GAO of 1.5 trillion barrels and the recoverable* ***reserve*** *amount will be less than the resource amount.* This strongly suggests the size of the oil shale industry in the Uintah Basin will be much smaller than previous estimates and less water than originally estimated will be needed.

Shale Development Activities Requiring Water

There are five activities for which oil shale development requires water. The water requirements of each vary depending on whether mining and retorting or in-situ processes are used to extract the oil. These are explained in the following paragraphs. [35]

Extraction and Retorting

Water is used for building roads, constructing facilities, controlling dust, mining and handling ore, drilling wells for in-situ extraction, cooling equipment and shale oil, producing steam, in-situ fracturing of the retort zones, and preventing fire. Water is also needed for on-site sanitary and potable uses.

Upgrading of Shale Oil

That is, improving the quality of produced shale oil so that it can be easily transported to a refinery. The degree to which the shale oil needs to be upgraded varies according to the retort process. Shale oil produced by surface retorting generally requires more upgrading, and therefore, more water than shale oil produced from in-situ operations that heat the rock at lower temperatures and for a longer time, producing higher-quality oil.

Reclamation

Water is needed to cool, compact, and stabilize the waste piles of retorted shale and to revegetate disturbed surfaces, including waste pile surfaces. For in-situ operations, in addition to the typical revegetation of disturbed surfaces, water also will be needed for reclamation of the subsurface retorted zones to remove residual hydrocarbons. The volume of water that would be needed to rinse the zones at present is uncertain and could be large, depending primarily on how many times the zones need to be rinsed. Some companies envision reducing water demands for reclamation, as well as for extracting, retorting, and upgrading, by recycling water produced during oil shale operations, or by treating and using water produced from nearby oil and gas fields.

Power Generation

Water is also needed throughout the life cycle of oil shale production for generating electricity from power plants needed in operations. The amount of water used to produce this electricity varies significantly according to generation and cooling technologies employed.

Population Growth

In isolated rural areas where oil shale is located, the required number of sufficiently skilled workers may not be available. Additional water would be needed to support anticipated population increases due to oil shale workers and the families who migrate into the area. This increase in population will increase the demand for water for domestic uses.

Variation of Estimates

Water use estimates to extract oil from shale vary widely and depend on the process used. The wide variations also stem from the uncertainty associated with reclamation technologies for in-situ methods and because of the various ways to generate power for oil shale operations.[36] 2010 estimates suggested, "That from one to 12 barrels of water could be needed for each barrel of oil produced from in-situ operations,

Shell Oil Company experimental in-situ site. (Source: GAO Report.)

with an average of about five barrels. About two to four barrels of water could be needed for each barrel of oil produced from mining operations with a surface retort."[37] Many industry analysts believe the higher water usage, even five barrels of water per barrel of oil produced, are unrealistic and would result in the technology becoming non-viable in arid regions where those quantities are not readily available.[38] As will be seen further in this chapter, 2015 estimates are in the range of 0.5 to 2 barrels of water needed per barrel of oil.

The modified in-situ or surface impoundment technology described earlier is estimated to use about 0.5 barrel of water per barrel of oil extracted. This includes four of the five water requirements considered in the GAO report but excludes population growth. The process is designed to extract and use the water naturally found in the oil shale.[39]

AMOUNT OF WATER NEEDED FOR OIL SHALE DEVELOPMENT

There are many uncertainties involved in estimating the amount of oil to be derived from the oil shale deposits in the Uintah Basin. These include:[40]

- The unproven nature of shale oil technologies.
- Choices in how to generate the electrical power needed.
- The final size of the industry.
- A lack of surface water and groundwater baseline conditions, including water chemistry, interaction with aquifers, and the age and movement of groundwater.

Therefore, there is much ambiguity in predicting the impacts oil shale extraction will have on the basin's water supply. While much is known about potential impacts to the water resources in the Uintah Basin, a great deal of information is still unknown. As extraction technologies mature over time, overall impacts (especially to the water supply) can be better defined.

In 2006 the Department of Energy (DOE), Office of Petroleum Reserves, estimated the water needed to develop the oil shale industry in Utah and Colorado varied from 40,000 to 420,000 acre-feet per year.[41] This is a range of 10.5 times from the lowest to the highest figure. DOE acknowledged that, "oil shale has a high water content" varying from 2 to 40 gallons of water per ton.[42] This is a variance of 20 times from the lowest to the highest figure. DOE further noted that, much of this water can be recovered during processing and used to support operations.[43] The purpose of presenting this information is to demonstrate the wide range of estimates because there are not yet any commercial production facilities to provide reliable numbers.

Development companies are very much aware that water is in short supply where the shale deposits are located. Moreover, using more water makes the process more expensive. Thus, companies are motivated to do everything possible to devise methods that use the least amount of water. The following industry estimates illustrate that.

Obtaining oil from oil shale deposits is not a new industry. It has been done commercially in Estonia for over 50 years.[44] The two largest oil shale fired power stations in the world are in that country. About 85 percent of Estonia's total electricity generation comes from mined shale oil.[45] In 2012, 70 percent of mined oil shale was used for electricity production, 27 percent for shale oil production, and 3 percent for thermal energy, cement and chemical products.[46] Daily production in that country is over 20,000 barrels of oil.[47] The process employs surface mining techniques and uses pyrolysis[48] to obtain the oil. Using this technology in Utah would require adaptation based on local shale properties; investigation into doing just that is currently under way with an anticipated production of 50,000 barrels of oil per day.[49] The operation is estimated to need about one barrel of water for each barrel of oil extracted. Using these figures, the operation only would require about 2,352 acre-feet per year, assuming operating 365 days each year.

The modified in-situ or surface impoundment technology described earlier is estimated to use about 0.5 barrel of water per barrel of oil extracted. This has been validated by pilot operations.[50] This method also uses surface mining. Assuming 9,500 barrels of oil are produced per day,[51] the water required would be about 223 acre-feet per year. Together, the surface mining and in-situ operations would use a total of about 2,575 acre-feet per year. From a process point of view, the water demand for oil shale production is expected to be very low. As discussed earlier, several other endeavors are needed to support mining and accommodate industry workers that require water. When this technology is developed on a commercial scale the actual amount of water needed will be known.

AMOUNT OF WATER AVAILABLE

The GAO study indicates that, "Water is likely to be available for the initial development of an oil shale industry, but the eventual size of the industry may be limited by the availability of water and demands for water to meet other needs."[52] All of the companies contacted by the GAO report authors expressed confidence that, "they hold at least enough water rights for their initial projects and will likely be able to purchase more rights in the future."[53] Based on other investigations the report indicates oil shale companies already hold considerable water rights and options exist to obtain more.[54]

It may be possible to obtain additional water rights from local water conservancy districts (two hold rights to tens of thousands of acre-feet per year of water in the Uintah Basin), conversion from agricultural uses, and from the Ute Indian Tribe.[55] Oil shale is likely to use surface water, although groundwater could also be used.[56]

There are limits to the amount of water that would physically and legally be available in the White River. An estimate of the amount of water available from the White River is as follows: The average historic flow of the White River at Meeker, Colorado was used as a base for estimating the amount of water physically available. From this, the average water use by water rights holders was subtracted, as was the estimated increase in municipal and industrial use by 2030. This left an estimate of the water available in 2030 of about 297,000 acre-feet per year.[57] Depending on economics, other surface water sources such as the Yampa, Green and Colorado rivers, and groundwater, could also be developed.[58] The mining use of 2,575 acre-feet is about 10 percent of the 2010 total M&I water use for the Uintah Basin indicated in Chapter 3. These numbers provide an initial estimate of the amount of surface water potentially available, and thus, an estimate of the possible size of the oil shale industry.

WATER SOURCES FOR OIL SHALE AND TAR SAND DEVELOPMENT

While there is always competition for available water, it appears unlikely the oil shale and tar sands industry water needs will greatly impact agricultural irrigation or the municipal and industrial water demands in the Uintah Basin for the following reasons:

- Oil shale and tar sand deposits are located in remote regions. See Figures 17, 18 and19. Water for agriculture and M&I comes almost exclusively from surface supplies that originate in the Uinta Mountains and are stored in reservoirs. Over 95 percent of water demands in the basin are met using surface water. Except for the Green River and the White River, there is a scarcity of surface and groundwater resources where the oil shale and tar sands are located.
- The oil shale and tar sands industry locations are downstream of the storage reservoirs and this water could conceivably be transported by gravity to where it is needed. However, upstream water rights would have to be acquired and the point of diversion transferred downstream to the Green River close to the shale and tar sand mines. Water right holders are unlikely to sell the rights if the water is needed to satisfy present demand or future growth.
- As discussed in the Government Accounting Office report, the most likely water sources for the oil shale industry are the White River and the Green River. Both streams are convenient to the shale location. See Figures 17 and 18. Again, this would require acquisition of existing water rights either upstream of, downstream of, or within the shale area location for both rivers. When it is anticipated that those rights will be used in the future, those rights could be held.

It is possible that the price of water could be driven high enough by the energy industry that it becomes advantageous to sell one's water rights and no longer be involved in agriculture. If this occurs, the agriculture industry would be impacted by oil shale mining. However, such transfers of demand from agriculture to M&I would not affect the total demand. Such willing buyers to willing seller transfers are common throughout Utah.

TAR SANDS

Utah has both the largest number of tar sand occurrences and the largest individual deposits in the United States. Tar sands are often referred to as oil sands. The deposits are located mainly in two areas of Utah: the Uintah Basin of northeastern Utah, and central southeastern Utah. See Figure 19. Within these areas, there are more than 50 identified tar sand deposits, which contain an estimated resource total of 19 to 29.2 billion barrels of oil in place.[59] The estimated average resource amount is 24.1 billion barrels. The Uintah Basin contains 25 known tar sand deposits. About 80 to 90 percent of Utah's total tar sand resource is found in the Uintah Basin.[60]

As previously defined, a resource is the total amount of a particular commodity *available in the ground*; a recoverable **reserve** is the amount of that commodity *that can be economically recovered*. For comparison, the estimated average resource amount of about 24 billion barrels in tar sands is 31 percent of the 77 billion barrel resource number for oil shale. The size of the tar sands recoverable **reserve** will be less than the 24 billion barrels resource amount. As with oil shale, these numbers suggest the size of the tar sands industry in the Uintah Basin will be smaller than previous estimates and require less water.

MCW Oil Sands Recovery

MCW Oil Sands Recovery, LLC (OSR), in partnership with Amerisands, LLC, was established to commercialize a solvent-based extraction process for Utah oil sands.[61] The technology was first developed by OSR's parent company MCW Energy Group, based in Canada. In October 2014, the plant (located about 10 miles south of Vernal, UT) successfully demonstrated extraction capabilities in a "limited demonstration testing mode" for production of up to 50 barrels per day.[62] The company reports that the next step is to increase that to a "full scale production" of 250 barrels per day.[63] This is approximately equivalent to one average, good-producing oil well in the Uintah Basin.[64] Future plans call for construction of another extraction unit which is expected to have a 5,000 barrels per day capacity. The location will be either Asphalt Ridge or the nearby Temple Mountain Energy lease site.[65] This new unit is planned to be operational in about one year and is estimated to employ about 25 persons.[66]

No water is used in the extraction process,[67] which is a significant advantage. The number of people needed to operate the two OSR plants is small. As envisioned at this time (September 2015) OSR extraction of oil from sands by MCW will have an overall de minimis impact on the water demand in the Uintah Basin.

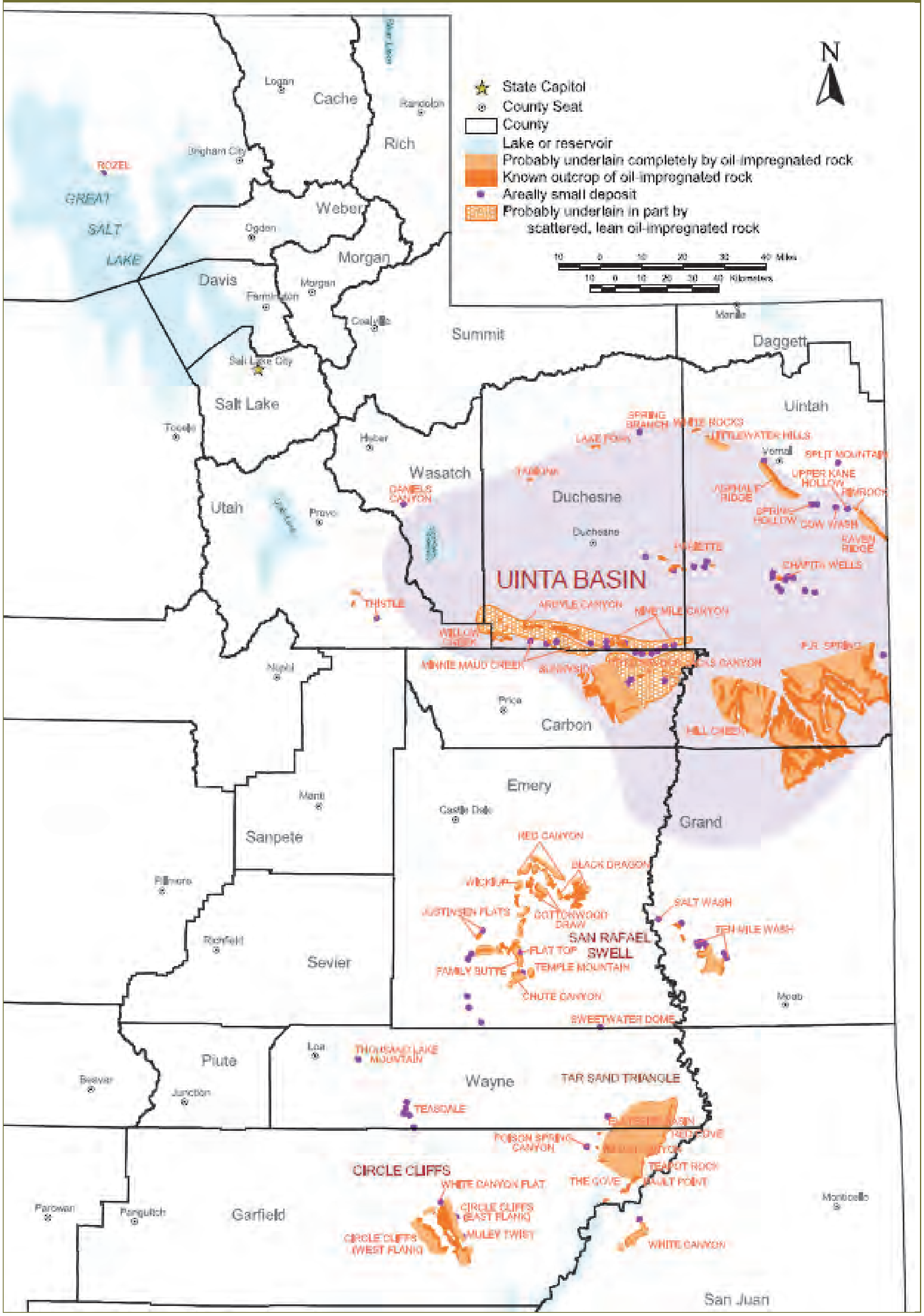
US Oil Sands

Another company, US Oil Sands (based in Calgary, Alberta, Canada) is developing an oil sands extraction project at PR Spring, located about 55 miles south-southeast of Vernal, Utah.[68] See Figure 19. The project will surface mine the sands and process them; the project is expected to be operational by the end of 2015.[69] US Oil Sands holds leases to mine about 32,000 acres and production at full capacity would be 700,000 barrels per year. [70] Water consumption is estimated to be two barrels of water per barrel of oil with an initial daily production rate of 2,000 barrels of oil. Water for the process will be obtained from wells drilled by the company.[71] This means the basin water suppliers will not be providing water to US Oil Sands. Moreover, the technology recycles 95 percent of the water.[72] An estimate of water consumption for the mining process only is less than 135 acre-feet per year initially.

American Sands Energy Company

Based in Salt Lake City, this company's initial operation will take place at the Sunnyside Lease area near Price, Utah. The company has rights to mine oil sand ore and extract bitumen from about 1,800 acres of private property.[73] The operation would consist of an underground mine with ore processing facilities nearby. Tailing rock left over after processing would be disposed of on-site until the rock could be returned to the mine, while the oil product would be trucked out. Water for the operations would be obtained from local surface water sources.[74] The process itself uses no water and produces only bitumen and clean sand. Solvents used in the extraction process would be recycled.[75] No estimate of oil production is available.

FIGURE 19
Location of Tar Sand Deposits in Utah



Source: J. Wallace Gwynn & Francis V. Hanson, *Annotated Bibliography of Utah Tar Sands Deposits,* Open File Report 503, (Salt Lake City, Utah), Page 2.

WATER SOURCES FOR SHALE MINING COMPANIES

Red Leaf Resources

Red Leaf Resources (a South Jordan, Utah company) has developed a, "patented process designed to produce high quality oil and gases" from the shale rock.[76] The company "is constructing a commercial demonstration project."[77] The company expects to have the process developed to a commercial scale by about 2017.[78] Until then it cannot be said the technology is commercially viable under Utah conditions. This assessment has been confirmed by Red Leaf Resources Vice-President of Government Affairs.

Red Leaf Resources has obtained water and has drilled 26 test wells on their property.[79] Some of that water is leased from the Uintah Water Conservancy District.[80] Two wells are currently (September 2015) operational. It is anticipated that an adequate water supply is available on the mining property and the operation will be self-sufficient regarding water.[81] Moreover, the retorting process produces water and that will also be available. At this point trucking water in is not anticipated, however, it could be utilized for some far reaches of the property.[82]

Enefit American

Another company, Enefit American (a Salt Lake City, Utah company), is developing a process to extract oil from shale in Uintah County.[83] Its parent company (based in Estonia) has 80 years of oil shale mining experience.[84] Enefit is a mining and oil company with 30 years of experience processing shale oil.[85] At this time, the project in Uintah County is in the planning and design stage and has not yet produced any shale oil or other products.[86] Until it does it cannot be said the technology is commercially viable under Utah conditions. This assessment has been confirmed by Enefit's Head of Development and Environment. Moreover, some technical people in Estonia believe that due to technical issues, "oil production from Utah shale is not a matter of five to six years, as Enefit predicts, but more a question of decades."[87] In addition, the Estonian Finance Minister, Jurgen Ligi, indicated, "it is too soon to evaluate the Utah project" due to financial limitations.[88]

According to Enefit's Head of Development and Environment the company already has sufficient surface water for their oil production.[89] The primary water sources are the Green River and White River using changed points of diversion. Water will be conveyed through a new pipeline that follows an existing right of way for part of the route to the mining operations. The company does not plan on getting water from any water suppliers in the cities located north of the oil shale formations.[90] Enefit says they have rights to 10,480 acre-feet of water on the White River, which it wants to trade out to take water from the Green River for use in its Utah project.[91] The company hopes to have all its permits in place by 2017 and be producing its first oil by 2020. Full production would begin by 2024.[92]

TomCo Energy

TomCo Energy is incorporated and registered in the Isle of Man (in the British Isles). It holds a 100 percent interest in two oil shale leases which cover 2,919 acres within the Uinta Basin.[93] In 2010, TomCo entered into a license agreement with Red Leaf Resources to use the EcoShale™ In-Capsule Process to extract oil from the company's holdings. The targeted production is 9,800 barrels per day.[94] TomCo is waiting until Red Leaf achieves commercial production on its holdings before developing theirs. TomCo has received all necessary permits from the various Utah State agencies and is ready to begin development and production.[95] It is not known at this time (October 2015) where water will come from for the operation.

Figure 18 shows the distance separating cities in the basin from the oil shale resources. It also shows that the Green and White rivers flow through those shale resources thus providing locations to get water that are much more convenient than going to municipal water suppliers in the cities. Figure 17 also shows the locations of rivers near the oil shale resources. When these companies actually implement the respective technologies and produce oil in commercial quantities it will be possible to determine how much water is needed per barrel of oil produced. Then it will be necessary to estimate the number of barrels of oil produced per year. Both of these are major factors in determining the water needs of that industry.

ESTIMATING FUTURE OIL SHALE AND TAR SANDS WATER NEEDS

Summary of Factors Impacting Water Needs

The 77 billion barrel resource number from oil shale is only about 5 percent of the USGS estimate quoted by GAO of 1.5 trillion barrels. The tar sands industry is estimated to be 31 percent of the oil shale industry. Together, these suggests much less water will be required than the amounts estimated several years ago.

Technology advances over the last five years have reduced the estimated number of barrels of water needed to produce a barrel of oil from 1 - 12 barrels to 0.5 – 2 barrels.

The Green and White rivers flow through the shale resource localities thus providing locations to get water that are much more convenient than going to municipal water suppliers in the cities. See Figure 18.

Of the three companies extracting oil from tar sands, one company's process uses no water while the second will get water from nearby surface water sources. The third will use water from nearby wells; in addition, the technology recycles 95 percent of the water. It appears that, at least for the foreseeable future, none of the three sand extraction companies expects to get water from existing water suppliers in the basin.

Of the three companies extracting oil from shale, one expects to get water from wells on the mining property. In addition, the extraction process produces water. The second oil shale company uses the same process as the first; however, the water source is unknown. The third shale oil company expects to pump water from the Green River. It appears that, at least for the foreseeable future, none of the three shale extraction companies expects to get water from water suppliers in the basin.

The GAO study identified five activities impacting the amount of water needed to extract oil from shale. When applied to Utah operations the water demands appear as follows. Taken together these activities appear to require less water than initially estimated when applied to Utah operations:

Upgrading of shale oil. While surface retorting that is expected to be used in Utah generally requires more water than in-situ retorting, the latest extraction processes are designed to use the least amount of water possible.

Reclamation. Since surface retorting is expected to be used in Utah, the large amounts of water needed to rinse subsurface retort zones will not be required. Water will still be needed to revegetate disturbed surfaces. Some companies have reduced water demands for reclamation by making reclamation part of the extraction process.

Power generation. While water for power generation will be needed for surface extraction methods, the amounts will be substantially less than the amount of power needed to heat the rocks for in-situ operations.

Population growth. Additional water will be needed to support anticipated population increases due to oil shale workers and the families who migrate into the area. These population increases will increase the demand for water for domestic uses. The magnitude and location of these population increases are difficult to predict.

Extraction and retorting. Water will be needed for building roads, constructing facilities, controlling dust, mining and handling ore, and preventing fire. Water is also needed for on-site sanitary and potable uses. However, water will not be needed for drilling wells for in-situ extraction, cooling equipment and shale oil, producing steam, and in-situ fracturing of the retort zones.

Estimating Water Demand Based on Information Known at this Time

Since the oil shale and tar sand industries will start small and likely expand in the future, it is prudent for water suppliers to plan for some minimal water demand for these industries at this time. As will be clear from the comparisons discussed below, the largest oil production estimates for both oil shale and tar sands are used to develop estimated water demands. The following data will be used to estimate those demands.

- Water demand estimates for oil shale and tar sands development from the report *Conceptual Analysis of Uinta and Green River Water*

Development Projects by CH2MHILL and Franson Civil Engineers.

- Present day estimates of initial production rates and larger future potential production rates from the companies doing the oil shale and tar sands extraction,
- Present day estimates by the same companies of the number of barrels of water needed per barrel of oil produced, and
- Indexing the number of barrels of water needed per barrel of oil produced from past estimates to present day estimates. Technological advances have resulted in needing less water.

Comparison of Oil Shale Production Estimates

The 2007 CH2MHill & Franson report estimated shale oil production rates for an industry in Uintah and Duchesne counties only.[96] The industry sizes (in barrels of oil produced per day) discussed in the report are 200,000, 500,000 and 1,000,000.[97]

The 2010 Government Accounting Office report estimated shale oil production rates for an industry in the Piceance Basin of northeast Utah and northwest Colorado for mining and surface retorting, and for in-situ retorting.[98] Sizes of an oil shale industry were based on input from industry and the Department of Energy. They are hypothetical sizes and are not meant to imply that the oil shale industry will grow to those sizes.[99] The industry sizes (in barrels of oil produced per day) discussed in the report are 25,000, 50,000, 75,000, 100,000 and 150,000.[100]

In 2015 Enefit American estimates initial production of 50,000 barrels per day. In 2015 Red Leaf Resources estimates initial production of 9,500 barrels of oil per day. In 2015 the TomCo production estimate is 9,800 barrels of oil per day. Even considering these are initial production estimates, there is a very wide range of estimated industry sizes depending on when the estimate was made and by whom.

Water Needed for Extracting Oil from Shale

Table 20 shows initial shale oil production estimates, the amount of water needed for those production rates and updated numbers based on current industry estimates. As discussed previously, Enefit American estimates initial production to be 50,000 barrels of oil per day and the extraction process will require one barrel of water per barrel of oil. As discussed previously, Red Leaf Resources, Inc. estimates initial production to be 9,500 barrels of oil per day and the extraction process will require 0.5 barrels of water per barrel of oil produced. TomCo estimates were not used since that production would begin after Red Leaf has demonstrated their process is commercially viable.

It was initially estimated that 2.3 barrels of water would be needed for each barrel of oil produced.[101] Using present day production rates and water usage rates, the amount of water needed is indexed to be 0.92 barrels of water per barrel of oil. This is 40 percent of the initially estimated 2.3. Using this percentage, Table 20 shows the updated estimated water needs for the given oil shale production rates.

Table 20
Water Needed for Extracting Oil from Shale

Oil Production Rate (bbl/day)	2006 Estimated Water Need (ac-ft/yr)	2015 Estimated Water Need (ac-ft/yr)
200,000	21,600	8,640
500,000	54,000	21,600
1,000,000	108,000	43,200

Oil Production Rate and 2006 Estimated Water Need from CH2MHILL & Franson Civil Engineers report. See Endnote 97.

Comparison of Tar Sands Production Estimates

The 2007 CH2MHill & Franson report estimated tar sand production rates for an industry in Uintah and Duchesne County.[102] The industry sizes (in barrels of oil produced per day) discussed in the report are 500,000, 1,000,000 and 1,500,000.[103]

The 2010 Government Accounting Office report did not deal with tar sands.

In 2015 MCW Oil Sands Recovery estimates a total production rate of 5,000 barrels of oil per day. In 2015 US Oil Sands estimates initial production to be 2,000 barrels of oil per day. No production estimate is available for the third company. Even considering these are initial production estimates, there is a very wide range of estimated industry sizes depending on when the estimate was made and by whom.

Water Needed for Extracting Oil from Tar Sands

Table 21 shows initial tar sands oil production estimates, the amount of water needed for those production rates and updated numbers based on current industry estimates.[104] As discussed previously, MCW Oil Sands Recovery, LLC estimates production to be 5,000 barrels of oil per day and the extraction process will not require any water. As discussed previously, US Oil Sands estimates initial production to be 2,000 barrels of oil per day and the extraction process will require two barrels of water per barrel of oil produced. Moreover, the technology recycles 95 percent of the water.

It was initially estimated that 2.3 barrels of water would be needed for each barrel of oil produced.[105] Using present day production rates and water usage rates, the amount of water needed is indexed to be 0.57 barrels of water per barrel of oil. This is 25 percent of the initially estimated 2.3. Using this percentage, Table 21 shows the updated estimated water needs for the given oil sand production rates.

Table 21
Water Needed for Extracting Oil from Tar Sands

Oil Production Rate (bbl/day)	2006 Estimated Water Need (ac-ft/yr)	2015 Estimated Water Need (ac-ft/yr)
500,000	54,000	13,500
1,000,000	108,000	27,000
1,500,000	162,000	40,500

Oil Production Rate and Initial Estimated Water Need from CH2MHILL & Franson Civil Engineers report. See endnote 97.

Combined Oil Shale and Tar Sands Water Needs

Combining the updated estimated water needs produces a range of 22,140 acre-feet (8,640 for shale + 13,500 for tar sands) to 83,700 acre-feet (43,200 for shale + 40,500 for tar sands) per year. These numbers appear reasonable given the present day production rates and the potential for eventual production expansion. Also, the present day amount of water needed per barrel of oil is substantially less than originally estimated.

The estimates are based on several assumptions that may, or may not, be accurate; it is the best that can be done with currently available data. As has happened before, the many different numbers will change (up or down) as technology changes and various production facilities are phased in over time. It will be necessary to wait for future developments before the full impacts of the oil shale and tar sands industries to the water supply in the Uintah Basin can be evaluated. The aforementioned executive of Enefit American agrees with this assessment.[106]

The "Water Development Projects under Investigation" section of Chapter 6, Water Development, describes a study that identifies 14 possible water development projects, along with five preferred ones. Detailed information is given for all projects. Planners are encouraged to look for ways to fund and build these projects in order to prepare for the oil shale and tar sands industries, in addition to other future water needs planners have identified.

NOTES

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5

MUNICIPAL AND INDUSTRIAL WATER CONSERVATION AND OTHER WATER MANAGEMENT STRATEGIES

This chapter discusses municipal and industrial water conservation, the potential to convert agricultural water to meet future industrial needs, increasing agricultural water use efficiency, secondary water systems, conjunctive management and water banking to help meet future water needs.

MUNICIPAL AND INDUSTRIAL WATER CONSERVATION

Municipal and industrial (M&I) water conservation will play a valuable role in satisfying future water needs in the Uintah Basin. M&I water conservation will be achieved primarily by reducing future water demands of public community water systems.[1] Water conservation will also decrease the costs associated with additional water development.

Utah's M&I Water Conservation Goal

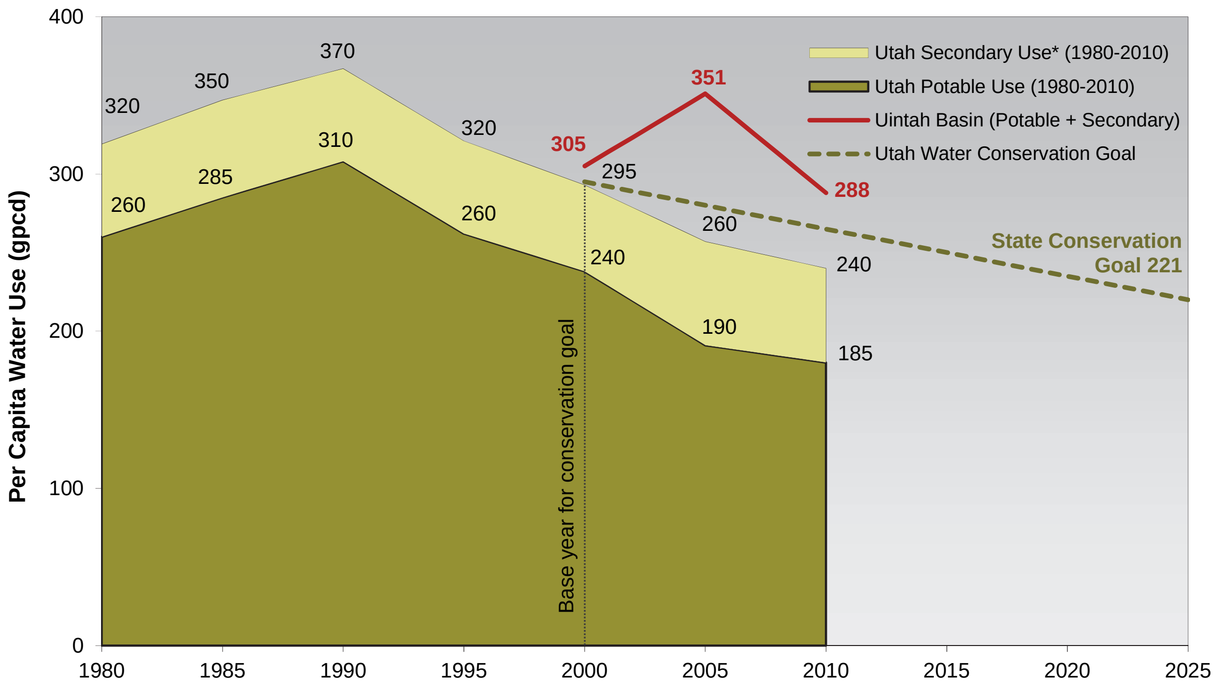
The State of Utah has developed a specific goal to conserve municipal and industrial (M&I) water supplies. This goal is to reduce the per person, or "per capita" water demand from public community water systems by at least 25 percent before 2025. The base year for measuring the decrease is 2000. Thus, the overall reduction is one percent per year for 25 years. Specifically, statewide per capita demand will need to decline from 295 gallons per person per day (gpcd) to a sustained 221 gpcd or less. A 25 percent reduction in the Uintah Basin would decrease the 2000 water demand of 305 gpcd to 229 gpcd by 2025. Consuming about 68 percent of the total public water use, outdoor residential demand is the largest area of consumption.[2] Thus, outdoor use represents the greatest potential for water conservation of all M&I water uses.

The state has made significant progress toward achieving this goal. In 2010, statewide per capita use of publicly supplied water declined from the 2000 level of 295 gpcd to 240 gpcd, a reduction of 19 percent in ten years. This is a reduction of 1.9 percent per year which is almost double the state goal. Public water suppliers in the Uintah Basin have also made progress in reducing per capita water use. Per capita water use in the Uintah Basin has declined from 305 gpcd in 2000 to 289 gpcd in 2010, a reduction of 5.2 percent. Thus, the basin is reducing water use overall by about 0.5 percent per year, which is half the state goal. See Figure 20 for a graphic representation of per capita water use in the state and Uintah Basin.

Uintah Basin is Unique Regarding Water Conservation

Statewide, industrial water use is about two percent of the total public community system use. However, as discussed in Chapter 3, some systems in the Uintah Basin have unusually high industrial water demands. In 2010, Johnson Water District supplied about 53 percent of the total water delivered to industrial users. In 2014, Johnson Water District supplied about 73 percent of the total water delivered to industrial users. Over that four year period, the amount of industrial water supplied increased by 84 percent while the percentage of total water supplied increased by 32 percent.[3] This increase was partially due to Roosevelt City being unable to supply industrial water for four months in 2014.[4] Similarly, in 2014, East Duchesne Improvement District supplied 84 percent of its water to commercial and industrial customers and only 16 percent to residential customers.[5]

FIGURE 20
Per Capita Water Use of Public Community Systems in Utah and the Uintah Basin



Source: USGS, *Estimated Water Use in the United States,* 1980, 1985 & 1990, and Utah Division of Water Resources, M&I Data Collection Program.

Much of the industrial water use in the Uintah Basin is the result of numerous oil, gas and mining operations. Because of the importance of these industries to the economic future of the basin and the significant volume of water provided to them by various water systems, the Utah Division of Water Resources does not anticipate these demands will decline (on a per capita basis) in the future. Consequently, in calculating its public water supplier demand projections (shown in Table 19), the division held the *per capita industrial water use* constant. The result is an overall conservation goal in the Uintah Basin of 21 percent by 2060.

Water Conservation's Role in Meeting Future Needs

When Utah successfully achieves the M&I water conservation goal, the total statewide demand will be reduced by approximately 500,000 acre-feet per year. This represents the most significant component in meeting Utah's future water needs. Approximately 1.2 percent of this amount, or 5,035 acre-feet per year, should occur within the Uintah Basin. Without water conservation, it is estimated that by the year 2060 public community water systems in the Uintah Basin would experience a water demand of about 25,216 acre-feet per year. With conservation, this demand can be reduced to approximately 21,237 acre-feet per year, only 3,979 acre-feet per year more than is presently being used. This could save millions of dollars in infrastructure costs. Especially since the current reliable supply would be able to adequately supply the 2060 demand.

What Water Providers Can Do to Meet Water Conservation Goals

In July 2003, the Division of Water Resources published an M&I water conservation plan for the State of Utah.[6] This plan was updated in 2014 and outlines the state's strategy to meet the water conservation goal and contains specific programs and other activities to help water providers meet conservation goals. These are discussed in the following paragraphs.

Prepare Water Conservation Plans

In 1998 the Utah Legislature passed the Water Conservation Plan Act. The act was revised in 1999 and 2004 and requires any water retailer with more than 500 connections and all water conservancy districts to prepare water conservation plans and submit them to the Division of Water Resources. Those required to submit water conservation plans must update and resubmit them every five years from the date of the original plan. Specific requirements of the act include the following:[7]

- Water conservation plans shall include an overall water use reduction goal, implementation plan, and a timeline for action and measuring progress.
- Water conservancy districts and water providers shall devote a part of at least one regular governing body meeting every five years to discuss and formally adopt the water conservation plan and allow public comment.
- Water conservancy districts and water providers shall deliver a copy of the plan to the local media and the governing body of each municipality and county to which water is provided.
- The Division of Water Resources shall publish an annual report in a newspaper of statewide distribution a list of water conservancy districts and water providers that have not submitted a plan or five-year update to the division.
- No entity shall be eligible for state water development funding without satisfying the water conservation plan requirements outlined in the act.

In addition to these legislative requirements, the Board of Water Resources also requires that petitioners for funds implement a progressive water rate structure and a time-of-day watering ordinance.

Table 22 shows the status of the required conservation plans within the Uintah Basin as well as when the updates are due. As of December, 2015, 100 percent of the water retailers and conservancy districts in the Uintah Basin, who are required to submit a plan or update, have done so.[8]

TABLE 22
Status of Water Conservation Plans

Community System	Measures Implemented	Update Due
Ashley Valley Improvement District	5,6,7	Dec 2020
Duchesne Co. Upper Country Improvement District	3,5,6,7	Dec 2019
Duchesne Water System	3,5,7	Dec 2019
Jensen Water Improvement District	5	Dec 2016
Johnson Water District	1,3,5,6,7	Dec 2019
Maeser Water Improvement District	3,7	Dec 2019
Roosevelt Municipal Water System	1,3,5,6,7	Dec 2020
Vernal Municipal Water System	5,7	Dec 2020

List of measures:
1 - Time-of-day or other water restrictions (BMP 4)
2 - Landscape ordinances and/or programs (BMP 4 & 8)
3 - Conservation pricing (BMP 3)
4 - Water reuse (BMP 13)
5 - Water metering upgrades (BMP 2)
6 - Public education and outreach programs (BMP 6 & 11)
7 - Other BMPs

Support the Public Information Program of the Governor's Water Conservation Team

All local water providers have the opportunity to choose between creating a Public Information Program (PIP) or simply utilizing the public information program created by the Governor's Water Conservation Team and the "Slow the Flow" media campaign. These programs are designed to educate the public by providing water conservation information and education. The Division of Water Resources supports these programs by providing information through a water conservation web page, and a water-wise plant tagging program and web page, all of which are available to water providers to use when creating a PIP campaigns. For more information, see: www.conservewater.utah.gov & www. slowtheflow.org.

Implement Best Management Practices

The Division of Water Resources recommends that the basin's water providers consider using the following list of Best Management Practices (BMPs) when creating a water conservation plan. Water providers should implement a mixture of these practices that best fits their unique needs.

BMP 1 - Comprehensive Water Conservation Plans

- Develop a water management and conservation plan as required by law for all systems with more than 500 connections and for any system seeking financial assistance from state funding boards. Plans are to be adopted by the water agency authority (for example, city council, water district board of trustees) and updated no less than every five years.

BMP 2 - Universal Metering

- Install meters on all residential, commercial, institutional, and industrial connections. Meters should be read on a regular basis.
- Establish a maintenance and replacement program for existing meters.
- Meter secondary water at the source level as well as the individual customer level and implement an appropriate tiered rate structure.
- Promote the development of Automatic Meter Reading (AMR) systems.

BMP 3 - Incentive Water Conservation Pricing

- Implement a water pricing policy that promotes water conservation.
- Charge for secondary water based on individual use levels as soon as technology permits.

BMP 4 - Water Conservation Ordinances

- Adopt an incentive water rate structure.
- Adopt a time-of-day watering ordinance.
- Adopt an ordinance requiring water-efficient landscaping in all new commercial development. This should include irrigation system efficiency standards and an acceptable plant materials list.
- Adopt an ordinance prohibiting the general waste of water.

BMP 5 - Water Conservation Coordinator

- Designate a water conservation coordinator to facilitate water conservation programs. This could be a new person or an existing staff member.

BMP 6 - Public Information Programs

- Implement a public information program consistent with the recommendations of the Governor's Water Conservation Team. Such programs can be adapted to meet the specific needs of the local area and may use the "Slow the Flow" logo with approval of the Division of Water Resources.

BMP 7 - System Water Audits, Leak Detection and Repair

- Set specific goals to reduce leaks and unaccounted for water to a specific, acceptable level.
- Set standards for annual water system accounting that will quantify system losses and trigger repair and replacement programs. Use methods consistent with American Water Works Association's *M36 Water Audits and Loss Control Programs* manual.

BMP 8 - Large Landscape Conservation Programs and Incentives

- Promote a specialized large landscape water conservation program for all schools, parks, and businesses.
- Encourage all large landscape facility managers and workers to attend specialized training in water conservation.
- Provide outdoor water audits to customers with large landscape areas.

BMP 9 - Water Survey Programs for Residential Customers

- Implement residential indoor and outdoor water audits to educate residents on how to save water.

BMP 10 - Plumbing Standards

- Review existing plumbing codes and revise them as necessary to ensure water-conserving measures in all new construction.

- Identify homes, office building and other structures built prior to 1992 and develop a strategy to distribute or install high-efficiency plumbing fixtures such as ultra low-flow toilets, showerheads, faucet aerators, hot water recirculators, and similar technologies.

BMP 11 - School Education Programs

- Support state and local water education programs for the elementary school system.

BMP 12 - Conservation Programs for Commercial, Industrial and Institutional Customers

- Change business license requirements to require water reuse and recycling in new commercial and industrial facilities where feasible.
- Provide comprehensive site water audits to those customers known to be large water users.
- Identify obstacles and benefits of installing separate meters for landscapes.

BMP 13 - Reclaimed Water Use

- Use reclaimed or recycled water where feasible.

BMP 14 - "Smart Controller" Technology

- Install "smart controller" technology to irrigate public open spaces where feasible.
- Encourage customers to utilize "smart controller" technology by offering rebates for these products.

The Uintah Basin qualifies for financial assistance for water conservation projects under provisions of the Central Utah Project Completion Act. The act provides funds for up to 65 percent of the cost of the water conservation measures. These funds are available through the following programs or funds: Water Conservation Credit Program, Water Conservation - General Administration Fund and Water Conservation Technology Grants. More information can be obtained from the Central Utah Water Conservancy District.

Set Example at Publicly Owned Facilities

It is important that government entities within the basin be good examples of water conservation. To help accomplish this at state facilities, the state recently revised building guidelines and policies to incorporate water-wise landscapes and more water-efficient appliances (faucets, showerheads, toilets) at new facilities. In June 2015 Governor Herbert mandated that all state facilities set the example in water conservation. This includes using current technology to the maximum extent possible, institute a leak detection and repair program, installing current technology water conservation appliances during regular maintenance and not watering between 10 a.m. and 6 p.m.[9] Local governments should consider making similar adjustments to watering operations. This will help ensure that water use at public facilities sets a good example for citizens to conserve water.

AGRICULTURAL TO MUNICIPAL AND INDUSTRIAL WATER CONVERSIONS

In the state's more urban basins, agricultural water is being converted to M&I use with increasing regularity. The Uintah Basin is the sole exception to this norm. So far, municipal and industrial water supplies have been more than adequate to meet the basin population growth. Consequently there has not been any pressure from the demand side to convert agricultural water to M&I use. Additionally, the basin's population growth has not caused much agricultural land to be converted to municipal, commercial or industrial uses. Limited water supplies and rapid population growth are the primary motivators for conversion of irrigation water to M&I use throughout the urban areas of the state outside of the Uintah Basin. Without these factors the basin's irrigated acreage has actually increased slightly over the past decade. Potentially, more agricultural land could be added in the future.

The one caveat to this scenario is oil shale and tar sands production. As explained in Chapter 4, water needs in 2015 for these potential growth industries are minimal. However, future expansion of these industries may require commercial water suppliers to provide water. A prudent supply for 2015 has been estimated. Future needs may compete with other uses, primarily agriculture, for water that is available in the basin. It may end up that some agricultural water use will be converted to industrial use simply based on competition between water users. These would be market-based transfers between a willing buyer and a willing seller. Such agriculture to M&I conversion is common throughout Utah. Being conversions, the total demand may not change significantly.

AGRICULTURAL WATER-USE EFFICIENCY

Salinity control projects throughout the Colorado River Basin have had a large impact on water management. In addition to reducing salt concentrations for downstream water users, these efforts have resulted in significant reduction of water losses in canals and ditches and improved irrigation system efficiency. The result is more water being available for delivery to the farm field and greatly increased crop yields from the same irrigated acreage.

Overall Program

Salt loads in the Colorado River have been a concern in the United States and Mexico for a long time. Salt concentrations increase as a river flows downstream. Salts are naturally occurring and pervasive throughout basin watersheds. Salts contained in sedimentary rocks are easily eroded, dissolved and transported into the river system.[10] A 1971 study by the U. S. Environmental Protection Agency concluded the following:

- About 47 percent of the salinity concentration in water reaching Hoover Dam (Arizona) is from natural causes, with the remaining 53 percent resulting from human activities.
- About 37 percent of the salt concentration arriving at the dam is from irrigation return flows.[11]
- About 75 percent of lands within the Colorado River Basin are owned and administered by the federal government.
- Much of the salt load concentration contributed from irrigated agriculture is from federally developed irrigation projects.[12]

In 1973 the Colorado River Basin states formed the Colorado River Basin Salinity Control Forum to control salinity increases in the river in order to comply with Section 303 (a) and (b) of the Clean Water Act.[13] Membership includes all of the basin states working together with the U. S. Bureau of Reclamation (Reclamation), U. S. Department of Agriculture, Natural Resources Conservation Service (NRCS), and the U. S. Bureau of Land Management (BLM).[14] Reclamation may implement a variety of effective salinity control measures, but most projects concentrate on improving irrigation delivery systems that are not on farms. This usually involves putting water, formerly in canals and ditches, into pipelines. NRCS generally concentrates on improving on-farm systems. These projects improve the efficiency of water actually delivered to the crop. The BLM administered lands contribute salts primarily from non-point sources, so this agency works mostly to minimize soil erosion. Cost sharing is required and the states contribute funds to projects through the Basin States Program. Money to fund the Basin States Program comes from a levy assessed on hydropower revenues on the Colorado River. All of these activities are directed by Public Law 93-320 enacted in 1974, as amended.[15]

The Plan of Implementation focuses mainly on improving agricultural practices in the Upper Colorado River Basin both on- and off-farm. To date, it is estimated that the program has reduced the salt loading in the Colorado River by about 1.3 million tons per year.[16] Salt contributions from the Uintah Basin have been reduced by 179,000 tons per year or about 15 percent of the total reduction.[17] It is estimated that an additional overall reduction of 1,362,000 tons per year can be achieved on the Colorado River. Of that, about an additional 108,000 tons per year (or eight percent) reduction may come from the Uintah Basin.[18] Throughout the Colorado River Basin, the easiest and most effective projects have already been implemented. This means future projects will be more costly in terms of dollars per ton of salt reduced.

Program in the Uintah Basin

Of the 200,000 irrigated acres in the basin, it is believed that about 80 percent, or 160,000 acres, may ultimately have salinity improvement projects applied to them.[19] Comparing past reductions from the Uintah Basin to anticipated future reductions indicates about 62 percent of the total reductions from the basin have been achieved, with an additional 38 percent still to be achieved. With respect to the original plan, salt load reductions in the Uintah Basin have exceeded expectations and this was done at a lower amortized cost per ton than anticipated.[20] Reductions in the Uintah Basin have been ongoing and many salinity control funded irrigation systems have reached the anticipated life expectancy. Sixty-four percent are 15 years old or older and 25 percent are 25 years old or older.[21]

As mentioned earlier, agricultural irrigation is a major source (about 37 percent) of salt loading into the Colorado River. Thus, irrigation improvements have a great potential to control salt loading. Off-farm practices consist of reducing or eliminating canal and ditch seepage, typically by installing pipelines. On-farm practices include improving flood systems, using sprinkler systems and a few drip systems. The result is reduced over-irrigation and deep percolation.[22]

So far, about 18 percent of the overall salt load reduction in the basin has come from off-farm projects with the remaining 82 percent coming from on-farm projects.[23] About 90 percent of the on-farm applied systems are higher efficiency sprinkler systems.[24] Upgrading a flood irrigation system to wheel lines is estimated to reduce salt loading by about 36 percent and upgrading to center pivots the reduction is about 45 percent.[25] Intensive monitoring confirms that, when installed and operated as originally designed, these systems achieved the desired improved irrigation efficiencies. This has resulted in, "sharply reduced deep percolation, reduced farm labor and improved yields."[26] While these improved yields have not been formally studied, many farmers report having doubled their alfalfa yields.[27] The labor reduction and improved yield is important to basin farmers since about two-thirds of them have full-time occupations other than farming. Those farmers participating in salinity reduction programs feel the labor decreases and production increases adequately offset participation costs.[28] So far, about $90,159,622 has been spent in the Uintah Basin to reduce salinity loading.[29]

Planning Study: Findings and Strategies for the Uinta Basin

In February 2014 the U.S. Bureau of Reclamation published a report titled, *"Comprehensive Planning Studies for Salinity Control Measures in the Upper Colorado River Basin."* The study has the following objectives:[30]

- Identify and summarize information regarding sources of salinity in the basin.
- Identify and summarize salinity control accomplishments.
- Identify impediments to full implementation of the Salinity Control Program, both off-farm and on-farm.
- Identify strategies that move the Salinity Control Program forward in the Uinta Basin.

The study is comprehensive and detailed so only the highlights are presented here. Improvements in study methodology have resulted in slightly different numbers than those indicated in the previous section. Readers are encouraged to get a copy and use it.[31]

<u>*Sources of Salinity*</u>

The Uinta Basin salinity load is estimated to be 500,000 tons of salt annually. Of this, 328,120 tons (65.6 percent) comes from agricultural practices. The remaining 120,000 tons (34.4 percent) are derived from natural sources. Of the 328,120 tons derived from agricultural practices, 208,120 tons (63.4 percent) come from on-farm practices while 120,000 tons (36.6 percent) comes from off-farm practices.[32] This suggests the greatest reductions in salinity loading can be achieved by improving on-farm practices.

<u>*Salinity Control Accomplishments*</u>

Off-farm Category

Program accomplishments include treating 653 miles (37.0 percent) of the 1,761 total miles of canals and laterals. This leaves 1,108 miles (63.0 percent) yet to be treated.[33] It is estimated the lining or piping of canals and laterals has reduced salinity by about 42,454 tons per year.[34] This represents about 35 percent of the off-farm loading in the Uinta Basin.

On-farm Category

There are a total of 211,200 acres irrigated in the Uinta Basin. Of these, 126,600 acres (60 percent) have sprinklers and improved flood irrigation practices. The remaining 84,600 acres (40 percent) utilize flood irrigation.[35] There are a total of 21,000 acres (10 percent of the total irrigated acres) of irrigated land on Ute Tribal lands. Of these, 3,100 acres (14.8 percent) have sprinklers. The remaining 17,900 acres (85.2 percent) utilize flood irrigation.[36]

Totals

Totaling the off-farm (U.S. Bureau of Reclamation) and on-farm (NRCS) reported cumulative salinity reductions, the contribution from the Uinta Basin has been reduced by 190,854 tons of salt per year. This is about 58 percent of the total on-farm and off-farm salinity loading of 328,120 tons per year from agricultural practices.[37]

<u>*Impediments to Full Implementation*</u>

Lack of Off-Farm Improvements

Sometimes the lack of upstream (off-farm) improvement can impede down-stream (on-farm) improvements. Many farmers believe that in order for on-farm sprinklers to be cost effective, gravity pressure systems that eliminate pumping costs are needed. In some cases, due to topography, greater head is needed than can be developed by on-farm improvements. In other cases the off-farm improvements are limited because of difficulty in securing a right-of-way. If efforts are made to complete upstream, off-farm improvements, more incentive will arise for on-farm improvements.[38] Nine strategies were developed to deal with this obstacle. While all had significant disadvantages and obstacles, only minimal mitigations actions that would be required were identified for any of them.[39]

Aging On-Farm Equipment

About 65 percent of all on-farm installations funded through the Salinity Control Program having now reached the end of their useful life. Many farmers are concerned with the replacing these systems. Some feel federal funding of replacement equipment is appropriate. Some feel the Salinity Control Program should fund replacement of aged irrigation systems because salt reduction benefits continue for those downstream. Others make the case that since improved irrigation practices have their own inherent economic benefits to the farmer, that can fund replacement.[40] Four strategies were developed to deal with this obstacle, three of which were mutually exclusive. While all had significant disadvantages and obstacles, none had a mitigation strategy.[41]

Misunderstanding of Reclamation Funding Opportunity Announcement (FOA) Process

Applicants feel discouraged due to repeated non-selection in the FOA process. This has led many to believe there is a lack of transparency in the FOA process. Reclamation tried to improve communication by pointing out the following.[42]

- The application process is outlined in the FOA and a timeline is provided for the FOA process.
- With each FOA, a workshop is offered shortly after the FOA release to help applicants understand the requirements of the FOA, answer questions, and discuss requirements.
- Thirty days prior to the submittal due date, completed salt load reduction estimates are provided to applicants. Applicants are then to complete their applications based on cost share ability.
- Once the dollars-per-ton figure is determined and the final details decided, the final application is submitted.
- Applicants that were not selected are offered a debriefing to discuss application insufficiencies.

Applicants were encouraged to increase personal engagement and ownership in the FOA process and not rely solely on consultants. Also, local water conservancy districts could evaluate and improve applications and help identify additional funding sources.[43]

Ute Tribe Considerations

The tribe comprises about 5.8 percent of the basin population[44] and occupies about 10 percent of the irrigated acreage in the basin. In addition to members of the Ute Tribe participating in the planning study, the study team met with the Uintah Indian Irrigation Project Board and to the Ute Tribe Business Committee.[45 46] Forty-four individuals from across the basin were interviewed during the study.[47] During those interviews, issues associated with the Ute Tribe came up more frequently than any other.[48] Concerns centered on the inability of Utes and non-Utes to benefit from the Salinity Control Program both on-farm and off-farm due to the following:[49]

- The inability to line or pipe canals for which Utes and/or BIA have responsibility
- The inability to line or pipe canals that cross Ute lands
- The perceived unwillingness to allow use of right-of-way
- Low-participation in the program by Ute Tribe members

The Ute Tribe and its members have not participated in the Salinity Control Program to the extent of other agricultural producers in the basin. This is believed to be due to tribal members and tribal leadership placing greater value on wildlife and wildlife habitat, and winter stock watering, than on agricultural production.[50] In addition, some sections of open canals are used for tribal ceremonies and water flowing across Ute land provides a sense of spiritual connection to the earth.[51]

Of the 21,000 irrigated acres of tribal lands, 3,100 acres (14.8 percent) use sprinkler irrigation; the remaining 85.2 percent employs unimproved flood irrigation.[52] About 800 miles (74 percent) of the remaining 1,077 miles of untreated canals in the Uintah Basin are either Bureau of Indian Affairs canals or canals that pass over Ute-controlled lands.[53]

The following Ute Tribe considerations were identified.[54]

- Mutually beneficial relationship required
- Ute right-of-way
- Leased Ute lands
- Loss of seepage for wildlife habitat
- Lack of winter water for livestock
- Value of flowing water
- Cost effectiveness of Ute off-farm projects

Nineteen strategies were developed to deal with the above considerations. Each strategy includes listings of Purpose/Benefits, Disadvantages, Obstacles and Mitigation. Many included involvement of the tribe's Water Resources Engineer.[55]

Study Conclusions and Recommendations

The challenges to sustain past levels of participation in the program are significant. They include:[56]

- With few or no off-farm projects approved for federal funding, there is a potential that on-farm projects will decrease significantly.
- Many of those most willing to participate have already treated lands and canals. Those remaining are less interested in participating. Reasons for not participating are often justified because of farm limitations or the nature of farming operations.
- There are issues that inhibit Ute participation in both on-farm and off-farm salinity control treatments. Included are objections to pipes and pivots with greater values placed on local habitat, winter stock watering and in-stream flows.
- Although 63 percent of canals remain untreated, there are few opportunities remaining in the Uinta Basin to treat off-farm canals without some involvement of the Ute Tribe.

Strategies to Move the Salinity Control Program Forward

The most promising strategies to sustain participation in the Salinity Control Program include:[57]

- Engage the Ute Tribe and its members to identify non-irrigation projects that meet salinity goals.
- Consider a focused Funding Opportunity Announcement for the Ute Tribe that could include both irrigation improvements and non-irrigation improvements.
- Receive feedback from the Ute Tribe through its Water Resource Engineer and appointed liaison.
- Increase non-Salinity Program funding sources, State and Ute Tribe, to spread the costs of increased local cost share.
- Increase local planning efforts to identify most cost effective projects and plan smarter ways to compete for federal funds. Seek federal planning funds such as WaterSmart funding
- Leverage non-salinity funds such as Ute Settlement, Mitigation Commission and State Revolving Loan funds to supplement increases in local cost share to make projects more competitive for FOA funding.

- Ute Tribe contracting for on-farm improvements to lessen cost-share and remove impediments to treatment of leased lands.
- Provide an in-basin coordinator to help applicants and to coordinate between applicants, Reclamation, NRCS and Utes.

It will be challenging to maintain historical levels of participation in the Salinity Control Program. The two most important changes needed are increased local funding of off-farm projects and engaging the Ute Tribe.[58]

Salinity Reduction Funding

Basin states are required to contribute 30 percent of the project cost for an off-farm Reclamation project. However, most of that 30 percent comes from a levy assessed on power revenues on the Colorado River. For Upper Basin states (Utah, Colorado, New Mexico and Wyoming), the amount actually paid by the participant is 15 percent of the 30 percent. For example, assume an off-farm project to put the irrigation company's canal into a pipeline is estimated to cost $10,000,000. Seventy percent, or $7,000,000, comes from a *grant* from the Bureau of Reclamation. The remaining 30 percent ($3,000,000) comes from the state, with the participant required to pay 15 percent of that amount or $450,000. $2,550,000 comes from the Basin State Fund, which is obtained from power revenues. Participants often obtain low-interest loans from the Utah Board of Water Resources. Thus, participants typically pay only four and one-half percent (15 percent of 30 percent, or $450,000) of a $10,000,000 project. If the participant borrows the $450,000, interest would also be paid on that loan. Water loss reduction from putting a canal into a pipeline varies from 25 percent to 40 percent, depending on the soil types upon which the canal is built. Thus, a one-time expense of $450,000 results in substantial project lifetime water saving, which is very cost effective for the participant.[59]

On-farm salinity reduction projects are roughly funded with 75 percent coming from the NRCS, and 25 percent from the state. The Basin States Fund will pay for part of the 25 percent. However, the program has considerable variability. Provisions for a first-time farmer (as defined in the program) allow up to 90 percent NRCS funding. In some cases, a set fee is

Soil moisture data recorder with graphing capability.

required from the participant for specified improvements. Administration of funds includes participation by the Utah Department of Agriculture and Food. Importantly, the participant can provide in-kind labor and provide a portion of the 25 percent by installing irrigation pipe or other portions of the project. While each project varies, the participant ends up paying a very small percentage while obtaining a considerable increase in irrigation efficiency.[60] Depending on the type of system, that increase ranges from 36 percent to 47 percent per year.

Recent Developments

Probably the ideal way to determine when to irrigate a field and how much water to apply is to continuously monitor the soil moisture content in the field at several locations, sensing the content at two or three depths at each location. The recent development of an electronic tool makes this otherwise complex problem much easier. NRCS is demonstrating and guiding operators in the use of a soil moisture monitoring system using electric probes and data recorders (See photo). NRCS provides higher pay incentives for using this instrument which costs about $700.[61]

The result of using this instrument is to keep the available water capacity of the soil in the 50 percent to 100 percent range. This is optimum for plant growth without over watering or drying out the plants. The instrument makes it a simple matter to estimate when the next irrigation will be needed. See Figure 21 for an example graph of irrigation timing. Each pivot pass produces a peak in the curve.

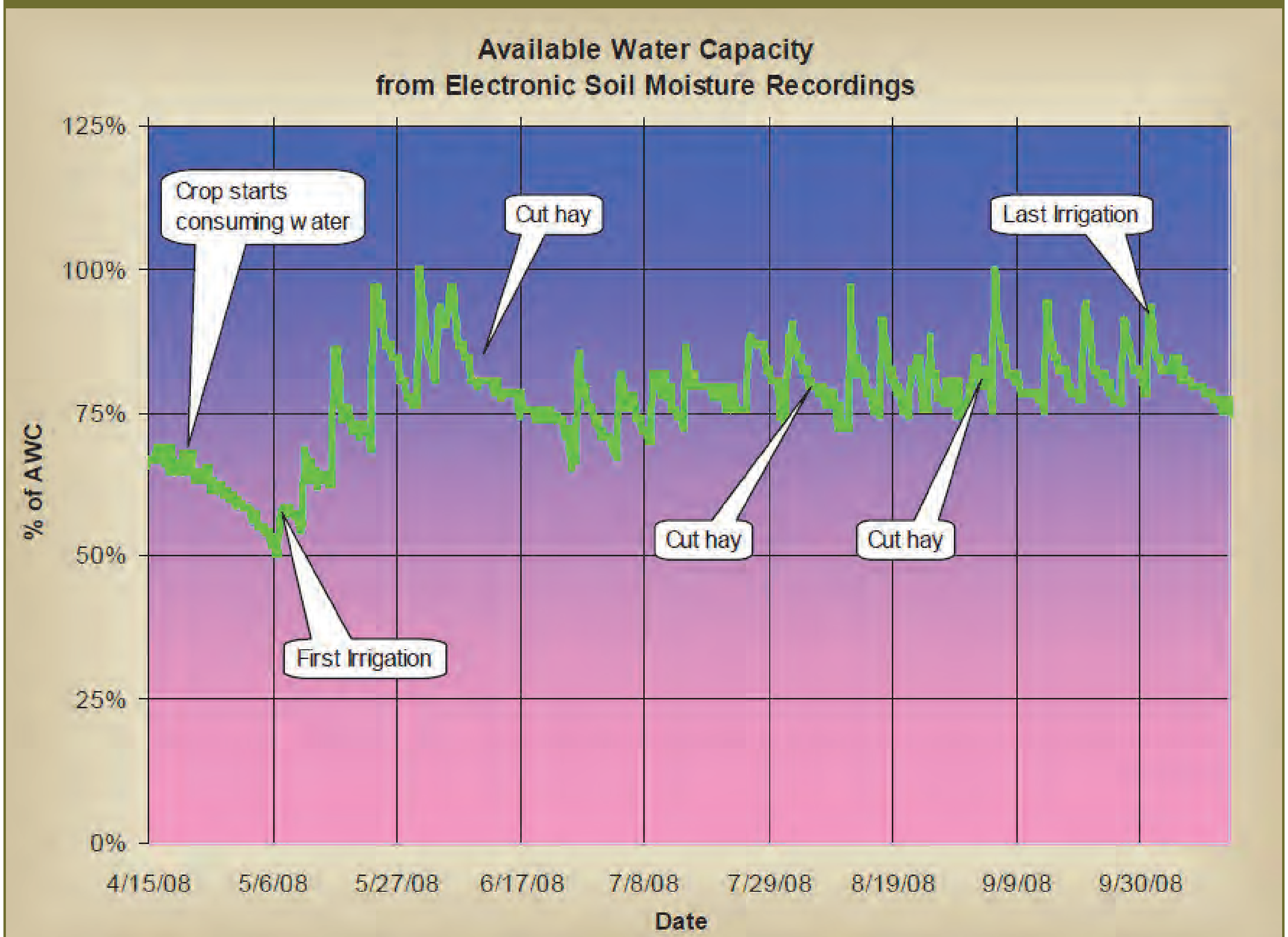
Greater irrigation efficiency results in the reduction of over-watering of farm fields. This results in reduced return flows from those fields. In some cases this reduces the amount of water available for downstream water users. Offsetting this reduced return flows could be the reduced diversion needed for adequate watering.

Conjunctive Management of Surface and Groundwater

Definition of Conjunctive Management[62]

In the broadest definition, conjunctive management is the coordinated and combined use of surface water and groundwater. It involves using more surface water and less groundwater when surface water is available during wet periods. Unused surface water can be stored, above ground and/or underground, during wet periods. Wet periods include the annual spring season snowmelt and consecutive years of above normal precipitation. Conversely, less surface water and more groundwater is used during dry periods when surface water supplies are reduced. Water previously stored above and below the ground is taken out of storage

FIGURE 21
Available Soil Water Capacity over Time to Determine Watering Frequency



Source: USDA, Natural Resources Conservation Service, *Colorado River Basin Salinity Control Program, Uintah Basin Unit, Monitoring and Evaluation Report, FY2010,* (USDA, Roosevelt, Utah: 2010), Page 27.

during dry periods. Dry periods include the annual summer months and consecutive years of below-normal precipitation. The key point is that unused surface water is intentionally stored above ground and/or underground in order to have it available when it is needed. This can be accomplished on an annual basis by storing water in the spring and withdrawing it in the summer. It can also be accomplished on a year-to-year basis by storing water during a wet year (or consecutive wet years) and withdrawing it during a dry year (or consecutive dry years). Such coordinated management can change the timing and location of water use to result in greater efficiency. It transfers water from the high supply season to the high demand season.

Conjunctive management is intended to increase the available water supply of a region and improve the reliability of that supply. It may be implemented to meet other objectives as well. These include reducing groundwater mining and land subsidence, protecting water quality, and improving environmental conditions. It encompasses full utilization of all possible water sources in creative ways that are unique to the location where the water is needed, such as a surface drainage basin or groundwater basin.

Numerous surface reservoirs throughout the Uintah Basin store water when it's available, thus enabling water use during dry periods. This is an effective implementation of conjunctive management.

Uintah Basin Opportunities Using Aquifer Storage and Recovery

In January 2011 the Utah Division of Water Resources prepared an internal report titled, *Preliminary Assessment of the Potential for Managed Aquifer Recharge in the Uinta Basin, Utah*. The report is preliminary in that it is based solely on researching available literature and did not include obtaining additional field data from drilling. That report is the basis for the material presented in this section. While unpublished, the report is available from the Utah Division of Water Resources. Aquifer Storage and Recovery (ASR) projects are entirely dependent on the suitability of local geology to accommodate them. The most appropriate geologic formations are unconsolidated deposits that are loose and not cemented together. This results in open voids between the particles in which to store water. Such deposits are typically characterized by gravels, sands, silts and some clay layers. Tight formations, such as bedrock, have only limited ASR potential.

The geologic setting of the Uinta Basin was evaluated by seeking formations suitable for ASR projects.[63] There are few unconsolidated deposits available in the basin and these are associated with active rivers and streams or glacial deposits.[64] Most are of limited thickness and provide only limited usefulness as aquifers to accommodate an ASR project. Still, there is the possibility for some ASR projects in thicker deposits near Neola, Hayden, Leeton, Mountain Home, Altamont and along the Duchesne River.[65] Cross-sections of specific geologic conditions in the basin suitable for ASR were developed to help guide those interested in pursuing such a project.[66]

Throughout Utah, surface water is developed before groundwater simply because it is less expensive. This is particularly true in the Uintah Basin. As a result, there has been little need to develop groundwater resources. Currently, groundwater accounts for less than five percent of the total water utilized in the basin. [67] Much more surface water could be utilized directly before ASR becomes attractive. Given geologic conditions, and the large quantities of surface and groundwater available, ASR is not presently needed. If, in the future, ASR is thought to be feasible in specific areas of the basin, in-depth investigations could be pursued.

WATER BANKING

Overview of Water Banking

A water bank can best be defined as "an institutional mechanism that facilitates the legal transfer and market exchange of various types of surface water, groundwater and storage entitlements."[68] For years, water banks have existed in many of the western states in various forms. The common goal of these banks has been to act as a mediator—or broker—in bringing together willing sellers and buyers to facilitate the transfer of lower-valued uses to higher-valued uses. Other reasons to establish a water bank may include one or more of the following:[69]

- to create reliability in water supply during dry years,

- to create seasonal water reliability,
- to ensure a water supply to meet future needs,
- to promote water conservation by encouraging water-right holders to conserve and deposit water rights into the bank,
- to act as a market mechanism,
- to resolve issues of inequity between groundwater and surface water users, and
- to ensure compliance with intrastate agreements of instream flow.

Many benefits are created by simply providing a mechanism for the locating and transferring of water rights from those with interruptible water uses or from those simply willing to sell or lease a water right to those in greater need during dry periods. Transactions may occur between individual persons, between a municipality and individual or even between various organizations. Water banks may vary in the timing of operations by providing services only during times of drought, or on an on-going basis regardless of the hydrologic situation.

Although water banking is often associated with aquifer storage and recovery, it is not limited to this method of operation. The three general types of water banks in the West include: institutional, surface storage and groundwater storage. Institutional water banks provide services primarily to aid the transfer of legal documents or entitlements to a specific quantity of natural-flow, surface water. These types of banks are developed largely in areas where little or no storage is available or for large geographic areas. Surface storage banks are typically established in areas with a reservoir or series of surface storage areas where storage allotments can be stored and exchanged. Unlike institutional banks where the right is only to a natural flow, exchanges through a surface storage bank are backed by a physical block of water, which typically provides a greater level of reliability. Groundwater banking is a relatively new type of banking, but it operates much like a surface storage bank with the reservoir located underground. Groundwater banks typically operate by depositing water that is later withdrawn by the same entity or sold to someone else. Utah water law facilitates water banking.

Water Banking Opportunities in the Uintah Basin

Current M&I water supply surpluses suggest that there is little need for a water bank in the Uintah Basin. However, if oil shale and tar sands development or population were to increase considerably, the demand for water could grow and create conditions that may warrant the creation of a water bank. If conditions are right, a water bank could be a useful mechanism to facilitate the movement of water within the basin to meet growing demands.

SECONDARY WATER SYSTEMS

A secondary (or dual) water system supplies non-potable water for uses that do not have high water treatment requirements, such as residential landscape irrigation. A secondary system's major purpose is to reduce the overall cost of providing water by using cheaper, untreated water for irrigation, and preserving higher-quality, treated water for drinking water uses. Secondary systems are also an efficient way to transfer agricultural water to M&I uses as farm lands are sold and are converted to urban lands, as many of the same facilities and right-of-ways that were used to deliver water to farms can be used to deliver secondary water to homes.

In 2010 (the latest year for which data is available), about 2,441 acre-feet of secondary water was delivered to residents of the Uintah Basin. See Table 23. This represents about 10 percent of the total M&I water demand and about 41 percent of the total outdoor water demand in the basin.[70] In Duchesne County secondary system water deliveries were significant in the community of Roosevelt and the Duchesne County Upper County Water Improvement District. In Uintah County, significant secondary use occurs within the communities served by the Ashley Valley Water and Sewer District and in Maeser. As the communities served by these water systems continue to grow, it is likely that expanding existing secondary water systems and constructing new ones will meet a larger percentage of outdoor water use. 2010 is the most current year for which secondary water use data is available.

TABLE 23
Secondary (Non-potable) Water Use in Public Community Systems (2010) (acre-feet)

Water Supplier	Residential	Commercial	Institutional	Industrial/ Stockwater	TOTAL
Daggett County					
Greendale Water Company	12	15	21	0	**50**
Manila Municipal Water System	0	0	47	0	**45**
DAGGETT COUNTY TOTAL	**12**	**15**	**68**	**0**	**95**
Duchesne County					
Central Utah Water Conservancy District					
Duchesne Water System	76	0	12	0	**88**
Myton Municipal Water System (BIA)	15	0	0	0	**15**
Johnson Water District	0	0	0	0	**0**
East Duchesne Improvement District	0	0	0	0	**0**
Duchesne County Upper County WID	126	0	135	0	**261**
Hanna Water & Sewer Improvement Dist.	21	0	0	0	**21**
Roosevelt Municipal Water Systems	0	0	692	0	**692**
Neola Water District	81	0	20	0	**101**
Tabiona Water System	83	0	12	0	**95**
DUCHESNE COUNTY TOTAL	**402**	**0**	**871**	**0**	**1,273**
Uintah County					
Ashley Valley Water & Sewer Improve Dist.	602	0	0	0	**602**
Maeser Water Improvement District	352	0	0	0	**352**
Central Utah Water Conservancy District					
Vernal Municipal Water System	0	0	0	0	**0**
Ute Indian Tribe Water System					
Ballard Water Improvement District	96	0	0	0	**96**
Ouray Park Water Improvement District	23	0	0	0`	**23**
Tridell-Lapoint Water Improvement District	0	0	0	0	**0**
UINTAH COUNTY TOTAL	**1,073**	**0**	**0**	**0**	**1,073**
UINTAH BASIN TOTAL	**1,487**	**15**	**939**	**0**	**2,441**

Source: Utah Division of Water Resources, *State of Utah Municipal and Industrial Water Supply and Use Study Summary 2010,* 2014.

High Water Use in Secondary Systems

The Utah Division of Water Resources has been investigating ways to reduce high water use in secondary systems. One way to deal with over-watering is to meter the water and charge according to an incentive pricing rate structure. Secondary water meter technology has advanced to provide an economically feasible device to meter this type of untreated water. In addition, newer water meters without moving parts have provided acceptable levels of performance. Another option that would help reduce the amount of water used by secondary water customers would be to install some type of "smart" timer that automatically applies water according to the needs identified by a local weather station or a soil moisture sensor. Studies show that water use can be decreased up to 30 percent. These studies also demonstrate that targeting the highest water users with a "smart" timer is extremely effective, with an average savings of 50 percent.

Health Issues

Because secondary water is untreated, care must be taken to protect the public from inadvertently drinking from a secondary system and possibly becoming ill. Codes preventing cross-connections and providing adequate backflow prevention devices need to be enforced and secondary lines and connections need to be clearly labeled. Pipes conveying untreated water can be color coded. In public areas, signs need to be installed to warn individuals against drinking from the irrigation system.

NOTES

[1] A public community water system a private or public community water system which provides service to at least 15 connections or 25 individuals, year-round.

[2] Utah Division of Water Resources, *State of Utah Municipal and Industrial Supply and Use Study—Summary 2010s,* (Salt Lake City: Department of Natural Resources, 2014), Page 104

[3] Retrieved from Internet web page: http://www.waterrights.utah.gov/cgi-bin/wuseview.exe?Modinfo=Pwsview&SYSTEM_ID=1021, March, 2015.

[4] Personal communication with Ryan Clayburn, Water Technician, April, 2015.

[5] Personal communication with Lee Moon, Director East Duchesne Improvement District, April 9, 2015.

[6] Utah Division of Water Resources, *Utah's M&I Water Conservation Plan,* (Salt Lake City: Department of Natural Resources, 2003). This plan is available through the Division's web page at: www.conservewater.utah.gov.

[7] *Utah Administrative Code Annotated, Title 73-10-32,* (2004).

[8] For an updated list of systems that have submitted plans to the Division of Water Resources, visit the following web page: www.conservewater.utah.gov/compliance .html. All plans are available to the public at the Division's office in Salt Lake City.

[9] Retrieved from Internet web page: http://blog.governor.utah.gov/2015/06/governor-signs-water-conservation-executive-order/, October 2, 2015.

[10] Colorado River Basin Salinity Control Forum, *2011 Review, Water Quality Standards for Salinity, Colorado River System DRAFT,* Colorado River Basin Salinity Control Forum, June 2011, Page 2.

[11] Ibid.

[12] Ibid.

[13] Ibid., Page 3.

[14] Ibid., Pages 2 & 13.

[15] Ibid., Page 13.

[16] Retrieved from Internet web page: http://coloradoriversalinity.org/, October 2, 2015.

[17] Ibid., Pages 14 & 15.

[18] Ibid.

[19] Colorado River Basin Salinity Control Program, *Uintah Basin Unit, Monitoring and Evaluation Report FY 2010,* Colorado Basin Salinity Control Program, 2011, Page 2.

[20] Ibid., Page 9.

[21] Ibid., Page 17.

[22] Ibid., Page 11.

[23] Ibid., Page 3, Table 1.

[24] Ibid., Page 20.

[25] Ibid., Page 18.

[26] Ibid., Page 22.

[27] Personal communication with Don Barnett, Colorado River Basin Salinity Control Program, October, 13, 2011.

[28] Colorado River Basin Salinity Control Program (2011), Page 2.

[29] Ibid., Page 3, Table 1.

[30] Colorado River Basin Salinity Control Program, *Comprehensive Planning Studies for Salinity Control Measures in the Upper Colorado River Basin,* Final Report on Findings and Strategies, Uinta Basin, Utah, 2014, Pages 4 & 5.

[31] The study is available at: http://www.coloradoriversalinity.org/docs/Uinta%20Basin%20-%20Final%20Report%20complete.pdf.

[32] Colorado River Basin Salinity Control Program (2014), Page 7.

[33] Ibid., Page 9.

[34] Ibid., Page 11.

[35] Ibid., Page 10.

[36] Ibid.

[37] Ibid., Page 12.

[38] Ibid., Page 37.

[39] Ibid., Pages 21-23.

[40] Ibid., Page 49.

[41] Ibid., Pages 23 & 24.

[42] Ibid., Page 57.

[43] Ibid., Pages 25 & 26.

[44] This is based on the 2010 Census and the number of Ute Tribe members indicated on the Tribe's Internet website: http://www.utetribe.com/, April, 2015.

[45] Colorado River Basin Salinity Control Program (2014), Page 2.

[46] Ibid., Page 17. The report includes the following disclaimer: "The following descriptions of Ute Tribe considerations have not been vetted with the Ute Tribe Water Rights Commission, the entity identified by the Business Committee to participate in this study."

[47] Ibid., Page 12.

[48] Ibid., Page 27.

[49] Ibid.

[50] Ibid., Page 2.

[51] Ibid., Page 34.

[52] Ibid., Page 10.

[53] Ibid., Page 2.

[54] Ibid., Pages 18-21.

[55] Ibid.

[56] Ibid., Page 62.

[57] Ibid.

[58] Ibid., Page 63.

[59] Personal communication with Don Barnett, Colorado River Basin Salinity Control Forum, October, 13, 2011.

[60] Ibid.

[61] Colorado River Basin Salinity Control Program (2011), Page 26.

[62] Utah Division of Water Resources, *Conjunctive Management of Surface and Ground Water in Utah*, (Salt Lake City: Department of Natural Resources, 2005), Page 9.

[63] Utah Division of Water Resources, *Preliminary Assessment of the Potential for Managed Aquifer Recharge in the Uinta Basin, Utah*, (Unpublished Report, 2011), Figure 6, Generalized Geology, Upper Green River Basin, Utah.

[64] Ibid., Page 10.

[65] Ibid., Page 14.

[66] Ibid., Page 17.

[67] Ibid., Page 18.

[68] Clifford, Peggy, Clay Landry and Andrea Larsen-Hayden, *Analysis of Water Banks in the Western States*. Publication No. 04-11-011 (Washington Department of Ecology, July 2004), Page ii.

[69] Ibid., Page 3.

[70] Utah Division of Water Resources (2014), Pages 103 & 104.

6

WATER DEVELOPMENT

Water development was an essential element of early settlements and continues to play a major role today. The availability of water resources is critical to survival in Utah's semi-arid environment. Early Mormon leaders stressed community development over individual ownership, especially with regard to natural resources. The early pioneer's approach was to develop cooperative water distribution systems. Those early ideals laid the foundation for many of the principles embodied in Utah's water law, and the methods now employed to administer and manage the state's water resources. Community rights led to a standard of beneficial use as the basis for the establishment of an individual water right. The overriding principle of Utah's water law is that all water belongs to the citizens of the state collectively, not individually. An individual citizen may own a water right entitling them to put the water to beneficial use, but the actual ownership of the water continues to rest, collectively, with the citizens of the state. Throughout the years, water planning and development has been founded upon this principle.

The Uintah Basin has a unique collection of natural resources that have been, and will continue to be, utilized for the benefit of the state and the nation. Crude oil, shale oil, tar sands oil, and numerous minerals are examples. Tourism and recreation are also growing industries in the basin. As populations increase to accommodate these industries, the need for water will also increase. Thus water suppliers will need to develop additional water as necessary.

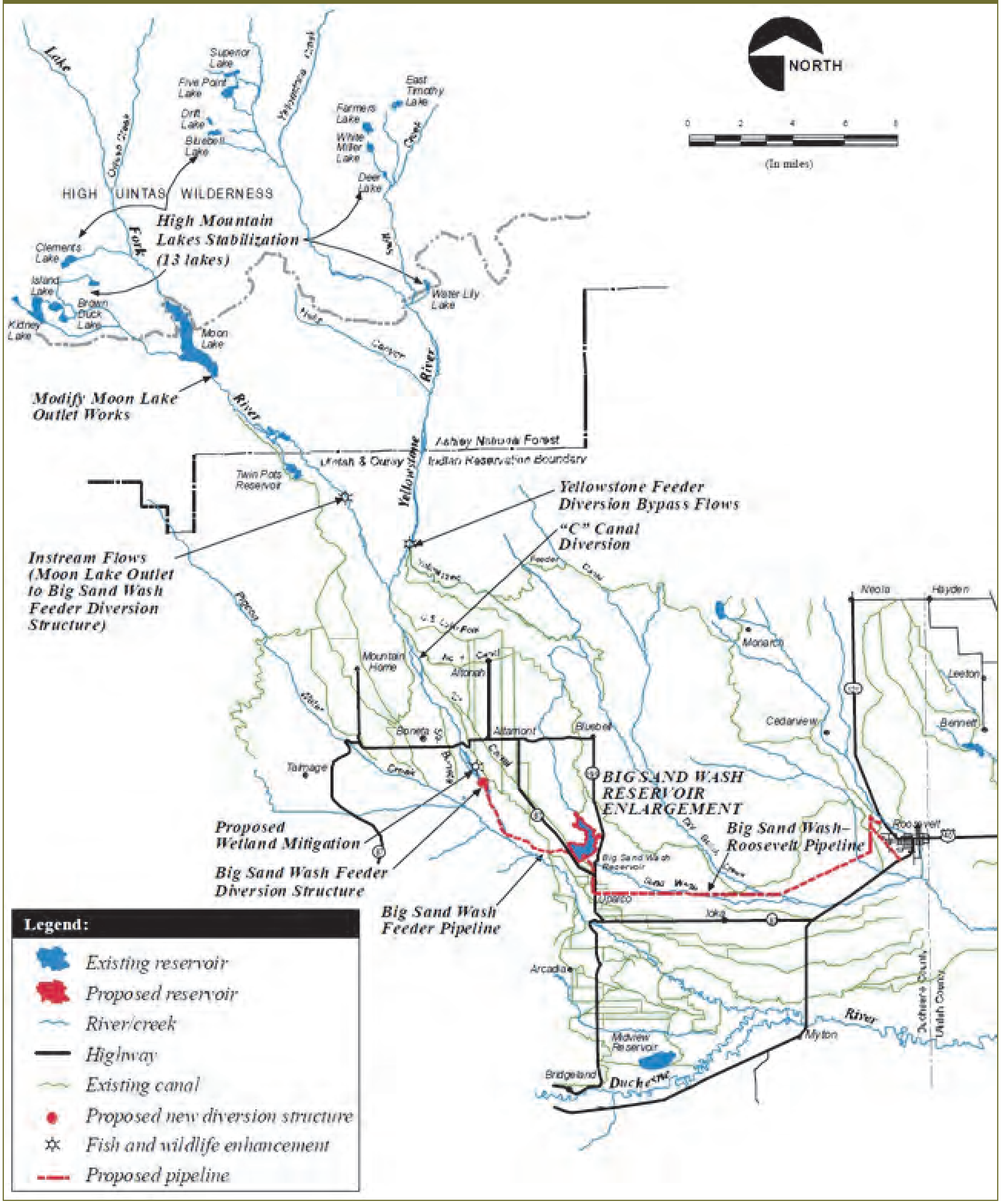
As discussed in Chapters 1 and 2, water development has been going on in the Uintah Basin since before the 20th century. Strawberry Reservoir was begun in 1906 and reservoirs and canals have been constructed as an ongoing part of basin expansion ever since. By the year 2000, mountain lakes were upgraded and reservoirs built to achieve a storage capacity of over 1.6 million acre-feet. Projects built between 2000 and 2012 increased storage by about 13,500 acre-feet. The importance of water development to the inhabitants of the basin is evident from early construction of water infrastructure. While current residents of the basin often take these developments for granted, they are the beneficiaries of the visionary water developments of the past. This chapter outlines some of the more recent projects, as well as current projects under construction or investigation in the Uintah Basin.

RECENT PAST WATER DEVELOPMENT PROJECTS

Uintah Basin Replacement Project

In 2003, the Central Utah Water Conservancy District undertook the Uintah Basin Replacement Project (UBRP).[1] The project provides additional early and late season irrigation water, improves municipal and industrial (M&I) water supplies, and modified several high mountain lakes and valley reservoirs to improve environmental conditions. See Figure 22. Specifically, the Big Sand Wash Reservoir capacity was increased by enlarging the dam. This allowed water that had been stored in high mountain lakes to be stored in the reservoir. The Big Sand Wash Feeder Diversion Structure was built on the Lake Fork River. Water is then taken through the Big Sand Wash Feeder Pipeline to the enlarged Big Sand Wash Reservoir and used for irrigation, as well as municipal and industrial purposes. Thirteen mountain lakes in the Uinta Mountains were stabilized. Minor modifications were also made to the Moon Lake outlet works to facilitate release of instream flows on the

FIGURE 22
Uintah Basin Replacement Project Map



Source: United States Department of the Interior, *Finding of No Significant Impact, Lake Fork Section 203 Alternative, Section 203(a), Uinta Basin Replacement Project,* (Central Utah Project Completion Act Office: Provo, Utah: 2001), Pages 2 to 5.

Lake Fork River. Finally, the Big Sand Wash to Roosevelt Pipeline conveys M&I water from the reservoir to the city as well as irrigation water to lower portions of the Lake Fork drainage.[2]

Benefits of the UBRP include the following:[3]

- Increased irrigation water supplies of 1,963 acre-feet per year.
- Increased M&I water supply of 3,000 acre-feet per year for the City of Roosevelt.
- Stabilized 13 high mountain lakes enabling constant water elevations and reduced maintenance.
- Stabilized instream flows on the Lake Fork and Yellowstone Rivers which resulted in more constant and extended water flows during late summer, fall and winter.
- Improved high mountain lake and stream habitat which returned them to more natural hydrologic runoff patterns. This resulted in enhanced wilderness recreation experiences.
- Total annual benefits are estimated to be about $2.4 million.

Red Wash Dam and Reservoir Project

In 2009 the Mosby Irrigation Company completed construction of a diversion structure on Deep Creek, a feeder canal, an offstream earthfill dam and dike (Redwash Dam), and an emergency spillway. Located about two miles northeast of Lapoint, the project stores about 2,523 acre-feet of water for late season irrigation. Costing about $9.5 million, the project enables irrigation of an additional 2,173 acres of land resulting in an estimated annual benefit of $60,000 per year for the irrigators.

Green River Pumping Project

This project enabled the Uintah Water Conservancy District (UWCD) to develop and use about 8,500 acre-feet of its 51,800 acre-feet allotment of the Flaming Gorge Water Right. See the "Flaming Gorge Water Right" section of Chapter 3. There are several aspects to the project; it begins with a water intake structure and pumping station on the Green River, about three miles of 42-inch high density polyethylene pipe, a 30 acre-foot regulating pond and a connection to the existing Ouray Park Pipeline. Finally, there is another three and one-half miles of 30-inch high density polyethylene pipe that conveys water from the West Side Combined Canal Salinity Project to Brough Reservoir. The pumping station and pipeline are sized to provide up to 65 cfs.

The project enables supplemental water only and increases the amount of water available to irrigate 8,750 acres up to a full duty. This results in a net annual benefit of $975,000 per year to the irrigators. In addition, the project prevents about 3,000 tons of salt from entering the Colorado River system annually. Overall management of irrigation water delivered to the area is also improved.

WATER DEVELOPMENT PROJECTS UNDER INVESTIGATION

In 2007, a collaborative study was done by the Central Utah Water Conservancy District (CUWCD), Duchesne County Water Conservancy District (DCWCD) and the Uintah Water Conservancy Districts (UWCD). The purpose of this study was to show how the districts intended to use the Flaming Gorge water rights that the Board of Water Resources awarded them. The study also identified and evaluated scenarios to use the water rights on the Uinta and Green Rivers (held by the Duchesne County WCD and Uintah WCD) to meet municipal, agricultural, and energy industry demands.[4] These demands were split into two categories—near future and likely future. Near future demands refer to applications for a portion of the Green River Allocation that have been approved by the Uintah WCD and Duchesne County WCD and are imminent water needs. Likely future water demands are those that are expected to be realized in the future because of projected growth based on previous studies and discussions with land owners, municipalities and energy industry developers.[5]

The methodology used in the 2007 study is very different from that used by the Utah Division of Water Resources. Moreover, this study was done some years earlier and appears to not have covered the same geographic areas. As a result, the water demand figures obtained in the study are not at all like those enumerated in Chapters 4 and 5, done by the division. Another significant difference is the amount of water estimated to be needed for extracting oil from shale. The amount used in the 2007 study was based on a process developed by the Oil Shale Exploration Company (OSEC). That company was bought out by Eesti

Energia which uses an entirely different technology to extract the oil; it also uses about 60 percent less water.[6] These are detailed in Chapter 4. The following water demand summary, Table 24, is from the study.

TABLE 24
Summary of Overall Existing and Future Demands

Type	Demand (ac-ft/yr) Total Existing	Total Near Future	Total Likely Future
Agricultural	253,424	261,882	286,055
Municipal	4,228	14,782	14,782
Energy Industry	4,230	116,710	241,710
TOTAL	**261,882**	**393,374**	**542,547**

Source: Franson Civil Engineers & CH2M Hill, *Conceptual Analysis of Uinta and Green River Water Development Projects*, (2007), Page ES-5.

The 2007 study went on to identify several projects that could be implemented to develop available water and satisfy anticipated demands. These projects included the following:[7]

- Four proposed new reservoir sites
- Two proposed enlarged reservoirs
- Extension of the Yellowstone Feeder Canal
- Pumping from the Green River
- Multiple water right exchanges

These projects were then combined into ten scenarios and each of these scenarios was evaluated. The specific projects and scenarios are summarized in Table 25. Scenario 1 is a "Do nothing" scenario.

Combinations of computer models were used to estimate the water yield for each scenario. A cost estimate was developed for each project and for each scenario. Ranking criteria were then developed that, "assumed an alternative must be complete, effective, efficient and acceptable in order to be viable."[8] Each scenario was then ranked and assigned a score. Finally, in September 2007 a public meeting was held with all of the stakeholders participating. The outcome was a decision that scenarios two, four, six, eight and 10 would remain as viable ones to consider. In addition to being the ones most favored, these also

TABLE 25
Water Development Scenario Summary

Project Features	Scenario 1	2	3	4	5	6	7	8	9	10
Upper Uinta Reservoir (28,000 ac-ft storage)		X	X			X	X			
Brown's Draw Enlargement (1,900 ac-ft storage increase)				X	X	X	X			
Montes Creek Enlargement (950 ac-ft storage increase)				X	X	X	X			
Bennett Reservoir (5,000 ac-ft storage)				X	X	X	X			
Neola Reservoir (5,000 ac-ft storage)				X	X	X	X			
East Cottonwood Reservoir (5,200 ac-ft storage)				X	X	X	X			
Renn Smith Reservoir		X	X	X	X	X	X	X	X	X
Cliffs and Whiterocks High Mountain Lakes transfer to M & I demand		X								
Fill Cottonwood Reservoir with Exchange								X	X	X
Yellowstone Feeder Canal Extension to Area 16 (capacity = 19 cfs)				X	X	X	X			
Pump from Green River to Pelican Lake		X		X		X		X	X	X
Pump from Green River to Ouray Park, Cottonwood Service Area		X		X		X		X		
Pump from Pelican Lake to Cottonwood Area (3,500 acres in Cottonwood Service Area)										X

Source: Franson Civil Engineers & CH2M Hill, *Conceptual Analysis of Uinta and Green River Water Development Projects*, (2007), Page ES-8.

TABLE 26
Viable Scenario Summary

Scenario	Water Developed Ac-ft	Total Capital Cost	Capital Cost per ac-ft of Developed Water	Score
2	22,300	$137,468,000	$6,200	593
4	17,900	$251,865,100	$14,100	525
6	26,200	$355,523,600	$13,600	565
8	9,800	$25,133,300	$2,600	464
10	8,400	$35,978,400	$4,300	427

Source: Franson Civil Engineers & CH2M Hill, *Conceptual Analysis of Uinta and Green River Water Development Projects*, (2007), Page ES-12.

had either the highest ranking score or lowest total cost.[9] Table 26 shows the preferred scenarios along with the water developed, total capital cost, cost per acre-foot and score.

The present value per acre-foot of developed water figures indicates the increasing cost of water development that is common throughout the water supply industry. It is clear from the above study that water suppliers in the Uintah Basin are proceeding into the future with plans to develop available water to meet future needs.

Uinta River Simulation

The Uinta River Simulation models the flows, reservoirs, and diversions on the Uinta River and Whiterocks Rivers before the confluence of the Duchesne River.

History

The original Uinta River Simulation was developed in 1978 as a monthly FORTRAN model. This model was used to evaluate Browns Draw and Cottonwood Reservoir which were completed in 1981 and 1982, respectively. In 1998, the model was converted to a daily FORTRAN model for the Uinta Unit Replacement Project. Scenarios were run to evaluate the benefits of a reservoir on the Uinta River. In 2000, the simulation was modified to model the Green River Pumping Project (GRPP) for the Uintah Water Conservancy District.

Current Model

In 2010, the daily FORTRAN model was converted to a RiverWare model.[10] This model uses both the rule based simulation and accounting functions of RiverWare. The rule based simulation has a set of rules that operate the reservoirs, water users and diversion structures in the simulation (similar to the prior FORTRAN models). The accounting portion of the model does two things:

1. It keeps track of the paper water rights and delivers those water users with the highest priority right first, progressively down to those having the last water right.
2. It keeps track of the exchanges in the system.

This accounting portion of the model was a huge advantage to manage the complicated water rights in the area and exchanges from the GRPP. There are four exchanges that replace water that would normally go to the lower Cottonwood water user with GRPP water. There is the ability to exchange water to the Whiterocks, Moffat, Bench Area and Upper Cottonwood water users.

One additional component that is being developed for this model is a forecasting element to help determine when the GRPP should be turned on. Using the Colorado Basin River Forecast Center forecast for the Uinta near Neola and the Whiterocks near Whiterocks gages and the current conditions (including reservoir elevations and known flows) the model can be used to evaluate the water conditions and timing of the pump operations.

NOTES

[1] U. S. Bureau of Reclamation, "Uinta Basin Replacement Project," April 2003. Retrieved from the U. S. Bureau of Reclamation's Internet web page: http://www.cuwcd.com/cupca/ubrp_pdf/UBRP.pdf, April 2011.

[2] Ibid., Pages 2 & 3.

[3] Ibid., Page 3.

[4] Franson Civil Engineers & CH2M Hill, *Conceptual Analysis of Uinta and Green River Water Development Projects*, (2007), Page ES-1.

[5] Ibid., Page ES-2.

[6] Enefit American Oil, "*Enefit American Oil*." Retrieved from the Internet web page: https://en.wikipedia.org/wiki/Enefit_American_Oil, December 2, 2014.

[7] Franson Civil Engineers & CH2M Hill, *Conceptual Analysis of Uinta and Green River Water Development Projects*, (2007), Page ES-7.

[8] Ibid., Page ES-11

[9] Ibid.

[10] See: http://cadswes.colorado.edu/creative-works/riverware, December 13, 2015.

7

WATER QUALITY THE ENVIRONMENTAND OTHER CONSIDERATIONS

Regulation of water quality in Utah began in 1953 when the state legislature established the Water Pollution Control Committee and the Bureau of Water Pollution Control. Later, with the passage of the federal Clean Water Act in 1972 and the federal Safe Drinking Water Act in 1974, strong federal emphasis was given to preserving and improving water quality. Today, the Utah Water Quality Board and Division of Water Quality as well as the Utah Drinking Water Board and Division of Drinking Water are responsible for the regulation and management of water quality in the State of Utah.

The State Water Plan identifies several water quality programs or concerns that are of particular importance to the future of the state's water resources. These are also of concern to the Uintah Basin. These programs will be outlined as follows:

- Total Maximum Daily Load program
- Storm water discharge permitting
- Concentrated animal feedlot operations
- Septic tank densities

TOTAL MAXIMUM DAILY LOAD PROGRAM

Section 303 of the Federal Clean Water Act directs each state to establish water quality standards to protect beneficial uses of surface and groundwater resources. The Act also requires states to identify impaired water bodies every two years and develop a total maximum daily load (TMDL)[1] for each pollutant causing impairments in the various water bodies. A TMDL, as defined by the U.S. Environmental Protection Agency is, "a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that load among the various sources of that pollutant. Pollutant sources are characterized as either point sources that receive a wasteload allocation, or nonpoint sources that receive a load allocation."

The Division of Water Quality (DWQ) has identified the beneficial uses of each water body in the Uintah Basin. See Table 27 for beneficial class definitions. DWQ has also determined which stream segments and other water bodies fully support, partially support or do not support designated beneficial uses by comparing existing water quality to standards appropriate for each use. See Figure 23. Table 28 lists the impaired water bodies for which TMDLs have been developed, the reductions needed for each pollutant or impairment, and the actions that will be taken to reach supporting conditions. Many additional stream segments have been classified according to beneficial uses. However, in some cases there is currently insufficient data to determine whether the designated uses are impaired. Data is being collected in an ongoing basis and each water body will be evaluated as it becomes available.

In cooperation with state, federal and local stakeholders, DWQ organizes and facilitates locally-led watershed groups for each of the impaired water bodies under consideration for a TMDL. Below is a brief description of some of the TMDLs currently under investigation and/or completed in the Uintah Basin.

River Segments

Lower Ashley Creek[2]

Located southeast of Vernal, 8.5 miles of the Lower Ashley Creek and associated tributaries are listed as not supporting beneficial uses 3B (warm water game fish and aquatic life) and 4 (agricultural use, irrigation

TABLE 27
Designated Beneficial Uses for Rivers, Streams, Lakes and Reservoirs

Class	Description
1C	Protected for **domestic purposes** with prior treatment by treatment processes as required by the Utah Division of Drinking Water.
2A	Protected for **primary contact recreation** such as swimming.
2B	Protected for **secondary contact recreation** such as boating, wading, or similar uses.
3A	Protected for **cold water species** of game fish and other cold water aquatic life, including the necessary aquatic organisms in the food chain.
3B	Protected for **warm water species** of game fish and other warm water aquatic life, including the necessary aquatic organisms in the food chain.
3C	Protected for **nongame fish** and other aquatic life, including the necessary aquatic organisms in the food chain.
3D	Protected for **waterfowl, shore birds and other water-oriented wildlife** not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in the food chain.
3E	Severely **habitat-limited** waters. Narrative standards will be applied to protect these waters for aquatic wildlife.
4	Protected for **agricultural uses** including irrigation of crops and stock watering
5	The **Great Salt Lake**. Protected for primary and secondary contact recreation, aquatic wildlife, and mineral extraction.

Source: *Utah Administrative Code Annotated,* R317-2-6.

and stock watering) for high total dissolved solids (TDS) and selenium. The source of most TDS and selenium impairment was the now-closed Ashley Valley Sewage Lagoons and the highly-soluble Mancos Shale geologic formation underlying them. Loading calculated before closure of the lagoons was 1,637 lbs/year of selenium and 36,247 tons/year TDS. To reach the state limits for each of these impairments, selenium will have to be reduced by 78 percent or 1,276 lb /year to 361 lb/year, and TDS reduced by 20 percent or 7,194 tons/year to 29,053 tons/year.

The Ashley Valley Water Reclamation Facility (AVWRF) was built in 2001 to replace the leaky sewage lagoons. Since closing the lagoons, selenium and TDS loads in the river downstream have been significantly reduced. Approximately 2,000 lb. of selenium and 9,000 tons of TDS were previously contributed to the river annually from the lagoons. Flows from seeps and springs supplied by the lagoons have gradually declined and eventually those contributions will be negligible. The AVWRF was identified as a point source for these impairments and as such, has been issued a UPDES permit apportionment based on a 130 mg/L (maximum tested concentration) inflow and a degradation allotment of 400 mg/L for TDS, and five µg/L maximum for selenium.

During low flows, the river upstream of the AVWRF is entirely diverted into Steinaker Reservoir, dewatering 6.5 miles of the river bed. Further efforts to reduce TDS, mainly associated with the Colorado River Salinity Control Program, have implemented irrigation improvements such as flood to sprinkler conversion for approximately 17,000 acres. In addition, lining of the Union Canal reduced deep-percolation. These efforts have been effective in reducing TDS levels in Ashley Creek. Despite closure of the sewage lagoons and the corresponding drop in both TDS and selenium, the Lower Ashley Creek continues to be under a consumption advisory for fish, ducks, and American Coots (since August 1991). The advisory warns against eating these creatures due to elevated levels of selenium found in the tissues.

Duchesne River Watershed [3]

The Duchesne River watershed drains approximately 1.8 million acres of the Uintah Basin through various creeks and streams including Yellowstone Creek and the Strawberry, Lake Fork, and Duchesne rivers. Two of the state's larger reservoirs, Strawberry (1,106,500 acre-feet) and Starvation (162,798 acre-feet) lie within the watershed. Strawberry Reservoir's water quality is addressed in its own TMDL while Starvation Reservoir does not yet have a TMDL, although it has been listed for low dissolved oxygen and high temperatures.

Five different stream segments within the watershed are impaired due to high concentrations of total dissolved solids (TDS). All five reaches' have beneficial

FIGURE 23
Water Quality Impairments and Beneficial Use Support Assessment

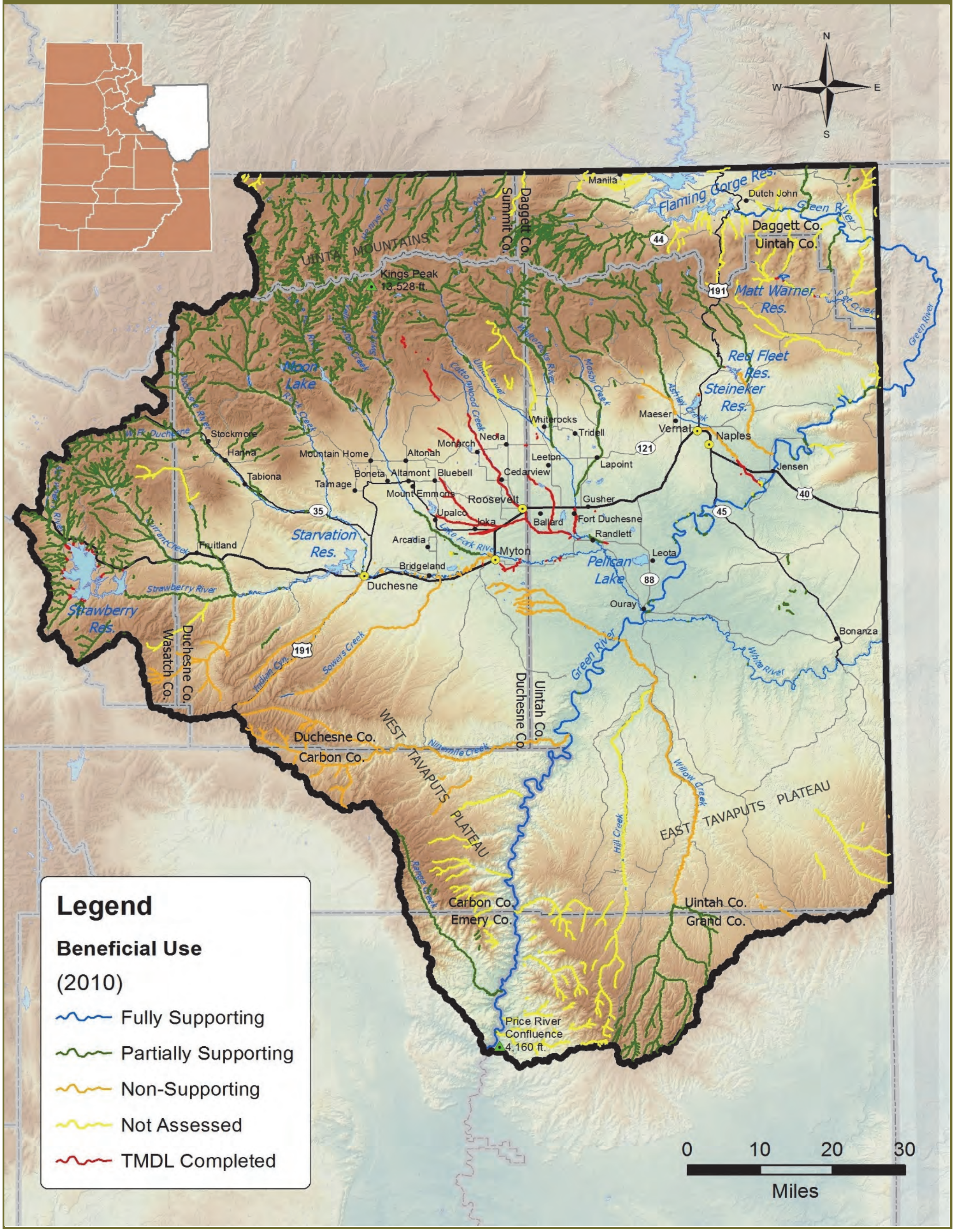


TABLE 28
Impaired Water Bodies in the Uintah Basin with Related Information

Impaired Water Body	Impaired Use	Impairment Source	Required Reduction	Action(s) to Address Impairments
Lower Ashley Creek	3B, 4	TDS Selenium	-7,194 tons/year (-20%) -1,276 l bs/year (-78%)	Ashley Valley Water Reclamation Facility lagoons were closed in 2001, Union Canal was lined, Colorado Salinity Control Program.
Duchesne River Randlett to Green River	4	TDS	-25,607 Kg/day (-12.6%) during low flows	Controlling stream bank erosion, promoting both proper irrigation and grazing management practices, restoration of grasses and deep-rooted woody plant species on stream banks and in upland and riparian areas and the Colorado Salinity Control Program.
Duchesne River Myton to Randlett	4	TDS	-40,101 kg/day (-17.8%) during low flows	
Lake Fork River	4	TDS	-11,070 kg/day (-4.23%) during high flows	
Indian Canyon Creek	4	TDS	2,182 mg/L (target)	
Pariette Draw	3B, 3D, 4	TDS Selenium Boron	-48.72 tons/day (-75%) -0.33 lbs/day (-72.8%) -36.38 tons/day (-64.3%)	Irrigation water and riparian best management practices. (Very little flood-irrigated land is left to convert to sprinkle irrigation via CRBSCP projects.)
Uinta River / Deep Creek	4	TDS	-19,400 tons/day (-21%)	Controlling stream bank erosion, promoting both proper irrigation and grazing management practices, restoration of grasses and deep-rooted woody plant species on stream banks and in upland and riparian areas.
Dry Gulch Creek	4	TDS	-18,200 tons/day (-31%)	
Brough Reservoir	3A	Phosphorus Dissolved Oxygen	-289 kg/year (-97%)	No significant sources identified. Phased implementation approach to pursue development of tiered aquatic life uses and use attainability analysis to better characterize beneficial use support.
Steinaker Reservoir	3A	Phosphorus Dissolved Oxygen	-755 kg/year (-97%)	
Red Fleet Reservoir	3A	Phosphorus Dissolved Oxygen	-1,339 kg/year (-90%)	
Browne Lake	2B, 3A, 4	Phosphorus Dissolved Oxygen	-25 kg/year (-23%)	Maintain and improve upland range condition through application of best management practices. Maintain and improve riparian area function through application of best management practices. Reduce nonpoint source pollution from recreation by applying the best available technologies. 2010 assessment -fully supporting beneficial uses
Matt Warner Reservoir	3A	Phosphorus Temperature	-22 kg/year (-9.9%)	Maintain and improve existing watershed and grazing management practices. Maintain fishery management practices. 2010 assessment -both reservoirs fully supporting beneficial uses.
Calder Reservoir	3A	Phosphorus	-118 kg/year (44.9%)	
Strawberry Reservoir	3A	Phosphorus Dissolved Oxygen	-reservoir at loading capacity	Maintain and improve existing watershed and grazing management practices. Maintain fishery management practices.

Source: Taken from individual TMDLs found on the web at: http://www.waterquality.utah.gov/TMDL/.

uses of Class 4 (protected for agricultural uses including irrigation of crops and stock watering). Three segments, the Duchesne River, from the confluence with the Green River to Randlett, the Duchesne River, from Randlett to Myton, and the Lake Fork River, have waste load allocations calculated with appropriate TDS reductions to meet state water quality standards. The Duchesne River from the confluence with the Green River to Randlett will need a TDS reduction of 25,607 Kg/day (12.6%) during low flows, the Duchesne River from Randlett to Myton needs a TDS reduction of 40,101 kg/day (17.8%) also during low flows, in order to meet the 1,200mg/L state standard. The Lake Fork River exceeds state TDS limits only during high flows and will need TDS reductions on the order of 11,070 kg/day (4.23%).

The two remaining segments, Indian Canyon Creek and Antelope Creek have recommended site-specific criteria since "it is unlikely that these watersheds can feasibly meet the current TDS water quality criterion of 1,200 mg/L due to a combination of naturally saline soils and irreversible modifications from irrigation activities."[4] Proposed TDS criteria for these segments are 2,183 mg/L for Indian Canyon Creek and 2,655 mg/L for Antelope Creek.

Since the high TDS in each of these river segments comes from nonpoint sources, strategies to reduce TDS will be similar. Anthropogenic sources are mainly attributable to agriculture related activities. The measures will also be implemented on a voluntary basis and will include irrigation and riparian best management practices, salinity control measures such as are provided through the Colorado Salinity Control Program to reduce deep percolation from irrigation, promoting proper grazing management on uplands, and improving stream bank stability.

Pariette Draw [5]

Pariette Draw is located to the south and east of the town of Myton and Highway 40. The drainage is bounded by the Duchesne River on the north, the Tavaputs Plateau to the south and west, and by the Green River to the east. Waters of the drainage have been identified as not supporting the listed Class 4 beneficial uses since 2002 for high levels of TDS and boron, and since 2004 as not supporting beneficial use classes 3B and 3D due to high levels of selenium.

Much of the irrigation supply in the drainage is brought to the area through the Pleasant Valley Piped Canal. The canal water, diverted from the Duchesne River 15 miles upstream, is of good quality, testing below 500 mg/L TDS, 0.5 µg/L selenium, and 580 µg/L boron (state water quality limits: 1,200 mg/L TDS, 4.6 µg/L selenium, and 750 µg/L for boron). Water leaving the basin is tested at a location approximately one mile upstream from the entrance into the Green River. Concentrations of over 6,500 mg/L TDS, 18.0 µg/L for selenium, and 3,000 µg/L for boron were typical. These increases are five times greater for TDS, thirty-six times for selenium and 13 times for boron.

Of the 6,806 acres of irrigated land in the watershed, 6,335 are sprinkler irrigated, 429 remain under flood irrigation. Improvements in land management and irrigation brought about through the Colorado Salinity Control Program have been largely responsible for changing flood irrigated acreage to sprinkle irrigation. Estimated reductions in salt load since the program began indicate a decrease of 5,769 tons/acre/year.[6] Since there is little flood irrigated land left in the basin, further reductions in salinity, boron and selenium will largely have to come from sources other than conversion to sprinkle irrigation. In addition to natural background sources, irrigation return flows are still suspected to be contributing a large portion of the drainages high TDS load. Part of the reason is that sprinkler irrigation requires a slight over application of water to flush salts out of the upper portion of the soil column in order to remain productive. The water then enters the shallow groundwater aquifer, continuing to dissolve salts and minerals as it flows through the soluble rock and mineral formations of the basin. The water then resurfaces through seeps and springs and returns to surface waters.

Oil and gas mining activities may also contribute to diminished water quality. There are 2,945 oil and gas wells located in the Pariette Draw Basin, which may contribute to loads through disturbed soils and possibly some groundwater intrusion; although it is not known to what extent these operations may affect water quality. The Division of Water Quality has recommended further testing to study possible sources of contamination within the drainage. As of the fall of 2010, the BLM was conducting these extensive water tests, spending approximately $90,000 annually.

Because no point sources for any of the impeding contaminants can be identified in the watershed, mitigation measures are implemented on a voluntary basis. Measures to reduce all contaminants include controlling stream bank erosion, promoting proper irrigation practices, proper grazing management, and restoration of grasses and deep rooted woody plants to stream banks and riparian and upland areas. Other control measures mandated by the BLM in conjunction with oil and gas leases require erosion and wastewater control which help to reduce the impacts of mining operations.

Uinta River Watershed [7]

The Uinta River watershed drains the south side of Kings Peak through the Uinta River, Deep Creek, and Dry Gulch Creek and other smaller tributaries. The drainage, located between Roosevelt and Kings Peak, covers approximately one million acres. Soils in the upper reaches of the drainage flow through the Duchesne River Formation which is typically not saline and is therefore a low salt producer. Lower down in the drainage, the predominant geologic feature is the Uinta formation which consists of gray or green, saline and gypsiferous clays, shales, sandstones and marlstone. Agricultural operations are located primarily on this latter formation which is the predominant salt producer in the Uintah Basin. Watershed streams have been identified as having impaired Class 4 beneficial use - protected for agricultural uses, due to high TDS.

Dry Gulch Creek, an intermittent stream, is fed mostly by irrigation return flows from runoff or deep percolation. With much of the impairment due to agricultural practices, it is from there that much of the remedy will have to come.

The TMDL for the Uinta River and Deep Creek identifies a needed reduction of TDS of 19,400 tons/year, from 92,500 tons/year to 73,100 tons/year—a 21 percent reduction. The Dry Gulch Creek needs a reduction of 18,200 tons/year from 59,000 tons/year to 40,800 tons/year—a 31 percent reduction.

Likely reduction measures will target increased efficiency of water use and transport, and minimizing surface water runoff, seepage and deep percolation. Improvements to irrigation have already been started with the Colorado River Basin Salinity Control program already treating 4,400 acres adjacent to Dry Gulch Creek. Estimated annual reductions due to salinity control measures on basin agricultural lands range from 2.92 tons per acre (Dry Gulch Creek area) to 3.19 tons per acre (Whiterocks-East Uinta River) for each acre-foot of deep percolation eliminated. Conversion of additional acreage in the basin to sprinklers is currently limited by the absence of upstream storage, which would provide water for late-summer irrigation. Other control measures target upland and stream bank erosion control. Measures include proper grazing management, improving riparian areas through planting, excluding livestock from stream banks and riparian areas, and developing alternative watering sites. In addition, stream bank stabilization through sloping stream banks to allow vegetation to establish, planting deep-rooted species, and physical channel control to deflect currents away from erosive banks.

Lake and Reservoir TMDLs

Brough, Red Fleet and Steinaker Reservoirs [8]

These three reservoirs are located near Vernal. Brough and Steinaker are off stream reservoirs. Brough Reservoir, 15 miles southwest of Vernal, is fed from the Whiterocks River by way of the 29 mile long Ouray Valley Canal. Steinaker Reservoir, two miles northwest of Vernal, is fed from Ashley Creek by the 2 ½ mile long Steinaker Feeder Canal. Red Fleet Reservoir, 10 miles northeast of Vernal, is located on Brush Creek with most of the water supply coming from Big Brush Creek. All three reservoirs are listed as impaired for 3A (cold water fishery) beneficial use due to low dissolved oxygen levels.

Oxygen depletion is believed to occur as a result of elevated phosphorous in each of the reservoirs. The TMDL for Brough (4,000 ac-ft capacity) and Steinaker (38,380 ac-ft capacity) reservoirs requires a reduction in phosphorous of 97 percent while the TMDL for Red Fleet (26,170 ac-ft capacity) a 90 percent reduction. Oxygen demand is currently double the amount that would allow meeting beneficial use requirements in Red Fleet and Steinaker reservoirs, and triple the amount in Brough Reservoir.

The source of phosphorous in Brough Reservoir is believed to come mainly from native sediments, with a portion coming into the reservoir from erodible canal soils. Sources for Red Fleet Reservoir include native sediments, upland erosion and minor amounts from recreational use. Steinaker Reservoir phosphate sources are listed as coming from native sediments, grazing, logging and un-reclaimed mine sites. Steinaker Reservoir also still receives considerable phosphorous from the sediments generated during the washout of the Mosby Canal in May of 1997 which continue to be flushed into the reservoir.

Native phosphorous loads can be generated by wave action disturbing the bottom sediments as each reservoir is drawn down in the late summer, and through a combination of anaerobic conditions that can exist at the bottom of the reservoir (which convert bottom phosphates into more soluble forms that algae can use). Additionally, the spring or fall turnover within the reservoir transports the phosphates up into the water column to be used by algae for growth.[9] Although high levels of phosphorus are present in all three reservoirs, algal growth is much lower than would be expected. Testing has revealed that all three reservoirs have a one to two meter refuge layer with temperature below 23^{o} C and dissolved oxygen level greater than 4.0 mg/L in which cold water fish species can survive. This makes it possible for these reservoirs to partially support designated use as cold water fisheries.

Modeling has shown that there is a poor correlation between phosphorous and low dissolved oxygen levels. This leads to a calculation of un-achievable levels of phosphorus reduction in order to meet dissolved oxygen requirements. As a result, the TMDL report recommended a phased implementation and possible development of an alternative tiered beneficial use classification appropriate for these types of water bodies. These reservoirs will continue being monitored through sampling every two years to better determine if the beneficial use 3A is appropriate.

Browne Lake

Located 10 miles southwest of Manila Utah, Browne Lake (Brownie Lake by some sources) is a 54 acre lake impounding 642 acre-feet of water, primarily from Beaver and Weyman Creeks. The lake was stabilized in 1954 for recreational fishing. Categorized as having impaired beneficial uses 2B (recreation use and aesthetics), 3A (cold water game fish and organisms in the food chain), and 4 (agriculture), the lake is listed for total phosphorous and dissolved oxygen. The phosphorous load which causes both impairments is due mainly to grazing, recreation and logging.

In 1985 a fire, called the Weyman Burn, burned 40 percent (5,500 acres) of the Browne Lake watershed. As a result, phosphate rich sediments, liberated by vegetative losses, are washed to the lake and deposited. These sediments deposit on the lake-bottom and contribute to in-reservoir phosphate loads when converted to water-soluble forms. Lodge Pole Pines in the area have recently been infested by Pine beetles. On-going logging activities to salvage a portion of the beetle-killed timber, has also contributed to erosion. Sediments collecting by annual run-off from all over this stressed watershed continue to enter the lake each year. The TMDL calculates the current loading of total phosphorous to be 108 kg/year. The load capacity with five percent safety factor, is calculated to be 83 kg/year, requiring a 23 percent reduction (25 kg) in annual phosphate load.

The TMDL for the basin recommends managing recreation activities within the basin along with rangeland best management practices to reduce phosphate loads. To this end the shoreline has been protected from some human and animal activity through fencing and blocking of roads leading to the water's edge. Logging within the basin will also be managed to limit those impacts. Continued vegetative success will increasingly stabilize the soil within the burn areas, helping to limit phosphate runoff. Phosphate rich sediments already deposited on the reservoir floor will be gradually covered with sediments less-rich in phosphates, reducing in-reservoir contributions to the water column. Additional water testing is recommended to better understand seasonal phosphate loading.

Matt Warner and Calder Reservoirs [10]

Matt Warner (2,796 ac-ft) and Calder (1,630 ac-ft) reservoirs are located in the Pot Creek drainage northeast of Vernal (nine and fourteen miles east of highway 191 respectively). Pot Creek and other small tributaries drain into Matt Warner Reservoir. The outflow from Matt Warner then flows to Calder Reservoir through four additional miles of Pot Creek. Both reservoirs have been listed as not supporting beneficial use 3A, cold water fishery. Calder is listed as impaired due to total phosphorous and low dissolved oxygen, and Matt Warner is listed as impaired for temperature.

The TMDL for this reservoir recommends delisting the reservoir for temperature impairment due to that impairment only occurring during low water drought-caused conditions. The elevated phosphorous levels found in Calder Reservoir come from the erosion of poorly vegetated areas of the watershed and stream banks, grazing activities, and from internal loads. The TMDL recommends a 45 percent reduction in total phosphorous. This means eliminating 145 kg from the 263 kg/ year entering the water column annually. Recommendations for reducing the total phosphorous load include improving watershed vegetation and riparian habitat to reduce hillside and stream bank erosion and livestock management. Livestock management activities include; fencing to exclude livestock from access to watercourses along with the concurrent development of off-site watering locations and better overall grazing management. Better livestock management will limit the loss of vegetation and the amount of soil disturbance which produce sediments, as well as reduce the chance that animal wastes will reach the reservoir.

<u>*Strawberry Reservoir*</u> [11]

Strawberry Reservoir is listed as having an impaired beneficial use 3A (protected for cold water species including the food chain) due to high total phosphorous which contributes to the low dissolved oxygen levels. Water samples, taken at various times of the year throughout the reservoir, indicate levels of phosphorous and dissolved oxygen that are detrimental to the fishery.

Through the TMDL process, it was determined that there is poor correlation between low dissolved oxygen samples and the health of the fishery. Many of the low dissolved oxygen levels occurred in deep water near the dam. The deep water there becomes stratified during much of the year, preventing the movement of oxygen from the surface into deeper levels. After stratification, the existing oxygen below the thermocline is used up by aquatic life, creating anaerobic conditions. The anaerobic conditions then change the chemistry at the bottom of the reservoir which, in turn, releases more phosphates from bottom sediments. Conditions near the dam are also influenced by Stinking Springs, (also a source of phosphorous) which were inundated when the new dam was built. Chemical oxygen demand also helps deplete the oxygen in the vicinity. During the spring and again in the fall the reservoir waters “turn-over” with the seasonally changing air and water temperatures at the surface, causing a mixing of oxygen rich water throughout the reservoir, raising oxygen levels for a couple of months.

Since treating with rotenone in 1990 to manage unwanted fish populations, the reservoir has become a very reliable cold water fishery and is one of the most productive in the state despite the periodic low dissolved oxygen levels.

Strawberry is a large reservoir with many small cold-water streams entering it. Even during the worst periods of the summer when lower dissolved oxygen levels and higher temperatures occur, these small streams provide cooler, more highly oxygenated water to the reservoir. The TMDL calculated for Strawberry Reservoir establishes both the total phosphorous load entering the reservoir and the loading capacity (TMDL) at 15,100 lbs/year. The margin of safety of five percent equals 755 lbs/year. Phosphorous load reductions that are required to support watershed improvement projects amount to 1,015 lbs/year, the bulk of which will come from flushing of phosphates liberated from bottom sediments. The amount of phosphates currently flushed from the reservoir each year is estimated to be about 4,000 lbs.

STORM WATER DISCHARGE PERMITTING

Pollution from storm water discharge is a result of precipitation and runoff flowing over land, pavement, building rooftops and other impervious surfaces where it accumulates pesticides, fertilizers, oils, salt, sediment and other debris.[12] To minimize the amount of pollutants that enter the nation’s water bodies through storm water runoff, the U.S. Environmental Protection Agency (EPA) initiated a two-phase process for implementation of storm water regulations. Implementation of Phase I began in 1990, and affected certain types of industry, construction sites larger than five acres, and cities or counties with a population larger than 100,000.

Phase II of EPA's storm water regulations, which began implementation in 2003, affects smaller construction sites and areas designated as an "Urbanized Area" by the U.S. Census Bureau.[13] Phase II rules also apply to any community outside an Urbanized Area that has a population greater than 10,000 and a population density higher than 1,000 people per square mile. Affected communities are required to apply for a storm water discharge permit, and to fully implement a storm water management program in compliance with the permit within five years.

Currently, there are no communities in the Uintah Basin that are required to obtain a storm water discharge permit. However, Vernal will likely reach the 10,000 person population threshold by the 2020 census and will be required to comply thereafter. Despite the specific rules that make permitting mandatory for larger storm water sources, smaller individual contributors may be required to obtain a discharge permit if they are identified as a significant source of pollution.

CONCENTRATED ANIMAL FEEDING OPERATIONS

Another water quality concern within the Uintah Basin is the impact from animal feeding operations (AFO) and concentrated animal feeding operations (CAFO).[14] These operations, where large numbers of animals are grown for meat, milk or egg production, can increase the biological waste loads introduced into rivers, lakes, and surface or groundwater reservoirs. Animal manure contains nutrients, pathogens, pharmaceuticals and salts.

The Animal Feeding Operations (AFOs) Committee, formed in 2001, is a partnership of the Division of Water Quality, Utah Department of Agriculture and Food, Utah Farm Bureau, Utah Association of Conservation Districts, Utah State University Extension, Natural Resources Conservation Service, and animal producer groups. The Committee developed the Utah AFO and CAFO strategy[15] which is a compliance assistance agreement to help animal feeding operations comply with environmental regulations to improve water quality. This strategy has three primary goals: (1) to restore and protect the quality of water for beneficial uses, (2) to maintain a viable and sustainable agricultural industry, and (3) to keep the decision-making process on these issues at the state and local level.

The strategy provided a five-year window for facilities of particular concern to make voluntary improvements. After this "grace" period more stringent regulatory action was to be directed toward those facilities located within priority watersheds with identified water quality problems. On December 22, 2008, the United States Environmental Protection Agency (EPA) implemented a new federal rule for Concentrated Animal Feeding Operations (CAFOs). This rule outlines how AFOs and CAFOs are regulated by EPA and authorized states across the country.

Permitting [16]

The new rule requires a National Pollution Discharge Elimination System (NPDES) permit for CAFOs (also called a CAFO permit) that "discharge" or "propose to discharge." AFOs and large CAFOs that do not discharge, or propose to discharge, are not required by law to obtain a permit. Table 29 lists the facilities requiring a CAFO permit. In Utah, two permitting options are available: a CAFO permit or Utah's AFO Permit-by-Rule. Both the CAFO permit and the AFO Permit-by-Rule will provide enforcement protection if a discharge occurs due to a 25-year, 24-hour storm event or greater.

<u>*Facilities Requiring a CAFO Permit:*</u>

Large CAFOs

- Large CAFOs that discharge or propose to discharge to a water of the State

Small and Medium AFOs

- Medium AFOs that discharge through direct animal contact or through a human-made device (e.g. pipe, ditch, culvert) to a water of the State.
- Small AFOs that are designated as a significant polluter based on an on-site inspection and discharges through a human-made device or direct animal contact.

<u>*Facilities that Do Not Require a CAFO Permit:*</u>

- AFOs and CAFOs that will not discharge, regardless of cause or storm event size, are not required by law to obtain a permit.

TABLE 29
Facilities Requiring a CAFO Permit

Large CAFO	Medium AFO	Small AFO
1000+ beef, heifers, or calves	300-999 beef, heifers, calves	1-299 beef, heifers, calves
700+ cows (milking or dry)	200-699 cows (milking or dry)	1-199 cows (milking or dry)
125,000+ laying chickens	37,500-124,999 laying chickens	1-37,499 laying chickens
55,000+ turkeys	16,500-54,999 turkeys	1-16,499 turkeys
2,500 + swine (≥ 55 pounds)	750-2,499 swine, (≥ 55 pounds)	1-749 swine, (≥ 55 pounds)
10,000+ swine (< 55 pounds)	3,000-9,999 swine (< 55 pounds)	1-2,999 swine (< 55 pounds)
10,000+ sheep	3,000-9,999 sheep	1-2,999 sheep
500+ horses	150-499 horses	1-149 horses

Modified from the U.S. Environmental Protection Agency's table found at: www.epa.gov/npdes/pubs/sector_table.pdf.

- Medium and Small AFOs that do not have discharges as described above are not required to obtain a permit. Although many Medium and Small AFOs may NOT require a CAFO permit, it may be advantageous to consider Utah's AFO Permit-by-Rule for some enforcement protection.

Facilities that May Get the AFO Permit-By-Rule:

- Medium and Small AFOs may voluntarily obtain Utah's AFO Permit-by-Rule.

Facilities that obtain the AFO Permit-by-Rule, and follow the requirements will have some enforcement protection without going through the CAFO NPDES permitting process.

The Utah Strategy provides assistance to AFOs through the compliance and engineering experts of the partnership. The partners conduct on-farm assessments, prepare nutrient management plans, help provide waste containment structures, and assist in the implementation of proper management practices. In addition, the partners assist producers in obtaining cost-share and loan funding to address manure management problems. The Utah Strategy focuses compliance assistance on the smaller AFOs which do not require discharge permits.

To date, nearly 3,000 facilities have been assessed statewide. Of those, 393 are AFOs with compliance problems. Since 2001, 98 percent of the problem AFOs have had management plans prepared for them, 90 percent have implemented BMPs to control runoff, 86 percent have implemented respective plans and 80 percent are certified as being in full compliance through the cooperative efforts of the partners.[17] As of fall 2011 there is one CAFO in the Uintah Basin (in compliance) and all of the 200 plus AFOs are either in the process of preparing plans or are in full compliance with permitting requirements.[18] Through the AFO Committee and the Utah Strategy, water quality impacts from animal agriculture have been greatly reduced.

SEPTIC TANK DENSITIES

In much of the basin, advanced wastewater treatment systems have not been constructed and individual septic tank systems are used to dispose of domestic wastes. While septic tanks are designed to partially treat domestic waste and disperse of the remaining pollutants into the natural environment in quantities that are not particularly harmful, when densities become too high, concentrations of certain pollutants (nitrogen, for example) can begin to cause problems.

The Hancock Cove area west of Roosevelt has experienced problems with septic tank densities. In March, 2015 people in that area petitioned the Duchesne County Commission requesting formation of a sewer district. There are considerations other than density that may be contributing to the problems.[19] The Utah Geologic Survey (UGS) has produced a guide for designing septic systems in Duchesne County due to shallow soils overlying impervious rock or clay formations. The guide can be obtained from the UGS website: http://geology.utah.gov/online/ri/ri-238.pdf.

POSSIBLE IMPACTS TO ASHLEY SPRINGS BY PROPOSED PHOSPHATE MINE

Phosphate fertilizer has been mined on the south slope of the Uinta Mountains north of Vernal for decades. Typically, the opening of a new mine would be welcome news since it offers new jobs and improves the economy of the Uintah Basin. However, when the new mine overlies the largest source of culinary water in Uintah County, it's understandable that many people are concerned and want to exercise caution. Such is the case for a proposed phosphate mine that straddles Ashley Springs located about 13 miles northwest of Vernal.

Uses of the Springs

Ashley Springs is the primary source of water for the Ashley Valley Water Treatment Plant owned by Central Utah Water Conservancy District.[20] The spring supplies about 80 percent of the water for this plant that provides water to the Uintah Water Conservancy District and to Vernal City. The remaining 20 percent is pumped from Red Fleet Reservoir when the springs flow decreases.[21] Over 9,000 people are served by the plant. In addition, Ashley Springs supplies all of the water distributed by the Ashley Valley Water & Sewer Improvement District Treatment Plant. This plant supplies water to over 9,000 people, primarily in Uintah County outside Vernal City including the towns of Jensen and Maeser.[22] Thus, Ashley Springs supplies culinary water to over 18,000 people, over 50 percent of the population of Uintah County.[23] "Ashley Spring is one of the largest springs in Utah, with a reported discharge that ranges from about 15 cubic feet per second at low or baseflow to at least 90 cubic feet per second during the snowmelt runoff period in May and June."[24]

Proposed Mine Proximity to Ashley Springs

Utah Phosphate Company (UPC) is a subsidiary of the Canadian firm Agrium.[25] UPC owns three mining leases.[26]

- State lease 30662 has about 1,794 acres while lease 30663 has about 1,045 acres. This is a total of about 2,840 acres on State Institutional Trust Lands (SITLA). These are shown in blue in Figure 24.
- State lease 47679 has two parcels; one is about 392 acres while the other is about 40 acres. This is a total of about 432 acres on private land as shown in Figure 24.

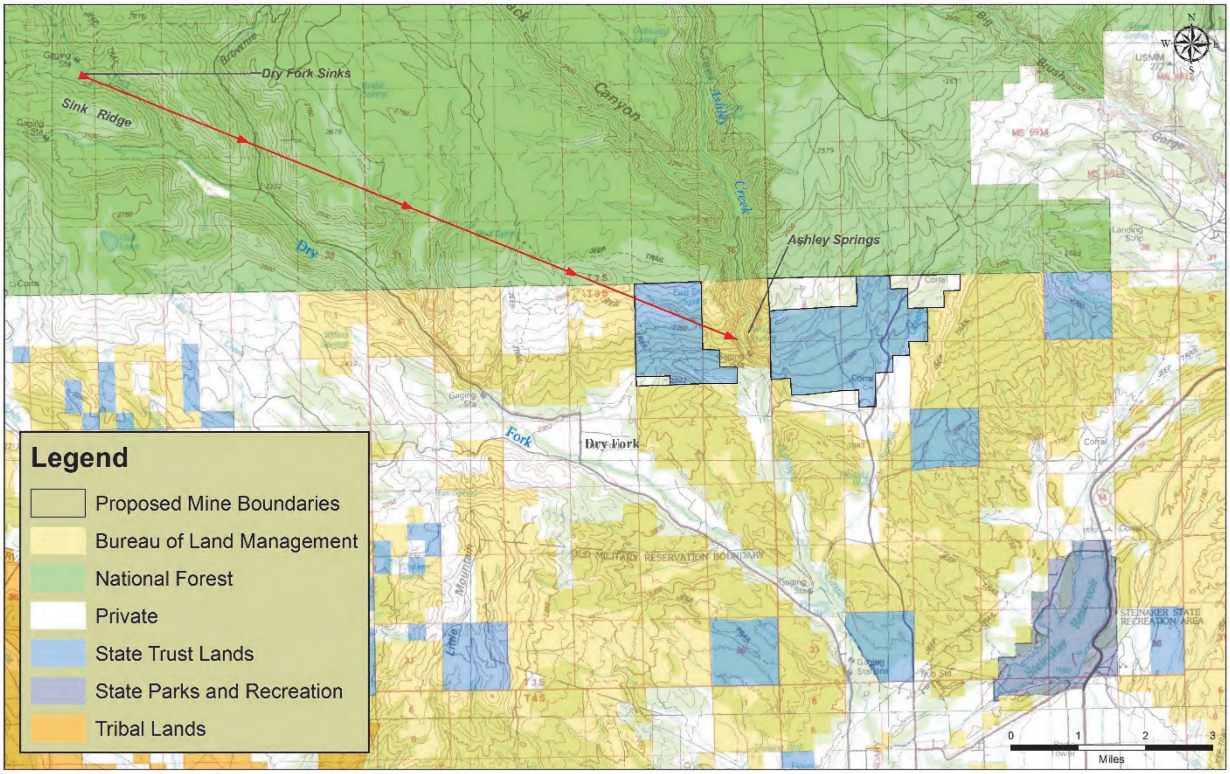
The total mine acreage is about 3,271 acres or a little over five square miles. About 32 percent of the mine is west of Ashley Creek while about 68 percent is east of Ashley Creek. As can be seen in Figure 24, planned mine areas are on both sides of Ashley Creek with borders about one quarter-mile from Ashley Springs.

Geologic Setting of Ashley Springs and the Phosphate Mine

The Ashley Springs rise in three separate areas: (1) A large perennial spring in the valley bottom issues from the lower part of the Weber Sandstone through the alluvium on the east side of the Ashley Creek channel; (2) several smaller springs also issue directly from the Weber Sandstone on the west side of the channel; and (3) several smaller springs and seeps issue from the channel bottom.[27] High above Ashley Creek on both sides of the canyon, the Park City Phosphate Formation crops out on the surface while the Weber Sandstone formation lies directly below it.[28] Both formations slope south at from 10 to 20 degrees below the horizontal.[29] The phosphate bearing part of the formation (lower 20 to 30 feet) will be excavated and removed during mining.

Recharge for the Ashley Springs is mostly from surface water flows infiltrating into the karstic[30] Madison Limestone Formation at a site referred to as the Dry Fork Sinks; these are located about 10.5 miles west and north of the discharge point. Dry Fork Sinks are about 1,820 feet higher than the spring so there is considerable hydraulic head to move the water.[31] See Figures 24 and 25. An additional source of water for Ashley Springs is from a losing reach of Ashley Creek itself about seven miles upstream of the springs.[32]

FIGURE 25
Ashley Springs Recharge Path & Property Ownership

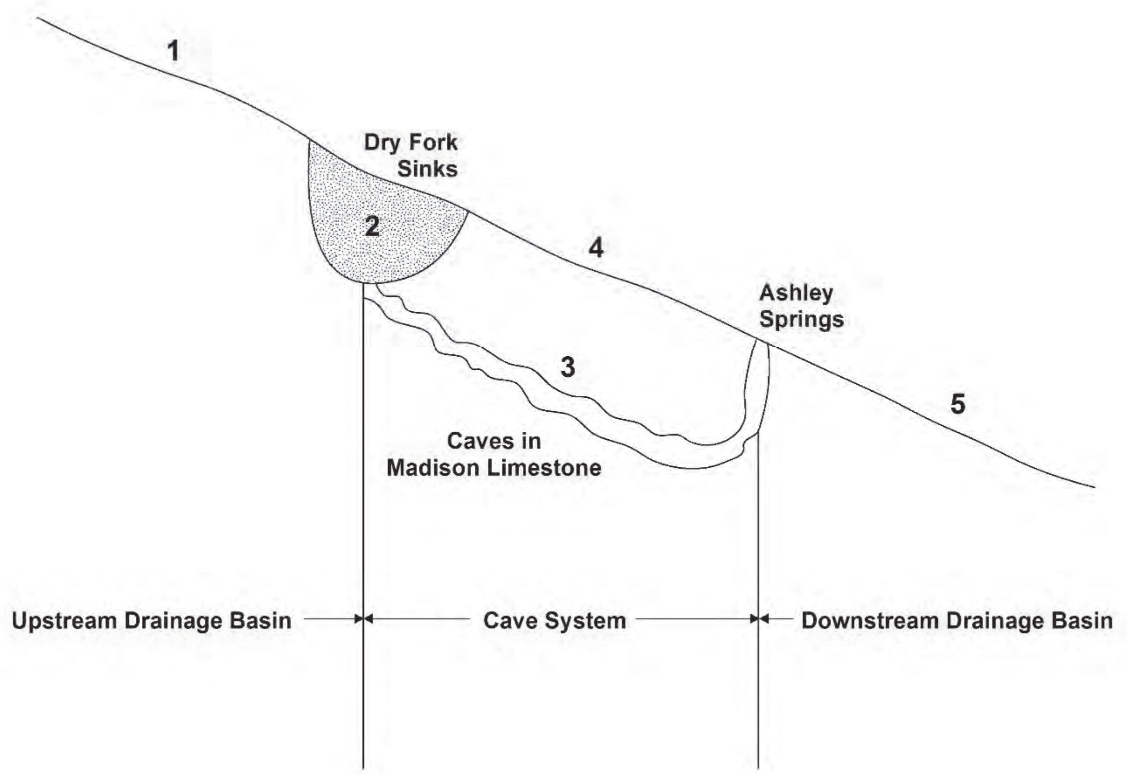


Colored dye tests done in 1971 determined that, "The main Dry Fork Sinks are the major source of the flow of Ashley Springs. The tests gave no evidence that the water entering the Dry Fork Sinks has any other place of discharge…"[33] It took only three days for the dye to appear.[34] See red arrowed line in Figure 25.

Based on the dye tests, groundwater flow from Dry Fork Sinks to Ashley Springs takes three days to travel about 10.5 mile. This is approximately 13 feet per minute or 0.2 feet per second. This is exceptionally fast for subsurface flows and, from a geologic perspective, indicates an unobstructed underground flow path between the two points. As indicated by the red arrowed line in Figure 25, the underground flow path appears to pass directly under the west area of the phosphate mine lease. The actual path may vary somewhat, but there is little room for variance with the mine lease located so close to Ashley Springs itself.

The connection between the sinks and the spring is confirmed by fine-grained sediments discharging from the spring during high water flows in the spring of the year.[35] Interestingly, the sediments that discharge from Ashley Springs are not related to the drainage area above Dry Fork sinks. "Sediment is produced within the cave system by solution of the limestone. This material is produced year-round by solution of the floor, walls and roof of the cave. Most of the limestone presumably is dissolved by the stream water entering through Dry fork Sinks, but some may be dissolved by waters entering the cave system along secondary openings extending up the dip of the limestone."[36] Chemical analyses of the sediments show that water discharging from the springs is derived only from the limestone. During the increased spring runoff, the increased flows scour out the sediments accumulated during the previous year from the walls, roof and pockets of the cave system.[37] This process is shown schematically in Figure 26.

FIGURE 26
Schematic Diagram of Water and Sediment Movement (Dry Fork to Ashley Springs)



Taken from *Karst Hydrology of the South Slope of the Uinta Mountains, Utah* by Andrew E. Godfrey, 1985, page 284.

Figure 26 is a schematic diagram of water and sediment movement in the Dry Fork-Ashley Spring system. It functions as follows:[38]

1. Water and some sediment are supplied to the sinks and cave system from the upstream basin,
2. Sediment is filtered out in the sand and gravel which fill the sinks,
3. Water flows through the cave system year round and dissolves the limestone of the cave walls releasing an insoluble residue,
4. During high flow, water overrides the sinks and flows down the surface channel,
5. Water emerges from the cave system at Ashley Spring and flows on downstream, but during high flows at spring runoff, the caves are scoured out so the annual accumulation of insoluble residue is also carried to the downstream drainage basin.

Concern Mining May Impact Flows to Ashley Springs

Considering the surface features and the geology describe above, many people are concerned that the close proximity of the proposed open pit mine would adversely impact Ashley Springs. There are two specific concerns: (1) ground shaking due to ongoing blasting typical in phosphate mines could block, divert or otherwise modify the underground water channels and (2) mining operations might cause contamination of the water issuing from the springs and the water in Ashley Creek.

Concern Phosphate Mining May Contaminate the Water from Ashley Springs and Ashley Creek

Phosphate mines are known to generate waste materials that are potentially harmful to wildlife and to people. Selenium is a naturally occurring metal that is released when waste rock surrounding the phosphate deposit is moved to expose the phosphate ore. Contact with air and water oxidizes selenium, allowing the metal to dissolve and migrate via subsurface and surface waterways. Root systems in plants are able to take up the element and absorb it into the foliage. Selenium is bio-accumulative. Animals eating plants that have absorbed the element are subject to selenium poisoning. This can be lethal. Consumption of animals with high selenium levels by humans and other animals continues accumulation in the food chain.[39] In 2012, "deformed trout were discovered in a creek polluted with selenium runoff from Simplot's Smoky Canyon (phosphate) Mine in Caribou-Targhee National Forest in eastern Idaho."[40] Moreover, "the nearby waterway of Hoopes Springs still measures 70 parts per billion of selenium, 14 times the federal limit."[41]

Production of phosphate fertilizer and phosphate animal feed can result in risks to human health and to the environment from non-radioactive constituents such as arsenic, cadmium, lead and mercury.[42]

Another concern is the radioactive content of the phosphate mineral that can potentially be deposited in streams and/or be leached into local groundwater with the risk of exposure to humans. Phosphate ore naturally contains radionuclides. During processing these are released from the ore and concentrated. This is referred to as Technologically-Enhanced, Naturally-Occurring Radioactive Materials (TENORM).[43] "Phosphate rock contains radionuclides in concentrations that are 10 to 100 times the radionuclide concentrations found in most natural material. Most of the radionuclides consist of uranium and its decay products. Some phosphate rock also contains elevated levels of thorium and its daughter products. The specific radionuclides of significance include uranium-238, uranium-234, thorium-230, radium-226, radon-222, lead-210 and polonium-210."[44]

Materials handling and processing operations can emit radionuclides as dust…[45] "The presence of these radionuclides of natural origin creates a potential need to control exposures of workers and members of the public in accordance with International Atomic Energy Agency safety standards."[46] Considerable effort is directed toward minimizing airborne dust levels in the phosphate processing industry.[47] Members of the public in the vicinity of phosphate rock mining and beneficiation operations may be exposed through (among other pathways) the ingestion of groundwater contaminated with radionuclides migrating from the mining and tailings management facilities.[48] The exposure from this route is normally considered to be low since mines are typically located at considerable distances from residential areas. Moreover, process water is typically recycled within the facility.[49] However, the proposed phosphate mine, with associated processing facilities, is located immediately adjacent to, and on both sides of Ashley Springs and Ashley Creek. With mining continuing for years, and such dust accumulating, and surface water percolating down through them, people are concerned about the possibility of pollution of both surface water and groundwater.

Geology Study of the Situation

In order to address these concerns the U. S. Geological Survey (USGS) was engaged to do a comprehensive and in-depth study of the hydrogeology surrounding Ashley Springs to help determine the potential effects the proposed mining might have on the spring.[50] This study is a major undertaking with a team of hydrologic technicians and hydrologists. It is expected to be completed in the spring of 2016 and will include:[51]

- Studying geologic features for several miles west, north and east of the springs. This will include geologic formations, earth faulting in the area and numerous springs throughout the area.
- Analyzing chemical components of the water from several springs; this may indicate what rock formations the water flows through and provide baseline chemistry for the various bedrock units.
- Investigating possible phosphate mining impacts on Big Brush Creek Springs located in a similar geologic setting a few miles east of the Ashley Springs area. Mining has been going on there for decades.
- Separating flows recorded on Ashley Creek below the springs from flows occurring above the springs. Some of the base flow in Ashley Creek comes from springs in the canyon several miles above Ashley Springs.

Additionally, the study will investigate the hydrologic connection between the Madison Limestone aquifer that supplies water to Ashley Spring and the overlying aquifers in the Weber Sandstone and Park City (phosphate) Formations. This is to address the concern for mining operations to potentially increase the movement of contaminants into Ashley Spring.[52] The USGS study is expected to provide a good indication of whether or not the proposed mine will adversely affect flow to the springs and to Ashley Creek.[53]

Community and Government Involvement

On April 3, 2012 Utah Phosphate Company held an open house in Vernal to inform people of exploratory drilling for the proposed mine. Over 200 people attended. All but one of them, including several public officials, expressed serious concerns about operating a phosphate mine in such close proximity to Ashley Springs and Ashley Creek. Their concerns are the same as those described above. Some of the officials expressing concern include:[54]

- Brad Grammer, Plant Manager, Ashley Valley Water Treatment Plant,
  Central Utah Water Conservancy District
- David Hatch, Ashley Valley Water and Sewer Improvement District, District Manager
- Mike Davis, Ashley Valley Water Reclamation
- Bob Leake, Area Engineer, Utah State Engineer's Office
- Ken Bassett, Vernal City Manager
- JoAnn Cowan, Vernal City Council Member

An informal meeting was held in Vernal on August 31, 2012 to discuss the issue of the proposed mine being so close to such a major water supply. A community-based citizens group, the Uintah Water Source Protection Coalition, has been formed to oppose the proposed mine. Dana Dean, Associate Director of the Utah Division of Oil, Gas and Mining explained that as long as operators meet the rules and statues, the division must grant a permit. Uintah County Commission Chairperson Darlene Burns indicated the commission has ongoing concerns in the matter and the commission is working with SITLA on a possible land exchange.[55]On April 8, 2013 the Uintah County Commission voted unanimously to institute the Ashley Springs Protection Zone Ordinance. The ordinance "draws a protection zone around Dry Forks Sinks extending to the Ashley Springs for the purpose of limiting ground disturbing activities over the underground karst aquifer."[56] The newly passed ordinance will limit mining activity within the protected zone. In effect this ordinance means Uintah County will be asserting police power over state and federal land.[57]

"The Uintah County Commission wants Agrium (parent company of Utah Phosphate Company) to prove no harm will come to the aquifer before any mining is authorized. This is because, once damage occurs, there is no way to fix it. The commission hopes to resolve the controversy by arranging a land swap in which SITLA would give up the Ashley Springs holdings in exchange for federal mineral-rich land elsewhere."[58] Such action will likely take years. Stakeholders include the Federal Bureau of Land Management, SITLA, Utah Phosphate Company (Agrium), Uintah County, Vernal City, Utah Division of Oil, Gas and Mining, and private individuals. There is a wide variety of interests and it is not clear whether all parties can be satisfied by such an arrangement. It appears the situation will drag on for some time.

While not wanting to impede economic development in the basin, the Utah Division of Water Resources encourages taking whatever actions are necessary to preserve the water quality and quantity of such an important source of culinary water as Ashley Springs.

NOTES

[1] A TMDL sets limits on pollution sources and outlines how these limits will be met through implementation of best available technologies for point sources and best management practices for nonpoint sources. For more information, see U.S. Environmental Protection Agency,

"Total Maximum Daily Load (TMDL) Program." Retrieved from EPA's Internet web page: www.epa.gov/owow/tmdl/intro.html, December 2005.

[2] Division of Water Quality, TMDL Section, *Ashley Creek Selenium and Total Dissolved Solids TMDLs*, (Salt Lake City: Utah Department of Environmental Quality, 2003).

[3] Tetra Tech, Inc., Fairfax, Virginia, *TMDLs for Total Dissolved Solids in the Duchesne River Watershed*, (Virginia: 2007).

[4] Ibid., Page 79.

[5] Wingert, Sandy and Carl Adams, *TMDLs for Total Dissolved Solids, Selenium, and Boron in the Pariette Draw Watershed*, (Salt Lake City: Utah Division of Water Quality, 2010).

[6] Ibid., Page 90.

[7] Tetra Tech Inc. *Uinta River, Deep Creek and Dry Gulch Creek TMDLs for Total Dissolved Solids, Uinta River Watershed, Utah*, (2002), Page 6.

[8] MSE, Millennium Science & Engineering and Limno-Tech, Inc., *Total Maximum Daily Load Water Quality Study Brough, Red Fleet, and Steinaker Reservoirs*, (Salt Lake City: 2008).

[9] Ibid., Pages 77-80.

[10] Division of Water Quality, *Matt Warner and Calder Reservoirs TMDL*, (Salt Lake City: Utah Department of Environmental Quality, 2007).

[11] Division of Water Quality, *Strawberry Reservoir TMDL*, (Salt Lake City: Utah Department of Environmental Quality, 2007).

[12] U.S. Environmental Protection Agency, "Storm Water Phase II Final Rule," Fact Sheet 1.0, (Virginia: 2000), Page 1. This fact sheet is a concise, four-page description of the Phase II rules, their intent and who is required to comply. A copy of this and other fact sheets can be obtained from EPA's web page at: www.epa.gov/owm/sw/phase2.

[13] U.S. Census Bureau, "United States Census 2000." Retrieved from the U.S. Census Bureau's Internet web page: http://www.census.gov/main/www/cen2000.html, January 2003. As defined by the Bureau, an urbanized area is "an area consisting of a central place(s) and adjacent territory with a general population density of at least 1,000 people per square mile of land area that together have a minimum residential population of at least 50,000 people."

[14] Units used by the US Environmental Protection Agency and State Departments of Ecology to define animal feeding operations (AFO) and concentrated feeding operations (CAFO). A CAFO is defined as an operation with more than 1000 animal units confined on a site for more than 45 days. Any AFO that discharges manure or wastewater into a natural or man-made ditch, stream or other waterway is also defined as a CAFO. Example animal equivalents for 1000 animal units (AU) are: beef – 1000 head; dairy – 700 head; swine – 2500 pigs weighing more than 55 lb.; poultry – 125,000 broilers or 82,000 laying hens.

[15] Utah Department of Agriculture and Food, "Animal Feeding operations... A Utah Strategy: How Will it Affect You?" A brochure prepared in cooperation with EPA, USDA, NRCS, Utah Department of Environmental Quality, Utah Association of Conservation Districts, and USU Extension.

[16] Utah State University Cooperative Extension, *The Utah Strategy for Animal Feeding Operations Phase II*, 2009, Page 3. This document can be found in pdf format at; https://agwastemanagement.usu.edu/files/uploads/AFO-CAFOFINAL9212009.pdf

[17] Utah Department of Environmental Quality and Utah Department of Agriculture and Food in cooperation with NPS Task Force, *Utah Nonpoint Source Pollution Management Program Fiscal Year 2009 Annual Report*, (Salt Lake City: January 2010), Page 6.

[18] Personal communication with Don Hall, Environmental Scientist, Utah Department of Environmental Quality, September 2011.

[19] Personal communication (letter) from Mike Hyde, Duchesne County, Community Development Director, March 13, 2015.

[20] Retrieved from the Central Utah Water Conservancy District's Internet web page: http://www.cuwcd.com/drinkingwater/ashley.htm, April 15, 2014.

[21] Personal communication with the Plant Manager, Brad Grammer, March 12, 2012.

[22] Personal communication with Dave Hatch of the improvement district, March 30, 2012.

[23] United States Census Bureau, Retrieved from the Internet web page: http://quichfacts.census.gov/qfd/states/49/49047.htm, July 29, 2014.

[24] Spangler, Larry, *Hydrogeology and Vulnerability Assessment of the Ashley Spring Groundwater Flow System, Uintah County, Utah*, (Salt Lake City, Utah: U.S. Geological Survey, 2013), Page 1.

[25] KSL News, Retrieved from the Internet web page: http://www.ksl.com/?sid=19853759, July 29, 2014.

[26] *Utah Division of Oil Gas and Mining, Public Information Center*, File Number E/047/0065, Received February 22, 2012, Approved February 28, 2012. Area calculations approximate.

[27] Utah Department of Natural Resources, *Hydrogeology of the Eastern Portion of the South Slopes of the Uinta Mountains, Utah*, 1971, Page 46.

[28] *Geology of the Uinta River-Brush Creek Area Duchesne and Uintah Counties, Utah*, Geological Survey Bulletin 1007, 1955, pages 45 to 55. Also, *Correlation Chart of Detailed Stratigraphic Sections, From Whiterocks River to Green River, Uintah County, Utah.*

[29] Ibid. *Geologic Map and Structure Sections of the Uinta River-Brush Creek Area, Duchesne and Uintah*

Counties, Utah. See Section 12 near the label, "Ashley Creek Anticlinal Nose."

[30] Karst topography is a landscape formed from the dissolution of soluble rocks such as limestone, dolomite, and gypsum. It is characterized by underground drainage systems with sinkholes, and caves. Retrieved from the Wikipedia website http://en.wikipedia.org/wiki/Karst_topography, July 30, 2014.

[31] Lawrence E. Spangler, *Geology and Karst Hydrology of the Eastern Uinta Mountains - An Overview*, (Utah Geological Association, 2005), Page 209.

[32] Ibid. Page 205.

[33] Utah Department of Natural Resources (1971), Page 46.

[34] Ibid. Figure 12, "Dye Concentrations versus Time – Dry Fork Sinks Test."

[35] Personal communication with Dave Hatch of the improvement district, March 30, 2012.

[36] Andrew E. Godfrey, *Karst Hydrology of the South Slope of the Uinta Mountains, Utah,* (Geology and Energy Resources, Uinta Basin of Utah, 1985), Page 284.

[37] Ibid.

[38] Ibid.

[39] Idaho Conservation League & Boulder-White Clouds Council, *Hardrock and Phosphate Mining in Idaho, (*2002), Pages 22 & 23.

[40] "Two-headed Trout Near Phosphate Mine Spark Pollution Alarm in Idaho." Retrieved from the Internet web page: http://www.allgov.com/news/controversies/two-headed-trout-near-phosphate-mine-spark-pollution-alarm-in-idaho?news=844077, August 26, 2014.

[41] "Mutated Trout Raise New Concerns Near Mine Sites." Retrieved from the Internet web page: http://www.nytimes.com/2012/02/23/science/earth/mutated-trout-raise-new-concerns-over-selenium.html?pagewanted=2, August 26, 2014.

[42] International Atomic Energy Agency, *Radiation Protection and Management of NORM Residues in the Phosphate Industry,* (IAEA: Vienna, 2013), Page 2.

[43] "Radiation Protection Laws and Regulations." Retrieved from the Internet web page: http://www.epa.gov/radiation/tenorm/regs.html, August 27, 2014.

[44] "Phosphate Rock Processing" Retrieved from the Internet web page: http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s21.pdf, August 27, 2014, Page 11.21-4.

[45] Ibid.

[46] International Atomic Energy Agency (2013), Foreword.

[47] Ibid., Pages 18-32.

[48] Ibid., Page 52.

[49] Ibid., Page 53.

[50] Personal communications with Lawrence E. Spangler, Ground-water Hydrologist, U. S. Geological Survey, Salt Lake City, Utah, May 15, 2014.

[51] Ibid.

[52] Spangler, 2013, Pages 2 & 4.

[53] Ibid.

[54] Vernal Express, "Dry Fork, Maeser residents concerned about proposed phosphate mine." Retrieved from the Internet web page: http://www.ubmedia.biz/vernal/news/article_f8239845-01f6-5989-aac1-d8de72b11381.html, August 26, 2014.

[55] Vernal Express, "Group tries to stop mine exploration." Retrieved from the Internet web page: http://www.ubmedia.biz/vernal/news/article_9635077d-dbe3-5237-841f-c34e12976f53.html, August 27, 2014.

[56] Vernal Express, "County passes protection ordinance for springs." Retrieved from the Internet web page: http://www.ubmedia.biz/vernal/news/article_a73c6d7a-a208-11e2-856a-001a4bcf887a.html, August 27, 2014.

[57] Ibid.

[58] Salt Lake Tribune, "Phosphate mine could harm Vernal's water source, residents fear." Retrieved from the Internet web page: http://www.sltrib. com/sltrib/news/57724369-78/ashley-phosphate-utah-springs.html.csp, August 29, 2014.

8

THE ENVIRONMENT & OTHER MATTERS

If water planners and managers in the Uintah Basin are to effectively meet future water needs, they will need to do more than provide adequate water supplies and delivery systems. Water supply decisions can greatly impact the environment and recreation. For the most part, water planners and managers are aware of these impacts and are working to protect these important values. However, there is still much that can be done. This chapter discusses these in more detail, as well as other matters not readily included in previous chapters will be covered.

THE ENVIRONMENT

Threatened, Endangered and Sensitive Species

In 1973, the federal Endangered Species Act (ESA) was passed by Congress to prevent plant and animal species from becoming extinct. Although the ESA has had some success, it has been widely criticized because of its negative impacts on the communities located near threatened and endangered species. Once a species is federally listed as either threatened or endangered, the ESA restricts development, land management and other activities that may impair recovery of the species.[1] As a preemptive measure, species in Utah under consideration for federal listing are given a special designation and are managed by the state in an effort to preclude their listing. These species are listed as "candidate" species (CS). In addition, the state also has studied other "species of concern" (SPC) that may be covered by a conservation agreement, if sufficient evidence supports such a listing.

Forty species in the Uintah Basin are listed as candidate, threatened or endangered.[2] As of January 2012 two of these species are thought to no longer exist in Utah, they are; the gray wolf and the "threatened" brown grizzly bear. While once thought to be extinct, the black footed ferret was found to live in Wyoming.[3] Portions of that population have been successfully introduced into Coyote Basin, south of Myton, in Utah.[4]

The Utah Sensitive Species List identifies the species most vulnerable to population or habitat loss. In addition to the eight federally listed species (S-ESA), Table 30 lists the state's seven candidate species (CS) and 21 species of concern (SPC) in the Uintah Basin.[5] The Utah Division of Wildlife Resources' goal is to develop and implement appropriate conservation strategies for these species that will preclude their being listed as threatened or endangered.[6]

In 1998, the Utah Legislature created the Endangered Species Mitigation Fund (ESMF) to help protect essential habitat for Utah's threatened, endangered and sensitive species. The fund makes it possible for Utah land and water developers to continue responsible economic growth and development throughout the state while providing for the needs of various wildlife species. Through innovative, cooperative partnerships funded by the ESMF, state wildlife managers are working to create conservation and habitat agreements aimed at down-listing existing threatened and endangered species and avoiding the listing of other sensitive species. The ESMF provides a stable, non-lapsing revenue base which addresses the needs of Utah communities, local government and citizens who have struggled financially to comply with the requirements of federal law.[7]

TABLE 30
Uintah Basin Listed Species

Species	Listing	Species	Listing
American White Pelican	SPC	Greater Sage-Grouse	S-ESA
Bald Eagle	SPC	Humpback Chub	S-ESA
Big Free-Tailed Bat	SPC	Kit Fox	SPC
Black-Footed Ferret	S-ESA	Lewis's Woodpecker	SPC
Bluehead Sucker	CS	Long-Billed Curlew	SPC
Bobolink	SPC	Mountain Plover	SPC
Bonneville Cutthroat Trout	CS	Northern Goshawk	CS
Bonytail	S-ESA	Northern Leatherside Chub	SPC
Brown (Grizzly) Bear	S-ESA	Razorback Sucker	S-ESA
Burrowing Owl	SPC	Roundtail Chub	CS
Canada Lynx	S-ESA	Short-Eared Owl	SPC
Colorado Pikeminnow	S-ESA	Smooth Greensnake	SPC
Colorado River Cutthroat Trout	CS	Spotted Bat	SPC
Columbia Spotted Frog	CS	Three-Toed Woodpecker	SPC
Cornsnake	SPC	Townsend's Big-Eared Bat	SPC
Desert Mountainsnail	SPC	Western Pearlshell	SPC
Ferruginous Hawk	SPC	Western Red Bat	SPC
Flannelmouth Sucker	CS	Western Toad	SPC

S-ESA = Federally-Listed or Candidate species under the Endangered Species Act.
SPC = Utah Wildlife Species of Concern - a wildlife species or subspecies within the state of Utah for which there is credible scientific evidence to substantiate a threat to continued population viability.
CS = Species receiving special management under a Conservation Agreement in order to preclude the need for Federal listing.
Source: List compiled using the Utah Natural Heritage Program's Biodiversity Tracking and Conservation System (BIOTICS) Last updated on March 29, 2011. Utah Division of Wildlife Resources.

In 2001, the State Wildlife Grants (SWG) program was established to increase funds necessary for the conservation of fish and wildlife species. SWG is now the nation's core program to help keep fish and wildlife from becoming federally threatened and endangered. Efforts are underway in Utah to restore habitat, enhance or reintroduce native species, and improve the stewardship of public and private lands using grant funds. In order to receive these grants from the federal government, states are required to submit a Comprehensive Wildlife Conservation Strategy outlining conservation priorities for up to 10 years to:

- Identify priority fish and wildlife species and their habitats,
- Assess threats to their survival, and
- Identify actions that may be taken to conserve them over the long term.

Utah's strategy was accepted and approved by the U.S. Fish and Wildlife on September 9, 2005, and will help sustain and enhance the ecological, social and economic viability of communities to ensure a better quality of life for all. Funds obtained through this program must be matched with state or private money.[8]

Upper Colorado River Endangered Fish Recovery Program[9]

The Upper Colorado River Endangered Fish Recovery Program was established to help bring four species of endangered fish back from the brink of extinction: the humpback chub, bonytail, colorado pikeminnow and razorback sucker. The program is a unique partnership of local, state, and federal agencies, water and power interests, and environmental groups working to recover endangered fish in the Upper Colorado

River Basin. The program allows water development to proceed in accordance with federal and state laws and interstate compacts. This major undertaking involves restoring and managing stream flows and habitat, boosting wild populations with hatchery-raised endangered fish, and reducing negative interactions with certain nonnative fish species such as northern pike, bass and green sunfish. The goal of recovery is to achieve natural, self-sustaining populations of endangered fish so they no longer require protection under the ESA.

The recovery program was initiated in 1988 with the signing of a cooperative agreement by the Governors of Colorado, Utah and Wyoming; the Secretary of the Interior; and the Administrator of the Western Area Power Administration. These parties have agreed to extend the cooperative agreement through September 30, 2023.[10] The Recovery Program provides ESA compliance for continued operation of federal water and power projects in accordance with project purposes.

The program's success is a direct result of the active commitment and participation of its partners[11] and relies on goals to develop and implement management actions and measure success. The recovery goals provide objective, measurable criteria for downlisting to "threatened" and delisting (removal from ESA protection). Recovery is based on reduction of threats and improvement of a species' status during the time it is listed under the ESA. Recovery goals identify the number and age of fish that comprise a self-sustaining wild population. They also identify site-specific management actions that reduce threats to the species. The U.S. Fish and Wildlife Service (USFWS) will consider downlisting or delisting the endangered fishes once the required demographic and genetic standards for self-sustaining populations are reached and the necessary management actions are achieved to reduce the threats that caused the fish to be listed. The USFWS approved the initial recovery goals on August 1, 2002, with the requirement that they be reviewed and updated at least every five years to include any new information. The most current status of recovery efforts[12] are shown in Table 31.

The recovery program works cooperatively with water and power customers and landowners to improve fish habitat. Projects include constructing fish passages at diversion dams for endangered and other native fishes; screening diversion canals to keep fish from entering and becoming trapped, and acquiring and restoring floodplain habitat to serve primarily as fish nursery areas. Some recovery measures benefit more than just the endangered fish. In some locations, river habitat improvements increase the regeneration of cottonwoods and willow trees along the river. Cottonwoods and willows are an important source of food and shelter for birds and mammals and provide a shady and pleasant place to enjoy the river.

Wetland[13] and Riparian[14] Restoration

Due to human encroachment, wetland and riparian environments in the Uintah Basin have been impacted in many areas. While wetland and riparian corridors cover only a small percentage of the landscape, these habitats harbor a large variety of wildlife, provide flood protection, and perform a wide number of ecological functions that maintain the integrity of stream channels and the quality of the water passing through them. In some areas of the Uintah Basin, diminished water flows have substantially reduced periodic flooding and the overall supply of water wetland and riparian areas depend on, diminishing their overall area and reducing the effectiveness of those areas that remain. Although reservoirs can increase the total acreage of wetlands along the river reach they inundate, fluctuating water levels within the reservoir can diminish those wetlands ability to function normally. The regulation of river flows by dams also reduces periodic flooding and leads to channelization of the river downstream of the reservoir, reducing nutrients to wetland areas and drying up many of them. Replacing or mitigating the impacts of water development on these important areas has been recognized as an important part of water development in the Uintah Basin since the 1950s.

One entity currently working to protect and restore riparian and wetland corridors in the Uintah Basin is the Utah Reclamation Mitigation and Conservation Commission. This commission is a branch of the federal government that is responsible for the funding, design, and implementation of projects to offset the impacts to fish, wildlife and other resources caused by the Central Utah Project and other federal projects in Utah. The commission is currently involved in the Lower Duchesne River Wetlands Mitigation Project,

TABLE 31
Estimated Timelines for Downlisting/Delisting[15]

Species	Estimated Dates[1]	Downlisting Criteria[2]
Colorado Pikeminnow	2018 / 2023	Management Actions: 78% of the actions required by USFWS to downlist have been met or partially met. Demographics: Preliminary population estimates gathered in 2011 and 2012 from portions of the Green River sub-basin indicate a persistent decline. Researchers point to nonnative predators as a primary cause. USFWS thought that downlisting could be considered in 2013, but postpones until nonnatives are reduced and Pikeminnow show signs of rebound.
Humpback Chub	2016 / 2019	Management Actions: 60% of the actions required by USFWS to downlist have been met or partially met. Demographics: IF, over a 5-year period, one of the five upper Basin populations rebounds to meet the "core criteria" of 2,100 adults, and the other Upper Basin populations increase (low to mod likelihood) - Downlisting could occur in 2016.
Razorback Sucker	2020 / 2023	Management Actions: 85% of the actions required by USFWS to downlist have been met or partially met. Demographics: Stocking programs in the GR, CO, and San Juan rivers appear to be successful. Neither Program has initiated population estimation, but current information indicates the 2020 timeline is still achievable.
Bonytail	2020 / 2023	Management Actions: 72% of the actions required by USFWS to downlist have been met or partially met. Demographics: Stocking programs in the GR and CO rivers have been marginally successful. However, there is not enough new information to suggest the 2020 deadline should be revised.

[1]Estimated delisting dates assume that threats to recovery have been addressed.
[2]As presented in the U.S. Fish and Wildlife Service's draft 5-yr reviews. The Service will determine if these percentages are adequate to downlist.

the Montes Creek Mitigation Site and the Stewart Lake Waterfowl Management Area.

Lower Duchesne River Wetlands Mitigation Project

The Lower Duchesne River Wetlands Mitigation Project is a federal project required to restore and enhance wetland and riparian areas along the Duchesne River. The project fulfills commitments to the Ute Indian Tribe to mitigate wetland losses due to development of the Bonneville Unit of the Central Utah Project (CUP).

The Bonneville Unit of the CUP transports water from the Uintah Basin to the Wasatch Front by way of the Strawberry Aqueduct and Collection System. As a result of all federal and private projects diverting water, Duchesne River flows entering the Green River have decreased from an average of 768,000 acre-feet to 209,000 acre-feet annually. Since the completion of the Upper Stillwater Reservoir, depletions to Rock Creek have averaged 79 percent annually, bringing flows down to approximately 161,000 acre-feet. As a result, the Duchesne River has become more channelized and many of its oxbows have become cut off from river flows and dried up.

Planning efforts to mitigate wetland losses were undertaken jointly by the U.S. Department of the Interior, the Ute Indian Tribe, and the Utah Mitigation and Conservation Commission. The plan that resulted will create or restore 1,025 acres of wetlands and enhance 1,656 acres of existing habitat. Four oxbow systems along the Duchene River between Myton and Randlett Utah would be reconnected to river supplied water. In addition, the Uresk Drain (a five mile long channel cut down into a gravel formation) will be strategically plugged to create large marsh areas. Appropriate wetland and riparian plant species would be planted and some cropland adjacent to the project would be converted to grassland for wildlife forage. All areas will be fenced to exclude livestock. Tamarisk and Russian Olive trees will be removed and controlled as well as invasive weed species.

Mosquito control measures which previously were applied to 34 percent of the project area will be extended to 100 percent of the project area. Up to 120 acres of riparian habitat will be developed each year over a seven year period. The LDWP record of decision was signed in April of 2008. Total project costs including past expenditures and future needs to 2019 are estimated to be about $24 million (2015 dollars).[16]

Montes Creek Mitigation Site

The Montes Creek Wetlands were built to mitigate the effects of the Uinta Basin Replacement Project and Big Sand Wash Replacement Project within the Montes Creek Wildlife Management Area. Overseen by the Utah Reclamation Mitigation and Conservation Commission and Allred Restoration Inc., the project area is located just downstream of Little Montes Creek Reservoir, four miles northeast of Roosevelt, Utah. The project entailed constructing five ponds through excavation, and seven smaller ponds through the plugging of a large drain channel downstream of the main project area. Russian olive trees were removed from 24 acres of existing wetlands and four acres of upland areas. Planting with native and local plants was completed by the Utah Division of Wildlife Resources, which included wetland and riparian seed blends as well as woody plant species. Water for the project comes from groundwater sources for much of the year and can be supplemented with irrigation water from the reservoir in late summer if needed. Since completion in the spring of 2009, the project has seen robust growth and will be monitored for five years to measure success.

Stewart Lake Waterfowl Management Area

Stewart Lake Waterfowl Management Area (WMA), which supports a considerable acreage of wetlands, covers more than 500 acres adjacent to the Green River just above the confluence of Ashley Creek. The WMA was set aside by the State of Utah in 1936, primarily as waterfowl habitat. Stewart Lake itself covers approximately 300 acres when full and was supplied with water from Ashley Creek and the Green River until 1981. Between 1981 and 1997, the primary water sources for the lake were five subsurface irrigation drains, draining about 700 acres of irrigated farmland that overlay the of Mancos Shale formation, which contains selenium. Between 1997 and 2001, Stewart Lake was intentionally kept dry except for small contributions from the irrigation drains.

Studies show that adverse effects occur in some fish and wildlife species when the concentration of total recoverable selenium is as low as two to four micrograms per liter (µg/L). Reproductive impairment in some species of fish can occur when the concentration of selenium in whole-body fish tissue reaches four to six µg/L dry weight.

Mitigation was undertaken by the National Irrigation Water Quality Program (NIWQP). This program was organized by the Department of the Interior (DOI) and includes scientists from the U.S. Geologic Survey, USFWS, U. S. Bureau of Reclamation (USBR), and Bureau of Indian Affairs. NIWQP is charged with studying possible adverse effects of DOI managed projects. Mitigation started with draining Stewart Lake and extending subsurface irrigation drains out to the Green River to pass high selenium flows without mixing with lake water. New inlet and outlet structures were built to facilitate the annual filling of Stewart Lake from, and draining to, the Green River in order to flush selenium from the lake's sediments. Additionally, a permanent new source of water low in selenium (2 µg/L) was secured from Brush Creek.

Filling and draining the lake will gradually flush selenium, liberated from bottom sediments by chemical and biological means, into the Green River. The goal is to eventually lower Stewart Lake's selenium concentrations to the target of 4 µg/L, or less. After several cycles of flushing, the anticipated selenium reductions were not realized. It was discovered through additional sampling that another high selenium source of water was entering the lake on its north side. New drains were installed by the USBR and the flushing cycles are continuing under the management of wildlife officials. To date, selenium levels are not low enough to leave the lake filled year round.

High Mountain Reservoir Stabilization

A component of the Uinta Basin Replacement Project (UBRP) was the stabilization of 13 high mountain lakes located in the High Uintas Wilderness Area (HUWA). Details of this project are provided in Chapter 6. These were formerly used to store irrigation water, and were restored to "No-Hazard" levels as mitigation for the UBRP. The water rights from these reservoirs have been transferred downstream for storage in the enlarged Big Sand Wash Reservoir, another feature of the UBRP. Stabilization of these thirteen high mountain lakes has resulted in constant lake water levels year-round. Consequently, stream flows originating in these upper watersheds have returned to natural hydrologic runoff patterns, and wilderness fishery and recreational values are gradually being restored. Operation, inspection, and maintenance impacts formerly required by the dams have been eliminated. Nine of the lakes (Bluebell, Drift, Five Point, Superior, Water Lily, Farmers, East Timothy, White Miller and Deer) are located in the upper Yellowstone Creek watershed and four (Brown Duck, Island, Kidney and Clements) are in the Brown Duck Basin portion of the upper Lake Fork watershed.

Stabilization required removing or plugging outlet works (two dams) and breaching (11 dams) to obtain a status of "no hazard" with the State Engineers office. After each dam was breached, an enlarged spillway or channel was created with gabions (rock filled wire baskets) and riprap placed within the breach to limit erosion. Because of the sensitive nature of the HUWA, all of the work had to be completed with minimal equipment to limit disturbance. Also, because of concerns that a partially breached dam could be a substantial risk for failure, all work on any dam had to be completed in one season.

Instream Flow Maintenance

An instream flow is often defined as "free flowing water left in a stream in quantity and quality appropriate to provide for a specific purpose."[17] In general, the purpose of an instream flow is to provide habitat for fish and other aquatic wildlife; however, an instream flow may also provide water for terrestrial wildlife and livestock watering, maintain critical riparian vegetation, accommodate recreational purposes, or simply enhance the aesthetics of the natural environment. The quantity and timing of instream flows vary with each purpose and are not necessarily the same as a minimum flow. In Utah, there are three ways to obtain instream flows; these are listed below.

Instream Flow Agreements **-** When water storage and diversion facilities are constructed, minimum instream flows are often negotiated among the various water users as a means of mitigating negative impacts of the project to fish and wildlife. These agreements often describe conditions where the minimum flows may be compromised and have no legal mechanism of enforcement. Instream flow agreements are the most common form of stream flow maintenance in Utah.

Conditions on New Water Rights Appropriations **-** Since 1971, the State Engineer has had the authority to place a condition on the approval of a water right application if, in his judgment, approval of the full requested right would "unreasonably affect public recreation or the natural stream environment." In other words, the State Engineer can reject (or reduce the amount of) a new appropriation or reject a change application in order to reserve sufficient flow for recreation or the environment.

Conditions of Permits or Licenses **-** Hydroelectric facilities must receive a license from the Federal Energy Regulatory Commission to operate. Alterations to streams must receive a permit from the Utah Division of Water Rights. Before a license or permit is issued or renewed, the public is given the opportunity to comment. If this process identifies instream flows as critical to other uses of the water, such as wildlife habitat, these flows may become part of the permit or license conditions.

Instream Flow Water Rights

In 1986 the Utah Legislature amended the water rights law of the state to allow the Utah Division of Wildlife Resources to file for changes of a perfected water right that would provide sufficient instream flow for fish propagation. These water rights may be obtained through purchase, lease, agreement, gift, exchange or contribution. Acquisition of such flows must be approved by the legislature before the State Engineer can make a determination. The Utah Division of State Parks and Recreation was later given the same authority.

Instream Flow Agreements in the Uintah Basin

Table 32 lists the minimum instream flow agreements within the Uintah Basin. Some of these flows are part

TABLE 32
Minimum Instream Flow Agreements in the Uintah Basin

Reservoir or Diversion	River	Summer/ Winter Flow (cfs)
Currant Creek Reservoir	Currant Creek	24 / 9
Strawberry Reservoir	Strawberry River	26 / 13
Starvation Reservoir	Strawberry River	15 / 30
Hanna/Tabiona	Duchesne River	12-24 / 7
Upper Stillwater Reservoir	Rock Creek	29 / 23
Flaming Gorge Dam	Green River	800 to 4,800

Source: Central Utah Completion Act Instream Flow Agreements 1980, amended 1990 (Sections 303 and 505).

of the Central Utah Project to help mitigate damages from the construction of new projects and various diversions. Most of the minimum flows are already set; however, two of the segments shown are in progress of acquiring and establishing critical information to determine minimum flows.

Wild and Scenic River Designation

The Wild and Scenic Rivers Act of 1968 states that, "certain selected rivers of the nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural, or similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."[18] Only Congress has the authority to designate a stream or river segment as "Wild and Scenic." In most cases, such designation would prevent construction of flow modifying structures or other facilities on designated river segments. The area for which development is limited along a wild and scenic river varies, but includes at least the area within one-quarter mile of the ordinary high water mark on either side of a designated river segment.

Through the Omnibus Public Lands Management Act of 2009 (P.L. 111-11), Congress designated approximately 165.5 miles of the Virgin River and its tributaries across Federal land, within and adjacent to Zion National Park as part of the National Wild and Scenic Rivers System. Eleven river segments totaling 19 miles of the Virgin River drainage are managed by BLM and all are classified as "wild". Each of the segments flows into or out of Zion National Park and a majority are within wilderness areas that were also designated in the 2009 legislation.[19] The recent completion of reviews by the U.S. Forest Service for wild and scenic suitability as well as the BLM Resource Management Plans for Utah, however, have identified river segments within the Uintah Basin that could be included in the national inventory. These segments are shown in Table 33 and their location briefly described below.

U.S. Forest Service[20]

For inclusion in the National Wild and Scenic Rivers System the Forest Service conducted an environmental impact statement that evaluated 86 eligible river segments totaling 840 miles, located on National Forest lands in Utah. The study was concluded in November of 2008 when a Record of Decision was signed by Forest Service officials designating the river segments that were found suitable. The Forest Service determined that 10 river segments totaling 108 miles (74 miles classified as Wild, 22 miles classified as Scenic, and 12 miles classified as Recreational) are suitable to be designated by Congress as components of the National Wild and Scenic Rivers System within National Forest boundaries. The Forest Service consulted with the Bureau of Land Management and National Park Service in evaluating the impacts of designation to segments managed by other agencies.

Two river segments in the Ashley National Forest lying within the Uintah Basin were found to be suitable; the Green River from the Flaming Gorge Dam to the National Forest Boundary 13 miles south (designated as scenic), and the Upper Uinta River, including Gilbert Creek, Center Fork, and Painter Draw – a total of 40 river miles (designated as wild).

Bureau of Land Management

There are four BLM Areas of Responsibility (AOR) that manage lands that lie within the Uintah Basin. They are the Salt Lake, Vernal, Price and Moab offices. The Green River is the only Uintah Basin River having segments recommended for Wild and Scenic River Designation within these BLM AORs.

TABLE 33
Proposed Wild and Scenic River Segments in the Uintah Basin

Managing Entity	Segment Recommended for Designation	Miles	Characteristic
Ashley National Forest	Upper Uinta River including Gilbert Creek, Center Fork and Painter Draw	39.9	Wild
Ashley National Forest	Green River - Flaming Gorge Dam to N.F. boundary at Little Hole	12.6	Scenic
BLM Vernal	Green River - Little Hole to State Line	12	Scenic
BLM Vernal	Green River - Ouray (Duchesne River confluence) to Carbon County Line	27	Scenic
BLM Price	Green River - Carbon County Line to Chandler Canyon (Desolation Canyon)	44.5	Wild
BLM Price	Green River - Chandler Canyon to Florence Creek (Desolation Canyon)	8	Scenic
BLM Price/Moab	Green River - Florence Creek to Nefertiti Boat Ramp (Desolation and Gray Canyons)	19	Wild
BLM Price/Moab	Green River - Nefertiti Boat Ramp to Swasey's Boat Ramp (only 3 of 8 miles in Uintah Basin)	3	Recreational
166 river miles total in the Uintah Basin: 103.4 Wild, 59.6 Scenic & 3 Recreational miles			

The first segment of the Green River (within the BLM Vernal AOR) extends from the Ashley National Forest Boundary at Little Hole to the state line 12 miles east, and managed as scenic. A section from Ouray (near the confluence with the Duchesne River) south 27 miles to the Carbon County line, is also being managed as scenic. The next section of river is managed as wild by the Price BLM and extends from the Carbon County line 44.5 miles south (through Desolation Canyon) to Chandler Canyon. The next three sections of the Green River flow through Gray Canyon and are jointly managed by both the Price and Moab BLM offices whose areas extend to the west and east of the river respectively. The first eight-mile section extends south from Chandler Canyon to Florence Creek and is managed as scenic. The next 19 mile section extends from Florence Creek to the Nefertiti Boat Ramp and is managed as wild. The final section extends eight miles (only three of these miles are in the Uintah Basin) from the Nefertiti Boat Ramp to Swasey's Beach Boat Ramp and is managed for recreational values.

Both the BLM and the National Forest Service will manage the respective river segments as if they were designated by Congress until they are officially designated in order to maintain their outstanding characteristics.

Wilderness Areas

In 1976, the President Gerald Ford signed the Federal Land Policy and Management Act. This act directed the Bureau of Land Management (BLM) to conduct a study of its remaining roadless areas and make recommendations as to whether or not each area should become a congressionally designated Wilderness Area. In 1980, BLM completed an inventory of the roadless areas in Utah and identified 95 Wilderness Study Areas totaling approximately 3.3 million acres. Table 34 lists the Wilderness and Wilderness Study Areas in the Uintah Basin. In order to be considered a Wilderness Study Area (WSA), an area must possess the following characteristics as identified in the Wilderness Act:[21]

- Size - roadless areas of at least 5,000 acres or of a manageable size, and roadless islands;
- Naturalness - generally appears to have been affected primarily by the forces of nature;

- Opportunities - provides outstanding opportunities for solitude or primitive and unconfined types of recreation.
- WSAs may also possess special qualities such as ecological, geological, educational, historical, scientific and scenic values.

Once an area is designated as a WSA, BLM manages the area as a wilderness area until Congress determines if it should indeed be classified as wilderness by law. In managing a WSA, the BLM must provide opportunities for the public to use wilderness for recreational, scenic, scientific, educational, conservation and historical purposes in a manner that will leave the area unimpaired for future use and enjoyment as wilderness.[22] The High Uintas Wilderness Area is the only area in the Uintah Basin that has been designated by Congress as a Wilderness Area. There are currently nine WSAs in the Uintah Basin (see Figure 27).

OTHER MATTERS

High Hazard Dams

Utah's dam safety law governs the hazard designation of dams. Under these statutes, all dams that impound over 20 acre-feet of water are assigned a hazard rating. Dams impounding less than 20 acre-feet may be ruled exempt if they do not constitute a threat to human life or property. Hazard ratings reflect high, moderate or low damage potential if the dam were to fail. Hazard ratings do not reflect the condition or reliability of the dam, but rather the potential for loss of life or property damage in the event the dam failed. Ratings are assigned as follows:

- High Hazard - those dams which, if they fail, have a high probability of loss of life, extensive economic loss, including damage to critical public utilities.
- Moderate Hazard - those dams which, if they fail, have a low probability of causing loss of human life, but would cause appreciable property damage, including damage to public utilities.
- Low Hazard - those dams which, if they fail, would cause minimal threat to human life, and economic losses would be minor, or limited to damage sustained by the owner of the structure.

Hazard ratings determine the frequency of inspection. High, moderate and low-hazard dams are inspected every one, two and five years, respectively. Following inspection, a letter from the State Engineer suggests maintenance needs and requests specific repairs. The State Engineer can declare the dam unsafe and order it drained and even breached after drainage. Efforts are always made to work with dam owners to schedule necessary repairs.

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

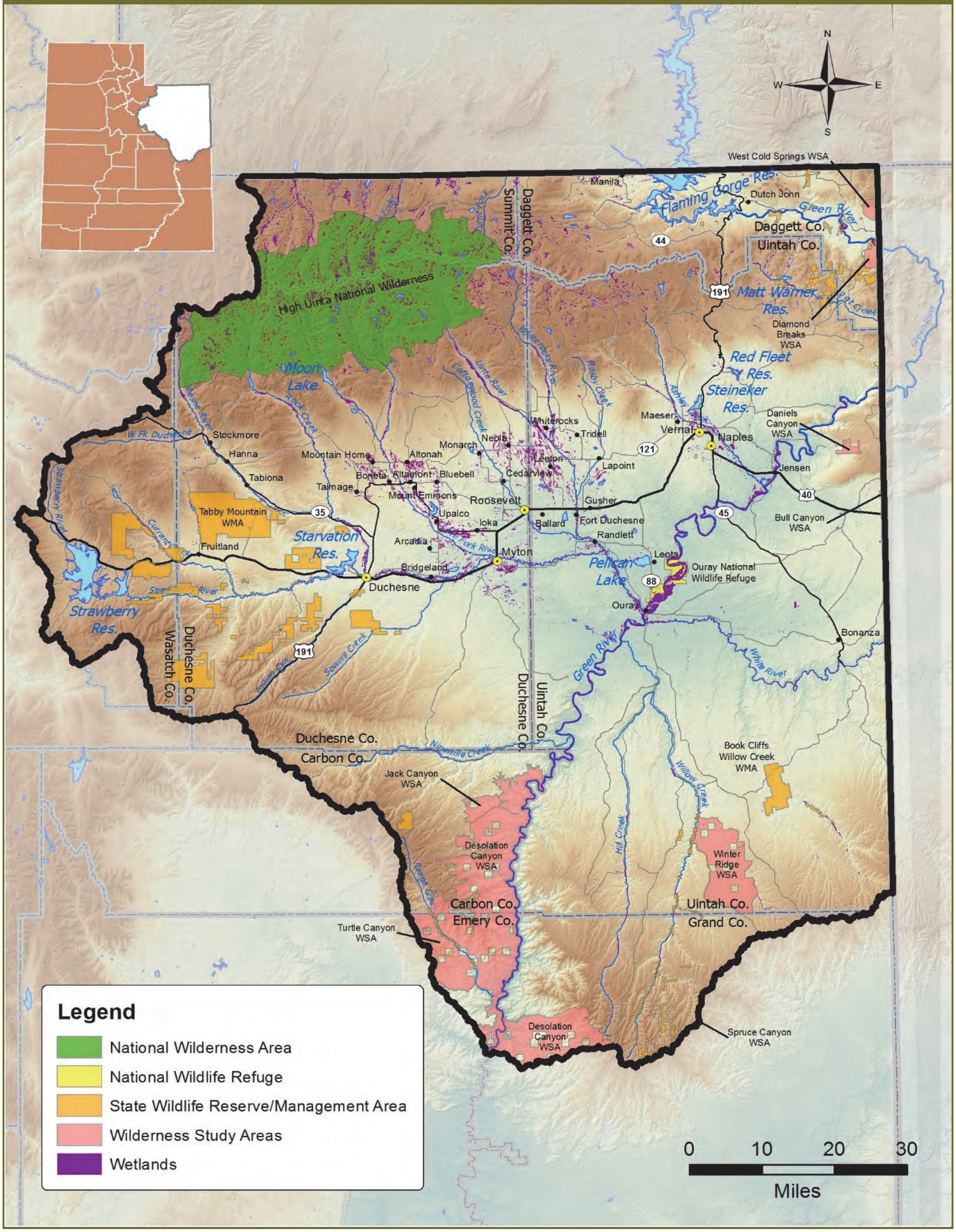
The State Engineer assesses the ability of all high hazard dams to meet minimum safety requirements. The assessment includes seismic stability

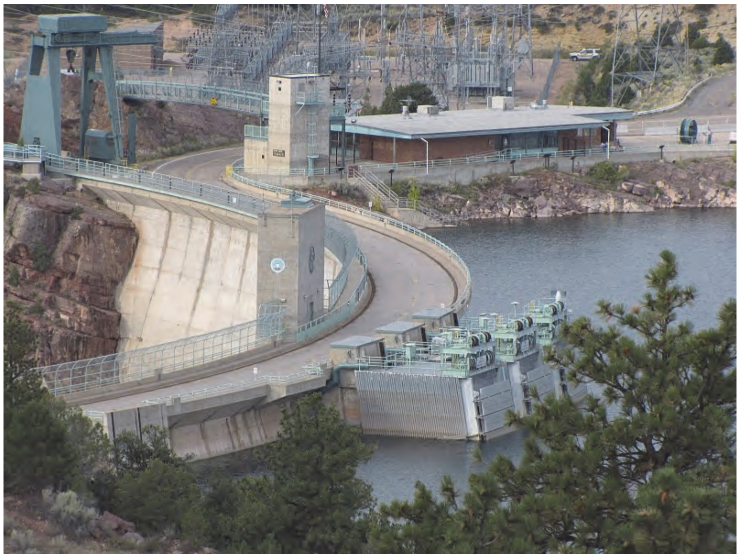
TABLE 34
Uintah Basin Wilderness and Wilderness Study Areas

Managing Entity	Area	Acres
U.S. Forest Service[1]	High Uintas Wilderness	456,705
BLM-Vernal	Bull Canyon WSA	598
BLM-Vernal	Daniels Canyon WSA	2,516
BLM-Moab / Price	Desolation Canyon WSA	184,979
BLM-Vernal	Diamond Breaks WSA	3,924
BLM-Price	Jack Canyon WSA	7,203
BLM-Moab	Spruce Canyon WSA	399
BLM-Price	Turtle Canyon WSA	27,739
BLM-Vernal	West Cold Springs WSA	3,283
BLM-Vernal	Winter Ridge WSA	43,322
	TOTAL	**730,668**

[1] Wasatch-Cache and Ashley National Forests.

FIGURE 27
Wetlands, Wildlife Management Areas and Wildlife Preserves





Flaming Gorge Dam and outlet works.

and the dam's capability to pass the appropriate Inflow Design Flood.

Table 35 lists the High Hazard Dams in the Uintah Basin. The Division of Water Rights rates federal dams, but these are exempt from the requirements of the State Dam Safety Program. The Bureau of Reclamation inspects dams constructed under its programs. The federal government holds title to all the major reservoirs in the Uintah Basin. As new storage projects are completed, water conservancy districts usually take over their management and maintenance.

The State Engineer must examine dams of significant hazard potential at least once every five years. This office is also responsible for setting minimum maintenance and operating standards for dams, and for implementing a program for the investigation of the state's 25 top priority dams each year for the purpose of determining compliance to such minimum standards. These standards are basically the same as the design criteria for new dams, for spillway capacity, seismic and static stability.

Flaming Gorge Dam Operations

Background

The Green River is the largest water course in the Uintah Basin. The river flows through Flaming Gorge Reservoir and continues downstream capturing the outfall of all tributary streams in the basin. Given Flaming Gorge Dam's importance to the Uintah Basin, a brief description of the dam and its operations is included here. Basic information about the dam and reservoir include the following:[23]

- Concrete thin-arch structure with maximum height of 502 feet and crest length of 1,285 feet.
- Total capacity 3,788,900 acre-feet and active capacity 3,515,700 acre-feet.
- Surface area 42,020 acres at normal water surface elevation.
- Floodwaters spill through a tunnel spillway with a maximum capacity of 28,800 cubic feet per second.
- The outlet works consist of two 66-inch hollow jet valves through the dam. Total discharge capacity is 4,000 cubic feet per second.
- Three, 10-foot-diameter penstock pipes near the center of the dam convey water to the powerplant which houses three 50,000-kilowatt generators. See photo above.

Dam Operation Decision-Making Process

The Colorado River Compact, and subsequent legislation, divided the western states through which the river flows into upper basin and lower basin states. The 1956 Colorado River Storage Project Act (CRSPA), facilitated the development of the water and power resources of the upper basin, and authorized construction of various projects, including Flaming Gorge Dam. [24] The dam was completed in 1962 and is owned and operated by the U.S. Bureau of Reclamation (USBR).[25] In response to the 1973 Endangered Species Act, USBR began regulating releases to accommodate endangered fish research and recovery efforts. A 1985 agreement between USBR and the U.S. Fish and Wildlife Service revised releases to assist in the protection of critical nursery habitats for endangered fish in the Green River downstream from Jensen, Utah. In general, this has resulted in reduced fluctuation of power demand releases.[26]

Continuing research and collaboration resulted in establishment of the Upper Colorado River Endangered Fish Recovery Program in 1988, which was discussed earlier in this chapter. In 2000, the program issued

TABLE 35
Uintah Basin High Hazard Dams

Dam Name	Ownership	Year Completed	Height (feet)	Capacity (ac-ft)
Midview (Lake Boreham)	BIA	1937	54	5,800
Bottle Hollow	BIA	1970	86	11,100
Moon Lake	BR/Moon WUA	1938	101	49,500
Steinaker	CUP/BR	1961	162	38,170
Flaming Gorge	CUP/BR	1964	502	3,789,000
Starvation	CUP/BR	1970	200	164,120*
Soldier Creek	CUP/BR	1973	251	1,106,500
Currant Creek	CUP/BR	1977	177	15,670
Red Fleet	CUP/BR	1980	161	26,170
Upper Stillwater	CUP/BR	1987	195	32,010
Montes Creek	Dry Gulch Irr. Co.	1937	48	1,220
Twin Pots	Moon Lake WUA	1931	38	4,050
Browns Draw	Moon Lake WUA	1981	89	5,900
Big Sand Wash	Moon Lake WUA	2006	136	25,740
Red Wash	Mosby Irr. Co.	2005	74	2,520
Cliff Lake (Duchesne)	Ouray Park Irr. Co.	1957	28	1,090
Whiterocks Lake	Ouray Park Irr. Co.	1957	29	920
Brough	Ouray Park Irr. Co.	1975	75	4,000
Cottonwood	Ouray Park Irr. Co.	1982	76	6,270
Red Creek	Red Creek Irr. Co.	1960	107	5,700
Long Park (Daggett)	Sheep Cr. Irr. Co.	1980	112	13,700
Paradise Park	Whiterocks Irr. Co.	1924	42	3,140
Chepeta Lake	Whiterocks Irr. Co.	1944	42	2,810
LaPoint	Whiterocks Irr. Co.	1985	70	1,700
M & S Dam	Whiterocks Irr. Co.	2010	80	2,700
East Park	Wildlife Resources	1919	35	3,780
Bullock Draw	Wildlife Resources	1970	35	1,040

*Volume per Tom Bruton, CUWCD.

flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam. [27]

USBR prepared an Environmental Impact Statement (EIS) on the operation of Flaming Gorge Dam that describes the effects of operating Flaming Gorge Dam to achieve, to the extent possible, the information outlined in the flow recommendations. The EIS was completed in November 2005 and a Record of Decision (ROD) was signed February 16,

Flaming Gorge Reservoir looking east.

2006. The result was to operate Flaming Gorge Dam to protect and assist in recovery of the populations and designated critical habitat of the four endangered fishes. This was done while maintaining all authorized purposes of the Flaming Gorge Unit of the Colorado River Storage Project, including those related to the development of water resources in accordance with the Colorado River Compact, and to comply with Section 7 of the Endangered Species Act.[28] In addition, the ROD established the Flaming Gorge Technical Work Group. This group consists of biologists and hydrologists from the U.S. Fish and Wildlife Service, Western Area Power Administration, and Reclamation. Its objective is to coordinate with the Recovery Program and annually propose an initial flow regime to the existing Flaming Gorge Working Group. The annual proposal from the Flaming Gorge Technical Working Group considers research flow requests from the Recovery Program on how best to achieve the ROD objectives for the endangered fish based on current year hydrologic conditions and all authorized purposes.[29]

Another organization, the Flaming Gorge Working Group, was formed in 1993 to provide a forum for information exchange and for public groups to express their views on operation of the dam. It meets twice a year, usually in April and August. Information and recommendations from the Flaming Gorge Technical Work Group are presented to the Flaming Gorge Working Group. Reclamation considers input from both these groups and develops dam operations consistent with the authorized purposes for the reservoir under the CRSPA, and that best achieve the ROD objectives for the endangered fish.

Hydraulic Fracturing

Much of the Uintah Basin is underlain by shale deposits that are a source of natural gas. In the past, it was not economical to recover much of this gas due to low gas yields from wells; however, with a relatively new technology called hydraulic fracturing, extracting natural gas from these formations has become very profitable. Hydraulic fracturing, also known as "hydrofracking" or simply "fracking," is an innovative process that pumps a mixture of water, sand and chemicals into the shale formation at very high pressures, forming new cracks or fractures in the rock. These cracks release the natural gas trapped within the shale and greatly increase the productivity of each well. The process also produces millions of gallons of toxic wastewater that is laden with petroleum products, chemicals used in the injection mixture, and often natural radioactive elements released from the shale.[30]

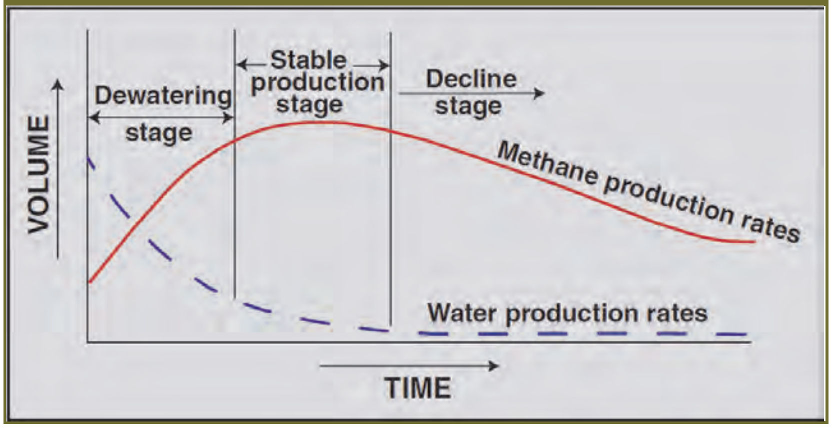
While hydraulic fracturing has been a boon for the oil and gas industry, it is believed by many to be the cause of numerous environmental problems. In fracking-intensive areas, it has been blamed for groundwater contamination, surface water pollution, unhealthy air pollution, and even an increased frequency of small earthquakes. While the industry claims fracking is not the cause of these problems, scientists are beginning to speak out and new evidence is emerging that links hydraulic fracturing to elevated pollution levels. In New York and Pennsylvania, the issue is so controversial that citizens are demanding that elected officials implement new regulations and oversight of fracking activities. In Utah there have been a few complaints about hydraulic fracturing causing groundwater contamination and other problems, but to date none of these have been confirmed to be related to nearby fracking activities. Less than five percent of the Uintah Basin water supply comes from groundwater, and most groundwater wells are outside the area where gas wells are drilled. Moreover, water wells typically do not go deeper than

500 feet while fracking occurs at depths from 4,000 to 10,000 feet.[31] It is unlikely there will be significant problems for the basin water supply due to fracking.

The U.S. Environmental Protection Agency is currently conducting a multi-year study of hydraulic fracturing and is likely to issue new rules and guidelines for hydraulic fracturing activities nationwide. [32] In the meantime, Utah's Division of Oil, Gas and Mining is monitoring industry activities to ensure proper procedures are followed. An Internet website devoted to fracking provides a great deal of information including the following. See http://fracfocus.org/

- How hydraulic fracturing works
- Hydraulic fracturing water use
- Why and what chemicals are used
- State by state regulatory requirements
- Finding a specific well to learn it's characteristics

FIGURE 28
Water and Methane Production Curves For a Typical Coal Bed Methane Well



Source: *Coal Bed Methane: Potential and Concerns*, U. S. Geological Survey, Fact Sheet 123-00, October 2000.

Coal Bed Methane

Groundwater is brought to the surface during the extraction of methane from coal beds. This water is disposed of by reinjection into the ground, surface discharge or evaporation in surface ponds. It has been proposed that this water be used for municipal and industrial or agricultural purposes. This is not feasible for the following reasons.

First, the water is typically salty, having high total dissolved solids or TDS. Average values in the Uintah Basin vary from 8,900 mg/l to 26,000 mg/l.[33] For comparison, the recommended TDS limit for drinking water is 500 mg/l and for stock ponds or irrigation 1,000 to 2,000 mg/l.[34] Treatment costs to bring the water to usable standards are prohibitive.

Second, the amount of water coming to the surface varies widely between basins, and within each basin. The amount of water varies over time with the general trend shown in Figure 28.[35] As can be seen, the water volume drops significantly in a relatively short time as methane is extracted. The time for the water to decrease varies among wells. The decline in water production is permanent. For these reasons, "long-term reliance on produced water should not be encouraged."[36]

Third, the average amount of water produced over the typical 18-year life of a well is only 40 acre-feet.[37] Even with many wells, the low volume of water that could be developed would not justify the investment to make it available to consumers.

Finally, the coal bed methane fields in the Uintah Basin are located primarily in the remote southeast corner of Uintah County, with a minor source in the far southwest part of the basin. Both of these are distant from the population centers in the basin. It's unlikely to be cost effective to transport the water from the source to consumers.

NOTES

[1] Utah Division of Wildlife Resources, *Species on the Edge Benefits to Local Communities*, (Salt Lake City: Dept. of Natural Resources, 2002), 7.

[2] Utah Division of Wildlife Resources, "Federal Threatened and Endangered List by County" (Salt Lake City: Dept. of Natural Resources, March 29, 2011). This

and other lists are updated frequently and can be obtained online at the division's Conservation Data Center: http://dwrcdc.nr.utah.gov/ucdc.

[3] Utah Division of Wildlife Resources, "Black-Footed Ferret," (Salt Lake City: Dept. of Natural Resources, June, 2003) Page 3.

[4] Ibid., Page 4.

[5] Utah Division of Wildlife Resources, *Utah's Sensitive Species List* (Salt Lake City: Dept. of Natural Resources, March 29, 2011).

[6] Utah Division of Wildlife Resources, 2002.

[7] Ibid., Pages 3 & 4.

[8] Utah Division of Wildlife Resources, *Utah Comprehensive Wildlife Conservation Strategy*. Retrieved from the Utah Division of Wildlife Resources' Internet web page: http://wildlife.utah.gov/cwcs/, November 2005.

[9] "Upper Colorado River Endangered Fish Recovery Program" Retrieved from the Internet web page: http://coloradoriverrecovery.org/general-information/about.html, April 2011. Much of the text for this section is taken directly from the program's web page.

[10] Upper Colorado River Endangered Fish Recovery Program, *Highlights 2014-2015*, Upper Colorado Endangered Fish Recovery Program, Page 3. Downloaded from the Internet website http://www.coloradoriverrecovery.org/general-information/general-publications/briefingbook/2015HighlightsDig.pdf, April, 2015.

[11] Partners include the State of Colorado, State of Utah, State of Wyoming, Bureau of Reclamation, Colorado River Energy Distributors Association, Colorado Water Congress, Western Resources Advocates, National Park Service, The Nature Conservancy, U. S. Fish & Wildlife Service, Utah Water Users Association, Western Area Power Administration and Wyoming Water Association.

[12] Upper Colorado River Endangered Fish Recovery Program, *2010-2011 Highlights Upper Colorado River Endangered Fish Recovery Program, San Juan River Basin Recovery Implementation Program,* (Denver: 2010), 7 Retrieved from the program's Internet web page: http://coloradoriverrecovery.org/general-information/general-publications/program-highlights.html, April 2011.

[13] According to the Environmental Protection Agency, under the Clean Water Act, wetlands are defined as, "those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas." See: http://water.epa.gov/lawsregs/guidance/wetlands/definitions.cfm.

[14] According to the U. S. Army Corp of Engineers, there is considerable difficulty in defining wetlands and riparian areas. For a complete discussion of these terms, see: http://el.erdc.usace.army.mil/elpubs/pdf/sr25.pdf. According to the Environmental Protection Agency, "Wetlands and riparian areas typically occur as natural buffers between uplands and adjacent water bodies. They act as natural filters of nonpoint source pollutants, including sediment, nutrients, pathogens, and metals, to waterbodies, such as rivers, streams, lakes, and coastal waters. It is important to preserve and restore damage to wetlands and riparian areas because these areas can play a significant role in managing adverse water quality impacts. Wetlands and riparian areas help decrease the need for costly storm water and flood protection facilities." See: http://water.epa.gov/polwaste/nps/wetlands.cfm. Finally, the Merriam-Webster dictionary defines "riparian" as, "relating to or living or located on the bank of a natural watercourse, as a river or sometimes of a lake or tidewater." See: http://www.merriam-webster.com/dictionary/riparian.

[15] U. S. Bureau of Reclamation, *Upper Colorado River Endangered Fish Recovery Program*. Retrieved from the Bureau's Internet web page: http://www.usbr.gov/uc/water/crsp/wg/fg/pdfs/FGWG%20April%2024%202013%20T Chart%20-%20to%20heather%202.pdf, April, 2013.

[16] Personal communication with Richard Mingo, Utah Reclamation Mitigation & Conservation Commission, November 10, 2015.

[17] Holden, Mark A., "The Importance of Instream Flow and Recreational Needs in State Water Planning" transcript of a talk given at the Sixteenth Annual Conference, Utah Section, American Water Resources Association, April 21, 1988.

[18] U.S. Congress, *Wild and Scenic Rivers Act, P.L. 90-542,* as amended, 16 U.S.C. 1271-1287, (Washington D.C.: Government Printing Office, 1986).

[19] Retrieved from the U.S. Bureau of Land Management's Internet web page: http://www.blm.gov/ut/st/en/prog/blm_special_areas/wild_and_ scenic_rivers.html, October 7, 2015.

[20] U.S. Forest Service, *Wild and Scenic River Suitability Study for National Forest System Lands in Utah, Record of Decision and Forest Plan Amendments,* (Salt Lake City: USDA, 2008).

[21] Utah Bureau of Land Management, "Questions & Answers Regarding Wilderness Study Areas" Retrieved from the Utah Bureau of Land Management's Internet web page: http://www.ut.blm.gov/utahwilderness/qandas.htm, November 2005.

[22] Ibid.

[23] U.S. Bureau of Reclamation, "Flaming Gorge Dam Overview." Retrieved from the U. S. Bureau of Reclamation's Internet web page: www.usbr.gov/projects/Facility.jsp?fac_Name=Flaming+Gorge+Dam, February 2011.

[24] Colorado River Storage Project Act (43 USC 620), enacted April 11, 1956.

[25] U. S. Bureau of Reclamation, "General Information Flaming Gorge Dam," Retrieved from the Bureau of Rec-

lamation's Internet web page: http://www.usbr.gov/projects/Facility.jsp?fac_Name=Flaming+Gorge+Dam&groupName=General, February 2011.

[26] Personal communication with Heather Hermansen, Hydraulic Engineer, U. S. Bureau of Reclamation, February 2011.

[27] Muth, R. T., et al., *Flow and Temperature Recommendations for Endangered Fishes in the Green River Downstream of Flaming Gorge Dam*, Upper Colorado River Endangered Fish Recovery Program, Final Report, Project FG-53, (2000). Available at: http://www.coloradoriverrecovery.org/documents-publications/technical-reports/isf/flaminggorgeflowrecs.pdf.

[28] U.S. Bureau of Reclamation, "Record of Decision on the Operation of Flaming Gorge Dam Final Environmental Impact Statement," February 2006.

[29] Ibid.

[30] Mooney, Chris, "The Truth About Fracking" Scientific American, November 2011, 80-85. Published by the Nature Publishing Group, London.

[31] Personal communication with John Rogers, Associate Director, Utah Division of Oil, Gas & Mining, April, 2015.

[32] For more information, see EPA's hydraulic fracturing web page: http://www.epa.gov/hydraulicfracture/.

[33] U.S. Geological Survey, "Water Produced With Coal-Bed Methane" (U. S. G. S. Fact Sheet FS-156-00, 2000), 2.

[34] Ibid., Page 1.

[35] U. S. Geological Survey, "Coal-Bed Methane: Potential and Concerns" (U. S. G. S. Fact Sheet FS-123-00, 2000),

[36] Western Governors' Association, *Coal Bed Methane Best Management Practices* (2004), Page 8.

[37] Personal communication with Gil Hunt, Associate Director, Utah Division of Oil, Gas and Mining, July 2004.

GLOSSARY

Acre-Foot (ac-ft) - The volume of water it takes to cover one acre of land (a football field is about 1.3 acres) with one foot of water; 43,560 cubic feet or 325,850 gallons. One acre-foot is approximately the amount of water needed to supply a family of four with enough water for one year (assuming a residential use rate of 225 gpcd).

Animal Feedlot Operations (AFO) - A lot or facility where animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period; and where crops, vegetation, forage growth, or post-harvest residues are not sustained over any portion of the lot or facility in the normal growing season.

Aquifer - A geologic formation that stores and/or transmits water. A confined aquifer is bounded above and below by formations of impermeable or relatively impermeable material. An unconfined aquifer is made up of loose material, such as sand or gravel, that has not undergone settling, and is not confined on top by an impermeable layer.

Beneficial Use - Use of water for one or more of the following purposes including but not limited to, domestic, municipal, irrigation, hydro power generation, industrial, commercial, recreation, fish propagation, and stock watering; the basis, measure and limit of a water right.

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

Concentrated Animal Feedlot Operations (CAFO) - An animal feedlot operation (see above) where more than 1,000 animal units are confined, or 301 - 1,000 animal units are confined and waters of the United States pass through the facility or the operation discharges via a man-made device into waters of the United States. Also, AFOs can be designated as CAFOs on a case-by-case basis if the NPDES permitting authority determines that it is a significant contributor of pollution to waters of the U.S.

Conjunctive Use - Combined use of surface and ground water systems to optimize resource use and minimize adverse effects of using a single source.

Conservation - According to Webster's Dictionary, conservation is the act or process of conserving, where conserve is defined as follows: (1) To protect from loss or depletion, or (2) to use carefully, avoiding waste. In this document, the second definition is used exclusively. However, in the water resources field the first definition is also used. Using the first definition, constructing a reservoir to capture excess runoff in order to more fully utilize the water is also considered conservation.

Consumptive Use - Consumption of water for residential, commercial, institutional, industrial, agricultural, power generation and recreational purposes. Naturally occurring vegetation and wildlife also consumptively use water.

Culinary Water - See "Potable Water."

Depletion - The net loss of water through consumption, export and other uses from a given area, river system or basin. The terms consumptive use and depletion, often used interchangeably, are not the same.

Developable - That portion of the available water supply that has not yet been developed but has the potential to be developed. In this document, developable refers to the amount of water that the Division of Water Resources estimates can be developed based on *current* legal, political, economic and environmental constraints.

Diversion - Water diverted from supply sources such as streams, lakes, reservoirs, springs or wells for a variety of uses including cropland irrigation and residential, commercial, institutional, and industrial purposes. This is often referred to as withdrawal.

Drinking Water - See "Potable Water."

Dual Water System - See "Secondary Water System."

Efficiency - The ratio of the effective or useful out-put to the total input in a system. In agriculture, the overall water-use efficiency can be defined as the ratio of crop water need (minus natural precipitation) to the amount of water diverted to satisfy that need.

Eutrophication - The process of increasing the mineral and organic nutrients which reduces the dissolved oxygen available within a water body. This condition is not desirable because it encourages the growth of aquatic plants and weeds, is detrimental to animal life, and requires further treatment to meet drinking water standards.

Evapotranspiration - The scientific term which collectively describes the natural processes of evaporation and transpiration. Evaporation is the process of releasing vapor into the atmosphere through the soil or from an open water body. Transpiration is the process of releasing vapor into the atmosphere through the pores of the skin of the stomata of plant tissue.

Export - Water diverted from a river system or basin other than by the natural outflow of streams, rivers and ground water, into another hydrologic basin. The means by which it is exported is sometimes called a transbasin diversion.

Gallons per Capita per Day (gpcd) - The average number of gallons used per person each day of the year for a given purpose within a given population.

Ground Water - Water which is contained in the saturated portions of soil or rock beneath the land surface. It excludes soil moisture which refers to water held by capillary action in the upper unsaturated zones of soil or rock.

Hydrology - The study of the properties, distribution, and effects of water in the atmosphere, on the earth's surface and in soil and rocks.

Incentive Pricing - Pricing water in a way that provides an incentive to use water more efficiently. Incentive pricing rate structures include a base fee covering the system's fixed costs and a commodity charge set to cover the variable costs of operating the water system.

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

Institutional Use - Uses normally associated with operation of various public agencies and institutions including drinking water; personal sanitation; facility cleaning and maintenance; and irrigation of parks, cemeteries, playgrounds, recreational areas and other facilities.

Instream Flow - Water maintained in a stream for the preservation and propagation of wildlife or aquatic habitat and for aesthetic values.

Mining - Long-term ground water withdrawal in excess of natural recharge. (See "Recharge," below.) Mining is usually characterized by sustained (consistent, not fluctuating) decline in the water table.

Municipal Use - This term is commonly used to include residential, commercial and institutional water use. It is sometimes used interchangeably with the term "public water use," and excludes uses by large industrial operations.

Municipal and Industrial (M&I) Use - This term is used to include residential, commercial, institutional and industrial uses.

Nonpoint Source Pollution (NPS) - Pollution discharged over a wide land area, not from one specific location. These are forms of diffuse pollution caused by sediment, nutrients, etc., carried to lakes and streams by surface runoff.

Nutrient Loading - The amount of nutrients (nitrogen and phosphorus) entering a waterway from either point or nonpoint sources of pollution. Nutrients are a byproduct of domestic and animal waste, and are present in runoff from fertilized agricultural and urban lands. Nutrients are not typically removed from wastewater effluent, and if present in excessive amounts result in growth of aquatic weeds and algae.

Phreatophyte - A plant species which extends its roots to the saturated zone under shallow water table conditions and transpires ground water. These plants are high water users and include such species as tamarisk, greasewood, willows and cattails.

Point Source Pollution - Pollutants discharged from any identifiable point, including pipes, ditches, channels and containers.

Potable Water - Water meeting all applicable safe drinking water requirements for residential, commercial and institutional uses. This is also known as culinary or drinking water.

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.

Public Water Supply - Water supplied to a group through a public or private water system. This includes residential, commercial, institutional, and industrial purposes, including irrigation of publicly and privately owned open areas. As defined by the State of Utah, this supply includes potable water supplied by either privately or publicly owned community systems which serve at least 15 connections or 25 individuals at least 60 days per year.

Recycling - See "Reuse."

Recharge - Water added to an aquifer or the process of adding water to an aquifer. Ground water recharge occurs either naturally as the net gain from precipitation, or artificially as the result of human influence. Artificial recharge can occur by diverting water into percolation basins or by direct injection into the aquifer with the use of a pump.

Residential Use - Water used for residential cooking; drinking; washing clothes; miscellaneous cleaning; personal grooming and sanitation; irrigation of residential lawns, gardens, and landscapes; and washing automobiles, driveways, etc.

Reuse - The reclamation of water from a municipal or industrial wastewater conveyance system. This is also known as recycling.

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

Safe Yield - The amount of water which can be withdrawn from an aquifer on a long-term basis without serious water quality, net storage, environmental or social consequences.

Secondary Water System - Pressurized or open ditch water delivery system of untreated water for irrigation of privately or publicly owned lawns, gardens, parks, cemeteries, golf courses and other open areas. These are sometimes called "dual" water systems.

Self-supplied Industry - A privately owned industry that provides its own water supply.

Stakeholders - Any individual or organization that has an interest in water management activities. In the broadest sense, everyone is a stakeholder, because water sustains life. Water resources stakeholders are typically those involved in protecting, supplying, or using water for any purpose, including environmental uses, who have a vested interest in a water-related decision.

Total Maximum Daily Load (TMDL) - As defined by the EPA, a TMDL "is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. [Its] calculation must include a margin of safety to ensure that the water body can be used for the purposes the State has designated. The calculation must also account for seasonal variation in water quality." The TMDL must also provide some "reasonable assurance" that the water quality problem will be resolved. The states are responsible to implement TMDLs on impaired water bodies. Failure to do so will require the EPA to intervene.

Water Audit - A detailed analysis and accounting of water use at a given site. A complete audit consists of an indoor and outdoor component and emphasizes areas where water could be used more efficiently and waste reduced.

Water Yield - The runoff from precipitation that reaches water courses and therefore may be available for human use.

Watershed - The land above a given point on a waterway that contributes runoff water to the flow at that point; a drainage basin or a major subdivision of a drainage basin.

Wetlands - Areas where vegetation is associated with open water and wet and/or high water table conditions.

Withdrawal - See "Diversion."

UTAH STATE WATER PLAN
Uintah Basin—Planning for the Future

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