League of Women Voters of Utah Water Study

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The League of Women Voters is a nonpartisan political organization that encourages informed and active participation in government, works to increase understanding of major public policy issues, and influences public policy through education and advocacy.

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Reading Instructions

Here are some suggestions for absorbing the material. However, we cannot tell you which sections are the most important for you to read. That depends upon what you already know.

1. Read and ponder the Executive Summary.

2. Read the Discussion and Consensus Questions and pick a consensus question about which you already have a strong opinion. Then contemplate the possibility of changing your mind.

3. Now take a break and study the maps (in the Appendix).

4. Become acquainted with the Table of Contents. Find a topic that interests you and read it for fun.

5. Read a section you do not know much about but might help you with a discussion question that puzzles you.

6. Read about a river basin – the one where you live or one that particularly interests you, or both.

7. Finally, if you have time, do read the whole thing. The committee members thought we were quite familiar with water facts and policy but we found we had a lot to learn.

8. Please use the reference section to find your way to all the state agency web sites and other sources we have used. The information in the Utah State web sites is well worth exploring.

Discussion Questions

1. What line of evidence for the probability of future drought seems the most convincing to you? What might be the most compelling to decision makers? If these differ how might you be able to convince the latter that we face a difficult future?

2. Review Utah's beneficial use policy, which is the cornerstone of western water law. Does it agree with your concept of how water should be allocated? Does it agree with your concept of beneficial use of water?

3. Review the various institutions and people who create water policy. Why did this system evolve? What problems did it solve? Water districts and the State Engineer are subject to the whims of the state legislature. How might this affect their ability to make water policy decisions? What are the positive and negative elements of this system?

4. Are instream flows and healthy lakes and wetlands valuable to you? Would you like to see these waters given more certain protection and how might that be done? You might consider two examples on the Wasatch Front. The Jordan River depends upon return flows from Municipal and Industrial (M & I) which might be reduced by re- use, ever diminishing agriculture, and duck club water rights which could be sold for other *beneficial* uses and not return to the river. The Wasatch Mountain streams are our purest source of culinary water and will be under great pressure in times of drought.

5. Is it more important to change the water allocation system or is it more effective to change people's attitudes and habits? Why do you think so?

6. Is it necessary to make a choice between water for people and water for the natural world?

7. Developing more water sources supports more urban growth. Does conservation do the same?

Consensus Questions

1. In Utah, according to law, water belongs to the public and must be put to a beneficial use. The public trust doctrine requires government to protect the public's interests in commonly held assets such as wildlife, public land and water.

- Do you think that current allocation of water between human needs and environmental uses is equitable? If not, what changes do you think would make the allocation more equitable?
- Since population growth is linked to economic development, do you think that the state's tendency to emphasize economic development should be curtailed?
- Would you like to see changes in the way water in Utah becomes a quasi-permanent property right?

2. What is the best way to change how Utahns use water?

- Which is preferable: voluntary campaigns and education or mandatory programs with monetary penalties or incentives?
- Is conservation best left to local entities or do we need state laws and policies to accomplish our goals?

3. What would be the ideal water policy statement for the state of Utah? Below is the committee's suggestion for your consideration.

Draft Position on Utah's Water Resources:

Background: The LWVUT recognizes the scarcity of water in the State of Utah. Utah is the second driest state in the nation; Utah has the second highest per capita water use. The League's approach to dealing with this reality is to further citizen understanding of basin watersheds, and to approach looming problems with solutions that will benefit a growing population as well as an environment rich in wildlife habitat and diverse, often exquisite, topography.

Statement of position:

Therefore, the League's position with respect to water use is:

- To support water policies that are structured to address human needs while protecting water tables, lakes, streams, wetlands and their attendant wildlife. (Policies can include possibly steeper water rates if necessary, xeriscaping requirements for new developments, maintaining the integrity of water basins.)
- To support environmental safeguards that recognize the interrelationships among water, air, land resources and wildlife (the Snake Valley proposal by SNWA is a perfect example of ignoring land use and air quality throughout a vast portion of the Great Basin)
- To support implementation of stringent controls that protect surface supplies and recharge areas for principal aquifers (aquifer storage and recovery; maintaining instream flows, the main source of aquifer recharge)

Advice to the Board

1. What further advice would you like to give to the Utah League Board on writing a water position? What do you think must absolutely be included? Is there something you would like to say that has not come out in this study and discussion?

2. Is there a water topic you would like to study in more depth? Are you willing to contribute to such an inquiry?

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INTRODUCTION

In 2008 the League of Women Voters of Utah decided to do a study of Utah water so that we could better advocate for our members' deep concerns about water for people and water for the environment. This paper is concerned with accounting for our water and how we manage it, not with water quality either for human uses or for wildlife.

It is generally agreed that in the future the state will see less water and more people. The League believes that the decisions we make in the next few years will shape both the human and natural environment for the rest of this century and beyond. We hope this study describes Utah's water facts and dilemma: how much water we have now and how much we might have in the future; how we use water now and how we might use water in the future. Here are some public policy questions to keep in mind while reading this study.

1. We cannot predict the future with much accuracy. However, we are told to expect more people, and the climate section will show that Utah can most likely expect longer, hotter droughts at the least and more likely a hotter, drier climate overall. So how should we prepare for the uncertainties of a water future that may be quite different from our experience of the last century and a half?

2. How should we allocate water among municipal and industrial, agriculture, and the environment as population grows and/or water becomes scarcer? Are we in danger of neglecting agriculture when in the future we may become more dependent upon food and fiber grown close to home?

3. In the legal section and the descriptions of the river basins of Utah you will see that managing water is a convoluted undertaking in both physical structure and in governance. Where is the most effective forum for water decisions: cities, state agencies, the governor, the legislature?

We hope that the following information will help both League members and the public better understand Utah's water supply and usage and that the report is fair and balanced enough that someone from another perspective might read the facts and explanations herein and come to quite different conclusions than ours. We also hope that we have not omitted any critical information or misrepresented anyone or any institution or organization.

UTAH WATER – A LIMITED RESOURCE

Utah is a semi-arid state with the southern half of the state drier than the northern. Water experts, planners, and political leaders acknowledge that water will be the limiting factor in nearly all future human endeavors in Utah. However, there is not total agreement as to just how dry the state will be or with how water should be allocated in the future (Spr. Runoff Conf, 2009).

It is widely accepted that Utah water has been over-allocated. A prime example is the Colorado Compact where more water was divided among the contiguous states than usually flows in the river. Internal Utah river basins suffer from similar stresses. Over-allocation simply means that more water has been legally promised to water users than actually exists or can be safely or practically removed from natural systems. Much of this over-allocation can be attributed to ignorance of the water and climate history of the intermountain southwest.

Climate History

Although there are no written records, scholars can tell us a great deal about interaction of humans and climate and water for centuries past. The history of native peoples is instructive. Highly organized, settled populations with extensive irrigation systems would arise and then disappear (or move elsewhere) – indicating wet and dry cycles (Grahame, 2002). Tree ring, fossil pollen, and lake sediment studies also point to long droughts, some lasting the greater part of a century (Utah Division of Water Resources [UDWR], 2007, Drought in Utah, ch. 3). We now know that even with its periodic droughts our climate for the past century and a half has in fact been the wettest scientists can find in the evidence available to them, so historical experience may be of little value to us in describing our climate future. In fact there is good reason to expect there will be long dry periods in the state's future (UDWR, Drought in Utah, p. xv).

Climate Future – Modeling or Guessing?

Climatologists and hydrologists are using new scientific data on climate trends and greater understanding of its variability to create models, which attempt to predict future climate and water regimes for Utah. The outcomes from the models vary from severe drought with dire consequences to more moderate declines in precipitation that, although serious, may be manageable. Scientists and most water managers agree that global warming will bring higher temperatures to all of Utah. How much warmer depends upon the model and data used (Spr. Runoff Conf. 2009). Model predictions are always subject to new data and improvements of the models themselves. No scientist will say anything in absolute terms.

To add to the uncertainty, Utah is geographically perched on the divide between the latitudes to the south that are expected to be drier and the latitudes to the north which may be wetter. Just where the dividing line between wet and dry will be is uncertain (Gillies, Spr. Runoff 2009). So there is agreement on a hotter, drier southern Utah, but no one wants to predict how wet or dry northern Utah may be (Spr. Runoff Conf., 2009). However, there is a consensus that whether wetter or drier northern Utah is destined to be hotter A warmer climate will have serious consequences for a state that depends upon snowpack to create a reliable and easily stored water supply.

Snowfall Dilemma

Most of Utah's usable water comes from snowpack. The state's system of reservoirs fills in late spring and early summer from the slow snowmelt. The water level in the reservoirs starts to be drawn down beginning in late summer, through the rest of the year and into the next spring. The system depends upon a substantial snowfall and the timing of the spring snow melt. Little snow or more precipitation falling as rain does not allow for timely storage in Utah's high mountain reservoirs or for efficient seasonal allocation. If Utah has a hotter and drier climate, there will be less water in any form, a smaller snowpack, and probably higher human usage to counter the hotter, drier weather. Even if Utah were to be warmer but wetter, there are problems. More precipitation will fall as rain rather than snow, filtering through the ground to our aquifers not to our reservoirs, where it is more accessible to the water delivery system now in place. The smaller snowpack will melt early, and since Utah receives little summer moisture, it is likely that summer water use will still be high and long (Spr. Runoff Conf, 2009, Drought in Utah 2007).

Growth

Utah's population is predicted to continue to grow at an unusually fast rate for a western, industrial nation. The Governor's Office of Planning and Budget projects that the population will grow from 2,833,337 in 2010 to 5,368,567 in 2050, mostly on the Wasatch Front (GOPB, 2009). In their current planning for the future all water managers consider population growth first and foremost. However, at the state level water planners are also concerned about the consequences of a hotter and drier climate and the threat of a diminished and/or early melting snowpack (Spr. Runoff Conf, 2009, UDWR Drought in Utah 2007). Our population is projected to double over the next forty years while our water resources are expected to diminish.

WATER LAW AND REGULATION

Two Systems of Water Law Applicable In Utah

Federal Reserved Water Rights

When Congress reserves public land for a particular purpose, *e.g.* Indian reservations, parks, military bases, it implicitly reserves proprietary rights in the water flowing through the reservation sufficient for the purposes of the reservation. The proprietary rights of the riparian land owner to water flowing through his land in Utah is limited to federal reserved lands, although it is the system applicable in states other than in the arid west. The allocation of water of the Colorado River between the riparian states is governed by the Colorado River Compact.

Utah Water Rights

Water law applicable in Utah to other than federal reservations is the fundamentally different system of *prior appropriation*. All water other than federally reserved water in the State of Utah is owned by the people of the state. Persons or entities acquired rights to use water historically by appropriating it, *i.e.* by diverting it from streams or springs (or by pumping ground water) and then putting it to beneficial use. This right was independent of any ownership of riparian land and the beneficial use could be anywhere. The basic tenet is to give priority to the senior appropriator who is entitled to all the water he initially appropriated before a junior appropriator is entitled to any. Historically, in times of scarcity, use for domestic purposes was given first preference, and agriculture was given second preference over other uses. Currently there is no Utah law addressing priorities in time of drought. This right to water, although it is free to the appropriator and it can be lost by non-use for five consecutive years, is a property interest which may be transferred by conveyance, that is, sold.

After 1903 (1935 for ground water), a new appropriator was required to obtain the approval of the State Engineer but existing rights based upon prior appropriation and use continue to be protected. Approval is also required to change the place of diversion, the quantity of water, or the nature of the use (*e.g.* from irrigation to power generation*).* The engineer may reject approval if it will interfere with a prior appropriation or will unreasonably affect "public recreation" or the "natural stream environment" (O'Connell, 2009).

Where Water Law Is Made – The State Legislature

As representatives of the people, the Utah legislature makes state water law and changes it at will. There is only one line in the state constitution that speaks to water and that is to confirm existing water rights put to beneficial purpose at the time of the constitution's adoption. Therefore, it is in statute that Utah's waters are declared to be the property of the public, the state engineer's powers and duties are described, and the governor is given a limited power to declare drought and curtail further appropriations of water during the period of the drought declaration. And as one would expect in so critical and contentious an area, there is a Utah water establishment of water lawyers and water managers, affectionately referred to as the "water buffaloes."

Where Water Decisions Are Made

The State Engineer

The State Engineer is empowered to decide water disputes, permit new appropriation of available water, and protect water supplies. His decisions can be taken to court. Most available Utah water has been appropriated and in many areas over-appropriated. As a general rule, if water is needed, it is necessary to purchase an existing water right. The State Engineer (Director of the Division of Water Rights) is also responsible for the health of aquifers, wells and streams and oversees dam safety, irrigation ditches, and more (Utah Code 73-2).

Water Conservancy Districts and Irrigation Companies or Districts

A water conservancy district is a creature of the state under the purview of the state legislature. It is charged with putting the waters of the state to beneficial use, conserving water use, and developing unappropriated water resources. It may be concerned with municipal and industrial (M & I) uses as well as irrigation waters. A district is governed by a board of directors appointed by the county governing body or by a system for recommending candidates to the governor in the case of multi-county districts. A conservancy district is bound by interstate agreements and federal laws, contracts, and treaties. Examples of water conservancy districts are the Jordan Valley Water Conservancy District in the Salt Lake Valley and the Weber Basin Water Conservancy District in Weber County. Irrigation companies were acknowledged in state statute in 1919 well before water districts. They are beholden to their stockholders rather than a political entity; however, they are vulnerable to take-over by the water conservancy district in their geographic area (UC 17A).

State Government Agencies

The Department of Natural Resources has three divisions involved in water activities. The Division of Water Resources finds and develops water. The Division of Forestry, Fire and State Lands over sees the Great Salt Lake. The Division of Wildlife Resources has a special concern for the waters of the state in its role as protector of the state's wildlife. The Division of Water Quality in the Department of Environmental Quality monitors water quality.

Protection for Streams, Lakes, and Wetlands

Utah streams have some limited protections in statute. The State Engineer can deny a request for unappropriated water if he deems such would damage fisheries, recreation, or habitat. Because he only has this power over yet to be appropriated water, it is of limited value. Currently the Divisions of State Parks and Recreation and Wildlife Resources can own water rights for instream flow and certain non-profit organizations interested in fishing can do so on a ten year trial basis.

Instream Flow

Instream flow is particularly useful legal terminology because it can be used to keep water in streams. The State of Utah recognizes instream flow. It was designated a beneficial use in a 1986 amendment to the established water code (UC 73-3-11). In the current statute, instream flow is designated a beneficial use for the propagation of fish, public recreation, or the reasonable preservation or enhancement of the natural stream environment. The Utah Divisions of Wildlife Resources and Parks and Recreation were given the power to hold instream flow water rights on a temporary or permanent basis. However, a division is required to follow the same procedure as any other applicant for a water right and is limited to acquiring already appropriated water. In other words, instream flow water must come from water that has already been assigned to another beneficial use. What this means in practice is that agricultural water has been reassigned to instream flow. In 2009 the Utah water code was again amended to give certain classes of non-profit organizations such as Trout Unlimited the right to acquire instream flow rights with the same strictures and for a trial ten year program (Utah Water Rights Fact Sheet, 2001, UC 73-3-30).

Federal Protection

Federal protection for instream flow resides with the Corps of Engineers, the Bureau of Reclamation and the Environmental Protection Agency. The Corps oversees waters of the United States and connected wetlands. The Bureau of Reclamation requires water releases to streams from the dams in which it is involved but with no guarantee as to how long the water must be left in the stream. Implementing the Clean Water Act, the EPA requires each state to have an antidegradation policy equal or superior to the standards of the act. The principle of antidegradation can be used to protect instream flow since water volume is important to diluting pollutants (River Network 2009).

Public Trust Doctrine

The public trust doctrine has a long history in western civilization dating to the Romans. It originated with the concept that waters and shorelines belonged to and could be used by everyone. In the United States, the doctrine has been expanded to protection of species and habitat. The Mono Lake decision is a recent application of the doctrine, and legal arguments proffered to protect the integrity of the Great Salt Lake ecosystem use this concept. "The public trust doctrine, however, retains the anthropocentric focus of property law in which trust assets are held by the government for the common benefit of users." (Adler 2007, p. 199) There still remains the problem of whether wildlife and habitat have legal standing of their own. At present the courts have only considered human interests in the quality of the environment, not the survival of its flora and fauna.

Who in Fact Owns the Water?

Utah statute and the constitution speak of beneficial use as the fundamental requirement for the people's water. Utah recognizes the following beneficial uses: agriculture, culinary, domestic, industrial, irrigation, manufacturing, milling, mining, municipal, power, stock watering, instream flow, recreation and the reasonable preservation or enhancement of the natural stream environment and aquatic culture (UDWR, 2001, State Plan).

As long as water is used for one of these purposes the owner of the water right can sell it to someone else for the same or another beneficial use. By holding to the doctrine of prior-appropriation, it appears that the waters of Utah no longer belong to all the citizens, but to the owners of the water rights.

WATER SOURCES

Utah's Water Budget – the Big Picture

Water planning is the responsibility of the Utah Division of Water Resources. As a part of planning the Division is involved in several major data collection programs. These data provide the basis of the figures used in the following narrative. Information following the table provides an explanation of each category.

The statewide water budget is based on averages. Actual water supplies rarely match averages. Often these variations occur in prolonged wet and dry cycles. The early 1980s were one of the wettest periods on record. This period was immediately followed by one of the driest periods on record (1987-1992) (UDWR, 2001, State Plan, p.13).

ESTIMATED STATEWIDE WATER BUDGET
Based on 1961-1990 Records

		000 Acre-Ft/Year
1.	Total Precipitation	61,500
2.	Used by Natural Systems	- 53,789
3.	Basin Yield	7,711
4.	Interstate Compact Changes	- 535
5.	Groundwater Mining	- 35
6.	Inflow into West Desert from Nevada	+ 100
7.	Available Supply	7,311
8.	Agricultural Depletion	- 2,175
9.	Municipal & Industrial Depletion	- 443
10.	Great Salt Lake Evaporation	- 3,000
11.	Other Depletions	- 998
12.	Yield that flows out of state	695

Line 1, Total Precipitation - Precipitation is the principal source of Utah's water. The precipitation is stored temporarily during the winter as snow in the mountains and for longer periods in reservoirs and aquifers.

Line 2, Used in Natural Systems - The state's water budget shows that about 87% of the total precipitation that falls in the state returns to the atmosphere as evaporation from the surface and transpiration from native plants (not crops).

Line 3, Basin Yield - Precipitation that is not returned to the atmosphere makes its way into streams and other surface water bodies or percolates into groundwater aquifers making it available for use. Surface water is measured at gaging stations by the U.S. Geological Survey. Groundwater aquifers are modeled using information from wells.

Line 4, Interstate Compact Changes - The Colorado River system and the Bear River flow into Utah from neighboring states. Interstate rivers are covered by Compacts negotiated by the federal government. Under the Colorado River Compact, the upper basin states (Wyoming, Colorado and Utah) are responsible for 7.5 million acre-feet to the lower basin states and for half of the 1.5 million acre-feet that goes to Mexico annually making a total of 8.25 million acre-feet. Of this amount, 20,000 acre-feet is assumed to be delivered from the Paria River. The balance would be delivered out of Lake Powell. As a result of this

Compact, Utah's water is decreased by 819,000 acre-feet per year. As a result of the Bear River Compact it is increased by 284,000 acre feet, resulting in a net decrease of 535,000 acre-feet.

Line 5, Ground Water Mining - 35,000 acre feet is a result of groundwater mining in the Beryl-Enterprise area. In the state's 2001 Water Plan this is the only area in which such mining is documented.

Line 6, Inflow into West Desert from Nevada - 100,000 acre-feet comes into Utah's western desert from Nevada

Line 7, Available Supply – The Interstate Compacts, ground water mining and other inflows combined with the Basin Yield result in the average "Available Supply" for the state of 7,311,000 acre-feet per year.

Line 8, Agricultural Depletions – Of the "Available Supply", 30% or 2,175,000 acre-feet per year are consumed by agriculture.

Line 9, M&I Depletions – Six percent or 443,000 acre-feet per year are consumed by residential, commercial, institutional and industrial uses which are lumped under the heading "Municipal & Industrial".

Line 10 & 11, Great Salt Lake and Other Depletions – Evaporation from the Great Salt Lake and other open water bodies and transpiration from wetlands and riparian areas deplete the water supply by 3,998,000 acre feet per year (55% of the Available Supply).

Line 12, Yield that flows out of state - These amounts result in an average of 695,000 acre feet flowing out of the state in addition to that flowing out to satisfy the Colorado Compact.

Utah's Groundwater - Aquifers

Aquifer Types

Utah has no single, continuous, hydraulically connected aquifer like the Ogallala of Oklahoma/Nebraska. It has four different *types* of aquifers, each of which is more common in a different physiographic Utah province. Describing these "provinces" first will help the reader understand what distinguishes the aquifer settings. These aquifer types were described by Schlotthauer and others in 1981 and Gates in 1985. See the map, "Physiographic Provinces in Utah," in the Appendix.

Middle Rocky Mountain Physiographic Province. We are familiar with the Middle Rocky Mountain physiographic province, which encompasses mostly Northeast Utah, the rugged uplands of the Wasatch Range, the Uinta Mountains, and back-valley basins and river valleys like Heber. The aquifer found in this region is labeled by geologists as *valley-fill unconsolidated aquifer*. Valley-fill aquifers have confined, unconfined, and perched groundwater conditions, and to a limited extent are also found on the Colorado Plateau (Gates, 1985), another physiographic province discussed below.

Colorado Plateau Physiographic Province. The remainder of eastern Utah is distinguished by the Colorado Plateau which contains a *fractured-rock* type of aquifer. Sandstone holds the groundwater primarily in fractures and pore spaces, and such aquifers are more common in the Colorado Plateau than anywhere else in Utah (Eisinger and Lowe, 1999). The Entrada, Navajo, and Wingate sandstones are the most widespread and contain the most useable water in Utah, but other bedrock units may be important aquifers (Schlotthauer and others, 1981; Gates, 1985).

Basin and Range Physiographic Province. Picture the west side of Utah, vast sparsely populated basin and range country, with an immense aquifer that we have heard little about, until recently – the *carbonate*. It is also a fractured-rock type mainly of limestone and dolomite formations (Gates, 1985) like Lehman Caves at

Great Basin National Park. A less extensive carbonate aquifer exists around Utah Lake in central Utah (Gates, 1985). The carbonate aquifer extends into Nevada as well, and is undergoing extensive study as the Southern Nevada Water Authority negotiates with Utah to develop the groundwater from Spring and Snake Valleys in northeast Nevada for the future growth of Las Vegas.

Also in the basin and range "province," is the type of aquifer that serves Utah's densest population, the *basin-fill aquifers* of north western and western Utah. Like the valley-fill, they occur under confined, unconfined, and perched conditions, but are thicker and have more area. A typical basin-fill aquifer ranges from zero to several thousand feet thick, and contains fresh water in a zone up to 500 to 1500 feet thick (Gates, 1985). The Cache Valley, the East Shore area of the Great Salt Lake, and the Salt Lake Valley top unconsolidated basin-fill aquifers.

The alluvial basin-fill deposits yield water at rates averaging from 200 to 1,000 gal/min (Gates, 1985). "The most productive basin-fill aquifers consist of coarse, clean, well sorted gravel and sand, and yield large quantities of water to wells" (Lowe and others, 2003, p. 8). These are the wells that serve our current growing population in northern Utah.

Principal Aquifers

Utah harbors the above four types of aquifers: unconsolidated valley- and basin-fill, and sandstone and carbonate fractured-rock aquifers. However, most of Utah's groundwater comes from basin- and valley-fill aquifers, although less extensive bedrock units yield some (Schlotthauer and others, 1981; Gates, 1985). Recharge to the aquifers comes primarily from precipitation within the drainage basins, which are discussed below. Streams are the main source of recharge. Irrigation run-off can also be a source of recharge to the aquifers (Lowe and others, 2003, p. 4).

Within the four types, Utah has 13 principal aquifers, some of them sounding familiar: Curlew Valley, Cache Valley, East Shore area, Salt Lake Valley, Tooele Valley, Utah and Goshen Valleys, Juab Valley, Sevier Desert, Pahvant Valley, Milford area, Parowan Valley, Cedar Valley, and the Beryl-Enterprise area. These are unconsolidated basin-fill aquifers and they are mapped. Also mapped are the unconsolidated valley-fill aquifers, the sandstone, and the carbonate aquifers, though some have uncertain boundaries (Lowe and others, 2003, p. 7, Fig. 3 modified from Gates, 1985). See this map in the Appendix.

As Utah's population grows at an astounding rate, due both to an emphasis on attracting industry as well as a high birth-rate, the health of these aquifers has become paramount. As stream flows have declined or been diverted, there has been greater emphasis on storage. In the study team's extensive interviews with water managers, the question, "are we depleting our aquifers?" failed to elicit specific responses, but there was verbal confirmation that shallow aquifers are contaminated or there is a threat of contamination through mechanized recharge, new emphasis on energy sources such as heat pumps, or unforeseen events. One outstanding example of aquifer "mining" (the result of withdrawing ground water from natural aquifers at a rate exceeding the natural recharge) (Arthofer, 2009, p. 9) is the Beryl-Enterprise aquifer. "A 2008 study conducted by the Division of Water Rights estimates the Beryl-Enterprise area has a long-term average annual recharge of 34,000 acre-feet per year while USGS data indicate withdrawals for the period of 1995-2004 averaged about 85,000 acre-feet annually" (Greer, 2008). The Division developed a Beryl-Enterprise Ground Water Management Plan (GWMP) which elicited several objections from the public including economic loss, the reduction of current market value of land, and loss of individual water rights (Arthofer, p. 9). The state legislature responded by halting the GWMP funding for the 2008 budget year.

This action has effectively suspended further progress by the Division in groundwater management of the area (Arthofer, p. 10).

In its most recent report, the Division of Water Rights has identified groundwater mining in six groundwater basins, and seven basins are "over-appropriated based on the amount of water rights approved as compared to the available supply" (Utah Division of Water Rights, April 7, 2008). The consequences of groundwater mining are not inconsequential. They include, according to the State Engineer's Office, decreasing water quality as a result of expansion or migration of poorer quality water, increasing rates of surface land subsidence, loss of aquifer capacity due to subsurface compaction, and the necessity for deeper wells. "Moreover, economic impact studies show groundwater mining pushes a greater cost to obtaining an equivalent quantity of resource in the future while hydrologic studies suggest the injury to the resource may be irreversible" (Lindon, Nov. 19, 2008, p. 9 of Arthofer, 2008).

The Division adheres to a central goal of determining the safe yield for sustainable groundwater withdrawals, a concern that was echoed by the water officials this study team interviewed. How willing the legislature is to deal with this issue in a timely manner, as evidenced by the funding cut-off to the Beryl/Enterprise GWMP, does little to inspire confidence.

RIVER BASINS WITHIN THE STATE

Utah is divided into 11 hydrologic river basins. The 3 eastern river basins and the southern basin around the Virgin River empty into the Colorado River system. The remaining river basins are a part of the Great Basin (UDWR, 2001 State Water Plan, p. 13). Precipitation that falls in the Great Basin does not flow to the ocean.

Water supply and demand are reported by basin because normally the water supply of a basin is all that is available for use. However, the Central Utah Project and the proposed Lake Powell pipeline are examples of large interbasin transfers. Several small interbasin transfers also exist. A map of the river basins is included in the Appendix.

ESTIMATED WATER SUPPLY BY BASIN

Basin	000 Ac.-Ft/Yr.
Bear River	2,106
Weber River	1,046
Jordan River & Utah Lake	1,278
West Desert	329
Sevier River	819
Cedar/Beaver	216
Uintah	688
West Colorado River	446
Southeast Colorado River	136
Kanab Creek/Virgin River	247

(UDWR, 2001)

This study will concentrate on the Bear River, Weber River, Jordan River, Utah Lake, West Desert, and Kanab Creek/Virgin River. These basins contain most of the population in the state or are of particular interest.

Regions of Utah differ significantly. To understand what water is available for development in Utah, first recognize what is available by major drainage basin. Utah's Division of Water Resources estimates water sources. Counties and municipalities estimate water needs. Here are facts and figures about the basins. Hopefully, this section will provide a review of geography and water sources. Some but not all big issues and impacts of water planners are identified.

Bear River Basin

Basin Conditions

The Bear River Basin covers land in southeastern Idaho and southwestern Wyoming as well as Utah. Within Utah, the basin includes about 3,300 square miles. The Bear River is the western hemisphere's largest stream that does not reach the ocean. The headwaters of the Bear River are in Summit County, Utah, on the north slope of the Uinta Mountains, approximately 60 miles due east of Salt Lake City. The river follows a 500 mile circuitous route through Wyoming and Idaho before returning to Utah and flowing into the Great Salt Lake. (UDWR, Bear R Basin, 2004, p. 1)

Utah's portion of the Bear River Basin consists of all of Cache and Rich Counties, the eastern one-third of Box Elder County and a small portion of Summit County containing the headwaters. The current population of this basin (2000 census) is 136,097. Estimated population in 2050 is 297,597.

The earliest users of water in the basin were irrigators in the Lower Bear River Valley and Cache Valley. Consequently they hold the earliest water rights. The management of the river is accomplished with delivery of irrigation water as the primary objective.

Historically the river did not naturally flow into Bear Lake. The feasibility of diverting water from Bear River into Bear Lake was presented in 1898. In 1902 the predecessor to Utah Power and Light began constructing inlet and outlet canals to divert Bear River water into the lake for later release during the agricultural growing season. In 1914 a pumping plant was constructed at the north end of the lake to pump water from Bear Lake into the outlet canal. This construction created an active storage capacity of 1,452,000 acre-feet in Bear Lake (UDWR, Bear R Basin, p. 1).

Total average annual precipitation in the Utah portion of the Bear River Basin -	4,000,000 acre-feet
Used by vegetation and natural systems	1,900,000 acre-feet
Basin yield	2,100,000 acre-feet
Agricultural depletion	536,000 acre-feet
M&I depletion	21,000 acre-feet
Wetlands, riparian depletion and reservoir evaporation	340,000 acre-feet
Flow into the Great Salt Lake.	1,200,000 acre-feet

Water rights held by the Bear River Migratory Bird Refuge account for a great deal of the flow into the Great Salt Lake. The Bear River Compact designates how the developable waters of the river are to be allocated. Assuming full development of the Bear River by Idaho and Wyoming there remains an average annual developable flow of about 250,000 acre-feet for Utah. Because this water is winter and spring flow, development of a firm (reliable) yield will require new storage (UDWR, Bear R Basin, p. 11).

Basin Issues

Throughout Cache County the water supply should take them well into the 2040s while Box Elder County's supply should meet the county needs through 2025. However, these projections are based upon a countywide condition for average water years and average yearly demand. Some systems are hard pressed even now to provide adequate flows during drought conditions and peak demand. Local water suppliers will continue to develop available water sources. In Cache County this will mean additional groundwater development. The State Engineer's office will allow an additional 25,000 acre-feet per year of groundwater withdrawals. In Box Elder County, groundwater supplies are not so abundant and water purveyors will continue to acquire existing high quality groundwater rights from willing sellers and develop whatever additional groundwater is available along the east side of the county. (UDWR, Bear River Basin, p. 49)

The Bear River Development Act passed in 1991 directs the Division of Water Resources to plan and construct facilities on the river to develop water for the Jordan Valley Water Conservancy District, the Weber Basin Water Conservancy District, the Bear River Water Conservancy District and Cache County. We assume this is to direct the developable flow of 250,000 acre feet to these other areas. The current plan for Bear River development is to:

- Develop an agreement with the Weber Basin Water Conservancy District to store surplus Bear River water in Willard Bay,
- Connect the Bear River with a pipeline and/or canal to Willard Bay,
- Construct conveyance and treatment facilities to deliver water from Willard Bay to the Wasatch Front, and
- Build a dam in the Bear River Basin as demand for additional water increases.

(UDWR, Bear R Basin, p.50)

Weber River Basin

Basin Conditions

This basin includes 1.5 million acres extending from the Wasatch Mountains and the west- draining slopes of the Uinta Mountains to the Great Salt Lake. It includes all of Weber, Davis and Morgan Counties and most of Summit County (UDWR, Weber R Basin, 1997, p. 3-2).

Major tributaries to the Weber River are Beaver, Chalk, Lost, and East Canyon Creeks and the Ogden River. Total storage capacity on the system is 525,900 acre feet in eight major reservoirs: Causey, East Canyon, Echo, Lost Creek, Pineview, Rockport, Smith and Morehouse, and Willard (UDWR, Weber River Basin, p. 3-4).

Average annual basin water yield	979,400 acre feet
Annual M&I use (potable water)	92,262 acre-feet
Annual M&I use (secondary water)	101,121 acre-feet
Agricultural depletion	359,800 acre-feet
Wetland & riparian use	270,000 acre-feet
(UDWR, Weber R Basin, 1997, p.14-3)	

Springs account for 10% and wells for 78% of the potable water supply with the balance coming from surface water. Secondary water use in this basin is the most extensive in the state (UDWR, M & I Water Supply & Uses in the Weber R Basin, 2008, p. xiii).

Reports published by the Utah Division of Water Resources show a decrease in surface irrigated land from 119,094 acres in 1999 to 83,081 acres in 2007 (UDWR, February 2008, p. 8). The latest published figure for use of water for irrigation on inventoried irrigated land is 359,800 acre-feet in 2003 (UDWR, Weber R Basin Plan, 2004, p.38). This publication estimates that 3.4 acre-feet of water is diverted per acre of irrigated cropland.

With the exception of Echo Reservoir, minimum instream flows are required on all reaches of the Weber and Ogden River below existing reservoirs extending to the flat area near the Great Salt Lake because instream flows are required below reservoirs constructed with federal funds.

The Weber River Basin consists of six groundwater basins which although connected by surface flows are generally considered geologically isolated. The East Shore area is a string of coalescing alluvial fans and river deltas on the hanging wall of the Wasatch Fault (UDWR, Weber R Basin, 1997, p. 19-1). Groundwater levels in the East Shore area have experienced significant declines in recent years (UDWR, Weber R Basin, 1997, p. 19-7). Records have documented groundwater declines of 50-80 feet in the densely pumped areas between 1958 and 1985. The other five groundwater basins are closed to further appropriations (UDWR, Weber R Basin, p. 19-4).

Basin Issues

Population of the Weber River Basin in 2005 was 533,120. Projections were made in 1997 of 699,590 people in 2020 and 1,316,860 in 2050 (UDWR, Weber R Basin, p. 4-2) may now be too low. However, based on those projections the 1997 Water Plan stated that the basin is projected to have a surplus of water to the planning year of 2020 although some areas would have shortages. After 2020 water is expected to be imported from the Bear River Basin.

The residents of Park City feel there is a critical need for supplemental sources of water. This need can be met with the importation of water currently held in East Canyon Reservoir.

Jordan River Basin

The state has designated Salt Lake County (or the Salt Lake Valley) to be the Jordan River Basin. It is bounded by the Oquirrh Mountains on the west, the Wasatch Mountains on the east, the Great Salt Lake on the north and the Traverse Mountains (at the Point of the Mountain) to the south. The Jordan River Basin has 370 square miles of mountainous terrain, 26 of water, and 429 of developable land for a total of 805 square miles. Correctly defined, the Jordan River Basin is all the area drained by the Jordan River and its tributaries: Salt Lake County plus the Utah Lake Basin. The latter is described in the next section (Jordan R. Plan, pp. 3-4-5).

The Jordan River Basin receives a large portion of its surface water from the Jordan River whose drainage includes a piece of the Uintah Mountains. After it enters the Salt Lake Valley, the Jordan is fed by the seven major and thirteen minor Wasatch Mountain streams, and six intermittent or ephemeral streams in the Oquirrhs. Storage is provided in Wasatch Mountain reservoirs, groundwater repositories and natural aquifers (Jordan R. Plan, p. 2-2).

The valley's total average annual water supply as measured in 1986-1995 was 825,000 acre-feet. The sources are the streams described above, groundwater, and imported water. All the available surface water of the valley has been fully appropriated and developed. Groundwater is not yet fully developed but is considered to be over-appropriated which makes it a problematic source for future water. However, water is becoming available for M & I use as agricultural land is sold for development. There will be no agricultural land in the Salt Lake Valley by 2050.

The water from the Utah Lake/Jordan River system is of poor quality and therefore expensive to improve to culinary standards. Its best use may be in secondary systems such as outdoor watering or low grade industrial processes. The assumption of water managers is that up to 90% of the surface flow in the Salt Lake Valley will be diverted to human use as needed in the future. (Jordan R. Plan, pp. 2-5,6)

Instream flow protection for the Jordan River is currently dependent upon return flows from irrigation and M & I waters. It is suggested that the streams of the Wasatch and Oquirrh Mountains should be protected by Salt Lake County zoning requirements such as those of the Salt Lake County Wasatch Canyon Master Plan.

Total Water Supply for the Jordan River Basin

Source	Average Annual Supply (acre-feet)
Jordan River	308,000
Wasatch Mountain streams	173,000
Oquirrh Mountain streams	4,000
Groundwater	168,000
Imported water	825,000 (CUP and other sources)

The Salt Lake Valley is underlain by two aquifers, a deep somewhat confined aquifer of high quality water and a shallow generally contaminated aquifer. Both are in unconsolidated valley fill but are incompletely separated by clay soils. As long as the deep aquifer percolates upward, it will not be contaminated by the shallow aquifer. However, the deep aquifer is considered to be very near to being mined, and if all the appropriated water were in fact developed, mining of that aquifer would occur. Then it would be in danger of contamination from downward movement from the shallow aquifer. This shallow aquifer has been contaminated by mining and industrial processes and the by-products of our chemically based life-style (Jordan R. Basin, p. 2.9, Niermeyer, 2009).

Salt Lake Valley water development history began when Mormon pioneers began diverting the waters of the Wasatch streams. Perhaps the first big water exchange was made when a deal was made to acquire Utah Lake or Jordan River water for irrigation so the better quality mountain waters could be used for culinary purposes in Salt Lake City. Since then the basin has a long and convoluted legal history of agreements and disagreements, too numerous to recount. Perhaps the most substantial are the Federal Central Utah Project and the Salt Lake-Utah Valley Welby-Jacobs Exchange, which bring water to the Salt Lake Valley via Utah Lake Basin water infrastructure (Hooten, Utah Lake & Jordan R., Jordan R. Basin, p.9.1). The Salt Lake Valley is served by two major water conservancy districts, the Metropolitan Water District of Salt Lake City and Sandy and the Jordan Valley Water Conservancy District, although there are a few other minor water distributors. There were 26 irrigation companies in the valley as of 1997. (Jordan R. Basin, p.6-1)

The Salt Lake Valley, as all Wasatch Front river basins, is expecting more than a doubling of population by 2050. Water managers, planners, and political leaders generally project a total build out for the valley portion of the Jordan Basin.

Water managers plan for population growth in the basin and propose these alternatives:

- Develop Utah Lake/Jordan River water
- Develop additional water from the Wasatch Range streams
- Develop additional groundwater
- Groundwater recharge
- Bear River water development
- Conservation

  (Jordan R. Basin Plan, p.2-4)

Utah Lake Basin

Basin Conditions

The Utah Lake Basin consists of most of Utah and Wasatch Counties, eastern Juab County and small parts of Summit and Sanpete Counties (UDWR, Utah Lake Basin, 1997, p. 3-2).

Utah Lake is the destination of nearly all rivers and streams in this drainage and the source of the Jordan River. The Provo River, with its headwaters on the western slopes of the Uinta Mountains, is the primary tributary. Storage is provided in Jordanelle, Deer Creek and Mona Reservoirs and Utah Lake. Water is imported through the Weber-Provo Canal, through the Duchesne Tunnel and the Syar Tunnel (UDWR, Utah Lake Basin, p. 3-4).

M&I diversion	141,345 acre- feet
M&I secondary use	5,100 acre-feet
Agricultural diversion	453.700 acre-feet
Depletions from wetlands and riparian areas	26,700 acre-feet
Evaporation from Utah Lake	230,000 acre-feet

(UDWR, Utah Lake Basin, p. 5-7).

Under the Central Utah Project (CUP) Completion Act, 101,900 acre-feet will be supplied to the Utah Lake Basin from Strawberry Reservoir for irrigation use in southern Utah and eastern Juab Counties and for M & I use in southern Utah County. Water will be delivered to Utah Lake for northern Utah and Salt Lake Counties in exchange for water retained in Jordanelle Reservoir. Delivery of water in the Utah Lake Basin will be managed to provide minimum flows in Diamond Fork Creek and the Spanish Fork River to enhance fish and riparian habitat as required by the federal government under the CUP. This water is provided by transbasin diversion from Strawberry Reservoir (UDWR, Utah Lake Basin, p. 5-5).

The Utah Lake Basin encompasses five groundwater basins. They are: Heber Valley, Round Valley, Cedar Valley, Utah-Goshen Valley and Juab Valley. Most of the groundwater comes from unconsolidated valley fill which creates a number of confined, unconfined and perched aquifers. All major groundwater producing areas in the Utah Lake Basin were closed to new appropriations by the State Engineer (UDWR, Utah Lake Basin, p. 19-1). Under approved water rights approximately 300,000 acre-feet may be withdrawn. Presently developed rights withdraw about 152,000 acre-feet annually (UDWR, Utah Lake Basin, p. 19-8).

Basin population in 1994 was 318,020. By 2020, the total is projected to be 569,803 (UDWR, Utah Lake Basin, p. 4-2).

A groundwater management plan for Utah and Goshen Valleys has been completed. The State Engineer wants to encourage the transfer of irrigation water to municipal purposes as farmland converts to subdivisions. To accomplish this will require that change applications to transfer surface water rights to groundwater sources be filed with the State Engineer (UDWR, Utah Lake Basin, p. 19-8). The present groundwater management plan provides for an annual withdrawal of 160,000 acre-feet more in addition to the 109,000 acre-feet now being withdrawn. This amount is conditional on the effect on surface water rights being mitigated. The Utah Lake plan recommends that major water suppliers aggressively pursue the possibility of large groundwater recharge projects and exchanges in the most urbanized areas of Utah Valley (UDWR, Utah Lake Basin, p. 19-10). The plan also recommends that agencies providing water implement pricing practices that provide an incentive to conserve water and are revenue neutral.

West Desert Basin – includes Snake Valley

Basin Conditions

According to the Utah State Water Plan, the West Desert Basin extends from the northwest corner of the state along the Nevada state line into the southern portion of the state, extending just past the north boundary of Iron County (UDWR, West Desert Basin, 2001, p. 2-1). The basin has been divided into four sub-basins: (western) Box Elder County, Great Salt Lake Desert, Tooele/Rush Valley and the Great Salt Lake (UDWR, West Desert Basin, p. 3-3). For the purpose of this study we will only consider the Great Salt Lake Desert, which is important because of the current issue involving water from Snake Valley, which is located in both Utah and Nevada.

Residents throughout the basin are dependent on groundwater for culinary water supplies, principally from wells (79%) and to a lesser extent from springs (UDWR, West Desert Basin, p. 2-7). Because the basin is a very dry environment and most of its streams are intermittent and ephemeral, in many locations groundwater is also a primary irrigation water source (UDWR, West Desert Basin, p. 5-1).

Most of the Great Salt Lake Desert is underlain with groundwater, much of which does not meet present drinking water standards for salinity. The largest and most dependable springs of the basin are fed by regional carbonate aquifers (UDWR, West Desert Basin, p. 2-13). Carbonate rocks form large gathering systems which discharge in single large springs (UDWR, West Desert Basin, p. 19-4).

Surface water recharge is the primary supply for the groundwater aquifer. The erratic nature of the winter snows can easily double the annual snowpack or cut it drastically during mild winters. This results in a significant fluctuation in the surface water runoff (UDWR, West Desert Basin, p. 5-2).

According to the Surface/Groundwater Budget, there is a total of 26,600 acre-feet per year that flows from Nevada into Utah in Millard County (UDWR, West Desert Basin, p. 5-10).

Basin Issues

In 1989, the Southern Nevada Water Authority filed a request with the Nevada State Engineer for water rights in Snake Valley among other areas. According to Mike Styler, Executive Director of the Utah Department of Natural Resources, Utah will not have to give up rights to water it currently uses. Negotiations are currently under way to work on issues. The negotiators plan to divide the water, upholding each state's existing rights and splitting up the rest between the two states (Styler, December, 2008, Address to American Society of Public Administration).

Kanab Creek/Virgin River Basin – includes St. George

Basin Conditions

The Kanab Creek/Virgin River Basin is tributary to the Lower Colorado River. According to the State Water Plan, the Virgin River Basin covers 3.2 million acres. Of that total 1.8 million acres are in Utah with the remainder in Arizona and Nevada. The whole basin includes most of Washington County, the western part of Kane County and a very small part of Iron County (Utah Board of Water Resources (UBWR), 1993, p.2-2).

In 1993, when the State Water Plan for Kanab Creek/Virgin River Basin was written, annual water use was:

M&I	10,570 acre-feet
Secondary	11,170 acre-feet
Irrigation	51,300 acre-feet
Exports	2,600 acre-feet
Reservoir evaporation	5,300 acre-feet

(UBWR, p. 2-5)

Groundwater is the primary source of drinking water, but surface water has been used more extensively since population has increased (UBWR p. 11-1). The principal aquifer is made up of Navajo sandstone. The long-term annual recharge in the Virgin River basin is estimated to be the same as the discharge of 155,000 acre-feet. Recharge and discharge for the Kanab Creek and Johnson Wash drainages is estimated at 31,000 acre-feet. Groundwater inflow from the Sevier River Basin is estimated at 16,500 acre-feet annually. Discharge from wells in 1982 was 27,000 acre-feet (UBWR p. 2-9). Most of the area underlain by the Navajo aquifer is closed to new appropriation (UBWR , p. 9-15).

There are 25,600 acres of irrigated cropland in the basin. The largest portion (31%) is used for alfalfa and grass hay. Crop production is used to support the livestock industry (UBWR, p. 10-7).

Water is exported from the Santa Clara River into Pinto Creek in the Cedar/Beaver Basin (UBWR, p. 5-26).

Quail Creek Reservoir, completed in 1985, has a total capacity of 40,325 acre-feet. Pine Valley, Baker, Lower Gunlock and Ivins reservoirs provide about 13,000 acre-feet of storage on the Santa Clara River system. Kolob and Ash Creek reservoirs have been built on the upper Virgin River. Blue Springs, Aspen Lake and Stratton are small reservoirs on tributaries (UBWR, p. 9-5).

Water for instream flows is required in the reach of the Virgin River from the Quail Creek Reservoir diversion to the St. George and Washington Canal diversion for the protection of endangered species (UBWR, p. 5-26).

Projections are that depletion of the water supply for culinary and secondary water will increase with increased population. Use of water for irrigation is expected to decrease as population growth displaces irrigated farmland (UBWR, p. 9-11).

Export of water may increase because of an agreement between Cedar City and the Washington County Water Conservancy District (WCD) under which Cedar City helped to pay for Quail Creek Reservoir in exchange for the potential to divert 6,100 acre feet from springs in the upper Virgin River basin (UBWR,p. 9-22).

Basin Issues

However, the largest increase in water demand would come from increased population. The State Water Plan written in 1993 used the 1990 population of 52,742 for the basin with a projected population in 2020 of 158,381 (UBWR p. 2-2).

However, according to the Lake Powell Pipeline Water Needs Assessment (2008), the estimated population in 2005 to be served by the pipeline was 165,802 while the 2020 projection is 349,846 (p. 6). This population includes 32,860 people in Iron County in 2005 and 61,236 in 2020. This population is not in the basin but served by the pipeline. Subtracting the Iron County population figure leaves a population of 132,942 in 2005 and 288,610 in 2020 in the basin, a much larger population than was projected in 1993.

The Lake Powell Pipeline is now in the planning stage. It is planned to serve not only communities in the Virgin River Basin but also Cedar City. According to the Lake Powell Pipeline Water Needs Assessment (2008), the estimated populations are

	2005	2020
Total Served by Pipeline	165,802	349,846
Served in Iron County	32,860	61,236
Served in Virgin River Basin/Kanab Creek	132,942	288,610

The Water Needs Assessment projects a much larger population in 2020 than was project in 1993 by the State Water Plan.

According to the 1993 Kanab Creek/Virgin River Plan, basin-wide use was 350 gallons per capita per day (gpcd) (p. 2-5). In 2005, a study of the municipal and industrial water supply showed water use of 309 gpcd, (p. xi). This report includes Iron County in measurements of water supply and use.

Per capita water use for culinary and secondary use in the Lake Powell Pipeline Water Needs Assessment (p. 7) is shown as

Washington County WCD – 328 gpcd
Central Iron County WCD – 243.5 gpcd
Kane County WCD – 430.3 gpcd

The statewide average water use is 293 gpcd. (UDWR, M&I Water Supply & Uses, State Summary, 2000, p. xiii)

The purpose of the Lake Powell Pipeline is to deliver about 100,000 acre feet in 2020 to the Washington County WCD, the Kane County WCD and the Central Iron County WCD (www.water.utah.gov/Lake Powell Pipeline) at a total cost of $1.06 Billion. Construction costs are to be shared by the conservancy districts (www.water.utah.gov/Lake Powell Pipeline/ OPCC).

Future per capita water use is assumed to decrease by 16% between 2005 and 2060 in the Washington County WCD and the Central Iron County WCD and by 31% in the Kane County WCD. Phase 2 of the Assessment will include a detailed evaluation of past and potential future water conservation (www.water.utah.gov/Lake Powell Pipeline/WNA p. 7).

According to a report that questions the assumptions used in planning for the pipeline, estimates made by Boyle Engineering for the Washington County WCD were inflated. The findings of this report are that projections of future population are too high, estimates of per capita water use are too high and the projections overestimate future water demand. This report says that in 2050 when the Boyle Report estimates population at 525,000 residents there will actually be only 328,000 residents because that is the "buildout" population envisioned by the consolidated development plans of the 12 municipalities. The report further states that future water use would be about 185 gpcd based on more realistic assumptions regarding growth in different sectors and that the effect of rising prices would further reduce water use (price elasticity). The final conclusion is that no imported water is required to meet realistic water needs of the region (Hydrosphere Resource Consultants, 2000, Executive Summary).

HOW OUR WATER IS CURRENTLY USED

Amounts Used by Type of User

The USGS estimates Utah's total water use in 2000 as 4.97 billion gallons per day. (1 **b**illion gal/day is roughly 1 **m**illion acre-ft/yr.) "Use" is how much is withdrawn from lakes, streams and groundwater. Part is "consumed," while the rest returns to the ground- or surface water after use. Agriculture used 76% of the total in 2000 at about 3.8 billion gallons per day. Except for the small amount of water taken from private wells, the remaining water use was municipal and industrial (Hutson, S, et. al., 2004). M & I includes residential, commercial (retail, restaurants, hotels, etc.), institutional (government buildings, parks, schools, etc.), and industrial uses.

It is surprisingly difficult to determine how much water is used in each category. There are many water providers, which may supply water to more than one type of user and don't keep data broken down the same way. Nevertheless, in 2001 the Utah Department of Water Resources (UDWR) published estimates of the residential, commercial, institutional, and industrial water use for each basin in Utah. The statewide totals are shown below. The "non-potable" column refers to what we call "secondary" water. These numbers are derived from data collected in 1993-1998.

Average Daily M&I Water Use in Utah
in gallons per capita per day (gpcd)

	Potable	Non-potable	Total
Residential	169	44	213
Commercial	34	5	39
Institutional	45	10	55
Industrial	14	0	14
Total M & I			321

(Adapted from: UDWR, 2001, State Plan, Table 8: Public community system and secondary system water use.)

Water for Wildlife

The discussion above considers only human use. Since damming and diversion of water for human use can profoundly alter ecosystems and bring species near extinction, it may be desirable to reserve water to keep streams flowing and wetlands wet. This is being done in many locations in Utah, often when a regulatory agency negotiates an agreement before project permits are issued. As discussed previously, the Utah Division of Wildlife Resources and Division of Parks and Recreation now have authority to buy water rights to maintain instream flows, as long as they have willing sellers and the legislature appropriates the money (UDWR, 2001, State Plan, p. 57). The federal government also holds water rights which may benefit the environment. For example, the water right held by the Bear River Migratory Bird Refuge benefits the Great Salt Lake ecosystem.

Aside from these situations, however, the natural environment receives whatever water falls upon it, whatever hasn't been developed (perhaps because it is polluted or difficult to reach), and whatever remains of developed sources.

How Does Utah Compare?

Two commonly stated facts about Utah water are: 1) Utah is the second driest state in the nation (at 13 inches precipitation yearly, behind Nevada at 9 inches); and 2) Utah's per capita water use is the second highest (or highest) in the nation. What does this mean? Per capita water use is the average amount of water used per day divided by the population. It is usually based on M & I (i.e. non-agricultural) water use and is expressed in gallons per capita per day, abbreviated gpcd. The per capita water use in several Western states during 2000 is shown here (calculated from Hutson et. al., 2004, Table 5).

Nevada: 336 gpcd
Utah: 293 gpcd
Wyoming: 264 gpcd
Idaho: 263 gpcd
Colorado: 240 gpcd
Oregon: 207 gpcd
New Mexico: 203 gpcd

Per capita M & I water use is influenced most by climate (high water loss to evaporation), so it's not surprising that the two driest states use the most water per capita. That is, unless you consider that most of Utah's population lives in the wetter northern part of the state. Some other factors affecting per capita water use figures are lawn size, hotel occupancy (the tourists aren't counted in the population), workers commuting from outside the area (not counted either), age of municipal infrastructure (leaks) and presence of industries with especially high water needs.

Of more interest if you are promoting household water conservation is *residential* water use per person. Taylorsville, UT was included in a recent study of household water use in several Western cities by Western Resource Advocates (2003, appendix B).

Water Use in 2001, gpcd

	Single Family Residence	M & I
Albuquerque	105	205
Boulder, CO	142	180
Denver	159	205
Las Vegas	230	302
Taylorsville, UT	193	221
Tucson	107	170

These comparisons show that it is possible for residents of a dry state to get along with less water than the average Utahn. The U.S. in general uses water at a high per capita rate—twice the European rate (U.N. Development Programme, 2006). The world's poor can barely obtain enough water to live, as this comparison from a Welsh web site brings home:

> "The average person in the developing world uses 10 litres [2.6 gal.] of water every day for drinking, washing and cooking. This is the same amount used in the average flush of a UK toilet." (www.dwrcymru.co.uk/English/waterefficiency/school/_pdf/waterfacts.pdf)

Imagine—five 2-liter bottles!

Whenever water statistics are quoted, it is important to know how the parameters are defined, where the numbers came from, and how reliable they are. For example, per capita water use might be defined as M & I water use divided by population or just municipal water use divided by population. The data may be recent or old, and the numbers may have been measured or estimated. If water use is said to be going up or down, take note whether this is per capita or total use.

Using Water Efficiently

Tucson has low per capita water use (see above), and Utah's dropped from 293 gpcd in 2000 to 260 gpcd in 2005 (UDWR (2009) Weber R. Basin, p. 47). Both are largely attributable to efficiencies achieved by both suppliers and consumers of water. "Conservation," meaning using less water to achieve a particular purpose (Western Resource Advocates, 2003), is receiving increased attention. It depends on end users such as households, schools, farms, and industry to change their use patterns, invest in more efficient appliances and equipment, fix leaks, etc.

We hear a lot about residential water conservation (e.g. "Slow the Flow"), especially reducing outdoor water use, since two-thirds of M & I use is residential and two-thirds of residential use is outdoors. (UDWR, 2001, State Plan, p.28). The reader is probably familiar with common conservation methods. There is some resistance to conservation based on the perception that saving water facilitates additional housing developments. Indeed, the planning focus has been on reducing per capita water use to compensate for population growth.

Since agriculture uses so much water, improvements in irrigation can save a lot. Pressurized sprinkler or drip irrigation reduces loss to evaporation. An alternative is laser land leveling to make traditional flood irrigation efficient. Both may increase crop yields and reduce the amount of fertilizer and pesticides carried to streams in runoff (UDWR, 2001, p. 38).

There are also opportunities for suppliers to achieve efficiencies throughout the delivery system. Fixing leaky dams and canals, dredging reservoirs, and repairing leaks in pipes all along the system are simple in concept. Although expensive, these may be more cost-effective than developing new water sources (Western Resource Advocates, 2003, pp. 27-28). Other supply-side strategies are less-used and less understood. They include:

Dry-year leases
Water Salvage Transfers
Aquifer storage and recovery (ASR)
Conjunctive use
Water re-use
(See the Glossary)

The benefits of a particular form of conservation, and who reaps the benefits, depend on the local situation. For example, ideally irrigation efficiency will increase crop yields, reduce pollution, and also leave more water for riparian habitats. However, in the common situation where all of a stream's water is claimed by agricultural users, conservation makes the water last longer and may benefit holders of junior water rights , but it only briefly increases instream flow. In fact the total amount of water available decreases, because it remains in a reservoir longer so more evaporates (UDWR, 2001, State Plan, p. 36). A third situation occurs in the upper Colorado River basin, where unconsumed irrigation water percolates through salt-laden formations before finding its way into a river. Efficient sprinkling systems there reduce the load of salts flowing into the Colorado River (UDWR, 2001, State Plan, p. 37).

Another example is re-use. Fifty percent or more of the water supplied to a municipality is not consumed (Western Resource Advocates, 2003, p. 33), so re-use can help growing cities stretch their water supplies. Along the Wasatch Front though, the return flow ends up in the Great Salt Lake. A significant amount of water re-use, since it isn't 100% efficient, would deprive the Great Salt Lake of life-giving water.

Increased efficiency by both consumers and suppliers can save money on water treatment and infrastructure, conserve energy, and reduce non-point source pollution. If combined with slower population growth, it could make additional water development unnecessary and leave more water for the natural environment.

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(Click on Planning Programs on the left side of the home page; the following references are divided according to which subheading of Planning Programs contains them. Some are only available as Executive Summaries online.)

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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 use rate of 225 gpcd).

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. See also: Perched.

Aquifer Storage and Recovery (ASR) - Storing surface water in aquifers instead of in reservoirs, where a lot is lost to evaporation. This can be accomplished by injecting water into wells or by forming recharge ponds over porous ground, so that the water percolates into the groundwater slowly. The water is pumped out when needed.

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.

Conjunctive Use - Coordinated use of surface and ground water systems to optimize resource use and minimize adverse effects of using a single source.

Consume (water) - Use water in a way that doesn't return it to the land. It may become part of a plant or animal or product or enter the atmosphere by evaporation or transpiration.

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 Water- 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.

Developed Water - Water that can be supplied to consumers because the necessary infrastructure (dams, pipelines, canals, pumps, etc) is in place.

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.

Dual Water System - See "Secondary Water System."

Dry Year Lease – Temporary lease of a water right to a municipality in particularly dry years. In those years, irrigation water would usually run short, resulting in poor crop yields. The farmer reduces his losses by not planting and receives payment for the water, while the city supplies more of its needs.

Efficiency - The ratio of the effective or useful output 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.

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.

Groundwater - 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.

Instream Flow - Water maintained in a stream to support wildlife, maintain aquatic, riparian or wetland habitats, provide recreation, and for aesthetic values.

Laser Land Leveling – making a field very level using earth-moving equipment equipped with a laser receiver. A rotating laser source is set up in the field to sweep out a level plane. The receiver controls the height of the blade on the leveler.

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 and Industrial (M&I) Use - This term is used to include residential, commercial, institutional and industrial uses of water that is publicly supplied.

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.

Perched Aquifer or Groundwater - Unconfined ground water separated by unsaturated rock from the underlying main body of ground water or aquifer.

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.

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 "Re-use."

Recharge - Water added to an aquifer or the process of adding water to an aquifer. Groundwater recharge occurs either naturally as the net gain from precipitation, or artificially. Artificial recharge can occur by diverting water into percolation basins or by direct injection into the aquifer with the use of a pump.

Return Flow - The portion of water diverted for use (often irrigation) that returns to the water supply, usually by entering a stream, canal or irrigation ditch.

Re-use - The reclamation of water from a municipal or industrial wastewater conveyance system. Depending on the extent of treatment the water receives, it may be used for irrigation or returned to the municipal supply. 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.

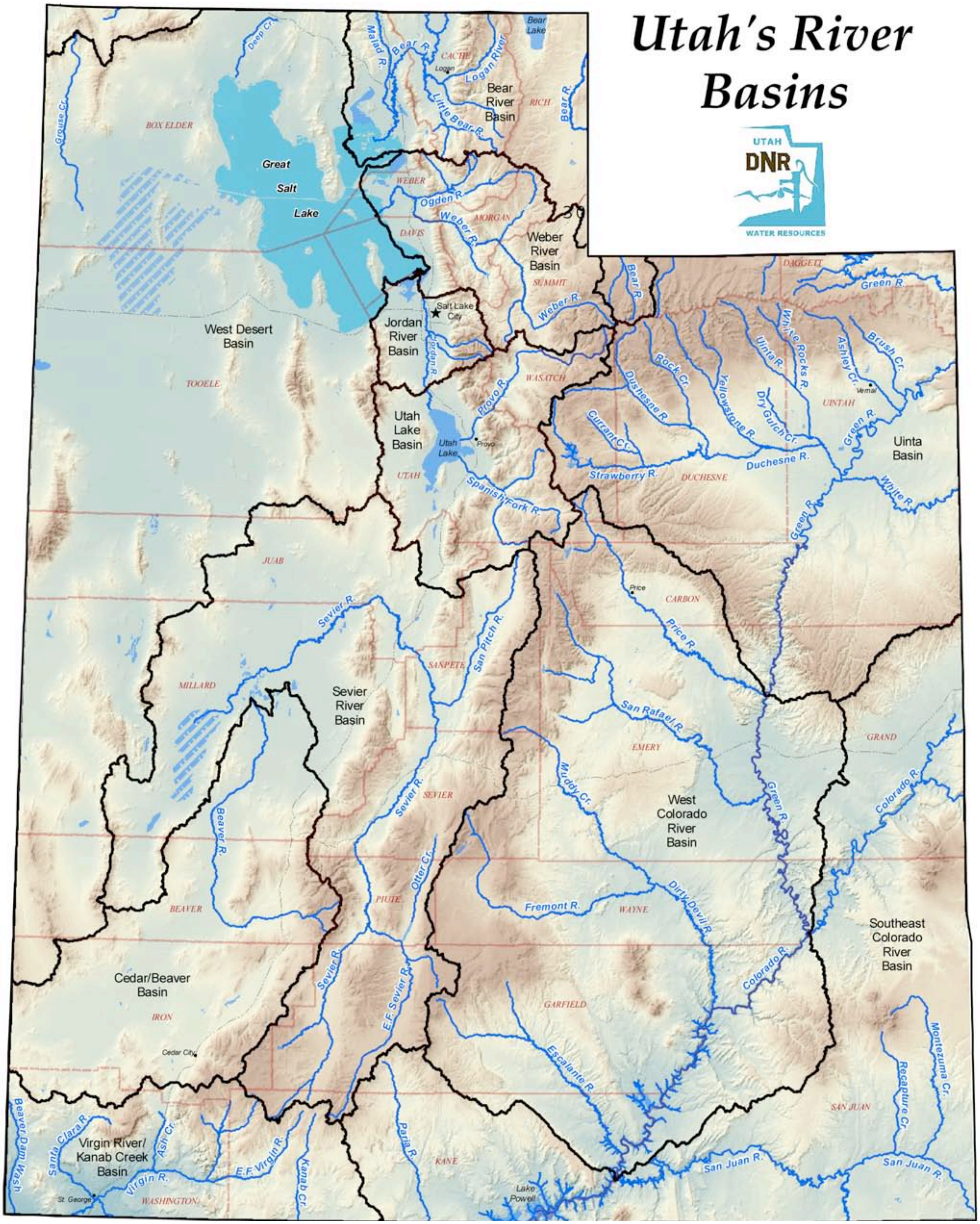
Senior/Junior Water Rights - Priority of water rights ranked by year of appropriation. An older water right is senior to any newer water right.

Transbasin Transfer – See Export.

Transpiration - The process of releasing vapor into the atmosphere through the pores of the skin or the stomata of plant tissue.

Water Salvage Transfer - One water supplier pays for capital improvements needed for another (usually agricultural) supplier to conserve water. The first gets use of the saved water. Complex agreements are required.

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.



Courtesy Utah Department of Natural Resources, Division of Water Resources
(former title: "Utah's Major Watersheds")

Physiographic Provinces in Utah

Modified from Stokes, 1977 in Lowe, p. 5

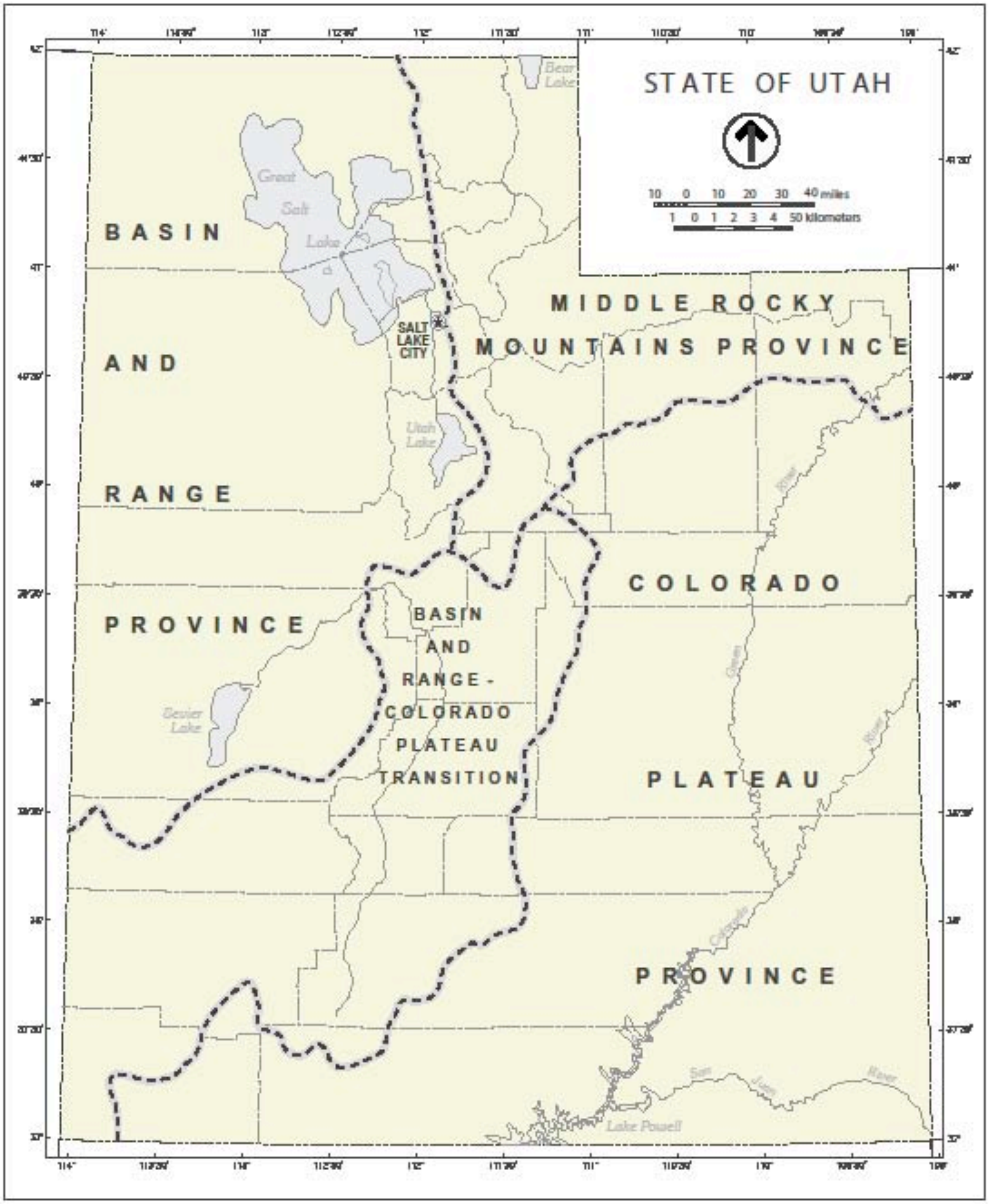
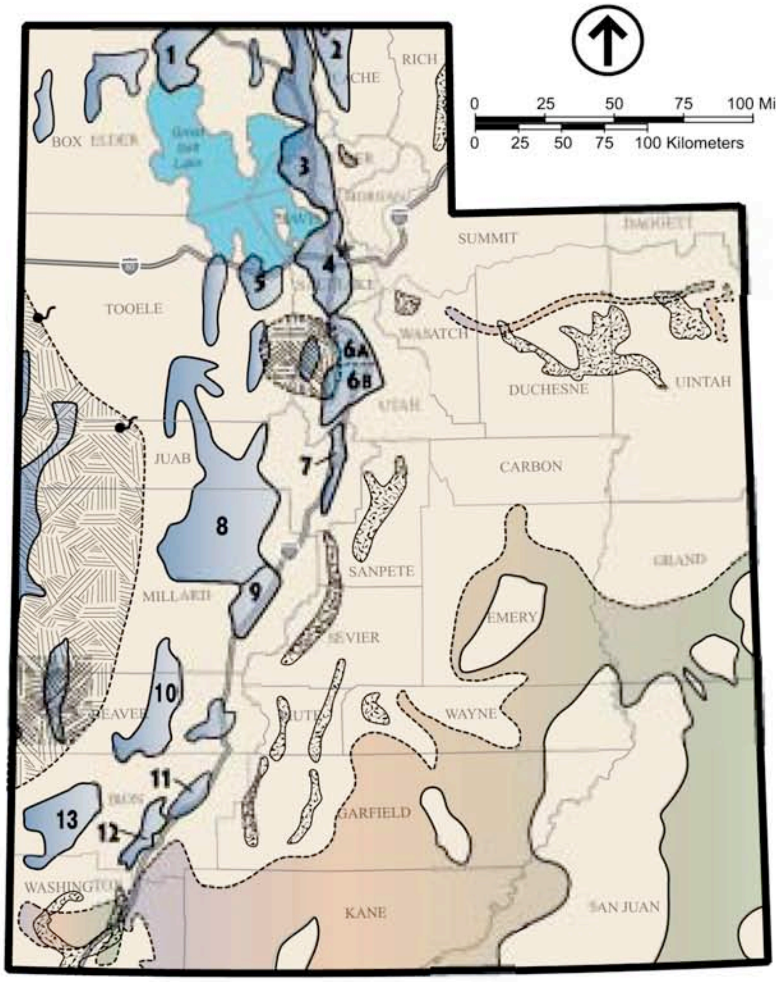


Figure 1. Physiographic provinces in Utah (modified from Stokes, 1977).

Geographic distribution of principal aquifers in Utah (modified from Gates, 1985).



Principal Aquifer and Subdivision

Unconsolidated Basin-fill Aquifers (1-13)

(1) Curlew Valley
(2) Cache Valley
(3) East Shore area
(4) Salt Lake Valley
(5) Tooele Valley
(6) Utah and Goshen Valleys
  (6a) Northern Utah
  (6b) Southern Utah-Goshen
(7) Juab Valley
(8) Sevier Desert
(9) Pahvant Valley
(10) Milford area
(11) Parowan Valley
(12) Cedar Valley
(13) Beryl-Enterprise area

Unconsolidated Valley-fill Aquifers

Sandstone Aquifers

Carbonate Rock

Not a principal aquifer

Boundary of aquifer uncertain

Spring – Discharges large volumes of water from carbonate-rock aquifer