UTAH DNR

Lake Powell Pipeline Study

WATER NEEDS ASSESSMENT

Phase 1 Report

Final Draft

August 2008

MWH

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Glossary

Acre-foot – a volumetric unit of water used in water supply planning, which is equivalent to water spread over an acre of area with a depth of 1 foot (325,851 gallons)

Annual Growth Rate – the yearly compounding increase in a value, used in this report to represent the yearly rate of growth for population projections

Aquifer – an underground water-bearing geologic formation

Buy and Dry – the conversion of agricultural water rights for other uses, typically through purchase by municipal and industrial water providers, with a resulting dry-up of irrigated land

Conservation – reduction in per capita water use typically achieved through water savings measures such as water reuse, efficient lawn watering practices, and low flow water fixtures

Culinary Water – water supply that meets drinking water quality standards and can be used to meet all water demands (synonymous with potable water)

Ground Water – water contained in an aquifer, and sometimes extracted for water supply (typically extracted through a ground water well)

Integrated Water Resources Plan – a balance of forecasted water demands and existing and future water supply projects, typically prepared for planning the timing and volume of future potential water supplies

Maximum Annual Supply – the yearly volume of water that could be delivered at the maximum daily flow rate of a given water supply

Maximum Contaminant Level (MCL) – the greatest level of a particular contaminant within a water source that is considered to be a threshold for making the water source available for beneficial use (e.g., a drinking water MCL for total dissolved solids)

Non-Potable Water – water supply that does not meet drinking water standards, which can be used to meet demands that do not require drinking water quality (e.g., irrigation and lawn watering) (synonymous with secondary water)

Per Capita Water Use – the average rate of water consumption per person, typically calculated in gallons per person per day

Permanent Population – the number of residents living in an area that occupy their residences year-round (i.e., not including tourists or part-time residents)

Potable Water – water supply that meets drinking water standards, which can be used to meet all water demands (synonymous with culinary water)

Prior Appropriation Doctrine – a water administration system typically used in the western United States, which prioritizes water rights by the date that the rights were first administered (i.e., through seniority of the rights)

Reliable Annual Supply – The annual volume of water that is readily available to meet peak demands (in this report, reliable supply is based on the Utah Division of Water Resources definition – the portion of the maximum potable water supply that can be used to meet annual water demands)

Secondary Water – water supply that does not meet drinking water standards, which can be used to meet demands that do not require drinking water quality (e.g., irrigation and lawn watering) (synonymous with non-potable water)

Sustainable Yield – the volume of ground water that can be withdrawn from an aquifer on an average annual basis without depleting the long-term storage of the aquifer, which is generally equal to the amount of recharge to the aquifer

Water Reuse – the use of treated wastewater for a beneficial use, such as lawn and golf course irrigation or industrial water; potable water reuse refers to the use of treated wastewater to meet culinary demand

Yield – the amount of water can be delivered from a particular supply, typically given in terms of annual supply

Abbreviations and Acronyms

CFP	Capital Facilities Plan
CICWCD	Central Iron County Water Conservancy District
CII	Commercial/Industrial/Institutional
DATC	Dixie Applied Technology Courses
DWRe	Utah Division of Water Resources
DWRi	Utah Division of Water Rights
GOPB	Utah Governor's Office of Planning and Budget
GPCD	Gallons per capita per day
KCWCD	Kane County Water Conservancy District
LPP	Lake Powell Pipeline
M&I	Municipal and Industrial
NEPA	National Environmental Policy Act
RWSA	Regional Water Supply Agreement
SITLA	Utah State Institutional Trust Lands Administration
SWAT	Smart Water Applied Technology
TMDL	Total Max Daily Load
USGS	United States Geological Survey
WCWCD	Washington County Water Conservancy District
WCWMCP	Washington County Water Management and Conservation Plan
WECCO	Western Electrochemical Company

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Executive Summary

ES-1 Introduction

The Lake Powell Pipeline Study Water Needs Assessment was conducted to evaluate the need for future water supplies by the Lake Powell Pipeline Project participants. The Lake Powell Pipeline (LPP) would deliver water from Lake Powell to water users in southwest Utah. The LPP participants are the Washington County Water Conservancy District (WCWCD), the Central Iron County Water Conservancy District (CICWCD), and the Kane County Water Conservancy District (KCWCD). The three participating water conservancy districts are referred to as the "Districts" throughout this report, and their service area locations are shown in **Figure ES-1**.

The Districts have requested allotments of water from the LPP project based on their own assessments of future water needs. These requests are summarized as follows.

- WCWCD – 70,000 acre-feet per year (ac-ft per year)
- CICWCD – 20,000 ac-ft per year
- KCWCD – 10,000 ac-ft per year

The objectives of the LPP Water Needs Assessment are to:

- Determine the validity of the participants' requests based on estimates of future supplies and demands
- Determine the likely timing of the need for the LPP supply when integrated with other potential supplies
- Determine additional water supply needed to meet projected demands on top of existing supply
- Provide the groundwork for a Purpose and Need Statement that would be required as part of the National Environmental Policy Act (NEPA) environmental permitting process for the LPP, if the project goes forward

The Water Needs Assessment is being conducted in two phases. Phase 1, which is summarized in this technical report, consists of developing preliminary population forecasts, water use rates, future conservation savings, and future water demands. In Phase 2, more detailed studies of future conservation measures and water reuse opportunities will be conducted. After completion of Phase 2, this technical report will be updated and finalized with the revised information.

Phase 1 of the Water Needs Assessment included the following specific analyses.

- Population projections
- Water demand projections
- Existing water supply descriptions
- Potential water supply project descriptions
- Water conservation projections
- Coordination with local stakeholder groups
- Integrated water resource plan including Lake Powell Pipeline
- No Action Alternative development

The Water Needs Assessment was prepared by MWH Americas, Inc. under contract to the State of Utah.

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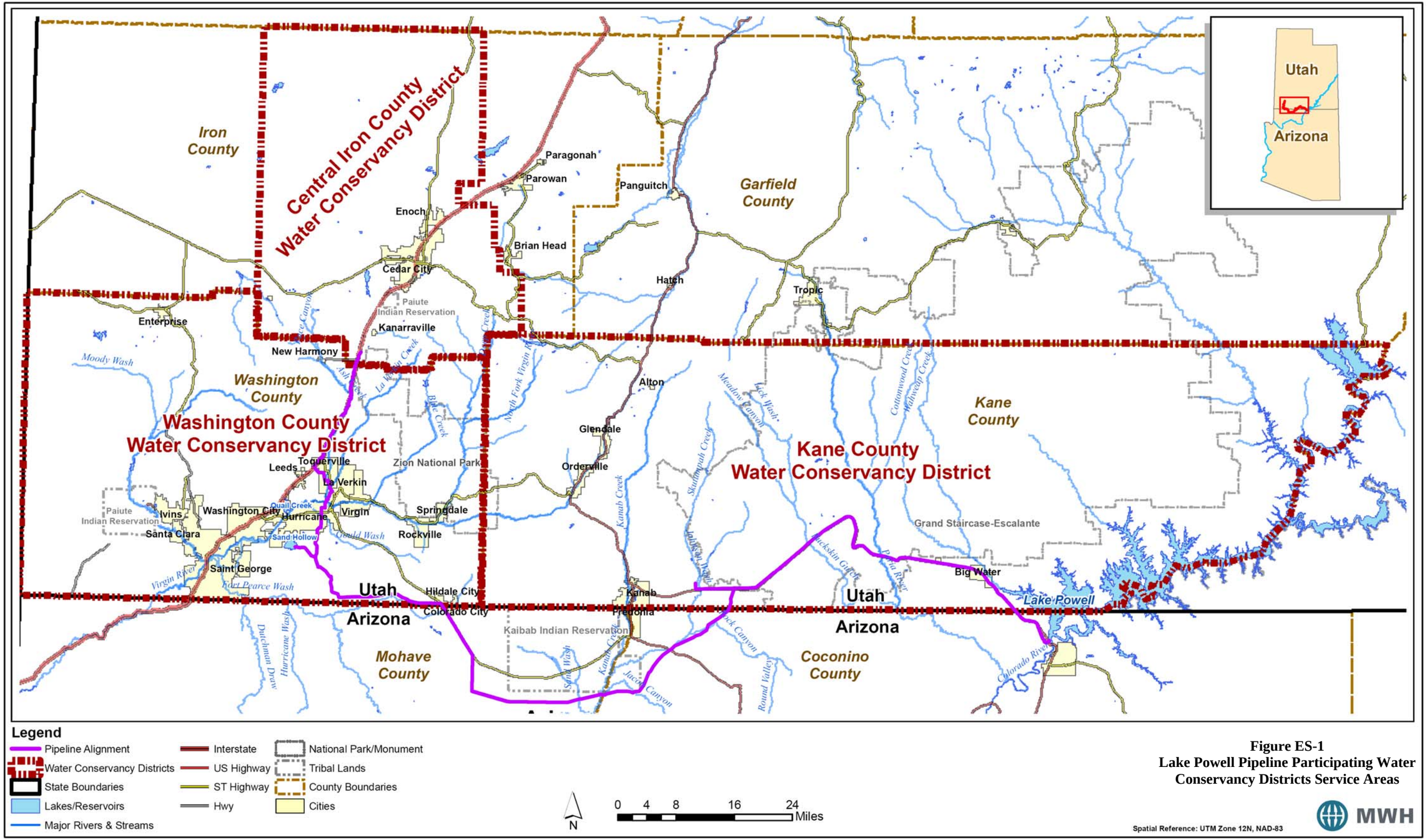

Figure ES-1
Lake Powell Pipeline Participating Water Conservancy Districts Service Areas

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ES-2 Methodology

The study area for the Water Needs Assessment consisted of the areas that are potential recipients of water from the Lake Powell Pipeline. These include the following:

- All of WCWCD service area
- All of CICWCD service area
- All of KCWCD service area

WCWCD was organized in 1962 under the Water Conservancy Act and is a regional water supply agency in Washington County (WCWCD 2003). The WCWCD service area encompasses all of Washington County, and includes all of the property within the boundaries of the incorporated cities and towns. The main role of the WCWCD is to develop or purchase water rights and deliver this water within its service area. It is primarily a wholesaler of water for the municipalities in Washington County, and serves water on a retail basis only when other local providers are not available or do not have the facilities to do so.

CICWCD was formed in 1997 and serves customers in the central portion of Iron County, primarily including the unincorporated areas around Cedar City, Enoch City and Kanarraville. These three cities have their own independent supplies and water systems, as do rural water users within the CICWCD boundary. CICWCD currently serves culinary M&I water to several customers, and is planning on extending existing culinary and secondary water systems into areas of new development. CICWCD is engaged in long-term regional water supply planning for all entities in the Cedar Valley area.

KCWCD was formed in 1992, and has a service area incorporating all of Kane County. It has a very limited customer base and limited supply sources at present. Existing KCWCD customers are rural developments located in the Cedar Mountain and Johnson Canyon areas. The only substantial community in Kane County - the City of Kanab - has developed its own water supply system over time, and intends to continue to meet the needs of M&I customers within its current city boundaries, and within future annexation areas as well. Although all of the KCWCD service area was considered in the water needs assessment, there are four subbasins within the service area with independent water supplies due to restrictions that prevent water transfers between the subbasins. Therefore, water needs for these four subbasins were evaluated separately. Additionally, a portion of Kane County would be too remote relative to the proposed Lake Powell Pipeline alignment and could not be served by the pipeline. However, permanent population in these remote areas is minimal and the KCWCD population used to estimate demand for this needs assessment was assumed to be equal to the population of all of Kane County.

The following general study methods were used for planning and analysis of water needs associated with the Lake Powell Pipeline alternatives.

- Population forecasts were based on officially adopted forecasts provided by the Utah Governor's Office of Planning and Budget (GOPB).
- Future per capita water use rates were based on 2005 per capita use rates for culinary (potable) and secondary (nonpotable) water, reduced by assumed future conservation.
- Water conservation goals for the study area were compared to the State's goal of 25 percent reduction in water use by 2050 as compared to 2000 water use rates.
- Population and water needs were forecasted for the 2005 to 2060 study period, the adopted planning horizon for future environmental studies.
- Estimated yields of existing and potential water supply projects were obtained from previous studies and information provided by the LPP participants and the State of Utah.

- Existing and potential future water supply projects were combined in an integrated water resource plan to meet 2060 forecast demands based on qualitative assessments of cost, water quality, and other factors.
- WCWCD, CICWCD and KCWCD demands and water supply projects were evaluated independently, although future potential water supply projects could be developed to serve customers in more than one jurisdiction.
- Effects of possible climate change on per capita water use were not considered.

ES-3 Water Demand Forecast

Total annual municipal and industrial (M&I) water demand forecasts were developed for the 2005 to 2060 study period for the three Districts using population projections, 2005 per capita water use data, and an assumed conservation savings based on the 2005 per capita water use. A projected water demand was calculated for the Districts as the product of the projected population and future per capita water use rates including projected conservation.

ES-3.1 Population Projections

A range of population projections was determined for each of the Districts based on population projection data from the GOPB. Population projections released in 2005 were used as the starting point for the projections for the Districts. GOPB projections were updated in January 2008, and these values were used as the primary population forecast for this study. The range of population projections used in this report was determined by increasing and decreasing the 2008 projections by 10 percent. Population projections for the Districts, based on GOPB projections, are summarized in **Table ES-1**.

Table ES-1
Population Projections

District	Parameter[2]	Year							2005 to 2060 AGR
		2005	2010	2020	2030	2040	2050	2060	
WCWCD	Pop.	127,090	168,078	279,864	415,510	559,670	709,674	860,378	--
	AGR	--	5.59%	5.10%	3.95%	2.98%	2.37%	1.93%	3.48%
CICWCD	Pop.	32,860	45.358	61.236	78,563	98,833	123,020	150,936	--
	AGR	--	6.45%	3.00%	2.49%	2.30%	2.19%	2.05%	2.77%
KCWCD	Pop.	5,952	6,893	8,746	10,394	12,034	14,267	17,276	--
	AGR	--	2.94%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%

[1] Source of population projections is GOPB (2008), except for the 2005 population, which is estimated population data accessed from DWRe (2006c; 2007a; 2007b; 2008).
[2] Pop = GOPB population projection; AGR = annual growth rate.

ES-3.2 Per Capita Water Use

Current and future per capita water use rates were determined for the Districts based on 2005 per capita M&I water use rates provided by the Utah Division of Water Resources (DWRe). Current per capita water use rates were based on 2005 water use data summarized in DWRe M&I water supply and use reports, and are provided in **Table ES-2**. The per capita water use provided throughout this report and used in projecting water demands was calculated as the total water use (culinary and secondary) divided by the total permanent population. This is consistent with the methodology used in the DWRe M&I water supply and use reports.

Table ES-2
2005 Per Capita Water Use

District	Culinary (gpcd)	Secondary (gpcd)	Total (gpcd)
WCWCD	276.0	52.3	328.3
CICWCD	221.9	21.6	243.5
KCWCD	345.7	84.6	430.3

Source: (DWRe 2006c; DWRe 2007a; DWRe 2007b; DWRe 2008a)

Future per capita water use for the study period was based on the 2005 per capita water use summarized in **Table ES-2** reduced by an assumed conservation percentage. The percent reduction applied to the 2005 per capita water use was based on the DWRe conservation goal of achieving 25 percent reduction in per capita water use statewide by 2050 relative to 2000 per capita use. The following reductions in per capita use were assumed for the Districts to calculate future M&I per capita water use.

- **WCWCD -** 16 percent reduction in per capita water use from 2005 to 2060 (based on the DWRe statewide target of 13 percent reduction in per capita water use for 2005 to 2050 and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal), with a linear distribution of the conservation over the period. A 12 percent reduction in per capita water use was estimated for WCWCD from 2000 to 2005.
- **CICWCD -** 16 percent reduction in per capita water use from 2005 to 2060 (based on the DWRe statewide target of 13 percent reduction in per capita water use for 2005 to 2050 and based on direction from DWRe to extend conservation through 2060 using the rate of reduction in DWRe's current goal), with a linear distribution of the conservation over the period. A 12 percent reduction in per capita water use was estimated for CICWCD from 2000 to 2005.
- **KCWCD -** 31 percent reduction in per capita water use from 2005 to 2060. Kane County has not achieved any conservation over the 2000 to 2005 period, and as a result, KCWCD should achieve 25 percent reduction from 2005 to 2050 based on the state's goal and an additional 6 percent from 2050 to 2060 based on direction from DWRe to extend conservation through 2060 using the rate of reduction in DWRe's current goal.

Phase 2 of the LPP Water Needs Assessment will include a detailed evaluation of past and potential future water conservation, and will refine the assumptions described above.

ES-3.3 Demand Projections

Total M&I projected water demands were estimated for the Districts using the population projections described above and the 2005 M&I per capita use rates reduced by the conservation percentages described above. The projected water demands were calculated using the GOPB (2008) population projections multiplied by the per capita water use with conservation described in the previous section. In addition to the demand forecasts developed based on population projections and per capita water use, additional commercial and industrial water use was added to the CICWCD and KCWCD water demand forecasts. Additional demand for CICWCD is associated with requests made by the Palladon Mines, Western Electrochemical Company (WECCO), and two Paiute Indian bands. Additional demand for KCWCD is associated with the Coral Cliffs golf course expansion. No additional CII demands were included for WCWCD.

The demand forecast for WCWCD shown in **Figure ES-2** indicates that total M&I demand for WCWCD would increase from 46,700 ac-ft per year in 2005 to 265,780 ac-ft per year in 2060. The demand forecast for CICWCD shown in **Figure ES-3** indicates that total M&I demand for CICWCD would increase from about 9,000 ac-ft per year in 2005 to 41,600 ac-ft per year in 2060. The demand forecast for KCWCD shown in **Figure ES-4** indicates that total M&I demand for KCWCD would increase from about 2,900 ac-ft per year in 2005 to 6,030 ac-ft per year in 2060. The overall demand for KCWCD was broken down into demand for each of the four subbasins within the KCWCD service area. The demand projections for the subbasins are shown in **Table ES- 3**.

Figure ES-2
WCWCD Total M&I Water Demand Forecast

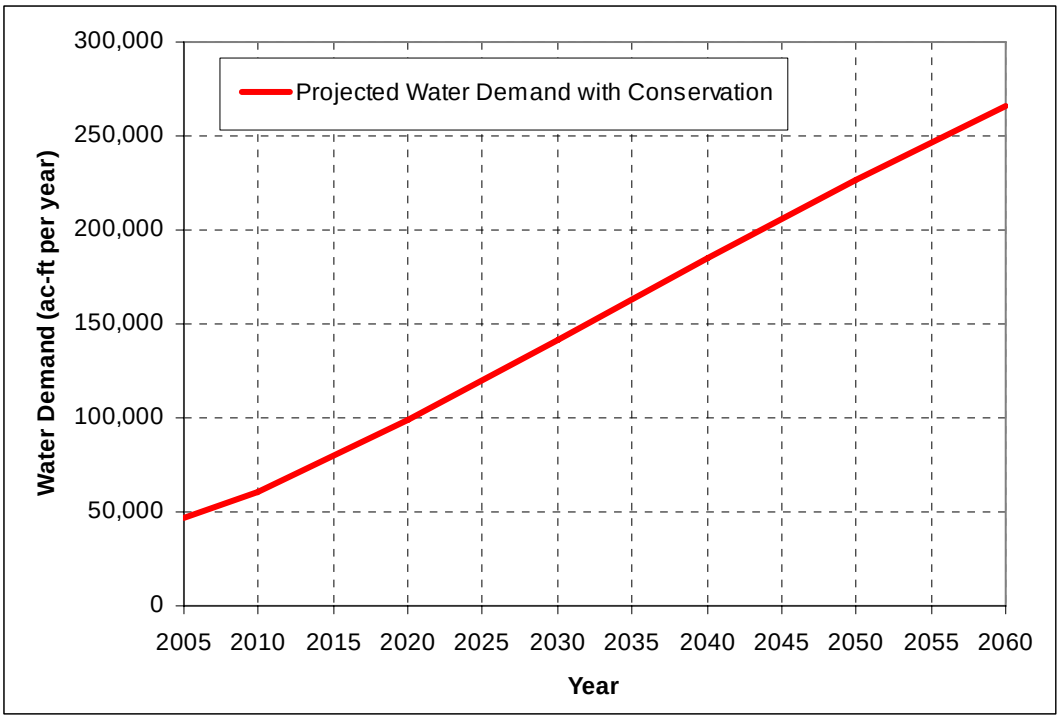


Figure ES-3
CICWCD Total M&I Water Demand Forecast

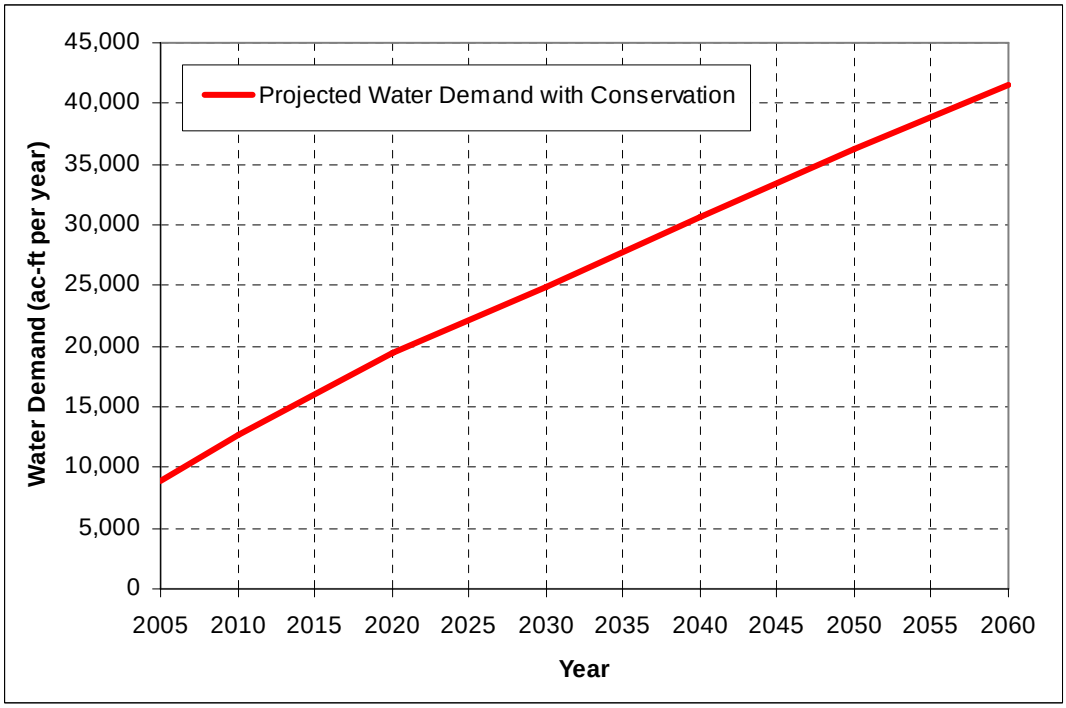


Figure ES-4
KCWCD Total M&I Water Demand Forecast

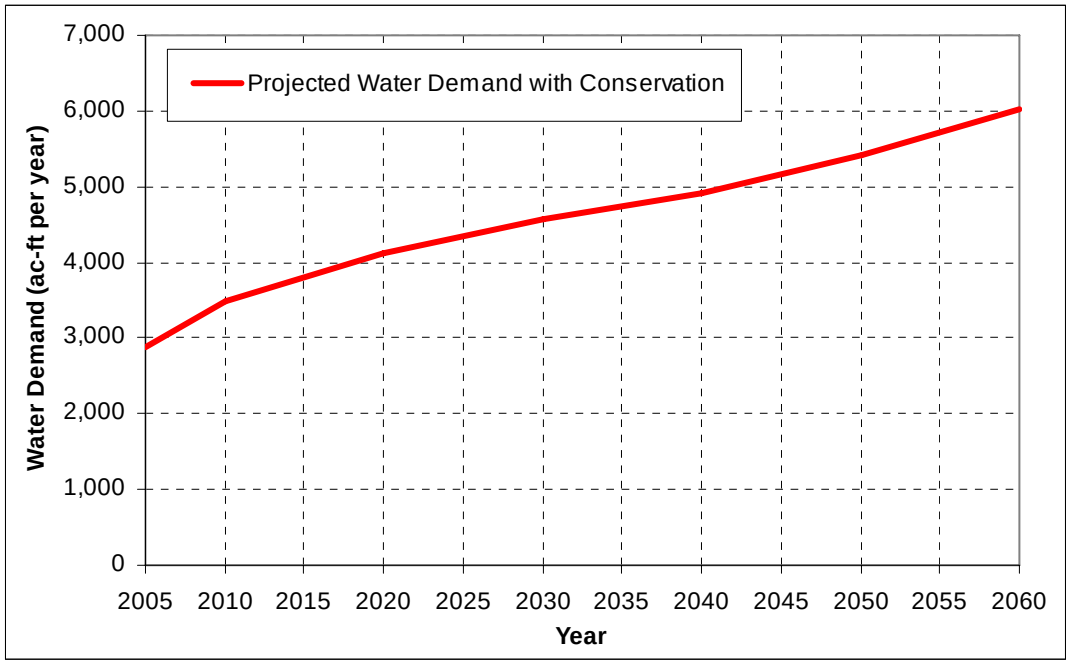


Table ES- 3
KCWCD Subbasin M&I Water Demand Forecast

	Projected Water Demand (ac-ft per year)						
Subbasin	**2005**	**2010**	**2020**	**2030**	**2040**	**2050**	**2060**
East Fork Virgin River	500	560	670	750	810	900	1,010
Kanab Creek	1,990	2,240	2,670	2,990	3,230	3,570	4,250
Johnson Canyon	90	110	130	140	150	170	190
Wahweap Creek	290	330	390	440	470	520	590

ES-4 Water Supply Conditions

Existing and future planned and potential water supplies for the Districts were summarized based on information provided by the Districts and the State of Utah. Water supply projects for all M&I water use (culinary and secondary) were discussed. Existing reliable annual culinary and secondary supply, as estimated by the Utah Division of Water Resources in their Municipal and Industrial Use Reports, was used to estimate the yield of existing water supplies. Reliable annual supply for future water supplies was determined based on estimates made from other reports completed for the Districts and updated estimates of yield determined during meetings with the Districts regarding this Water Needs Assessment.

ES-4.1 WCWCD Water Supplies

Water supply for WCWCD originates from ground and surface water sources. The Navajo Sandstone Aquifer and shallow alluvial aquifers provide ground water resources. Surface water sources consist of water originated from the Virgin River and its tributaries either taken directly through diversions or stored in reservoirs. Ground water sources within the WCWCD area are considered to be fully appropriated and closed to further appropriations at this time (DWRi 2008b). Existing WCWCD culinary and secondary water supply projects and their associated yields are summarized in **Table ES-4**. Existing secondary M&I water supplies for WCWCD consist of the Toquerville Secondary Water System and the Gunlock to Santa Clara Pipeline.

Total water supply within Washington County includes those rights owned by WCWCD and rights owned by other cities and towns in the District. WCWCD has executed a Regional Water Supply Agreement (RWSA) with five municipalities in Washington County (St. George, Washington, Ivins, Hurricane, and LaVerkin). The RWSA provides the structure by which WCWCD will provide water throughout the county in the future. The municipal customers will retain their existing water resources, rights and facilities, except to the extent that they choose to integrate them with WCWCD's water supplies provided through the RWSA, which would require additional contracts with the District. The RWSA changes the approach for providing water supply, with water being sold at rates that are structured to encourage conservation (i.e., customers only pay for water they use). Impact fees discourage excessive outdoor water use. The RWSA also imposes conservation and water quality requirements on municipal water customers through stipulations on water use, landscape ordinances, and water reuse.

Table ES-4
WCWCD Existing Supplies – Reliable Yield

Project	Reliable Culinary Quality Water Yield (ac-ft/yr) [1]	Reliable Secondary Quality Water Yield (ac-ft/yr) [1]
Quail Creek and Sand Hollow Reservoir	29,500	0
Sand Hollow Ground Water	8,000	0
Kolob Reservoir	2,000	0
Meadow Hollow Reservoir	200	0
Cottam Well Field	2,000	0
Sullivan Well Field	750	0
Kayenta (Ence Wells) Water System	1,000	0
Gunlock to Santa Clara Pipeline	0	2,500[2]
Toquerville Secondary Water System	0	160
Total	**43,450**	**2,660**

Notes:
[1] Source of data: (WCWCD 2006; WCWCD 2007c; DWRe 2008a), except for Gunlock to Santa Clara Pipeline reliable secondary yield.
[2] Source of data: WCWCD (2008)

The total existing reliable supply in Washington County, including those rights owned by the WCWCD, is approximately 72,560 ac-ft per year of potable supply and 7,450 ac-ft per year of secondary supply (DWRe 2007a; DWRe 2008a). Additional supplies available from current or pending projects include 3,900 ac-ft per year of available supply from a newly constructed water reuse plant in St. George. Reliable supply for surface water sources was calculated for a 75 percent reliability level (i.e., maximum surface water shortage of 25 percent in any given year that would be made up with ground water supply). The resulting total reliable existing and near-term supply for Washington County is approximately 83, 910 ac-ft per year.

Table ES-5 summarizes the water supply projects currently planned by WCWCD to meet the demands of existing and future water users in Washington County, and those that those being considered if certain technical, environmental or cost concerns were resolved. Individual projects would supply either culinary or secondary water to District customers.

Water quality issues will influence the potential for use of several of the future projects. For example, elevated levels of total dissolved solids in water associated with agricultural conversions associated with development will limit the cost effective use of this water to selected secondary water uses such as turf irrigation; culinary use of this predominantly surface water based supply would require advanced water treatment such as reverse osmosis. Current TDS concentrations of the WCWCD water supply range from 100 to 800 mg/L, with an average of about 450 mg/L. TDS concentrations of untreated Lake Powell water in the top 100 feet range from 350 to 600 mg/L. Virgin River water near the existing Washington Fields agricultural diversion (where a majority of agricultural conversions will likely occur) has an average TDS of approximately 1,500 mg/L (USEPA 2008). Blending with other lower TDS sources or even advanced water treatment may be required for widespread secondary use of water associated with agricultural conversions, in order to reduce salinity to a level appropriate for irrigation of common residential turf and ornamentals. Treatment of surface water supplies would be economically and technically challenging relative to other potential projects. Reverse osmosis requires expensive and technically advanced water treatment processes that have not been applied to water of this quality on a large scale in inland areas. In addition, disposal of the waste brine stream in an environmentally acceptable manner would be very difficult and expensive.

Table ES-5
Future Planned and Potential WCWCD Water Supply Projects

Project	Estimated Reliable Culinary Supply (ac-ft/yr)	Estimated Reliable Secondary Supply (ac-ft/yr)
Ash Creek Pipeline	5,000	0
Crystal Creek Pipeline	2,000	0
Maximize Existing Wastewater Reuse [1]	0	1,700
Quail Creek Reservoir Agricultural Exchange	4,000	0
Agricultural Conversion from Development[2]	0	12,400[3]
Lake Powell Pipeline	70,000	0
Potential Future Wastewater Reuse	0	54,500[4]
Total Potential Yield from Future Projects	**81,000**	**68,600**

[1] The maximum capacity of the existing reuse treatment plant is 3,360 ac-ft/yr, but this supply can only be used to meet secondary demands during the irrigation season (April through October) and there is no storage capacity resulting in the loss of any supplies that are not used by the end of a given month. Assumed that only 50 percent of treatment capacity could be utilized because of lack of storage capacity for reuse water.

[2] Of the 17,300 ac-ft per year of available supply, 4,000 ac-ft/yr of this supply would be reserved for the Quail Creek Reservoir Agricultural Supply Exchange to meet culinary demands, leaving 13,300 ac-ft/yr available for the agricultural conversion projects. An additional loss from advanced water treatment was assumed as described in the following footnote, resulting in 12,400 ac-ft per year reliable yield.

[3] Although reverse osmosis would be less likely than blending with a higher quality water source as described in Section 4.1.5.5, reverse osmosis was assumed to conservatively estimate the secondary supply from this source. A 20 percent loss was realized for the portion of this supply that must be treated with reverse osmosis to reduce salinity to a level where mixing would reduce the TDS to the appropriate maximum contaminant level (i.e., 500 mg/L TDS recommended MCL for culinary use, and 1,000 mg/L TDS for secondary use.

[4] Wastewater reuse could potentially be increased up to the wastewater effluent rate for communities served by the St. George wastewater treatment plant (i.e., St. George, Washington, Santa Clara, and Ivins), limited by secondary demand. The wastewater effluent available for reuse is calculated assuming the ratio of wastewater effluent to total M&I water supply (approximately 27 percent) remains constant for these cities in the future, and using the 2060 projected total M&I water use for these cities. However, the actual amount of this potential reuse that could actually be used as secondary supply would be limited by storage constraints and secondary demands which were considered in Chapter 6 when determining a realistic estimate of the portion of this supply that could be used.

ES-4.2 CICWCD Water Supplies

Existing M&I water supply within the service area of CICWCD consists of ground water supply from the Cedar Valley ground water basin. CICWCD is building its customer base and currently has limited water supply because of this small but growing customer base. The District's existing infrastructure consists of two wells on the north side of Cedar City with a combined capacity of 2,000 gpm, two tanks with combined storage of 2.4 million gallons, and approximately 10,000 feet of distribution pipeline. CICWCD has been in the process of acquiring existing agricultural water rights and entering into interlocal agreements with several subdivisions in its service area. Existing and proposed water rights for CICWCD total 1,308 ac-ft per year. Future water supplies in the CICWCD service area could be developed by the CICWCD or by the individual cities within the District's service area.

Total reliable M&I water supply in the CICWCD portion of Iron County consists of 11,360 ac-ft per year of potable supply (3,800 ac-ft from springs and 7,560 ac-ft from wells) and 800 ac-ft per year of secondary supply. This primarily occurs in Cedar City.

The Cedar Valley ground water basin is considered to be over appropriated at this time. The sustainable yield for the aquifer was estimated to be between 33,600 and 42,000 ac-ft per year (USGS 2005). Future water use scenarios for this report were developed using an assumed sustainable yield of 37,600 ac-ft per year. Ground water withdrawal above the sustainable yield may be curtailed by the Utah State Engineer. Any new M&I water supply will need to originate from either transfer of existing agricultural water rights within the basin, or importation of water supply from outside of the basin.

A summary of potential future water supplies for CICWCD is provided in **Table ES-6**. Two of the substantial sources of future developable CICWCD supplies would involve transfer of agricultural water rights for M&I uses (agricultural conversions from development of irrigated land, and M&I acquisition of agricultural water rights outside the future development boundary). Depending on the actual amount of agricultural water rights that would be transferred to M&I, these transfers could have adverse socioeconomic impacts on central Iron County. Transfers of agricultural water rights would result in a shift in the way of life in central Iron County away from a relatively rural culture to a more urban culture. Additionally, water quality issues within the Cedar Valley Aquifer may influence which of the potential future projects would be implemented to meet projected future demands. Elevated concentrations of nitrates and total dissolved solids exist in some areas within the aquifer, which could migrate towards existing ground water wells if ground water levels are substantially drawn down in the existing wells.

Table ES-6
Summary of Future Developable CICWCD Source Waters

Source	Maximum Potential Yield (ac-ft/yr)	Comments
New Local Surface Water Rights	0	Basin is considered over-appropriated by State Engineer
Development of Existing Local Ground Water Rights	3,610	Develop up to total existing ground water rights for Cedar City and Enoch City, limited by an assumed sustainable yield of 37,600 ac-ft per year
Agricultural Conversions from Development over Irrigated Land	14,060	Rate of conversion modified from Capital Facilities Plan. Would result in conversion of approximately 5,320 acres of land.
Water Reuse Capacity	3,450	Wastewater effluent currently recharges ground water basins. New supply from in-basin wastewater reuse limited to saved evapotranspiration losses. Actual amount of reuse would be limited to 2,470 ac-ft/yr by projected secondary water demand.
M&I Acquisition of Agricultural Water "Buy and Dry"	6,970	Dependent on future M&I demand. "Buy and dry" program resulting in dry-up of 2,640 acres of irrigated lands discussed in the No Action Alternative (**Section 6.1.3).**
Lake Powell Pipeline	20,000	CICWCD has requested 20,000 ac-ft from LPP
West Basin Ground Water Rights	0 – 20,000	No certainty of short-term development; expect significant objections to water right filing. Filed on 37,000 ac-ft/yr but yield would be less as shown.
Imported Water from Southern Utah	0	All surrounding basins are currently over-appropriated or will use local supplies to meet future local demands
Total Potential Yield	**48,090 – 68,090**	Includes all potential sources

ES-4.3 KCWCD Water Supplies

KCWCD owns and operates its own wells in the Johnson Canyon area. The reliable potable supply available from this well system is 96.3 ac-ft (DWRe 2008a).

Total reliable potable supply in Kane County including water rights owned by KCWCD is about 3,540 ac-ft per year and reliable secondary supply is about 500 ac-ft per year, for a total reliable water supply of approximately 4,040 ac-ft per year (DWRe 2006c; DWRe 2008a; DWRe 2007b). All existing water supplies come from local ground water aquifers. There are four subbasins within Kane County that were considered independently for water supply and demand because transfers of water supply between the subbasins are not allowed by the Utah State Engineer. Consequently, water supply and demand were calculated for each of the four subbasins to forecast water supply needs for each of the subbasins. The four subbasins considered for Kane County are the East Virgin River basin, the Kanab Creek basin, the Johnson Canyon basin, and the Wahweap Creek basin.

Future M&I water supplies for KCWCD will most likely originate from the Kanab Creek/Virgin River ground water basin in Kane County or water rights from Lake Powell. Potential new ground water development within each of the four KCWCD subbasins based on an assumed sustainable yield of 49,000 ac-ft per year is outlined in **Table ES-7.** However, ground water permits have been issued for a total of over 150,000 ac-ft per year, greater than the amount available for development under a sustainable yield constraint. As a result, no new ground water withdrawal permits will be issued by the Utah State Engineer, and any new M&I water supply for KCWCD would need to come from the transfer of existing agricultural ground water pumping permits to KCWCD, or importation of water from outside the basin. Future water supply options for KCWCD are summarized in **Table ES-7.**.

Table ES-7
Potential Developable KCWCD Supplies

Source	Maximum Potential Yield (ac-ft/yr)				Comments
	East Fork Virgin River Basin	Kanab Creek Basin	Johnson Canyon Basin	Wahweap Creek Basin	
New Ground Water Production	1,000	2,900	4,100	100	Limited by assumed ground water sustainable yield of 49,000 ac-ft per year
Agricultural Water Conversion	1,050	660	1,000	0	Assumed 20% of irrigated agricultural water use could be transferred to M&I. Estimate is based on full conversion of agricultural diversions to M&I diversions assuming no increase in consumptive use.
Lake Powell Pipeline	0 – 4,000	0 – 4,000	0 – 4,000	0 – 10,000[(1)]	KCWCD has requested 10,000 ac-ft from LPP which would be limited to 4,000 ac-ft/yr of total depletions to the Upper Colorado River Basin. Supply would be divided among the 4 subbasins based on need.
Total Potential Yield	**2,050 – 6,050**	**3,560 – 7,560**	**5,100 – 9,100**	**100 – 10,100**	

Notes:
[(1)] Wahweap Creek Basin is within the Upper Colorado River Basin, and as a result could receive the full 10,000 ac-ft per year request from the Lake Powell Pipeline if maximum depletions associated with the delivery would be 4,000 ac-ft per year.

ES-5 Water Conservation Programs

In 1998 and 1999 the Utah legislature passed and revised the Water Conservation Plan Act, which required water conservancy districts and water agencies with more than 500 drinking water service connections to submit water conservation plans to the Utah Division of Water Resources by April 1999. Cities and Districts that exceed the 500 service connection limit are required to develop conservation plans that outline conservation goals, programs and methods for implementing the programs in their area. The existing water conservation programs adopted by the Districts in Washington, Iron and Kane Counties were described along with the reductions in per capita water use the conservation programs may have produced.

ES-5.1 Washington County

Water conservation plans have been adopted by five cities and one water conservancy district in Washington County: Washington County Water Conservancy District, St. George, Santa Clara, Washington, Hurricane, and La Verkin (WCWCD 2007b).

ES-5.1.1 Conservation Plans

WCWCD created a water conservation plan and began implementing it in 1996, before conservation plans were required by the state of Utah in 1999 (WCWCD 2003). The final revision was completed on December 31, 2003 and was submitted to the state in April 2005. The cities of St. George, Hurricane and La Verkin adopted conservation plans in 2002; Washington passed a conservation plan in 2004 and Santa Clara adopted its in 2005.

WCWCD's Regional Water Supply Agreement requires its municipal customers to conserve and protect water by complying with the following requirements:

- Prepare and maintain a current water conservation plan
- Execute a water conservation rate structure for municipal system water use, time of day water use ordinances, and suitable landscape ordinances
- Act in accordance with the Determination of Recommended Septic System Densities for Ground water Protection report issued on July 20, 1988, by Hansen Allen & Luce
- Evaluate and advocate the maximum use of secondary irrigation systems within their jurisdictions
- If requested, participate in the planning process to ensure maximum use of the St. George Water Reuse Project water. The secondary water shall be used on all municipal facilities, when feasible.

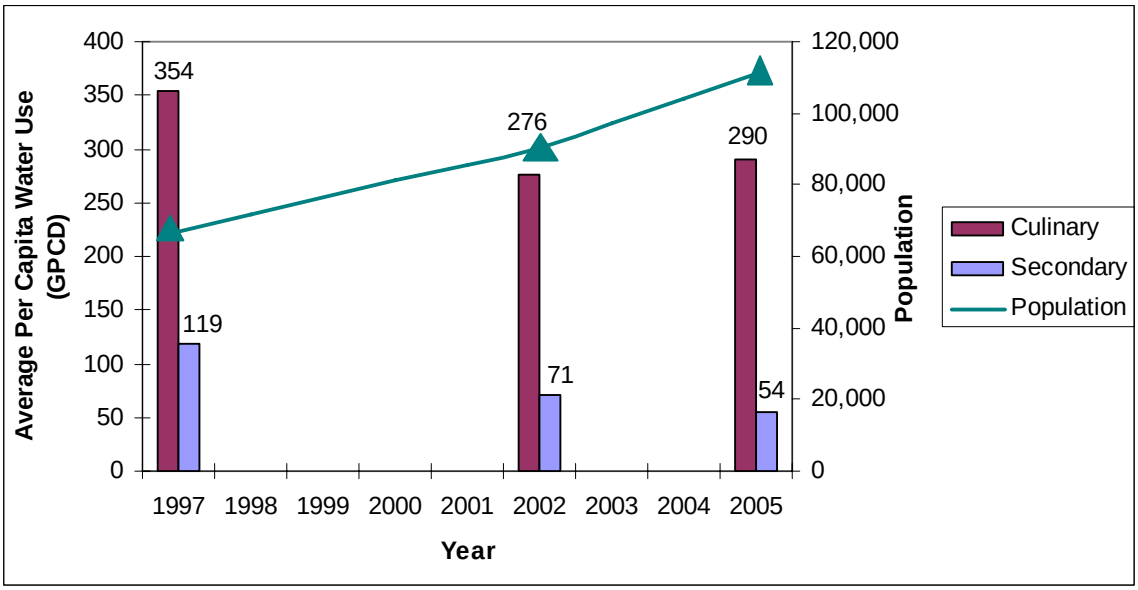
Various water conservation programs WCWCD has implemented since 1996 include the following:

- Increasing block rate structure for water pricing, with higher unit rates for higher usage
- Golf course water budget for each WCWCD golf course customer, with a 50 percent surcharge billed for courses that exceed budgeted water supply
- Development of secondary water supply systems to offset culinary water demands, and increasing efficiency of secondary water systems through conversion of open-ditch irrigation to pressurized systems (e.g., Toquerville Secondary Water System and Gunlock to Santa Clara Pipeline)
- Appliance rebates for retrofitting of existing toilets with low flow toilets, and for replacement of dish and clothes washers with water efficient appliances
- District evaluation of the efficiency of irrigation systems and development of efficient irrigation schedules (i.e., "Slow the Flow Program")
- Conservation and education certification for homeowners and landscape managers

ES-5.1.2 Conservation Savings

The Utah DWRe M&I water supply and use reports were used to track the progress of the conservation programs in Washington County. A weighted average (based on population) of the culinary per capita water use for six cities was used to represent WCWCD's average per capita water use. The six cites are: St. George, Washington, Santa Clara, Ivins, Hurricane and La Verkin. **Figure ES-5** shows an 18 percent reduction in average per capita culinary water use and a 55 percent reduction in average per capita secondary water use from 1997 to 2005. Many factors can affect per capita water use data from year to year, including temperature and precipitation. However, the downward trend in water use from 1997 to 2005 in the WCWCD area appears to be considerable.

Figure ES-5
Washington County Average Per Capita Water Use from 1997 to 2005
(DWRe 2000a; DWRe 2006b; DWRe 2008a)



ES-5.2 Iron County

The CICWCD prepared a Water Conservation and Management Plan in 2005. Cedar City created its own water conservation plan in 2004 and Enoch City created a water conservation plan in 1999.

ES-5.2.1 Conservation Plans

CICWCD's conservation programs have been primarily focused on public education and awareness, with the following components implemented from 2000 to 2005:

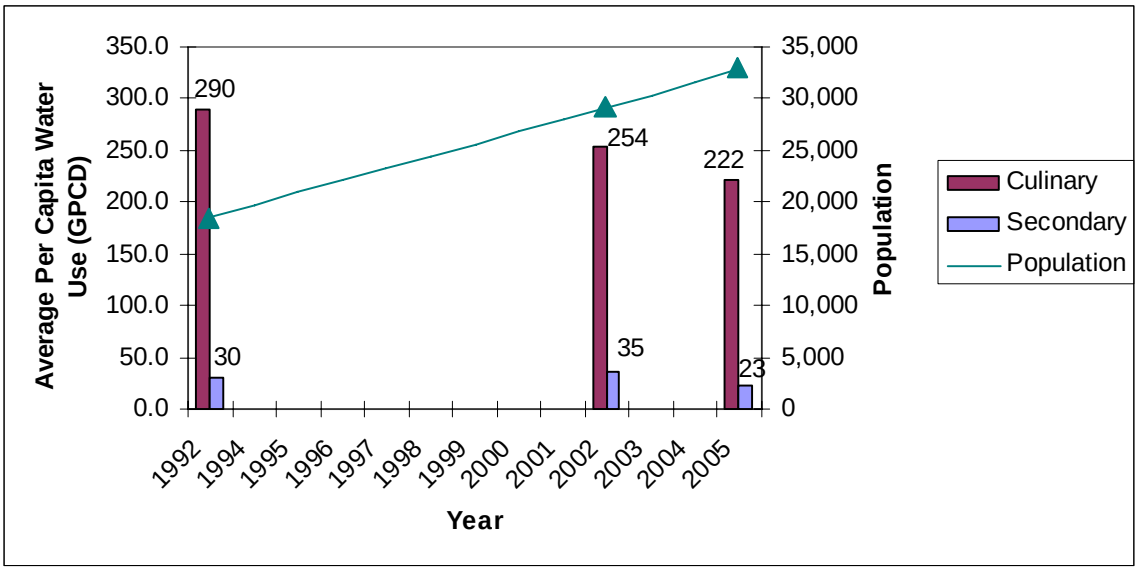
- Public education including presentation on water conservation at local schools
- Revisions to zoning ordinances made through the Iron County Planning Commission that encourage water conservation

The conservation programs in Cedar City encourage water conservation through customer education on outside watering and irrigation restrictions, and new water rate structures. Enoch City has been implementing conservation programs such as developing a secondary water source, installing a demonstration garden for efficient water use, requiring time-of-day watering ordinances, and implementing a water pricing structure.

ES-5.2.2 Conservation Savings

Average per capita use in the CICWCD boundary was determined using water use data for all water suppliers in the CICWCD service area. There has been an apparent 23 percent reduction in culinary per capita water use from 1992 to 2005 for the CICWCD communities and a 24 percent reduction in secondary per capita water use; see **Figure ES-6**. Many factors can affect per capita water use data from year to year. However, the downward trend in water use from 1992 to 2005 in the CICWCD area appears considerable.

Figure ES-6
CICWCD Average Per Capita Water Use from 1992 to 2005
(DWRe 1994; DWRe 2006a; DWRe 2007a)



ES-5.3 Kane County

At this time KCWCD does not have a conservation plan but it intends to adopt the same conservation plan as the Duck Creek Area Water System (Noel 2007). Duck Creek is an area in the northwest corner of Kane County on Cedar Mountain that is served by KCWCD. However, it will not be served by the Lake Powell Pipeline due to its remote location. A conservation plan was drafted for the Duck Creek Area Water System in July 2007 by the KCWCD and is referred to below.

ES-5.3.1 Conservation Plans

The water conservation programs in the Duck Creek area of KCWCD address conservation education, maintenance of the water distribution system and water sources, as well as increasing block rate structures. Kanab City's conservation approach has been to provide an efficient culinary water supply system to its customers. The city has completed system upgrades to improve the efficiency including completion of a pressurized irrigation system.

ES-5.3.2 Conservation Savings

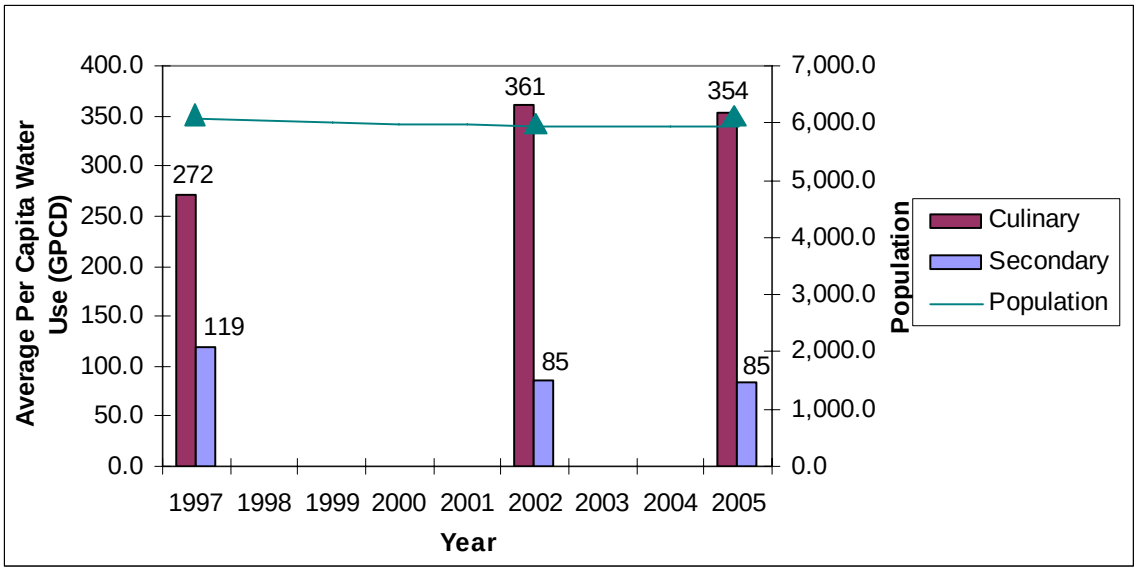
Based on available water use data in the Kanab Creek Virgin River Basin M&I water supply and use report, the per capita culinary water use in Kane County, as a whole, has increased from 1997 to 2005 by 39 percent while the population has decreased by 8 percent. This is shown in **Figure ES-7**. Between 2002 and 2005, the time period in which KCWCD began providing culinary water to the Duck Creek area, the culinary water use decreased by 2 percent and the secondary water use decreased by 0.2 percent.

ES-5.4 Summary

Washington County and Central Iron County have been successful in implementing water conservation measures that have reduced per capita water use rates. Little conservation resulting in measurable water use reduction has occurred in Kane County over the past decade. Specific additional conservation measures that could be

implemented effectively in each of the three Districts will be the subject of further investigation in Phase 2 of the LPP Water Needs Assessment.

Figure ES-7
Kane County Average Per Capita Water Use from 1997 to 2005
(DWRe 2000a; 2006b; 2008)



ES-6 Water Resources Planning

Integrated water resources plans were developed for each of the Districts using previously discussed information on projected demand and existing and future supplies. The water resources plans define the magnitude and timing of future water project development compared to future water demands. They show a likely scenario of how future water supplies could be developed in a logical sequence to meet future demands for culinary and secondary water. The objective of preparing integrated water resources plans is to determine whether the Lake Powell Pipeline Project will be needed within the planning horizon (present to 2060), and if so, when it will be needed. Integrated water resource plans for WCWCD and CICWCD include consideration of separate culinary and secondary demand projections, and limits on potential supplies such as water treatment capacity, demands, and supplies. The integrated water resource plan for KCWCD was based solely on total water demand forecast, because existing and future culinary supply would be adequate to meet total water demand for the District. The suggested order of implementation of future water sources is based on a comparison of qualitative unit cost, current status of project development, and preferences expressed by the Districts based on past studies. A No Action Alternative (i.e., no Lake Powell Pipeline Project) was also developed for each District.

ES-6.1 WCWCD Integrated Water Resources Plan

The information used to develop the integrated water resource plan for WCWCD is summarized in **Table ES-8**, and the results are shown in **Figure ES-8**. The difference between the projected 2060 demand of 265,800 ac-ft per year and existing and near term projects (which include: existing supplies, Quail Creek Reservoir, Ash Creek Pipeline, and Crystal Creek Pipeline) is 181,900 ac-ft per year. It is estimated that the LPP will be needed in approximately 2020 after all other feasible local projects have been implemented. The LPP is the only major new culinary water source available to WCWCD after the small local improvements have been completed. Because of water quality concerns, other significant supply sources are limited to secondary water uses. The timing of LPP is determined by the time when demand for culinary water exceeds existing and planned supplies. Even with the full LPP supply of 70,000 ac-ft per yr, existing and planned supplies cannot meet demand after 2039. WCWCD has not determined how these potential shortages will be addressed.

Table ES-8
WCWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)	Type of Supply (Culinary or Secondary)	Timing	Start Date	Comments
Existing Supplies	83,910[1]	Culinary & Secondary		-	Combined culinary and secondary supply
Future Supplies					
Quail Creek Reservoir Agricultural Supply Exchange	4,000	Culinary	Begin when needed; phase in over time	2017	Culinary supply currently used by agriculture, exchanged for secondary-grade quality water from the Virgin River.
Ash Creek Pipeline	5,000	Culinary	When Needed	2017	Culinary supply indirectly by supplying secondary supply grade water to offset current culinary use.
Crystal Creek Pipeline	2,000	Culinary	When Needed	2019	Culinary supply
Maximize Existing Wastewater Reuse Capacity of 10 mgd	1,700[2]	Secondary	Begin when needed; phase in over time	2020	Treatment capacity and distribution system can be phased as needed to meet secondary demand.
Agricultural Conversions from Development	12,400[3][4]	Secondary	Begin when needed; phase in over time	2020	Consists of multiple projects and water rights changes. Linear annual increase to meet secondary demand.
Lake Powell Pipeline	70,000	Culinary	When needed	2020	Can be used to meet culinary and/or secondary supply as needed.
Future Wastewater Reuse	16,900[5]	Secondary	When needed	2037	Phased in as needed to meet secondary demand

Notes

[1] Includes WCWCD reliable water supply from DWRe M&I Water Use Reports for 2005 (72,560 ac-ft per year culinary plus 7,450 ac-ft per year secondary) and existing wastewater reuse (3,900 ac-ft/yr based on demand and capacity restrictions).

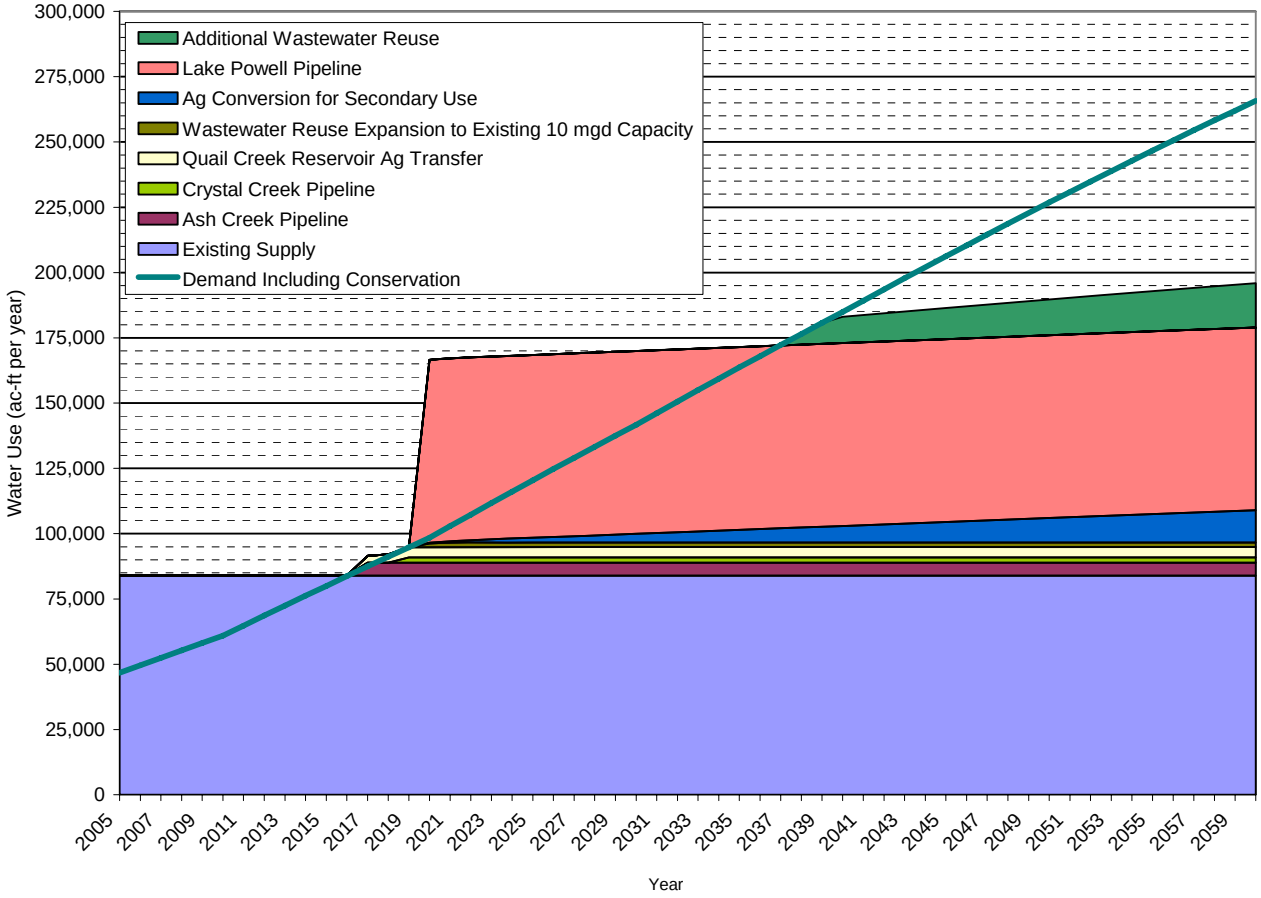
[2] The water reuse plant recently constructed in St. George has a total capacity of 11,200 ac-ft per year. Two of three filters have been installed to date (current capacity of 7,800 ac-ft per year), with 3,400 ac-ft per year of additional future capacity as needed. This supply can only be used to meet secondary demands during the irrigation season (April through October) and there is no storage capacity resulting in the loss of any supplies not used by the end of a given month. Average annual yield was estimated as 50 percent of capacity.

[3] A 20 percent loss was realized for treatment with reverse osmosis to reduce salinity to a level where the supply would be usable for secondary M&I purposes. (MWH 2006).

[4] Total amount available from this supply would be 12,400 ac-ft per year in 2060. Limited by the projected rate of agricultural conversions discussed in Section 4.1.5.5.

[5] The maximum potential future wastewater reuse (54,500 ac-ft per year) would be greater than the amount given, as described in Section 4.1.5.4, but the actual amount was limited to the amount given by seasonal fluctuations in secondary demand and storage capacity.

Figure ES-8
WCWCD Supply and Demand - Total



ES-6.2 CICWCD Integrated Water Resources Plan

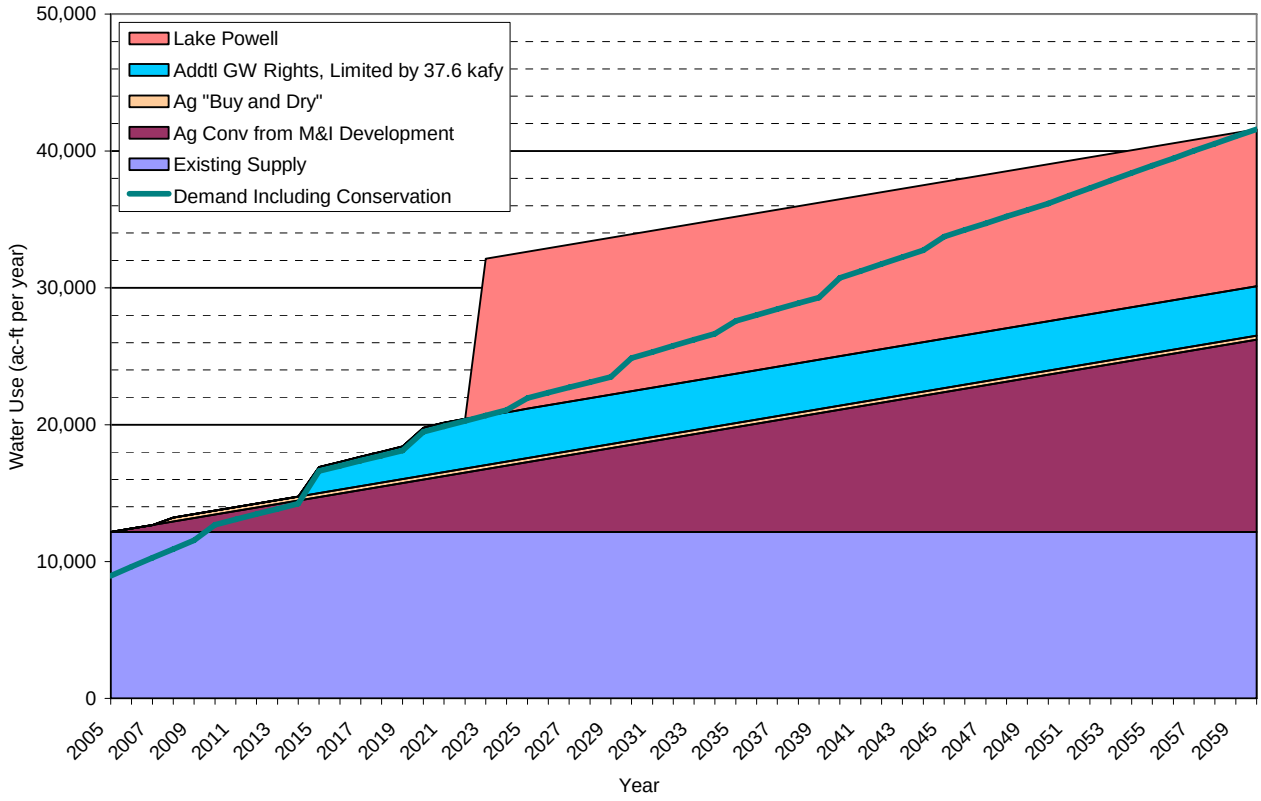
The information used to develop the integrated water resource plan for CICWCD is summarized in **Table ES-9**, and the results are shown in **Figure ES-9**. The difference between the projected 2060 demand of 41,600 ac-ft per year and the existing supply of 12,160 ac-ft per year is 29,440 ac-ft per year. The CICWCD integrated water resource plan includes existing water supplies and future supplies including M&I conversion of irrigated lands due to development, development of existing water rights that are not yet utilized, and the Lake Powell Pipeline. The suggested order of implementation of these future water sources is based on a comparison of unit cost, current status of project development, and preferences expressed by the CICWCD. "Buy and dry" acquisition of agricultural water rights from irrigated lands outside the future development boundary in Cedar Valley is not considered to be a future water source, based on the preference of CICWCD to avoid this practice.

A LPP supply of 11,470 ac-ft per year is shown in **Table ES-9** and **Figure ES-9**. This is the amount of water needed from LPP to meet the demand at the 2060 planning horizon. If additional LPP water were available it could be used to replenish the Cedar Valley aquifer or provide a reserve drought supply. It is estimated that the LPP will be needed in 2023. The timing of the LPP is highly dependent on the rate of urban development over irrigated lands, the schedule for implementation of a ground water management plan by the State Engineer, and other factors.

Table ES-9
CICWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)	Date Needed	Comments
Existing Supplies	12,160	-	Combined culinary and secondary supply
Assumed Sustainable Basin Yield	37,600	-	
Future Supplies			
Agricultural Conversion (due to Development over irrigated lands)	14,060	2010	Based on timing of expansion of development onto irrigated lands.
Agricultural Conversion from buy and dry of existing agricultural rights	300	2008	Enoch City purchased approximately 300 ac-ft per year of supply from buy and dry of agricultural water rights in 2009.
Development of Existing Local Ground Water Rights	3,610	2015	Limited by total existing ground water rights for Cedar City, Enoch City, and CICWCD, and an assumed sustainable yield of 37,600 ac-ft per year
Lake Powell Pipeline	11,470	2023	Implement when needed as last priority due to high cost

Figure ES-9
CICWCD Supply and Demand



ES-6.3 KCWCD Integrated Water Resources Plan

The information used to develop the integrated water resource plan for KCWCD is summarized in **Table ES-10**, and the results are shown for each of the four subbasins in **Figure ES-10** through **Figure ES-13**. The difference between the projected KCWCD 2060 demand of 6,030 ac-ft per year and the existing supply of 4,040 ac-ft per year is 1,990 ac-ft per year. For all four subbasins, a combination of existing and new ground water supplies is sufficient to meet all future needs within the planning horizon. Thus based strictly on water need, LPP supplies are not needed in the KCWCD service area within the 2060 planning horizon.

However, KCWCD may choose to participate in the LPP project for other reasons. The LPP will traverse Kane County on its way to Washington and Iron Counties. Therefore, there is an opportunity for KCWCD to participate in the LPP simply out of convenience. Tapping into the pipeline would add a reliable supply to their system that would stretch local supplies further into the future. LPP deliveries could be used for culinary supplies, saving local ground water for use as secondary water.

Table ES-10
KCWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)				Comments
	East Fork Virgin River	Kanab Creek	Johnson Canyon	Wahweap Creek	
Existing Supplies	845	2,560	100	540	Combined culinary and secondary supply
Future Supplies					
New Ground Water (Amount and Year Needed)	240	1,770	110	90	Phase in as needed. For all subbasins, this is the only Future Supply needed to meet demand.
	2044	2018	2006	2052	
Agricultural Water Conversion	0	0	0	0	Phase in as needed. Based on 20 percent of current agricultural use.
Lake Powell Pipeline	0 (1)	0 (1)	0 (1)	0 (1)	When needed, Supply would be divided among the 4 subbasins based on need. KCWCD requested 10,000 ac-ft/yr from LPP, which would be limited to 4,000 ac-ft/yr of depletions in the Kanab Creek/Virgin River Basin.

Notes:
(1) Lake Powell Pipeline would not be needed in the planning horizon.

Figure ES-10
KCWCD Supply and Demand – East Fork Virgin River

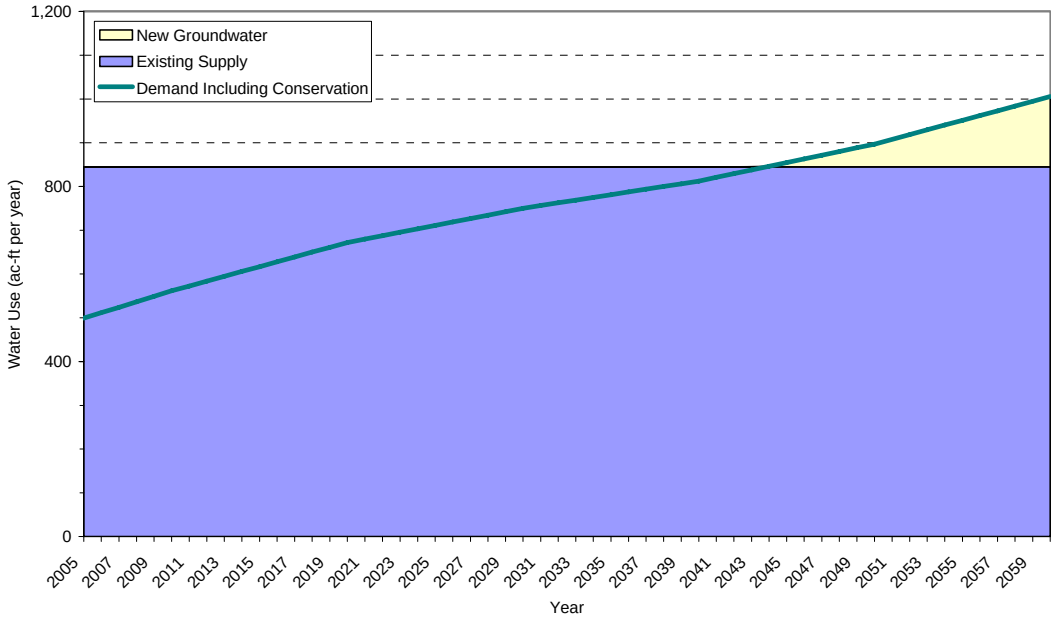


Figure ES-11
KCWCD Supply and Demand – Kanab Creek

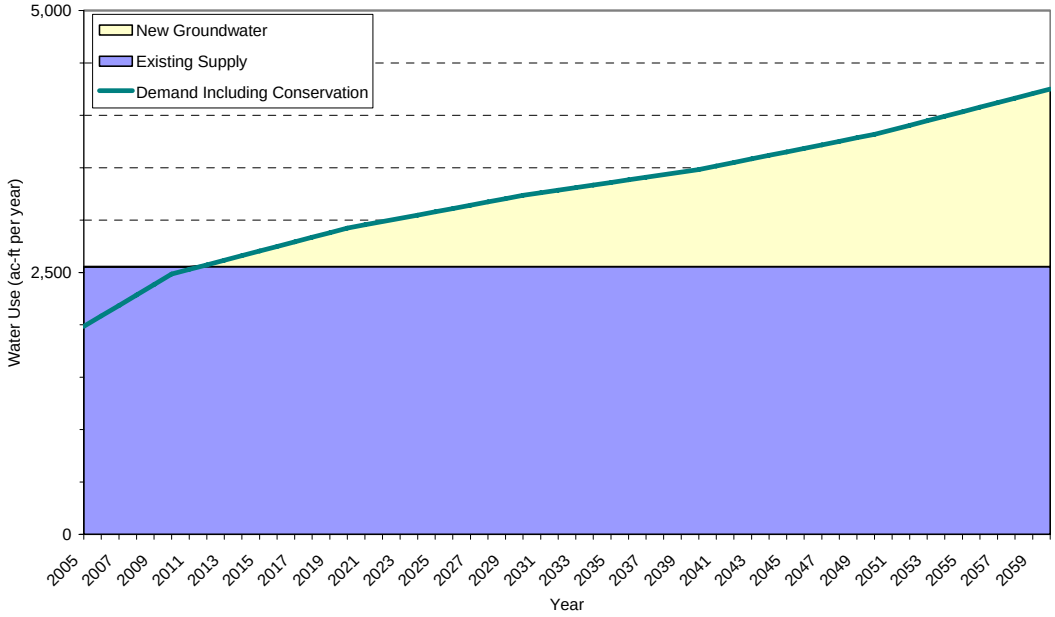


Figure ES-12
KCWCD Supply and Demand – Johnson Canyon

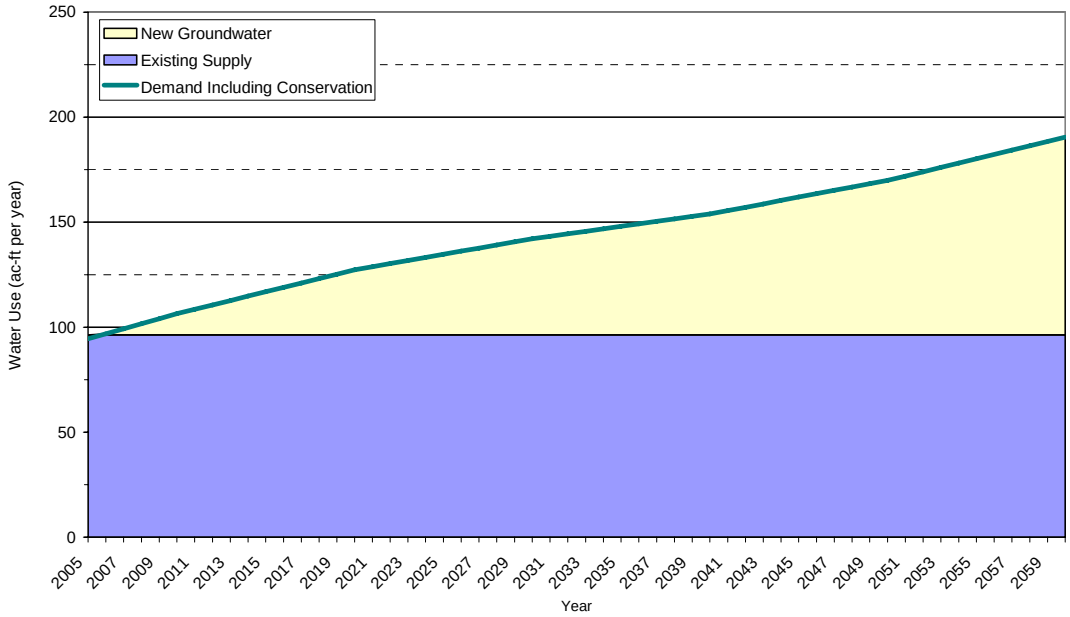
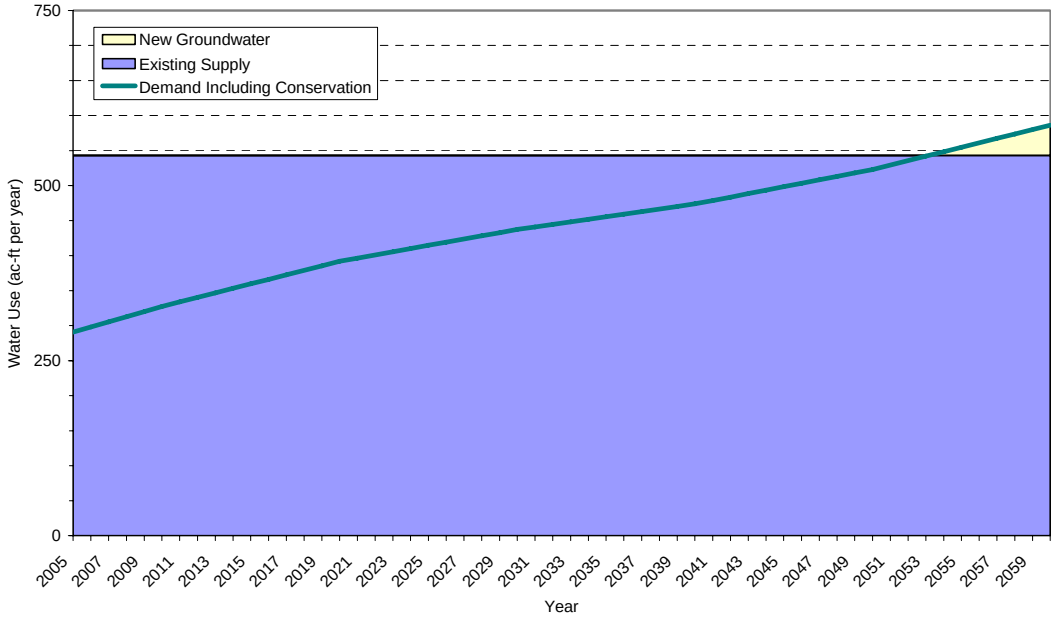


Figure ES-13
KCWCD Supply and Demand – Wahweap Creek



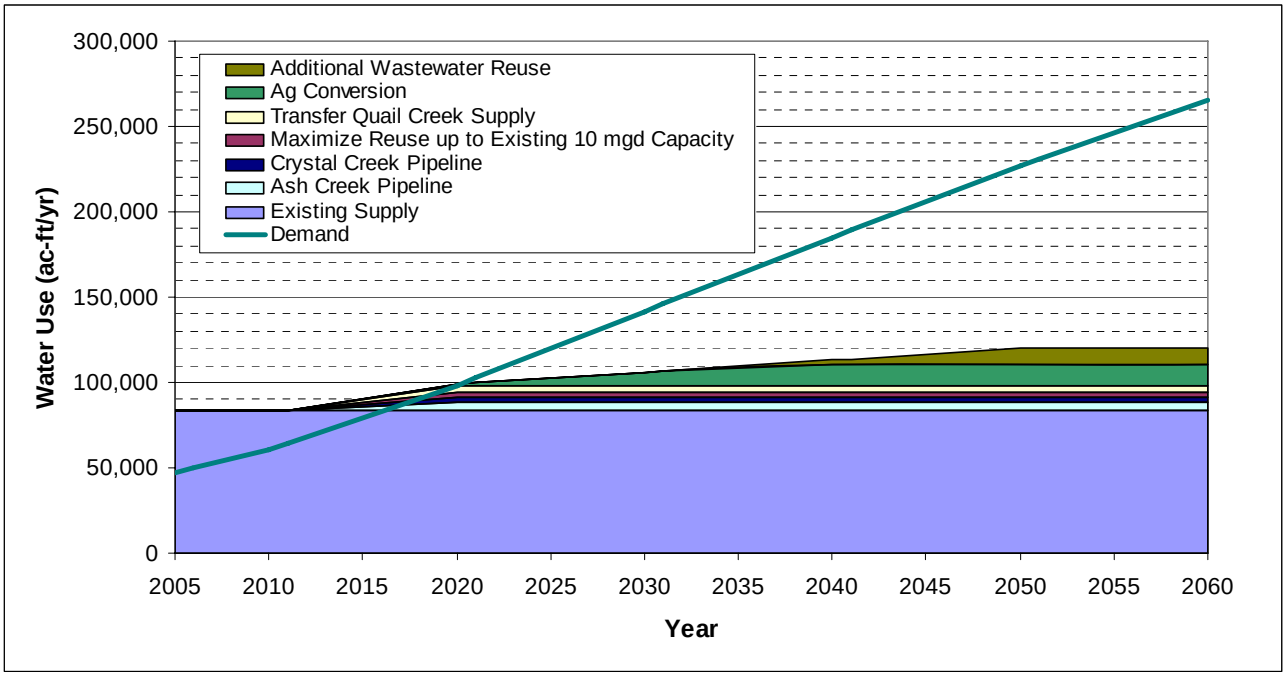
ES-6.4 No Action Alternative

The No Action Alternative defines how the LPP Districts would likely meet the water needs of future growth without the LPP. The No Action Alternative is needed for the future NEPA environmental permitting process.

The No Action Alternative for WCWCD would involve a combination of future projects currently planned by the District, additional water reuse/reclamation, transfer of Quail Creek Reservoir agricultural water supplies, and conversion of agricultural water use to M&I use as a result of development in agricultural areas. The supply and demand for the No Action Alternative is shown in **Figure ES-14**. Demand would be met up to 2020, but there would be a shortage of approximately 145,200 ac-ft per year by end of the planning period (2060). The WCWCD No Action Alternative would have several consequences including:

- changes to Virgin River water quality (e.g., increased reuse would decrease phosphorous levels associated with decreased wastewater discharge from the St. George wastewater treatment plant),
- water shortages could limit economic development in the WCWCD service area,
- water rates may be increased because of the high cost of treatment associated with the Virgin River Treatment option,
- the No Action Alternative would be less drought resistant than the proposed Lake Powell Pipeline project because of reduced surface water carryover storage.

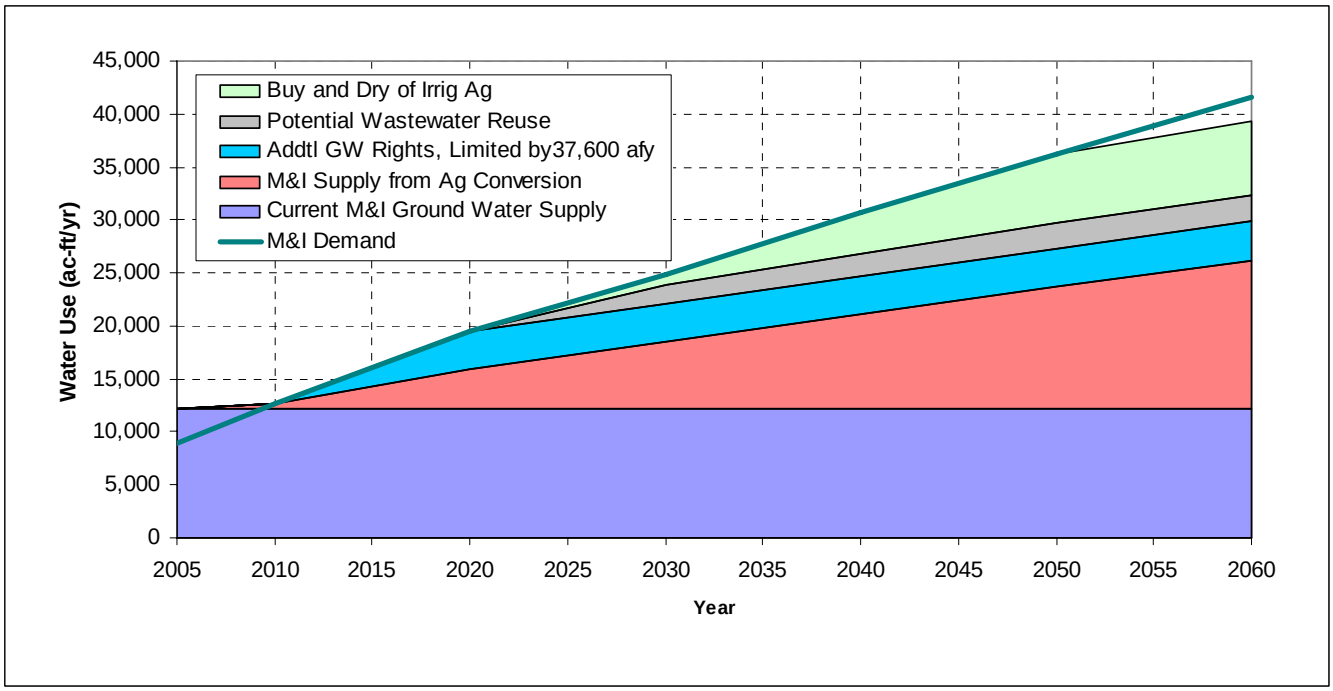
Figure ES-14
WCWCD No Action Alternative - Supply and Demand



The most likely No Action Alternative for CICWCD would include some combination of conversion of agricultural water supply to M&I water supply as a result of urban development in current agricultural areas, wastewater reuse, and "buy and dry" of water rights currently used for irrigated agriculture. It was assumed that additional ground water pumping (M&I and agricultural) would be limited to development of additional ground water associated with currently appropriated but undeveloped water rights that would remain in priority assuming a sustainable yield of 37,600 ac-ft per year for the Cedar Valley Aquifer. Supply and demand for the CICWCD No Action Alternative is shown in **Figure ES-15.** The consequence of the CICWCD No Action Alternative would include a reduction in irrigated acreage from agricultural conversion due to development and buy and dry of

agricultural water rights in CICWCD of approximately 8,000 acres (58 percent reduction in total irrigated agricultural land) over the 2005 to 2060 planning period. There would be an unmet demand of 2,330 ac-ft/yr in 2060.

Figure ES-15
CICWCD No Action Alternative – Supply and Demand



The No Action Alternative for KCWCD would be to utilize existing and future ground water supplies from within each of the four subbasins supporting M&I use within the District's service area. The existing and future ground water supplies for each of the four subbasins are greater than the maximum demand in each of the basins. The consequences of the KCWCD No Action Alternative would be that each of the four subbasins would need to increase ground water pumping above the current discharge rates. Although the ground water in these basins is currently fully appropriated, there is available ground water that is appropriated but not currently used. This currently non-utilized ground water would be pumped to meet future demands within KCWCD.

ES-7 Summary

Results of Phase 1 of the LPP Water Needs Assessment are summarized in **Table ES-11**.

Table ES-11
Summary of the LPP Water Needs Assessment

Description	WCWCD	CICWCD	KCWCD
Existing (2005) M&I Reliable Supply	83,900	12,150	4,040
Existing (2005) M&I Demand	46,740	8,960	2,870
Existing (2005) Unmet Demand	0	0	0
Existing (2005) Surplus	37,160	3,190	1,170
2060 Demand without Conservation	316,400	48,180	8,580
2060 Demand with Conservation	265,770	41,590	6,030
2060 Conservation Savings/Supply	50,630	6,590	2,550
2060 Unmet Demand	**181,870**	**29,440**	**1,990**
2060 Additional Supply from Likely Projects	25,100[1]	17,960[2]	10,810[3]
2060 Unmet Demand	**156,770**	**11,480**	**0**
Water Supply Available from LPP	70,000	11,480	0
2060 Unmet Demand	**86,770**	**0**	**0**
2060 Additional Supply from Possible Projects	16,890[4]	0	0
2060 Unmet Demand	**69,880**	**0**	**0**

Notes:
[1] Likely projects for WCWCD include Quail Creek Reservoir Exchange, Ash Creek Pipeline, Crystal Creek Pipeline, Maximize Existing Wastewater Reuse, and Agricultural Conversion associated with M&I development. See **Table 6-2** for timing and water supply for each of the projects.

[2] Likely projects for CICWCD include: Agricultural water conversion from developed land, Agricultural water conversion from "buy and dry", and Local ground water rights. See **Table 6-3** for timing and water supply for each of the projects.

[3] Likely projects for KCWCD include: Agricultural Water Conversion and Local ground water rights. See **Table 6-4** for timing and water supply for each of the projects.

[4] Possible projects for WCWCD include future wastewater reuse. See **Table 6-2** for timing and water supply for future wastewater reuse.

There are a number of factors that introduce significant uncertainty into the results of this water needs assessment. These include:

- Population forecasts for a period exceeding 50 years are highly speculative, particularly given past difficulties with accurately forecasting population growth in Southwest Utah. Actual population will be driven by many factors that cannot be accurately forecasted. The most defensible forecast has been used for this study.
- Actual future conservation efforts may exceed or fall short of the goals assumed in Phase 1 of this study. Phase 2 will further investigate reasonable conservation assumptions by evaluating the potential for implementing specific conservation measures in the study area.
- Sustainable yield for the Cedar Valley ground water basin has not been determined definitively; the assumed sustainable yield significantly affects the need for and timing of alternate sources of supply.
- The rate at which urban development occurs over areas of existing irrigated agriculture will affect the rate at which agricultural supplies are converted to M&I supplies without buy and dry programs. This in turn would affect the timing of other new supplies including LPP.

- The mix of culinary and secondary water use at present was assumed to continue into the future. Complex economic factors, outdoor landscaping practices, and regional and local water use policies could substantially affect the ratio of secondary water use to total water use.
- Advanced water treatment processes (e.g. reverse osmosis) are assumed to be financially and environmentally prohibitive with regard to providing culinary water from local surface waters. Technological breakthroughs in treatment processes or brine disposal methods could make advanced water treatment feasible for Southwestern Utah in the future, making it possible to develop additional local water resources.

These and other uncertainties affect the reliability of the water supply and demand estimates used in this report. Assumptions other than those made in this report could be reasonable based on alternate assumptions of future growth, hydrology, community values, political influences, etc. Despite these uncertainties, the methods and assumptions used in this water needs assessment were selected to be the most defensible methods and assumptions possible given available information, and the results are considered to be usable for long-range regional water supply planning purposes.

Chapter 1 - Introduction

1.1 Introduction

The Lake Powell Pipeline Study Water Needs Assessment was conducted to evaluate the need for future water supplies by the Lake Powell Pipeline Project Districts. The Lake Powell Pipeline (LPP) would deliver a portion of Utah's Colorado River water allotment from Lake Powell to water users in southwest Utah. The Districts are the Washington County Water Conservancy District (WCWCD), the Central Iron County Water Conservancy District (CICWCD), and the Kane County Water Conservancy District (KCWCD). In this report they will be referred to collectively as the "Districts." **Figure 1-1** shows the location of the Water Needs Assessment study area. The Water Needs Assessment study has been conducted as part of the LPP Feasibility Study, which also includes evaluation of technical and environmental aspects of the project.

The Districts have requested allotments of water from the LPP project based on their own assessments of future water needs. These requests are summarized as follows:

- WCWCD - 70,000 ac-ft/year
- CICWCD - 20,000 ac-ft/year
- KCWCD - 10,000 ac-ft/year

The objectives of the LPP Water Needs Assessment are to:

- Determine the validity of the Districts' requests based on estimates of future supplies, demands, and conservation estimates;
- Determine the likely timing of the need for the LPP supply when integrated with other potential supplies;
- Determine additional water supply needed to meet projected demands on top of existing supply
- Provide the groundwork for a Purpose and Need Statement that would be required as part of the National Environmental Policy Act (NEPA) environmental permitting process for the LPP, if the project goes forward.

The Water Needs Assessment is being conducted in two phases. Phase 1, which is summarized in this technical report, consists of developing preliminary population forecasts, water use rates, future conservation savings, and future water demands. In Phase 2, more detailed studies of future conservation measures and water reclamation opportunities will be conducted. After completion of Phase 2, this technical report will be updated and finalized with the revised information.

The Water Needs Assessment technical report is organized as follows.

- Executive Summary
- Chapter 1 - Introduction
- Chapter 2 - Methodology
- Chapter 3 - Water Demand Forecast
- Chapter 4 - Water Supply Conditions
- Chapter 5 - Water Conservation Programs
- Chapter 6 - Integrated Water Resources Plans
- References

The Water Needs Assessment was prepared by MWH Americas, Inc. under contract with the State of Utah.

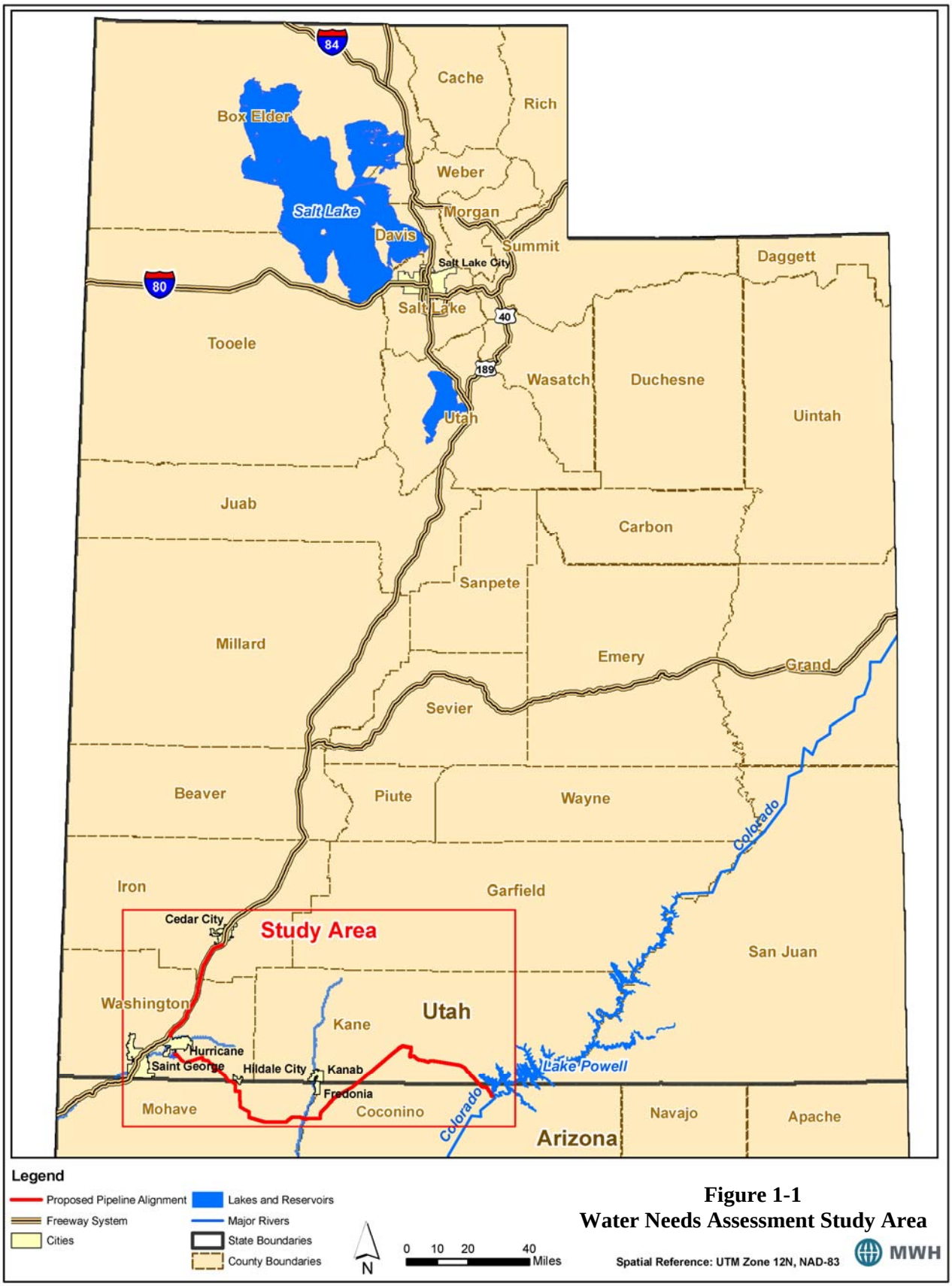


Figure 1-1
Water Needs Assessment Study Area

1.2 Summary Description of the Lake Powell Pipeline Project

In 2006 the Utah State Legislature passed the Lake Powell Pipeline Development Act, which authorized the Board of Water Resources to build the Lake Powell Pipeline to meet a portion of southwestern Utah's future water demands. The Lake Powell Pipeline will transport water from Lake Powell to Washington, Kane and Iron counties. The pipeline will consist of approximately 140 miles of buried 69-inch pipe from Lake Powell to Sand Hollow Reservoir near St. George and approximately 38 miles of 30-inch pipe from Quail Creek Reservoir to Cedar City. Pumping facilities near Glen Canyon Dam and booster pumping stations along the pipeline alignment will provide the approximately 2,500 foot lift needed to transport the water over the high point in the pipeline. The 3,000 foot drop between the high point and end of the pipeline will be utilized to generate hydropower by new hydroelectric generation facilities. The power sales from the hydroelectric generation facilities will contribute to offsetting pumping costs.

The estimated cost of the Lake Powell Pipeline project is approximately one billion dollars. The cost estimate was currently updated to reflect present market conditions and delivery requests from project participants. The state will construct the project and the Districts will reimburse the expenses through water sales.

1.3 Overall Design Criteria

Overall design criteria governing the LPP water needs assessment are listed below.

- Future water supplies (including but not limited to the LPP) will be analyzed in conjunction with existing water supply systems.
- Future water need estimates will be prepared using the Utah Governor's Office of Planning and Budget (GOPB) population forecasts, as these forecasts are the officially sanctioned forecasts for use in all State planning studies.
- Methodologies and assumptions for computing future water need estimates must be consistent, to the extent possible, between all of the Districts in the LPP project.
- The preliminary water needs assessment (Phase 1) must be based on existing information with limited new data collection to avoid duplicating previous work and meet the project schedule. The final water needs assessment (Phase 2) can be based on additional data collection and analyses.

1.4 Specific Analyses

The specific analyses comprising the water needs assessment included the following.

- Population projections
- Water demand projections
- Existing water supply descriptions
- Potential water supply descriptions
- Water conservation projections
- Coordination with local stakeholder groups
- Integrated water resource plan including Lake Powell Pipeline

Project activities are being performed in two phases. Phase 1 consists of activities associated with developing feasibility-level water demand projections to assist with the alternative screening analysis. Phase 2 will consist of activities associated with developing more refined water demand projections and performing a detailed evaluation of existing and potential future conservation programs and water reuse opportunities. This phase will support the detailed analysis of alternatives, particularly the No Action Alternative.

Chapter 2 - Methodology

This chapter describes the data and methodology used in the LPP Water Needs Assessment study.

2.1 Introduction

This section provides an overview of the study area, water supply conditions in the Districts' service areas, and design criteria adopted in the Water Needs Assessment.

2.1.1 Study Area

The study area for the Water Needs Assessment consisted of the areas that are potential recipients of water from the Lake Powell Pipeline. These include the following:

- All of Washington County Water Conservancy District service area
- All of Central Iron County Water Conservancy District service area
- All of Kane County Water Conservancy District service area

Figure 2-1 is a map showing the boundaries of the three Districts and the proposed alignment of the Lake Powell Pipeline.

Portions of the study area are located in areas that are remote relative to the proposed Lake Powell Pipeline alignment (e.g., Enterprise in Washington County and Glendale in Kane County). There may be economic and engineering considerations that would limit the ability of the three conservancy districts to supply Lake Powell Pipeline water to these remote areas. WCWCD would not serve Enterprise with Lake Powell Pipeline project water due to the remote location of Enterprise. However, Enterprise only represents approximately 1 percent of the overall population of Washington County (United States Census Bureau 2007), and due to its insignificant effect on overall Washington County water demand was left in the water needs assessment. KCWCD would likely not serve communities remote from the selected pipeline alternative (e.g., Orderville, Glendale, and Alton) with Lake Powell Pipeline project water, depending on the final alignment that is chosen for the pipeline. Water demand and supply were calculated for four subbasins in the KCWCD service area including the subbasin that encompasses Orderville, Alton and Glendale. This subbasin was left in the report to provide information on water needs for all of the subbasins in the KCWCD service area in order to include supply and demand estimates for all potential areas that could be served by the Lake Powell Pipeline. The information is provided independent from the remainder of the water demands for Kane County so that the information can be discarded if an alignment is chosen that would not be able to serve the area. Additionally, there are areas within the KCWCD service area within the Sevier River Basin (i.e., northwest portion of Kane County) that would not be served by the Lake Powell Pipeline because of the remote location of this area relative to potential Lake Powell Pipeline alignments. However, population from this area was included in the water needs assessment study because of the small population of this area relative to overall Kane County population and the associated minimal effect on the projected water demand for KCWCD.

The conservancy districts may be able to implement arrangements or partnerships that would enable indirect use of Lake Powell Pipeline water to remote communities through exchanges or substitute supply agreements. As a result of these potential partnerships, the entire service area for each of the three conservancy districts was used for the study area at the outset of the study. **Chapter 4** and **Chapter 6** discuss possible limitations to use of LPP water based on economic or engineering factors despite the opportunities for interagency agreements.

Washington County Water Conservancy District. Figure 2-2 is a map of the WCWCD service area. Washington County is located in the southwestern corner of the state of Utah adjacent to both Nevada and Arizona. The county has diverse topography and climate due to a wide range of elevations, but is generally characterized by a desert landscape. Most Washington County residents live in fairly narrow corridors along the Santa Clara and Virgin Rivers. The county's scenery and indoor and outdoor activities have promoted a high population growth rate and thriving tourist industry. Washington County has an arid climate: its average precipitation is 8 inches per year. The largest cities within the county are:

- St. George
- Washington
- Hurricane
- Ivins
- La Verkin
- Virgin
- Toquerville
- Santa Clara
- Enterprise
- Springdale
- Hilldale
- Apple Valley
- New Harmony
- Rockville

The WCWCD was organized in 1962 under the Water Conservancy Act and is a regional water supply agency in Washington County (WCWCD 2003). The WCWCD service area encompasses all of Washington County, and includes all of the property within the boundaries of the incorporated cities and towns. The main role of the WCWCD is to develop or purchase water rights and deliver this water within its service area. It is primarily a wholesaler of water for the municipalities in Washington County, and serves water on a retail basis only when other local providers are not available or do not have the facilities to do so.

Central Iron County Water Conservancy District. Figure 2-3 is a map of the CICWCD service area. Since establishment in 1997, the CICWCD has been working towards developing a regional water system in the Cedar Valley area to serve private independent water systems and larger public water systems within the District. The CICWCD includes the central portion of Iron County in south central Utah, and incorporates approximately 1,380 square miles. The District's northern and southern boundaries coincide with the northern and southern boundaries of the county. The western boundary is the dividing line between Range 14 West and Range 15 West in the Salt Lake Base and Meridian coordinate system. The eastern boundary generally follows the section lines located in Range 9 West and Range 10 West. It passes immediately east of Cedar Breaks National Monument and immediately west of Summit; it excludes the communities of Parowan and Paragonah. The current District boundary includes the following communities:

- Cities and towns: Cedar City, Enoch City, Kanarraville
- Subdivisions: Fife Town, Cedar Vistas, Big Meadows, Monarch Meadows, Rancho Bonita, West View Estates
- Other entities: Iron County School District, portion of Zion National Park

For the past several decades, the Cedar City, Enoch City and Kanarraville municipal systems have been the sole public water systems in Cedar Valley. As recent growth has extended beyond the boundaries of the incorporated cities, individual water systems have been established to serve rural developments. The CICWCD mission is to supply water to these rural subdivisions, and assist the cities and towns in meeting demands as they grow.

Kane County Water Conservancy District. Figure 2-4 is a map of the KCWCD service area. KCWCD is a new water conservancy district, formed in 1992. It has a very limited customer base and limited supply sources at present. The only substantial community in Kane County - the City of Kanab - has developed its own water supply system over time, and intends to continue to meet the needs of M&I customers within its current city boundaries, and within future annexation areas as well. The KCWCD boundary encompasses all of Kane County. The county extends from Lake Powell and the Colorado River on the east to Washington County on the west. Although KCWCD encompasses all of Kane County, there are portions of the district that are too remote to practically be served by the Lake Powell Pipeline (e.g., the Duck Creek area in northwest Kane County). The main communities include:

- Kanab
- Orderville
- Alton
- Glendale
- Big Water

The Utah State Institutional Trust Lands Administration (SITLA) administers a large tract of land in east Kane County within the KCWCD service area. The eastern part of KCWCD, including Big Water, drains to Lake Powell. It is therefore in the Southeastern Colorado River Basin as defined by the State of Utah, and is in the Upper Colorado Basin as defined by the Colorado River Compact.

There are four subbasins within the KCWCD service area, which are discussed in this report because of the independent nature of their water supplies. The four subbasins and the cities within the subbasins are described below and shown in **Figure 2-4.** Integrated water resources plans discussed in **Section 6.1** are prepared for each of the four subbasins because of restrictions by the Utah State Engineer on transfers of water supply between the subbasins.

- East Fork Virgin River – Orderville and Glendale
- Kanab Creek – Alton and Kanab
- Johnson Canyon – KCWCD (Johnson Canyon)
- Wahweap Creek – Church Wells and Big Water

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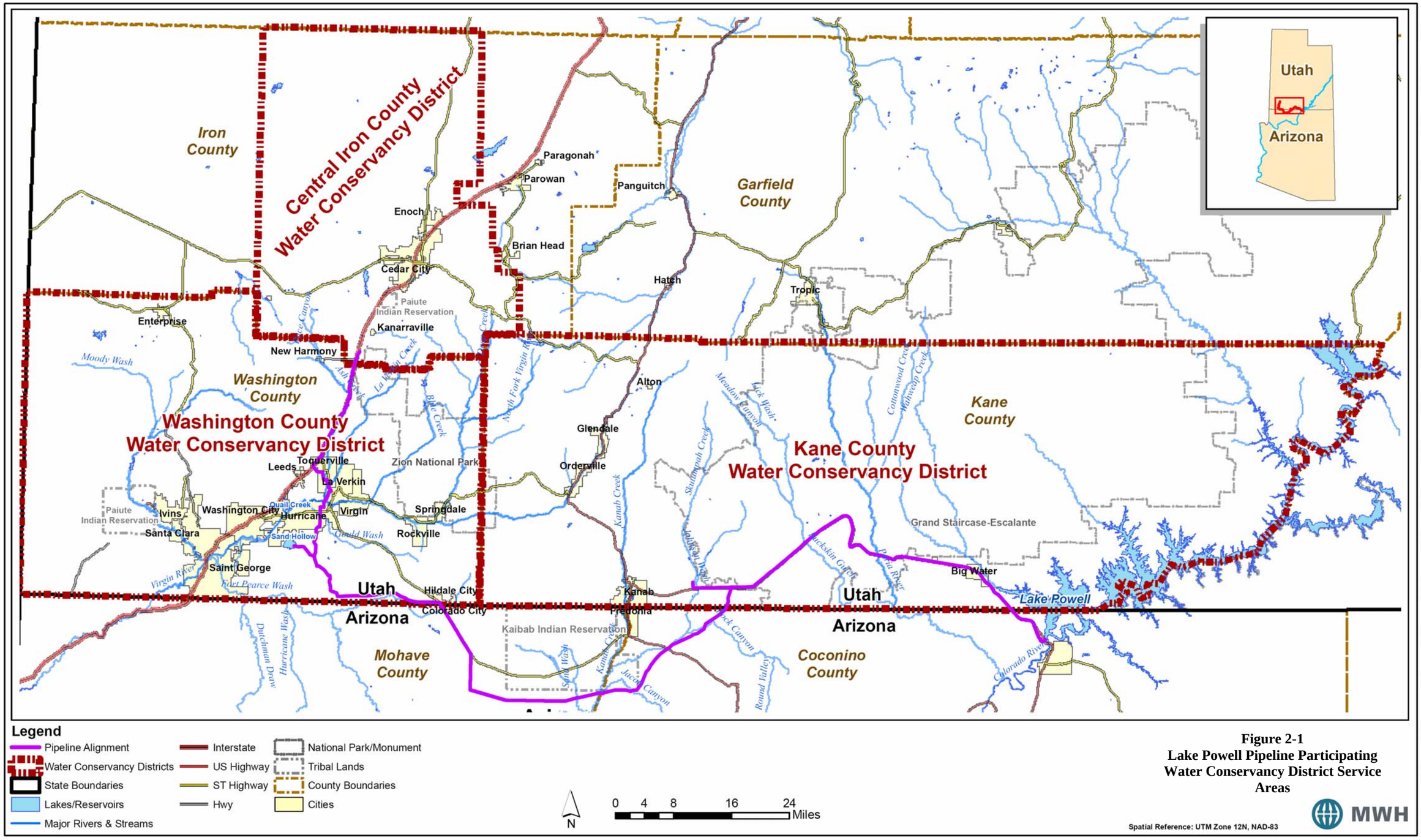

Figure 2-1
Lake Powell Pipeline Participating Water Conservancy District Service Areas

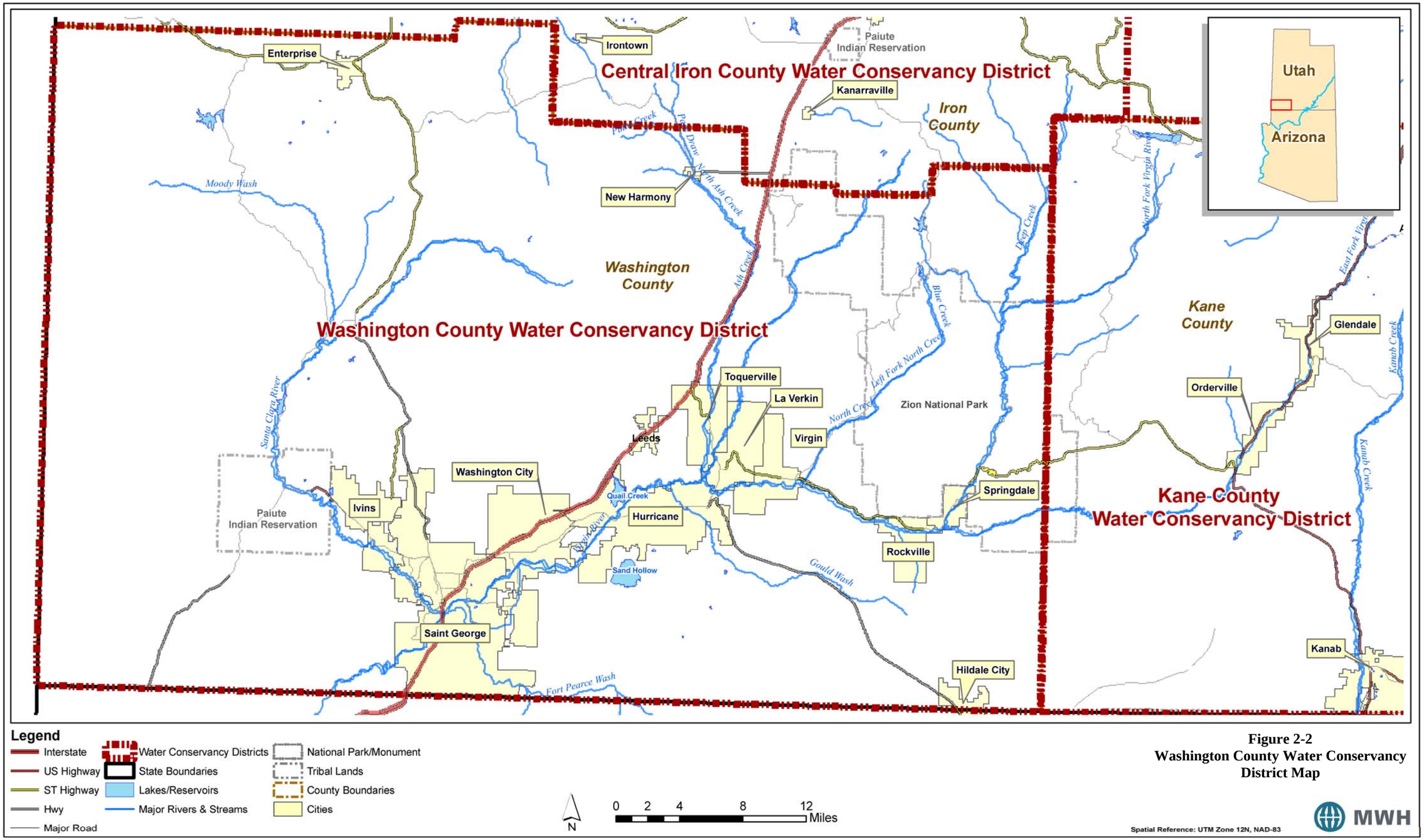

Figure 2-2
Washington County Water Conservancy District Map

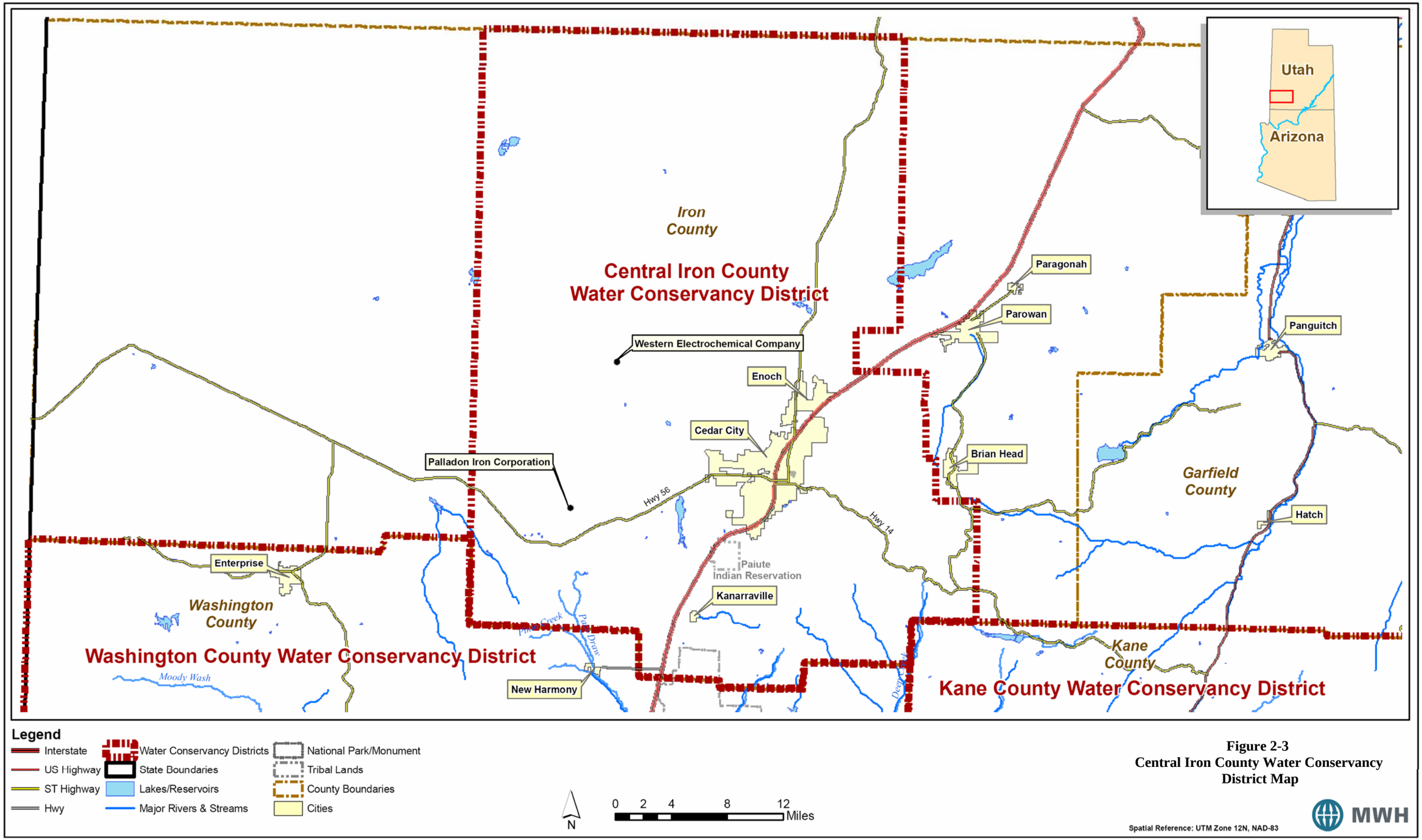

Figure 2-3
Central Iron County Water Conservancy District Map

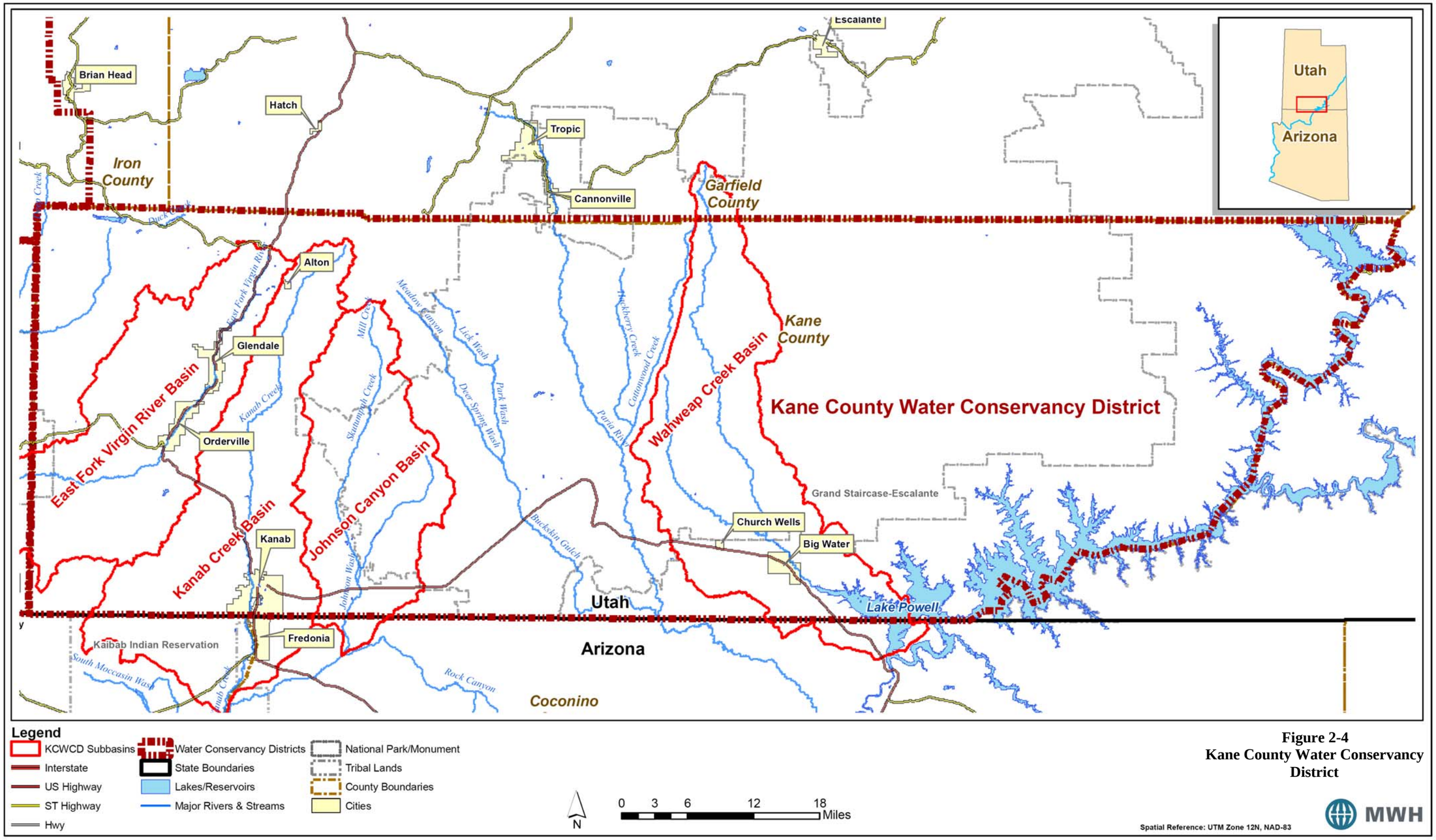

Figure 2-4
Kane County Water Conservancy District

2.1.2 Overview of Water Supply Conditions

Water supplies in southwestern Utah have been developed over the past 150 years to meet agricultural, municipal and industrial demands. Supplies have been derived from diversions from surface streams such as the Virgin River in Washington County and Coal Creek in Iron County, and through pumping from ground water sources such as the Navajo Sandstone Aquifer.

Two categories of water are provided to customers in the study area: culinary (or potable) water and secondary (or non-potable) water. Culinary water is treated to meet drinking water standards, and is delivered to retail and wholesale customers through systems of pipelines, pump stations, storage tanks, and reservoirs. Secondary M&I water generally originates from agricultural water supply that is conveyed through urban areas in irrigation ditches and pipelines, and is untreated.

The southwest Utah population has experienced rapid growth during the past 40 years. Much of this growth has occurred in the greater St. George area (including Washington City and Hurricane City) and the Cedar Valley. This growth has utilized most of the existing water supplies, and it has forced communities to pursue new water projects and develop comprehensive water conservation programs. Growing water demands are increasing the use of local water sources in some areas to a level that is approaching or surpassing the sustainable yield of available resources. This condition is causing water providers to pursue water sources outside their respective basins to meet the projected demands of future growth.

2.1.3 Preliminary Design Criteria

The following preliminary design criteria were identified for planning and analysis of water needs associated with the Lake Powell Pipeline alternatives.

- Population forecasts were based on officially adopted forecasts provided by the Utah Governor's Office of Planning and Budget (GOPB).
- Population and water needs were forecasted from 2005 to 2060, the adopted planning horizon for future environmental studies associated with the LPP.
- Water conservation goals for the study area were compared to the State's goal of 25 percent reduction in per capita water use by 2050 as compared to 2000 water use rates.
- Existing and potential future water supply projects were combined to meet 2060 forecast demands.
- WCWCD, CICWCD and KCWCD demands and water supply projects were evaluated independently, although future potential water supply projects could be developed to serve customers in more than one jurisdiction.
- Effects of possible climate change on water usage were not considered for the Water Needs Assessment. The 2005 per capita water use was used as the baseline for predicting water demands with reduction associated with conservation. Possible effects of climate change, such as an increase in per capita water use with decreased precipitation, were not included in this analysis because of uncertainties in effects of climate change.

2.2 Population Data

Population projections were obtained from the GOPB, and information on the type of residences (e.g., permanent and non-permanent) and the tourism population were obtained from cities where the data were available.

2.2.1 Population Projections

Population projections from 2006 through the year 2060 were obtained from the GOPB for the counties within the Districts' service area boundaries (GOPB 2008). These population projections were made by the Utah GOPB in 2008 and are referred to as the 2008 baseline projections throughout this report. A range of population projections was determined (2008 baseline projections plus/minus 10 percent) to estimate a range of potential population projections. However, the GOPB 2008 baseline projections were the only projections used to determine the projected water needs for each of the Districts. Population for the beginning of the Lake Powell Project planning horizon (2005) was assumed to be equal to the population data reported in the Utah Division of Water Resources (DWRe) municipal and industrial water supply and use reports for 2005 (DWRe 2006c; DWRe 2007a; DWRe2008; DWRe 2007b), and GOPB (2008) projections were used to estimate population for 2010 through 2060.

Population projection data were summarized for WCWCD, CICWCD, and KCWCD. Total Washington County population was used for WCWCD as the District boundaries are coincident with the county boundaries. Total Kane County population was estimated for KCWCD (District boundary is coincident with county boundary), but population projections were also estimated for each of the four individual subbasins within Kane County. The subbasin population projections were used to determine the corresponding water need for each of the subbasins. The Lake Powell Pipeline alignment will affect locations within the subbasins that can feasibly be served by the pipeline. The population for CICWCD was estimated as the total Iron County population less the population served by Kanarraville and water suppliers that are not located within the District's boundary (i.e., Brian Head Water Supply, Escalante Valley Water System, Parowan Municipal System, Parogonah Municipal Water System, and Summit Sanitary Sewer District). The percent of Iron County within the CICWCD boundary was calculated to be 90 percent, based on the 2005 population data provided in the DWRe M&I Water Supply and Use Reports for the Cedar/Beaver Basin and the Kanab Creek/Virgin River Basin (DWRe 2007a; DWRe 2008a). It was assumed that the 90 percent ratio for the CICWCD would remain the same throughout the projected population period (i.e., through 2060). Assumptions used to calculate District population forecasts from County-based population data are summarized as follows.

- **WCWCD -** total Washington County population.
- **CICWCD -** total Iron County population less the population served by Kanarraville and water suppliers that are not located within the District's boundary (i.e., Brian Head Water Supply, Escalante Valley Water System, Parowan Municipal System, Parogonah Municipal Water System, and Summit Sanitary Sewer District)
- **KCWCD -** total Kane County population (population projections were given for total Kane County population, and were also determined separately for the four subbasins within the KCWCD service area that are shown in **Figure 2-4)**.

The increasing accuracy of GOPB past population projections since GOPB began projecting population for southwestern Utah in the late 1960s was determined by comparing GOPB historical population projections to actual historical population data obtained from the U.S. Census Bureau. The trends and accuracy of the population projections were summarized for Washington, Kane, and Iron counties.

2.2.2 Non-Permanent Population Data

Southwestern Utah has unique population variability due to a high percentage of part time, second home owners that reside there during the winter months. These second home owners typically are not included in base population records, but do add to the water needs and should be accounted for. Therefore, the number of part-time residents, which are not included in the GOPB population projections, were estimated using information from the county assessors' offices within each of the three Districts' service areas.

The number of tourists was also estimated for each of the Districts based on data for the number of hotel rooms, the occupancy rate, and the average people per room for each of the Districts' service areas. The following equation was used to estimate the annual number of visitors, assuming 1.5 average number of people per room:

Annual Visitors = (# of hotel rooms) × (occupancy rate) × (average people per room) × 365 days per year

Additionally, the average annual college student population that could not be included in the GOPB population data was estimated based on information collected from the following universities: Dixie State College, Dixie Applied Technology College, Southwest Applied Technology College, Southern Utah University, and Utah State University.

The combined effect of the non-permanent, tourist, and college student populations was qualitatively discussed. However, effects of these populations on per capita water use and total water demand were not quantified. The future ratio of non-permanent population to permanent population was assumed to be equal to the current ratio, and thus the non-permanent population was assumed to grow at the same rate as the permanent population within the planning horizon.

2.2.3 Population Density and Growth

Available buildout population information was obtained for the Districts' service areas where possible. Population growth scenarios developed by local entities such as counties, cities, and other non-profit groups were used to evaluate whether the GOPB projected population may be affected by growth boundaries and population density targets identified by the local entities.

2.3 Methodology for Determining Current Per Capita Water Use

Various methods are used by cities throughout the United States to calculate per capita water use. Per capita water use is generally determined by dividing the amount of water used by an entity by the population served by the entity. However, the types of water use (e.g., residential only, total culinary, or total culinary and secondary) and the types of population (e.g., permanent population or total population including non-permanent residents) included in the per capita water use calculation vary from entity to entity. The various methods utilized to calculate per capita water use greatly influence the resulting per capita water use numbers, and can make it difficult to accurately compare per capita water use between two different entities. For example, one city may only include culinary water use (i.e., potable water use) in their total use number that is input to the per capita water use calculation, while another city may include culinary plus secondary water use (i.e., non-potable water use) in the calculation. As a result, the second city that includes both culinary and secondary water use would have a higher per capita use, given an equal population for both cities. Consequently, it is important to understand how per capita water use data are calculated when making a comparison between different entities. The following assumptions were made in determining per capita water use for the entities within the Districts' service areas:

- Water use forecasts were developed for total use (culinary plus secondary)
- Water use included use by both permanent and non-permanent population
- Population baseline data included the 2005 population as reported in the DWRe municipal and industrial (M&I) water supply and use reports (DWRe 2006c; DWRe 2007a; DWRe 2008a; DWRe 2007b)

- 2005 water use was assumed to represent current per capita water use
- Per capita water use was calculated based on municipal and industrial use but not agricultural use

The assumptions described above used to determine per capita water use are consistent with the method used by the Utah DWRe, but may not be consistent with the methods used by other entities across the U.S. There is no standard procedure for calculating per capita water use published by an accepted professional organization (e.g., American Water Works Association).

Current per capita water use was determined for municipal and industrial water use categories using 2005 water use data from the DWRe draft municipal and industrial water supply and use reports (DWRe 2006c; DWRe 2007a; DWRe 2008a; DWRe 2007b). Water use data in the M&I Water Supply and Use Reports were submitted by public community water providers, and subsequently verified by the DWRe during yearly field surveys between the water provider and the DWRe. Agricultural water use was not included in the per capita water use data provided, and is not discussed further in this report, with the exception of current agricultural water supply that may represent a source of supply for the M&I sector in the future.

Water use was separated into five categories, which are the same as those used by the DWRe in the municipal and industrial water supply and use reports: residential indoor, residential outdoor, commercial, industrial, and institutional. Per capita water use was determined by dividing the total volume of water used by the permanent population for each water provider. The population used to determine existing per capita water use was obtained from the DWRe M&I water supply and use reports. The population data from DWRe was assumed to be the most accurate information. Only permanent full-time residents were considered in the calculation of per capita water use. Although non-permanent population was not figured into the actual per capita water use data, the effects of non-permanent residents and tourism were described (i.e., causes for high per capita water use were discussed, including the effect of non-permanent population). Per capita water use was determined for each of the three Districts as follows.

- **WCWCD –** Per capita use for Washington County as reported in the Kanab Creek/Virgin River Basin M&I Water Supply and Use Report (DWRe 2008a) was assumed to be representative of per capita water use for the WCWCD. Enterprise was not included because it is located in the Cedar/Beaver Basin and would not be served by Lake Powell Pipeline project due to its remote location,
- **CICWCD -** Per capita use for all the public community water systems within Iron County as reported in the Cedar/Beaver Basin M&I Water Supply and Use Report (DWRe 2007a), except those entities that will likely not receive water from the CICWCD (i.e., Brian Head Water Supply, Escalante Valley Water System, Parowan Municipal System, Parogonah Municipal Water System, and Summit SSD). Kanarraville was not included because it makes up one percent of the CICWCD population and is located in the Kanab Creek/Virgin River Basin.
- **KCWCD -** Average per capita water use for Kane County was assumed to be representative of per capita water use for the KCWCD. Although most water users within the county are not served by the District (e.g., Kanab City), average countywide per capita water use was used as a reasonable approximation of per capita water use for the District.

Per capita water use for 2005 was also summarized by culinary and secondary water uses for each of the five water use categories. Per capita secondary water use was provided in total volume per year in the DWRe M&I Water Supply and Use Reports; it was not presented in per capita units. However, secondary water use is presented in per capita units in this report, in order to make the units consistent with those used for culinary water use. To calculate per capita secondary water use, the total volume of secondary water used was divided by the overall entity's population. For example, the Ivins Irrigation District secondary water use in 2005 was reported as 80.7 ac-ft per year (DWRe 2008a). Although the irrigation District may only serve a portion of the city of Ivins,

the per capita use was determined by dividing the 80.7 ac-ft per year by the total permanent population of Ivins City.

The per capita water use data for the Districts were compared to previously published per capita water use information obtained from capital facilities plans for local entities and from DWRe River Basin Plans for the Kanab Creek/Virgin River and Cedar/Beaver basins (DWRe 1993; DWRe 1995).

The final per capita water use baseline data that was used in the calculation of future water demands for the three Districts was the 2005 per capita water use data taken from the DWRe M&I Water Supply and Use Reports. The 2005 water use data was used as the baseline for water use in 2005, and future per capita water use (i.e., 2005 to 2060) was based on the 2005 per capita water use with an assumed percent reduction for conservation. This data was assumed to be the best available data for the following reason: it is the most recent data available, consistent data is available for the three Districts, and the data have been verified by an independent public agency (i.e., the DWRe). The baseline for per capita use was adjusted according to projected conservation goals, but no further adjustments were made for other influences on water use such as climate change. The influence of these other factors was not considered because of the uncertainty of these other influences.

2.4 Methodology for Determining Projected Conservation

Projected conservation for the three Districts was based on conservation information from the DWRe. The conservation goals described in this report were applied to total M&I per capita water use (culinary plus secondary use).

The DWRe has set several statewide conservation goals over the past few years. The DWRe stated a goal of achieving 25 percent reduction in per capita water use statewide relative to 1995 water use in the July 2003 Utah M&I Water Conservation Plan (DWRe 2003). This is being updated to a goal of 25 percent reduction relative to 2000 use rates. The DWRe has documented that a 12 percent reduction was achieved statewide between 2000 and 2005, and has set a goal of an additional 13 percent reduction to be achieved from 2005 to 2050 (Klotz 2007). In addition, conservation was projected from 2050 through 2060 based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal. Education for water consumers on typical water use practices, such as how to water lawns efficiently, is likely responsible for much of the statewide average reduction in per capita use of 12 percent from 2000 to 2005. The last half of the per capita use reduction goal will be more difficult to achieve and will take longer than the first 12 percent (i.e., 55 years from 2005 to 2060 to achieve the second half of the conservation goal). Where conservation has not been achieved over the 2000 to 2005 period, the DWRe expects these communities to achieve the full 25 percent reduction in per capita water use from 2005 to 2050 based on the statewide goal and has extended the conservation goal through 2060 using the same rate of reduction in per capita water use. The schedule of assumed conservation savings was determined starting with the year 2005 and linearly interpolating for each year through 2060 to the maximum conservation amount.

The methods for estimating future water savings due to conservation in this Phase 1 analysis are approximate. Phase 2 of the Water Needs Assessment will include a detailed quantitative analysis of potential future conservation measures and their effectiveness in each of the Districts.

2.5 Water Demand Forecast

Total projected water demand (i.e., ac-ft per year) was determined for the three Districts for the period from 2005 to 2060 by multiplying the projected population for each of the Districts by the total M&I per capita water use (culinary plus secondary) with conservation as described in the previous section. Separate culinary and secondary water use demands were also estimated for WCWCD and CICWCD to determine the potential secondary supply that could be utilized by each of the Districts. Separate secondary water demand was not estimated for KCWCD because culinary water supply was sufficient to meet total KCWCD water demands throughout the planning

horizon. Water demand forecasts were made for 2005 and every ten years for 2010 to 2060. These forecasts start two years prior to the date of publishing this report because of the availability of the baseline population and per capita water use for the year 2005.

2.6 Existing Water Supplies

Information on existing water supplies available to water users within the service areas of the three Districts was obtained from previously published reports on local and regional water use. Key documents reviewed to determine existing water supplies included Capital Facilities Plans for the Districts and cities within the Districts; basin plans developed by the Utah Board of Water Resources for the Kanab Creek/Virgin River Basin and the Cedar/Beaver Basin; and recent studies of municipal and industrial water use in the study area conducted by the Utah Division of Water Resources. When different references reported different values for yields of existing water supplies, a decision was made as to which source would be most reliable. In general the most recent report was considered to provide the most reliable information.

Water supply planning is typically done using estimates of reliable yield for water supplies in order to prevent overestimating necessary water supplies and potential water shortages. Reliable yield estimated by the DWRe (2007a, 2008, 2007b) was used to estimate yield for the existing water supplies within the Districts. For WCWCD, average annual yield with a maximum annual surface water shortage of 25 percent using the critical historical drought period was used to represent reliable surface water supplies. Annual surface water shortages would occur during dry periods, and ground water supplies would be used to fill the deficit between water demand and surface water supply during the dry periods. Reliable yield of ground water supplies were assumed to be equal to those estimated in the DWRe reports regarding M&I water supply and uses, which are 50 percent of the maximum yield of wells or their pump capacities (unless otherwise indicated by the well owner) (DWRe 2007a, 2008, 2007b). WCWCD is the only Participant that relies heavily on surface water supplies, and ground water supplies and/or reserves were assumed to be capable of meeting any short-term shortages in surface water supplies during droughts. As a result, there would not be any supply shortages, and the combination of surface and ground water supplies would fully meet demand. CICWCD and KCWCD both rely primarily on ground water supply, which is considered to be more reliable relative to surface water supplies because of less influence on ground water supplies by hydrologic conditions.

Water providers currently rely on demand management – or emerging conservation measures – to get through drought periods when water supplies are well below normal. The reliable yield concept incorporates the idea that the projected demands will become more firm in the future as a result of conservation discussed in **Section 2.4**. Projected demand is based on a per capita water use that is reduced in the future with increases in conservation. As per capita water use is reduced, the ability to use demand management as a drought protection strategy is also reduced. This decrease in flexibility of per capita water use is referred to as “demand hardening.” It is important that reliable yield estimates for the Districts are not overestimated because of demand hardening that will occur in the future as additional conservation measures are enacted. With demand hardening, reliable yield estimates for water supplies need to be great enough to meet projected demands in all years, because there is little potential to reduce projected demands in extremely dry years when actual yield of a water supply is less than the reliable yield. It was assumed for the analyses in this report that the reliable yield used for existing and future supplies would be adequate to accommodate demand hardening.

2.7 Potential Future Water Supplies

Information on potential future water supplies that could be developed by each of the Districts was obtained from previously published reports and from interviews with staff members of each District. Projects that could be developed to meet future water needs have been described in Capital Facilities Plans, and in previous feasibility studies for the LPP project. As is the case for existing supplies, reliable supply is used to estimate the yield for potential future water projects.

2.8 Water Conservation Programs

Information on the water conservation programs currently being implemented by the Districts and the water users within their service areas was obtained from published water conservation plans that must be submitted to the State of Utah. In some cases key information was verified by interviewing water conservation coordinators or water resources planners at the various entities. In this phase of the project, no effort was made to field-verify the implementation of specific conservation measures described in the water conservation plans. This may be done in Phase 2.

Documentation of recent water use reductions that could be attributed to State and local water conservation programs was expressed in terms of per capita water use rates as determined from review of information provided by the entities or the State.

2.9 Integrated Water Resources Plans

Integrated water resources plans consist of integrating demand forecasts with existing and potentially available supplies in a strategic manner. New supply sources were added sequentially in priority when demand exceeds supply based on factors such as qualitative unit cost, current status of project development, and preferences expressed by the Districts. Because detailed cost estimates for future water supply projects were not developed at this stage of analysis, any cost comparisons between water supply sources were qualitative only. The timing for bringing new supply projects on-line was determined based on when the demand estimate exceeds the reliable supply as described in **Section 2.6** from available supplies. Timing for bringing new secondary water supplies on-line was based on both the availability of supply and the projected secondary water demand.

2.10 Coordination with Local Stakeholders

Several meetings were held with local stakeholders in order to provide the opportunity for stakeholders to help develop the methods used to determine water needs for the Districts for the Water Needs Assessment. Stakeholder meetings were held with representatives from the public (e.g., cities within the Districts' service areas, local citizens, and environmental groups) in May 2007. Additional meetings were held with the Districts in July 2007, September 2007, and January 2008 to gain additional insight on operations of each of the Districts' water supplies and issues associated with current and future supplies.

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Chapter 3 - Water Demand Forecast

Population data, per capita water use, and water demand forecast information are summarized in this Chapter.

3.1 Population Data

The results of the compilation of population projection data, permanent population data, and effects of non-permanent population are described in this section.

3.1.1 Population Projections

Population projections were calculated for the three Districts based on the GOPB 2008 baseline projections and the methods described in **Section 2.2**.

Staffs of entities in the study area have uniformly commented that past GOPB population forecasts have underestimated actual population growth over the past two decades. The accuracy of previous GOPB population projections was evaluated, and the trends in the accuracy of the projections (i.e., does the accuracy of the projections for more recent projections increase over previous projections) were evaluated using data provided by the GOPB (2007a). Historical GOPB projections are plotted with the U.S. Census Bureau population data for Washington, Iron, and Kane counties in **Figure 3-1, Figure 3-4, and Figure 3-7**, respectively. The U.S. Census Bureau population data are plotted with the black line and are labeled as "Actual" in each of the three figures. Historical GOPB population projections are plotted using colored lines, and are labeled with the year that the population projections were made. GOPB population projections have typically been getting more accurate recently as discussed in the following sections. As a result, the most recent GOPB (2008) projections were assumed to be reliable population projections, and were used to determine total water demand for the planning horizon as discussed in the following paragraph.

The GOPB 2008 baseline population projections (GOPB 2008) were plotted and a range of potential population was estimated as plus/minus 10 percent of the 2008 projections. The range of potential population projections is shown in the plots for the Districts' population projections in order to acknowledge the uncertainty in projections that extend over 50 years into the future (i.e., economic factors such as trends in housing markets and the possibility of new developments currently not anticipated). However, the 2008 projections were used to determine the projected water needs described in **Section 3.4**. These water needs projections, which were based solely on the GOPB 2008 baseline projections without regard to the plus/minus 10 percent band, were used to determine the necessary timing for introducing new supplies into the water conservancy districts' water systems.

3.1.1.1 WCWCD Population Projection

Eight historical population projections made by GOPB for Washington County are plotted with the U.S. Census Bureau actual population data in **Figure 3-1.** The first GOPB population projection (1967 baseline) predicted approximately 30 percent population growth between 1970 and 2000, and the U.S. Census Bureau data shows approximately 560 percent growth in the same time period. On average, the 1967 baseline projections are 62 percent lower than the U.S. Census Bureau population data. Each successive GOPB population projection increased in accuracy, with the average percent error decreasing from 62 percent lower than the U.S. Census Bureau data for the 1967 baseline projections to 8 percent lower than the U.S. Census Bureau data for the 2000 baseline projections.

Population projections used in this analysis for WCWCD and the six largest cities in the District are shown in **Table 3-1**, where the GOPB 2008 projections are shown (i.e., the population projections used to determine projected water needs in **Section 3.4**), and **Figure 3-2**, where the range of potential population projections is shown (2008 baseline projections plus/minus 10 percent). **Figure 3-3** displays the historical GOPB population estimates (2007b) along with the GOPB 2008 projections.

Figure 3-1
Washington County Historical Population Projections Comparison (GOPB 2007a)

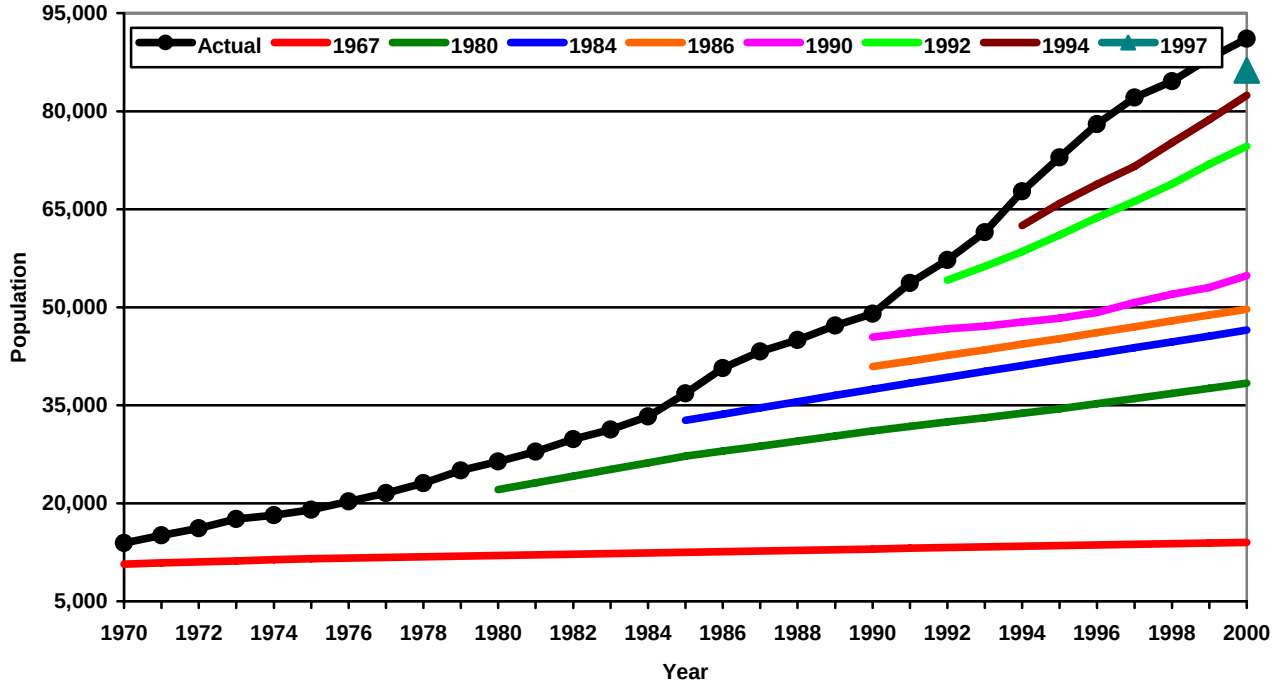


Table 3-1
Population Projections for WCWCD

District / City	Parameter[2]	Year							2005 to 2060 AGR
		2005	2010	2020	2030	2040	2050	2060	
WCWCD	Pop.	127,090	168,078	279,864	415,510	559,670	709,674	860,378	--
	AGR	--	5.59%	5.10%	3.95%	2.98%	2.37%	1.93%	3.48%
Ivins	Pop.	6,860	10,477	17,436	25,886	34,867	44,213	53,602	--
	AGR	--	8.47%	5.09%	3.95%	2.98%	2.37%	1.93%	3.74%
La Verkin	Pop.	4,370	5,162	8,592	12,756	17,182	21,787	26,413	--
	AGR	--	3.33%	5.09%	3.95%	2.98%	2.37%	1.93%	3.27%
Hurricane	Pop.	11,180	16,381	27,287	40,512	54,568	69,193	83,887	--
	AGR	--	7.64%	5.10%	3.95%	2.98%	2.37%	1.93%	3.66%
St. George	Pop.	67,000	84,245	140,268	208,254	280,507	355,703	431,239	--
	AGR	--	4.58%	5.10%	3.95%	2.98%	2.37%	1.93%	3.39%
Santa Clara	Pop.	6,000	9,325	15,532	23,061	31,062	39,387	47,751	--
	AGR	--	8.82%	5.10%	3.95%	2.98%	2.37%	1.93%	3.77%
Washington	Pop.	15,400	22,858	38,285	57,050	77,011	97,793	118,818	--
	AGR	--	7.90%	5.16%	3.99%	3.00%	2.39%	1.95%	3.71%

[1] Source of population projections is GOPB (2008), except for the 2005 population, which is estimated population data accessed from (DWRe 2008a).
[2] Pop = GOPB population projection; AGR = annual growth rate.

Figure 3-2
WCWCD Population Projection Range

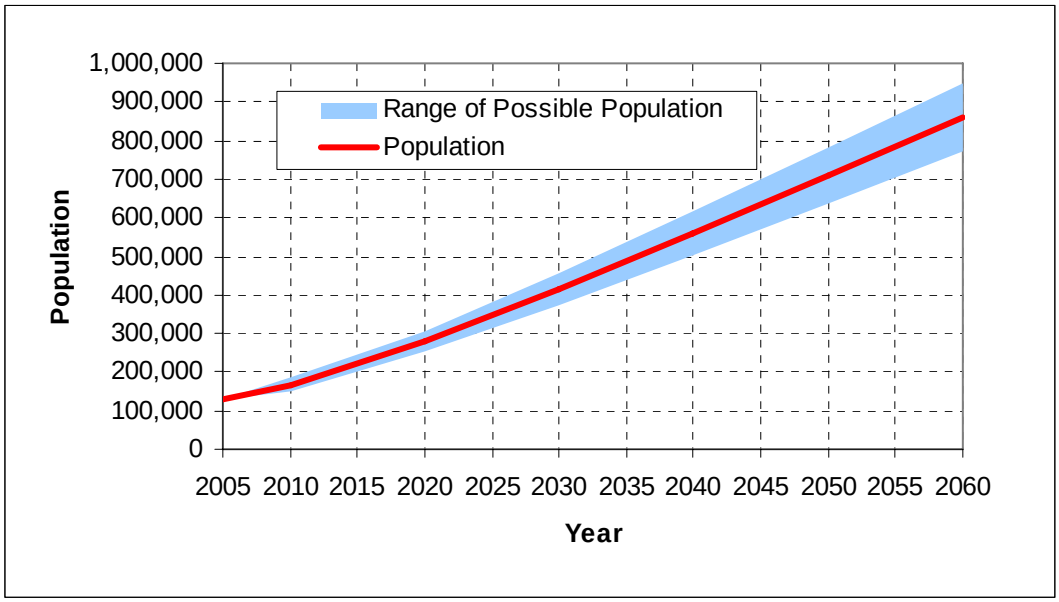
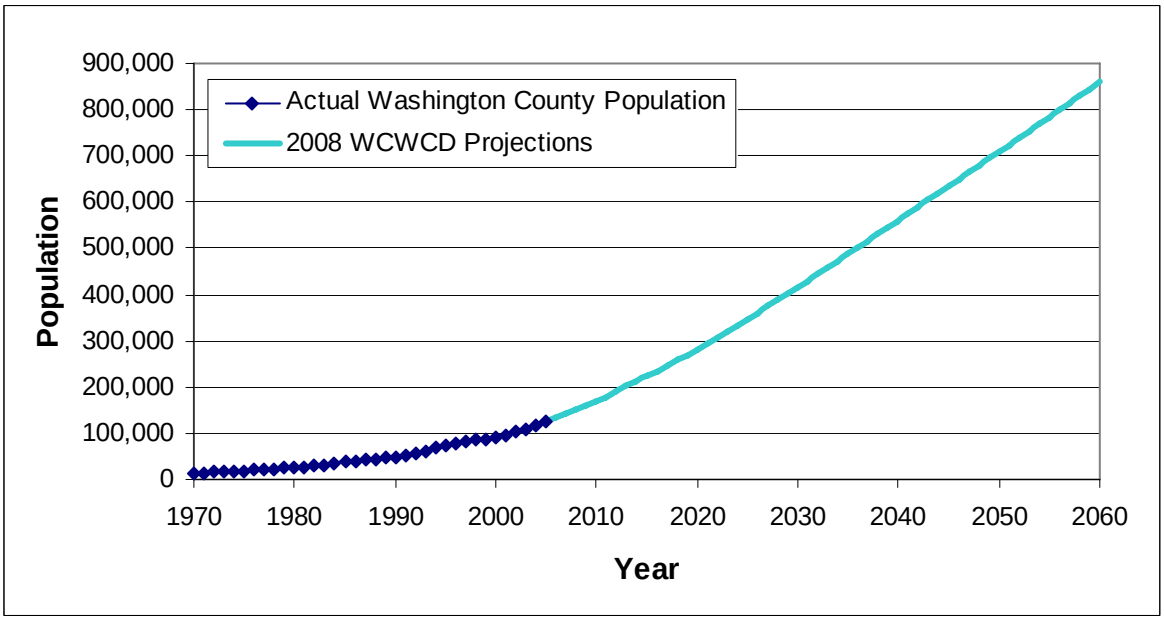


Figure 3-3
WCWCD Historical Population and 2008 Population Projections (GOPB 2007b)



3.1.1.2 CICWCD Population Projections

Eight historical population projections made by GOPB for Iron County are plotted with the U.S. Census Bureau actual population data in **Figure 3-4**. The first GOPB population projection (1967 baseline) predicted approximately 30 percent population growth between 1970 and 2000, and the U.S. Census Bureau data shows approximately 180 percent growth in the same time period. On average, the 1967 baseline projections are 34 percent lower than the U.S. Census Bureau population data. GOPB population projections generally increased in accuracy, with the average percent error decreasing from 34 percent lower than the U.S. Census Bureau data for

the 1967 baseline projections to 4 percent lower than the U.S. Census Bureau data for the 2000 baseline projections. However, the higher rate of population growth that occurred in the 1990s was not as accurately predicted as the slower growth rate in the late 1980s.

Population projections used for this analysis for CICWCD and the two major cities in the District are provided in **Table 3-2**, where the GOPB 2008 projections are shown (i.e., the population projections used to determine projected water needs in **Section 3.4**), and **Figure 3-5**, where the range of potential population projections is shown (2008 baseline projections plus/minus 10 percent). CICWCD population was assumed to be equal to the total Iron County population less the population served by Kanarraville and water suppliers not located within the District's boundary (i.e., Brian Head Water Supply, Escalante Valley Water System, Parowan Municipal System, Parogonah Municipal Water System, and Summit Sanitary Sewer District). **Figure 3-6** displays the historical GOPB population estimates (2007b) along with the GOPB 2008 projections.

Figure 3-4
Iron County Historical Population Projections Comparison (GOPB 2007a)

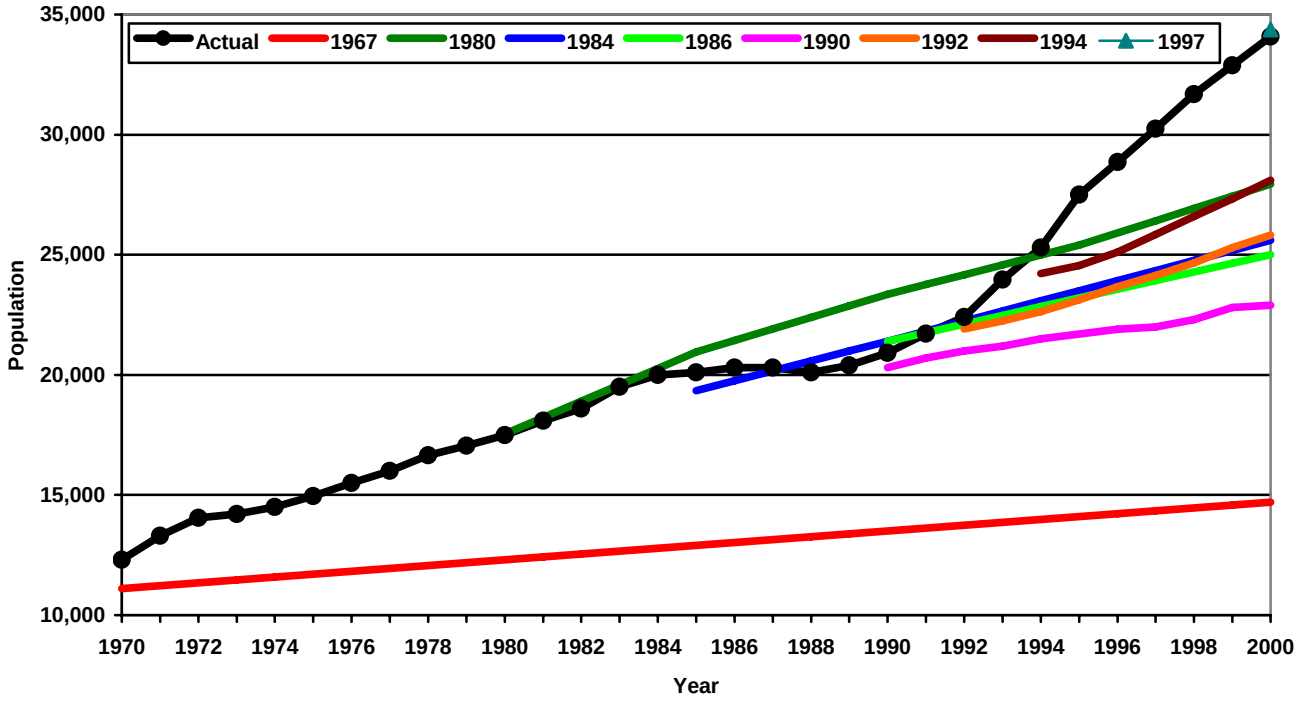


Table 3-2
Population Projections for CICWCD

District / City	Parameter[2]	Year							2005 to 2060 AGR
		2005	2010	2020	2030	2040	2050	2060	
CICWCD Total	Pop.	32,860	45,358	61,236	78,563	98,833	123,020	150,936	--
	AGR	--	6.45%	3.00%	2.49%	2.30%	2.19%	2.05%	2.77%
Cedar City	Pop.	24,000	29,907	40,376	51,799	65,165	81,113	99,516	--
	AGR	--	4.40%	3.00%	2.49%	2.30%	2.19%	2.04%	2.59%
Enoch City	Pop.	4,900	5,302	7,157	9,181	11,551	14,379	17,642	--
	AGR	--	1.58%	3.00%	2.49%	2.30%	2.19%	2.05%	2.33%

[1] Source of population projections is GOPB (2008), except for the 2005 population, which is estimated population data accessed from (DWRe 2007a).
[2] Pop = GOPB population projection; AGR = annual growth rate.

Figure 3-5
CICWCD Population Projection Range

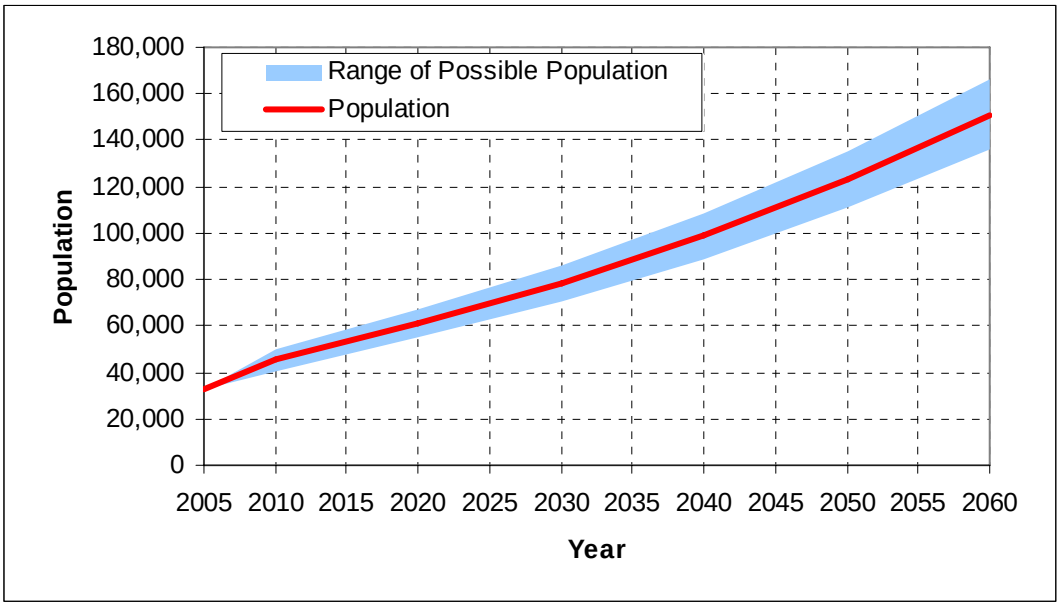
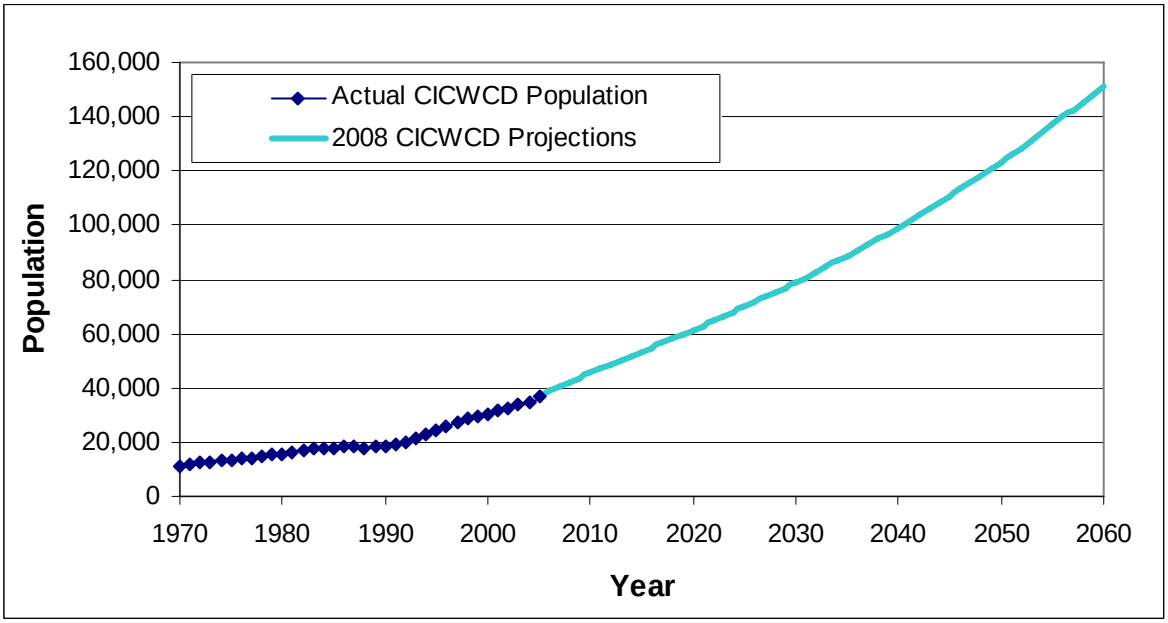


Figure 3-6
CICWCD Historical Population and 2008 Population Projections (GOPB 2007b)



3.1.1.3 KCWCD Population Projections

Eight historical population projections made by GOPB for Kane County are plotted with the U.S. Census Bureau actual population data in **Figure 3-7**. Population projections for Kane County were higher than actual U.S. Census Bureau data for the 1967 and 1980 baseline projections (by approximately 170 and 50 percent, respectively). More recent population projections have been within approximately 10 percent of simulated U.S. Census Bureau data.

Population projections for KCWCD and for Kanab City are provided in **Table 3-3**, where the GOPB 2008 projections are shown (i.e., the population projections used to determine projected water needs in **Section 3.4**), and **Figure 3-8**, where the range of potential population projections is shown (2008 baseline projections plus/minus 10 percent). **Figure 3-12** displays the historical GOPB population estimates (2007b) along with the GOPB 2008 projections.

Figure 3-7
Kane County Historical Population Projections Comparison (GOPB 2007a)

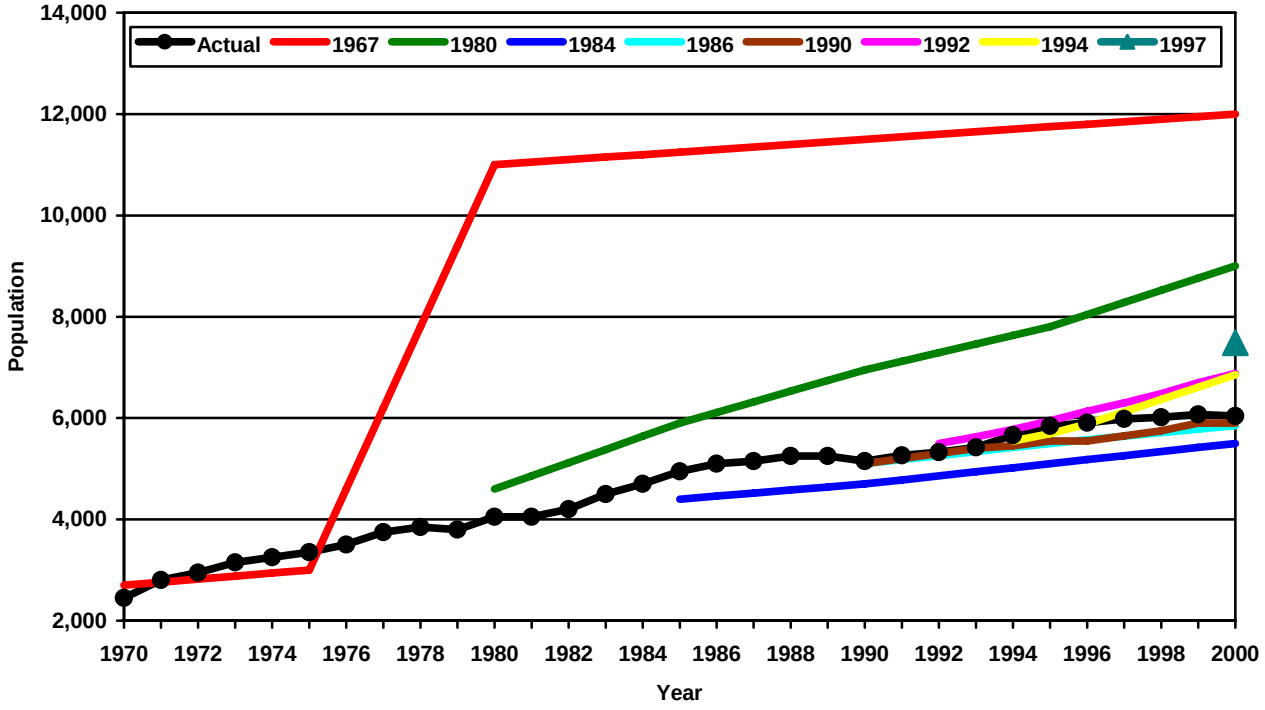


Table 3-3
Population Projections for KCWCD and Kanab

District / City	Parameter[2]	Year							2005 to 2060 AGR
		2005	2010	2020	2030	2040	2050	2060	
KCWCD	Pop.	5,952	6,893	8,746	10,394	12,034	14,267	17,276	--
	AGR	--	2.94%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Kanab	Pop.	3,540	4,100	5,202	6,182	7,157	8,485	10,275	--
	AGR	--	2.99%	2.38%	1.72%	1.47%	1.70%	1.91%	1.94%

[1] Source of population projections is GOPB (2008), except for the 2005 population, which is estimated population data accessed from (DWRe 2006c; DWRe 2007b; DWRe 2008a).
[2] Pop = GOPB population projection; AGR = annual growth rate.

Figure 3-8
KCWCD Population Projection Range

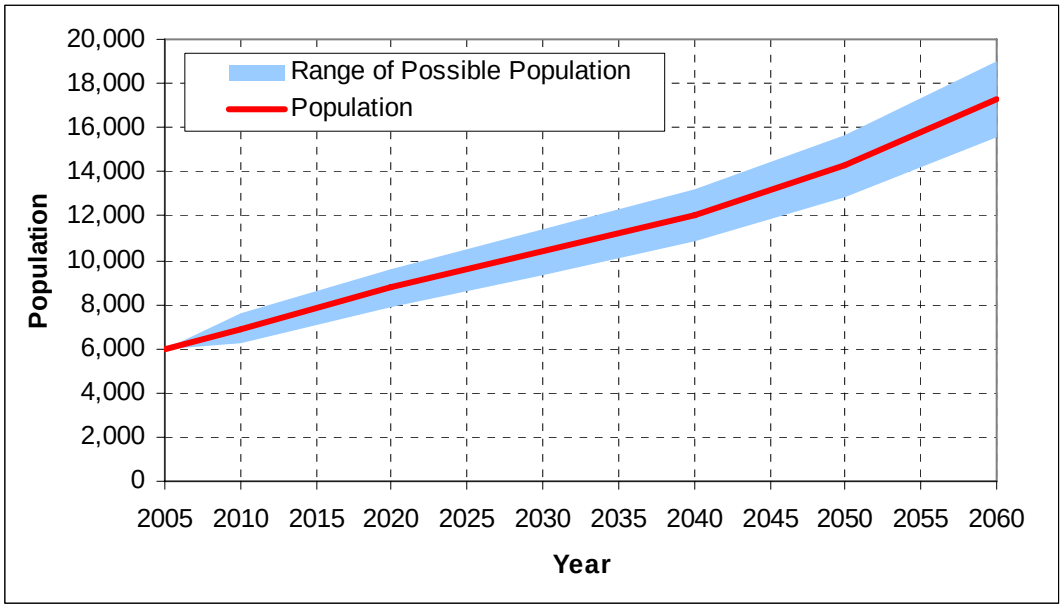
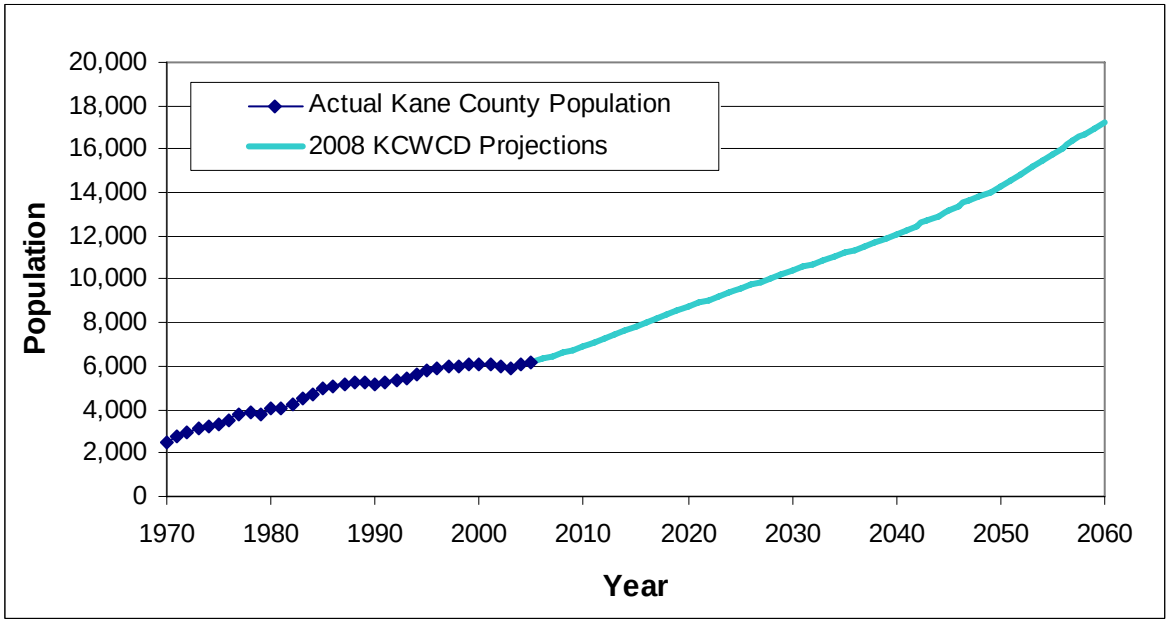


Figure 3-9
KCWCD Historical Population and 2008 Population Projections (GOPB 2007b)



KCWCD Subbasin Population Projections

Population projections for the entire service area for KCWCD are discussed above, and projections for the four individual subbasins within KCWCD that may be served by the Lake Powell Pipeline are summarized in **Table 3-4**. Cities within each of the four subbasins were described in **Section 2.1.1**. Population for each of the subbasins was estimated using GOPB (2008) population projections for Kane County and the ratio of population for the cities within each subbasin of Kane County divided by the total Kane County population.

Table 3-4
Population Projections for KCWCD Subbasins

Subbasin	Parameter[2]	Year							2005 to 2060 AGR
		2005	2010	2020	2030	2040	2050	2060	
East Fork Virgin River	Pop.	1,035	1,198	1,521	1,807	2,092	2,481	3,004	--
	AGR	--	2.94%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Kanab Creek	Pop.	4,118	4,769	6,050	7,191	8,325	9,870	11,952	--
	AGR	--	2.94%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Johnson Canyon	Pop.	196	227	288	342	396	470	569	--
	AGR	--	2.94%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Wahweap Creek	Pop.	603	699	887	1,054	1,220	1,447	1,752	--
	AGR	--	2.94%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%

[1] Source of population projections is GOPB (2008), except for the 2005 population, which is estimated population data accessed from (DWRe 2006c; DWRe 2007b; DWRe 2008a).
[2] Pop = GOPB population projection; AGR = annual growth rate.

3.1.2 Growth Scenarios and Population Density

The WCWCD completed a study in 1994 to determine the area of land available for residential development within Washington County (WCWCD 1994). The three buildout scenarios evaluated by WCWCD are summarized in **Table 3-5**. A comparison of the GOPB 2008 population projection for 2060 for WCWCD (approximate population of 860,400) with the buildout scenarios in **Table 3-5** indicates that the population projection may be limited by the growth assumptions in all 3 growth scenarios by 2060. Scenario C, the most extensive development scenario, assumes that all buildable land between West Black Hills and East Black Hills will be developed. The average population density of 2,000 people per square mile was based on the current density in the urban center of St. George.

Table 3-5
WCWCD Buildout Population Scenarios for Washington County

Scenario	Assumptions	Buildout Population
A	• Based on community zoning plans of October 1993 (low intensity of growth) • 207,000 acres of total development (Population density of approximately 440 people per square mile)	142,000
B	• Based on Blooming Hills community (moderate intensity of growth) • 225,000 acres of total development (Population density of approximately 950 people per square mile)	333,000
C	• Based on the area from West Black Hills to East Black Hills (high intensity of growth) • 225,000 acres of total development (Population density of approximately 2,000 people per square mile)	707,000

Source: (WCWCD 1994).

Washington County commissioned a population buildout study in 1997 to determine buildout population based on the development as described in the general plans adopted at that time for the major urban communities within Washington County. The resulting estimate for Washington County buildout population was an approximate population of 328,000 (Washington County 1997), which is similar to the buildout population in Scenario 2 of the WCWCD study described above. The GOPB population projections would exceed this estimate for buildout population some time between the years 2020 and 2030. General Plans, including annexation boundaries and development densities, are routinely modified by Planning Commissions and City Councils to respond to changing conditions. It is the intention of Washington County planners that urban growth should occur within corporate boundaries of existing cities. This has resulted in policies to encourage development/infill within existing city boundaries, and to annex areas of pending development into existing cities. Thus the 1997 buildout

study results should be considered appropriate for the General Plan conditions in effect at that time, but not for future conditions when General Plans will certainly be amended.

Washington County population projections shown in **Table 3-1**, from the GOPB indicate a 2060 population of approximately 860,400, which is similar to the buildout population Scenario C from the past WCWCD study. In order to accommodate the projected 2060 population, the assumptions for Scenario C would become reality for Washington County: high intensity development would occur (i.e., approximately 2,000 people per square mile in the developed areas), and cities would need to annex additional land (after annexation a total of approximately 225,000 acres would be developed) to provide enough land to accommodate the projected population.

3.1.3 Non-Permanent Population Data

An estimate of permanent and non-permanent population was determined for each of the three Districts in order to determine the potential influence of non-permanent residents on the per capita water use. Water use by the non-permanent population is included in the per capita water use calculation, but the non-permanent population is not included in the calculation (i.e., per capita water use is calculated as total water used divided by permanent population). As a result, high non-permanent population increases per capita water use relative to other municipal areas where there is a less substantial non-permanent population.

Washington County
Permanent and non-permanent residential housing information was obtained for Washington County from the county's property tax assessment information for the six largest cities in the county (WCWCD 2007b), and the information is summarized in **Table 3-6**. It is assumed that the percentage of non-permanent residents is the same as the percentage of non-permanent residential properties. The average non-permanent residential population in Washington County is estimated to be 27 percent of the total population.

Table 3-6
Washington County Permanent/Non-Permanent Resident Data

Location	Percentage of Total Residential Properties	
	Permanent Resident	Non-Permanent Resident
Ivins	72%	28%
La Verkin	77%	23%
Hurricane	71%	29%
St. George	77%	23%
Santa Clara	72%	28%
Washington City	72%	28%
Washington County Average	73%	27%

Source: (WCWCD 2007b).

Iron County
Permanent and non-permanent residential housing information was obtained for Iron County from the county's property tax assessment information (Ayers 2007). According to the assessor's office, there are 11,459 primary homes (80 percent of the total) and 2,830 non-primary homes (20 percent of the total) in Iron County. However, most of these non-permanent homes are summer cabins that are located outside of the CICWCD service area. As a result, these non-permanent residences would likely not have a substantial effect on per capita water use for CICWCD, because water use outside of the CICWCD was not used for this report.

Kane County
Permanent and non-permanent resident information for Kane County was based on parcel information from the Kane County Information Technology Director (Owens 2007). The information for Kane County was provided for the number of primary and non-primary residential parcels, which do not necessarily represent the number of primary and non-primary homes (e.g., there are likely fewer homes than there are parcels). As a result, the

permanent and non-permanent population for Kane County may be inaccurate, but the data presented is the best available data. According to Kane County's records, there are 2,300 primary residential parcels (18 percent of the total parcels) and 10,526 non-primary residential parcels (82 percent of the total parcels) in Kane County. Some of the non-permanent population for Kane County is located far enough away from the proposed Lake Powell Pipeline routes (e.g., summer homes located in the Sevier River Basin) that the population would not be served by Lake Powell Pipeline water. However, the permanent versus non-permanent population data are presented for all of Kane County, because data obtained from the county were only available for the county as a whole.

A comparison of permanent versus non-permanent population for each of the three Districts is provided in **Table 3-7**. The data provided in the table are for informational purposes only. The data were not used in the calculation of per capita water use as described in **Section 2.3**, but are provided as information that may assist in understanding why per capita water use differs between the three counties. Although the data provided is countywide data and is not necessarily equal to the population within the associated water conservancy districts, the data are considered to be representative of the permanent versus non-permanent population for the corresponding Districts. Washington County and Iron County each have between 20 to 27 percent of the total population that is non-permanent population. Approximately 59 percent of Kane County parcels are reported as non-primary (country and recreational cabins). Most of the non-primary residences in Kane County are likely located in areas that would be too remote to be served by Lake Powell Pipeline (e.g., Duck Creek in the Sevier River Basin), and the permanent population within the potential Lake Powell Pipeline service area is likely higher than that shown for the entire county.

Table 3-7
Summary of Permanent vs. Non-Permanent Population

Entity	Permanent Population (% of Total)	Non-Permanent Population (% of Total)
Washington County (1)	73%	27%
Iron County (2)	80%	20%
Kane County (3)	41%	59%

(1) Source of data: (WCWCD 2007b).
(2) Source of data: Iron County Assessor (Ayers 2007).
(3) Source of data: (Noel 2008).
Data is for parcels, not population.

Per capita water use is determined by dividing the total water use (i.e., water used by both the permanent and non-permanent population) in an area by the permanent population. Consequently, the significant non-permanent population in the study area may contribute to a higher than average per capita water use relative to other municipal areas where there is a less significant non-permanent population. However, this may only be a significant factor for Washington County where the non-permanent population is located within major city limits and could potentially be served by the Lake Powell Pipeline. A large portion of the non-permanent population within Iron and Kane counties is associated with summer homes that are located remotely relative to the proposed Lake Powell Pipeline delivery points, and as a result may not have a substantial influence on per capita water use determined for this study to estimate water demand projections.

3.1.4 Tourism Population

Some cities in the southwestern U.S. experience a large tourism population as a result of the pleasant climate, plentiful recreational opportunities, and the scenic beauty of the area. St. George has a large tourism population associated with conventions, golfing, and visits to nearby national parks and other recreation areas. Cedar City also is influenced by tourism population associated with conventions and visits to nearby scenic destinations and recreation areas (albeit less of an influence than Washington County). Kane County is a gateway to Lake Powell and the Grand Staircase-Escalante National Monument. Average annual tourist visits for each of the three counties within the study area are summarized in **Table 3-8**.

Table 3-8
Average Annual Tourist Information for Southwest Utah Counties

County	Average Annual Tourist Estimate[1]
Washington County	16,013,000
Iron County	632,000
Kane County	465,000

Notes:
[1]Average annual tourists = (# hotel rooms) * (occupancy rate) * (1.5 people per room) * (365 days per year).
[2]Source: (Dixie Convention Center 2007; Iron County Tourism Bureau 2007; Hallisey 2007)

3.1.5 College Student Population

There are several colleges and universities within the study area. The average annual student population is summarized in **Table 3-9**. Student population data were obtained from the following universities and colleges.

- **Washington County -** Dixie State College of Utah, Dixie State College of Applied Technology, and Utah State University
- **Iron County -** Southern Utah University and Southwest Applied Technology College

The student population data are provided for informational purposes only, and the data were not used in the per capita water use calculations. The data are provided as information that may assist in understanding how per capita water use may be affected by non-permanent student population. However, some of the student population may be included in the permanent population data that were used to calculate per capita water use (i.e., students that permanently reside in the study area). For example, of the 5,944 students that were enrolled in Dixie State College in St. George in the fall 2007 term, 3,816 (64 percent) were from Washington County and consequently would be included in the GOPB population data for the county. Water use by college and university students would be considered institutional water use. Any non-permanent student population for Iron and Washington Counties would have the result of an inflated per capita institutional water use for the counties relative to other locations without non-permanent student populations.

Table 3-9
Average Annual Student Population for Southwest Utah Counties

County	Average Annual Student Population
Washington County	10,100
Iron County	9,700
Kane County	0

Notes:
[1]Source: (Utah State Board of Regents 2007).

3.2 Per Capita Water Use

Per capita water use is summarized by water use type (e.g., residential, commercial, etc.) and also by culinary and secondary use where the data were available.

3.2.1 Districts' 2005 Per Capita Water Use

Per capita water use is summarized for the water used during the year 2005, because these data are the most recent data available. Additionally, the data have been verified by the DWRe during yearly field surveys between the DWRe and the water providers. As described in **Section 2.3**, per capita water use data were determined by dividing total water use by the permanent population (i.e., non-permanent resident population was not included in the calculation of per capita water use).

Per capita water use for the year 2005 for each of the Districts is summarized in **Table 3-10** through **Table 3-12** and **Figure 3-10** through **Figure 3-12**, and per capita water use for the major cities in the study area is summarized in **Table 3-13**. The per capita water use data for KCWCD shown in **Table 3-12** were assumed to be applicable for each of the four subbasins within the KCWCD service area. The breakdown of indoor and outdoor residential use as a percentage of total residential water use is provided in **Table 3-14** for each of the three Districts. The breakdown of residential and commercial/industrial/institutional (CII) water use as a percentage of total water use with and without secondary water use is provided in **Table 3-15**, which provides an idea of what the major water uses are for each of the Districts. CICWCD has the largest portion of residential water use of the total culinary and secondary water use (70 percent of total use) of the three Districts, and KCWCD has the largest percentage of CII water use (45 percent of total use) of the Districts.

Local factors that can affect a city's water use include lot sizes, amount of green space/number of parks, and presence of golf courses. Per capita water use is also affected by factors associated with climate – for example, the warm climate in Washington County provides for a long growing season for grasses and personal vegetable gardens, creating a greater demand for outdoor water use than for areas with shorter growing seasons. A good example of elevated per capita water use associated with golf courses, public schools, and parks occurs for KCWCD per capita institutional water use shown in **Table 3-12** (about 120 gpcd). The golf courses, city and county parks, and school facilities within KCWCD use a similar volume of water as those in the other two districts, but per capita water use is higher in KCWCD because of a smaller population relative to the other two districts.

As calculated from **Table 3-10** through **Table 3-12**, 2005 secondary water use, as a percentage of total M&I use, was 15.9 percent in WCWCD, 8.8 percent in CICWCD, and 19.7 percent in KCWCD. This ratio of secondary to total water use is assumed to remain constant throughout the planning horizon for the Districts.

Table 3-10
WCWCD 2005 Per Capita Water Use (gpcd)

Water Use Categories	Culinary	Secondary	Total
Residential - Indoor	71.9	0.0	71.9
Residential - Outdoor	102.0	15.8	117.8
Commercial	71.4	9.5	80.9
Institutional	27.0	26.0	53.0
Industry/Stock Water	3.7	1.0	4.7
Total	**276.0**	**52.3**	**328.3**

Notes:
(1) WCWCD water use was assumed to be the water use for all of Washington County except Enterprise.
(2) Source: (DWRe 2008a).

Figure 3-10
WCWCD 2005 Per Capita Water Use

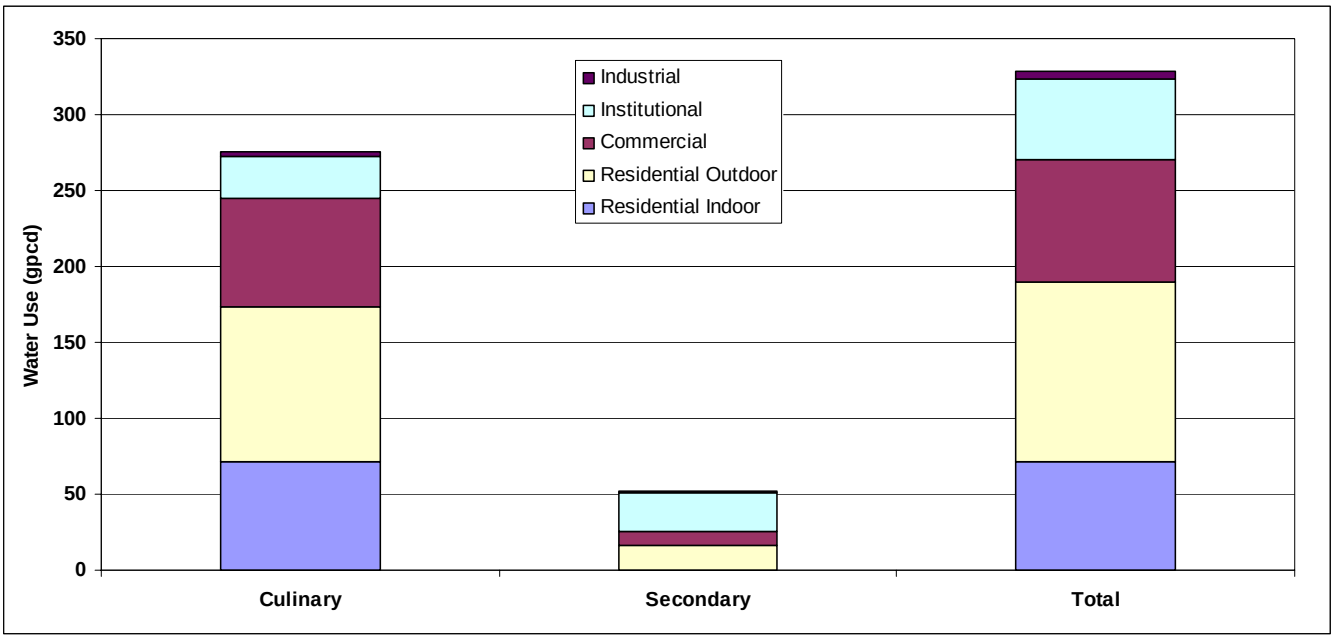


Table 3-11
CICWCD 2005 Per Capita Water Use (gpcd)

Water Use Categories	Culinary	Secondary	Total
Residential - Indoor	73.3	0.0	73.3
Residential - Outdoor	84.5	12.4	96.9
Commercial	36.4	0.0	36.4
Institutional	20.6	9.2	29.7
Industry/Stock Water	7.3	0.0	7.3
Total	**221.9**	**21.6**	**243.5**

Notes:
(1) CICWCD water use was assumed to be the weighted average of water use in all of Iron County in the Cedar/Beaver Basin with the exception of 5 water suppliers that are not in the CICWCD service area (i.e., Brian Head Water Supply, Escalante Valley Water System, Parowan Municipal System, Parogonah Municipal Water System, and Summit SSD).
(2) Source: (DWRe 2007a).

Figure 3-11
CICWCD 2005 Per Capita Water Use

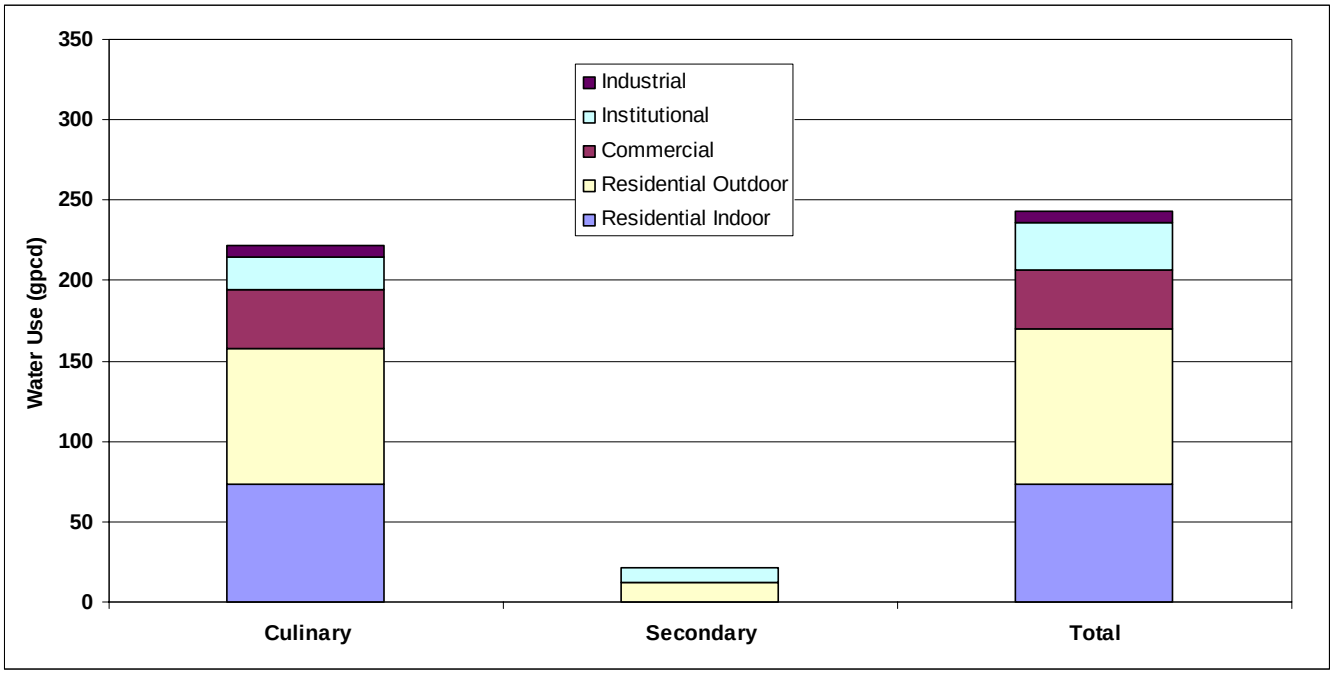


Table 3-12
KCWCD 2005 Per Capita Water Use (gpcd)

Water Use Categories	Culinary	Secondary	Total
Residential - Indoor	76.2	0.0	76.2
Residential - Outdoor	91.8	70.8	162.6
Commercial	68.5	0.0	68.5
Institutional	102.8	13.8	116.6
Industry/Stock Water	6.4	0.0	6.4
Total	**345.7**	**84.6**	**430.3**

Notes:
(1) KCWCD water use was assumed to be the weighted average of water use in Kane County within the Kanab Creek/Virgin River (without Fredonia, AZ), South Eastern Colorado River, and Western Colorado River basins.
(2) Source: (DWRe 2006c; DWRe 2008a; DWRe 2007b).

Figure 3-12
KCWCD 2005 Per Capita Water Use

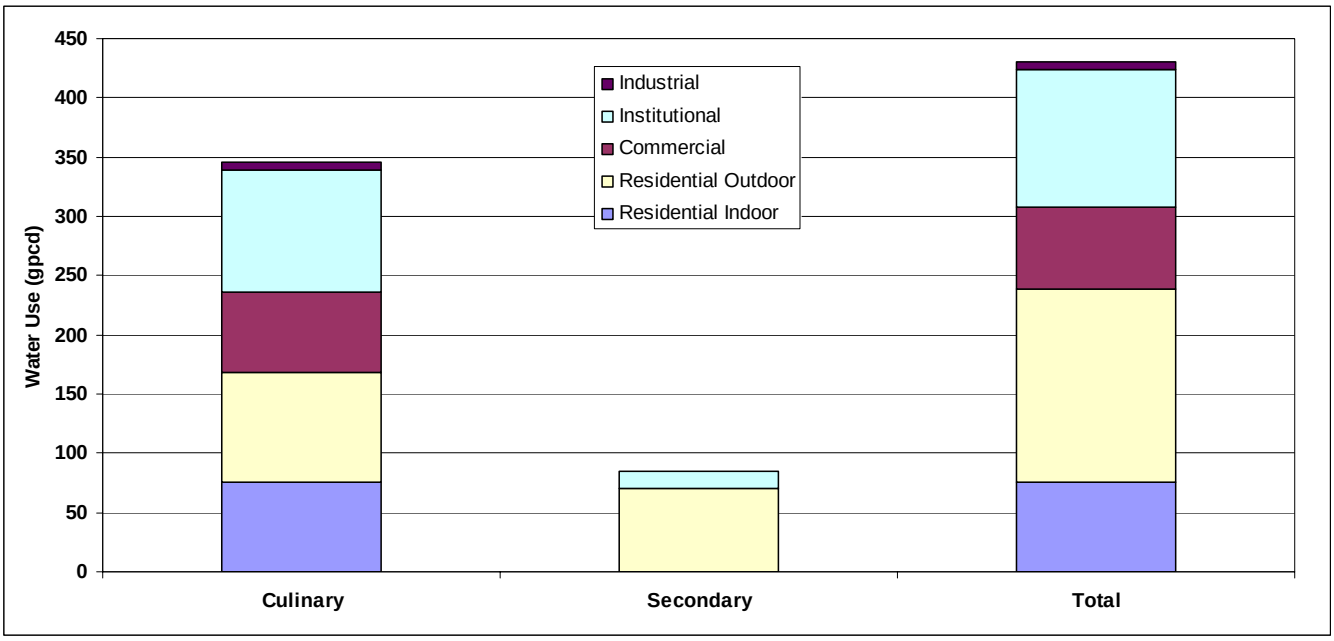


Table 3-13
2005 Per Capita Water Use (gpcd) for Major Cities in Study Area

Entity	Culinary	Secondary	Total
Hurricane City	300.3	86.1	386.4
Ivins City	163.4	10.5	173.9
La Verkin City	131.8	53.1	184.9
Santa Clara City	213.1	1.5	214.5
St. George City	323.7	59.3	382.9
Washington City	225.5	50.9	276.5
Cedar City	232.4	28.5	260.8
Kanarraville	408.9	145.8	554.7
Kanab City	383.1	33.5	416.6

Notes:
(1) Source: (DWRe 2006c; DWRe 2007a; DWRe 2008a; DWRe 2007b).

Table 3-14
Indoor/Outdoor Residential Water Use as Percentage of Total Residential Water Use

Entity	Percent of Total Residential	
	Residential - Indoor	Residential - Outdoor
WCWCD	38%	62%
CICWCD	43%	57%
KCWCD	32%	68%

Table 3-15
Residential and CII Use as Percentage of Total Water Use

Entity	Percent of Total Culinary Water Use (Percent of Total Water Use) (1)	
	Residential	CII (2)
WCWCD	63% (58%)	37% (42%)
CICWCD	71% (70%)	29% (30%)
KCWCD	49% (55%)	51% (45%)

(1) The first number given is the percentage of total culinary water use, and the second number given (the number in parentheses) is the percentage of total water use including secondary water use.
(2) CII is commercial, industrial, and institutional water use.

3.2.2 Non-Permanent Population Effects on Per Capita Water Use

Factors affecting water use were not used to adjust the final per capita water use numbers used in projecting water demand for the Districts, but the factors are discussed herein. The factors include those attributable to tourism and part-time residents as described in **Section 3.1.3** and **3.1.4.** For cities with a large non-permanent population, the per capita water use numbers will be largely influenced by this method of calculation. Non-permanent residents can affect indoor and outdoor per capita water use by increasing indoor water use 4 to 6 months out of the year and by maintaining lawns year round. The non-permanent resident impact on total per capita water use was estimated using the population percentages in **Table 3-7** along with the assumptions that non-permanent residents would incur outdoor water use throughout the year (i.e., automated outdoor watering) and indoor water use would occur 5 months out of the year (i.e., non-permanent residents assumed to live in Washington County from November through March). Based on these assumptions, non-permanent residents could affect per capita water use in WCWCD and CICWCD by approximately 40 gpcd and 25 gpcd respectively. The estimated effects from non-permanent residents were determined by factoring 100 percent of the non-permanent population into the residential outdoor per capita water use, and by factoring about 42 percent of equivalent population into the residential indoor per capita water use (i.e., non-permanent residents living in the Lake Powell Pipeline study area for 5 out of 12 months of the year). Most non-permanent residences in Kane County reside beyond the Lake Powell Service area; therefore, the non-permanent resident impact on total per capita water use was not estimated for KCWCD.

Temporary residents are a large part of Washington County's economy for several reasons: St. George is the business center of the area with business conventions drawing a large temporary population to the area, and the influence of college students in St. George described above. Temporary residents also play a large role in Central Iron County and Kane County as a result of tourism in the area. For example, approximately 10,675,000, 421,000, and 310,000 hotel rooms are occupied annually in Washington County, Iron County and Kane County respectively (**Table 3-8**). Average hotel water use in Kane County, 150 gallons per room per day, was assumed to be representative of all three counties (Alpha Engineering 2006). By applying the average hotel water use to the estimated number of hotel rooms used in each county it was estimated that the total commercial per capita water use in WCWCD, CICWCD and KCWCD could be affected by approximately 35 gpcd, 5 gpcd, and 20 gpcd respectively. The estimated effects from hotel occupants on commercial per capita water use were determined by removing the estimated volume of water used from the total commercial water use and recalculating per capita commercial water use with the reduced volume and permanent population data.

3.2.3 Previously Published Per Capita Water Use

Per capita water use from previously published reports is provided in this section in order to provide a comparison between the most current 2005 water use from the DWRe (DWRe 2007a; DWRe 2008a) and the previously published values. The previously published per capita water use values discussed in this section were developed using total water produced (culinary and secondary) and the total permanent population, with the exception of water use from the DWRe water basin plans. Per capita water use from the DWRe water basin plans (DWRe

1993; DWRe 1995) was provided for culinary water use only, and does not include secondary water use. The river basin plans provide the total secondary diversions but do not separate out the M&I secondary diversions from the total secondary diversions. As a result, secondary water use from the DWRe river basin plans is not included in the total M&I water use reported in this section.

Per capita water use data from several sources are provided in **Table 3-16** for each of the three water conservancy districts. Because of the different methods used to calculate per capita water use for different sources of data, the total M&I per capita water use varies for each District from one source to another. For example, per capita water use for WCWCD varies from 254 gallons per day (WCWCD 2007b) to 350 gallons per day (DWRe 1993). In order to address this potential issue, per capita water use is calculated for this report using a consistent method as described in **Section 2.3.**

Table 3-16
Comparison of Per Capita Water Use for Current and Previously Published Sources

Entity	Data Source	Year of Water Use	Total M&I Water Use (gpcd)
WCWCD	DWRe M&I Use Report (DWRe 2008a)	2005	334
	WCWCD Water Conservation Status Report	2005	254 (1)
	WCWCD CFP (Lewis et al 2006)	2004	343 (2)
	DWRe Kanab Creek/Virgin River Basin Plan (DWRe 1993)	1990	350 (2, 3)
CICWCD	DWRe M&I Use Report (DWRe 2007a; DWRe 2008a)	2005	255
	CICWCD CFP (CICWCD 2007)	2005	286
	DWRe Cedar/Beaver River Basin Plans (DWRe 1995)	1992	254 (2, 4)
KCWCD	DWRe M&I Use Report (DWRe 2008a)	2005	427
	Kanab CFP (Alpha Engineering 2006)	2005	410 (5)
	DWRe Kanab Creek/Virgin River Basin Plan (DWRe 1993)	1990	321 (2, 6)

(1) Calculated as total water use divided by permanent population plus an estimate of secondary residence population based on county property tax assessment. Includes culinary and secondary water use.
(2) Includes culinary water use only but not secondary water use.
(3) The Washington County average per capita water use was assumed to be representative of WCWCD per capita use.
(4) Estimated based on total culinary diversions for Iron County within the Cedar/Beaver Basin for the year 1992 (6,360 ac-ft) and 1992 population for Iron County (22,410).
(5) Estimated based on total equivalent residential units for 2005 (1,808), average water demand per ERU (292,850 gallons per year) and population for Kanab City for 2005 (3,558).
(6) The Kane County average per capita water use was assumed to be representative of KCWCD per capita use.

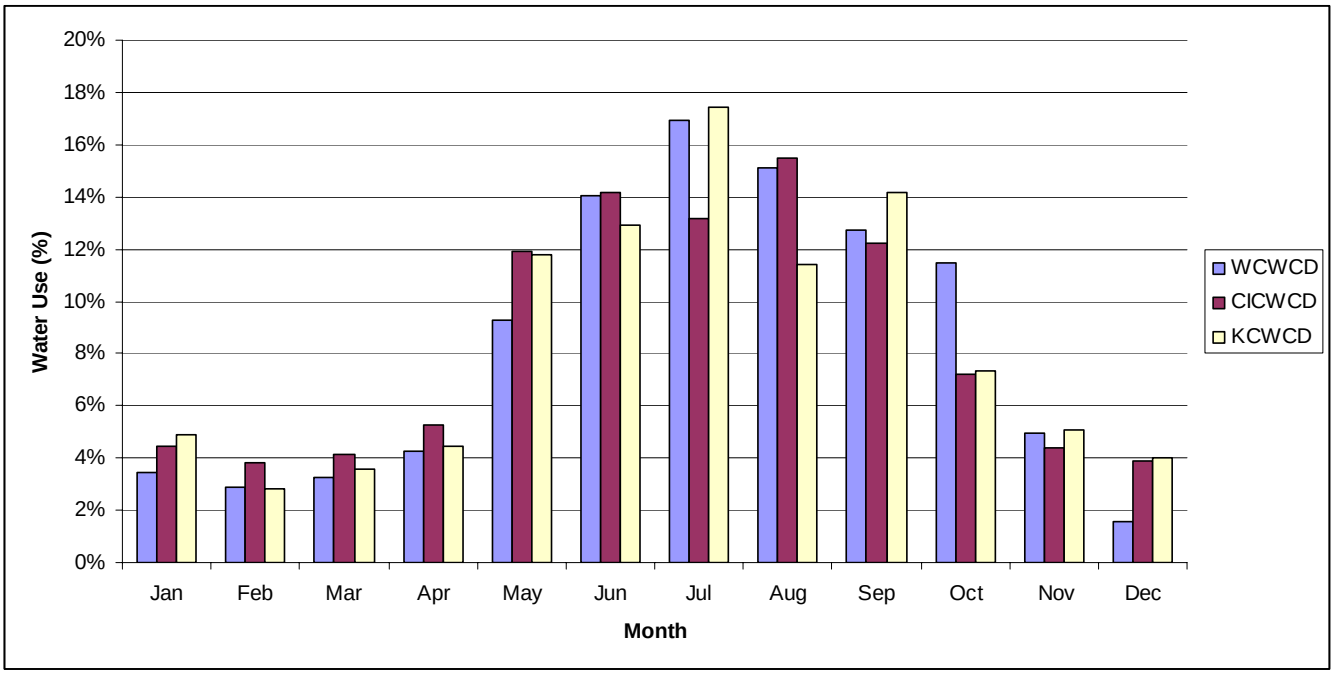
3.2.4 Monthly Water Use

Monthly M&I water use patterns for each District, as a percentage of total annual use, presented in **Figure 3-13**. As is shown in the plot, water use is not constant from month to month. For each District, the largest amount of water is used from April through October, during the irrigation season. Throughout the rest of the year water use is fairly constant. Monthly secondary demands were estimated by distributing total annual secondary water use throughout the irrigation season (May through October) using water use distribution obtained from the cities (St. George 2004; Cedar City 2004; Alpha Engineering 2006). **Figure 3-14** shows the monthly secondary water use pattern, estimated assuming no outdoor water use in January through April, November, and December.

Monthly water use patterns were used to determine monthly variations in secondary water use demands in order to determine the portion of available secondary supply that could be used by the Districts. Monthly secondary demand would need to be great enough to fully utilize potential secondary supply if there is no storage to capture the potential supply for later use. Monthly secondary demand variations were used to estimate the portion of potential secondary supply that could be used without storage capacity. For example, potential secondary supply is generated throughout the year as treated wastewater, but the secondary demand occurs only during the irrigation season. Without storage of potential wintertime secondary supply, wastewater generated during winter

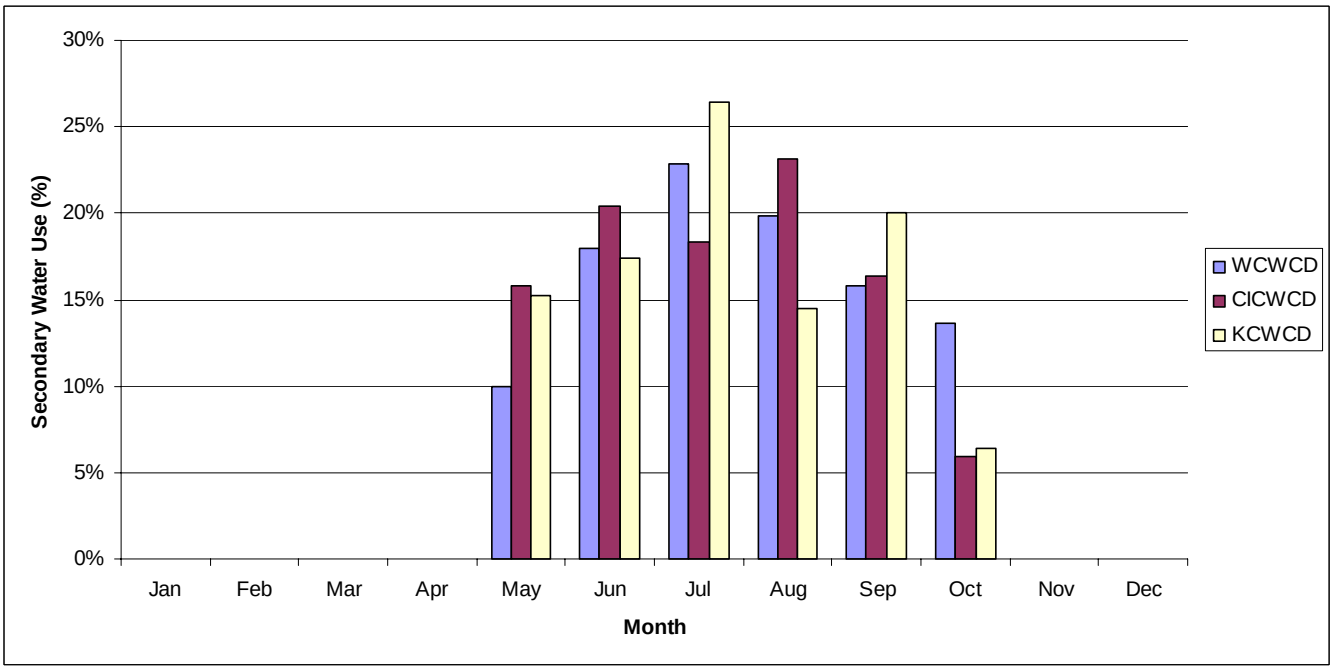
months could not be utilized to meet secondary demands. Monthly water use patterns were used to estimate potential secondary supplies described in **Chapter 4**.

Figure 3-13
Monthly M&I Water Use Pattern (Percentage of Total Annual Use)



Source: St. George Water Services Department, 2004;Cear City, 2006; Alpha Engineering, 2006

Figure 3-14
Monthly M&I Secondary Water Use Pattern (Percentage of Total Annual Use)



3.3 Conservation

Conservation goals, as a percent reduction from 2005 per capita water use, were determined for the period from 2005 to 2060 for each of the three Districts. As described in the Methods section above, the DWRe conservation goal was used to establish the following future conservation goals for each of the Districts:

- **WCWCD -** 16 percent reduction in per capita water use from 2005 to 2060 (based on the DWRe statewide target of 13 percent reduction in per capita water use for 2005 to 2050 and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal), with a linear distribution of the conservation over the period (Klotz 2007).
- **CICWCD -** 16 percent reduction in per capita water use from 2005 to 2060 (based on the DWRe statewide target of 13 percent reduction in per capita water use for 2005 to 2050 and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal), with a linear distribution of the conservation over the period (Klotz 2007).
- **KCWCD -** 31 percent reduction in per capita water use from 2005 to 2060 (based on the DWRe statewide target of 25 percent reduction in per capita water use for 2000 to 2050 and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal), with a linear distribution of the conservation over the period. Kane County has not achieved any conservation over the 2000 to 2005 period as other areas of the state have, and as a result, the DWRe expects entities within KCWCD to achieve 25 percent reduction from 2005 to 2050 (Klotz 2007). This conservation goal was assumed for each of the four subbasins within the KCWCD service area.

Chapter 5 discusses recent changes in per capita water use due to conservation and other factors, and provides information on conservation programs adopted by the Districts and major cities within the study area.

The conservation schedule for each of the three Districts is provided in **Table 3-17**, with conservation reported as percent reduction in per capita water use relative to the 2005 per capita water use described in **Section 2.4**. As described in the Methods section, conservation was assumed to increase linearly from 2005 to 2060.

It is recognized that a large portion of the progress towards the original DWRe conservation goal of a 25 percent reduction in per capita water use relative to 1995 conditions was probably achieved between 1995 and 2005. This is because the conservation measures with relatively high effectiveness in reducing per capita water use occurred initially (e.g., conservation that occurred as a result of educating homeowners on lawn irrigation). The additional 16 percent reduction in per capita water use over the 2005 to 2060 period will occur at a slower rate as additional conservation measures with comparably lower effectiveness or greater challenges in widespread application are implemented.

The conservation data shown in **Table 3-17** was used in Phase 1 of the Lake Powell Pipeline Water Needs Assessment to provide an estimate of the amount of timing of water needed from the LPP. Phase 2 of the study will determine specific measures that could be implemented in the future to achieve additional reductions in water demand. Based on these specific measures, assumed future conservation effectiveness will be estimated, and the resulting water need forecasts will be adjusted.

Table 3-17
Conservation Schedule for Districts

Year	Water Conservation Percentage (Relative to 2005 Per Capita Water Use)		
	WCWCD	CICWCD	KCWCD
2005	0%	0%	0%
2010	1%	1%	3%
2020	4%	4%	8%
2030	7%	7%	14%
2040	10%	10%	19%
2050	13%	13%	25%
2060	16%	16%	31%

3.4 Projected Water Demand

Projected total water demand for each of the three Districts was calculated as the product of the population projections (GOPB 2008) and per capita water use with conservation, plus anticipated large CII demands. Water demand forecasts for total municipal and industrial (M&I) water demand were developed for each District for the period from 2005 to 2060. Although a range of population projections (GOPB 2008 projections plus/minus 10 percent) is described in **Section 3.1**, one projected water demand was developed based on the GOPB 2008 population projections.

The demand forecasts were made using total per capita M&I water use and the projected population as explained in **Section 2.5**. Total per capita water use was reduced by the conservation goals described in the previous section for the 2005 to 2060 study period to calculate a conservation-adjusted total M&I per capita water use. This adjusted per capita water use was multiplied by projected population to determine the projected water demand.

As described previously, total water demand in the Districts is comprised of culinary and secondary water demands. Only the total combined water demand in 2060 was calculated based on the population forecasts and per capita use rates. However, secondary demand was estimated for WCWCD and CICWCD in order to estimate the maximum potential secondary water supplies that could be utilized by these Districts (e.g., secondary demand for future reuse). Secondary demand was not determined for KCWCD because culinary supplies in KCWCD are capable of meeting total demands, and secondary supplies are not expected for KCWCD as a result. Future culinary (indoor and outdoor potable) and secondary (outdoor secondary only) water demands will be affected by different factors. Future culinary water demand will be affected primarily by population increases and water conservation programs, but also by other factors such as typical residential lot size, development density, number of people per household, improvements in plumbing fixture and appliance efficiency, drought, and global warming will have an influence. Future secondary water demand will be affected by some of these same factors, but because of source and quality issues it will be affected by other factors as well. Secondary water has historically been delivered by irrigation ditches, and thus deliveries are limited by the location and capacity of old irrigation systems. Secondary water use in the region does not appear to be supply-limited at the present time, and as urbanization occurs over irrigated lands more secondary water may become available. However, significant increases in secondary water use would have to be accompanied by extensions of existing secondary delivery systems (**Chapter 4** describes the potential for extending these systems in the water conservancy districts.) Because secondary water is untreated, its use in urban areas is limited to landscape watering. Conservation measures targeting reduced outdoor water use (e.g., avoiding water waste, turf area limitations, increased sprinkler system efficiency) would continue to reduce the kinds of demands that could be served with secondary water. On the other hand, encouraging use of secondary water in lieu of more expensive treated water for outdoor landscape watering would tend to increase secondary water use. Predicting the complex interaction of these various factors with certainty at a time over 50 years from now is not possible.

In addition, records for secondary water use are poor, as most of this use is unmetered. While the 2005 secondary water use data published by DWRe is considered reliable due to the thorough validation process that was followed, reliable data for previous years is not available with enough frequency to assess possible trends in use by District or on a per capita basis.

As described above, separate demand forecasts for culinary and secondary water use were developed for WCWCD and CICWCD. The ratio of secondary water use to total water use was assumed to remain constant throughout the study period. Although the mix of culinary versus secondary water use may shift somewhat, future raw water supplies could be applied to either culinary (treated) or secondary (untreated) demands as necessary, based on benefit/cost and other criteria. Determining the exact distribution of future water supplies to these two use categories is not possible at this level of detail in the water needs analysis.

Demand forecasts are provided based on the total population within the participating water conservancy district boundaries. However, customers within the District boundaries may be served by individual cities and/or directly by the water conservancy districts. The potential influence of which customers will be served by the water conservancy districts and which will be served by individual cities will be discussed in **Chapter 4**.

M&I water use forecasts tied only to population projections assume that commercial, industrial and institutional uses will remain the same percentage of overall municipal use. Therefore, these estimates must be adjusted to include any major non-residential water users that are anticipated to move into the area that would significantly increase the percentage of future CII use relative to total water use. Significant future commercial or industrial water users that are considered to be "reasonably foreseeable" at this time are described below for each District service area.

New commercial and industrial water users that are reasonably foreseeable for the WCWCD service area were identified. An example of the projected demands is the Sunrock Pintura Mine and a paper mill that have been proposed for construction in Washington County. Specific water needs for these and other reasonably foreseeable industrial demands have not been developed because the demands were assumed to be included in the projected M&I demands indirectly through the 1.9 to 5.6 percent annual projected growth rate assumed for WCWCD based on GOPB planning projections.

Three potential industrial users or other special customers are currently reasonably foreseeable for the CICWCD service area:

- There are two Paiute Indian bands in the CICWCD service area. Their water needs are undetermined at present. They are working with the State Engineer to get their rights adjudicated. For this study it is assumed that CICWCD may be asked to provide a total of 500 ac-ft per year to these two tribes.
- Western Electrochemical Company (WECCO) is an industrial user in the District service area and is a producer of rocket fuel. The demand associated with WECCO is described in the following paragraph.
- The Iron Bull Mine (Palladon Mines) has plans to re-open mining operations in Iron County. Four phases of mine expansion have been planned, but the timing of the expansion has not been specified. The demand associated with Palladon Mines is described in the following paragraph.

WECCO and Palladon Mines are M&I water users located along the railroad corridor from Palladon to Lund approximately 20 miles northwest and west of Cedar City. Their current water source is ground water from the Enterprise/Beryl ground water basin. However, they have expressed interest with CICWCD for approximately 5,000 ac-ft per year for Palladon and 1,500 ac-ft per year for WECCO because of the potential curtailment of ground water pumping in the near future for the Enterprise/Beryl ground water basin. For purposes of this study, future mine water demand for the Palladon Mines and WECCO have been combined and the demand schedule for these two users has been assumed as shown in
Table 3-18.

Table 3-18
WECCO and Palladon Demand Schedule

Phase and Activity	Total Water Requirement (ac-ft/yr)	Year Online
WECCO Plus Palladon Phase 1 - Mill site construction, cement additive, aggregates	2,000	2015
WECCO Plus Palladon Phase 2 - 2 million metric tons (mt) iron concentrate, mining, additives, aggregate)	3,000	2020
WECCO Plus Palladon Phase 3 - 4 million mt iron concentrate, mining, additives, aggregate	4,500	2030
WECCO Plus Palladon Phase 4 - High smelt, 4 million mt iron concentrate, mining, additives, aggregate	6,500	2045

Notes:
Source: Nolte (2007)

There are several areas within the KCWCD service area that may experience an increase in M&I water demands within the planning horizon as a result of M&I development. Major development is being planned for the State Institutional Trust Land Administration (SITLA) in the eastern portion of Kane County. In addition, proposed uranium mining in the Arizona Strip area could bring in employees that would likely live in the SITLA area. The general residential and commercial growth and increased water demand associated with these changes has been included in the future water use estimates based on the GOPB population forecasts. The Coral Cliffs Golf Course, located in Kanab City, is a 9 hole golf course that will be expanded around 2010. The water demand at the golf course is expected to increase by approximately 250 ac-ft per year (Schollian 2008). Unique industrial water uses associated with these activities is not anticipated. Other possible projects within the KCWCD service area that could require additional water supplies include the Kaiparowits nuclear energy project, a coal mine near the town of Alton, East Zion development near the town of Orderville, and the Aman Resorts near the town of Big Water. The Aman Resorts were included in the GOPB population projections, but the other projects described were considered to be speculative at the time that the GOPB population projections were made and were not included in the Kane County population projections (Donner 2007).

Table 3-19 summarizes the reasonably foreseeable additional commercial, industrial and institutional future water demands added to the population-based projections described in the previous sections.

Table 3-19
Additional Commercial, Industrial and Institutional Demands

Water Conservancy District Service Area	Significant New Commercial/ Industrial User	Average Annual Demand (ac-ft/yr)	Timing
WCWCD	None	0	
CICWCD	Palladon Mine	5,000	Increasing from 2015 to 2045 by 500 ac-ft per year ever 5 years
	WECCO	1,500	Increasing from 2020 to 2040 by 500 ac-ft per year every 10 years
	Paiute Indian Tribes	500	2010 (assumed)
KCWCD	Coral Cliffs Golf Course	250	2010 (assumed)

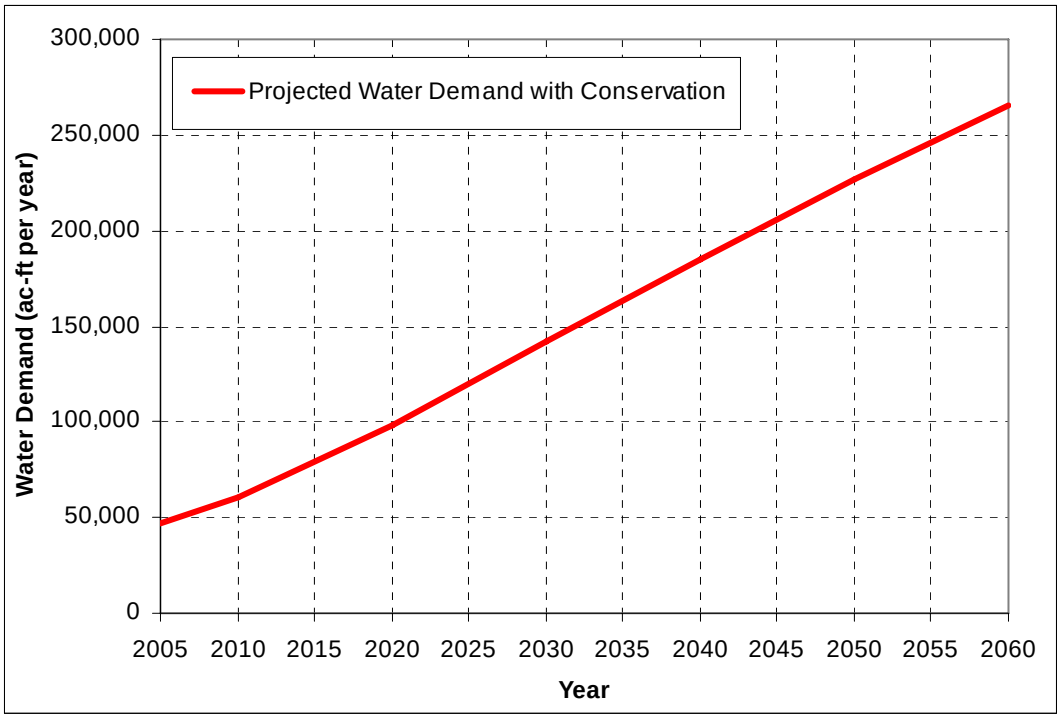
Water demand forecasts for total M&I water use are shown in **Table 3-20** and plotted for WCWCD in **Figure 3-15**. Total M&I water demand for WCWCD in the year 2060 would be approximately 265,780 ac-ft per year.

Table 3-20
WCWCD M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation from 2005	Per Capita Use with Conservation (gpcd)	Base Water Use Forecast Demand (ac-ft/yr)	Additional CII Demand (ac-ft/yr)[1]	Total Projected Water Demand (ac-ft/yr)
2005	127,090	328.3	0%	328.3	46,740	0	46,740
2010	168,080	328.3	1%	323.6	60,920	0	60,920
2020	279,860	328.3	4%	314.1	98,460	0	98,460
2030	415,510	328.3	7%	304.6	141,770	0	141,770
2040	559,670	328.3	10%	295.1	185,010	0	185,010
2050	709,670	328.3	13%	285.6	227,050	0	227,050
2060	860,380	328.3	16%	275.8	265,780	0	265,780

[1]Reasonably foreseeable demands not included in the base water use forecasts which are solely tied to population projections.

Figure 3-15
WCWCD Total M&I Water Demand Forecast



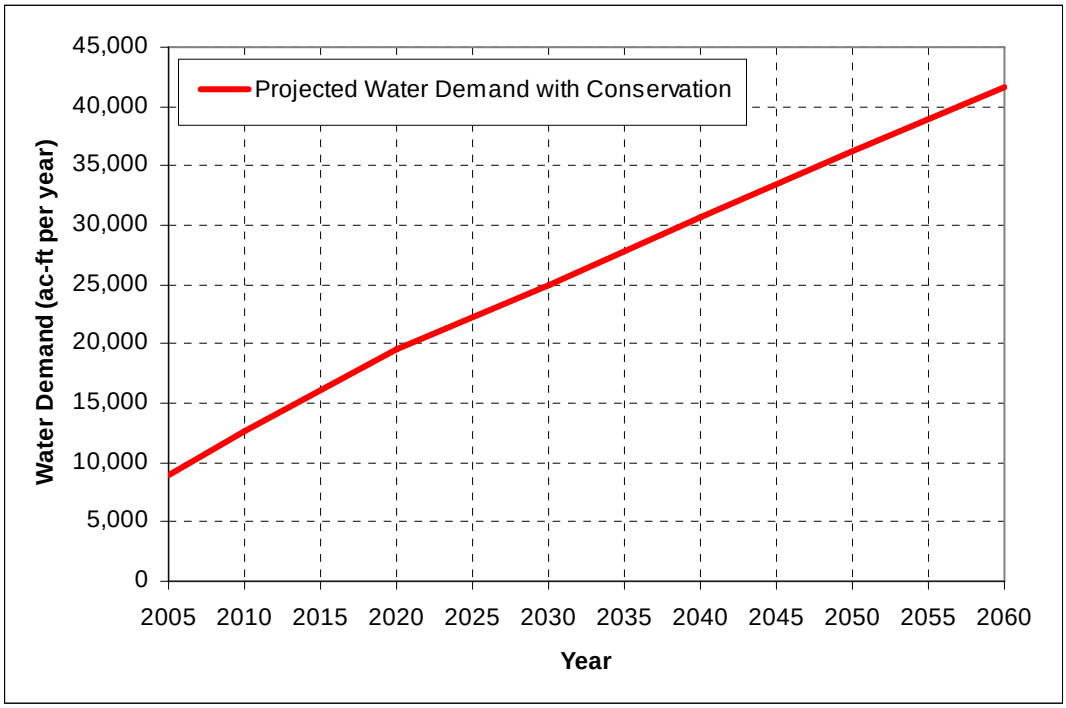
Water demand forecasts for total M&I water use are shown in **Table 3-21** and plotted for CICWCD in **Figure 3-16**. Total M&I water demand for CICWCD in the year 2060 would be approximately 41,600 ac-ft per year.

Table 3-21
CICWCD M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation from 2005	Per Capita Use with Conservation (gpcd)	Base Water Use Forecast Demand (ac-ft/yr)	Additional CII Demand (ac-ft/yr)[1]	Total Projected Water Demand (ac-ft/yr)
2005	32,860	243.5	0%	243.5	8,970	0	8,970
2010	45.360	243.5	1%	240.0	12,200	500	12,700
2020	61.240	243.5	4%	233.0	15,980	3,500	19,480
2030	78,560	243.5	7%	226.0	19,890	5,000	24,890
2040	98,830	243.5	10%	218.9	24,240	6,500	30,740
2050	123,020	243.5	13%	211.9	29,200	7,000	36,200
2060	150,940	243.5	16%	204.6	34,600	7,000	41,600

[1]Reasonably foreseeable demands not included in the base water use forecasts which are solely tied to population projections. This includes demands for Paiute Indian bands, WECCO, and Palladon Mines.

Figure 3-16
CICWCD Total M&I Water Demand Forecast



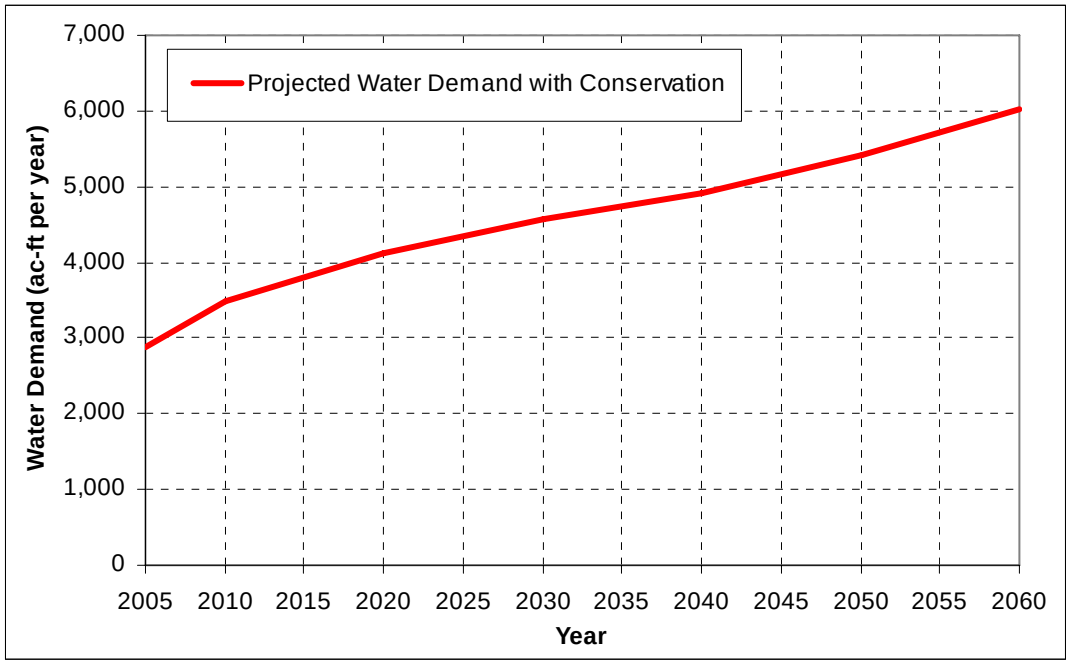
Water demand forecasts for total M&I water use are plotted for KCWCD in **Figure 3-17.** Total M&I water demand for KCWCD in the year 2060 would be approximately 6,030 ac-ft per year.

Table 3-22
KCWCD M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation from 2005	Per Capita Use with Conservation (gpcd)	Base Water Use Forecast Demand (ac-ft/yr)	Additional CII Demand (ac-ft/yr)[(1)]	Total Projected Water Demand (ac-ft/yr)
2005	5,950	430.3	0%	430.3	2,870	0	2,870
2010	6,890	430.3	3%	418.4	3,230	250	3,480
2020	8,750	430.3	8%	394.5	3,860	250	4,110
2030	10,390	430.3	14%	370.6	4,314	250	4,564
2040	12,030	430.3	19%	346.6	4,670	250	4,920
2050	14,270	430.3	25%	322.7	5,160	250	5,410
2060	17,280	430.3	31%	298.9	5,780	250	6,030

[1]Reasonably foreseeable demands not included in the base water use forecasts which are solely tied to population projections. Water demand is attributable to the expansion of the Coral Cliffs Golf Course.

Figure 3-17
KCWCD Total M&I Water Demand Forecast



Water demand forecasts for total M&I water use are plotted for the four subbasins in the KCWCD service area in **Figure 3-18** through **Figure 3-21**. The approximate total M&I water demands for each of the subbasins in the year 2060 would be as:

- East Fork Virgin River subbasin - 1,010 ac-ft per year
- Kanab Creek subbasin – 4,250 ac-ft per year
- Johnson Canyon subbasin – 190 ac-ft per year
- Wahweap Creek subbasin – 590 ac-ft per year

Figure 3-18
East Fork Virgin River Total M&I Water Demand Forecast

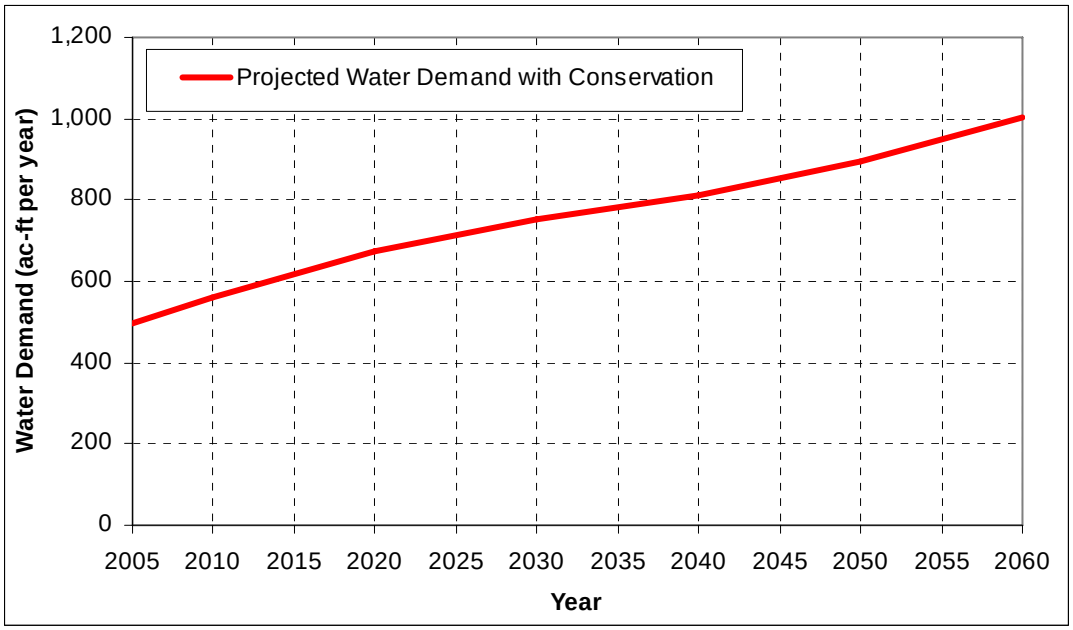


Figure 3-19
Kanab Creek Total M&I Water Demand Forecast

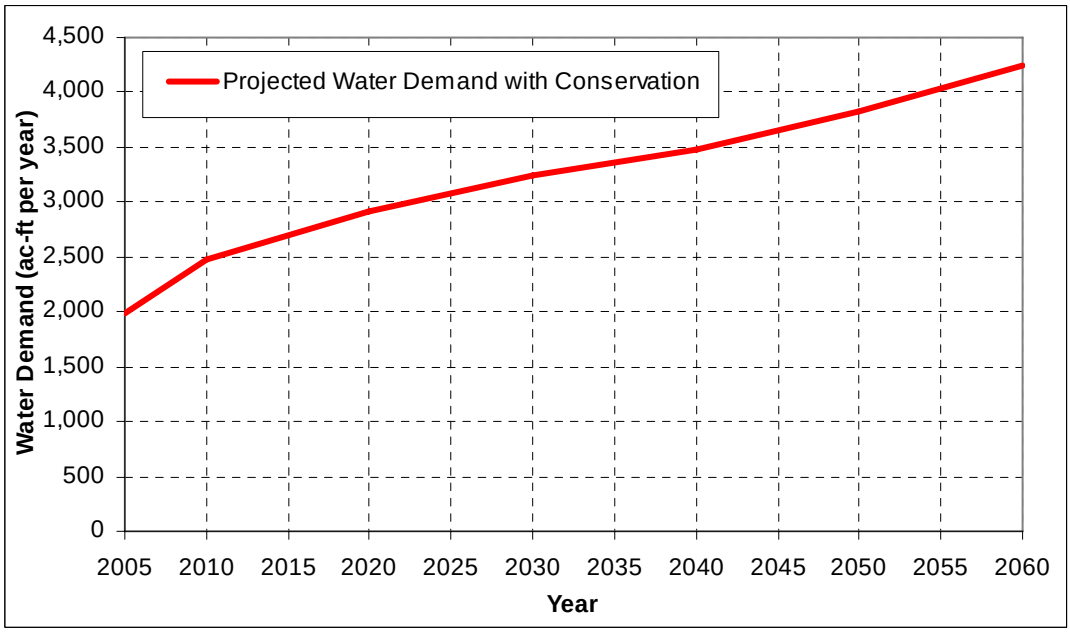


Figure 3-20
Johnson Canyon Total M&I Water Demand Forecast

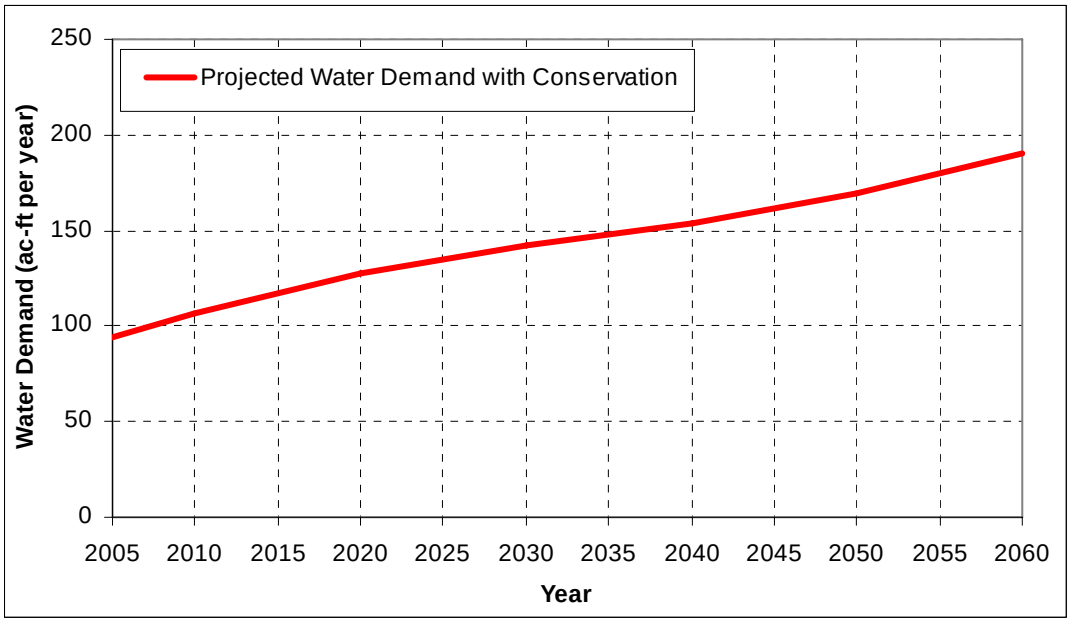
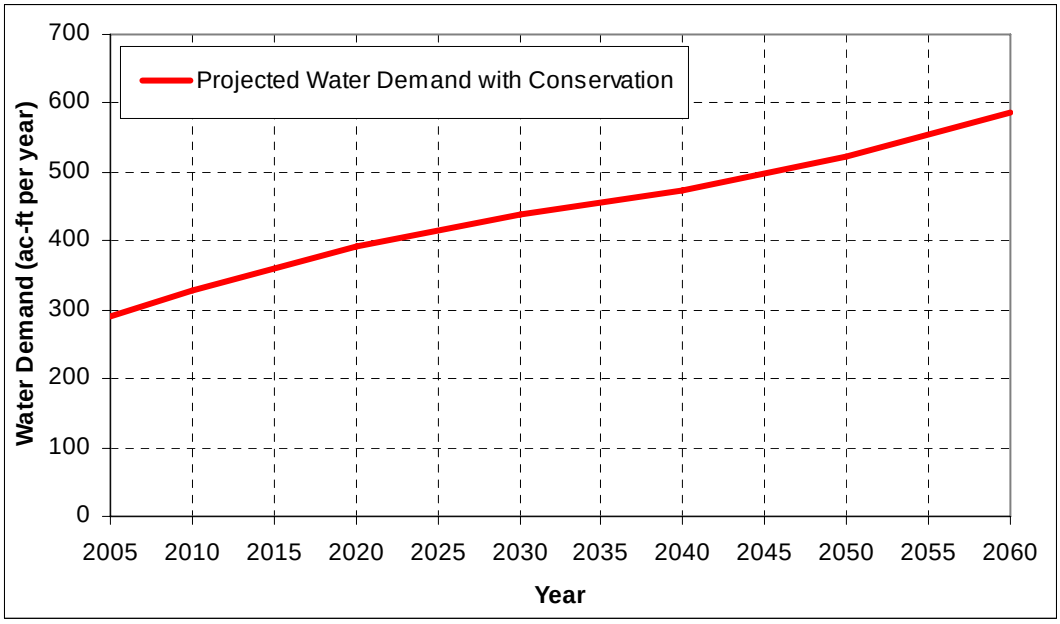


Figure 3-21
Wahweap Creek Total M&I Water Demand Forecast



Chapter 4 - Water Supply Conditions

This chapter describes the existing and future planned and potential water supplies available to the water users within the service areas of the potential LPP project. Existing supplies consist of water projects currently being used to meet existing water needs. Unless noted otherwise, it is assumed that these supplies will continue to be available on a sustainable basis in the future. Future planned projects are those projects that are currently planned or in the process of being implemented. Potential projects are those that are not currently planned for implementation in the short term, but could be part of the long term water supply portfolio of the Districts. All future projects have been contemplated in past studies by the Districts or by the Utah Division of Water Resources. The LPP project is included in this discussion because it is considered to be a key potential component of future water supply plans for WCWCD, CICWCD and KCWCD. The LPP project will also be considered in the discussion of approaches for meeting future water demands in the study area included in **Chapter 6**.

Estimates of existing and future water supply yield were made using the best estimate of reliable supply, which represents the approximate annual volume of water that is reliably available to meet peak demands. Estimates of reliable potable supply and secondary supply reported in the DWRe M&I Water Supply and Use Reports (DWRe 2007a; DWRe 2008a; DWRe 2007b) were generally used to represent the reliable yield of existing water supply systems. The Division of Water Resources' M&I Water Supply and Use Reports for 2005 (DWRe 2007a; DWRe 2008a) summarize available water supplies for all public community systems in Washington County. DWRe identifies two measures of available annual water supplies: maximum potable water supply and reliable potable water supply. Maximum potable water supply is defined as the yearly volume of water that could be delivered at the maximum daily flow rate of the system, as limited by water rights or facility capacities. The maximum daily flow rate for water system design is normally based on the peak daily demand. Because demand varies throughout the year, and most culinary water system storage tanks do not have long-term carryover storage, the maximum potable water supply value overestimates the usable yield of the water supply system. Therefore, reliable potable water supply refers to the portion of the maximum potable water supply that can actually be used to meet annual water demands. The reliable potable water supply is calculated by DWRe by adding together the maximum water supply capacities of surface sources, one-half of the maximum yield of wells or their pump capacities, and a percentage (50 - 100 percent) of the annual flow of spring sources depending on their seasonal fluctuations. The DWRe reliable water supply estimate is used for evaluating existing water supply sources in this assessment. Reliable yield for future projects was estimated using information from the water conservancy districts.

Both culinary and secondary water supplies for M&I use are discussed in this chapter. Water quality concerns were considered when determining which supplies would be available for secondary uses only and which could be used for culinary and secondary uses. One of the major water quality influences regarding potential uses of water supplies is total dissolved solids (TDS). Water supplies considered useful to meet culinary demands were assumed to meet the drinking water secondary maximum contaminant level (MCL) of 500 mg/L for taste and odor. The TDS secondary MCL of 500 mg/L is a recommendation made by the U.S. Environmental Protection Agency to maintain palatable taste and odor for drinking water, but the MCL is not an enforceable regulation. There is no similar MCL for TDS for water that will be used for secondary purposes. However, an upper limit of 1,000 mg/L TDS was assumed for M&I secondary water use in this report, which is the maximum TDS level for the least salt tolerant residential ornamental landscape.

Agricultural water supplies are not discussed in detail. Because the LPP project will supply municipal and industrial uses only, agricultural water supplies are considered only in the context of being potential sources of future M&I supplies through transfers and conversions. Irrigated acreage and agricultural water use are not expected to grow in the future based on the Cedar Beaver Basin Plan and Kanab Creek Basin Plans (DWRe 1993, 1995).

4.1 Washington County Water Conservancy District

This section describes existing and planned future supplies to meet the water demands in the Washington County Water Conservancy District service area.

4.1.1 WCWCD Water Supply Overview

Water providers in Washington County derive their water supplies from a combination of ground water (springs and wells) and surface water (direct diversions and reservoirs). From its earliest development, Washington County water users have tapped both ground water and surface water supplies. The Navajo Sandstone Aquifer and shallow alluvial aquifers provide ground water resources. Surface water sources consist of the Virgin River and its tributaries. In 2005, approximately 45 percent of the developed potable water supplies for public community water systems in Washington County were derived from ground water sources and 55 percent were from surface water sources (DWRe 2008a). Ground water supplies are of high quality, and can be used directly for potable uses after disinfection. Surface water supplies are used directly to meet secondary water demands, or are treated to meet culinary demands.

The individual cities and towns in Washington County developed their own independent raw water collection and treatment systems over the years. The WCWCD was organized in 1962 to sponsor the Dixie Project, a proposed U.S. Bureau of Reclamation dam on the Virgin River. Although the project was abandoned, the water rights were transferred to the State Board of Water Resources in 1973 by the Bureau of Reclamation. The Board of Water Resources transferred a portion of the water rights back to the WCWCD to store water in the Quail Creek and Sand Hollow reservoirs. Throughout the past four decades WCWCD has assumed a greater regional role in water development, to the point where WCWCD is now responsible for developing regional water supplies to meet all future growth within the communities in its service area.

Ground water sources within the WCWCD area are considered to be fully appropriated and closed to further appropriations at this time (DWRi 2008b). New diversions and uses must be accomplished by change applications filed on previously approved but undeveloped water rights. Changes between surface and underground sources are reviewed to indicate hydrologic connection, such that there is no interference with existing water rights. Exceptions are the Canaan Gap drainage east of the Hurricane Cliffs and the Beaver Dam Wash drainage, which are both open to small underground water appropriations for domestic filings (one family, ¼ acre of irrigation and up to 10 head of livestock).

4.1.2 WCWCD Regional Water Supply Agreement

WCWCD has executed a Regional Water Supply Agreement (RWSA) with five municipalities in Washington County, beginning with the City of St. George, effective April 23, 2006, and followed in 2006 by Washington, Ivins, Hurricane and LaVerkin. Toquerville has approved its execution and other municipalities are likely to follow. The RWSA is the vehicle by which WCWCD will provide water throughout the county in the future. As part of the agreement the municipal customers retain their existing water resources, rights and facilities, except to the extent they choose to integrate them with WCWCD's water supplies provided through the RWSA, which would require additional contracts with the District.

The RWSA operates under a new approach in contrast to the typical take or pay contracts traditionally relied upon by the District. Capital costs for water development are paid for largely by new growth in the form of impact fees. Users will pay a portion of capital costs through a surcharge. Water will be sold at a rate that covers operation, maintenance, repair and replacement. Thus, customers will pay for only the water they receive, eliminating disadvantages to conservation caused by contracts that require blocks of water to be paid for whether or not they are used.

The impact fees are structured to provide for a baseline amount of water, set as 0.89 acre feet, as required by the Utah Division of Water Quality, for one equivalent residential unit, which applies to lots up to 10,000 square feet in size. Larger lots must pay additional fees for all areas in excess of 10,000 square feet, or an agreement between WCWCD and the property owner is reached that will reliably limit water use and recover capital cost for water use greater than that equivalent for a 10,000 square foot lot. Thus, the impact fee structure also discourages excessive outdoor water use.

The District's Capital Facilities Plan (CFP), which is approved by the municipal customers, determines the components of the system necessary to provide adequate water to meet the current and future needs of the customers. The CFP includes the Lake Powell Pipeline as a future system component.

In addition to the conservation benefits of paying only for water that is used and the impact fee structure, the RWSA imposes other conservation and water quality requirements on its Municipal Customers, as follows:

> The Municipal Customers shall, at a minimum, take the following actions to conserve and protect water: (i) prepare and maintain a current water conservation plan which shall meet the requirements of, and any standards set forth by, the [Administration Advisory Committee]; (ii) enact a water conservation rate structure for water use through its Municipal System, time of day water use ordinance and appropriate landscape ordinances; (iii) comply with the Determination of Recommended Septic System Densities for Ground water Protection report issued on July 20, 1998, by Hansen Allen & Luce; (iv) evaluate and promote the maximum use of secondary irrigation systems within their jurisdictions; and, (v) if requested, shall participate in a planning process to ensure maximum use of the St. George Water Reuse Project water. Municipal Customers shall use secondary water on all municipal facilities for which such use is feasible. With the concurrence of the AAC, the Board may impose penalties and offer incentives to encourage actions to conserve and protect water. [Section 18.1]

Because most of the readily available water in the county has been developed and most of the county is closed by the State Engineer to the acquisition of new water rights, the municipalities and the development community are generally relying upon the District for future water supplies, most of which will be provided through large water projects that will require a regional funding base. While the RWSA has no requirement for new development to bring water rights to the District as a condition of receiving water, it is possible water rights could be traded for impact fees where appropriate.

4.1.3 WCWCD Existing Supplies

Existing water supplies developed by WCWCD have been described in several previous documents (WCWCD 2004; WCWCD 2006; WCWCD 2007b; WCWCD 2007c; Boyle 1998). Reliable supply for existing supplies within Washington County, as reported in the DWRe municipal and industrial water supply and use report for the Virgin River Basin, was established by the surface water providers within Washington County using average annual yield with up to 25 percent shortage in surface water supplies in drought years (WCWCD 2008a). The yield estimates used for Washington County are considered reliable because ground water supplies and agricultural water curtailment for M&I use can be used to supplement surface water supplies to fully meet demands during extreme drought years. Additionally, aspects of "operational flexibility" of the WCWCD supply system are continually being maximized by the District in order to avert any water supply shortages.

Figure 4-1 shows the general location of existing water supply projects described below.

4.1.3.1 Current Storage Facilities

Quail Creek Reservoir. Quail Creek Reservoir is a 40,000 ac-ft storage facility located about 15 miles northeast of St. George. Quail Creek Reservoir has a reliable surface water yield of about 22,000 ac-ft per year of raw water for culinary uses to the communities of St. George, Hurricane, La Verkin and Washington (WCWCD 2006). Water for storage in Quail Creek Reservoir originates in the Virgin River at the Quail Creek Diversion Dam, and is delivered to the reservoir in a pipeline. WCWCD operates a water treatment plant just below the reservoir.

Sand Hollow Reservoir. Sand Hollow Reservoir is a 50,000 ac-ft storage facility located about 5 miles southwest of Hurricane. Water to fill the reservoir is transported from the Virgin River in the same pipeline serving Quail Creek Reservoir. The reservoir has an active pool of about 30,000 ac-ft and a drought pool of 20,000 ac-ft that would provide water supplies in an extreme drought. However, the 20,000 ac-ft drought pool is considered in the reliable yield information for Sand Hollow Reservoir used in this report, and would not provide additional yield beyond the reliable yield. In addition, the reservoir serves as a ground water recharge facility for the Navajo Sandstone Aquifer. Quail Creek and Sand Hollow reservoirs are used by the WCWCD as a combined system, and together the combined reliable surface water yield of the two reservoirs is approximately 29,500 ac-ft per year. The existing reliable yield of surface water from Sand Hollow Reservoir was estimated to be 7,500 ac-ft per year (the difference between the total reliable yield of the Quail Creek/Sand Hollow reservoir system, 29,500 ac-ft per year, and Quail Creek Reservoir, 22,000 ac-ft per year).

Kolob Reservoir. Kolob Reservoir is a 5,585 ac-ft storage reservoir located about 36 miles northeast of St. George. The reservoir was built in 1957 by the Kolob Reservoir and Storage Association, Inc. and the Cedar City Corporation. When construction began on Quail Creek Reservoir, WCWCD entered into an agreement to acquire the water rights for Kolob Reservoir. It is now owned, managed and maintained by WCWCD. Kolob Reservoir stores local surface water runoff and has reliable yield of approximately 2,000 ac-ft per year (DWRe 2008a).

Gunlock Reservoir. Gunlock Reservoir is a 10,884 ac-ft impoundment on the Santa Clara River built in 1970. The reservoir is located about 20 miles northwest of St. George. The reservoir is managed to store water for agricultural and domestic secondary uses, M&I secondary uses, and instream flow requirements. Gunlock Reservoir is not part of the existing or proposed M&I system for WCWCD. However, a portion of the water stored in Gunlock Reservoir is diverted through the Gunlock to Santa Clara Pipeline and is used to meet secondary water demands. The Gunlock to Santa Clara Pipeline is described in **Section 4.1.3.4**, including the estimated annual yield of the secondary water delivered by the pipeline from Gunlock Reservoir.

Meadow Hollow Reservoir. Meadow Hollow Reservoir is a 600 ac-ft reservoir with approximately 200 ac-ft reliable annual yield (Thompson 2007). Meadow Hollow Dam is located on Spring and LaVerkin Creeks in Iron County, Utah and is owned by WCWCD. The reservoir was built in 1948 and is used for irrigation purposes. However, yield from the reservoir was considered to be reliable potable supply as indicated in the Kanab Creek and Virgin River municipal use and supply report (DWRe 2008a).

Ash Creek Reservoir. Ash Creek Reservoir is located 21 miles south of Cedar City and is west of Interstate 15. The Ash Creek drainage basin feeds to the Ash Creek Reservoir. The reservoir receives snowmelt and peak flow runoff from the area upstream of the reservoir. The reservoir seldom fills and the storage capacity has been restricted significantly because of dam safety concerns by the Utah State Engineer. The Ash Creek Pipeline is currently being built to convey water from Ash Creek Reservoir to the proposed Anderson Junction Reservoir. Water from the pipeline would be used as secondary water in Toquerville, La Verkin, and Hurricane. Yield information for the Ash Creek Reservoir is discussed as future supply because yield from the reservoir will be delivered through the Ash Creek Pipeline, which will be completed in the future as described in **Section 4.1.5**.

4.1.3.2 Current Culinary Water Systems

Sand Hollow Wells. The Sand Hollow well field includes 13 wells that draw water recharged to the Navajo Sandstone Aquifer by Sand Hollow Reservoir. Reliable yield from Sand Hollow ground water wells is approximately 8,000 ac-ft per year, which includes 7,000 ac-ft per year associated with recharge from Sand Hollow Reservoir and approximately 1,000 ac-ft per year associated with local ground water rights. Water is pumped to two storage tanks with a total of 3 million gallons of storage capacity (1 million gallon tank and 2 million gallon tank) and a chlorination treatment plant. Treated water is delivered to the Regional Pipeline described below. The existing system has been designed to be expanded by adding more wells. However, any additional wells would be used to add flexibility in pumping the total potential yield of 8,000 ac-ft per year from Sand Hollow ground water wells. As a result, there would be no new yield from additional Sand Hollow wells, and the entire Sand Hollow ground water yield was counted as existing supplies.

There is additional storage capacity in the Navajo Sandstone Aquifer that the WCWCD uses to store water recharged to the aquifer using Sand Hollow Reservoir. This water is in excess of the reliable annual yield for the Sand Hollow Wells described in the previous paragraph and the reliable surface supply for Sand Hollow Reservoir described in **Section 4.1.3.1**. WCWCD estimates that there is approximately 160,000 ac-ft of storage capacity available in the Navajo Sandstone Aquifer, which is not included in any of the WCWCD reliable annual yield estimates described in this report. This storage capacity could be used to store excess Sand Hollow water in wet years for subsequent use during dry periods to compensate for any deficit between reliable annual supply and total M&I demand. Currently the District estimates that there is approximately 50,000 ac-ft of stored ground water in the aquifer that could be used during drought periods to meet demands (WCWCD 2008a).

Anderson Junction (Cottam) Well and Pipeline Water System. The Anderson Junction System is a culinary water system located about 20 miles northeast of St. George. The system consists of four wells, with a total reliable yield of approximately 2,000 ac-ft per year. Wholesale water is delivered via pipeline to the cities of Toquerville and La Verkin and the Town of Virgin (none of these three communities has reached its full allotment of water from this system at this time), and can be delivered to Washington and Hurricane cities.

Sullivan Well Field. The Sullivan Well field is located about two miles southeast of Leeds and a mile north of Sandstone Mountain. The Sullivan wells do not currently tie into WCWCD's supply system, but will tie into the Anderson Junction Pipeline in the future. There are three wells total, and the total reliable yield of the wells is estimated to be 750 ac-ft per year (less than originally expected following recent pump tests) (WCWCD 2008a).

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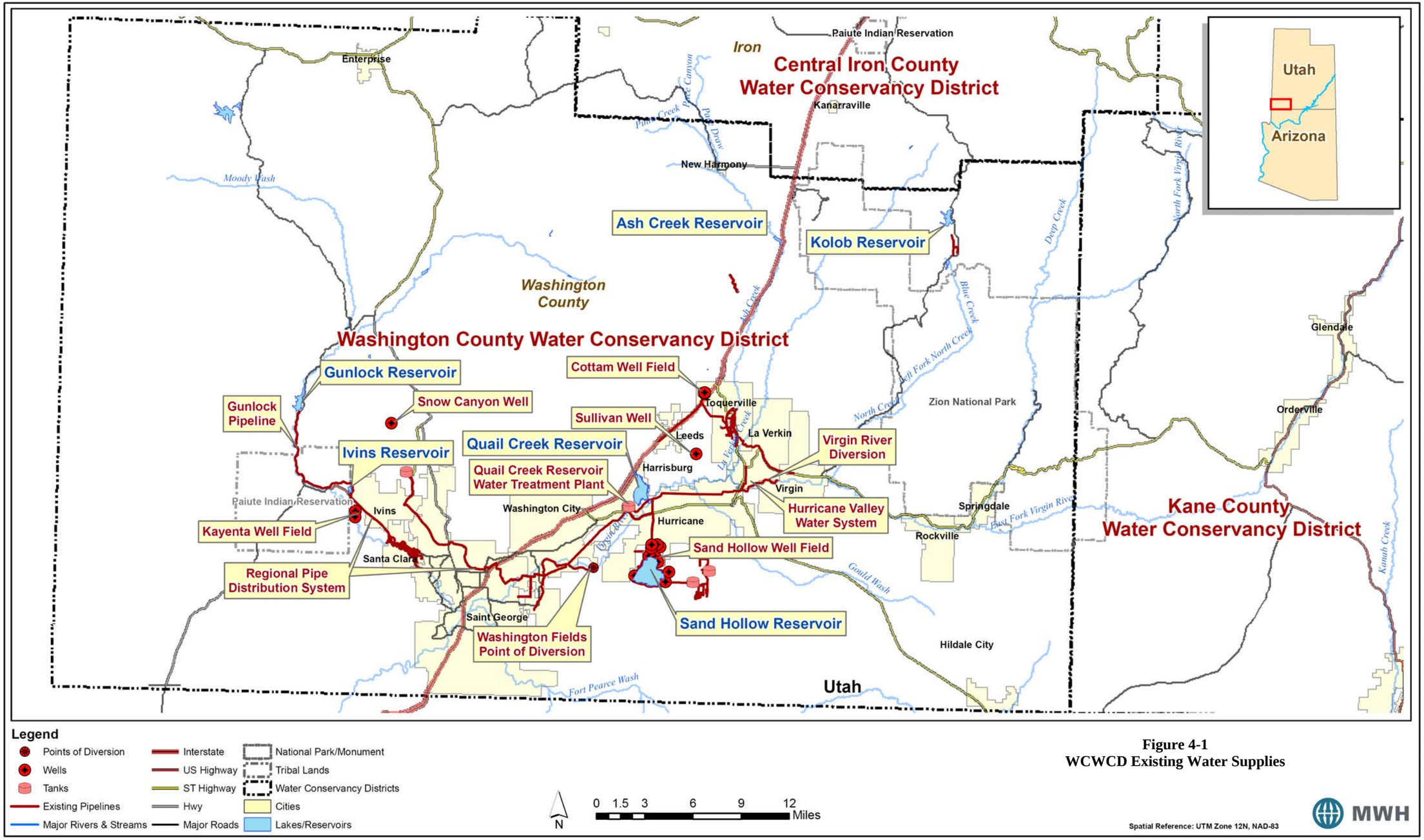

Figure 4-1
WCWCD Existing Water Supplies

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Kayenta (Ence Wells) Water System. The Kayenta Wells (also known as the Ence Wells) are located within the incorporated boundary of Ivins. They serve Ivins and the residential community of Kayenta. The Kayenta Water System consists of two wells with a total pumping capacity of 799 gpm. The reliable yield for the Kayenta/Ence wells is approximately 1,000 ac-ft per year (DWRe 2008a).

Regional Pipeline Transmission System. The Regional Pipeline transmission system was constructed by WCWCD in cooperation with St. George, Santa Clara, Washington and Ivins. The system (pipeline, 500,000 gallon tank and two pump stations) conveys water from the Sand Hollow/Quail Creek System to the western portion of Washington County. It begins at the Quail Creek Water Treatment Plant and runs approximately 20 miles west to the Snow Canyon water tank in the Ivins area. In addition to providing water to meet existing and future water demands, the distribution system offers the ability to meet new federal arsenic standards by providing a source of water to be blended with Snow Canyon Well water.

Hurricane Valley Retail Water System. The Hurricane Valley Retail Water System is located in the vicinity of the Hurricane Bench area, two miles northeast of Hurricane. The project was purchased by WCWCD from a private water company in 1987. It consists of two wells and water tanks, and serves the residential communities of Sky Ranch and Cliffdwellers. WCWCD upgraded the system, and currently serves 190 connections with retail water service; the system has a maximum capacity of 1,095 connections. Reliable supply for the Hurricane Valley Water System is approximately 60 ac-ft per year (DWRe 2008a).

4.1.3.3 Summary of Existing WCWCD Culinary Supplies

Table 4-1 summarizes the reliable yield for existing WCWCD projects, broken down into the amount of yield that can be utilized for culinary and secondary purposes. All culinary supplies can also be used to meet secondary water demands.

Table 4-1
WCWCD Existing Projects and Water Uses

Project	Reliable Culinary Quality Water Yield (ac-ft/yr) [1]	Reliable Secondary Quality Water Yield (ac-ft/yr) [1]
Quail Creek and Sand Hollow Reservoirs	29,500	0
Sand Hollow Ground Water	8,000	0
Kolob Reservoir	2,000	0
Meadow Hollow Reservoir	200	0
Cottam Well Field	2,000	0
Sullivan Well Field	750	0
Kayenta (Ence Wells) Water System	1,000	0
Gunlock to Santa Clara Pipeline	0	2,500[2]
Toquerville Secondary Water System	0	160
Total	**43,450**	**2,660**

Notes:
[1] Source of data: (WCWCD 2006; WCWCD 2007c; DWRe 2008a), except for Gunlock to Santa Clara Pipeline reliable secondary yield.
[2] Source of data: WCWCD (2008)

4.1.3.4 Existing WCWCD Secondary Water Systems

Toquerville Secondary Water System. WCWCD, Toquerville City and the Toquerville Irrigation Company created the Toquerville Secondary Water System. The agreement between the entities allowed WCWCD to purchase irrigation company water rights and convert their open ditch irrigation system to a pressurized system that distributes outdoor irrigation water to residents of the Toquerville area on a retail basis. The system includes water rights totaling 2,063 ac-ft per year. In 2004 the system served 283 connections; a maximum of 1,000 connections are possible on the system. The Toquerville Secondary Water System reported a total secondary water use of 163 ac-ft per year in 2005 (DWRe 2008a). The 2005 secondary use was assumed to be equal to the reliable secondary supply of the system because there were no other estimates of reliable supply available.

Gunlock to Santa Clara Pipeline. WCWCD connected Gunlock Reservoir to Ivins Reservoir with a pipeline. The project replaced four previous diversions and converted the old flood irrigation system to a pressurized system. The Santa Clara pipeline provides secondary M&I water to several WCWCD entities (e.g., Green Springs Golf Course, St. George City Parks, Ivins City, and about 100 residences). The Santa Clara system is a “flashy” system that is highly dependent on annual runoff from the Santa Clara River. It is difficult to accurately estimate reliable supply from such a “flashy” system, but WCWCD estimates reliable yield of the system to be approximately 2,500 ac-ft per year (secondary water supply) (WCWCD 2008a).

4.1.4 Total Washington County Municipal and Industrial Water Supplies

4.1.4.1 Potable Water Supplies

The total reliable potable water supply for all public community systems in Washington County is about 72,560 acre feet per year (DWRe 2008a). **Table 4-2** shows the reliable potable water supplies developed by each public community water system in Washington County. The annual potable water use in Washington County in 2005 was 39,291 ac-ft, representing about 54 percent of the reliable potable water supply.

Table 4-2
Reliable Potable Water Supplies - Washington County

Water Supplier	Reliable Potable Water Supply (ac-ft/yr)			
	Springs	Wells	Surface	Total [1]
Angell Springs SSD	80.7	16.8	0.0	97.5
Casa de Oro [2]	0.0	5.8	0.0	5.8
Central Culinary Water [3]	6.1	3.1	0.0	9.2
Dammeron Valley Water Works [2]	0.0	426.1	0.0	426.1
Diamond Ranch Academy	0.0	13.7	0.0	13.7
Diamond Valley Acres Water Company	0.0	163.0	0.0	163.0
Dixie Deer SSD	0.0	109.6	0.0	109.6
Gunlock SSD	42.5	31.9	0.0	74.4
Harmony Farms Water Users	0.0	71.2	0.0	71.2
Harmony Heights	0.0	42.1	0.0	42.1
Hildale/Colorado City	42.4	1,362.0	0.0	1,404.4
Homespun Village Water Company	0.0	11.2	0.0	11.2
Hurricane City Water System [3]	1,613.8	1,854.0	0.0	3,467.8
Ivins City [3]	48.4	177.4	0.0	225.8
Kayenta Water Users Association [3]	0.0	0.0	0.0	0.0
La Verkin City [3]	661.3	0.0	0.0	661.3
Leeds Domestic Water Users Association	79.6	338.8	0.0	418.4
Little Plains	0.0	132.5	0.0	132.5
Mountain Springs Water Company	0.0	124.0	0.0	124.0
New Harmony Town Water	27.9	724.0	0.0	751.9
Pine Valley Irrigation Company	90.5	23.5	0.0	114.0
Pine Valley Mt. Farms Water Company [2]	0.0	114.6	0.0	114.6
Rockville Pipeline Company	31.0	41.2	0.0	72.2
Santa Clara Municipal Water System [4]	96.8	1,273.9	0.0	1,370.7
Silver Reef SSD [5]	18.9	0.0	0.0	18.9
Springdale Culinary Water	204.8	129.0	498.0	831.8
St. George, City of [3,6]	1,200	13,442.5	0.0	14,642.5
Toquerville Water Dept. [3]	362.9	0.0	0.0	362.9
Veyo Culinary Water Association	239.5	40.8	0.0	280.3
Virgin Water Department [3]	0.0	0.0	0.0	0.0
Washington County WCD [7]	0.0	3,750.0	39,700	43,450
WCWCD – Hurricane Valley Retail	0.0	60.0	0.0	60.0
Washington Municipal Water System [3]	0.0	2,190.5	0.0	2,190.5
Winchester Hills Water Company [2]	0.0	267.0	0.0	267.0
Zion National Park	540.4	33.0	0.0	573.4
Totals	**5,387.5**	**26,973.2**	**40,198.0**	**72,558.7**

Notes:
[1] Wells are limited to 50% of their "maximum" capacity for reliable supply when well/pump capacity is the limiting factor. Springs and surface water supplies are equal to their respective "maximum" capacities.
[2] Reliable water supply is considered to be equal to calculated water use.
[3] Has contract with WCWCD for additional water supply
[4] Reliable well supply is calculated based on Santa Clara's 24.7% ownership of wells in Snow Canyon Compact yield. However, Santa Clara can purchase more than their 24.7% share when needed.
[5] Water supplied by Leeds Domestic Water Users Association
[6] Reliable well supply is calculated based on St. George's 63.3% ownership of wells in Snow Canyon Compact yield. However, St. George has more well water rights available for additional supply, if needed.
[7] Surface supplies: Quail Creek and Sand Hollow reservoirs collectively yield 29,500 ac-ft/yr. Kolob Reservoir yields 2,000 ac-ft/yr. Meadow Hollow Reservoir yields 200 ac-ft/year. The Sand Hollow recovery wells (surface water influenced, hence the classification) yield 8,000 ac-ft/yr. All stated reservoir/surface supplies based on 75% reliability level. Well supplies: Cottam Wells yield 2,000 ac-ft/yr, Sullivan Wells yield 750 ac-ft/yr, Kayenta wells yield 1,000 ac-ft/yr.
Sources: (DWRe 2008a)

4.1.4.2 Secondary Water Supplies

A number of irrigation companies deliver secondary water to most of the M&I systems in Washington County. While the 2005 secondary water use data published by DWRe is considered reliable due to the significant validation process followed, reliable data for previous years is not available with enough frequency to assess possible trends in use within the District or on a per capita basis. In 2005, total secondary water use by M&I systems in Washington County was about 7,450 ac-ft (DWRe 2008a).

Wastewater reuse is considered by WCWCD and other Washington County water providers to be a viable resource for secondary systems. Meeting outdoor irrigation demands or industrial demands with secondary water would allow higher quality potable supplies to be used for culinary purposes. For example, secondary water from the Washington Fields Canal system is currently being utilized in WCWCD to offset the demand on potable supplies. In Utah, water law specifies the original water rights owner retains ownership after the first-use water has been treated in a wastewater treatment plant. Therefore, reuse projects have to be implemented by the original water rights holders, unless agreements were reached whereby other water users (e.g., WCWCD) could distribute the reclaimed water.

St. George recently completed a reuse plant that takes water from the City's wastewater treatment plant and treats it for use as secondary water. The plant is designed for 10 mgd capacity (11,200 ac-ft per year); 2 of 3 filters have been installed to date so the current capacity is about 7 mgd (7,800 ac-ft per year). Because water use varies by month, as discussed in **Section 3.2.3**, the monthly supply of reuse water available for secondary supply also varies. The monthly pattern from **Figure 3-13** was used to calculate monthly influent to the wastewater treatment plant, based on predicted annual water demand. Monthly reuse supply was calculated assuming wastewater effluent represents approximately 27 percent of total M&I supply (discussed further in **Section 4.1.5.3**). The wastewater treatment plant typically produces good quality water so the reuse plant is very efficient. The current reuse plant capacity exceeds existing secondary demand from large secondary water customers that could be served feasibly by a reclaimed water system. At present there is only one large customer - a golf course on the south side of St. George. The reuse plant was built not in response to an immediate demand for reuse water, but as a result of the Shivwits Band of the Paiute Tribe water rights settlement on Santa Clara River water. As part of the settlement, St. George and others agreed to build the reuse plant and deliver 2,000 ac-ft of water annually to the Tribe. One part of the delivery system extends to the Shivwits Band and Ivins City. There are currently two parallel reuse delivery systems, one on the east side of the valley and one on the west. WCWCD has plans to connect the two systems to improve flexibility of management. Warner Valley Reservoir is proposed to store reuse water, and to store other secondary water including water that will be converted from agricultural use to secondary M&I use. Water from the reuse plant is about 1,000 ppm TDS, so it is generally not usable for industrial purposes.

As discussed in **Section 3.2.3**, demand for this secondary supply only exists during the irrigation season (April through October). It has been assumed that conveyance of secondary water (e.g., irrigation ditches) would not be a limiting factor for the potential secondary supply. However, with regard to the reuse facility, the plant design capacity is a limiting factor. With no available storage for reuse supplies, if reuse supplies exceed secondary demand, the unused water is lost. Based on these restrictions, the effective annual yield from the existing reuse facility is 3,900 ac-ft/yr.

4.1.5 WCWCD Future Water Supplies - Planned

WCWCD is responsible for developing additional water supplies to meet the needs of future residents and businesses in its service area. The municipalities in the WCWCD service area are relying on WCWCD to provide water to meet increased future demands within their corporate boundaries. These municipalities will make improvements to their individual systems that may improve efficiencies and reduce losses, but any major future water supplies for Washington County will be developed by WCWCD.

This section briefly describes water development projects currently planned or being implemented by WCWCD. The Lake Powell Pipeline project is also considered a planned source of future water supplies. **Figure 4-2** shows the general location of the planned projects.

4.1.5.1 Ash Creek Pipeline

The Ash Creek Pipeline Project is considered a water supply that will be completed in the short term. It is a cooperative project of WCWCD, several municipalities, and the State Division of Water Resources. It consists of two phases. In Phase 1, a collection system will be constructed to replace the current open ditches on Leap Creek, South Ash Creek and Wet Sandy Creek. Water will be carried from the existing points of diversion and the existing Ash Creek Reservoir to the proposed Anderson Junction Reservoir southeast of Anderson Junction. This would be a new 3,000 ac-ft reservoir; the exact location has not been determined. Phase 2 will consist of a pipeline from the proposed Anderson Junction Reservoir to Toquerville, La Verkin and Hurricane. Water delivered from the reservoir would be used as secondary water in the communities of Toquerville and La Verkin, thereby conserving the high quality Toquerville Spring water for culinary use. Water from the Ash Creek Pipeline could also be integrated into the Quail Creek Pipeline. Water developed by the Ash Creek Pipeline Project would be a new water resource, as the source water currently infiltrates into a disconnected stream reach of Ash Creek. It has been assumed the Ash Creek Pipeline will be sized to meet full demands during the summer irrigation period, but yield will be limited by secondary demand levels. The yield of the pipeline will be 5,000 ac-ft per year, which will be assumed to be culinary supply. The pipeline will indirectly create culinary supply by generating secondary supply to offset culinary-grade quality water that currently is used to meet secondary demands.

4.1.5.2 Crystal Creek Pipeline

WCWCD is constructing a pipeline to capture water from a diversion that was completed on Crystal Creek to convey water through a 12 mile pipeline south to Kolob Reservoir. The estimated reliable yield is 2,000 ac-ft per year (WCWCD 2008a), and the Crystal Creek Pipeline is considered a supply that will be completed in the short term. This water will be used to meet culinary water demands. The yield for the Crystal Creek Pipeline was assumed to be “new water” that would otherwise not be diverted from the Virgin River because of timing issues with the supply and demand.

4.1.5.3 Sand Hollow Well Field Expansion

Additional local ground water rights will be developed at the Sand Hollow well field site through the use of existing and future wells as needed. Total ground water withdrawal is being increased by WCWCD to the maximum allowable yield of 8,000 ac-ft per year as indicated in Section 4.1.3.2. However, no additional yield has been counted for Sand Hollow wells, because the full reliable yield of 8,000 ac-ft per year was assumed for the existing yield in Section 4.1.3.2.

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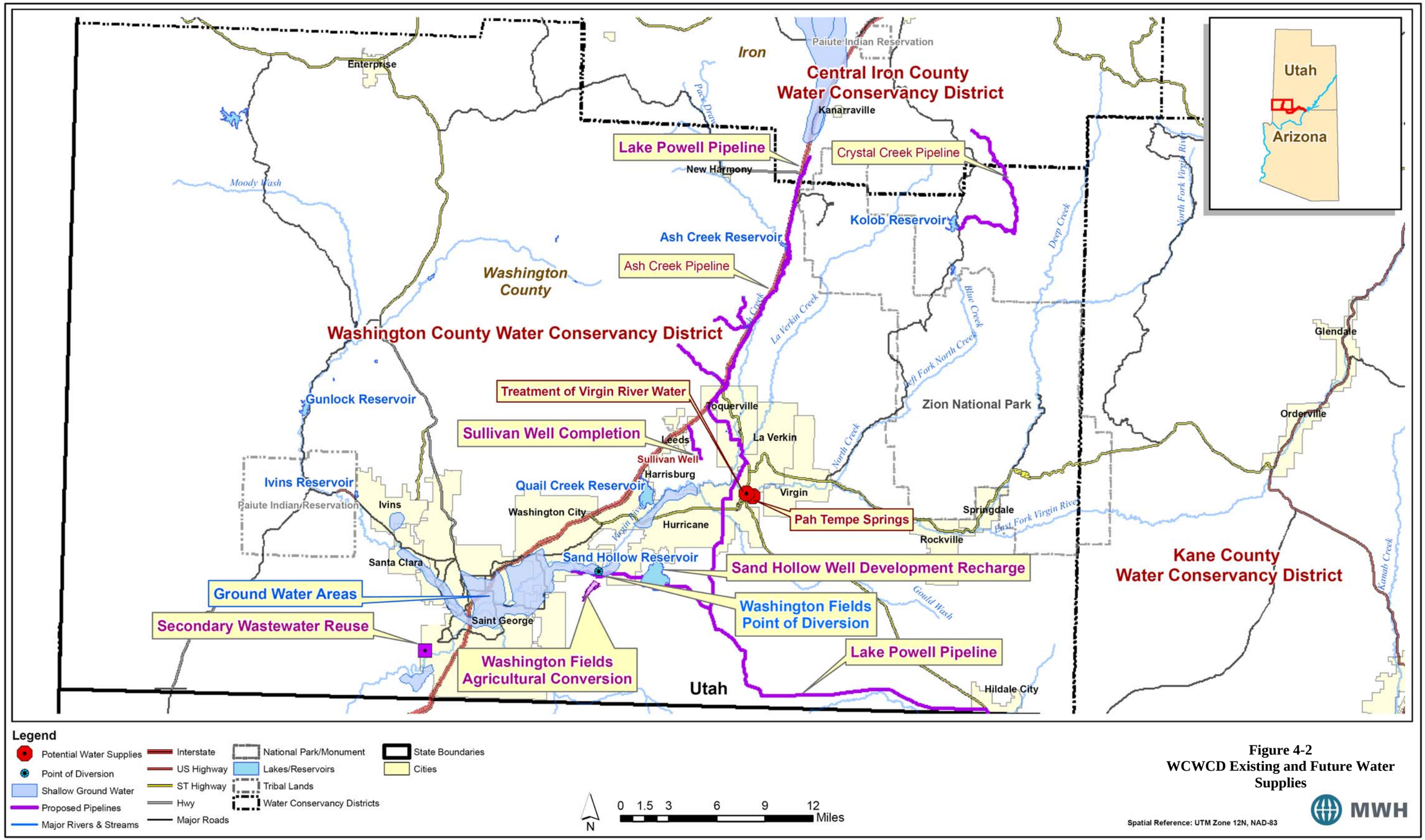

Figure 4-2
WCWCD Existing and Future Water Supplies

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4.1.5.4 Wastewater Reuse

The water produced by the St. George reuse plant could be distributed to meet a portion of the secondary water demand. A detailed study of potential demand for reuse water in the WCWCD service area has not been conducted (this will be researched further in Phase 2 of the Water Needs Assessment). However, WCWCD staff believe 5,600 ac-ft of secondary water use demand could be met by a future reuse system based on the potential to expand the current 7 mgd reuse capacity to 10 mgd capacity and the future demand for outdoor irrigation water, and an assumption that one-half of the capacity of the reuse plant could be utilized on an annual basis (i.e., secondary demand occurs predominantly from April through October, and any available reuse water is lost during the winter months because of the lack of storage for the reusable wastewater during winter months). St. George does not have an extensive secondary water use system for residential customers based on historical irrigation facilities, so a reclaimed water system would allow secondary water to be delivered to a larger portion of the community. Serving customers and communities away from the main St. George reclaimed water trunk line would require installation of a separate network of reclaimed water distribution pipelines and storage tanks. Installing secondary water systems in already developed communities is very expensive, and is often only done to meet large secondary demands at sites such as golf courses, cemeteries, parks, and other land uses with large outdoor irrigation needs. However, some cities are requiring secondary water systems in newly developed areas.

Wastewater reuse could potentially be increased up to the wastewater effluent rate for communities served by the St. George wastewater treatment plant (i.e., St. George, Washington, Santa Clara, and Ivins). Average daily wastewater effluent for 2005 for the St. George Wastewater Treatment Plant was 8.7 million gallons per day (approximately 9,700 ac-ft per year) (Ford 2007). Total M&I water supply to the four communities served by the St. George wastewater treatment plant in 2005 was approximately 36,300 ac-ft per year based on the data provided in **Section 3.2.1**. Assuming the ratio of wastewater effluent to total M&I water supply (wastewater effluent represents approximately 27 percent of total M&I supply) remains constant for these cities in the future, and using the 2060 projected population for these cities and 2005 total M&I per capita water use less 16 percent conservation, wastewater effluent available for reuse would be approximately 54,500 ac-ft per year in 2060 (2060 total WCWCD M&I supply of 265,780 ac-ft/yr, 76 percent of total WCWCD supply supplied to the four communities served by the St. George wastewater treatment plant, and 27 percent of M&I supply returns as wastewater effluent). This projected wastewater effluent represents the maximum wastewater reuse capacity for the St. George wastewater plant. However, wastewater reuse would be limited by water rights issues (e.g., water can only be reused by the original water right holder, and return flow requirements must be met), secondary demand, storage capacity for reusable water, and the infrastructure that exists to deliver the available supply. As a result, wastewater effluent used to develop an estimate of existing reuse for the supply and demand discussion in **Chapter 6** is limited to 3,900 ac-ft per year for existing supplies (50 percent of the existing capacity of 7,800 ac-ft per year). The St. George wastewater reuse treatment plant could be expanded by an additional 3,400 ac-ft per year up to the capacity of 11,200 ac-ft per year. One-half of the additional 3,400 ac-ft per year of additional reuse capacity could be utilized for the first phase of reuse expansion for future yield because of the lack of storage capacity, resulting in about 1,700 ac-ft per year of additional yield from the maximization of the current St. George wastewater plant reuse capacity. Additional reuse beyond the existing 10 mgd (11,200 ac-ft/yr) reuse capacity was limited by the projected wastewater effluent available for reuse, and also by the projected secondary demand. Any additional reuse beyond the existing 10 mgd capacity would require new reuse treatment facilities to be built. The amount of wastewater effluent will be adjusted in Phase 2 of the Needs Assessment following detailed evaluation of potential reuse.

Wastewater reuse has the benefit of maximizing use of available water supplies, but it does have adverse effects on water quality. Wastewater reuse has the potential to degrade local surface and ground water quality over time due to an increase in total dissolved solids and other constituents in the return flows. Reuse of water with already elevated levels of total dissolved solids (540 milligrams per liter at the Quail Creek Water Treatment Plant) would increase total dissolved solids above the drinking water secondary maximum contaminant level (MCL) of 500

mg/L for taste and odor without advanced water treatment (e.g., reverse osmosis) to reduce total dissolved solids. The TDS secondary MCL of 500 mg/L is a recommendation made by the U.S. Environmental Protection Agency to maintain palatable taste and odor for drinking water, but the MCL is not an enforceable regulation. The potential effects of wastewater reuse on water quality will be discussed in further detail in Phase 2 of the Water Needs Assessment.

It is noted that direct wastewater reuse for culinary water supply (i.e., direct potable reuse) is not considered to be a viable option in this study due to limitations in treatment technology, treatment cost, permittability, and public acceptance.

4.1.5.5 Agricultural Conversion for M&I Supply

As municipal development occurs over existing agricultural lands, water will be converted from agricultural to municipal uses. Existing agricultural water supplies could be converted to M&I use either through growth over currently irrigated lands or through "buy and dry" programs. However, no "buy and dry" projects are currently anticipated by WCWCD. Approximately 90 percent of irrigated agricultural water supply in the Kanab Creek/Virgin River Basin originates from surface water sources (DWRe 1993), and as a result has poor water quality associated with high TDS. As a result, the agricultural conversions supply would be usable only as secondary water supplies without advanced water treatment described below.

The "duty of water" for irrigated agricultural ranges from 3 to 6 ac-ft per year per acre of irrigated land (DWRi 2008), and was assumed to be an average of 4.5 ac-ft per year per acre of irrigated land for this study. Irrigated acreage within WCWCD was approximately 19,260 acres in 1990 (DWRe 1993; DWRe 1995). Assuming a "duty of water" of 4.5 ac-ft per year per acre for the 19,260 acres of irrigated land, there were approximately 86,670 ac-ft of diversion made in 1990 for agricultural irrigation. The Utah State Water Plan estimates that an approximate 27 percent decrease in 1990 agricultural water use levels in the Kanab Creek/Virgin River Basin will occur by 2040 (0.54 percent per year) as farmland is converted to M&I development, while no changes in agricultural land use are expected for WCWCD within the Cedar/Beaver Basin. This assumed rate of conversion is dependant on many factors including strength of the agricultural economy, water demand, growth rate, and location of M&I development within the WCWCD.

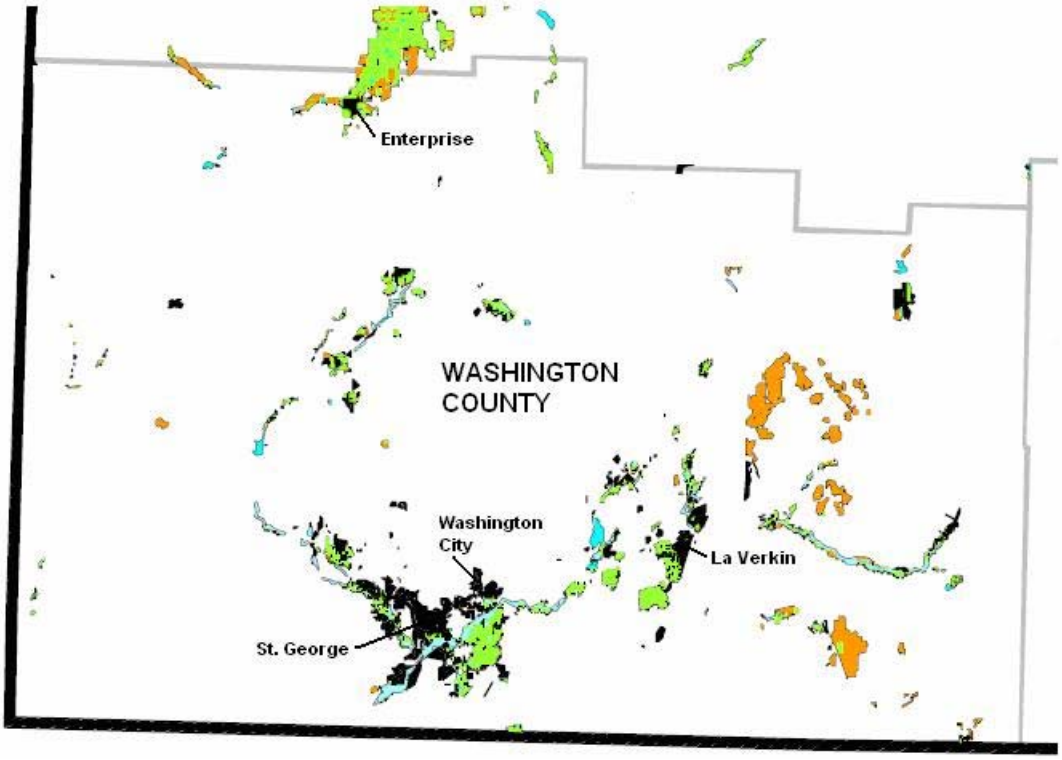
Table 4-3 provides estimated irrigated agricultural land area from 1990 to 2060 using known irrigated acreage in 1990 and 2007, and the assumptions described above for acreage in 2060. Total irrigated acreage in Washington County in 2005 was approximately 14,450 acres based on linear interpolation of the data provided in **Table 4-3**. The reduction in irrigated acreage of about 3,840 acres from 2005 to 2060 would result in additional M&I supply of approximately 17,290 ac-ft per year (assuming agricultural diversions of 4.5 ac-ft per acre per year) between 2005 and 2060 as a result of M&I development over currently irrigated land. Of this potential supply, 4,000 ac-ft per year of water was assumed to be used for the Quail Creek Reservoir agricultural exchange described in **Section 4.1.6.2**, leaving approximately 13,290 ac-ft per year of available supply by 2060.

Table 4-3. Estimated Irrigated Agricultural Lands for Washington County

	Irrigated Agricultural Land by Year		
Area	**1990**	**2007**	**2060**
Kanab Creek/Virgin River Basin	16,680	11,230	8,030
Cedar/Beaver Basin	2,580	2,580	2,580
Washington County Total	19,260	13,810	10,610

Figure 4-3 outlines the relative location of irrigated croplands to urban areas to help gain a better understanding of how much acreage could be potentially converted from agricultural to municipal uses. Irrigated croplands are represented by the areas shaded in green, while urban areas are colored black.

Figure 4-3
Washington County Irrigated Lands



Source: Modified from (DWRe 1999)

Notes: [1] Map Color Code: Green = Irrigated Cropland, Orange = Non-Irrigated Cropland, Blue = Water, Black = Urban

An example of conversion of agricultural water use to M&I use as a result of development is conversion that could occur at the Washington Fields area. The Washington Fields area was approximately 3,030 acres in 2007, and Washington County was approximately 12,740 acres in 2007. Of the 3,840 acres of total agricultural conversions expected by 2060 within Washington County, a large portion of the conversions will likely occur within the 3,030 acres of Washington Fields. The first step in utilizing a portion of current agricultural water for M&I purposes is to decrease the loss of agricultural water to evaporation. The St. George and Washington Canal Company replaced approximately 9.2 miles of open canal with a pipeline. This will conserve water from ditch loss (seepage) and evaporation, and will allow more efficient watering systems to be developed over time. Additional open ditch irrigation systems may be converted to pipelines in the future. M&I development of the Washington Fields agricultural areas in the future will also result in future M&I water supplies.

In the future, water from agricultural conversions made at the Washington Fields area could be stored in a reservoir at the mouth of Warner Valley (Warner Valley Reservoir), allowing efficient management of this water for secondary and other purposes in the St. George and Washington Fields area. WCWCD would only use this water for culinary supply if there are no other viable culinary supplies because of the economic and technical challenges associated with the advanced water treatment. The WCWCD's preferred use of Warner Valley Reservoir is to store existing water rights (some of which are currently used for agricultural purposes) to be used in an M&I pressurized secondary supply system in the future. Water could also be preserved for environmental uses such as providing target flows in the Virgin River for the endangered woundfin minnow and Virgin River chub.

The majority of agricultural supply that would be converted to M&I supply as a result of development has high levels of TDS that would either require blending with supplies with lower TDS or advanced water treatment to reduce overall TDS. TDS of untreated Lake Powell water in the top 100 feet ranges from 350 to 600 mg/L. Blending of approximately 2 parts untreated Lake Powell water and 1 part water from agricultural conversions would result in an overall supply with 1,000 mg/L TDS.

Another less desirable option for reducing TDS of the agricultural conversions supply for secondary use would be to treat a portion of the supply using reverse osmosis. This option is less desirable than blending the supply with another source as described in the previous paragraph because of environmental, technical, and economic feasibility issues described below. However, if reverse osmosis was used, a portion of the supply would need to be treated with reverse osmosis to reduce overall TDS of the water supply to the MCL of 1,000 mg/L for secondary use in order to conservatively estimate the potential yield of the agricultural conversions supply. A 20 percent loss to brine during the reverse osmosis process was assumed for this portion of the treated water (MWH 2006). Assuming a TDS concentration of 1,500 mg/L for the agricultural conversions supply (TDS equal to Virgin River water directly upstream of the Washington Fields diversion point where a substantial portion of the agricultural conversions supply would be diverted) and 100 percent removal of TDS in an RO process, 4,430 ac-ft/year of the total 13,290 ac-ft/year supply would have to be treated with RO to meet the secondary TDS MCL of 1,000 mg/L. Accounting for a 20 percent loss through the RO treatment process, the average annual yield would be 12,400 ac-ft/yr for secondary use.

The high cost and several technical feasibility issues associated with advanced water treatment for conversion of agricultural supply create a strong argument against using this surface water supply if reverse osmosis is required. The following issues affect the feasibility of advanced treatment of agricultural conversions.

- High cost of advanced water treatment options such as reverse osmosis
- High energy requirements associated with reverse osmosis
- Lack of an environmentally acceptable alternative for disposal of brine created from the reverse osmosis process
- High TDS of water supply may require substantial portions of the water supply to be treated to achieve the final desired TDS for secondary M&I uses

4.1.5.6 Additional Infrastructure

WCWCD anticipates completion of two new water supply pipelines in the near future that will not generate new yield, but will increase the flexibility of their water supply portfolio. The first of these pipelines will be constructed from Virgin City south to the Apple Valley area, which will provide for a portion of the anticipated water needs of the Hilldale and Apple Valley areas. The second pipeline currently being designed by WCWCD will deliver water from Sand Hollow ground water wells to Washington and St. George cities.

4.1.5.7 Lake Powell Pipeline

WCWCD has requested the delivery of 70,000 ac-ft of water per year from the LPP project. In order for the WCWCD to fully develop the 70,000 ac-ft they will need to construct additional storage. It was assumed the necessary storage will be constructed, so the WCWCD can meet the projected demands as described in **Section 6.1.2**. As currently conceived, the LPP would deliver water to Sand Hollow Reservoir, from which it could be distributed to most communities in the Virgin River and Santa Clara River corridors using the Regional Pipeline and other existing facilities.

4.1.6 WCWCD Future Water Supplies - Potential

The projects described in this section could be part of the long-term water supply portfolio of water providers in WCWCD, but some of the projects are not currently being pursued for economic and environmental reasons. The

likelihood of construction of these projects, and the potential technical and environmental challenges associated with each of the projects are discussed below.

4.1.6.1 Additional Virgin River Water Available for Development

After numerous studies by various State and Federal agencies, the DWRe and WCWCD have concluded there is no additional Virgin River water available to be developed for water supply in Washington County because of variable streamflow, poor water quality, lack of storage options, minimum streamflow requirements, and the potential for sedimentation of possible reservoir sites. An evaluation was completed for this analysis to confirm the above conclusions that there is no additional Virgin River water available for development.

It is estimated by the DWRe that the average annual Virgin River streamflow below the Washington Fields diversion point is about 62,300 ac-ft per year. A large portion of the available water supply occurs during short periods of high streamflow, which is difficult to divert with a standard river diversion and conveyance facilities. Even if an appropriate diversion structure and conveyance system were built, the poor water quality may inhibit the use of the supply for the majority of M&I uses (including secondary water use) without expensive water treatment. If the problems associated with being able to divert and treat the available Virgin River streamflow were solved, an off-channel water storage reservoir and associated conveyance facility would be needed with enough capacity to capture the available streamflow when it occurs. Any streamflow diversions would have to be limited so the remaining streamflow would not violate the existing minimum streamflow requirement of 3 cfs for the Virgin River below the Washington Fields diversion point. Additionally, the Virgin River is an interstate stream flowing downstream through Nevada and Arizona. Although there is not an interstate stream compact between Utah and the downstream states, further development of the Virgin River within Utah may raise concerns in both Nevada and Arizona about potential impacts in their states.

Simulated daily streamflow for the Virgin River downstream of the Washington Fields diversion from 1941 to 2006 is shown in **Figure 4-4**. Streamflow exceedance information for the same location and period of record is summarized in **Table 4-4** and **Figure 4-5**, which shows the frequency of various streamflow values. For example, **Table 4-4** and **Figure 4-5** indicate that 50 percent of daily streamflow values are greater than or equal to 25 cfs. The majority of annual flow volume occurs during infrequent higher flows, which decreases the potential for capturing these flows and developing additional Virgin River water. The simulated historical daily streamflows ranges from 0 to 21,100 ac-ft per day (0 to 10,600 cfs), with higher flows generally occurring during spring runoff and in response to short intense rainfall events. The variability of streamflow would require a large enough diversion structure and storage facility to result in enough reliable annual supply to make diversion of Virgin River water a technically and economically feasible project.

Table 4-4. Virgin River below Washington Fields – Percent Exceedance for Daily Streamflow, 1940-2006 (DWRe 2008b)

Percent Exceedance	Streamflow (cfs)
1	1,280
5	403
10	175
20	43
30	43
40	43
50	25
60	13
70	7.3
80	7.1
90	0.0
100	0.0

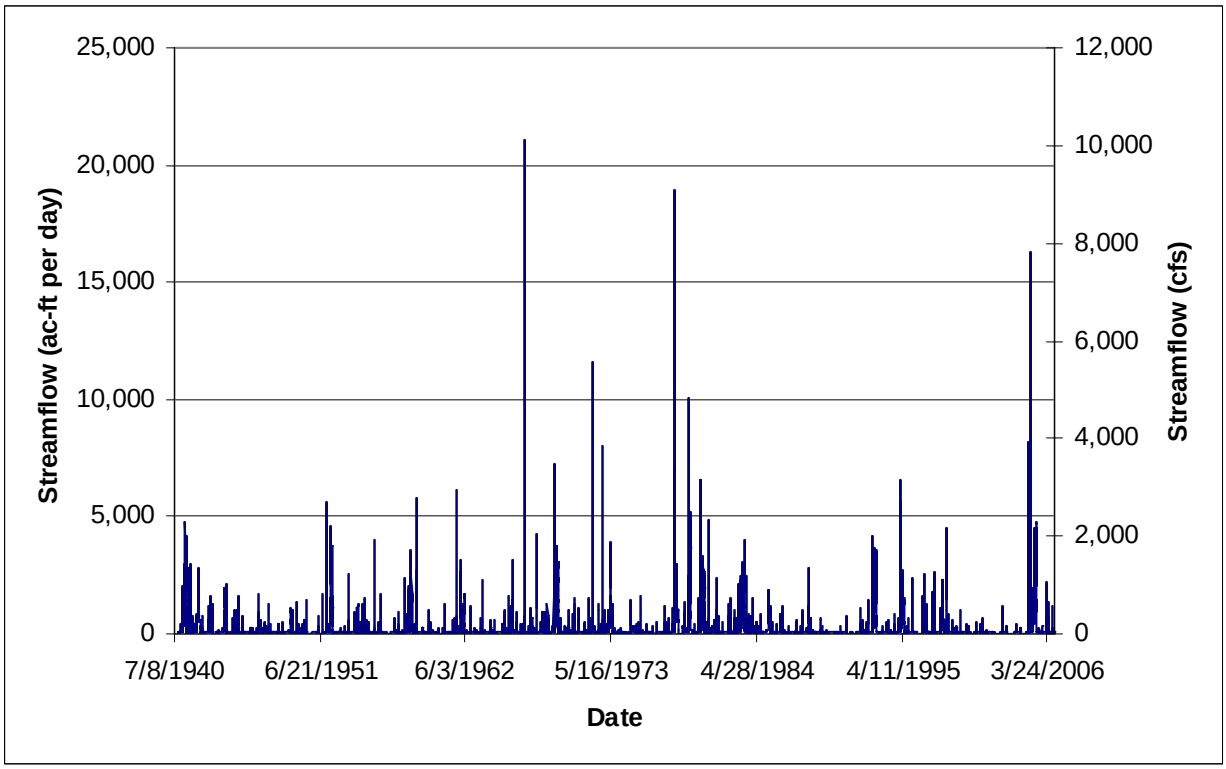


Figure 4-4. Daily Streamflow for Virgin River below Washington Fields (DWRe 2008b)

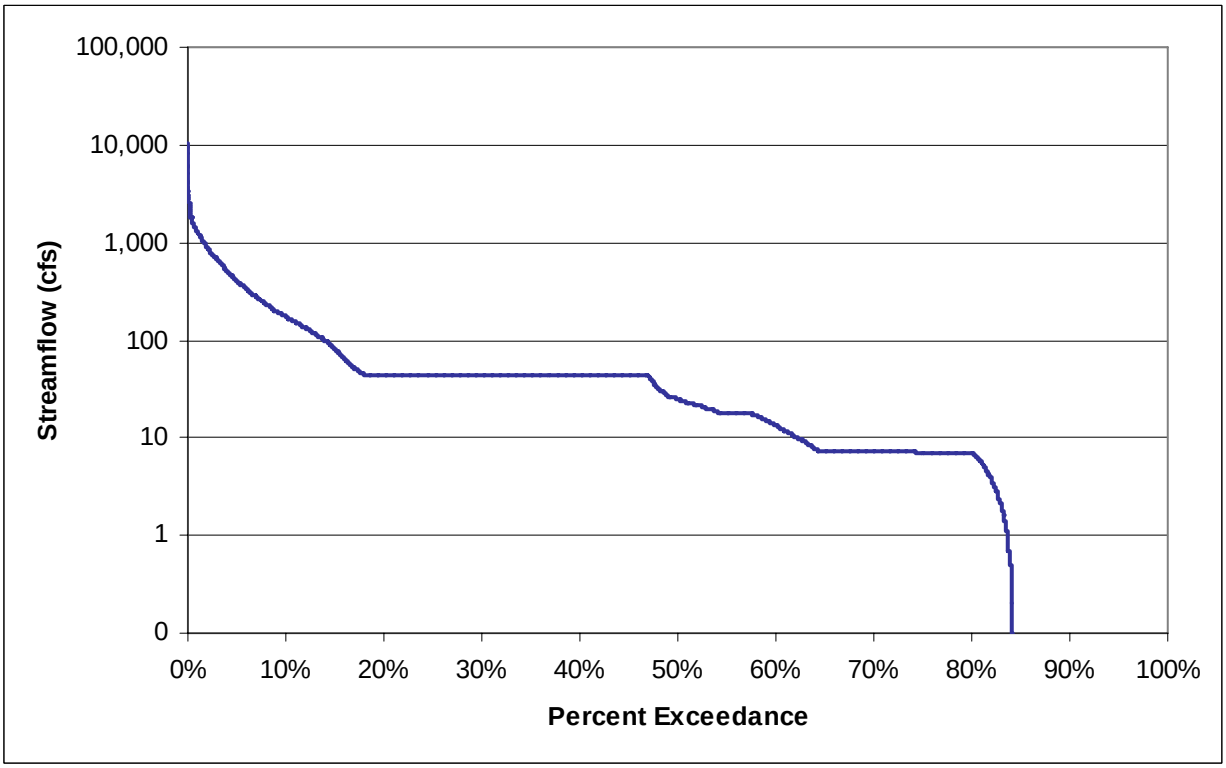


Figure 4-5. Virgin River below Washington Fields Flow Exceedance Curve (DWRe 2008b)

Potential storage locations within the Virgin River Basin were investigated by the DWRe (1988; 1992). Of the 96 potential sites considered, DWRe screened out all but 16 sites based on geologic flaws, potential storage capacity, onsite field reviews, and detailed characteristics such as cost and environmental considerations. Of the 16 sites remaining after DWRe's analysis, only two of the reservoir sites were deemed to be potentially feasible sites for this analysis for off-stream storage of additional Virgin River water: the Warner Valley Reservoir and Fort Pearce Reservoir sites. DWRe yield modeling of the Virgin River indicates that reservoir capacity for Virgin River water would need to be about 5 ac-ft of reservoir storage capacity per 1 ac-ft of reliable yield, because of the variability of streamflow in the Virgin River. Issues associated with storage of Virgin River streamflow in the Fort Pearce Reservoir site include the high cost per unit storage/yield, poor location for integration into the existing WCWCD water supply system, and potential environmental mitigation requirements such as those associated with the state historical site at the potential reservoir site. Additionally, the Fort Pearce Reservoir site is located within a large low elevation watershed which may result in high sediment load into the reservoir. The sediment load would reduce the capacity of the reservoir and increase the potential cost of maintenance for a reservoir at the site. The Warner Valley Reservoir site is already planned to be developed for a water supply storage facility by the WCWCD, and its capacity will predominantly be used to store wastewater reuse and existing Washington Fields agricultural water diversions. There appears to be no viable off-stream storage option for the development of a significant quantity of additional reliable Virgin River water.

An on-stream dam may be required to obtain significant reliable yield from this potential supply. However, an on-stream dam and reservoir would have significant drawbacks. The potential effects of an on-stream dam include impacts to endangered species such as the woundfin minnow and the Virgin River chub. An on-stream dam would have a detrimental effect on aquatic habitat at the location of the reservoir, and would also have serious sedimentation and erosion issues. Lastly, there is no known site on the Virgin River in Utah that would be suitable for an on-stream dam. For these reasons, an on-stream dam was not considered technically or economically feasible or permittable for storage of Virgin River streamflow.

Poor water quality in the Virgin River near the Washington Fields diversion, including elevated TDS associated with Pah Tempe Springs, poses a technical, economical, and environmental challenge to develop this potential water supply for culinary purposes. Virgin River water at the existing Washington Fields agricultural diversion has an average TDS of approximately 1,500 mg/L (USEPA 2008). The high TDS supply would require advanced water treatment such as reverse osmosis combined with other traditional treatment methods to render the water usable even for secondary uses such as residential lawn watering. As described in **Section 4.1.5.5**, the high cost, high energy demand, and lack of environmentally sound alternative for disposal of reverse osmosis waste brine stream would minimize the feasibility of advanced water treatment of the Virgin River water supply. Another alternative to reduce the high TDS would be to blend the high TDS Virgin River water supply with a lower TDS supply from another source (e.g., Lake Powell Pipeline). As discussed above for the Washington Fields agricultural conversions, blending of approximately 2 parts untreated Lake Powell water and 1 part Washington Fields water would result in an overall supply with 1,000 mg/L TDS. However, the alternative using blending with lower TDS supply may not be feasible because of a potential need for additional storage of lower TDS water which would have the same technical and environmental impediments as described above for storage of Virgin River water.

Development of additional Virgin River water was determined to not be feasible. Constraints associated with unpredictable and variable streamflow, lack of potential storage locations, potential interstate stream conflicts, and poor water quality make development of additional Virgin River water both technically and economically infeasible.

4.1.6.2 Quail Creek Reservoir Agricultural Exchange

Approximately 4,000 ac-ft of water per year is stored in Quail Creek Reservoir from November through April for the Hurricane and Washington Fields Irrigation companies. The water is stored in Quail Creek Reservoir,

managed by WCWCD, and is used by the irrigation companies for agricultural irrigation during the summer irrigation season. Quail Creek Reservoir water is of sufficient quality to be treated economically for culinary use. Therefore, an exchange for this water would allow the 4,000 ac-ft per year of culinary water currently used for agriculture to be utilized to meet culinary M&I demands, while the agricultural demand would be met with secondary-grade quality water. The source of the secondary water to be exchanged for Quail Creek agricultural water was assumed to come from the agricultural conversions supply discussed in **Section 4.1.5.5**, which would have water quality sufficient for agricultural use by the Hurricane and Washington Fields Irrigation companies. A new storage reservoir will be needed to store the secondary grade quality water from the Virgin River to be used by the Hurricane and Washington Fields Irrigation companies. The proposed Warner Valley Reservoir (planned project pending approval following completion of NEPA compliance and applicable permits and agreements) could be used to store the Virgin River water to be used to offset agricultural demands for the Hurricane and Washington Fields Irrigation companies.

4.1.6.3 Ground Water Development

The Virgin River ground water basin in Washington County (the Navajo Sandstone aquifer) is considered to be over-appropriated by the Utah Division of Water Rights (DWRe 2008aa). The ground water budget for the Navajo Sandstone aquifer presented in the Virgin River Basin Plan (DWRe 1993) was updated with current ground water pumping information from the Virgin River M&I Use Report for municipal demands (DWRe 2008a), and with projected agricultural ground water pumping for 2005 from the Virgin River Basin Plan (DWRe 1993). The updated ground water budget confirmed the aquifer is fully utilized, and there are no new supplies available for development.

The Navajo Sandstone aquifer is very difficult to analyze, in part because of the prominence of faults and fractures in affecting the ground water flow conditions, and debate exists over whether there is any additional ground water available for development from the aquifer. The USGS has completed modeling for WCWCD in the Sand Hollow area, including an analysis of natural infiltration to the Sand Hollow Basin. The USGS concluded natural recharge to the Sand Hollow ground water is 790 ac-ft per year, which has already been accounted for in the Sand Hollow ground water yield described in Section 4.1.3.2. It is possible that minimal additional ground water development could be achieved without depleting the aquifer. However, until definitive studies are completed, the State Engineer has closed the basin to new ground water development, and therefore for this study it is assumed no additional supplies are available from this source. WCWCD is not currently planning on developing any new ground water from the Navajo Sandstone aquifer beyond the District's current ground water rights described in **Section 4.1.3.2**.

4.1.7 Summary of Planned and Potential WCWCD Water Supply Projects

Table 4-5 summarizes the water supply projects currently planned by WCWCD to meet the demands of existing and future water users in Washington County, and those that could be considered potential long-term projects if certain technical, environmental or cost concerns were resolved. Individual projects would supply either culinary or secondary water to District customers. Each project would have limitations in the areas it could deliver water to economically.

Table 4-5
Future Planned and Potential WCWCD Water Supply Projects

Project	Estimated Reliable Culinary Supply (ac-ft/yr)	Estimated Reliable Secondary Supply (ac-ft/yr)
Ash Creek Pipeline	5,000	0
Crystal Creek Pipeline	2,000	0
Maximize Existing Wastewater Reuse [1]	0	1,700
Quail Creek Reservoir Agricultural Exchange	4,000	0
Agricultural Conversions from Development[2]	0	12,400[3]
Lake Powell Pipeline	70,000	0
Potential Future Wastewater Reuse	0	54,500[4]
Total Potential Yield from Future Projects	**81,000**	**68,600**

[1] The maximum capacity of the existing reuse treatment plant is 3,360 ac-ft/yr, but this supply can only be used to meet secondary demands during the irrigation season (April through October) and there is no storage capacity resulting in the loss of any supplies that are not used by the end of a given month. Assumed that only 50 percent of treatment capacity could be utilized because of lack of storage capacity for reuse water.

[2] Of the 17,300 ac-ft per year of available supply, 4,000 ac-ft/yr of this supply would be reserved for the Quail Creek Reservoir Agricultural Supply Exchange to meet culinary demands, leaving 13,300 ac-ft/yr available for the agricultural conversion projects. An additional loss from advanced water treatment was assumed as described in the following footnote, resulting in 12,400 ac-ft per year reliable yield.

[3] Although reverse osmosis would be less likely than blending with a higher quality water source as described in Sections 4.1.5.5, reverse osmosis was assumed to conservatively estimate the secondary supply from this source. A 20 percent loss was realized for the portion of this supply that must be treated with reverse osmosis to reduce salinity to a level where mixing would reduce the TDS to the appropriate maximum contaminant level (i.e., 500 mg/L TDS recommended MCL for culinary use, and 1,000 mg/L TDS for secondary use).

[4] Wastewater reuse could potentially be increased up to the wastewater effluent rate for communities served by the St. George wastewater treatment plant (i.e., St. George, Washington, Santa Clara, and Ivins), limited by secondary demand. The wastewater effluent available for reuse is calculated assuming the ratio of wastewater effluent to total M&I water supply (approximately 27 percent) remains constant for these cities in the future, and using the 2060 projected total M&I water use for these cities. However, the actual amount of this potential reuse that could actually be used as secondary supply would be limited by storage constraints and secondary demands which were considered in Chapter 6 when determining a realistic estimate of the portion of this supply that could be used.

4.1.8 Water Quality Effects of WCWCD Future Supplies

Several of the planned and potential future supplies for WCWCD would have water quality issues that would need to be considered prior to implementing these projects. Many of the future supplies would be limited to use for secondary water purposes such as turf irrigation because of high levels of dissolved solids. For example, the most appropriate use of water from agricultural conversions associated with development would be as secondary water rather than culinary water because of high total dissolved solids concentrations. However, an increase in the use of highly saline water for secondary water use purposes may still have a detrimental effect on the water quality of local surface and ground water supplies as a result of return flows and infiltration of a portion of the water used for irrigation. Effects on the water quality of existing surface and ground water supplies will need to be fully understood before utilizing water with high dissolved solids as a future supply so as not to decrease the quality of the existing culinary supply for the District or cause adverse environmental effects in receiving waters.

Use of supplies with high dissolved solids may be possible for culinary water use, but only if advanced water treatment such as reverse osmosis is completed for the poor quality water. The decision whether to use these supplies for culinary or secondary water use would be made on an economic, environmental, and technical feasibility basis because of the high cost of advanced water treatment options such as reverse osmosis. On the other hand, the proposed Lake Powell Pipeline project would import higher quality water with total dissolved solids concentrations more in line with the existing water supply for WCWCD.

The TDS and hardness levels in the Lake Powell water are similar to those of the existing WCWCD supplies, and would likely have a minimal effect on overall water quality of the District's supply. TDS concentrations of the water supply in the WCWCD service area ranges from 100 to 800 mg/L, with average of about 450 mg/L. TDS concentrations of untreated Lake Powell water within the top 100 feet ranges from 350 to 600 mg/L depending on seasonal fluctuations in water quality. The design and operation of the Lake Powell Pipeline intake at Lake Powell would ensure that water would be taken from the top 100 feet of Lake Powell to optimize water quality of the supply that would be taken through the pipeline. It may be possible to divert Lake Powell water with TDS levels commensurate with the TDS of the existing WCWCD supplies. However, a portion of the Lake Powell water may need to be blended with Virgin River water to reduce the TDS of the imported water and maintain the current TDS of the water supply below the drinking water secondary MCL of 500 mg/L. Total hardness of the water supply in the WCWCD service area ranges from approximately 100 to 400 mg/L as calcium carbonate, compared to the hardness of untreated Lake Powell water of 240 to 320 mg/L as calcium carbonate. Hardness will likely not be a significant water quality issue for imported Lake Powell water, because the hardness of untreated Lake Powell water is similar to that of the existing supply in Washington County. The potential water quality effects will be discussed in further detail in Phase 2 of the Water Needs Assessment and in the Lake Powell Pipeline water quality effects report.

4.2 Central Iron County Water Conservancy District

This section describes existing and planned future supplies to meet the water demands in the Central Iron County Water Conservancy District service area.

4.2.1 CICWCD Water Supply Overview

CICWCD serves customers in the central portion of Iron County, primarily including the unincorporated areas around Cedar City, Enoch City and Kanarraville. These three cities each developed their own water supplies and distribution systems as the area developed. CICWCD was formed in 1997, and has been working towards development of a regional water system in the Cedar Valley area to serve private independent water systems and larger public water systems within its service area. Eventually CICWCD hopes to be the regional water supplier for meeting all new growth in its boundaries.

All existing M&I supplies in the Cedar Valley Basin of CICWCD are derived from ground water resources (wells and springs). The Cedar Valley is essentially a closed basin, meaning there are no significant outflows of ground or surface waters during normal years. Ground water resources are generally of high quality, and are used directly for culinary purposes after disinfection, with the exception of a few isolated areas with elevated TDS and nitrate concentrations as discussed in **Section 4.2.4.2**.

Ground water sources within the Cedar Valley and Parowan Valley are considered to be fully appropriated and closed to further appropriations at this time (DWRi 2008b). New diversions and uses must be accomplished by change applications based on existing water rights. No change applications between subareas are allowed, and changes between surface and underground sources will be critically reviewed to assure that there will be no impairment of other rights.

4.2.2 CICWCD Existing Water Supplies

All existing CICWCD water supplies come from the Cedar Valley ground water basin. The CICWCD is a new water provider and does not have significant physical infrastructure in place at present. The initial system infrastructure consists of two wells north and southwest of Cedar City with a combined capacity of 2,000 gpm, two tanks with combined storage of 2.4 million gallons, and approximately 10,000 feet of distribution pipeline. The general location of this system is shown in **Figure 4-6**.

CICWCD has been in the process of acquiring water rights through purchasing wells and entering into interlocal agreements with several subdivisions in its service area. **Table 4-6** summarizes the current water rights holdings for CICWCD. Administration of the Cedar Valley ground water basin is divided by a geologic divide running east and west along Highway 56. This division separates allocated water rights into north and south parts of the valley, and transfers of water rights typically do not occur across the dividing line. This presents a challenge to CICWCD and other regional water providers in the valley, as separate supply sources are needed north and south of the divide.

At the present time, CICWCD delivers only potable water supplies; it has no secondary water customers. CICWCD has plans to extend a secondary system into areas of new development to minimize requirements for potable water.

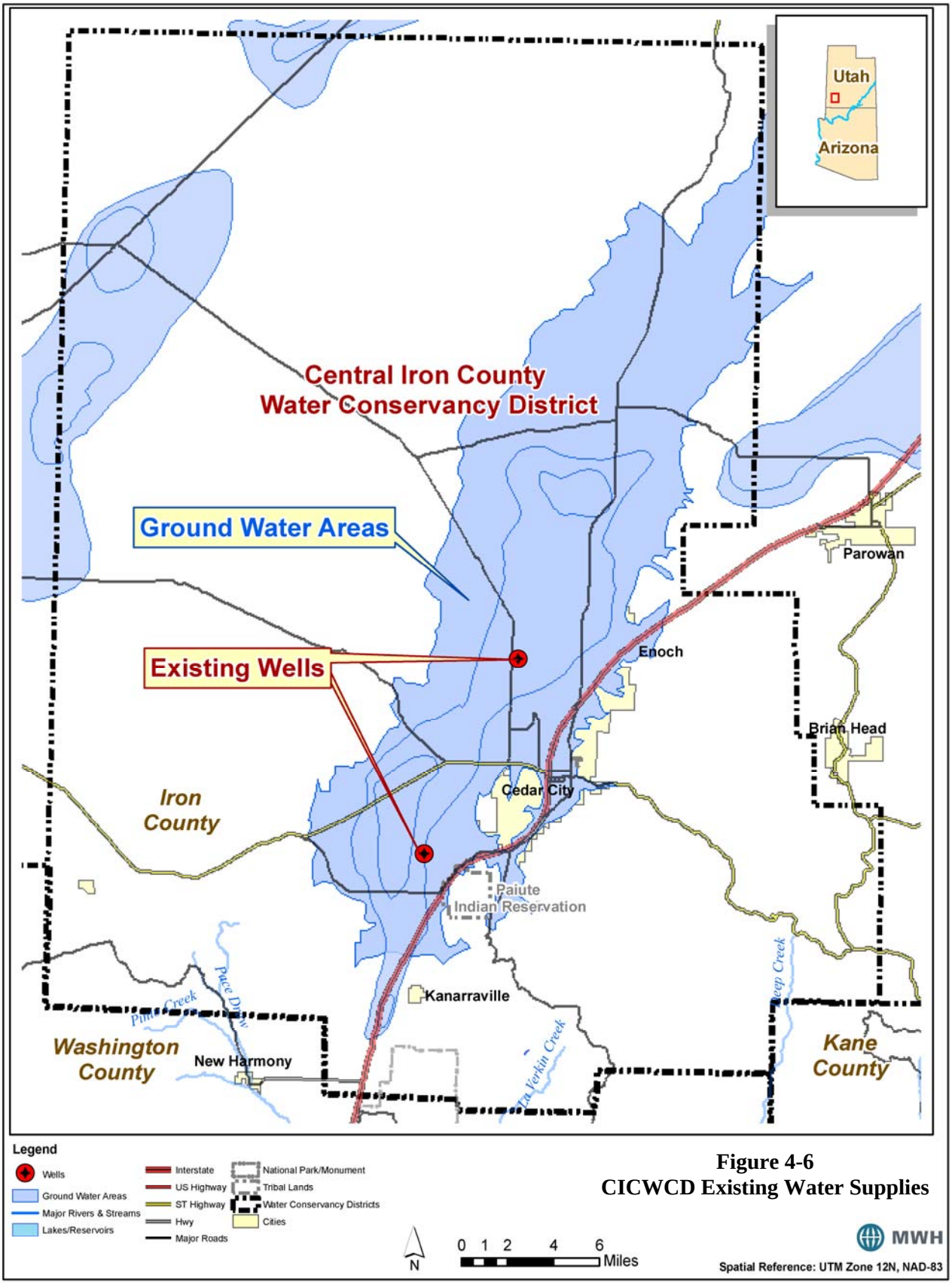


Figure 4-6
CICWCD Existing Water Supplies

Table 4-6
Existing and Proposed CICWCD Water Rights for Source Development

Water Right Number	Priority	Flow (ac-ft)
73-3607	6/1/1927	5.16
73-2456	6/1/1928	1
73-1991	6/1/1928	12
73-260	6/1/1931	2
73-3132	6/1/1931	1
73-3231	6/1/1931	1
73-3280	6/1/1931	2
73-3601	6/1/1931	10.5
73-3603	6/1/1931	1
73-3604	6/1/1931	2
73-3606	6/1/1931	60
73-2311	6/6/1931	1
73-2365	6/6/1931	1
73-2381	6/6/1931	1
73-2436	6/6/1931	1
73-2454	6/6/1931	1
73-1981	10/1/1933	1
73-3602	10/1/1933	1
73-1021	6/30/1934	4.6
73-1986	6/30/1934	4.6
73-2543	7/25/1934	1
73-3491	7/25/1934	29.502
73-3493	7/25/1934	0.75
73-999	7/25/1934	29.502
73-3324	3/16/1938	7.864
73-3071	7/17/1944	10
73-3573	7/17/1944	1
73-3608	7/17/1944	40
73-3490	8/15/1951	23.4783
73-2490	9/20/1951	3
73-3406	9/20/1951	0.136
73-1790	2/7/1953	15.583
73-2875	2/7/1953	40.25
73-2876	2/7/1953	86
73-3245	2/7/1953	1
73-3492	2/7/1953	55.834
73-1349	1/101956	30
73-2725	4/7/1956	2
73-2860	4/7/1956	400
73-3262	4/7/1956	1
73-3527	4/7/1956	1
73-3605	4/7/1956	385
73-2987	6/1/1860	30
Total		**1,307.759**

4.2.3 Central Iron County Existing Water Supplies

All existing potable water supplies developed by municipal water users in the Central Iron County area are derived from ground water sources. Agricultural users are supplied with a combination of ground and surface waters. Surface water quality is poorer than ground water quality, and additional water treatment would be needed to make it usable as a culinary M&I source. To date this additional treatment has not been considered economical.

Total reliable potable water supplies for Iron County public community water systems are 13,448 ac-ft (13,315 ac-ft in Cedar/Beaver Basin and 133 ac-ft in Kanab Creek/Virgin River Basin) (DWRe 2007a; DWRe 2008a). **Table 4-7** summarizes the total reliable water supplies by community. The annual potable water use in the county in 2005 was 9,010 ac-ft (8,845 ac-ft in Cedar/Beaver Basin and 165 ac-ft in Kanab Creek/Virgin River Basin), or 67 percent of the reliable potable water supply. In addition, secondary water use in 2005 was 1,570 ac-ft (1,510 ac-ft in Cedar/Beaver Basin and 60 ac-ft in Kanab Creek/Virgin River Basin) by public community water systems. It has been assumed that all facilities used to supply existing secondary water demands are capable of meeting full demands during the summer irrigation period.

In the CICWCD portion of Iron County, total reliable potable water supplies are 11,360 ac-ft per year (3,800 ac-ft from springs and 7,560 ac-ft from wells). In 2005, potable water usage in the CICWCD portion of Iron County was 8,170 ac-ft (DWRe 2007a; DWRe 2008a). Secondary water usage by M&I users in the CICWCD portion of Iron County in 2005 was 800 ac-ft, nearly all of which occurred in Cedar City.

Cedar City has an existing secondary water supply system, where secondary M&I water is supplied to some parts of the city using a pressurized irrigation system. This existing pressurized irrigation system could be used to supply water reuse in the future (Olmstead 2007), as discussed in **Section 4.2.5.3**. Enoch City is in the process of developing a secondary water supply system for residential irrigation, with approximately 10 percent of residents currently connected to the system (Brough 2007). Enoch City's secondary water supply originates from Coal Creek via irrigation ditches. The majority of this supply is used for agricultural irrigation, but is expected to be converted to secondary M&I use as agricultural land is developed for M&I use in the future (Brough 2007).

The effluent from the Cedar City regional wastewater treatment plant is not currently a source of reclaimed water for secondary use. The effluent is applied to a 400 acre land application site that is used for cattle and sheep grazing by a local farmer. Flood irrigation with piping and ditches distributes the water. There has been some discussion about water reuse being developed in Cedar City.

Table 4-7
Reliable Potable Water Supplies - Iron County

Water Supplier	Reliable Potable Water Supply (ac-ft/yr)			
	Springs	Wells[1]	Surface	Total
Angus Water Company, Inc.[1]	0.0	66.0	0.0	66.0
Brian Head Water System[4]	331.0	392.3	0.0	723.3
Buena Vista Community[1]	0.0	113.1	0.0	113.1
Cedar City Waterworks System	3,750.6	5,184.2	0.0	8,934.8
Cedar Highlands Subdivision	49.0	0.0	0.0	49.0
Cross Hollow Hills Subdivision	0.0	126.6	0.0	126.6
Eagle Valley Ranch[1]	0.0	16.6	0.0	16.6
Enoch City Water System[1]	0.0	1,127.2	0.0	1,127.2
Escalante Valley Water System[4]	0.0	16.1	0.0	16.1
Fifetown Water System[2]	N/A	43.6	N/A	43.6
Flying L Subdivision	0.0	30.0	0.0	30.0
Irontown	0.0	40.5	0.0	40.5
Karnarraville[3]	64.5	68.2	0.0	132.7
Meadows Ranch[1]	0.0	157.3	0.0	157.3
Mid Valley Estates	0.0	173.7	0.0	173.7
Monte Vista Community Water Company[1]	0.0	48.7	0.0	48.7
Mt. View SSD	0.0	50.0	0.0	50.0
New Castle Water Company[1] [4]	0.0	168.1	0.0	168.1
Old Meadow Water Company	0.0	46.8	0.0	46.8
Paragonah Municipal Water System[4]	415.5	0.0	0.0	415.5
Park West Water Company	0.0	37.0	0.0	37.0
Parowan Municipal System[4]	193.6	509.5	0.0	703.1
Rainbow Ranchos	0.0	74.9	0.0	74.9
Spring Creek Water Users	0.0	55.0	0.0	55.0
Summit SSD[1] [4]	0.0	98.0	0.0	98.0
Totals	**4,804.2**	**8,643.4**	**0.0**	**13,447.6**

[1]Reliable supply considered to be equal to metered/calculated use.
[2]No information on water supplies or water rights for Fifetown was available.
[3]Wells are limited to 50% of their "maximum" capacity for reliable supply when well/pump capacity is the limiting factor. Springs and surface water supplies are equal to their respective "maximum" capacities.
[4]Located outside of Central Iron County, would not be served by the Lake Powell Pipeline.
Sources: (DWRe 2007a) (all except Karnarraville). (DWRe 2008a) (Kanarraville)

4.2.4 Cedar Valley Ground Water Basin

4.2.4.1 Cedar Valley Ground Water Production and Sustainable Yield

As noted previously, the Cedar Valley ground water basin is considered to be over-appropriated by the Utah Division of Water Rights (DWRe 2007a). In 2005, the USGS completed a study of the available water sources for the Cedar Valley in Iron County to establish the reliable capacity of ground and surface water sources (USGS 2005). The Cedar Valley hydrogeologic system is fed by surface runoff from snowmelt and large rainfall events in Coal Creek, Shurtz Creek, and smaller tributaries. Coal Creek provides almost all surface water used for irrigation in the Cedar Basin and much of the recharge to the ground water aquifer. The average annual discharge from Coal Creek is about 24,000 ac-ft, most of which contributes to aquifer recharge. The total average annual recharge to the Cedar Basin was estimated by USGS to be between 33,600 ac-ft and 42,000 ac-ft.

For purposes of the LPP Water Needs Assessment, municipal water users in Cedar Valley agreed to assume that the State Engineer would mandate managing ground water production such that the average annual withdrawals would be limited to 37,600 ac-ft. (This value will be referred to as the "assumed sustainable yield" in this report.) This is higher than the minimum estimate of annual recharge from the USGS, (33,600 ac-ft per year) but is lower than the highest estimate of annual basin recharge (42,000 ac-ft per year). The 37,600 ac-ft per year sustainable yield assumption is based on annual recharge estimated by USGS (2005) for the future assuming existing

pumping conditions continue into the future. The USGS recently suggested 37,600 ac-ft per year could be considered the upper limit of sustainable yield under current pumping conditions, water management methods, and hydrology (USGS 2008).

Total M&I water use from the Cedar/Beaver Basin in CICWCD in 2005 was about 8,970 ac-ft (8,170 ac-ft per year of potable water use plus 800 ac-ft per year of secondary use) (DWRe 2007a, DWRe 2008a). Current agricultural ground water pumping in the Cedar Basin is about 29,000 ac-ft (Stanley Consultants 2007). Therefore the 2005 ground water production was about 37,970 ac-ft. This slightly higher than the minimum sustainable yield estimate of 37,600 from the USGS. Pumping in excess of the sustainable yield has led to a historical decline in ground water levels. The USGS analyzed water level data from 11 wells in the Cedar Basin with an average period of record of 55 years (1932 to 2003). The average rate of water level decline over that period was 0.4 ft/yr. The steady decline in ground water level suggests that the current rate of production is not sustainable, eventually resulting in decreases in well yields, increases in pumping costs, and decreases in water quality in the future.

The Utah State Engineer has the authority to regulate water supplies in the State, and has indicated that the current conditions in the Cedar Basin are not sustainable and must be changed. It is not certain how the State Engineer would choose to bring ground water production into closer alignment with the basin assumed sustainable yield. Similar conditions exist in other ground water basins in the state (e.g., Beryl/Enterprise area and Salt Lake City area), but there is not sufficient guidance from the State level to determine how the Cedar Basin would be addressed. The State Engineer has been meeting with local water users to discuss the situation, but has not developed guidelines at this time.

A ground water management program at the direction of the State Engineer is one possibility for aligning ground water production with the assumed sustainable yield of the basin. Such a program may necessitate curtailments of ground water production and likely transfers of water rights from the agricultural sector to the M&I sector just to meet existing demands. A portion of the overdraft may be curtailed by the State Engineer using the Prior Appropriation Doctrine (junior rights would be curtailed in favor of more senior rights). Additionally, given the greater ability of municipal water users to pay for water and the more critical nature of M&I uses to local economies, transfers from the agricultural sector to the municipal sector could also occur over time to bring total diversions more in line with the assumed sustainable yield of the aquifer. As M&I demand increases in the future in response to growth, additional transfers would be required. Based on experience elsewhere in the state, a ground water management program mandated by the State Engineer is likely to take many years to develop, and would be implemented gradually over a long period of time (perhaps 20 to 30 years).

If Cedar Basin ground water production is limited to the estimated assumed sustainable yield of 37,600 ac-ft per year strictly on the basis of water right seniority, municipal entities would be affected. **Table 4-8** summarizes the effects on the three major municipal water users within central Iron County of curtailing ground water production by water right seniority. However, the State Engineer has significant latitude in how specific overdraft situations are addressed, and can consider factors in addition to water right seniority such as socioeconomic impacts.

Table 4-8
Theoretical Curtailment of Municipal Cedar Basin Ground Water Development if Production is Limited to Sustainable Yield Based on Water Right Priority

Municipal Entity	Total Permitted Ground Water Rights in 2005 (ac-ft)[1,2]	Water Rights Curtailed by Seniority (ac-ft)[3]	Water Rights after Curtailment in 2005 (ac-ft)[3]
Cedar City	9,830	470	9,350
Enoch City	890	80	810
CICWCD	1,310	420	890
Total	12,030	970	11,060

Notes:
[1] Total permitted ground water rights is the sum of permitted well pumping and permitted withdrawal from springs.
[2] This analysis is based on water rights amounts; actual production has historically been less than the decreed water right.
[3] This analysis was completed using an assumed sustainable yield for the Cedar Valley Aquifer of 37,600 ac-ft per year.

4.2.4.2 Cedar Valley Aquifer Water Quality Considerations

Elevated concentrations of nitrates and total dissolved solids in Cedar Valley Aquifer ground water exist in locales within the basin and have been documented by the USGS (USGS 2005). The magnitude and distribution of nitrate and total dissolved solids concentrations in the aquifer and the potential effects on using the ground water as a water supply are discussed below.

Nitrate Concentrations
Various areas of the Cedar Valley ground water basin have high nitrate, NO_3, concentrations. Nitrate can be the result of natural and anthropogenic sources such as the leaching of nitrogen-bearing minerals in consolidated rocks, the application of fertilizer, and the application of wastewater effluent. To determine possible sources of nitrate concentrations, the samples can be analyzed for nitrogen-15 and oxygen-18 isotopes. The USGS performed a chemical analysis on water samples from 44 wells and 3 surface-water sites throughout Cedar Valley from 1999 to 2001 (USGS 2005). The results indicate ground water along the eastern margin of the basin between Cedar City and Enoch is unsuitable for domestic use because of high dissolved solids and nitrate concentrations (the drinking water maximum contaminant level for nitrate is 10 mg/L). Nitrate concentrations between Cedar City and Enoch are greater than 5 mg/L, and in some areas greater than 10 mg/L. One well located 8 miles north of Enoch had a nitrate concentration greater than 10 mg/L. Nitrate concentrations in the ground water for most of the southern, western, and northern parts of the valley are less than 1 mg/L. All of the surface water samples that were taken had nitrate concentration less than 0.1 mg/L. **Figure 4-7** shows the spatial distribution for nitrate during the sampling period.

Nitrate concentrations in the Enoch area have remained relatively constant from 1979-1999 which suggests that there has not been a deterioration in ground water quality (USGS 2005). Zones with elevated nitrate concentrations near Enoch and south along the eastern margin of the basin do not appear to be migrating beyond their previously noted extents. Some wells in the area have had fluctuations in nitrate concentrations but it is unclear whether the fluctuations are a result of a change in the well pumping level or are a result of a change in the spatial distribution of nitrate. Decreases in the nitrate concentrations could be due to withdrawal from areas with lower nitrate concentrations since the ground water levels have lowered. In contrast, increases in nitrate concentrations could be due to withdrawal from areas with higher nitrate concentrations and/or due to human influences such as mixing with waste-water effluent.

During 1976-1996 fields near a wastewater treatment plant located northeast of the Cedar City airport were irrigated with wastewater effluent. During the USGS study in 1999-2001 wells in the vicinity of the irrigated fields were sampled and analyzed for nitrate including the nitrogen-15 and oxygen-18 isotopes. The nitrogen-15 levels found in the water samples indicate the nitrate concentrations in the ground water are most likely the result of wastewater effluent recharging the ground water system in the area. However, no definitive conclusions can be

made identifying a single source as the constituent responsible for the increase in nitrate concentrations in the ground water (USGS 2005).

Elevated nitrate concentrations are important to M&I ground water supply in the Cedar Valley Aquifer because additional M&I supply will not be desirable from ground water with nitrate levels that are unsuitable for domestic use. As shown in Figure 4-7 there is an area of ground water directly southwest of Enoch City with nitrate levels that exceed the 10 mg/L drinking water standard for nitrate. Increased M&I withdrawal of ground water near Cedar City or Enoch City could create a ground water gradient that would induce flow of high nitrate ground water towards the M&I ground water wells. High levels of nitrate in some of the Cedar Valley Aquifer ground water suggest that Cedar Valley Aquifer should not be overdeveloped, in order to prevent an induced flow of high nitrate ground water towards existing or potential future M&I ground water wells.

Total Dissolved Solids

The Cedar Valley Aquifer also has various areas with high total dissolved solids (TDS) concentrations. The dissolved solids are transported by ground water flow in the aquifer resulting in higher TDS concentrations near Cedar City and lower TDS concentrations in the western portion of the basin. The USGS study reports that the TDS concentrations in isolated areas near Cedar City are greater than 1,500 mg/L and between 1,000 and 1,500 mg/L north of Cedar City (USGS 2005). The high concentrations make the ground water unsuitable for domestic use (the secondary maximum contaminant level for TDS in drinking water supplies is 500 mg/L). Ground water located in the western part of the basin and near Enoch has lower dissolved solids concentrations - less than 500 mg/L. **Figure 4-8** shows the spatial distribution for dissolved solids during the USGS study. As a result of high TDS concentrations near Cedar City, M&I supply is generally obtained from wells located west of Quichapa Lake (about 10 miles west of Cedar City) or wells near Enoch City (USGS 2005). Similar to the concerns described above for ground water with high nitrate concentrations, isolated areas of the Cedar Valley Aquifer with high TDS concentrations are a concern for existing and potential future ground water development. There is a potential for the high TDS ground water (with TDS greater than the drinking water MCL of 500 mg/L) to migrate towards M&I ground water supply wells (located north of Cedar City and west of Quichapa Lake, about 10 miles west of Cedar City) along ground water flow paths created as a result of drawdown that occurs at the water supply wells. As a result, overdevelopment of high quality ground water is not desirable in the future in order to prevent migration of high TDS ground water towards M&I ground water wells. The USGS (2005) study showed no substantial trend in TDS concentrations over time in the Cedar Valley Aquifer when current TDS concentrations were compared to historic data, other than minor differences in concentrations associated with differing pumping levels and migration of TDS.

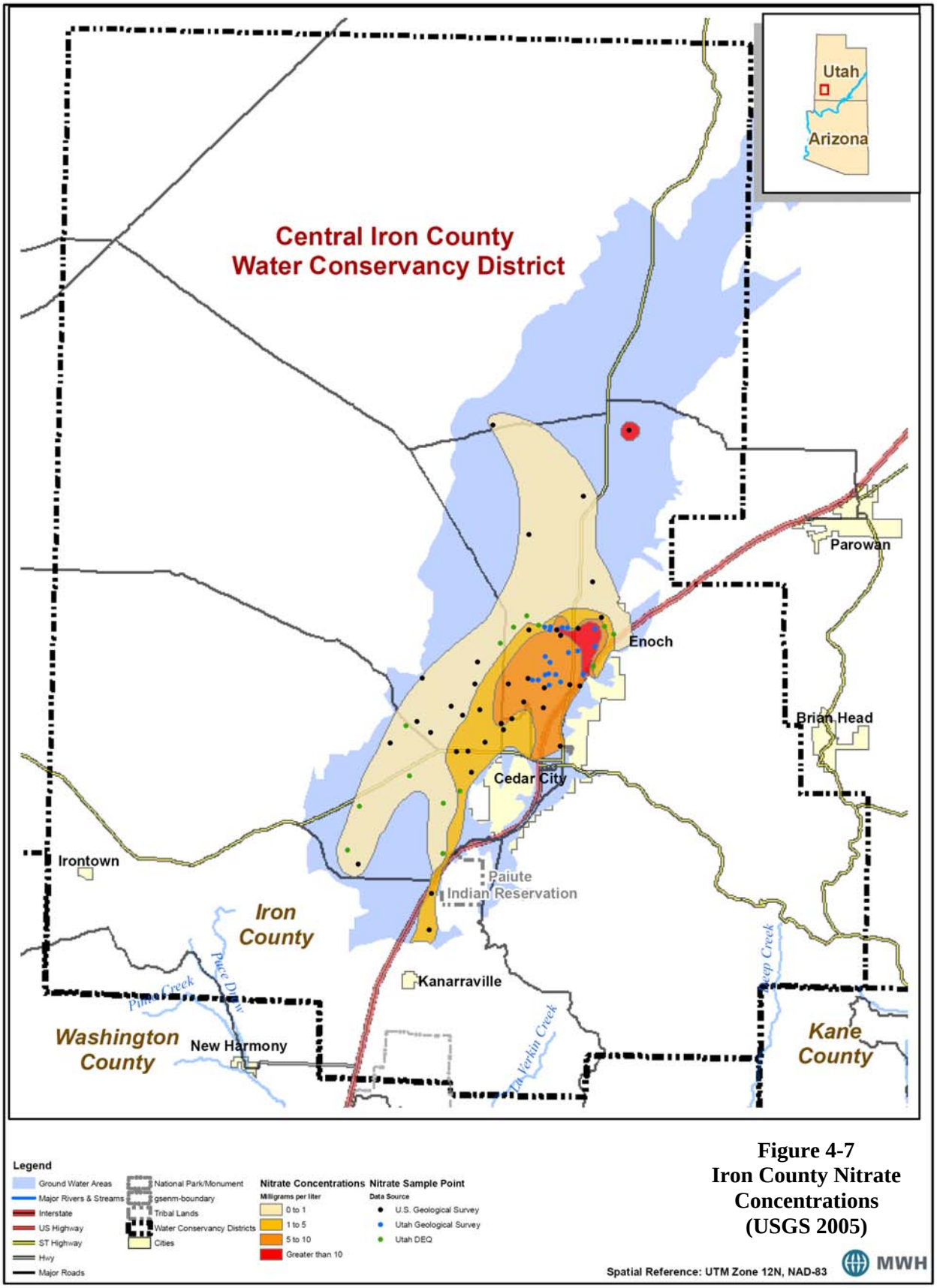


Figure 4-7
Iron County Nitrate Concentrations (USGS 2005)

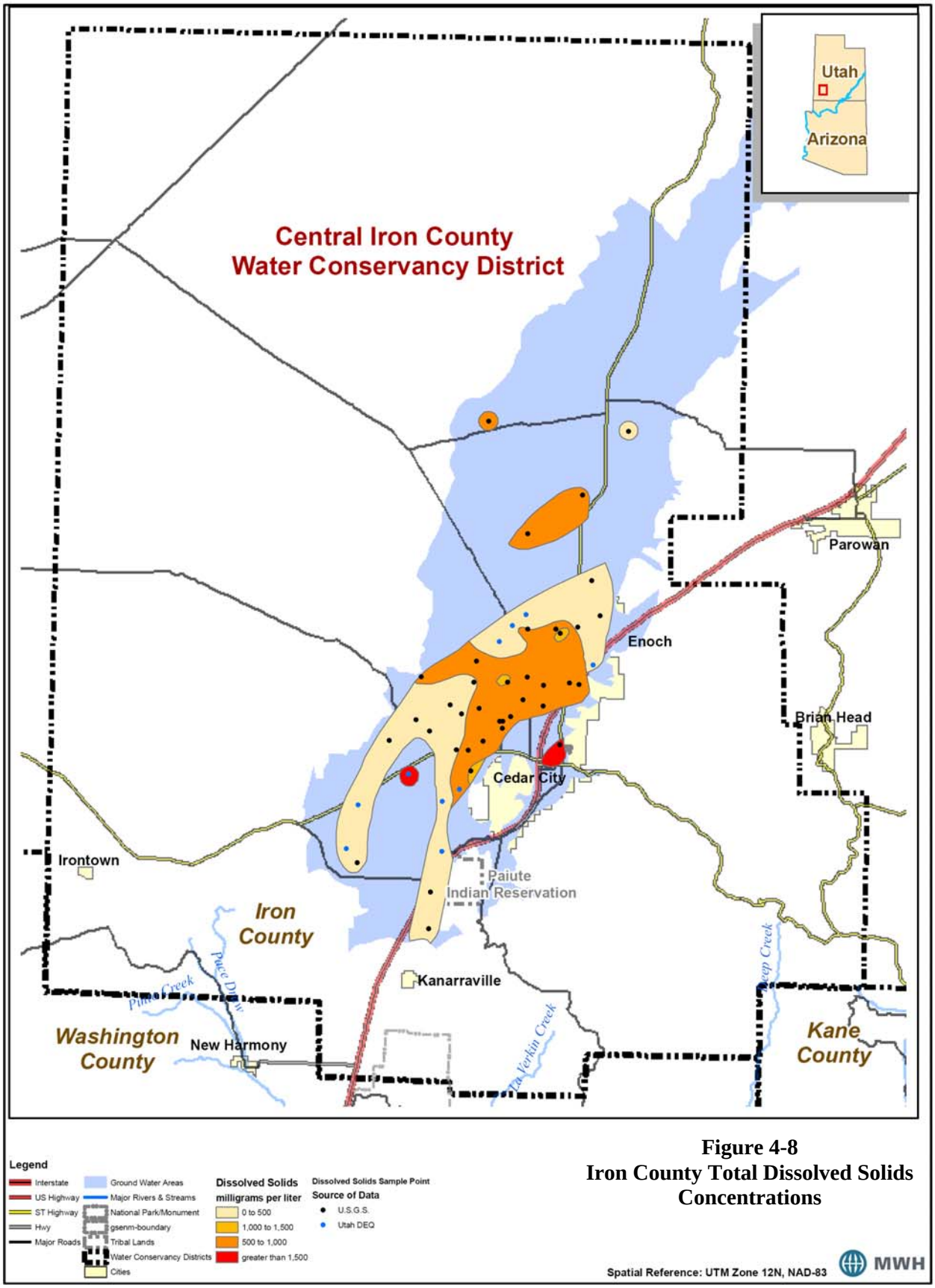


Figure 4-8
Iron County Total Dissolved Solids Concentrations

4.2.5 Planned and Potential CICWCD Water Projects and Sources

This section describes the planned and potential future water projects available to CICWCD and the other entities in the CICWCD service area. Until recently, each entity in Iron County was pursuing its own water sources in response to regional growth. Essentially this consisted of development of additional ground water supplies in the Cedar Basin and transfer of existing agricultural water rights to the M&I sector as development occurred. Cedar City and Enoch both have ordinances requiring new development to provide water supplies - or payment of a water development fee in lieu of water - as a condition of development approval. Cedar City requires developers to provide 1.5 ac-ft of water of annual supply per acre of development. In general, when water rights are provided they are associated with the land on which development is proposed to occur.

While the cities will continue to enhance their own water portfolios through acquisition of ground water rights associated with new development, they recognize that with the Cedar Basin sustainable yield issues other sources of supply will be needed. There is a growing willingness to cooperate regionally through the CICWCD to formulate and implement strategies to develop additional water supplies. For example, Cedar City has passed a resolution recommending that CICWCD seek an allocation of 20,000 ac-ft per year from the LPP to assist in meeting its future needs.

Figure 4-9 shows the general location of potential future water supply projects for CICWCD.

4.2.5.1 CICWCD Projects

CICWCD has plans to extend its existing infrastructure to serve future growth areas within its service boundary, and to build a regional distribution system that can be used to deliver imported water to its own retail customers as well as to wholesale customers such as Cedar City, Enoch and Kanarraville. Details of the planned infrastructure improvements are described in the CICWCD Capital Facilities Plan (Stanley Consultants 2007). All additional water supplies would come from acquisition of ground water rights (primarily associated with dedication of water associated with new developments) or from imported water. As development occurs over irrigated areas, water associated with those developments would be transferred to CICWCD and supplied on a just-in-time basis. This process would result in the progressive transfer of agricultural water rights to the M&I sector.

At present, the only imported water project currently anticipated by CICWCD is the LPP. CICWCD is currently requesting 20,000 ac-ft per year from the LPP. Several approaches for making this water available to retail and wholesale customers in Cedar Valley are being considered, including ground water recharge and construction of a regional water treatment plant to deliver treated water. These approaches are described in the CICWCD Capital Facilities Plan. A regional distribution system would be required to deliver LPP water to customers in Cedar City and Enoch, and to the two identified major industrial users (WECCO and Palladon Mine) in the eastern part of the service area.

Importing Lake Powell water could have an effect on the water quality of the existing Cedar Valley Aquifer ground water supply because of a difference in water quality between the two sources. Lake Powell source water from the top 100 feet has TDS concentrations that range from 350 to 600 mg/L, and the TDS concentrations in five major Cedar City and Enoch City ground water supply wells range from 210 to 410 mg/L. A portion of the imported Lake Powell water would infiltrate to the Cedar Valley Aquifer and would tend to increase the TDS of the local ground water supply towards the higher TDS concentrations of the Lake Powell water. The Lake Powell water has TDS concentrations that exceed the drinking water secondary MCL of 500 mg/L. As a result, treatment of a portion of the Lake Powell water with advanced treatment such as reverse osmosis or blending with other low TDS surface water supplies, may be necessary to maintain the existing water quality of the local ground water.

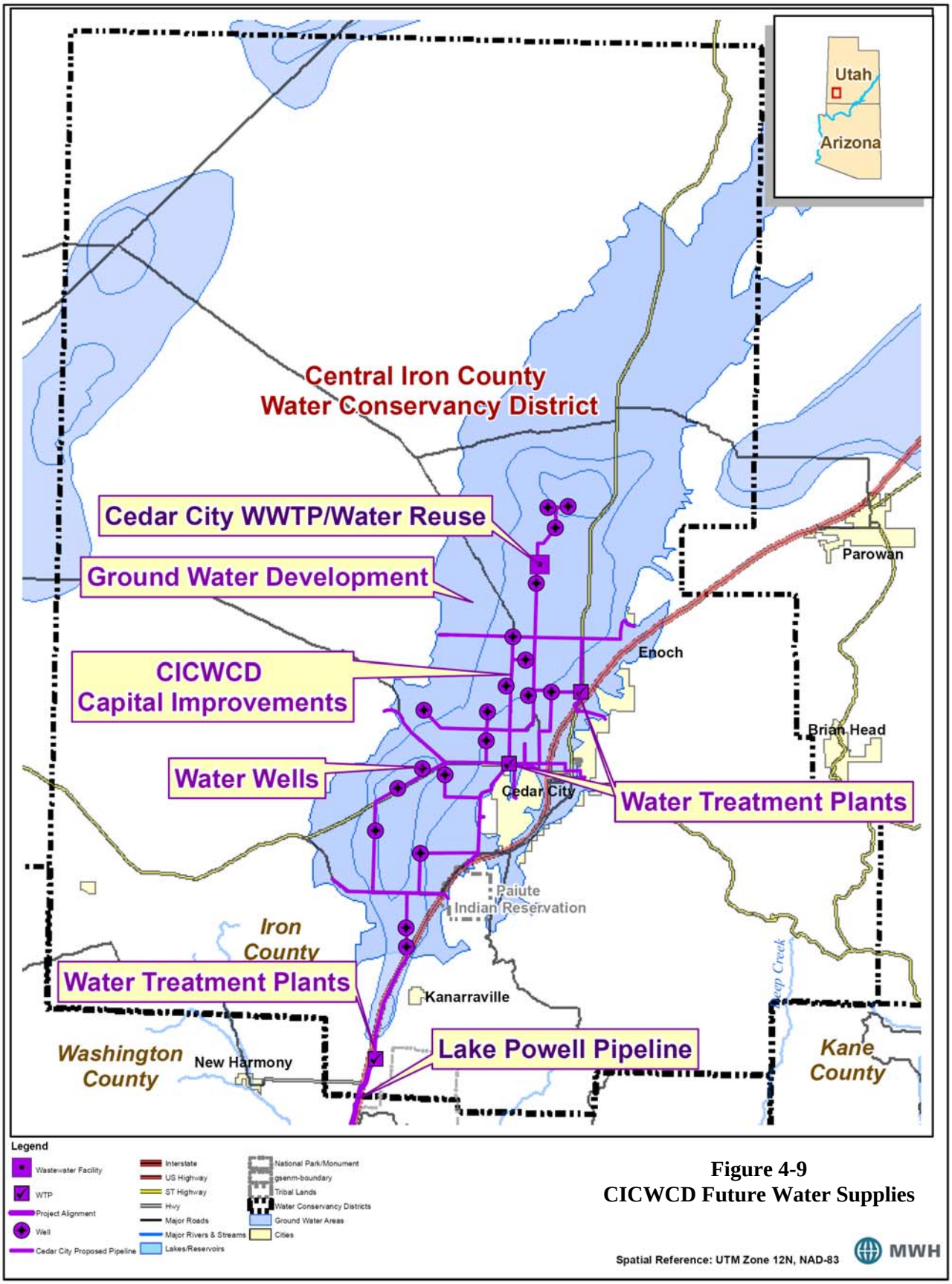


Figure 4-9
CICWCD Future Water Supplies

4.2.5.2 Cedar Valley Ground and Surface Water Development

The sustainable Cedar Valley ground water basin yield for purposes of LPP water supply planning is assumed to be 37,600 ac-ft; additional ground water resources can not be safely (or, after regulations are imposed by the State Engineer, legally) developed.

Surface water rights are owned by agricultural interests and by the municipal entities (e.g., Cedar City holds 2,580 ac-ft of surface water rights on Coal Creek). However, because the Cedar Valley is a closed basin and all surface water runoff recharges the local ground water basin, development of additional surface water resources will reduce ground water recharge and decrease the sustainable yield from the Cedar Basin. The assumed sustainable yield value of 37,600 ac-ft includes all ground and surface water supplies in the basin. Therefore it is not possible to rely on development of additional surface water resources to meet future demand increases.

4.2.5.3 Water Reuse

Water reuse options for the CICWCD area must be evaluated carefully. Normal water reuse strategies will not necessarily create new supplies because of the closed basin situation in Cedar Valley. Reclamation and reuse of water that currently recharges the ground water basin, for example, would not generate new water supplies since it would reduce the sustainable ground water yield by a like amount.

Existing secondary water systems are limited in the CICWCD areas. As described in **Section 4.2.3**, Cedar City and Enoch City have existing secondary water supply systems that could be expanded to supply additional secondary water to both M&I and agricultural water users. Cedar City currently uses a pressurized irrigation system that delivers irrigation water to parts of the city (Olmstead 2007). Enoch City is developing a pressurized secondary supply system that will deliver ground water from wells to residential customers (Brough 2007). Both the Cedar City and Enoch City secondary systems could be expanded in the future to meet secondary M&I demands if wastewater reuse becomes a viable option. CICWCD and Cedar City both have plans to extend secondary systems into areas of new development to maximize use of untreated water for outdoor irrigation. This system could be used to deliver reclaimed wastewater to M&I secondary water customers.

The Cedar City regional wastewater treatment plant currently provides secondary treatment of wastewater from Cedar City, Enoch City, and about 140 residential taps located in Iron County. A portion of wastewater treated at the regional wastewater plan could potentially be reused. The Cedar City regional wastewater treatment plant treated about 2,600 ac-ft per year of wastewater in 2005. During the growing season the treated effluent is applied to a 400 acre land application site consisting primarily of grasses and alfalfa. During the winter months the effluent water is applied to existing natural vegetation consisting of grasses and sage brush. A local farmer uses the land for sheep and cattle grazing. None of the effluent is stored, and flood irrigation with piping and ditches is used to distribute the water (Olmsted 2007).

An estimate of this potential reuse is provided in this report, and will be updated during Phase II of the Lake Powell Pipeline Water Needs Assessment. The following assumptions were made in order to estimate the potential wastewater reuse supply for CICWCD:

- Reuse would be technically and economically feasible for effluent treated at the Cedar City regional wastewater treatment plant only, because other wastewater generated within CICWCD is not routed through a centralized wastewater treatment plant where reuse would be economically and technically feasible (i.e., wastewater is primarily treated using septic systems). The wastewater potentially available for reuse was assumed to be limited to projected wastewater from Cedar City and Enoch City as a result.
- The ratio of wastewater effluent to raw water supply was calculated based on 2005 wastewater data from Cedar City and 2005 M&I use from DWRe M&I use and supply reports. The 2005 ratio indicated that

wastewater was 34 percent of M&I water supply (Stathis 2007). This ratio was assumed to remain constant through the study period to estimate projected wastewater.

- Wastewater associated with supplies originating from outside the Cedar Valley Aquifer (e.g., Lake Powell Pipeline) was considered 100 percent reusable.
- Reuse of wastewater associated with supplies originating from the Cedar Valley Aquifer (e.g., existing and future Cedar Valley Aquifer ground water supply) would be limited to the amount of reuse that would not affect recharge to the closed Cedar Valley ground water basin. Wastewater associated with supplies originating from the Cedar Valley Aquifer was considered 53 percent reusable. This assumption was based on the amount of water that would be saved if the current practice of spreading treated wastewater for irrigation was discontinued if reuse were initiated. The 53 percent value is based on the consumptive use portion of the irrigation use of treated wastewater (Stanley Consultants 2007), which would be reusable if the practice was discontinued.

Using the assumptions described above, maximum potential reuse in 2060 would be approximately 7,420 ac-ft per year if water was imported from outside Cedar Valley Aquifer, and 5,940 ac-ft per year if demands were fully met with supplies originating from the Cedar Valley Aquifer. The actual amount of reuse would also be restricted by monthly demand for secondary water generated through reuse. Because water use varies by month, as discussed in **Section 3.2.4**, the monthly supply of reuse water available for secondary supply also varies. The monthly pattern from **Figure 3-13** was used to calculate monthly influent to the wastewater treatment plant, based on predicted annual water demand. An estimate of the potential demand for reclaimed wastewater in the CICWCD service area was estimated for this report, and will be reviewed more closely in Phase 2 of the Water Needs Assessment. The resulting maximum potential for reuse supply in 2060 was calculated to be about 3,000 ac-ft per year based on projected secondary M&I demand (i.e., secondary demand only occurs during the outdoor irrigation season from late spring to early fall). The current secondary water use of 800 ac-ft per year is not reuse of treated wastewater, but is secondary water use diverted from Coal Creek through irrigation canals. Use of reclaimed wastewater would require construction of a separate delivery system tying into the existing and proposed secondary water system. Neither CICWCD nor Cedar City is currently proposing wastewater reclamation as a future water source.

Reuse of wastewater effluent would likely affect water quality of Cedar Valley Aquifer ground water. Concentrations of total dissolved solids of 500 to 1,000 mg/L are common near Cedar City, with concentrations up to 1,500 mg/L (**Section 4.2.4.2**). Reuse of sewage effluent in the Cedar Valley basin would increase concentrations of dissolved solids unless advanced water treatment (e.g., reverse osmosis) was used to remove dissolved solids with each successive reuse of wastewater effluent. Infiltration of a portion of the reuse wastewater (e.g., infiltration of turf irrigation runoff to the aquifer) would increase total dissolved solids concentrations. Reuse of wastewater effluent without proper removal of total dissolved solids may adversely affect use of the Cedar Valley Aquifer for potable water supply due to total dissolved solids concentrations in excess of the drinking water quality secondary maximum contaminant level of 500 mg/L.

4.2.5.4 Agricultural Water Conversions from M&I Development

As stated previously, expansion of developed areas in the Cedar Valley will result in conversion of irrigated land to developed land. **Figure 4-10** shows the relative location of irrigated croplands to urban areas in Iron County. Irrigated croplands are represented by the areas shaded in green, while urban areas are colored black. Within Central Iron County, there is significant irrigated cropland near the major urban areas of Cedar City and Enoch which could be converted for M&I uses in the future. The CICWCD Capital Facilities Plan estimated that approximately 4,140 acres of agricultural land will be converted to municipal and industrial use between 2005 and 2050 using the GOPB 2005 baseline population projections plus 25 percent. The projected amount of converted irrigated lands was adjusted by applying the ratio of 2008 baseline GOPB population projects for Iron County to the population projections used in CICWCD's CFP. The same rate of conversion of agricultural lands for 2040 through 2050 was used to extend the projections for agricultural conversion through 2060. Based on these

methods, about 4,360 acres of irrigated lands are expected to be converted to M&I use by 2050 and 5,320 acres by 2060.

Figure 4-11 provides a detailed image showing the relative location of existing irrigated lands to anticipated future annexation areas for Cedar City. The background image for the figure is a Color Infrared Air Photo in which the red shading represents areas of active photosynthesis. The distinct circular and square shaded areas are existing irrigated croplands. The yellow outline that overlays the infrared image represents expected areas of future urban growth and M&I water demand. Especially to the northwest of Cedar City, the proposed annexation areas are relatively close to multiple plots of irrigated cropland that could be converted for M&I use once the areas become developed.

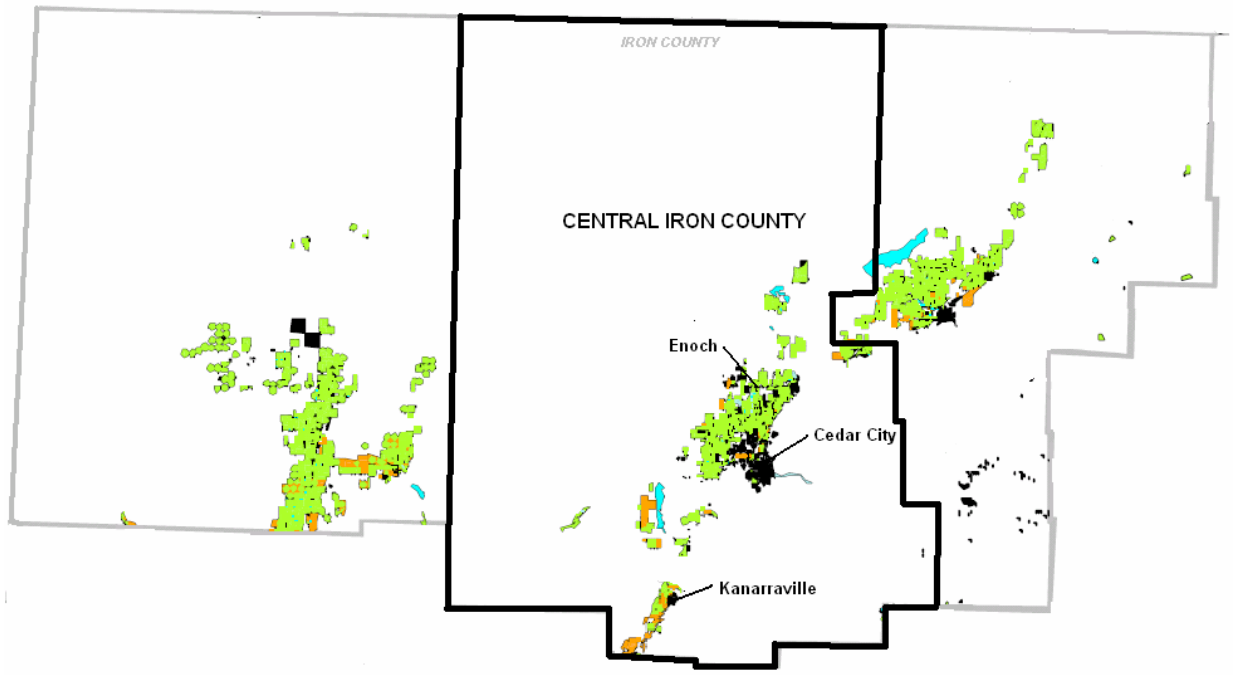
Based on the Utah State Engineer's policy of water rights conversions, agricultural water rights can be converted to M&I rights at a rate of 100 percent of the existing agricultural diversion, assuming the consumptive use of the water would not be increased and the new right is within the same basin as the old right. For purposes of this report, it was assumed that conversion of agricultural water rights to M&I water rights would not increase the consumptive use of the water right because the consumptive use for M&I water uses is typically less than (e.g., for indoor M&I use) or equal to (e.g., for outdoor turf irrigation) that for agricultural use.

Using the same assumptions described in **Section 4.2.4.1** for future ground water management plans for Cedar Valley Basin, approximately 34 percent of all agricultural ground water rights would be curtailed based on water right priority to meet the sustainable yield of 37,600 ac-ft per year. It was assumed that this same ratio would apply to agricultural water that would be transferred to the M&I sector due to development over irrigated lands. As a result, 66 percent of the projected agricultural water rights conversions were assumed to provide water supply to CICWCD.

A conversion of approximately 14,060 ac-ft per year of agricultural water to M&I use by the year 2060 was assumed for CICWCD based on the projected land use and conversions of agricultural water rights described above. The timing of agricultural conversions would be related to factors not readily quantifiable, including future economic trends and local farm land values.

Enoch City has acquired a portion of the potential agricultural water rights conversions between the period of existing conditions for this report (i.e., 2005) and the year of publication of this report (i.e., 2008). According to Enoch City, approximately 900 ac-ft per year of additional ground water rights supply were acquired between 2005 and 2008 (Brough 2008). Of the 900 ac-ft per year of additional supply, approximately 300 ac-ft per year was acquired through buy and dry of agricultural land and the remaining 600 ac-ft per year was acquired from conversion of agricultural water rights associated with land that either is currently or will be developed for M&I purposes. The 600 ac-ft per year of supply associated with M&I development over land previously used for agricultural purposes is assumed to be included in the overall CICWCD potential supply from agricultural water rights conversions associated with M&I development described above. The 300 ac-ft per year of buy and dry supply acquired by Enoch City will be accounted for as potential future supplies within CICWCD separate from agricultural water rights conversions associated with M&I development.

Figure 4-10
Iron County Water-Related Land Use



Source: Modified from (DWRe 1999)

Notes: [1] Map Color Code: Green = Irrigated Cropland, Orange = Non-Irrigated Cropland, Blue = Water, Black = Urban

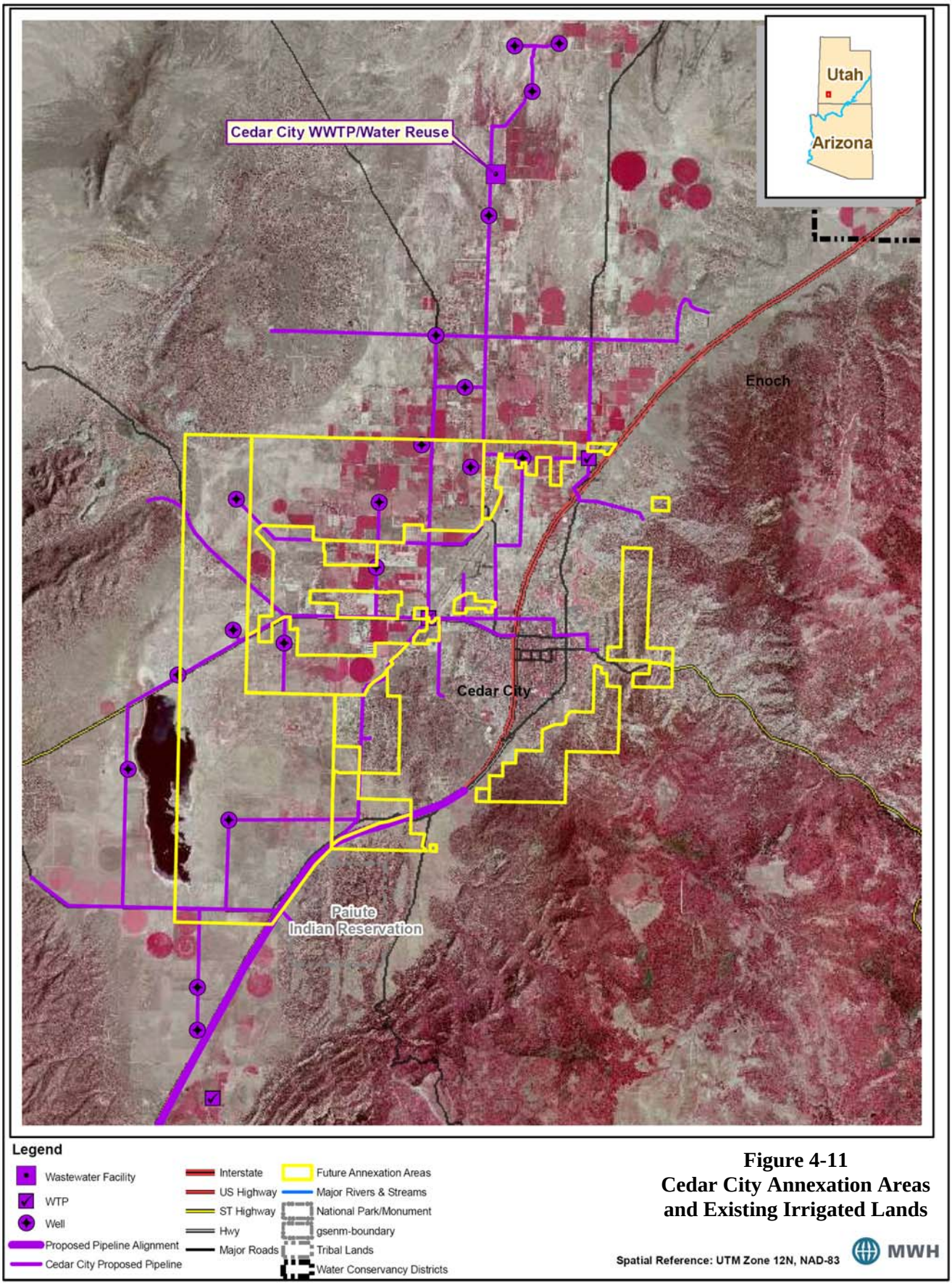


Figure 4-11
Cedar City Annexation Areas and Existing Irrigated Lands

4.2.5.5 Agricultural Water Conversions from Buy and Dry

None of the Central Iron County water providers have plans to purchase irrigated lands specifically for the purpose of acquiring the water rights ("buy-and-dry"). They are committed to maintaining the viability of agriculture as an important economic factor and as a way of life in the Cedar Valley. However, as described above, it is assumed that agricultural water conversions would occur in response to economic pressures tied to action by the State Engineer to limit ground water production to the sustainable yield. Buy and dry may be necessary if no other water supply from outside the basin is acquired. The potential supply from buy and dry of agricultural water rights is described in this section to provide an estimate of potential supply if no other water supplies became available for CICWCD in the planning period. Although none of the Central Iron County water providers plan to buy and dry existing agricultural water rights, Enoch City purchased approximately 300 ac-ft per year of water rights in 2008 (Brough 2008). Enoch City has no plans to purchase additional water rights through buy and dry in the near future.

Current irrigated agricultural acreage in Cedar Valley is about 13,735 acres (Stanley Consultants 2007). Each acre of irrigated agricultural land would account for approximately 4.0 ac-ft per year of potential agricultural water use resulting in 54,940 ac-ft of irrigation water rights. As discussed in **Section 4.2.5.4**, approximately 34 percent of the irrigated lands converted to M&I use would have water rights that would be curtailed in a theoretical ground water management plan based strictly on seniority of water rights. It is estimated that approximately 36,260 ac-ft of irrigation water was available in 2005. According to the Basin Plan, ground water supplies 58 percent of irrigation water used (DWRe 1995) resulting in 21,030 ac-ft per year.

Acquisition of over 5,320 acres of irrigated lands by 2060 is expected to convert about 14,060 ac-ft of agricultural water for M&I use. Acquisition of the remaining agricultural lands relying on ground water for irrigation, 2,640 acres, would result in 6,970 ac-ft per year of new supply through "buy and dry", as shown in **Table 4-9** (assumed 4.0 ac-ft per year per acre and 34 percent curtailment of water rights due to seniority-based ground water management plan). The amount of the remaining irrigation water that would actually be transferred is impossible to determine at this time, as it would be a function of economic conditions and other factors.

Table 4-9
Estimate of Potential Irrigated Water Right Conversions - CICWCD

Item	Water Use[1] (ac-ft/yr)	Irrigated Acreage (acres)
2005 Irrigated Agricultural Acreage	**36,260**	**13,735**
2005 Existing Agricultural Ground Water Use[2]	21,030	7,960
2060 Agricultural Water Rights Conversion due to M&I Development[3]	14,060	5,320
Maximum Potential Agricultural Water Right Conversion by Buy and Dry Program[4]	6,970	2,640
2060 Irrigated Agricultural Acreage[5]	**15,230**	**5,775**

Notes:
[1] Assumed water right conversion of 4.0 ac-ft per year per acre (DWRi 2008b) and 34 percent curtailment of water rights due to seniority-based ground water management plan.
[2] Assumed ground water provides 58 percent of irrigation supply (DWRe 1995)
[3] Calculated using the CICWCD CFP and methods discussed in **Section 4.2.5.4**
[4] Assumed maximum potential buy and dry would comprise all remaining agricultural ground water use after M&I development. Assumed water conversion of 4.0 ac-ft per year per acre (DWRi 2008b) and 34 percent curtailment of water rights due to seniority-based ground water management plan.
[5] Represents the remaining 42 percent of irrigation water attributable to surface water (DWRe 1995); assumed maximum buy and dry program

4.2.5.6 Additional Ground Water Pumping

Entities within the CICWCD service area could fully develop their appropriated Cedar Valley Aquifer ground water rights for future water supply, within the limitations of the sustainable aquifer yield. Several entities have currently developed something less than their total appropriated ground water rights, and the additional supply could be developed up to the assumed sustainable yield of 37,600 ac-ft per year for the Cedar Valley Aquifer. For this analysis, it was assumed that the Utah State Engineer would eventually implement a ground water management plan for the Cedar Valley Aquifer, which would permit ground water users to develop ground water rights assuming a strict priority system would be used to determine which rights would be curtailed to limit total Cedar Valley Aquifer ground water pumping to 37,600 ac-ft per year. Ground water rights for both springs and ground water wells for the three largest municipal water users in the basin (Cedar City, Enoch City, and CICWCD) were estimated to be equal to total municipal rights. Total ground water rights for the major municipal suppliers after the impending curtailment by the Utah State Engineer equal 15,770 ac-ft per year (11,060 ac-ft per year of ground water pumping rights as shown in **Table 4-8,** plus 4,710 ac-ft per year of springs rights). Total springs rights were estimated using springs rights for Cedar City, because Cedar City is the only entity within the CICWCD service area with substantial springs supply (DWRe 2007a). Existing reliable supply for CICWCD was described in **Section 4.2.3** to be about 12,160 ac-ft per year (11,360 ac-ft per year reliable potable supply plus 800 ac-ft per year reliable secondary supply). Based on these values, entities within the CICWCD service area could develop an additional 3,610 ac-ft per year of additional ground water (total ground water rights minus existing reliable supply) under their current water rights without threat of future curtailment by a seniority-based ground water management plan.

4.2.5.7 Water Imports from Surrounding Areas

CICWCD and the cities in Iron County have researched potential sources of water from areas surrounding Iron County. It has been concluded that there are no other regional supplies that can be developed for the District. To the west, the Beryl/Enterprise ground water basin is already over-appropriated. Similarly, to the north the Milford Valley and Parawon Valley basins are currently over-appropriated. Importing water from the Beaver Valley would be politically unacceptable because it is needed to meet future demands in that area. Washington County is to the south and, as described previously, supplies will be fully developed to meet future needs in that area.

The Central Iron County Water Conservancy District has filed on 37,000 acre-feet of water (likely maximum yield of 10,000 to 20,000 ac-ft/yr) in the Pine, Hamblin, and Wah-Wah Valleys northwest of Cedar City. These filings, collectively termed “West Basin ground water rights” in this report, have been the subject of numerous protests filed with the Utah Division of Water Rights. The favorable approval and future development of these filings at present is highly uncertain. Expected yield from these rights would have a maximum yield of 10,000 to 20,000 acre-feet per year. As a result of the uncertainty associated with these rights, reliable yield from the West Basin ground water rights was assumed to be zero in the integrated water resources plan for CICWCD described in **Chapter 6**.

4.2.5.8 Lake Powell Pipeline

CICWCD, with the support of Cedar City and Enoch City, has requested delivery of 20,000 ac-ft per year from the Lake Powell Pipeline. The Utah Board of Water Resources has not formally committed to support the full amount of this request at this time. LPP water would be delivered in a pipeline generally following the I-15 corridor from the south. Water could be treated in a new water treatment plant for direct M&I use, or recharged to the Cedar Valley ground water basin for withdrawal in the existing municipal well system.

4.2.5.9 Summary of Future Water Supplies

Table 4-10 summarizes the potential future developable water supplies in the CICWCD service area. The local basin is considered over-appropriated by the State Engineer, therefore, development of new surface and ground water rights is not an option. Importing water from Southern Utah is also not an option for future water development because all surrounding basins are also currently over-appropriated or will be used to meet future local demands.

Table 4-10
Summary of Future Developable CICWCD Source Waters

Source	Maximum Potential Yield (ac-ft/yr)	Comments
New Local Surface Water Rights	0	Basin is considered over-appropriated by State Engineer and new surface water development would reduce ground water yield.
Development of Existing Local Ground Water Rights	3,610	Develop up to total existing ground water rights for Cedar City and Enoch City, limited by an assumed sustainable yield of 37,600 ac-ft per year
Agricultural Conversions from Development over Irrigated Land	14,060	Rate of conversion modified from Capital Facilities Plan. Would result in conversion of approximately 5,320 acres of land by 2060.
Water Reuse Capacity	3,450	Wastewater effluent currently recharges ground water basins. New supply from in-basin wastewater reuse limited to saved evapotranspiration losses. Actual amount of reuse would be limited to 2,470 ac-ft/yr in 2060 by projected secondary water demand.
M&I Acquisition of Agricultural Water "Buy and Dry"	6,970	Dependent on future M&I demand. "Buy and dry" program resulting in dry-up of 2,640 acres of irrigated lands discussed in the No Action Alternative (**Section 6.1.3)**
Lake Powell Pipeline	20,000	CICWCD has requested 20,000 ac-ft from LPP
West Basin Ground Water Rights	0 – 20,000	No certainty of short-term development; expect significant objections to water right filing. Filed on 37,000 ac-ft/yr but yield would be less as shown.
Imported Water from Southern Utah	0	All surrounding basins are currently over-appropriated or will use local supplies to meet future local demands
Total Potential Yield	**48,090 – 68,090**	Includes all potential sources

4.3 Kane County Water Conservancy District

This section describes existing and future planned and potential water supplies for entities within the KCWCD.

4.3.1 Kane County Water Supply Overview

All existing M&I supplies in Kane County are derived from ground water resources (wells and springs). Most existing water supplies in Kane County are derived from ground water from the Navajo Sandstone Aquifer. This ground water is of high quality, and is used directly for culinary purposes after disinfection. Because of its proximity to Zion National Park and the Grand Staircase - Escalante National Monument, Kane County is a partner in an agreement with WCWCD and others that limits its well production and ground water development by prohibiting removal of water supplies from the Monument.

KCWCD encompasses parts of four different watershed basins: (1) Kanab Creek/Virgin River, (2) Southeastern Colorado River, (3) Western Colorado River, and (4) Sevier River. Surface and ground waters are considered to be fully appropriated at this time in the Kanab Creek/Virgin River and Southeastern Colorado River Basins. New diversions and uses must be accomplished by change applications filed on owned or acquired existing rights. Changes between surface and underground sources are reviewed to indicate hydrologic connection, that underlying rights are not enlarged or that there is no potential for interference with existing water rights.

However, ground water applications for isolated locations in Kanab Creek Basin and ground water and/or surface water applications for domestic purposes in Southeastern Colorado River Basin will be allowed on an individual basis. Within the Western Colorado River Basin surface water is fully appropriated. In areas outside of public system boundaries, ground water applications are limited to indoor uses for one family with one acre of irrigation and 10 head of stock. Locations within the Sevier River Basin are remote relative to the probable Lake Powell Pipeline water delivery points in Kane County. As a result, locations in the basin would not be served by the pipeline and the basin is not considered in this report.

The Navajo Sandstone Aquifer is the primary water source for the Kanab and Johnson Wash drainages. The water from the Navajo Sandstone Aquifer is usually of good quality. However, throughout the Kanab Creek and Johnson Wash drainage areas both good and poor water quality is found. The ground water at lower elevations of the basins tends to have poorer quality due to soluble minerals that are discharged from some geological formations. (DWRe 1993) As a result, the water from the lower elevations of the basins can only be used as secondary water unless treated by advanced processes such as reverse osmosis (Noel 2007).

4.3.2 KCWCD Existing Water Supplies

KCWCD is a new water conservancy district, formed in 1992. It has a very limited customer base and limited supply sources at present. The only substantial community in Kane County - the City of Kanab - has developed its own water supply system over time, and may continue to meet the needs of M&I customers within its current city boundaries, and within future annexation areas as well. However, it is possible that the City of Kanab may request water supply from the Lake Powell Pipeline in order to supplement its water supply portfolio.

There are four subbasins within Kane County that were considered independently for the summary of water supply and demand because transfers of water supply between the subbasins are not allowed by the Utah State Engineer. Consequently, water supply and demand was calculated for each of the four subbasins to forecast water supply needs for each of the subbasins. The four subbasins considered for Kane County are the East Fork Virgin River basin, the Kanab Creek basin, the Johnson Canyon basin, and the Wahweap Creek basin as shown in **Figure 2-4**.

Existing KCWCD customers are rural developments located in the Cedar Mountain and Johnson Canyon areas. KCWCD owns and operates its own wells in the Johnson Canyon area to meet these demands. The reliable potable supply available from this well system is 96.3 ac-ft (DWRe 2008a). **Figure 4-12** shows the general location of the existing KCWCD supply sources.

A summary of the reliable potable water supply sources for all of Kane County is provided in **Table 4-9** and existing reliable supplies are described separately for each of the four basins in subsequent sections. Reliable potable water supplies for KCWCD are 3,542 ac-ft per year, which includes Kane County minus Fredonia, AZ and National Park Service Bullfrog Recreation Site. Reliable secondary supply for Kane County is 497 ac-ft per year (DWRe 2008a; DWRe 2006c). The total reliable supply for KCWCD is 4,039 ac-ft per year (3,542 ac-ft per year reliable supply plus 497 ac-ft per year secondary supply).

Table 4-11
Reliable Potable Water Supplies - Kane County

Water Supplier	Reliable Potable Water Supply (ac-ft/yr)			
	Springs	Wells[1]	Surface	Total[1]
Alton [2]*	33.9	0.0	0.0	33.9
Church Wells Special Service District**	0.0	180.9	0.0	180.9
East Kanab Water Company*	0.0	0.0	0.0	0.0
Glen Canyon Special Service District #1 (Big Water)**	0.0	362.0	0.0	362.0
Glendale Town Corp. [2]*	104.8	14.9	0.0	119.7
Kanab Municipal Water System*	104.8	2,181.6	0.0	2,286.4
Kane County WCD (Johnson Canyon) [3]*	0.0	96.3	0.0	96.3
National Park Service Bullfrog Recreation Site[4]***	0.0	120.9	0.0	120.9
Orderville Town Water System [2]*	79.1	384.1	0.0	463.2
Fredonia (AZ) [5]*	362.9	217.2	0.0	580.1
Total KCWCD (Kane County minus Fredonia, AZ and National Park Service Bullfrog Recreation Site) [6]	322.6	3,219.8	0.0	3,542.4

[1]Wells are limited to 50% of their "maximum" capacity for reliable supply when well/pump capacity is the limiting factor. Springs and surface water supplies are equal to their respective "maximum" capacities.
[2] Service from the LPP to these water suppliers is dependant on the final pipeline alignment selected during future phases of the study.
[3]Two wells, one with 50 ac-ft per year capacity and the other with 60 ac-ft per year capacity (updated from DWRe 2008a)
[4]Would not be served by the Lake Powell Pipeline and is not located within any of the four subbasins being considered. Not included as reliable potable water supplies for KCWCD.
[5]Fredonia, AZ receives its water supply from Kane County, but it is not located within the county and is not included in the population or water demand values reported in **Chapter 3**. Therefore, Fredonia supplies are not included in the existing reliable potable supply total for Kane County.
Sources: *(DWRe 2008a); ** (DWRe 2006); ***(DWRe 2007b)
[6]Total KCWCD reliable potable water supplies include Kane County minus Fredonia, AZ and National Park Services Bullfrog Recreation Site. These two entities are excluded because they are located outside the KCWCD service area and would not be served by the Lake Powell Pipeline.

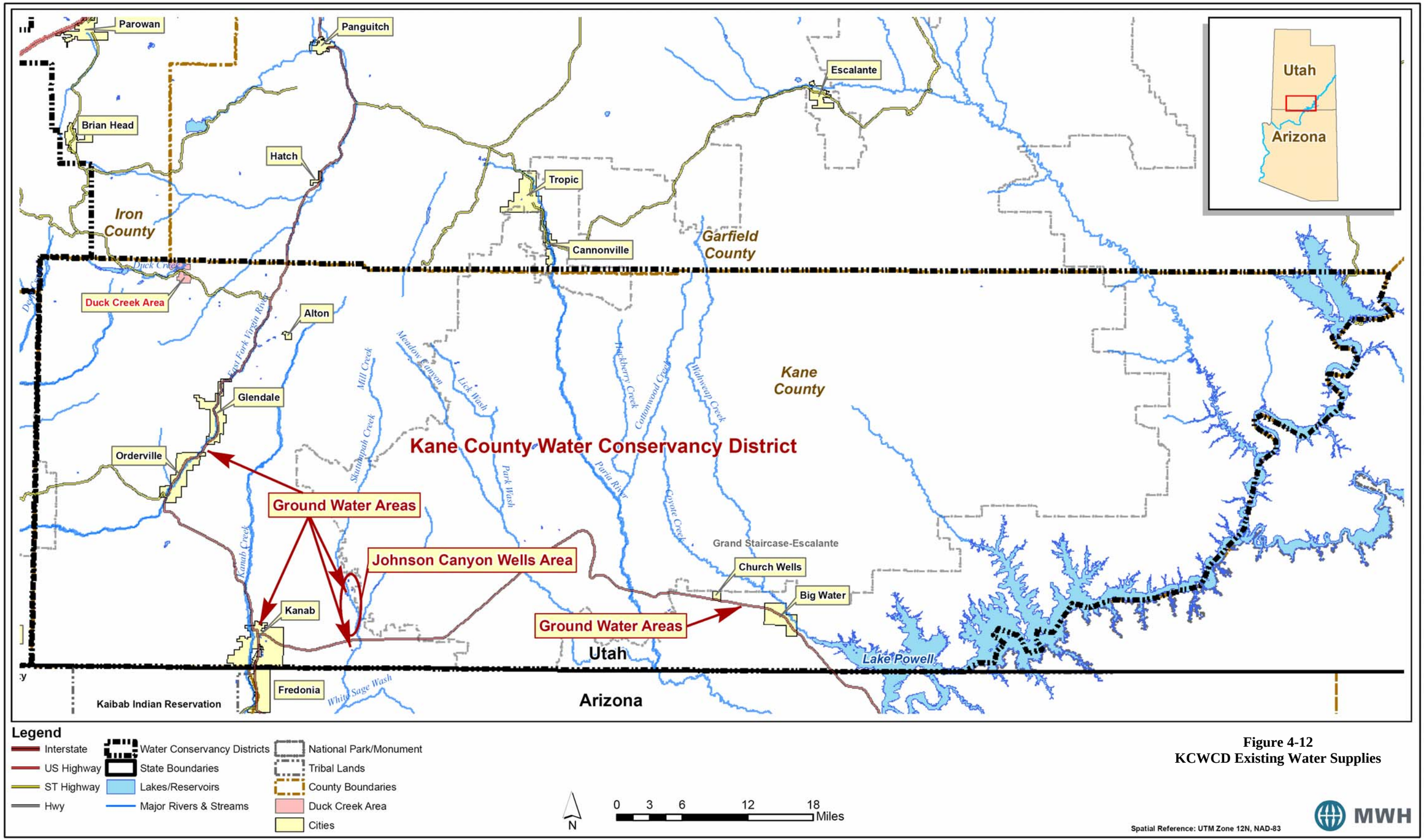


Figure 4-12
KCWCD Existing Water Supplies

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4.3.3 Kane County Existing Municipal and Industrial Supplies

Existing municipal and industrial supplies for each of the four subbasins in Kane County are described by summarizing reliable water supply for the public water suppliers within the four subbasins.

4.3.3.1 East Fork Virgin River Subbasin

Public community water systems in the East Fork Virgin River subbasin include the towns of Glendale and Orderville. Reliable potable and secondary water supplies for the basin are summarized in **Table 4-12**. The total reliable water supply for the basin is the combined culinary and secondary supply of 845 ac-ft per year (DWRe 2008a). Annual total potable use for 2005 was 295 ac-ft per year or 51 percent of the reliable potable water supply.

Table 4-12
Reliable Water Supplies – East Fork Virgin River

Water Source	Reliable Supply (ac-ft/yr)		
	Potable	Secondary	Total
Glendale Town Corp.	119.7	89.0	208.7
Orderville Town Water System	463.2	173.0	636.2
Total	**582.9**	**262.0**	**844.9**

4.3.3.2 Kanab Creek Subbasin

Public community water systems in the Kanab Creek subbasin include the towns of Alton and Kanab. Reliable potable and secondary water supplies for the basin are summarized in **Table 4-13**. The total reliable water supply for the basin is the combined culinary and secondary supply of 3,481 ac-ft per year (DWRe 2008a). Annual total potable use for 2005 was 1,530 ac-ft per year or 60 percent of the reliable potable water supply. Fredonia, AZ receives its water supply from Kane County, but it is not located within the county and is not included in the population or water demand values reported in **Chapter 3**. Therefore, Fredonia supplies are not included in the existing reliable potable supply total for Kanab Creek Subbasin.

Table 4-13
Reliable Water Supplies – Kanab Creek

Water Source	Reliable Supply (ac-ft/yr)		
	Potable	Secondary	Total
Alton	33.9	169.1	203.0
Kanab	2,286.4	65.8	2,352.2
Total	**2,320.3**	**234.9**	**2,555.2**

4.3.3.3 Johnson Canyon Subbasin

Public community water systems in the Johnson Canyon subbasin include Kane County WCD and East Kanab Water Company. Reliable potable and secondary water supplies for the basin are summarized in **Table 4-14**. The total reliable water supply for the basin contains only potable supply totaling 96.3 ac-ft per year (DWRe 2008a). Annual total potable use for 2005 was 37 ac-ft per year or 38 percent of the reliable potable water supply.

Table 4-14
Reliable Water Supplies – Johnson Canyon

Water Source	Reliable Supply (ac-ft/yr)		
	Potable	Secondary	Total
Kane County WCD (Johnson Canyon)	96.3	0.0	96.3
East Kanab Water Company	0.0	0.0	0.0
Total	**96.3**	**0.0**	**96.3**

4.3.3.4 Wahweap Creek Subbasin

Public community water systems in the Wahweap Creek subbasin include two public community water systems. Reliable potable and secondary water supplies for the basin are summarized in **Table 4-15**. The total reliable water supply for the basin contains only potable supply totaling 543 ac-ft per year (DWRe 2006c). Annual total potable use for 2005 was 188 ac-ft per year or 35 percent of the reliable water supply.

Table 4-15
Reliable Water Supplies – Wahweap Creek

Water Source	Reliable Supply (ac-ft/yr)		
	Potable	Secondary	Total
Glen Canyon Special Service District #1 (Big Water)	362.0	0.0	362.0
Church Wells Special Service District	180.9	0.0	180.9
Total	**542.9**	**0**	**542.9**

4.3.4 KCWCD Future Supplies - Planned

M&I water suppliers in Kane County anticipate using additional ground water production to meet increased future water demands. The amount of ground water available for development in Kane County without exceeding the sustainable yield of the basin was estimated from the ground water balance presented in the Kanab Creek/Virgin River Basin Plan (DWRe 1993). Average annual aquifer recharge and discharge and estimated ground water production in 2005 for the four Kane County subbasins are summarized in **Table 4-14**. DWRe Basin Plans were used to calculate the aquifer water balance for each subbasin, however, because well withdrawal information in the Basin Plans is outdated due to changes in water use since they were published. The more recent M&I reports were used to update the ground water pumping portion of the ground water balance. There was a total of approximately 8,100 ac-ft per year of undeveloped ground water between the four subbasins that would be available for development in the future, with the greatest amount of available ground water in the Johnson Canyon subbasin (4,100 ac-ft per year). However, there are substantial water quality issues that may limit the use of any additionally available ground water supply. Water quality diminishes from the upper portions of the four subbasins to the lower portion of the subbasins. For example, TDS concentrations increase in the lower part of the Kanab Creek subbasin to an extent that any available additional supply near the city of Kanab would only be of sufficient quality for secondary use.

The State Engineer has determined that no new ground water permits will be issued in Kane County. A review of existing records determined that the total of adjudicated ground water rights in the four subbasins within KCWCD is approximately 59,500 ac-ft per year (1,400 ac-ft per year in the East Fork Virgin River subbasin, 25,300 ac-ft per year in the Kanab Creek subbasin, 20,400 ac-ft per year in the Johnson Creek subbasin, and 12,400 ac-ft per year in the Wahweap subbasin). Total ground water use from the four subbasins was approximately 5,600 ac-ft per year in 2005 (3,100 ac-ft per year M&I ground water pumping and 2,500 ac-ft per year agricultural pumping). Thus well users could increase their production by approximately 53,900 ac-ft per year and remain within their permitted withdrawal rates. With the assumed total sustainable yield for the four subbasins within KCWCD of approximately 49,000 ac-ft per year reported in **Table 4-14** this would result in ground water depletions. For this study it is assumed that future ground water production should be limited to the assumed sustainable yield of the basin.

Table 4-16
Kane County Subbasins - Ground Water Balance

Mass Balance Component	Average Annual Volume (ac-ft)			
	East Fork Virgin River Basin [2]	Kanab Creek Basin[3]	Johnson Canyon Basin[3]	Wahweap Creek Basin[4]
Ground Water Recharge				
Precipitation infiltration	14,900	13,000	10,800	1,580 - 3,220
Streamflow infiltration	-	-	-	-
Subsurface inflow	2,800	3,100	2,500	-
Total Recharge	**17,700**	**16,100**	**13,300**	**1,580 - 3,220**
Ground Water Discharge				
Seepage into streams	11,400	4,100	3,400	-
Flow from springs/drains	2,800	400	300	1,260 - 2,900
2005 M&I ground water use[1]	560	2,330[5]	40	190
Agricultural Well Withdrawal[6]	810	770	890	0
Evapotranspiration	1,100	3,100	2,500	40
Subsurface outflow	unknown	2,500	2,100	-
Total Discharge	**16,700**	**13,200**	**9,200**	**1,490 - 3,120**
Available for Development	**1,000**	**2,900**	**4,100**	**100**

Notes and Sources:
[1]All values from Basin Plans except well withdrawal are from 2005 M&I Water Use Reports. Besides well withdrawal, all values are calculated based on a percentage of acreage within the Kane County boundary that was calculated with geographic information system (GIS) software. Well withdrawals include 2005 potable and secondary water use.
[2]East Fork Virgin River Subbasin within Kane County boundary = 225,000 acres. Located within the Upper Virgin River Basin (832,000 acres). Sources: (DWRe 1993; DWRe 2008a)
[3]Kanab Creek Subbasin within Kane County boundary = 212,000 acres. Johnson Canyon Subbasin within Kane County boundary = 177,000 acres. Both are located within the Kanab Creek and Johnson Wash Basin (416,000 acres). Sources: (DWRe 1993; DWRe 2008a)
[4]Wahweap Creek Subbasin within Kane County boundary = 262,000 acres. Located within the Kaiparowits Plateau Ground water Basin (1,376,000 acres). Sources: (DWRe 2000; DWRe 2006c)
[5]Fredonia, AZ water use was included to get an accurate estimate of the amount of water available for development.
[6]10 percent of total agricultural diversions are assumed to originate from ground water sources (DWRe 1993). See **Section 4.3.5** for discussion on agricultural water use calculations, total water diversions in 2005 were 24,730 ac-ft/yr. The percentage of irrigated lands for each of the four subbasins (Table 4-17) was used to calculate agriculture well withdrawal for each subbasin.

KCWCD has plans to construct Jackson Flat Reservoir south of Kanab. Jackson Flat Reservoir will be a 4,000 ac-ft facility to supply secondary and agricultural irrigation water to CII users that are currently served by well water. The reservoir would store surface water diversions that have typically been used by the Kanab Irrigation Company (approximately 7,500 ac-ft per year) in order to maximize the efficiency of the use of these agricultural diversions. Diversions would be stored in the reservoir throughout the year and would be available during irrigation season when demands are highest. Locations of potential future water supplies for KCWCD are shown in **Figure 4-13**.

KCWCD has requested delivery of 10,000 ac-ft of water annually from the LPP. The most likely delivery point for Lake Powell Pipeline water to KCWCD would be to a proposed water treatment plant in Johnson Canyon. Of the requested 10,000 ac-ft per year LPP diversion, KCWCD would be allowed 4,000 ac-ft per year of depletions to the Upper Colorado River Basin based on Colorado River Compact requirements and the agreement between KCWCD and DWRe for diversion of Lake Powell water supply. Delivery of LPP water in Kane County would have to be made such that a maximum total depletion to the Upper Colorado River Basin would be 4,000 ac-ft per year. The entire 10,000 ac-ft could be used to meet demands within the Southeast Colorado River Basin (e.g., Big Water and Church Wells), which would have return flows that return to the Upper Colorado River Basin. A maximum delivery of 4,000 ac-ft per year could be delivered to basins outside of the Upper Colorado River Basin

(e.g., the basins that Kanab and Orderville are located within), assuming no deliveries within the Upper Colorado River Basin.

The proposed Lake Powell Pipeline would have a limited service area within KCWCD. The proposed pipeline alignment is conveniently located to serve the Big Water, SITLA and Kanab areas. Although Kanab and Big Water currently have their own ground water-based supplies, KCWCD could agree to provide LPP water to these communities either in addition to ground water development when demand exceeds the allowable ground water supply, or in lieu of ground water development to allow additional ground water resources to be developed in communities that are not located near the LPP. In this way LPP water would free up use of additional ground water in the more remote and rural parts of Kane County. The Lake Powell Pipeline would not serve the Sevier River Basin because of its remote location relative to the pipeline alignment.

KCWCD would either store LPP water in a new surface reservoir, or use it to recharge ground water aquifers such as in the Johnson Canyon area to extend the life of the ground water basin. Lake Powell water would have lower TDS (approximately 350 to 600 milligrams per liter) relative to ground water in the lower portions of the Kanab Creek and Johnson Canyon subbasins (up to 1,200 milligrams per liter TDS). Consequently, if Lake Powell water was used to recharge the aquifers at these points of currently high TDS ground water, the Lake Powell water may improve the local ground water quality at the recharge locations. However, there are also locations in the Kanab Creek and Johnson Canyon subbasins with better water quality than Lake Powell (i.e., 200 to 300 milligrams per liter TDS). Recharge of Lake Powell water at these locations would decrease local ground water quality. KCWCD has considered constructing a pipeline from the LPP to the Orderville/Glendale area to meet future demands in that region of the District.

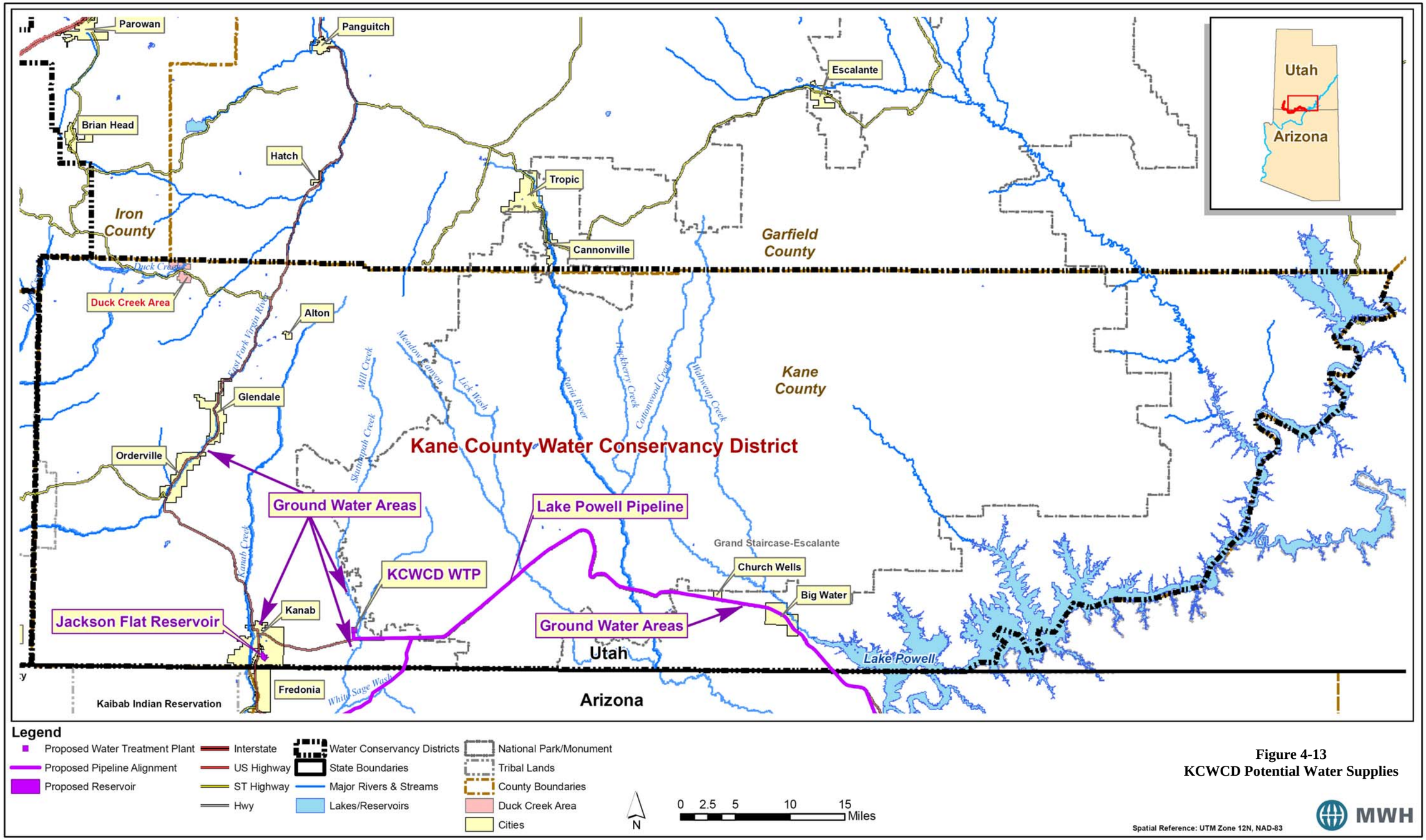

Figure 4-13
KCWCD Potential Water Supplies

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4.3.5 KCWCD Future Supplies - Potential

In addition to development of new ground water, existing agricultural water supplies could be converted to M&I use, either through growth over currently irrigated lands or through "buy and dry" programs. Agricultural land exists in Kane County in three of the four subbasins considered in this report: the East Fork Virgin River, Kanab Creek, and Johnson Canyon subbasins. There is no agricultural water use in the Wahweap Creek subbasin which is located in the Southeast Colorado River Basin. There were a total of approximately 8,570 acres of agricultural land in 2007 within Kane County, of which 2,970 were irrigated acres and 5,600 were non-irrigated agricultural acres (DWRe 2008ab). Irrigated agricultural acreage in 2007 and the associated agricultural water use (based on an agricultural diversions estimate of 4.0 ac-ft per year per acre of irrigated land for East Fork Virgin River Basin and 5.0 ac-ft per year per acre for Kanab Creek and Johnson Canyon Basins) are shown in **Table 4-17.** In order to calculate the amount of water available from potential agricultural water rights conversions to M&I use, it was assumed that the entire agricultural diversion right would be able to be transferred to M&I use (i.e., not just the consumptive use portion). The consumptive use for the new M&I water right was assumed to be no greater than the existing agricultural consumptive use. Although **Table 4-17** indicates that there is a total of 13,550 ac-ft per year of agricultural water use, it would not be reasonable to assume that all agricultural water use would be transferred to M&I. It was assumed that 20 percent of existing irrigated agricultural land could potentially be either developed for M&I purposes of purchased through "buy and dry" programs. Thus, there would only be a total of approximately 2,710 ac-ft per year of water supply available to M&I from existing irrigated agricultural (**Table 4-18**).

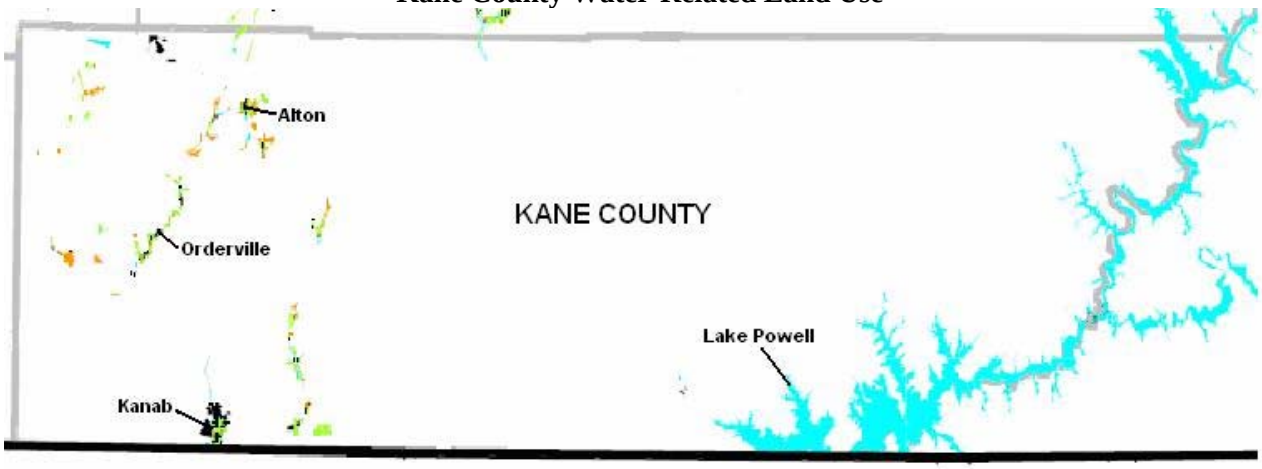
Table 4-17
Kane County Subbasins – 2007 Estimated Agricultural Water Use

Subbasin	Irrigated Lands (acres)[(1)]	Agricultural Water Diversions (ac-ft/yr)[(2)]
East Fork Virgin River Basin	1,312	5,250
Kanab Creek Basin	662	3,310
Johnson Canyon Basin	997	4,990
Wahweap Creek Basin	0	0

Notes:
[(1)]Source of irrigated land data: DWRe (2007d)
[(2)]Based on assumed agricultural water diversions of 4.0 ac-ft per year per acre of irrigated agricultural land for East Fork Virgin River Basin and 5.0 ac-ft per year per acre for Kanab Creek Basin and Johnson Canyon Basin. (DWRi 2008b) Also assumed that the entire agricultural water right would be able to be converted (diversions) and not just the consumptive use portion (depletions).

Figure 4-14 outlines the relative location of irrigated croplands to urban areas. Irrigated croplands are represented by the areas shaded in green, while urban areas are colored black. The significant irrigated lands are located in the Johnson Wash and East Fork Virgin River floodplains. Agricultural conversions in the East Fork Virgin River area could supply future M&I demands in Orderville and Glendale. Agricultural conversions in the Johnson Wash area could serve Kanab and Fredonia if a conveyance system were constructed to deliver the water from the Johnson Wash basin to the Kanab Creek basin.

Figure 4-14
Kane County Water-Related Land Use



Source: Modified from (DWRe 1999)

Notes: [1] Map Color Code: Green = Irrigated Cropland, Orange = Non-Irrigated Cropland, Blue = Water, Black = Urban

4.3.6 Summary of Potential Developable KCWCD Water Supplies

Table 4-18 summarizes the potential developable supplies to meet future demands in the KCWCD service area. KCWCD previously owned approximately 30,000 ac-ft per year of additional water rights referred to as the Andalex water rights. However, the District recently leased these rights to a nuclear power plant project in Emery County off the Green River. The water rights were leased on a 40-year term with a 30-year renewal option. The lease payment for the rights is planned to be used by the District to help pay for the District's portion of the cost for the Lake Powell Pipeline project.

Table 4-18
Potential Developable KCWCD Supplies

Source	Maximum Potential Yield (ac-ft/yr)				Comments
	East Fork Virgin River Basin	Kanab Creek Basin	Johnson Canyon Basin	Wahweap Creek Basin	
New Ground Water Production	1,000	2,900	4,100	100	Limited by assumed ground water sustainable yield of 49,000 ac-ft per year
Agricultural Water Conversion	1,050	660	1,000	0	Assumed 20% of irrigated agricultural water use could be transferred to M&I. Estimate is based on full conversion of agricultural diversions to M&I diversions assuming no increase in consumptive use.
Lake Powell Pipeline	0 – 4,000	0 – 4,000	0 – 4,000	0 – 10,000(1)	KCWCD has requested 10,000 ac-ft from LPP which would be limited to 4,000 ac-ft/yr of total depletions to the Upper Colorado River Basin. Supply would be divided among the 4 subbasins based on need.
Total Potential Yield	**2,050 – 6,050**	**3,560 – 7,560**	**5,100 – 9,100**	**100 – 10,100**	

Notes:
(1) Wahweap Creek Basin is within the Upper Colorado River Basin, and as a result could receive the full 10,000 ac-ft per year request from the Lake Powell Pipeline if maximum depletions associated with the delivery would be 4,000 ac-ft per year.

Chapter 5 - Water Conservation Programs

Water conservation is an important component of any future water supply plan, particularly for communities in the arid southwest United States. This chapter describes existing water conservation programs adopted by entities within each of the LPP District service areas, and describes their recent effectiveness in reducing per capita water use rates. The discussion in this chapter supports the development of assumptions for future water conservation used in the water need forecast analysis described previously in **Chapter 3**.

The discussion in this chapter represents Phase 1 of the conservation analysis that is part of the LPP Water Needs Assessment Study. Phase 2 will include a more detailed evaluation of potential conservation measures, including analyzing billing data from local water providers and working with local stakeholders to identify locally acceptable conservation measures that could be effective and affordable in the future.

5.1 Introduction

Utah is one of the five fastest growing states in the nation and is the second driest state in the country (only Nevada is drier). The population growth rate coupled with the semi-arid climate makes water conservation and demand management vital components in utilizing Utah's limited water resources. The state of Utah set a water conservation goal of reducing the 1995 per capita water demand from public community systems by at least 25 percent before 2050 (DWRe 2003). Based on recent progress in implementing water conservation programs and measures, the state revised the goal to be 25 percent reduction from 2000 per capita water use by 2050. DWRe estimated that the state of Utah achieved a 12 percent water use reduction between 2000 and 2005 and as a result the state's remaining goal is a 13 percent reduction statewide from 2005 to 2050. However, the state goal for specific communities is to achieve 25 percent reduction in per capita use from 2000 to 2050 regardless of statewide conservation from 2000 to 2005. As a result, the state's goal is 25 percent reduction from 2000 to 2050 for communities that have not achieved the statewide 12 percent reduction in per capita use.

As new water projects such as the Lake Powell Pipeline Project are considered, the state of Utah is promoting water management in terms of demand reduction to assure efficient water use. In 1998 and 1999 the Utah legislature passed and revised the Water Conservation Plan Act, which required water conservancy districts and water agencies with more than 500 drinking water service connections to submit water conservation plans to the Utah Division of Water Resources by April 1999. The water conservation plans guide the conservancy districts and water agencies in their water conservation activities for the next five years (DWRe 2003).

Cities and water districts within Washington, Iron and Kane Counties that exceed the 500 service connection limit are required to develop conservation plans that outline conservation goals, programs and methods for implementing the programs in their area. This section reviews the water conservation plans the cities and conservancy districts have implemented thus far in Washington, Iron and Kane Counties and the conservation savings these methods may have produced. For the purpose of this report, water conservation is defined as reducing municipal and industrial per capita water use, because these are the demand sectors that would be served by supplies from the Lake Powell Pipeline.

5.2 Washington County

5.2.1 Background

To meet the water needs for future growth, to support Utah's M&I Water Conservation Plan, and to comply with the state's requirement of a conservation plan for water districts and agencies with 500 or more service connections, Washington County has become a leader in conservation in Utah and continues to enhance its conservation programs.

Five cities and one water conservancy district have adopted water conservation plans in Washington County: Washington County Water Conservancy District, and the cities of St. George, Santa Clara, Washington, Hurricane, and La Verkin (WCWCD 2007b).

In August of 1993 a Long Term Framework for Water Resource Management, Development, and Protection Plan was approved by WCWCD, which stated that WCWCD would develop a water conservation plan. The same month a Water Conservation and Drought Management Committee comprised of water users including realtors, landscape professionals, irrigators, and concerned citizens was formed with the objective of examining water conservation practices that could be implemented within Washington County. From this committee's recommendations the first conservation plan was created and adopted in May 1996. It should be noted that WCWCD created a water conservation plan and began implementing it in 1998, before conservation plans were required by the state of Utah in 1999 (WCWCD 2003). The conservation plan was revised on December 31, 2003 and was submitted to the state in April 2005. In 2005 WCWCD also required all of its wholesale water customers to adopt water conservation plans (WCWCD 2007b).

The goals of the 1996 Washington County Water Management and Conservation Plan (WCWMCP), which was revised in 2003, are to conserve water through the improvement of surface water quality, seepage and evaporation reduction, drought management, watershed enhancement, irrigation practice improvements, public education, and conservation ordinance establishment.

The cities of St. George, Hurricane and La Verkin adopted conservation plans in 2002; Ivins City passed its conservation plan in 2003; Washington passed a conservation plan in 2004; and Santa Clara adopted its plan in 2005. All six cities are required to have water conservation plans because they have more than 500 service connections, based on the state of Utah's requirements. Additionally, WCWCD has several conservation requirements for its customers as part of the Regional Water Supply Agreement described in **Section 4.1.2**, which includes requiring a conservation plan and limitations on water use (e.g., time of day turf irrigation restrictions).

5.2.2 Conservation Programs

5.2.2.1 Washington County Water Conservation District

Since the completion of the original WCWMCP in 1996, WCWCD hired a conservation coordinator and the implementation of water conservation programs in Washington County began. Educating the public and professional landscapers has been a primary focus for WCWCD and the cities. Several educational methods that have been implemented by WCWCD are water conservation demonstration gardens; annual water fairs; school outreach programs; water conservation packets; a weather station website on evapotranspiration; and conservation tips in local newspapers, radio stations and television programs. The WCWCD also partnered with the Environmental Protection Agency (EPA) in the *WaterSense Program*.

To educate the public and landscape professionals on water-efficient landscaping, WCWCD, along with other agencies, decided to construct a demonstration garden in the fall of 2002. Self-guided tours, with the assistance of pamphlets and kiosks, allow visitors to learn about the importance of soil composition and fertilization; weather and climate; irrigation practices and technology; and plant design and selection. The garden also displays four distinct landscaping themes: Desert Highlands; Urban Desert; Desert Shrublands; a Native Garden; and Desert Oasis. To further assist the public with water-efficient landscaping a list of water-wise plants was developed by WCWCD and Utah State University Extension. Along with the garden, monthly workshops are hosted by WCWCD to give the public an opportunity to learn about water-wise practices from experts in the field.

WCWCD participates in a Water Fair that reaches approximately 1,500 elementary school students annually. The fair is hosted at Dixie State College where the students participate in presentations and a water jeopardy contest that addresses water treatment, water properties, water infrastructure, and water conservation.

The cities associated with WCWCD are given water conservation packets to hand out to new water utility customers. The packets contain information about water conservation programs offered, water-wise landscaping principles, local water conservation resources, and contact information for the local water conservation specialist.

Evapotranspiration (ET) values are used by landscape professionals and homeowners to gauge the landscape irrigation needs. WCWCD along with USU and St. George worked with Irrisoft to create a website that reports ET values based on data from three weather stations.

To further educate the public on conservation programs WCWCD launched a media campaign in 2000 to disseminate information via radio, television, newspapers and direct mailing. WCWCD also participates in the Governor's Conservation Team media campaign, which started in 2002. The goal of the campaign is to maintain a conservation ethic among Utahans and to effectively manage the state's water supply. Furthermore WCWCD supports the State designated water week to create awareness of water issues facing the state.

To educate professional landscapers and to encourage them to promote water conservation practices, Irrigation Association courses and Dixie Applied Technology Courses (DATC) that teach water efficient landscape management have been held. The Irrigation Association courses were held from 2001 to 2003 and included Irrigation System Design and Maintenance as well as Certified Landscape Irrigation Auditor. The DATC courses were geared toward landscape professionals but were also well received by homeowners. The courses offered were Water Efficient Turf Management and Planting for Success.

Water rebates have also been offered to homeowners to encourage the use of Smart Water Applied Technology (SWAT) devices that update irrigation controllers based on plant water needs, weather information and soil moisture sensors. The rebates are only offered if the homeowners participate in Water Checks. Water Checks were first offered by WCWCD in 2005 along with the Slow the Flow program. WCWCD staff runs several tests that evaluate the irrigation system's efficiency and application rate. The homeowners are given appropriate irrigation schedules and suggestions on how to improve their water efficiency.

WCWCD is also working with BYU and the state to identify water-wise plants and irrigation practices that will thrive in Washington County. BYU is conducting studies in which Virgin River water is being applied to plants to determine their salt tolerance and ability to survive on low water consumption. This will provide information on what plants will be best suited for secondary water use. WCWCD is also supporting the state's Utah Water-wise Plant Tagging program, a program that assists Utah citizens in identifying water-wise plants. The plants must be: water-wise; adaptable to Utah's arid climate and cold winters; available in the industry; relatively easy to maintain in the landscape; and have desirable landscape characteristics which remain desirable under limited water availability.

In addition WCWCD is matching grants for public athletic fields irrigated by culinary water when retrofitted with artificial turf (Breckenridge 2007b). WCWCD also completes a golf course water budget for each course that obtains irrigation water from the District, and charges a 50 percent surcharge for irrigation water for golf courses that exceed the budgeted water supply. County-wide impact fees have also been implemented for all new construction based on the size of the irrigable portion of the lot (WCWCD 2008b).

To minimize water loss and enhance the accuracy of measuring water right allocations, a telemetry project that monitors diversions along the Santa Clara River and Virgin River has been executed (WCWCD 2008b). Another conservation method that reduces irrigation water use is the conversion of open canals to pipelines; this method conserves water from ditch loss and evaporation. The St. George and Washington Canal Company replaced 9.2 miles of open canal with pipeline, the Gunlock Santa Clara pipeline replaced flood irrigation, and canals in La Verkin and Hurricane have been replaced with pipelines.

To discourage excessive water use all cities have time-of-day watering restrictions and the following cities have also converted to an increasing block rate structure: Springdale, Hurricane Valley, La Verkin, Ivins, Washington, Santa Clara, St. George, Enterprise, and Hurricane. **Table 5-1** gives a list of the various water conservation programs WCWCD has implemented since 1996 (WCWCD 2007b; 2008b).

Table 5-1
WCWCD Water Conservation Programs (WCWCD 2007b)

Category	Title	Description
Water Conservation Demonstration Garden	Educational Resource	A demonstration garden showing the art of water-efficient landscaping
	Monthly Workshops	Water-efficient landscape workshops taught by community experts
	Washington County Water-wise Plant List	List of water-wise plants for Utah climate
Media	Local Media Campaign	Uses local radio, TV, newspaper and direct mailing for dissemination of information
	Governor's Conservation Team	Uses media to unify the conservation message throughout the state among the different agencies
	State Water Week	Supports the State designated water week to create awareness of water issues facing Utah.
	Printed Material	Monthly ads in local publications on water saving tips and water conservation information
	EPA *WaterSense Program*	Began a partnership with the EPA in the *WaterSense Program*
Education and Outreach	Annual Water Fair	1,500 4th & 5th grade students participate in presentations and trivia contests about water education on water treatment, water properties, water infrastructure, and water conservation
	School Outreach Program	District staff members serve as resources to educators
New Arrival Water Survival Kit	Water Conservation Packets	District distributes water conservation information to cities to be handed out to new water utility customers
Conservation Education and Certification	Irrigation Association Courses	District hosts annual Irrigation Association certification courses to train and certify landscape professionals
	DATC Courses	A program created to educate landscape professionals and homeowners in water efficient landscape management.
Weather Station Link and Website	Evapotranspiration Website	Evapotranspiration values are provided on a website for landscape professionals and homeowners to gauge irrigation needs
SWAT Device Rebate Program	Rebates	Rebates are given to homeowners when they purchased Smart Water Applied Technology (SWAT) devices
Appliance Rebate Program (St. George Program)	Rebates	Rebates are given for retrofitting existing toilets with ultra low flow toilets and for replacing clothes or dish washers with water efficient appliances.
Water Checks	Slow The Flow Program and Water Checks	The District performs several tests on the irrigation system; evaluates system efficiency and application rate; and provides appropriate irrigation schedule.
On-going Studies	Study on High Salinity in Water	BYU's College of Biology and Ag is doing a study to identify plants and irrigation practices that are tolerant to high salinity water
Water-Wise Plant List and Tagging (State Program)	Utah Water-wise Plant Tagging	A list of water wise plants that meet 5 specified criteria was created. Tags are placed on plants that are water-wise to assist the population in identifying water-wise plants for use in the region
Watershed Management and Enhancement	Watershed Management Plan	Watershed Management Plan includes Total Max Daily Loads (TMDLs) for the Lower Colorado River Watershed and Surface Protection Plan for the Virgin River Watershed. The objective is to address the health of the Virgin River watershed and meet requirements of TMDL.

Category	Title	Description
Turf Replacement	Athletic Field Turf Replacement Program	Matching grants are offered to public athletic fields irrigated by culinary water when retrofitted with artificial turf.
Secondary Water Systems	Toquerville Secondary Water System	WCWCD purchased water rights from the Toquerville Irrigation Company's shareholders and converted the open-ditch irrigation system to a pressurized system which distributes irrigation water to Toquerville residents.
	Gunlock to Santa Clara Pipeline	The Gunlock to Santa Clara pipeline replaces four existing diversions and converts flood irrigation to a pressurized system. The pipeline delivers irrigation water to Ivins, Santa Clara, and the Shivwit's Tribe Reservation.
Telemetry Project	Telemetry Project for the Santa Clara River and Virgin River	Monitors diversions along both rivers to minimize water loss and enhance the accuracy of measuring water right allocations.
Conversion of Open Canals to Pipelines	Washington Canal Company/Washington Fields	The St. George and Washington Canal Company replaced approximately 9.2 miles of open canal with pipeline which conserves water from ditch loss and evaporation.
Ordinances	Time-of-day Watering Ordinance	All cities have time-of-day water restrictions.
Impact Fee	County-wide Impact Fee	A county-wide impact fee applies to all new construction based on the size of the irrigable portion of the lot.
Water Rates	Increasing Block Rate Structure	All cities converted to an increasing block rate structure. The price of water increases as usage increases.
	Golf Course Surcharge	WCWCD completes a water budget for each of its customers that are golf courses. A 50 percent surcharge is billed for any courses that exceed their budgeted water supply.

5.2.2.2 Cities in Washington County

The conservation efforts in the individual cities and in Washington County as a whole are similar in nature. The primary focus has been public awareness and education on water conservation. The sections below describe the water conservation programs in cities in Washington County.

St. George

St. George partners with WCWCD on several conservation programs. For three years they have participated in free residential lawn water audits. The city participates in the annual Water Fair sponsored by WCWCD. St. George has hired a Water Conservation Coordinator. The Water Conservation Coordinator speaks to K-12 students, Girl Scout troops, and Boy Scout troops throughout the year on water conservation, water quality, water sources, and water shortages. Presentations on water conservation are also given to the Chamber of Commerce and Rotary clubs. Furthermore St. George is teaming up with Siemens Corporation to present an Efficiency Workshop to all commercial customers (Fleming 2007b).

An appliance rebate program is being launched in St. George for water efficient dishwashers and washing machines. Coin operated laundromats and laundromat facilities in multi-family housing complexes that purchase or lease water efficient washing machines will be eligible for the rebates. St. George also completed a toilet retrofit program that offered a $100 rebate for toilets older than 1995 and were replaced with approved water efficient models.

St. George also implemented an increasing block rate structure to discourage excessive water use. High water use is penalized with price increases. The residents are charged a base rate that is determined by the meter size. The base charges include water use up to 5,000 gallons per month. Any water use over 5,000 gallons is charged based on the inclining block rate structure outlined in **Table 5-2** (City of St. George 2007).

Table 5-2
St. George's Residential Inclining Block Rate Structure (City of St. George 2007)

Block	Consumption (gallons)	Rate ($/gal)
1	0 - 5,000	Included in base charge
2	5,000 – 10,000	$0.71/1,000 gal
3	10,000 – 15,000	$0.82/1,000 gal
4	15,000 – 20,000	$0.91/1,000 gal
5	20,000 – 25,000	$1.01/1,000 gal
6	25,000 – 30,000	$1.11/1,000 gal
7	30,000 – 35,000	$1.21/1,000 gal
8	35,000 – 40,000	$1.31/1,000 gal
9	40,000 – 45,000	$1.41/1,000 gal
10	45,000 and above	$1.51/1,000 gal

Hurricane
Hurricane's water conservation plan addresses the implementation of time-of-day watering from April through September. The city's Water Department also participated in a Business Expo that entailed hosting a Water Conservation booth and passing out pamphlets provided by the Division of Drinking Water. They have also been educating the public on water conservation methods via Quarterly Newsletters and an article in the Hurricane Valley Journal addressing conservation and the Water Department (Martin 2007).

Santa Clara
Santa Clara City's Water Management and Conservation Plan promotes public awareness and education to reach their water conservation goal. The implementation of the conservation programs presented in this plan has not been verified. Education for students and teachers for water management and conservation is included in the conservation plan. Part of this education would include providing 1st, 4th, and 5th grade teachers with materials they can use to teach water conservation methods in their classes. Santa Clara also has committed to helping sponsor an annual water fair with WCWCD and other cities in Washington County. To promote conservation awareness to their water customers Santa Clara suggests educating customers on how to read and understand their water bills. They may also modify their water bills to provide more information such as comparisons to the previous year's bill, a list of water-wise plants or indoor conservation methods. They also propose hosting workshops for industry professionals such as landscapers, builders, plumbers, and irrigation contractors.

The conservation plan for Santa Clara recommends advertising WCWCD's free water audits and preparing an audit program for commercial and industrial users. To promote decreased water use, Santa Clara suggests the possibility of implementing City Ordinances that could be used to restrict landscaping to 20 percent or less of the property area for new developments. They could also support other ordinances that restrict certain types of plants that require large amounts of water. Santa Clara City may replace piping and meters for an older section of the city where approximately 90 percent of the water system problems come from. This could significantly reduce the amount of water lost in breaks and leaks (Santa Clara City 2005).

La Verkin
La Verkin has a water conservation plan in place that has four stages based on available water resources. Some of the conservation methods are public education; culinary water restrictions for large irrigators and homeowners; the prohibition of: washing paved areas, non commercial car washing, filling of private swimming pools, and irrigation of city parks or schools. The implementation of the conservation programs in La Verkin is unknown at this time (Sterling Codifiers, Inc. 2007).

Ivins
Landscape irrigation is a primary component of water use in Ivins. To reduce outdoor per capita water use, the City's conservation plan proposes to implement water conservation landscaping practices such as using low-water landscape materials (xeriscape) and reducing the areas of irrigated grass. Ivins water conservation plan also suggests using water-saving fixtures to reduce indoor water use (Ivins City 2003).

Washington
The conservation goals listed in Washington City's Conservation and Management Plan are to reduce the city's per capita water use rate by 10 percent by 2025, educate the public about the importance of water conservation and to maintain a quality water distribution system with modern technologies and operation and maintenance (O&M) practices (Washington City 2004). Large volume users were identified by Washington City and meter reading systems were installed to increase the accuracy and frequency of water audits. Water audits suggest conservation practices and/or alternative technologies large water users can implement to reduce overall water use. To maintain a quality water distribution system with modern technology and O&M practices, Washington City installed a new 2 mgd treatment plant, replaced half of its storage tanks, upgraded two major transmission lines, and upgraded 60 percent of the water meters.

Washington City is also promoting water conservation practices for new development. New developments are required to get approval for landscaping plans and plant lists. Xeriscaping is preferred which includes seven principles: planning and design, limiting turf areas, using efficient irrigation practices, mulching, improving soil, using lower water demand plants, and performing appropriate maintenance.

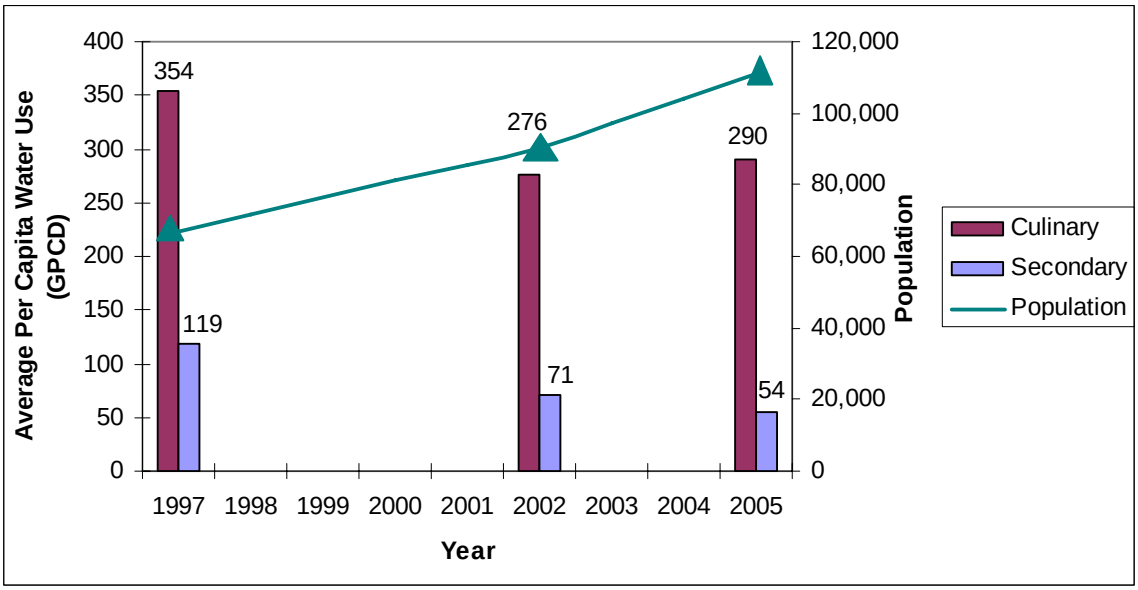
Washington City joins WCWCD in county wide radio, newspaper, and classroom education in water conservation to increase public awareness. The City also provides conservation pamphlets, tips, checklists, and lawn water guides.

A four stage drought management plan integrated into a rate schedule was enacted by Washington City. The City also adopted a new increasing block rate schedule to encourage and reward consumer conservation efforts.

5.2.3 Conservation Savings

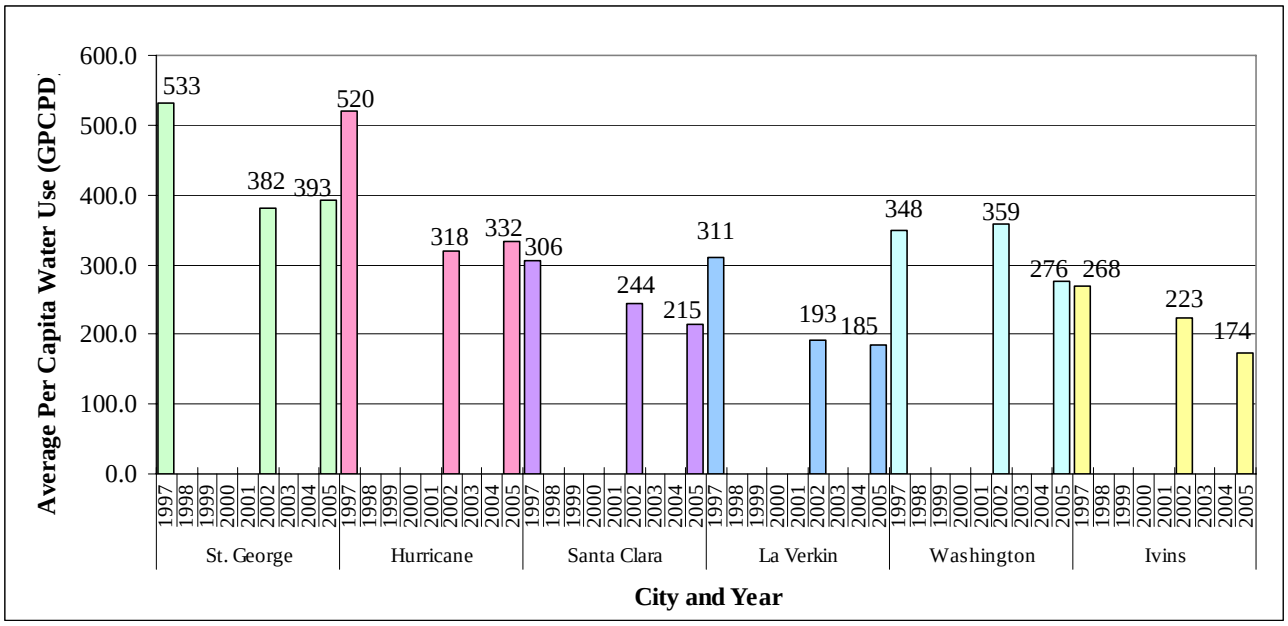
The Utah M&I Basin Reports (DWRe 2000a; 2006b; 2008) were used to track the progress of the conservation programs in Washington County. A weighted average (based on population) of the culinary per capita water use for six cities was used to represent WCWCD's average per capita water use. The six cites are: St. George, Washington, Santa Clara, Ivins, Hurricane and La Verkin. **Figure 5-1** shows an 18 percent reduction in average per capita culinary water use and a 55 percent reduction in average per capita secondary water use from 1997 to 2005.

Figure 5-1
Washington County Average Per Capita Water Use from 1997 to 2005
(DWRe 2000a; 2006b; 2008)



The average total (culinary and secondary) per capita water use from 1997 to 2005 was compared among the six cities individually (**Figure 5-2**). All six cities have experienced a general reduction in water use over this time period. **Figure 5-2** demonstrates the general variability in water use that can occur from year to year, and shows the differences that can occur even among similar communities. **Figure 5-2** also displays the general trend of total per capita water use in the urban areas of Washington County. The winter of 2004-2005 set a record for precipitation in the Virgin River basin. The total per capita water use declined in most of the cities with the exception of St. George and Hurricane which had minimal increases. The wet winter of 2005 may have affected the per capita water use by reducing the public perception for the need to conserve water during the following summer. This situation demonstrates the difficulty in drawing firm conclusions on the effectiveness of water conservation programs when several factors influence water use and limited water use data is available.

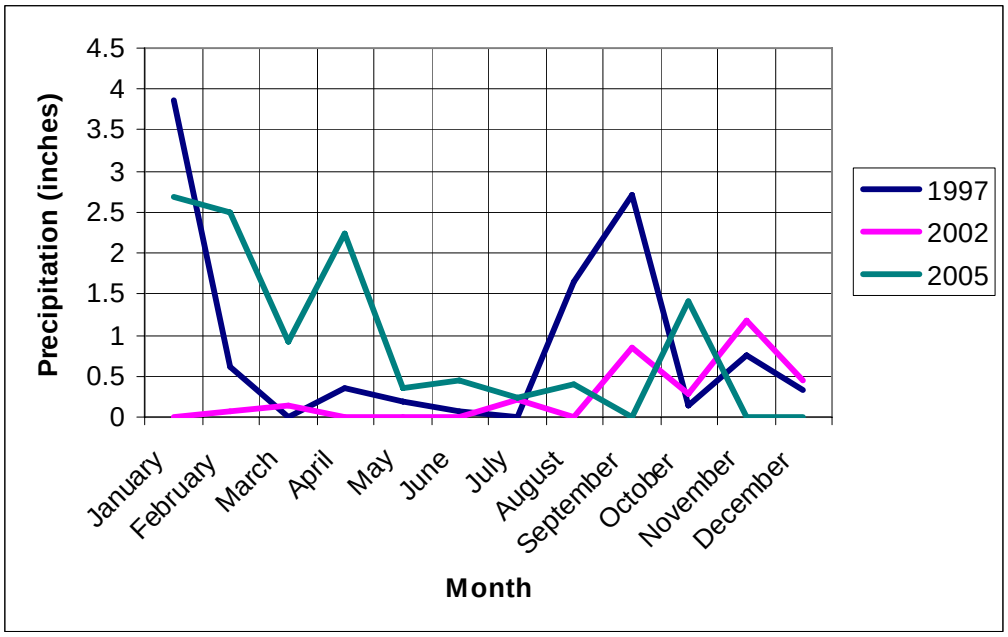
Figure 5-2
Total Per Capita Water Use for St. George, Hurricane, Santa Clara, La Verkin Washington, and Ivins from 1997 to 2005 (DWRe 2000a; 2006b; 2008)



In WCWCD there are several unique factors that can affect per capita water use. These include the high percentage of second homes, tourists, and college students. These factors further complicate the interpretation of annual water use data and the assessment of water conservation program effectiveness.

Another main factor that affects the per capita water use is the weather. The temperature and amount of rainfall, particularly in the summer, will influence behavior patterns such as the frequency with which residents water their lawns. Generally a correlation in per capita water use and weather patterns can be found. **Figure 5-3** shows the monthly rainfall for the three years for which per capita water use data is plotted in **Figure 5-1** and **Figure 5-2**.

Figure 5-3
Monthly Precipitation in St. George for 1997, 2002, and 2005
(WRCC 2007b)



The following possible conclusions can be made from the previous figures:

- Although 2002 was drier in the summer and much drier overall than 1997, per capita water use still dropped significantly. This suggests that outdoor watering conservation measures may have been effective.
- Secondary water use continued to drop in 2005 consistent with the wetter conditions compared to 2002 but culinary water use was about the same. This suggests that the effect of the rate of water conservation on per capita water use may be flattening out.
- The relationship between water use, weather, conservation and other factors is complex and difficult to predict.

As noted above, any conclusions regarding water conservation effectiveness based on limited data are speculative at best.

5.2.4 Future Goals and Water Conservation Programs

As stated earlier, the statewide conservation goal is 13 percent reduction in per capita water use from 2005 to 2050, based on an assumption of state-wide average conservation savings of 12 percent between 2000 and 2005. The data presented previously suggests that the District-wide savings in culinary water may be on the order of 18 percent from 1997 to 2005. Therefore, for this study it has been conservatively assumed that WCWCD achieved a reduction in water use similar to the state-wide average of 12 percent from 2000 to 2005. This resulted in a remaining conservation goal of 13 percent reduction in per capita water use by 2050. In addition, conservation was projected from 2050 to 2060 based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal. These assumptions resulted in a 16 percent reduction in total per capita water use from 2005 to 2060.

Typically when a community begins to aggressively pursue water conservation a high reduction in per capita water use is initially realized because behaviors that have a large affect on water waste, such as outdoor watering, are addressed. Over time the rate of reduction in per capita water use due to conservation slows because all

simple, low cost measures have been implemented and more time, cost and effort are required for lasting reductions in per capita water use. Based on the relatively high percent reduction in per capita water use reported for Washington County over the past 5-10 years it is assumed that most of the easy savings have been realized and the future rate of reduction in per capita water use relative to conservation efforts will be at a smaller, steadier rate than has been seen in the past. For purposes of this study, it was assumed that the 16 percent of conservation savings would occur linearly from 2005 to 2060.

Although the conservation goal for WCWCD is projected to be linear at this time, the District may achieve a higher rate of reduction in per capita water use during the beginning years of its conservation efforts due to the nature of its conservation programs. The linear rate of water use reduction is a conservative estimate that will be analyzed in greater detail during Phase 2.

To increase public awareness WCWCD will continue to implement programs in place and will monitor their progress. Some programs WCWCD will continue to support and develop are training 4th and 9th grade teachers on water education; developing assemblies for elementary and secondary schools; hosting the annual Water Fair; and using television and radio to disseminate water conservation information. A water conservation logo or theme can be created to help the public identify with water conservation.

WCWCD will continue to offer landscape seminars to homeowners and landscape professionals to educate them on water-wise plants, encourage the use of xeriscape and change the way they view landscapes. WCWCD will also continue to assist the cities with performing landscape audits and will encourage them to perform landscape audits on city-managed landscaping, county-managed landscaping, school district landscaping, college landscaping, church landscaping and individual homes. Certified Landscape Irrigation Auditor Courses will be promoted for landscape caretakers of schools, golf courses and churches.

Cities will be encouraged to design new subdivisions and public use buildings with secondary systems for landscape watering. To further educate the public on the importance of water saving fixtures like low-flow shower heads and faucets, low-flush toilets and leak detecting devices WCWCD may provide residents with kits containing some of these water saving devices (WCWCD 2003).

In Phase 2 of the Water Needs Assessment study a stakeholder group will be assembled to identify other specific conservation measures expected to be feasible and cost-effective in Washington County.

5.3 Iron County

5.3.1 Background

Iron County's water supply comes from minor surface water sources and ground water aquifers within the Cedar Valley. These water resources have been over-allocated and over-used. The Cedar Valley Aquifer ground water elevations have been declining, resulting in increased pump depths and costs. The population growth and limited water resources have made conservation a focus in Iron County (CICWCD 2007).

The CICWCD prepared a Water Conservation and Management Plan in 2005. The water conservation goals of CICWCD's Plan are to improve water service to customers; develop a more effective use of the available water supply and additional water supply capabilities; diminish ground water overdraft; postpone the need for new or expanded water supplies; improve the system and water supply reliability; and reduce drought impacts. Methods CICWCD proposes to use to promote conservation are public education, water wise landscaping, conservation oriented zoning ordinances, and reclamation of treated wastewater for beneficial purposes (CICWCD 2005).

Cedar City created its own water conservation plan in 2004. The infrastructure for the City's water distribution system is outdated and a significant amount of water is unaccounted for due to leaks in water lines that are in

excess of 70 years old. The City also uses old water meters that provide inaccurate water use data. About 310 acres of land within the city are used for parks; a golf course; and landscaping around schools, churches and major industries. To reduce the City's per capita water use the conservation plan recommends implementing conservation methods such as public education and starting an annual leak detection program (Cedar City 2004).

Enoch City created a water conservation plan in 1999. Some water conservation methods identified are replacing inefficient fixtures and appliances, repairing leaks in the distribution system and educating the public. These methods and others will be discussed in further detail below (Enoch City 1999).

5.3.2 Conservation Program

5.3.2.1 Central Iron County Water Conservancy District

CICWCD's conservation methods from 2000 to 2005 have primarily been focused on public education and awareness. A public education program was initiated by CICWCD in which CICWCD gave presentations on water conservation at a Water Fair at Cross Hollows Middle School. The middle school made water conservation a part of its curriculum and a video on easy ways to conserve water was shown. Since CICWCD is a newer district that is developing its customer base it has been focused on planning future conservation methods. See **Table 5-3** for a list of conservation programs CICWCD implemented from 2000 to 2005 (CICWCD 2005).

Table 5-3
CICWCD Conservation Programs for 2000-2005 (CICWCD 2005)

Category	Title	Description
Public Education	Presentations	Presentations on water conservation at a Water Fair for a local Middle School.
Zoning Ordinances	Conservation Oriented Zoning Ordinances	CICWCD is working with Iron County Planning Commission on revising zoning ordinances to encourage water conservation

5.3.2.2 Cedar City

To reduce its per capita water use, Cedar City has chosen to implement programs that encourage water conservation in several different ways (**Table 5-4**). Cedar City is educating its customers about water conservation and its importance through bill inserts and the City's monthly newsletter.

Table 5-4
Cedar City Water Conservation Programs (Cedar City 2004)

Category	Title	Description
Media	Printed Material	Monthly ads in local publications on water saving tips, water conservation information
Restrictions	Outside Watering	No outside irrigation with culinary water between 10:00 AM and 6:00 PM
Water Rates	Increasing Block Rate Structure	All cities converted to an increasing block rate structure. The price of water increases as usage increases.
Large Landscape Conservation	Secondary Irrigation System	A secondary irrigation system is being improved to increase its capacity and the amount of customers it can serve

Permanent outside watering and irrigation restrictions have been put into effect for daytime watering. To discourage excessive water use Cedar City implemented new water rate structures in 2001; high water use is penalized with price increases. There are different rate structures for residential users, non-residential users, and large irrigation users. Residential connections are charged a base monthly rate of $13.00 and are then billed according to an inclining block rate structure. The block rate structures for single-family and multi-family vary as can be seen in **Table 5-5 and Table 5-6**. Non-residential connections do not have an inclining block rate structure; they are charged a flat rate of $0.63/1,000 gallons. Large irrigation users that use culinary water are given monthly water budgets based on the landscaped area to be irrigated. The water budgets are individualized for each customer (Stathis 2007). When their water use is within their budget they are charged $0.63/1,000 gallons. If they exceed their budget their water rate increases to $1.20/1,000 gallons (Cedar City 2004). See **Table 5-7**.

Table 5-5
Cedar City's Single-family Residential Inclining Block Rate Structure (Cedar City 2004)

Block	Consumption (gallons)	Rate ($/gal)
1	0 - 8,000	$0.48/1,000 gal
2	8,001 - 25,000	$0.60/1,000 gal
3	25,000+	$1.20/1,000 gal

Table 5-6
Cedar City's Multi-family Residential Inclining Block Rate Structure (Cedar City 2004)

Block	Consumption (gallons)	Rate ($/gal)
1	0 - 5,000	$0.48/1,000 gal
2	5,001 - 15,000	$0.60/1,000 gal
3	15,000+	$1.20/1,000 gal

Table 5-7
Cedar City's Large Irrigation Users Inclining Block Rate Structure (Cedar City 2004)

Block	Consumption	Rate ($/gal)
1	Under Water Budget	$0.63/1,000 gal
2	Over Water Budget	$1.20/1,000 gal

Cedar City has also begun to improve its secondary irrigation system that will provide irrigation water to Cedar Ridge Golf Course, the Cedar City Cemetery, Bicentennial Park, and Cedar City High School. The capacity of the system will be upgraded to serve Southern Utah University, Canyon View High School, Cedar Middle School, and possibly other customers. Larger water users will be encouraged to use the secondary system because their cost will be reduced to $0.50/1,000 gallons for all water used (Cedar City 2004).

5.3.2.3 Enoch City

In 1999 Enoch City created a water conservation plan. Enoch City has been implementing conservation programs such as developing a secondary water source, installing a demonstration garden for efficient water use, requiring time-of-day watering ordinances, and implementing a water pricing structure (CICWCD 2005). The status of implementing the conservation programs has not been verified.

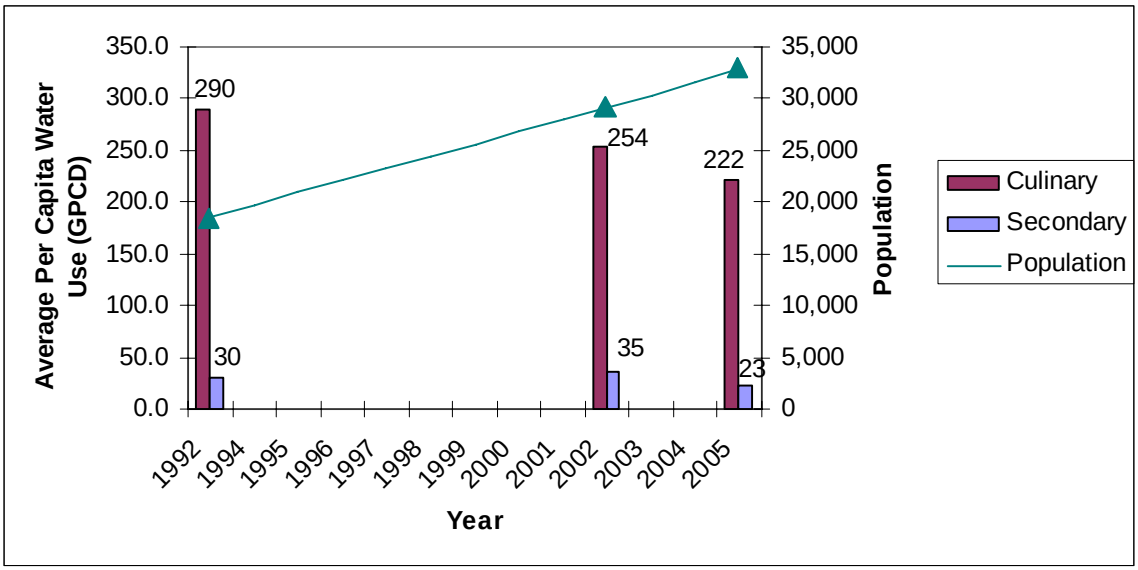
5.3.3 Conservation Savings

The Cedar/Beaver Basin M&I Water Supply and Use Reports from the Utah Division of Water Resources were used to show the trend in per capita water use in CICWCD and Cedar City.

5.3.3.1 CICWCD

Average per capita use in the CICWCD boundary was determined using water use data for all water suppliers in Iron County with the exception of Brian Head Water Supply, Escalante Valley Water System, Paragonah Municipal Water System, Parowan Municipal System, and Summit SSD. As can be seen in **Figure 5-4**, there has been a 23 percent reduction in culinary per capita water use from 1992 to 2005 for the CICWCD communities and a 24 percent reduction in secondary per capita water use. As described previously, many factors can affect per capita water use data from year to year.

Figure 5-4
CICWCD Average Per Capita Water Use from 1992 to 2005
(DWRe 1994; DWRe 2006a; DWRe 2007a)



5.3.3.2 Cedar City

According to the Cedar City Water Conservation Plan, the City had a 15.7 percent reduction in per capita water use from 1999 to 2004 (Cedar City 2004). Based on the Cedar/Beaver Basin M&I Water Supply and Use Reports Cedar City had a 16 percent reduction in culinary per capita water use from 1992 to 2003 and an 11 percent reduction in secondary per capita water use. This is shown in **Figure 5-5**. Despite the population growth in Iron County, the conservation efforts made thus far appear to be effective.

Figure 5-5
Cedar City Average Per Capita Water Use
(DWRe 1994; DWRe 2006a; DWRe 2007a)

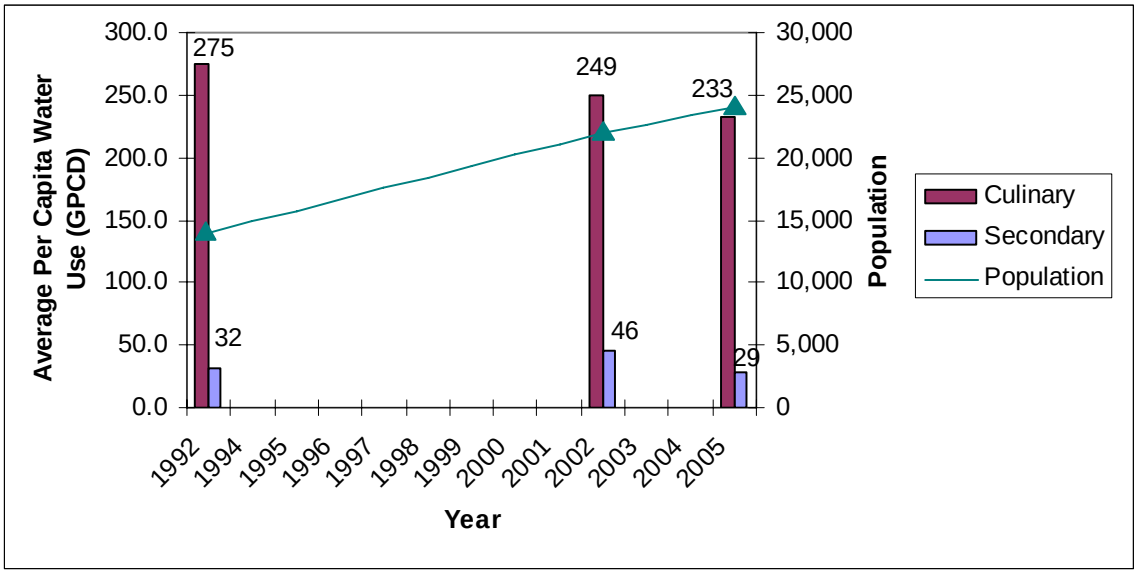
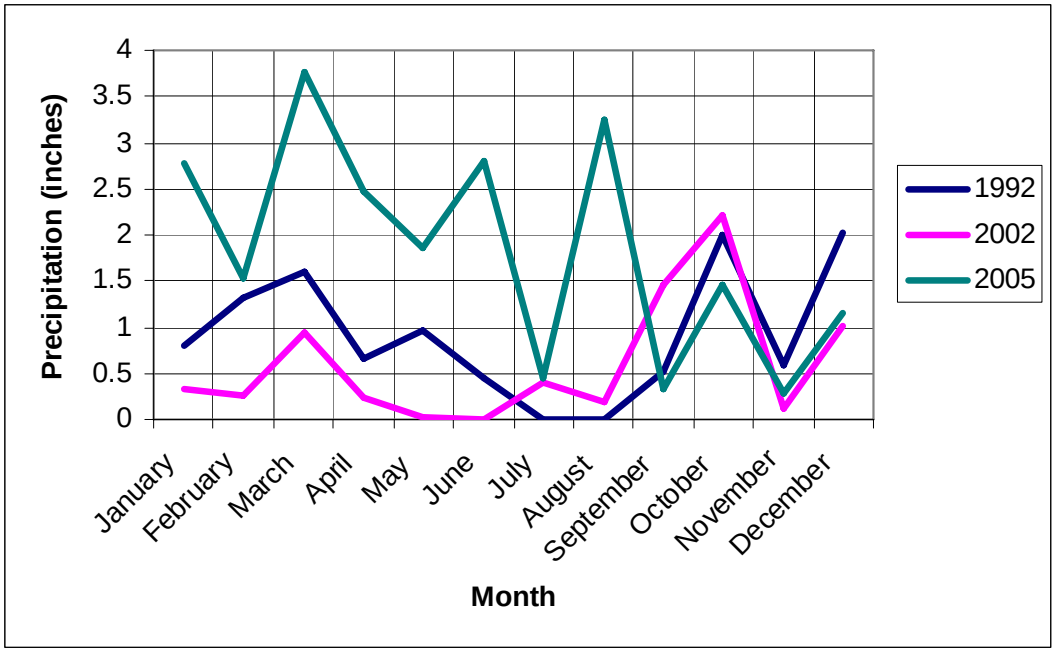


Figure 5-6 shows the monthly rainfall at Cedar City in the years for which water use was plotted in **Figure 5-5**.

Figure 5-6
Monthly Precipitation in Cedar City for 1992, 2002, and 2005 (WRCC 2007b)



For Cedar City, 2005 was a wet year; there was a high amount of precipitation from January through August in comparison to the other two years recorded. When comparing the summer (June, July, and August) it can be seen that 2002 had a slightly higher amount of precipitation than 1992. During the wettest summer, 2005, the culinary and secondary per capita water use was the lowest. In 2002 the precipitation during the summer was significantly lower than 2005 and the culinary per capita water use was higher. The highest per capita water use for this set of data was in 1992 and that summer was a dry summer with minimal precipitation. This correlation of higher precipitation during the summer and lower per capita water use and vice versa is common. Although there is a minimal amount of data presented here it can be seen that the reduction in per capita water use shown in **Figures 5-4 and 5-5** may be partially attributable to other factors besides conservation, such as the weather.

5.3.4 Future Goals and Water Conservation Programs

Based on the data presented above, it appears that the CICWCD communities have met or exceeded the State's estimated average of 12 percent water use reduction from 2000 to 2005. Therefore for Phase 1 of the Water Needs Assessment, CICWCD will be given a goal of 16 percent per capita water use reduction from 2005 to 2060 based on the statewide target of 25 percent reduction in per capita water use from 2000 to 2050 and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal. The 16 percent reduction is assumed to be linear from 2005 to 2060. Although CICWCD's conservation goal concurs with the state goal, cities such as Cedar City have previously set higher conservation goals for themselves in their water conservation plans. These assumptions will be verified in the Phase 2 study. Until then, the 16 percent reduction in water use from 2005 to 2060 will be adopted, with a constant linear reduction over the 55-year period.

5.3.4.1 CICWCD

To achieve the per capita water reduction goals, CICWCD has proposed several recommendations for future conservation methods. The Water Management and Conservation Plan for CICWCD lists several water

conservation programs for future implementation. Participation in a water conservation demonstration garden is proposed to exhibit water-wise plants and irrigation methods. In addition to the garden CICWCD will host water-wise landscaping classes and large water user workshops. Awards will also be given to encourage water-wise landscaping. To reduce indoor water use it will start an ultra low flush toilet replacement program and will offer water audits to residential, commercial and industrial water users. A complete list of future water conservation programs CICWCD suggested in its Water Management and Conservation Plan are listed below (CICWCD 2005).

- Public Information and Education Campaign
- Water Conservation Demonstration Garden
- Model Water-Efficient Residential and Commercial Landscape Ordinances
- Ultra Low Flush Toilet Replacement Program
- Residential, Commercial and Industrial Water Audits
- Water-Wise Landscaping Classes
- Large Water User Workshops
- Water Quest: Saving Water by the Yard
- District Facilities Re-Landscaping
- Water-Wise Landscape Awards
- Member Agency Assistance Program
- Water Conservation Plan Update
- Efficient use of surface water to reduce pumping ground water

Additional water conservation recommendations various states have used were also listed in CICWCD's Conservation Plan. To reduce indoor water use they suggest handing out water conservation kits that contain a shower flow restrictor, faucet aerator or faucet flow restrictor. They could also retrofit public facilities with water-efficient fixtures and promote a refitting program. Rebates could be offered for water-efficient appliances like washing machines. Indoor and outdoor water surveys could also be given. To reduce outdoor flow they could start a leak detection program or design secondary water systems (CICWCD 2005).

5.3.4.2 Cedar City

Cedar City listed several future goals in its Water Conservation Plan that are planned for implementation. The City will implement annual leak detection and repair programs that will identify potential problems in the area. Leak detection equipment can be used to identify leaks and subsequently, the leaks can be repaired to reduce the inefficiency of the older areas of the water distribution system. The City intends to replace all the meters by 2009. Defective meters have prevented the City from having an accurate understanding of the water usage for all its customers. The City also plans to conduct annual water conservation education campaigns to educate its residents on proper water use and conservation methods. In addition the City has plans to upgrade the secondary irrigation system. This will allow it to increase the number of users that can utilize secondary water (Cedar City 2004).

Cedar City's Water Conservation Plan listed 14 recommended Best Management Practices that were originally recorded in the Cedar City Water System Master Plan. They are listed below (Cedar City 2004).

- Water Surveys for Single-family and Multi-family Residential Customers
- Residential Plumbing Retrofit
- System Water Audits, Leak Detection, and Repair
- Landscape Ordinance for New Commercial Development
- Large Landscape Conservation Programs and Incentives
- High-efficiency Appliance Promotion Programs
- School Education Programs

- Conservation Programs for Commercial and Industrial Customers
- Updated Water Rates
- Water Conservation Coordinator
- Water Waste Prohibition
- Residential Ultra Low Flush Toilet Replacement
- Non-residential Ultra Low Flush Toilet Replacement

5.4 Kane County

5.4.1 Background

At this time KCWCD has not developed a conservation plan for the Johnson Creek or Kanab Creek areas, but the District intends to adopt a similar conservation plan as the Duck Creek Area Water System (Noel 2007). Duck Creek is an area in the northwest corner of Kane County on Cedar Mountain that is served by KCWCD. However, it will not be served by the Lake Powell Pipeline due to its remote location. A conservation plan was drafted for the Duck Creek Area Water System in July 2007 by the KCWCD and is referred to below to represent the future KCWCD conservation plan.

As with other parts of Utah, many of the homes in Duck Creek are secondary homes. As a result, water use increases during the summer months, holidays, and weekends. Several water systems in Duck Creek were out of compliance with the State standards and from 2002-2007, and KCWCD took over many of those systems. With year-round water service and fire protection some residences are becoming primary homes instead of secondary homes. In 2002 KCWCD began distributing culinary water to the Duck Creek area resulting in an increased number of connections. At the beginning of 2005 there were 898 connections (880 residential and 18 commercial). By the end of 2005, 508 connections were added. Multiple wells pumping water from a deep underground aquifer supply culinary water in the Duck Creek Area (KCWCD 2007).

The City of Kanab adopted a water conservation plan in 1999 and revised it in 2004. The water conservation plan addresses past water conservation measures, opportunities to develop and implement management conservation measures, and short and long term goals for efficient water use.

5.4.2 Conservation Program

5.4.2.1 KCWCD

Conservation programs in the Duck Creek area are focused on household usage. There is little to no outdoor water use due to the high elevation and the nature of the residences. The water conservation programs in Duck Creek address conservation education, maintenance of the water distribution system and water sources, as well as increasing block rate structures (KCWCD 2007).

KCWCD is educating the public on water conservation methods that can be implemented to reduce household water use. Increasing block rate structures are used for residential and commercial customers to discourage excessive water use (KCWCD 2007) (**Table 5-8 and Table 5-9**).

Table 5-8
KCWCD Increasing Block Rate Structure for Residential Customers (KCWCD 2007)

Level	Consumption	Rate
1	Base Minimum Fee	$15.00
2	1-15,000 gal/mo	$2.00/gal
3	15,001-20,000 gal/mo	$2.25/gal
4	20,001+gal/mo	$2.50/gal

Table 5-9
KCWCD Increasing Block Rate Structure for Commercial Customers (KCWCD 2007)

Level	Consumption	Rate
1	0-10,000 gal/mo	$35.00
2	10,000-15,000 gal/mo	$2.00/gal
3	15,001-20,000 gal/mo	$2.25/gal
4	20,001+gal/mo	$2.50/gal

Through the maintenance of source protection zones and protection of recharge and watershed areas the water sources will be protected. The efficiency of the culinary water distribution system will be sustained through maintenance and system upgrades. **Table 5-10** lists the conservation programs in greater detail (KCWCD 2007).

Table 5-10
KCWCD Conservation Programs (KCWCD 2007)

Category	Title	Description
Education and Outreach	Public Education	Teach children and adults about conservation methods to minimize water use.
Water Distribution System	Maintenance	Maintain an efficient culinary water system through maintenance and system upgrades.
Water Source	Protection	Maintain source protection zones and protect recharge and watershed areas.
Water Rates	Increasing Block Rate Structure	An increasing block rate structure is currently used and will be adjusted as needed. The price of water increases as usage increases.

5.4.2.2 Kanab City

Kanab City's conservation approach has primarily been to provide an efficient culinary water supply system to its customers, and the city has completed system upgrades to improve the efficiency including completion of a pressurized irrigation system. Kanab City has a four stage conservation approach, with the four stages of needed conservation based on four levels of water shortages or reduction in supply from drought or equipment failure. The shortages can be a result of reduction in supply associated with equipment failure, or a result of culinary demand exceeding culinary supply. Kanab City has a conservation management plan, with detailed requirements and restrictions for each of the four levels of water shortages. The management plan describes conservation requirements for indoor and outdoor water practices for each of the four levels of shortages, which are generally described in **Table 5-11** (Kanab City 2004).

Table 5-11
Kanab City Conservation Management Plan

Conservation Stage	Supply/Demand Relationship	Conservation Action
Stage 1	Supply 2-3% greater than total daily demand, or drought or equipment failure results in 2-3% reduction in supply	Voluntary restrictions on nonessential water use, with reduction goal of 2-3% of daily peak use.
Stage 2	Culinary demand greater than supply by 1-3%, or drought or equipment failure results in 5% reduction in supply	Mandatory restrictions on nonessential water use, with reduction goal of 5-10% of daily peak use.
Stage 3	Culinary demand greater than supply by 5%, or drought or equipment failure results in 10% reduction in supply	Mandatory restrictions on nonessential water use, with reduction goal of 10-25% of daily peak use.
Stage 4	Culinary demand greater than supply by 10%, or drought or equipment failure results in 25% reduction in supply	Water rationing plan for all available culinary water resources, with reduction goal of 25-60% of daily peak use.

5.4.3 Conservation Savings

The Kanab Creek/Virgin River Basin M&I water supply and use reports from the Utah Division of Water Resources were used to show the trend in per capita water use in KCWCD and Kanab City.

5.4.3.1 KCWCD

Based on available water use data in the Kanab Creek / Virgin River Basin M&I Reports, the culinary per capita water use in Kane County, as a whole, has increased from 1997 to 2005 by 30 percent while the permanent population has decreased by 2 percent. This is shown in **Figure 5-7**. Between 2002 and 2005, the time period in which KCWCD began providing culinary water to the Duck Creek area, the culinary water use decreased by 2 percent and the secondary water use decreased by 0.2 percent. The residential per capita water use for Kane County for 1997, 2002, and 2005 was 283 gpcpd, 291 gpcpd, and 273 gpcpd respectively. There has been a 4 percent reduction in residential per capita water use from 1997 to 2005. This indicates that commercial and industrial water use is the primary cause for the overall increase in per capita water use in Kane County. Although the residential per capita water use has decreased in Kane County the overall per capita water use will be used for the Water Needs Assessment to be consistent with the project methodology.

Figure 5-7
Kane County Average Per Capita Water Use from 1997 to 2005
(DWRe 2000a; 2006b, 2008)

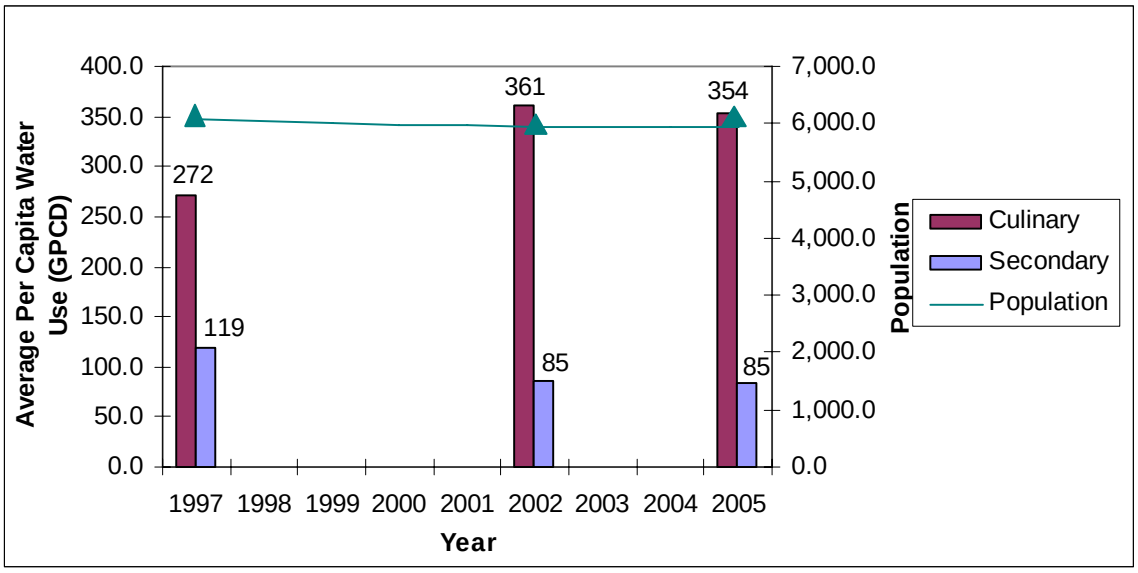
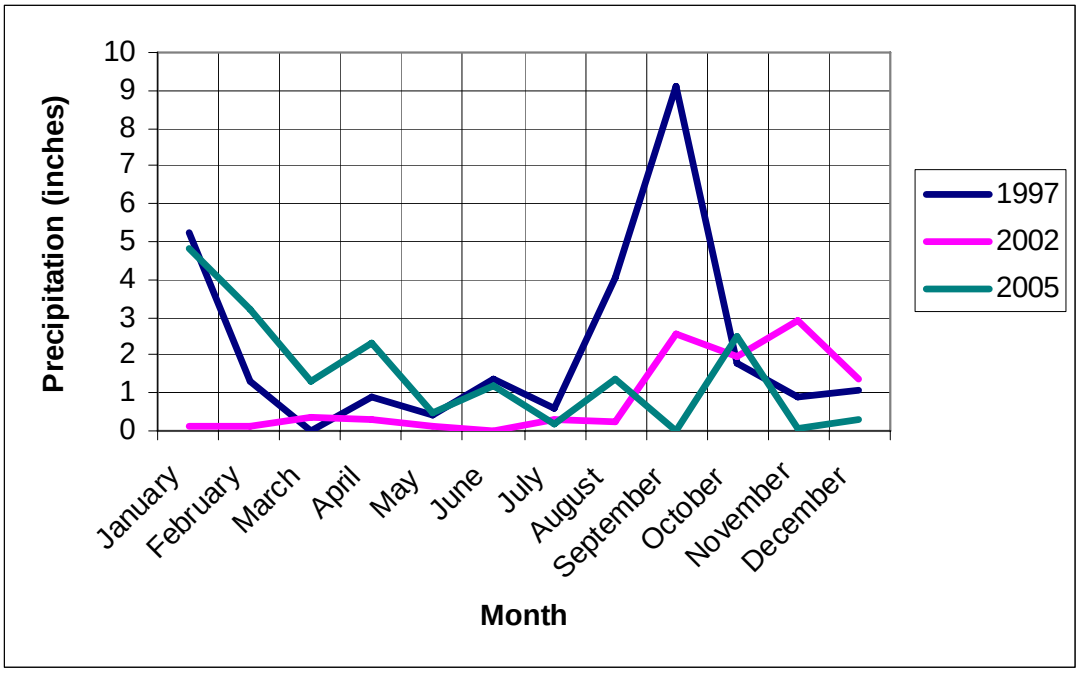


Figure 5-8 shows monthly precipitation for the years for which water use data was plotted in **Figure 5-7**.

Figure 5-8
Monthly Precipitation in Kanab for 1997, 2002, and 2005
(WRCC 2007b)

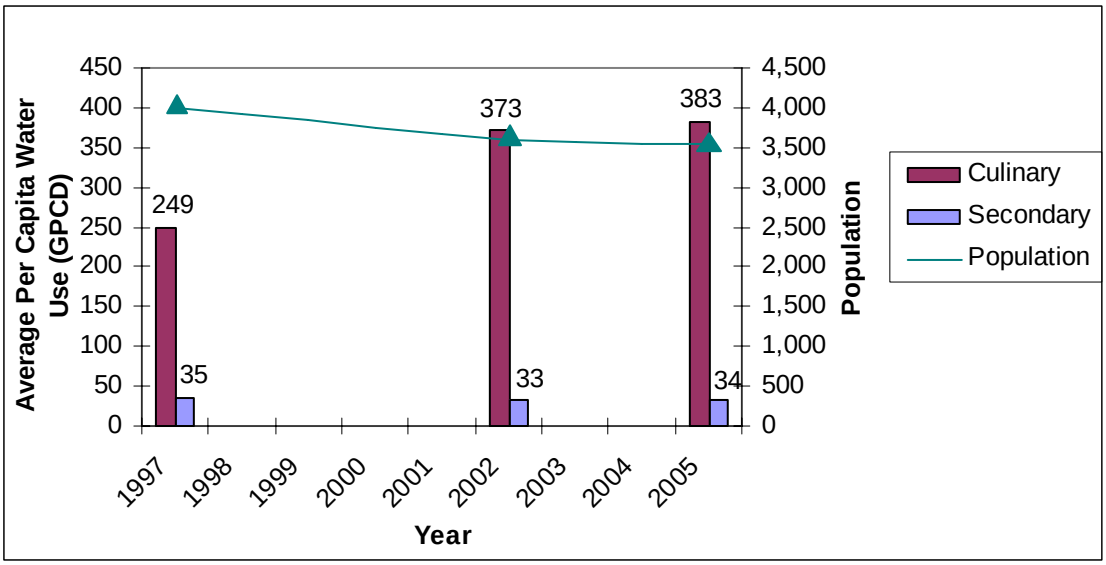


In 1997 the later months of the summer, July and August, there was a high amount of precipitation compared to the years 2002 and 2005. The per capita water use was also the lowest that year, in comparison to the other two years recorded. The precipitation for the summer of 2002 was minimal in comparison to 1997 and the per capita water use increased significantly from 1997 to 2002. In the year 2005 Kanab experienced a wetter summer than 2002 and the per capita water use declined by a small amount. As was discussed in **Section 5.3.3.2** the trend of high precipitation correlated with low per capita water use and vice versa is typically seen. From these observations it appears that the amount of precipitation did have an impact on the per capita water use, and may have overwhelmed any effects of conservation measures on water use.

5.4.3.2 Kanab City

Average per capita water use for Kanab City was determined using historical M&I use as reported in the DWRe M&I water supply and use reports for data collected in 1997, 2002, and 2005, and is summarized in **Figure 5-9.** Culinary per capita water use has increased over the 1997 to 2005 period, while secondary use has remained relatively constant. This trend is similar to that shown for KCWCD in Section 5.4.3.1.

Figure 5-9
Kanab City Average Per Capita Water Use from 1997 to 2005
(DWRe 2000a; 2006b, 2008)



5.4.4 Future Goals

For purposes of the Water Needs Assessment, it was assumed that Kanab and the remainder of Kane County have not achieved any measurable conservation savings over the 1997 to 2005 time period. Therefore, to meet the statewide conservation target, Kane County's conservation goal is 31 percent reduction in per capita water use from 2005 to 2060. This conservation goal of 31 percent is based on the current DWRe goal of 25 percent reduction in per capita water use from 2000 to 2050, and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal.

Future conservation programs and goals were not discussed in the KCWCD Duck Creek Area Water Management and Conservation Plan. However, future conservation programs and goals were described in the Kanab City Conservation Plan (Kanab City 2004). The following short- and long-term goals were specified for Kanab City water conservation.

- Public education program including courses on how to minimize water use associated with gardening, landscaping, and farming
- Completion of periodic maintenance and necessary system upgrades to the existing culinary water system
- Use of reuse water for irrigation of parks, golf courses, and other large turf areas
- Ground water source protection and recharge protection to ensure viability of existing ground water supply
- Ground water well management to prevent overdraft of local aquifers
- Coordination with Kanab Irrigation Company to conserve water that could be used for culinary M&I uses (e.g., development of storage reservoir that could store excess agricultural irrigation water to be used to meet culinary demands while still meeting agricultural demands)

Kanab City identified several alternatives to meet future water needs and the conservation goals described above. The city's future conservation plan includes the components described in **Table 5-12.**

Table 5-12
Kanab City Conservation Programs

Category	Title	Description
Education and Outreach	Public Education	Teach children and adults about conservation methods to minimize water use.
Water Distribution System	Maintenance	Maintain an efficient culinary water system through maintenance and system upgrades.
Residential Water Systems	Water Saving Devices	Flow restrictors for showers and faucets, toilet dams, leak protection kits, and lawn watering guides.
Residential Water Systems	New Construction Requirements	New residential construction must meet model landscape or xeriscape ordinances.
Water Rates	Impact Fees	Impact fees and water rates based on water usage.
Commercial and Industrial Water Systems	Best Management Practices	Best Management Practices for golf courses and parks including bubblers on trees, timed night watering, upgrade in sprinkler efficiency, use of low-pressure nozzles, minimization of well overflow, and immediate fixing of water leaks.

5.5 Comparisons of Conservation Programs in the Lake Powell Pipeline Study Area

5.5.1 Water Rate Structures

To encourage the reduction of water consumption, many cities are adopting inclining block-rate structures. Block rate structures consist of fixed amounts of water sold at a unit price. Increased block rate structures are based on the idea that consumers will use less water if the unit rate of water increases with increased volume consumption. Inclining block-rate structures are more effective in encouraging customers to reduce their water use when there is a significant price difference between each tier.

Figure 5-10 displays the block rate structures for:

- CICWCD (CICWCD 2005)
- Cedar City (Cedar City 2004)
- Kane County (KCWCD 2007)
- Santa Clara (Santa Clara City 2005)
- Hurricane Valley (Breckenridge 2007a)
- St. George (City of St. George 2007)

The block rate structure for Hurricane Valley has large price increases that affect high quantity water users consuming more than 27,000 gallons per month. It also has three blocks that affect customers consuming 12,000 - 27,000 gallons per month.

CICWCD, Kane County, Santa Clara, St. George, and Cedar City have block rate structures that affect low to moderate consumers within the range of 6,000 - 25,000 gallons per month. Santa Clara also has a block rate structure that affects high water users who consume over 50,000 gallons per month.

Figure 5-10
Increasing Block Rate Structures for Residential Customers in the Lake Powell Pipeline Service Area

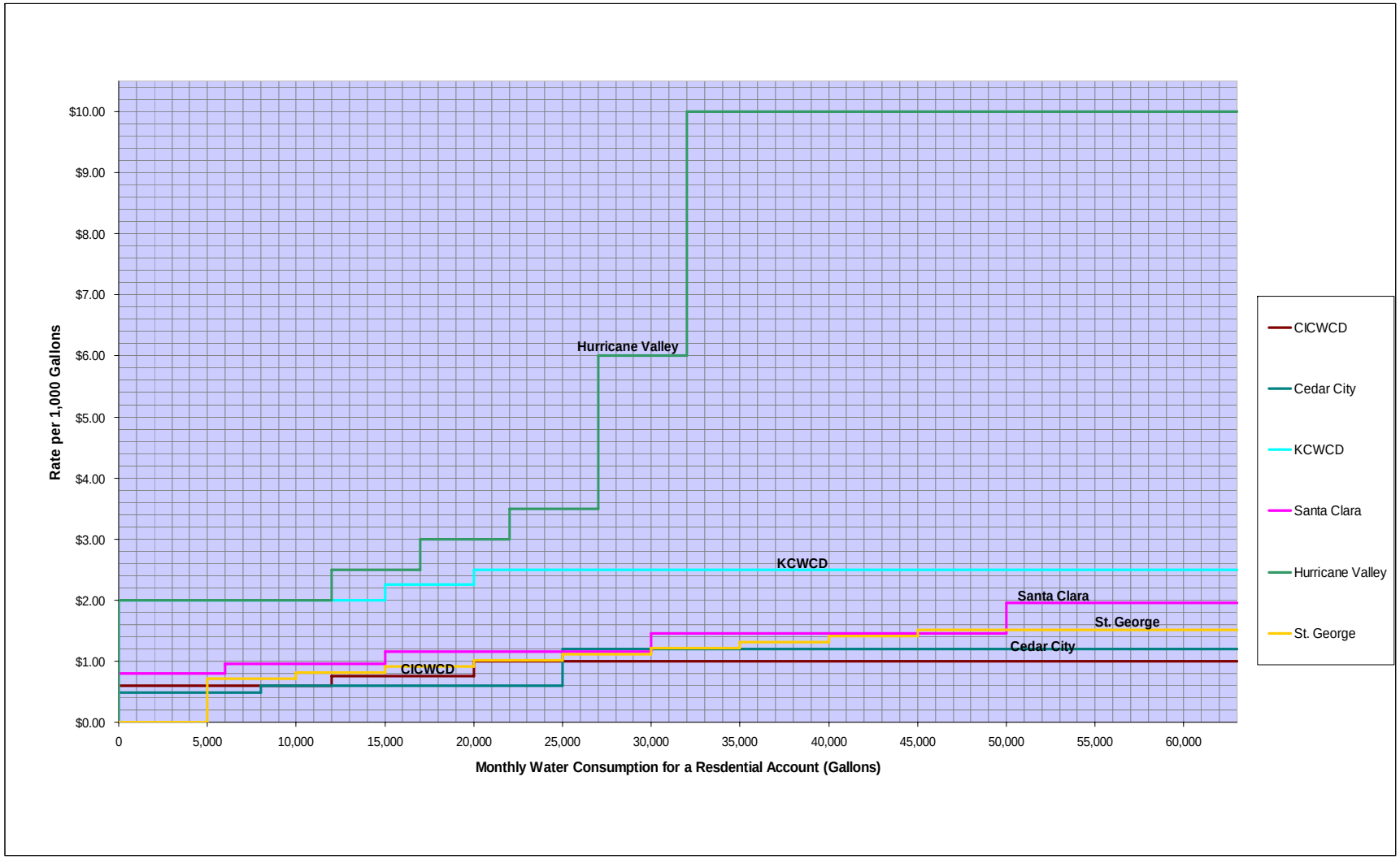


Table 5-13
Conservation Programs

Urban Cities Water Conservation Program Comparison														
City		**St. George**	**Ivins**	**Hurricane**	**La Verkin**	**Washington**	**Santa Clara**	**WCWCD**	**CICWCD**	**Cedar City**	**Enoch City**	**KCWCD**	**Kanab**	**Duck Creek Area**
Residential Programs														
Residential Water Audits	Indoor								x					
	Outdoor	**X**	x	x	x	x		**X**	x					
Media: newspaper, TV, radio, websites, etc.		**X**		x	x		x	**X**	**X**	**X**	**X**		x	
Landscape Retrofit Rebates*		**X**	x	x	x	x		**X**						
SWAT Controller and/or Multi-setting Controller Rebates		**X**	x	x	x	x		**X**						
ULF Toilet Rebates Or Replacement		**X**							x					
Miscellaneous Appliance Rebates: dishwashers, washing machines, etc.		**X**							x					
School Education Programs		**X**	x	x	x	x	x	**X**	**X**			x	x	x
Rainwater Harvesting Barrel Rebate														
Hot Water Recirculation Rebate Program														
Car Wash Coupons														
Demonstration Gardens		**X**	x	x	x	x		**X**	x		**X**			
Pool Cover Coupon														
Rain Sensor Coupon														
Leak Detection and Repair													**X**	
Indoor Fixture Replacement Programs: faucet aerators, low-flow showerheads, etc.									x				x	
Landscape Workshops or Helps		**X**	**X**	**X**	**X**	**X**	x	**X**					x	
Increasing Block Rate Structure		**X**	**X**	**X**	**X**	**X**	**X**	**X**	x	**X**	**X**	x	x	x
Large Water Users' Programs (Commercial, HOA, Institutional, etc.)														
Professional Landscaper Water-efficient Training		x	x	x	x	x	x	**X**	x					
SWAT Controller Rebates		**X**	x	x	x	x		**X**						
Large Water User's Workshops		x	x	x	x	x	x	**X**	x					
Commercial Rebates														
Commercial Audits									x					
Building Codes														
Restaurant-Water upon request signs														
Spray Rinse Valve Replacement		x												
Ordinances														
Time-of-day Watering Restrictions				x	x	x				**X**	**X**		x	
Water Waste Ordinance		x											x	
Landscape Ordinance							x		x				x	

*Washington County WCD collects an impact fee calculated by per square foot of irrigable landscape over 5,000 square feet.
*La Verkin's Conservation Program is based on their Conservation Plan. The enforcement of it is unknown.
*Hurricane's Conservation Program is based on their Conservation Plan. The enforcement of it is unknown.
*Santa Clara's Conservation Program is based on their Conservation Plan. The enforcement of it is unknown.
*We currently do not have information on Ivins' and Washington's Conservation Plans
*The Conservation Coordinator, Rene Fleming was contacted about St. George's Conservation Practices
X Bold indicates that the conservation program has been reported as being implemented
x Lower-case indicates that the Conservation Program has been recorded in a Conservation Plan but there has been no verification on whether or not it has been implemented

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5.5.2 Conservation Programs

To get an overall understanding of the Water Conservation Programs that have been adopted in Washington, Iron, and Kane Counties, their programs have been summarized in **Table 5-13**. The programs are organized based on residential programs, large water user programs, and ordinances. There is also differentiation between programs that have been verified for this report as being implemented and programs that are listed but their implementation has not been confirmed. Information for WCWCD and the cities in Washington County was provided by WCWCD. Information in other areas was provided by the individual entities.

5.6 Conclusions

The communities in the state of Utah have implemented measures to reduce their water consumption. DWRe has reported a 12 percent overall reduction in per capita water use during the period 2000 to 2005. The water Districts and water agencies in Washington, Iron, and Kane Counties have each played a role in reaching the state water conservation goal by creating and implementing water conservation plans. The state goal for 2050 is to have an additional 13 percent overall reduction in per capita water use compared to 2005 levels.

WCWCD's conservation goal as adapted for this Water Needs Assessment study is 16 percent reduction in total per capita water use from 2005 to 2060. The 16 percent conservation goal is in accordance with the state goal of 13 percent reduction in per capita water use by 2050 and is based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in the current state goal. The goal projects that the 16 percent reduction will occur linearly from 2005 to 2060. WCWCD developed its water conservation program before it was required by the State of Utah and has continued to expand the program and add measures to increase water conservation. Based on water records, their customers have reduced per capita water use within their service area over the past decade.

For purposes of the Water Needs Assessment study, CICWCD and Cedar City also have goals of 16 percent reduction in per capita water use relative to 2005 water use by 2060. The 16 percent conservation goal is in accordance with the state goal of 13 percent reduction in per capita water use by 2050 and is based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in the current state goal. The 16 percent reduction is also projected to be linear over the 55 year time span. Both CICWCD and Cedar City have developed water conservation programs that have produced recent reductions in per capita water use.

For purposes of the Water Needs Assessment study, KCWCD's conservation goal is 31 percent reduction in per capita water use by 2060 relative to 2005 water use, because it has not realized any demonstrated conservation savings from 2000 to 2005. The goal of 31 percent reduction in per capita water use is based on the current state goal of 25 percent reduction from 2000 to 2050 and based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in the current state goal. KCWCD is in the process of adopting a conservation plan for its service area.

Phase 2 of the LPP Water Needs Assessment Study will focus on identifying specific effective conservation measures applicable to the LPP participant service areas, and refining the future anticipated conservation savings relative to current per capita use rates.

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Chapter 6 - Water Resources Planning

6.1 Integrated Water Resources Plans

6.1.1 Introduction and Assumptions

This chapter describes integrated water resources plans for each of the Districts participating in the LPP. The water resources plans define the magnitude and timing of future water project development compared to future water demands. They show a likely scenario of how future water supplies could be developed in a logical sequence to meet future demands for culinary and secondary water. The objective of preparing integrated water resources plans is to determine whether the Lake Powell Pipeline Project will be needed within the planning horizon (present to 2060), and if so, when it will be needed. Integrated water resources plans are shown separately for each District because their systems are operated independently.

Criteria for bringing new water projects online, and the strategies for implementing new projects, vary among water utilities and can change substantially over time in response to many factors including hydrology, economics, and politics. The evaluation in this study is necessarily simplified, and is intended primarily to assess the need for the Lake Powell Pipeline Project in the context of long-term growth. Each entity in the study will have short-term planning objectives and priorities that may differ from the overall concepts developed in this study as they move into the future, but the effects of these short-term issues on whether or not the LPP is needed within the planning period should be minimal.

The following general assumptions were used in preparing integrated water resources plans for each of the LPP Districts. Assumptions specific to each individual district are described in the following sections.

- **Service Area.** The three water conservancy districts participating in the LPP currently have service areas that include cities that have historically developed their own water supplies. These cities have various policies - formal and informal - on how they want to participate with their water conservancy district in meeting future demands. Some plan to rely entirely on the water conservancy district to meet all increased demands in the future (e.g., many of the WCWCD cities), while others currently anticipate meeting increased future needs on their own (e.g., Kanab). For purposes of this study, total supplies and demands throughout the respective water conservancy districts have been considered when determining the need for and timing of new water sources. This assumes the benefits of regionalization in seeking new water sources will become sufficiently strong to encourage water suppliers to work together under the auspices of their water conservancy district rather than individually. It also assumes any local projects implemented individually in basins already over-appropriated will increase the need for new supplies on the part of other water users in the basin.
- **Unconstrained Distribution Systems.** It is assumed all supplies available to a water conservancy district are available for use anywhere in the District. The unique characteristics of specific regions within each District that might increase or decrease the relative growth in water demand have not been considered at this level of analysis. It is assumed either the required infrastructure will be provided to distribute new water sources, whether local or imported, to the areas of need, or exchanges or other agreements will be arranged to trade LPP water for other sources that could more easily be delivered to areas far from the LPP pipeline.
- **Total Water Use.** At this level of analysis, total water use (i.e., culinary and secondary) has been used as the primary tool to forecast water demand and determine the timing of necessary water supplies. Separate secondary water demand forecasts were also developed for WCWCD and CICWCD to predict the demand for projects with secondary grade quality water such as water reuse in both Districts and development of high TDS Virgin River water in Washington County. Secondary demand as a percentage of total demand was assumed to remain constant throughout the planning period based on the current (2005) percentage, and no attempt was made to project differences in the rate of increase for secondary demand versus culinary demand. Secondary demand forecasts were not developed for KCWCD, because KCWCD culinary supplies were

adequate to meet both culinary and secondary demands throughout the planning period. **Chapter 3 and Chapter 4** provide breakouts of culinary and secondary demands and supplies, respectively.

- **Sequential, Prioritized Project Implementation.** For simplicity it has been assumed new supply sources will be added to the water resource portfolios of each water conservancy district in a sequential manner. Projects have been prioritized based on a number of primarily qualitative factors, including current capital facility plans, qualitative unit cost, ease of implementation, and stated preferences of the water Districts. Although some projects would likely be implemented in parallel (i.e., progress would be made on multiple projects at the same time and they could be phased in during the same years), the uncertainty in this process can not be handled in the current analysis. The key assumption is how the priority of implementing the LPP compares with other competing supply sources. This is discussed separately for each of the districts.
- **Just-in-Time Supply.** New supply sources are assumed to be required in the year the forecasted water demand exceeds the available supply. The demand forecast based on the GOPB (2008) population forecast is used as the best estimate for when new supply sources will be necessary.
- **Project Certainty.** The future water projects considered for each district were described in **Chapter 4**. They include projects that have a reasonable certainty of being implemented within the study period. More speculative projects or those with a higher degree of uncertainty because of technical, cost or environmental concerns have not been included in this assessment.

6.1.2 WCWCD Integrated Water Resources Plan

Existing and future supplies for WCWCD are summarized in **Table 6-1**, including a breakdown of the portion of each supply that would be used to meet culinary and secondary water demands. Specific assumptions used to develop the WCWCD integrated water resources plan are presented in **Table 6-2**. The difference between the projected 2060 demand of 265,800 ac-ft per year and existing and near term projects (which include: existing supplies, Quail Creek Reservoir, Ash Creek Pipeline, and Crystal Creek Pipeline) is 181,900 ac-ft per year. Ways to meet this projected demand are discussed below.

The suggested order of implementation of all planned and potential projects is based on a comparison of conceptual unit cost, current status of project development, and preferences expressed by the WCWCD during meetings held with the district for the analyses completed for this report. Quail Creek Reservoir agricultural supply exchange and water reuse up to the existing St. George reuse plant capacity are listed as the first increments of future culinary and secondary supply, respectively. Although detailed cost estimates have not been completed at this level of analysis, it is assumed the unit cost for each of these projects is less than the unit cost of the LPP. The newly constructed reuse plant in St. George has a total capacity of 11,200 ac-ft per year, with a current operable capacity of 7,800 ac-ft per year, leaving 3,400 ac-ft per year of available capacity to be developed on an as needed basis to meet secondary water demands. As described in **Chapter 4**, 50 percent of the additional reuse capacity, or 1,700 ac-ft per year, was assumed to be available for secondary supply as a result of seasonal fluctuations in demand and lack of storage for reuse water. As discussed in **Section 4.1.5**, additional reuse expansion beyond the St. George reuse capacity would be implemented as the last increment of secondary supply because other projects would provide a large portion of the secondary water supply in a more cost effective manner (e.g., Washington Fields agricultural conversion). The volume of effluent available in 2060 will greatly exceed the existing reuse plant capacity of 11,200 ac-ft per year, but a plant expansion could be implemented when the demand for secondary water exists. This will be considered in more detail in Phase 2 of the Water Needs Assessment. As shown in **Table 6-2** all of these supplies would be phased in over time to meet demand. Other factors that will help determine the development rate of reuse supply will be the volume increase of annual treated effluent in response to population growth and water use, improvements in treatment technologies, and improved public acceptance of water reuse.

Table 6-1
WCWCD Summary of Existing and Future Supplies

Existing Project	Reliable Culinary Quality Water Yield (ac-ft/yr) [2]	Reliable Secondary Quality Water Yield (ac-ft/yr) [2]
Quail Creek and Sand Hollow Reservoir	29,500	0
Sand Hollow Ground Water	8,000	0
Kolob Reservoir	2,000	0
Meadow Hollow Reservoir	200	0
Cottam Well Field	2,000	0
Sullivan Well Field	750	0
Kayenta (Ence Wells) Water System	1,000	0
Gunlock to Santa Clara Pipeline	0	2,500[3]
Toquerville Secondary Water System	0	160
Future Project		
Ash Creek Pipeline	5,000	0
Crystal Creek Pipeline	2,000	0
Maximize Existing Wastewater Reuse [4]	0	1,700
Quail Creek Reservoir Agricultural Supply Exchange	4,000	0
Agricultural Conversions from Development[5]	0	12,400[6]
Lake Powell Pipeline	70,000	0
Potential Future Wastewater Reuse	0	54,500[7]
Total	**124,450**	**71,260**

Notes:

[1] Source of data: (WCWCD 2006; WCWCD 2007c; DWRe 2008a). Average yield with up to 25 percent shortage assumed to represent reliable yield for WCWCD projects.

[2] Culinary quality water was assumed to be able to meet culinary demands first, and then secondary demands with any portion of the culinary supply that is not fully utilized.

[3] Source of data: WCWCD (2008)

[4] The maximum capacity of the existing reuse treatment plant is 3,360 ac-ft/yr, but this supply can only be used to meet secondary demands during the irrigation season (April through October) and there is no storage capacity resulting in the loss of any supplies not used by the end of a given month. Reuse supply was limited by projected secondary demand.

[5] Of the 17,300 ac-ft per year of available supply, 4,000 ac-ft/yr of this supply would be reserved for the Quail Creek Reservoir Agricultural Supply Exchange to meet culinary demands, leaving 13,300 ac-ft/yr available for the agricultural conversion projects. An additional loss from advanced water treatment was assumed as described in the following footnote, resulting in 12,400 ac-ft per year reliable yield.

[6] Although reverse osmosis would be less likely than blending with a higher quality water source as described in Section 4.1.5.5, reverse osmosis was assumed to conservatively estimate the secondary supply from this source. A 20 percent loss realized for this supply for treatment of a portion of the supply with reverse osmosis to reduce salinity to a level where mixing would reduce the TDS to the appropriate maximum contaminant level (i.e., 500 mg/L TDS for culinary use, and 1,000 mg/L TDS for secondary use.

[7] Wastewater reuse could potentially be increased up to the wastewater effluent rate for communities served by the St. George wastewater treatment plant (i.e., St. George, Washington, Santa Clara, and Ivins), limited by secondary demand. The wastewater effluent available for reuse is calculated assuming the ratio of wastewater effluent to total M&I water supply (wastewater effluent represents approximately 27 percent of total M&I supply) remains constant for these cities in the future, and using the 2060 projected population for these cities (GOPB 2005) and 2005 total M&I per capita water use less 16 percent conservation.

Table 6-2
WCWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)	Type of Supply (Culinary or Secondary)	Timing	Start Date	Comments
Existing Supplies	83,910[1]	Culinary & Secondary		-	Combined culinary and secondary supply
Future Supplies					
Quail Creek Reservoir Agricultural Supply Exchange	4,000	Culinary	Begin when needed; phase in over time	2017	Culinary supply currently used by agriculture, exchanged for secondary-grade quality water from the Virgin River.
Ash Creek Pipeline	5,000	Culinary	When Needed	2017	Culinary supply indirectly by supplying secondary supply grade water to offset current culinary use.
Crystal Creek Pipeline	2,000	Culinary	When Needed	2019	Culinary supply
Maximize Existing Wastewater Reuse Capacity of 10 mgd	1,700[2]	Secondary	Begin when needed; phase in over time	2020	Treatment capacity and distribution system can be phased as needed to meet secondary demand.
Agricultural Conversions from Development	12,400[3][4]	Secondary	Begin when needed; phase in over time	2020	Consists of multiple projects and water rights changes. Linear annual increase to meet secondary demand.
Lake Powell Pipeline	70,000	Culinary	When needed	2020	Can be used to meet culinary and/or secondary supply as needed. 70,000 ac-ft per year used in 2060.
Future Wastewater Reuse	16,900[5]	Secondary	When needed	2037	Phased in as needed to meet secondary demand

Notes

[1] Includes WCWCD reliable water supply from DWRe M&I Water Use Reports for 2005 (72,560 ac-ft per year culinary plus 7,450 ac-ft per year secondary) and existing wastewater reuse (3,900 ac-ft/yr based on demand and capacity restrictions).

[2] The water reuse plant recently constructed in St. George has a total capacity of 11,200 ac-ft per year. Two of three filters have been installed to date (current capacity of 7,800 ac-ft per year), with 3,400 ac-ft per year of additional future capacity as needed. This supply can only be used to meet secondary demands during the irrigation season (April through October) and there is no storage capacity resulting in the loss of any supplies not used by the end of a given month. Average annual yield was estimated as 50 percent of capacity.

[3] A 20 percent loss was realized for treatment with reverse osmosis to reduce salinity to a level where the supply would be usable for secondary M&I purposes. (MWH 2006).

[4] Total amount available from this supply would be 12,400 ac-ft per year in 2060. Limited by the projected rate of agricultural conversions discussed in Section 4.1.5.5.

[5] The maximum potential future wastewater reuse (54,500 ac-ft per year) would be greater than the amount given, as described in Section 4.1.5.4, but the actual amount was limited to the amount given by seasonal fluctuations in secondary demand and storage capacity.

Besides the LPP, two other sources of water are available to WCWCD to meet total water demands: agricultural water conversions from M&I development (13,300 ac-ft per year before losses for reverse osmosis treatment), and future wastewater reuse (16,900 ac-ft per year). Each of these potential projects has substantial feasibility or economical constraints that make the Lake Powell Project a more viable option as a culinary M&I supply. Use of agricultural conversions and future wastewater reuse has water quality constraints, making them most cost-effective to meet secondary demands.

The Lake Powell imported water source is considered to be the last priority compared to the feasible local culinary water development projects due to its high relative cost and the other administrative and regulatory factors associated with its implementation (e.g., the environmental permitting process required by the National Environmental Policy Act).

Figure 6-1 through **Figure 6-3** show graphically the relationship between supply and demand, and the sequential timing of new projects brought on line in a just-in-time manner to meet the forecasted total water demand. Details of existing and future supplies shown in the figure were summarized in **Table 6-2**. It is estimated the LPP will be needed in approximately 2020. **Figure 6-1** represents culinary supply and demand. Three culinary supplies are either already in place at their full yield capacity (i.e., existing culinary supply) or will come on-line as large 'blocks' of supply (i.e., Quail Creek Reservoir Agricultural Exchange and Lake Powell Pipeline). Consequently, a portion of these supplies can be used to meet secondary demands as necessary until their full yield is needed to fulfill culinary requirements. These supplies are shown in **Figure 6-1** as solid blocks of supply, indicating that the full yield of the projects would be available to meet any M&I demand (i.e., both culinary and secondary demand) when the projects are complete. The portion of the culinary supplies above the demand line shown in **Figure 6-1** would not be needed to meet culinary demand until the demand line crosses the top of the supply line in **Figure 6-1**. As a result, this portion of the culinary supply would be used to meet secondary demand as necessary until the entire culinary supply would be needed to meet culinary demands, in order to delay the need for any additional secondary supplies**.** The portion of unused culinary supply assumed to meet secondary demand is represented with hatching in **Figure 6-2**. The following culinary supplies are brought on early in order meet secondary demands, and are partially used to meet secondary demands until their full yield is needed to meet culinary demands.

- Existing culinary supply (shared for culinary and secondary demands from 2013 to 2016)
- Quail Creek Agricultural Exchange (shared for culinary and secondary demands from 2017 to 2020)
- Lake Powell Pipeline (shared for culinary and secondary demands from 2020 through 2039)

Figure 6-3 represents total (culinary and secondary) supply and demand. **Figure 6-3** shows that even with the LPP supply, demand will exceed supply under the projected water demand before 2060. **Figure 6-1** shows that the shortage is in culinary supplies, not secondary supplies. The additional demand beyond the Lake Powell Pipeline supply could be met with a combination of any of the following potential projects, none of which are considered to be technically or environmentally feasible at present.

- Agricultural conversions, treated to culinary standards (500 mg/L TDS drinking water standard)
- Additional supplies from Utah's Upper Colorado River allocation of Colorado River supply (WCWCD would need to obtain an additional water right for this to become a viable option)
- Direct potable water reuse

Figure 6-1
WCWCD Supply and Demand – Culinary

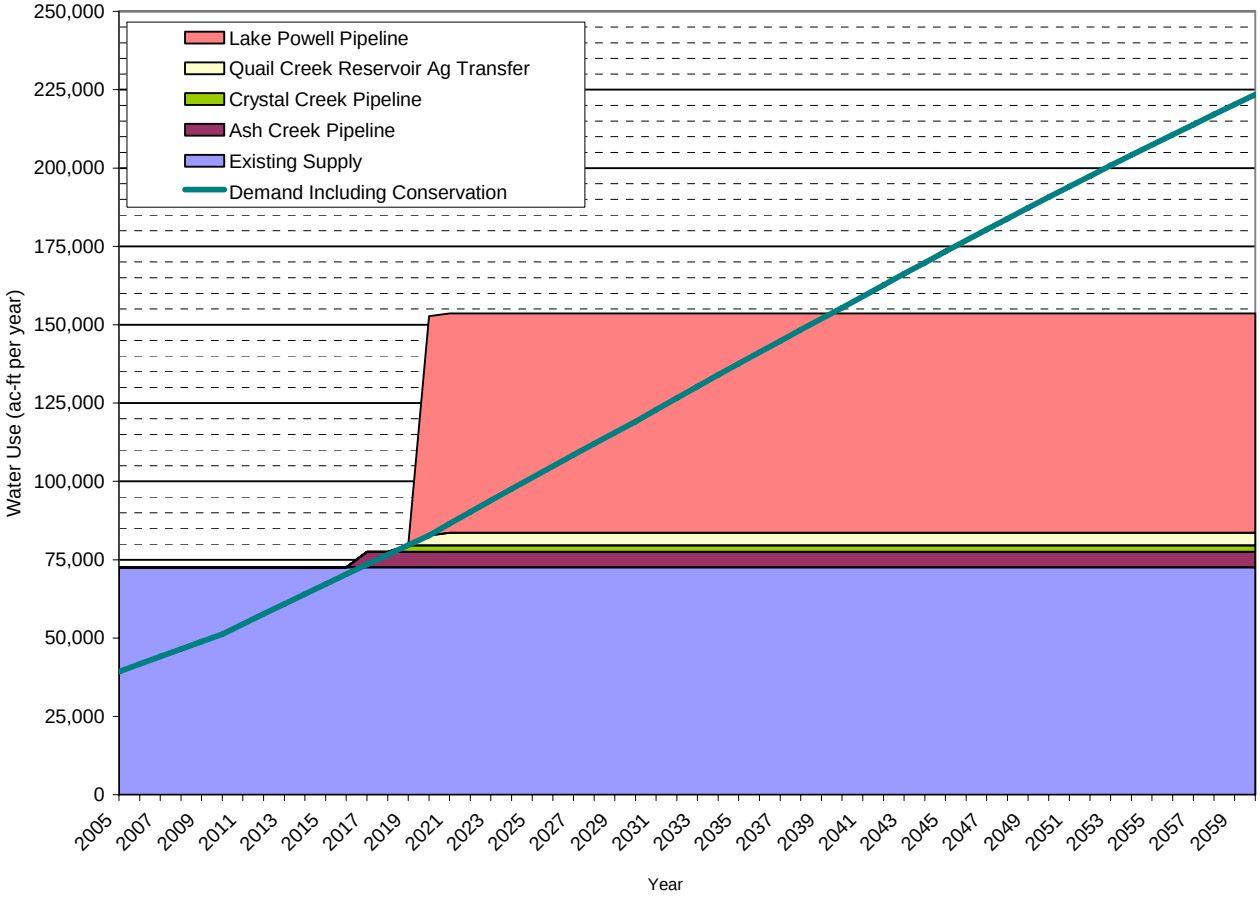


Figure 6-2
WCWCD Supply and Demand - Secondary

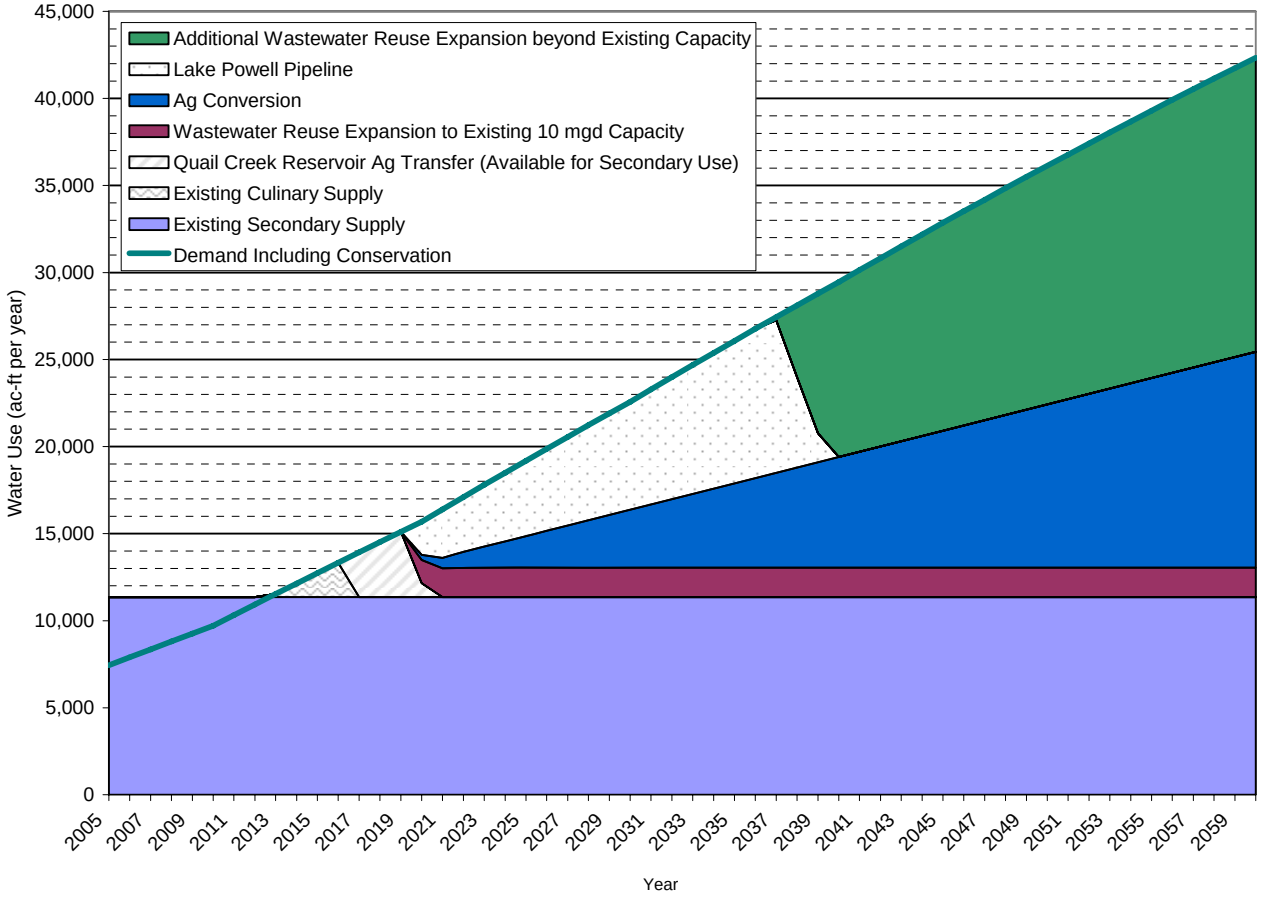
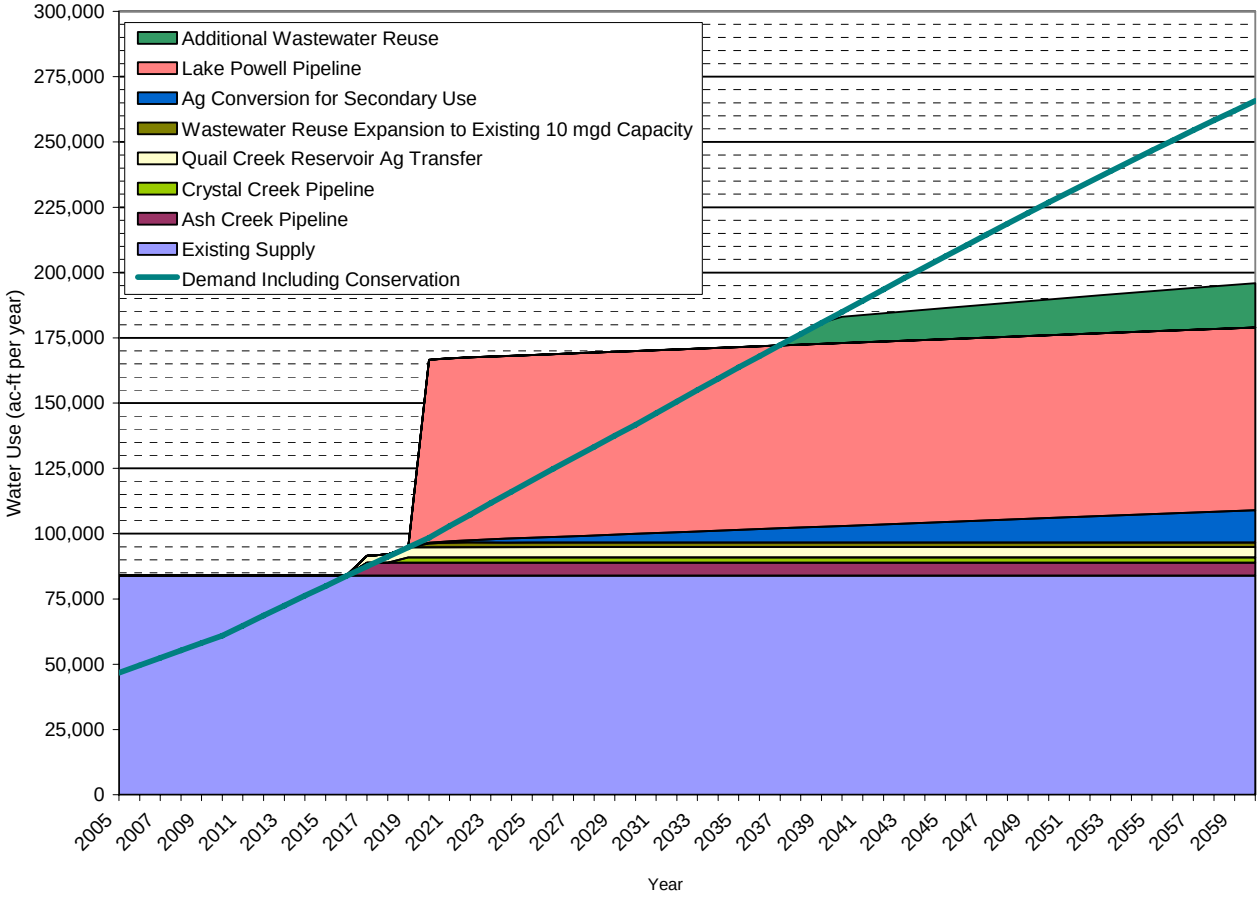


Figure 6-3
WCWCD Supply and Demand - Total



6.1.3 CICWCD Integrated Water Resources Plan

Future water resource development requirements in the CICWCD service area will be strongly determined by three factors that can not be predicted with certainty at this time. The three factors are:

- *What will the State Engineer determine the sustainable yield to be for the Cedar Basin aquifer?* Local municipal water users agreed to use a value of 37,600 ac-ft per year for this planning effort. The Utah State Engineer may assume a slightly different sustainable yield once the Cedar Valley Aquifer management plan is completed (the timing of the management plan is unknown but is not likely to be completed within the next five years).
- *How will M&I and agricultural water users share in curtailments if the State Engineer restricts ground water production to the sustainable yield?* It was thought by local M&I users that economics would dictate the transfer of agricultural rights to the M&I sector, keeping M&I users "whole" while reducing overall agricultural water production to meet the sustainable yield requirements. Current (2005) average annual ground water production is about 37,970 ac-ft. If the sustainable yield value is 37,600 ac-ft per year, curtailments in well pumping will be needed after the State Engineer develops a management plan for the basin. Future water use scenarios were developed assuming curtailment to limit ground water withdrawals to the sustainable yield based on the prior appropriation doctrine, with junior rights being curtailed in favor of senior rights.
- *Will M&I users implement a water reclamation project using effluent from the regional wastewater treatment plant?* Effluent is available for advanced treatment and distribution for reuse. It is currently evaporated in

wastewater treatment lagoons. Local water users have not proposed developing this source in the past. If water demand exceeds supply, water reuse could be developed. However, development of water reuse would have technical challenges because of the closed ground water basin in Cedar valley. With the Lake Powell Pipeline, water reuse will not be necessary during the study period (2005 to 2060). It will however, be needed for the no action alternative which is discussed in **Section 6.2.2**.

Specific assumptions used to develop the CICWCD integrated water resources plan are presented in **Table 6-3**. The difference between the projected 2060 demand of 41,600 ac-ft per year and the existing supply of 12,160 ac-ft per year is 29,440 ac-ft per year. The integrated water resources plan suggests future water sources that could meet this demand. The suggested order of implementation of these future water sources is based on a qualitative comparison of unit cost, current status of project development, and preferences expressed by the CICWCD. Agricultural conversion and wastewater reuse are the most viable and cost effective options, however, they are not sufficient in meeting future CICWCD demands. Reuse would negatively affect the water quantity and quality since CICWCD is located in a closed basin. Reuse would increase consumptive use, and decrease recharge to the aquifer, which would in turn decrease the sustainable yield. In addition, reuse would have an adverse effect on water quality by concentrating constituents such as TDS. Though the LPP has specific technical, environmental and financial concerns, it is anticipated that development of West Basin Ground water Rights will present greater obstacles and objections making it harder and more costly to implement.

Future demands could be met through acquisition of agricultural water rights in a “buy and dry” program. CICWCD indicated that the District intends to pass a resolution to discourage the buy and dry strategy due to adverse effects on the local quality of life and economy. Therefore the approach has not been included in the CICWCD integrated water management plan. However, it is possible that other entities (e.g., Cedar City and Enoch City) in the study area may use this strategy to meet demands.

CICWCD has requested 20,000 ac-ft per year in LPP supply. This imported water source is considered to be the last priority compared to the feasible local water development projects based on cost. The LPP would be needed in 2023, when demand exceeds supplies available from other sources. The timing of the State Engineer’s mandated Cedar Basin management plan is unknown, and greatly affects the schedule for bringing new water supplies on line. This program was assumed to be implemented in 2024, the year after Lake Powell Pipeline would be completed. The State Engineer would likely wait to implement the management plan until water users in the basin have an alternative water supply. In anticipation of this program, it was assumed that total Cedar Basin ground water development could not exceed the assumed sustainable yield of 37,600 ac-ft per year beginning in 2024.

There is considerable flexibility when the LPP water supply source would be needed in CICWCD. For example, the need for the project could be delayed by either:

- acquiring agricultural water rights in developable areas before development actually occurs; or
- overdrafting the ground water basin with the intention of replacing the mixed water with imported LPP water.

Neither of these options has been shown in the CICWCD integrated water resources plan.

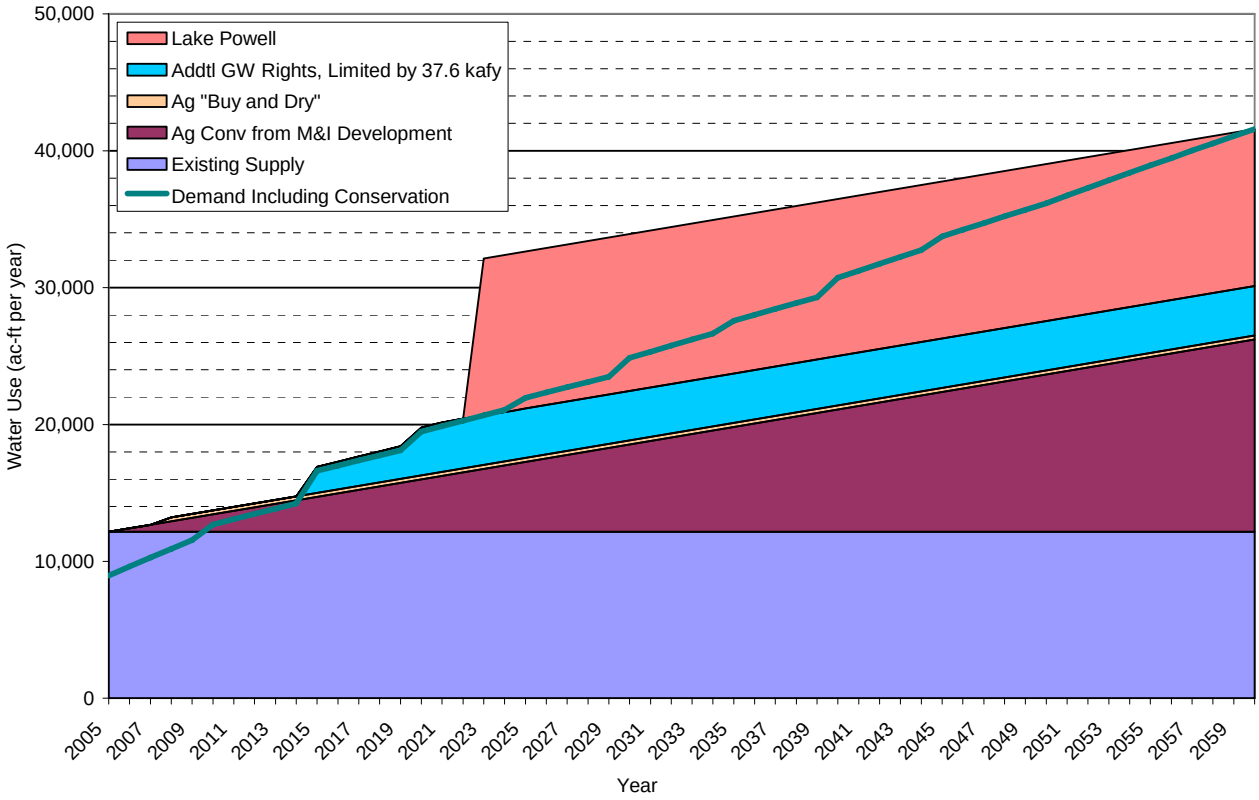
The maximum supply needed from LPP by 2060 is 11,470 ac-ft per year. This is the amount included in the integrated water resources plan. If CICWCD receives a larger LPP allocation from the state, the additional supply could be used to supply demands past the 2060 timeframe and build up a drought reserve in the Cedar Valley aquifer.

Table 6-3
CICWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)	Date Needed	Comments
Existing Supplies	12,160	-	Combined culinary and secondary supply
Assumed Sustainable Basin Yield	37,600	-	
Future Supplies			
Agricultural Conversion (due to development over irrigated lands)	14,060	2010	Based on timing of expansion of development onto irrigated lands.
Agricultural Conversion from buy and dry of existing agricultural rights	300	2008	Enoch City purchased approximately 300 ac-ft per year of supply from buy and dry of agricultural water rights in 2008.
Development of Existing Local Ground Water Rights	3,610	2015	Limited by total existing ground water rights for Cedar City, Enoch City, and CICWCD, and an assumed sustainable yield of 37,600 ac-ft per year
Lake Powell Pipeline	11,470	2023	Implement when needed as last priority due to high cost.

Figure 6-4 shows graphically the relationship between supply and demand under the future water supply scenario, and the sequential timing of new projects brought on line in a just-in-time manner to meet the forecasted total water demand. If agricultural users make up all the immediate curtailment in ground water production down to an assumed sustainable yield of 37,600 ac-ft per year, and if no wastewater reclamation is pursued, the LPP would be needed in 2023.

Figure 6-4
CICWCD Supply and Demand



6.1.4 KCWCD Integrated Water Resources Plan

There are four subbasins within Kane County that were considered independently for the summary of water supply and demand because transfers of water supply between the four subbasins are not allowed by the Utah State Engineer. Consequently, water supply and demand were calculated for each of the four subbasins to forecast water supply needs for each of the subbasins. The four subbasins considered for Kane County are the East Virgin River basin, the Kanab Creek basin, the Johnson Canyon basin, and the Wahweap Creek basin. The demand forecast used in the KCWCD integrated water resources plan includes demand associated with population within the Sevier River Basin because the KCWCD service area boundary includes all of Kane County. However, some of the potential future projects that could be implemented to meet demand within KCWCD would not be able to serve all areas of Kane County (e.g., Lake Powell Pipeline would not be able to serve areas such as the Sevier River Basin, which has a remote location relative to the proposed pipeline alignment).

Specific assumptions used to develop the KCWCD integrated water resources plan for each subbasin are presented in **Table 6-4**. The difference between the projected KCWCD 2060 demand of 6,030 ac-ft per year and the existing supply of 4,040 ac-ft per year is 1,990 ac-ft per year. The integrated water resources plan suggests future water sources that could meet this demand. The suggested order of implementation of these future water sources is based on a comparison of unit cost, current status of project development, and preferences expressed by the KCWCD. Development of new ground water supplies and agricultural conversion are the most viable and cost effective options, with ground water production, having less impact on the local economy, being implemented

first. Because the LPP has specific technical/environmental concerns and is significantly more expensive than the other two potential supplies, it is listed last in the order of implementation.

There are three alternatives considered for future supply. Maximizing development of local ground water resources to the limit allowed by the State Engineer is the least-cost option and should be exhausted before other projects are pursued. Conversion of agricultural supplies, either through conversion of agricultural rights associated with urbanizing land or through "buy and dry" programs, is the second alternative listed. This alternative would be lower in cost than the LPP for lands that are near urbanizing areas.

The third alternative for future supply is the Lake Powell Pipeline. KCWCD has requested 10,000 ac-ft per year in LPP supply. This imported water source is considered to be the last priority compared to the feasible local water development projects.

Table 6-4
KCWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)				Comments
	East Fork Virgin River	Kanab Creek	Johnson Canyon	Wahweap Creek	
Existing Supplies	845	2,560	100	540	Combined culinary and secondary supply
Future Supplies					
New Ground Water (Amount and Year Needed)	240	1,770	110	90	Phase in as needed. For all subbasins, this is the only Future Supply needed to meet demand.
	2044	2018	2006	2052	
Agricultural Conversion	0	0	0	0	Phase in as needed. Based on 20 percent of current agricultural use.
Lake Powell Pipeline	0 (1)	0 (1)	0 (1)	0 (1)	When needed, Supply would be divided among the 4 subbasins based on need. KCWCD requested 10,000 ac-ft/yr from LPP, which would be limited to 4,000 ac-ft/yr of depletions in the Kanab Creek/Virgin River Basin. 0 ac-ft per year needed in 2060.

Notes:
(1) Lake Powell Pipeline would not be needed in the planning horizon.

Figure 6-5 through **Figure 6-8** show graphically the relationship between supply and demand, and the sequential timing of new projects brought on line in a just-in-time manner to meet the forecasted total water demand. For all four subbasins, a combination of existing and new ground water supplies is sufficient to meet all future needs within the planning horizon. Of the two largest subbasins, Kanab Creek and Johnson Canyon a maximum of 60 percent of the available ground water supply will be needed. Thus based strictly on water need, neither agricultural conversion nor LPP supplies are needed in the KCWCD service area within the 2060 planning horizon.

However, KCWCD may choose to participate in the LPP project for other reasons. The LPP will traverse Kane County on its way to Washington and Iron Counties. Therefore, there is an opportunity for KCWCD to participate in the LPP simply out of convenience. Tapping into the pipeline would add a reliable supply to their system that would stretch local supplies further into the future. LPP deliveries could be used for culinary supplies, saving local ground water for use as secondary water. KCWCD has considered using LPP deliveries to recharge aquifers supporting local wellfields to sustain natural supplies and keep water levels high.

Figure 6-5
KCWCD Supply and Demand – East Fork Virgin River

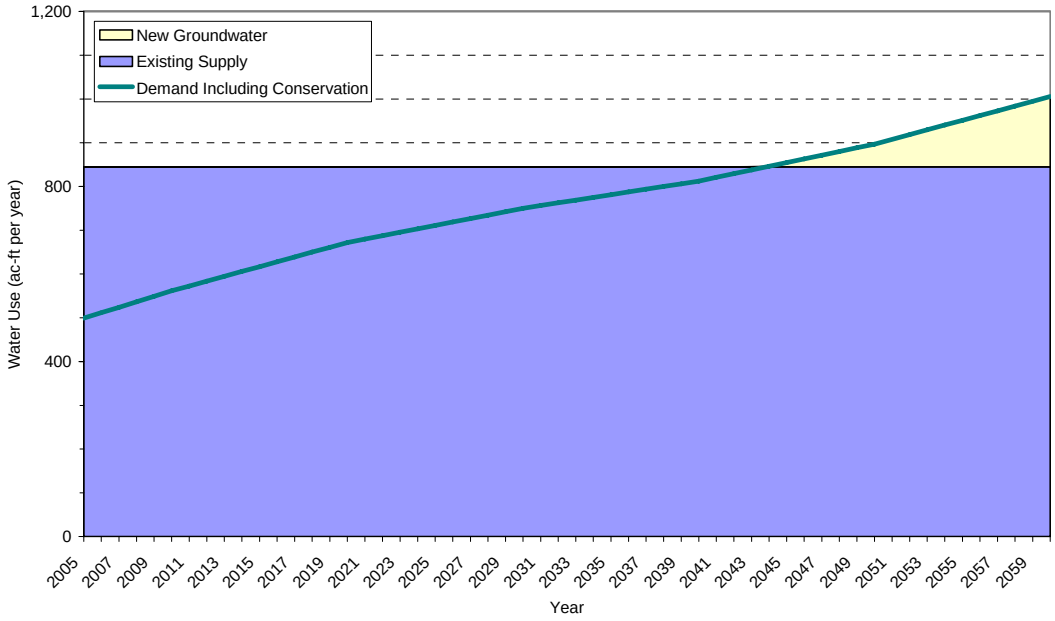


Figure 6-6
KCWCD Supply and Demand – Kanab Creek

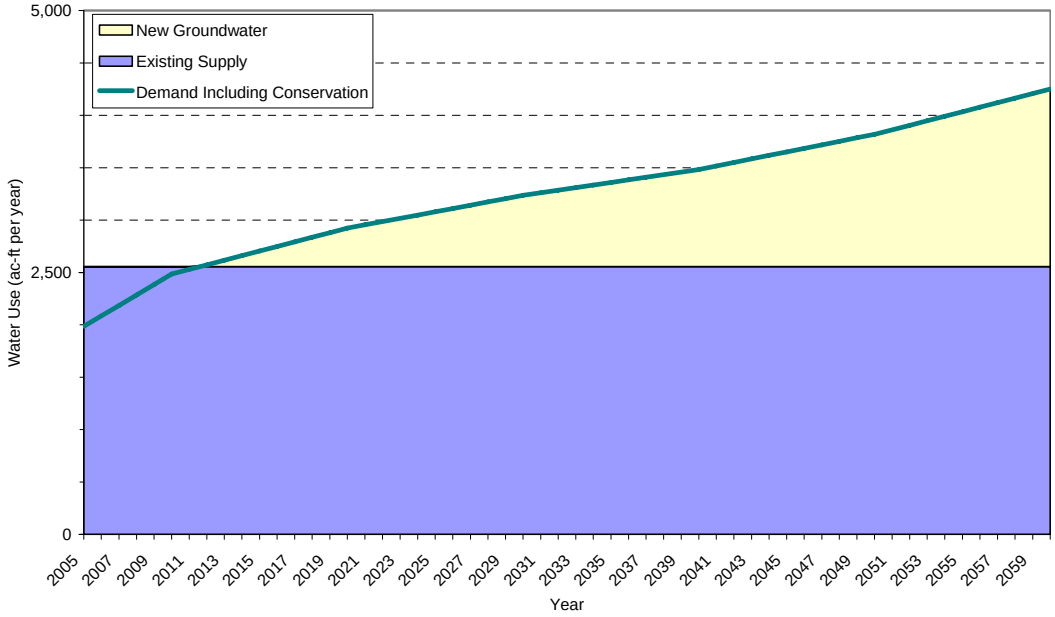


Figure 6-7
KCWCD Supply and Demand – Johnson Canyon

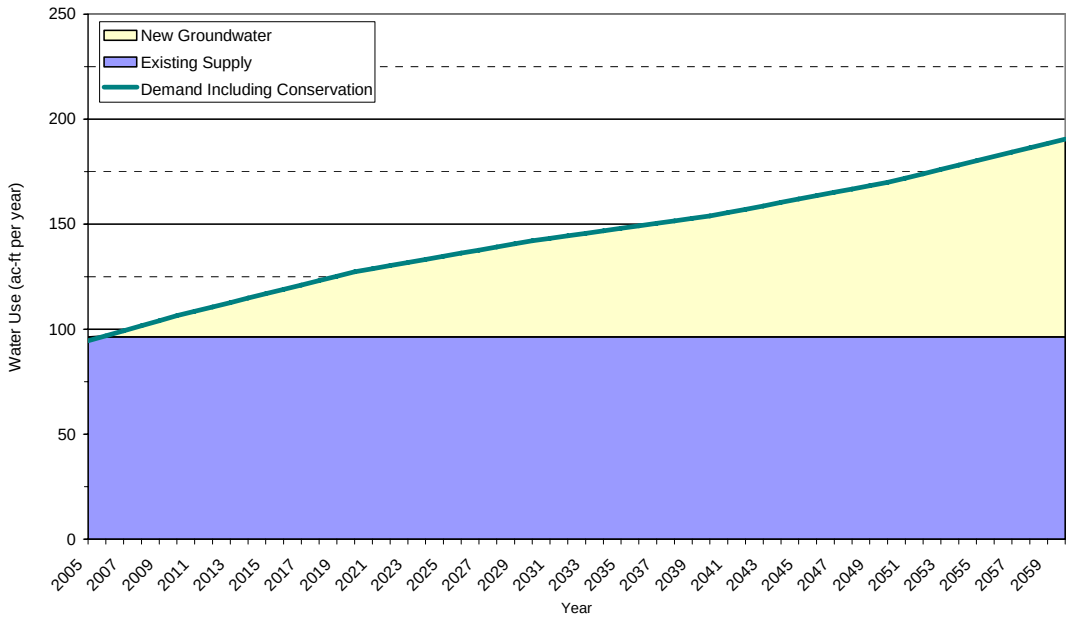
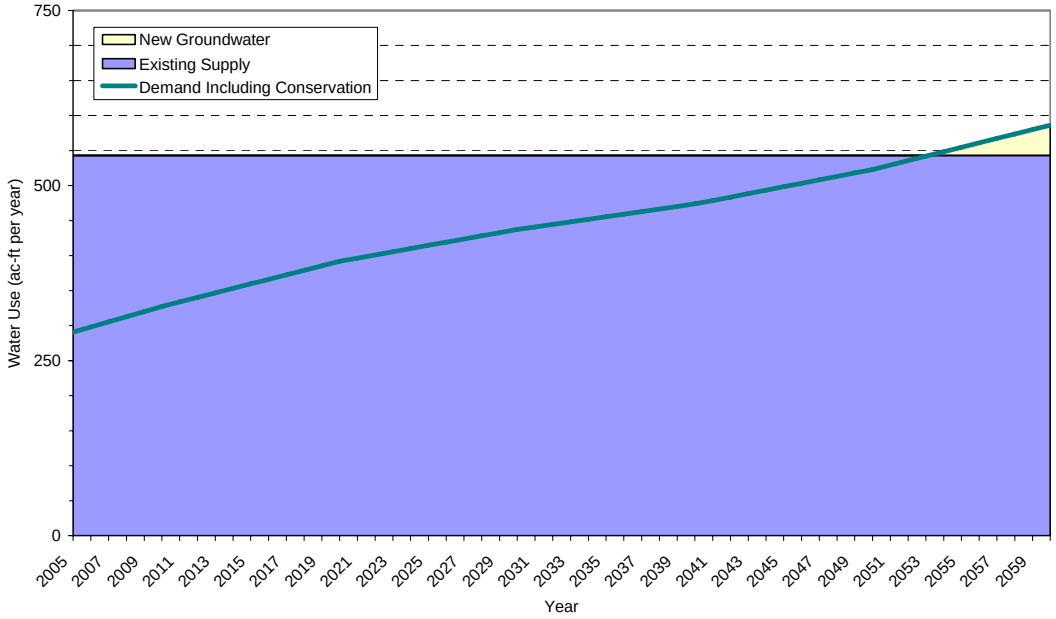


Figure 6-8
KCWCD Supply and Demand – Wahweap Creek



6.2 No Action Alternative

The No Action Alternative defines the water supply and demand for WCWCD, CICWCD, and KCWCD through the 2060 planning period without implementation and operation of the LPP. The No Action Alternative will be used to identify, analyze and document impacts during preparation of the LPP Environmental Impact Statement (EIS). Preliminary elements of the No Action Alternative were determined based on interviews with key water users in each water conservancy district. Further work will be performed to define the No Action Alternative for each water conservancy district during Phase 2 of the Water Needs Assessment Study. This discussion assumes that future population growth as projected by the Utah GOPB would occur within the water conservancy district existing service areas without the Lake Powell Pipeline project.

6.2.1 WCWCD No Action Alternative

The LPP would not be constructed or operated under the No Action Alternative. The WCWCD would implement other future water development projects currently planned by the District, develop additional water reuse/reclamation, convert additional agricultural water use to M&I use as a result of urban development in agricultural areas, and implement advanced treatment of Virgin River water. The WCWCD could also limit demand by enacting water conservation such as outdoor watering restrictions.

6.2.1.1 Assumptions

The following assumptions were made in developing the No Action Alternative for WCWCD. Conditions that would allow water supply development are incorporated into the assumptions where applicable.

- Existing M&I reliable annual supply of approximately 83,910 ac-ft per year would continue (72,560 ac-ft reliable culinary water supply, 7,450 ac-ft reliable secondary water supply, and 3,900 ac-ft wastewater reuse from the St. George wastewater treatment plant)

- Reliable annual yield of existing supply is estimated using Division of Water Resources reliable culinary supply plus reliable secondary supply (estimated as 2005 secondary water use) as described in **Chapter 4**.

- Projected total water demands are based on Utah GOPB population projections, per capita water use, and conservation assumptions (including 16 percent reduction in total M&I per capita water use from 2005 through 2060) as described in **Chapter 3** (per capita water use would continue to decrease as water conservation measures are implemented and practiced).

- Ash Creek and Crystal Creek pipelines would be developed as planned for water supply as in Chapter 4. Ash Creek would have a water supply of about 5,000 ac-ft per year. Crystal Creek would have a water supply of about 2,000 ac-ft per year.

- The next increment of reuse water supply development would be to maximize the 10 mgd build-out capacity of the St. George wastewater reuse treatment plant, yielding a total of 7,300 ac-ft per year (increase in reuse water supply of about 3,400 ac-ft per year; dependent on Virgin River in-stream flows meeting requirements under approved recovery plans and the Habitat Conservation Plan for federally listed species). It was assumed that storage would be built to capture all of the available treated wastewater, in order to capture potential reuse water supply during the winter months that could be delivered to meet secondary demands during the summer irrigation season.

- Approximately 4,000 ac-ft of water per year is stored in Quail Creek Reservoir from November through April for the Hurricane and Washington Fields Irrigation companies. Quail Creek Reservoir water is of sufficient quality to be treated economically for culinary use. Therefore, an exchange for this water would

allow the 4,000 ac-ft per year of culinary water currently used for agriculture to be utilized to meet culinary M&I demands, while the agricultural demand would be met with secondary-grade quality water.

- Urban development of the agricultural areas would result in converting 13,300 ac-ft per year in 2060 of agricultural water to secondary M&I water that would be stored in the proposed Warner Valley Reservoir and then treated with advanced water treatment to reduce overall TDS levels to below 1,000 mg/L. This supply is limited by the projected growth rate of M&I development into agricultural areas. Accounting for blending and a 20 percent loss through the RO treatment process, the maximum average annual yield would be 12,400 ac-ft/year. As discussed in **Section 6.1.2**, there are several feasibility issues that make advanced treatment a last resort for WCWCD, including energy requirements, lack of an environmental acceptable alternative for brine disposal, cost, and high TDS of Virgin River streamflow.

- Agricultural land would not be purchased to convert agricultural water into M&I water unless the farmland is planned for urban development (no "buy and dry" of agricultural land to develop M&I water supply)

- Additional future increases in reuse of treated wastewater flow at the St. George wastewater treatment plant would be developed to the maximum reuse potential of about 11,200 ac-ft per year (assuming that the only wastewater that will be available for reuse will originate from treated wastewater at the St. George wastewater treatment plant) and limited by the projected secondary water demands. Reuse potential is dependent on the following conditions: Virgin River in-stream flows meeting requirements under approved recovery plans and the Habitat Conservation Plan for federally listed species; local demand for reuse water as secondary water for outdoor use. Expansion of the capacity at the St. George wastewater treatment plant beyond the 11,200 ac-ft per year potential was considered feasible if there would be a large enough secondary demand and a large enough supply of treated wastewater for reuse. Additional reuse would be limited by the amount of treated wastewater available for reuse, which would be less for the No Action Alternative because of less wastewater available for reuse without the supply associated with the potential Lake Powell Pipeline.

6.2.1.2 Water Supply and Demand

Existing and future water supplies under the No Action Alternative would meet projected M&I water demand within the WCWCD service area through approximately 2020 (**Figure 6-9**). The total water supply of about 110,700 ac-ft per year would include existing supplies, planned WCWCD water supply projects, wastewater reuse, transfer of Quail Creek Reservoir supplies, and future agricultural water conversion resulting from urban development of currently irrigated lands (**Table 6-5**). Each future supply source would be phased in as needed to meet the M&I demand associated with the forecasted population. The No Action Alternative would not provide WCWCD with any reserve water supply (e.g., water to meet annual shortages because of drought, emergencies, and other losses). Maximum reuse of treated wastewater effluent for secondary supplies would be required to meet the projected M&I water demand starting in 2020. The quantity of required future water reuse compared with the total projected wastewater effluent is shown in **Figure 6-10**.

The No Action Alternative would not provide adequate water supply to meet projected water demands from 2020 through 2060 (end of study planning period). There would be a potential water shortage of approximately 145,200 ac-ft per year in 2060 under the No Action Alternative (**Figure 6-11**).

Table 6-5
WCWCD No Action Alternative Data

Item	Amount (ac-ft/yr)
2060 Demand	**265,780**
Existing Supplies	
Culinary Supply	72,560
Secondary Supply	7,450
Reuse	3,900
Future Supplies	
Ash Creek Pipeline	5,000
Crystal Creek Pipeline	2,000
Maximize Existing Wastewater Reuse Capacity of 10 mgd	3,400
Quail Creek Reservoir Agricultural Supply Exchange	4,000
Agricultural Conversion	12,400
Additional Future Wastewater Reuse	9,800
Total Supplies	**120,600**
Unmet Demand	**145,200**

Figure 6-9
WCWCD No Action Alternative Supply and Demand

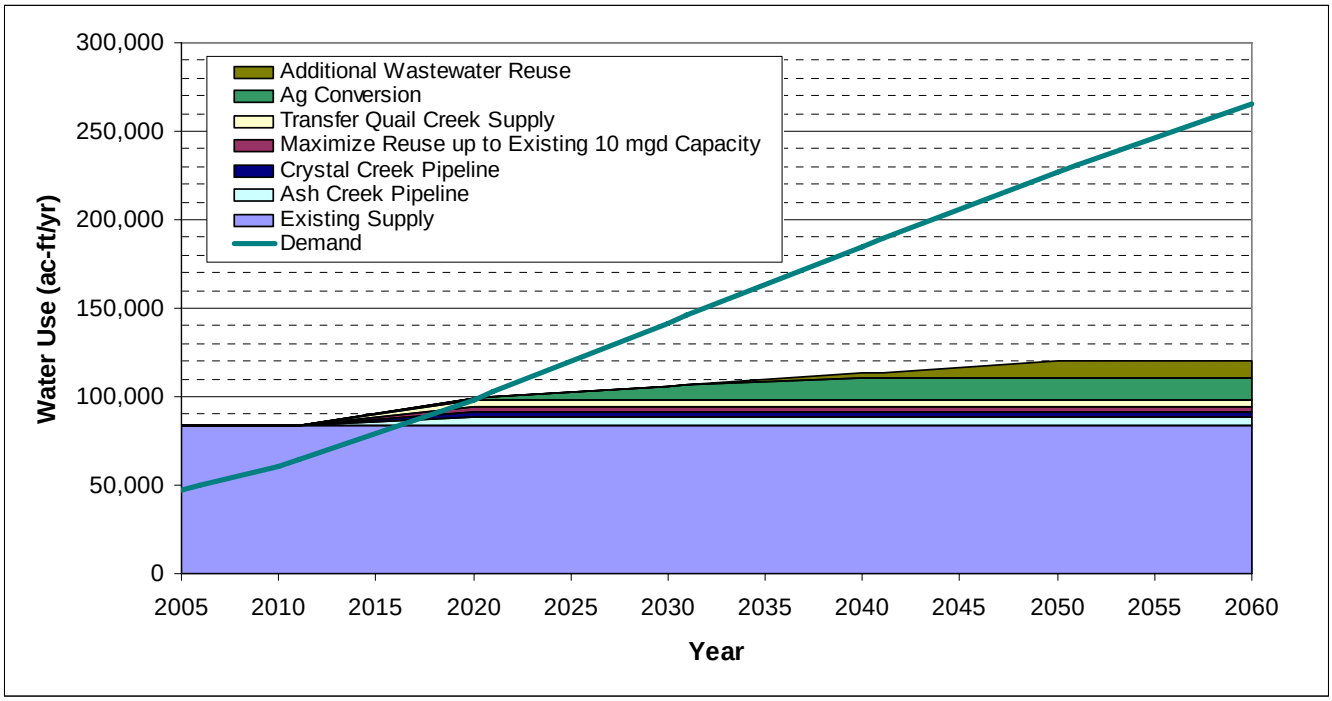
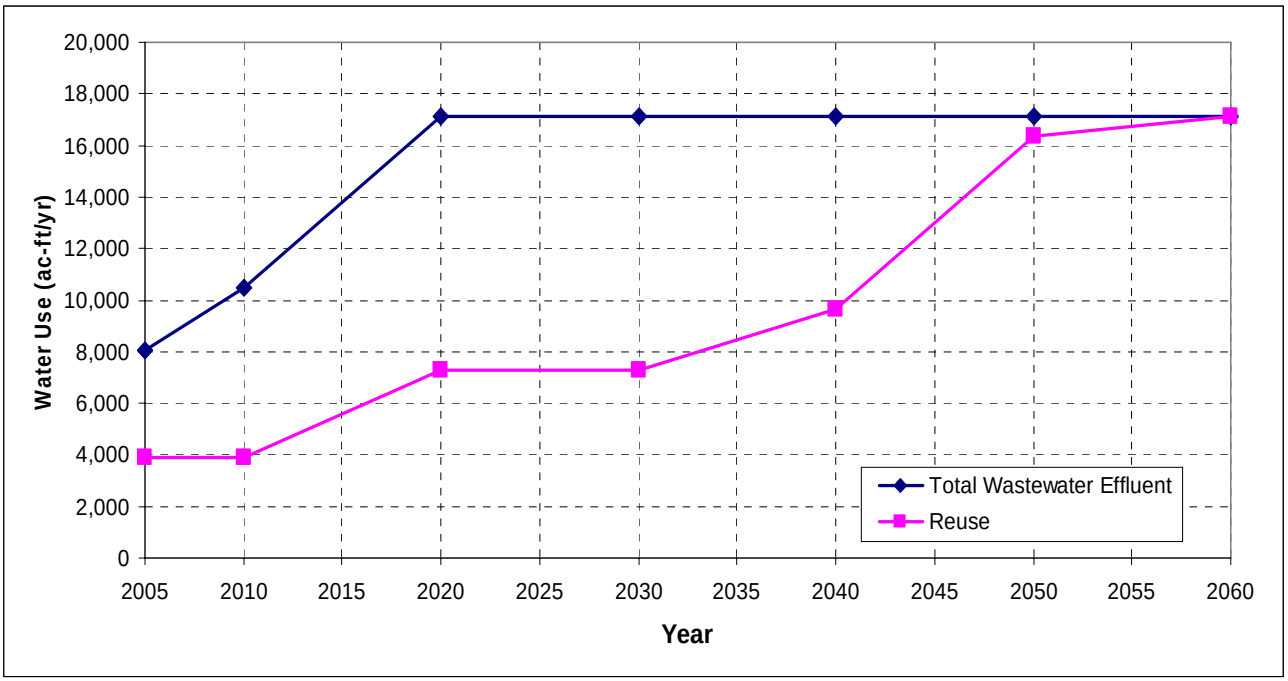
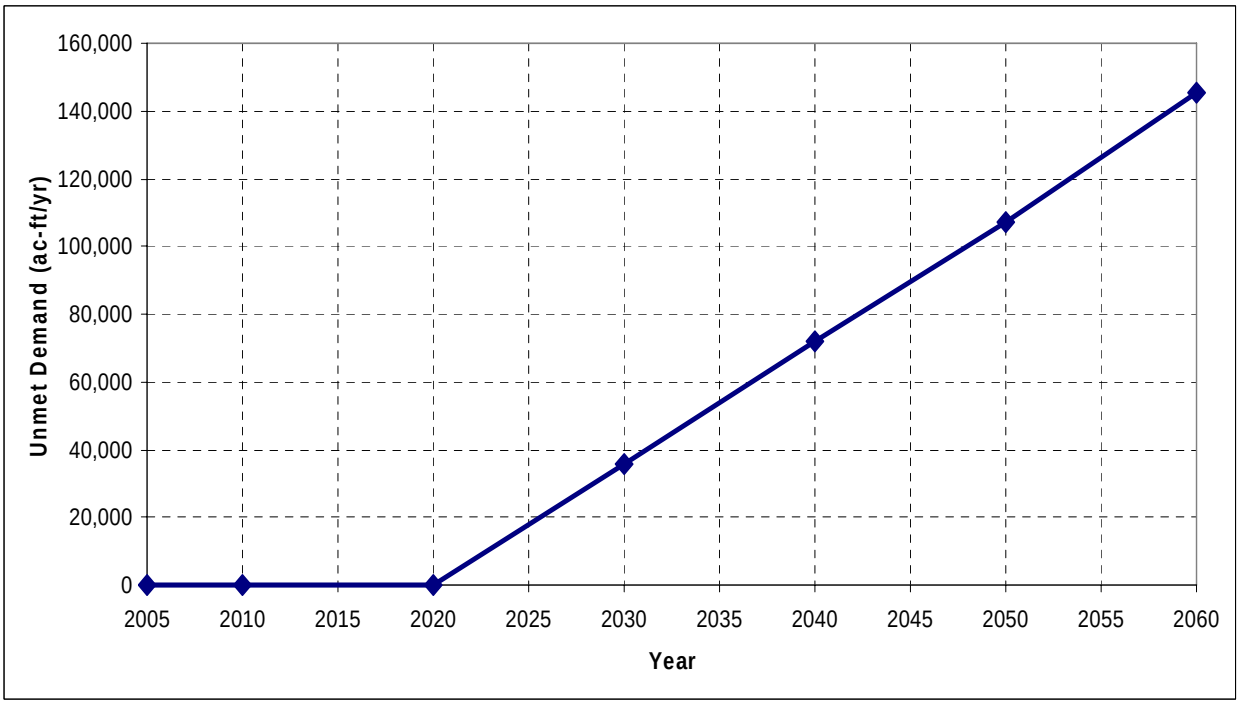


Figure 6-10
Washington County Projected Wastewater Effluent and Required Water Reuse to Meet Projected Secondary Demands



Note: Total wastewater effluent available for reuse is maximized at approximately 17,000 ac-ft per year in the year 2020, because additional culinary supply is not available to be used by communities served by the St. George Wastewater Treatment Plant beyond 2020.

Figure 6-11
WCWCD Unmet Demand for No Action Alternative



6.2.2 CICWCD No Action Alternative

The LPP would not be constructed or operated under the No Action Alternative. The Utah State Engineer would act to limit existing and future ground water pumping from the Cedar Valley aquifer in an amount not exceeding the assumed sustainable yield of 37,600 ac-ft per year. The CICWCD would implement future water development projects including converting agricultural water rights to M&I water rights as a result of urban development in agricultural areas, purchasing "buy and dry" agricultural water rights to meet M&I demands, and developing water reuse/reclamation.

6.2.2.1 Assumptions

The following assumptions were made in developing the No Action Alternative for CICWCD. Conditions that would allow water supply development are incorporated into the assumptions where applicable.

- Existing M&I reliable annual supply of approximately 12,160 ac-ft per year would continue (culinary plus secondary reliable supply).
- Reliable annual yield of existing supply is estimated using Division of Water Resources reliable culinary supply plus reliable secondary supply (estimated as 2005 secondary water use) as described in **Chapter 4**.
- Projected total water demand is based on Utah GOPB population projections, per capita water use, and conservation assumptions (including 16 percent reduction in total M&I per capita water use from 2005 through 2060) as described in **Chapter 3** (per capita water use would continue to decrease as water conservation measures are implemented and practiced).
- Approximately 5,320 acres of agricultural land could be converted to urban development based on the CICWCD Capital Facilities Plan, resulting in about 14,060 ac-ft per year of agricultural water converted to M&I water as a result of urban development of agricultural land.
- New ground water pumping from the Cedar Valley aquifer is limited to currently appropriated but undeveloped ground water rights, limited by seniority assuming a sustainable yield of 37,600 ac-ft per year. CICWCD could develop an additional 3,610 ac-ft per year of additional ground water.
- Water reclamation and reuse would be developed as possible, including treatment processes to control contaminants (dependent on the following conditions: treatment technologies would be available and implemented to remove contaminants such as nitrates and total dissolved solids that would otherwise concentrate within the basin supply as a result of successive uses of the water).
- Water reclamation and reuse would be limited to the amount of water that could be saved based on the consumptive use of the current practice of applying treated wastewater to grasses and alfalfa. It was assumed that the application of treated wastewater to grasses and alfalfa would cease, and the maximum reuse potential would be equal to the water that would be saved through the lack of consumptive use resulting in 2,470 ac-ft per year in 2060.
- "Buy and dry" of agricultural land as needed to meet unmet M&I water demand after existing water supplies and agricultural water is converted to M&I use as a result of urban development in agricultural areas. Approximately 2,640 acres would be available for "buy and dry" and would result in 6,970 ac-ft per year by 2060.

6.2.2.2 Water Supply and Demand

Existing and future water supplies under the No Action Alternative meet projected M&I water demand within the CICWCD service area through the planning period through agricultural conversion of water rights to M&I use, additional ground water development up to the assumed sustainable yield of 37,600 ac-ft per year, wastewater reuse, and implementing "buy and dry" practices on irrigated agricultural land (**Figure 6-12**). Each future water supply source would be phased in as needed to meet the M&I demand associated with the forecasted population. The No Action Alternative includes buy and dry of agricultural water rights because no other potential water supply has been identified to meet unmet demand without implementation of the LPP. However, CICWCD has indicated that the district is in the process of adopting a resolution opposing buy and dry of agricultural water rights because of the associated effect on the quality of life in Iron County. As a result, buy and dry of agricultural water rights may not be available to meet unmet demand and supplies from outside of the district's service area may be needed. The quantity of required future agricultural water conversion to M&I uses as a result of urban development over agricultural land and from buy and dry of agricultural water rights is shown in **Figure 6-13**. The consequence of the CICWCD No Action Alternative would include a reduction in irrigated acreage from agricultural conversion due to development and buy and dry of agricultural water rights in CICWCD of approximately 8,000 acres (58 percent reduction in total irrigated agricultural land) over the 2005 to 2060 planning period. The No Action Alternative would not provide CICWCD with any reserve water supply (e.g., water to meet annual shortages because of drought, emergencies, and other losses) after 2010 (i.e., after existing supplies would be maximized). There would be an unmet demand of 2,330 ac-ft/yr in 2060.

Table 6-6
CICWCD No Action Alternative Data

Item	Amount (ac-ft/yr)
2060 Demand	**41,600**
Existing Supplies	
Culinary Supply	11,360
Secondary Supply	800
Future Supplies	
Agricultural Water Rights Conversion to M&I Development	14,060
Development of Existing Local Ground Water Rights	3,610
Water Reuse	2,470
Agricultural Water Right Conversion to Buy and Dry	6,970
Total Supplies	**39,270**
Unmet Demand in 2060	**2,330**

Figure 6-12
CICWCD No Action Alternative – Supply and Demand

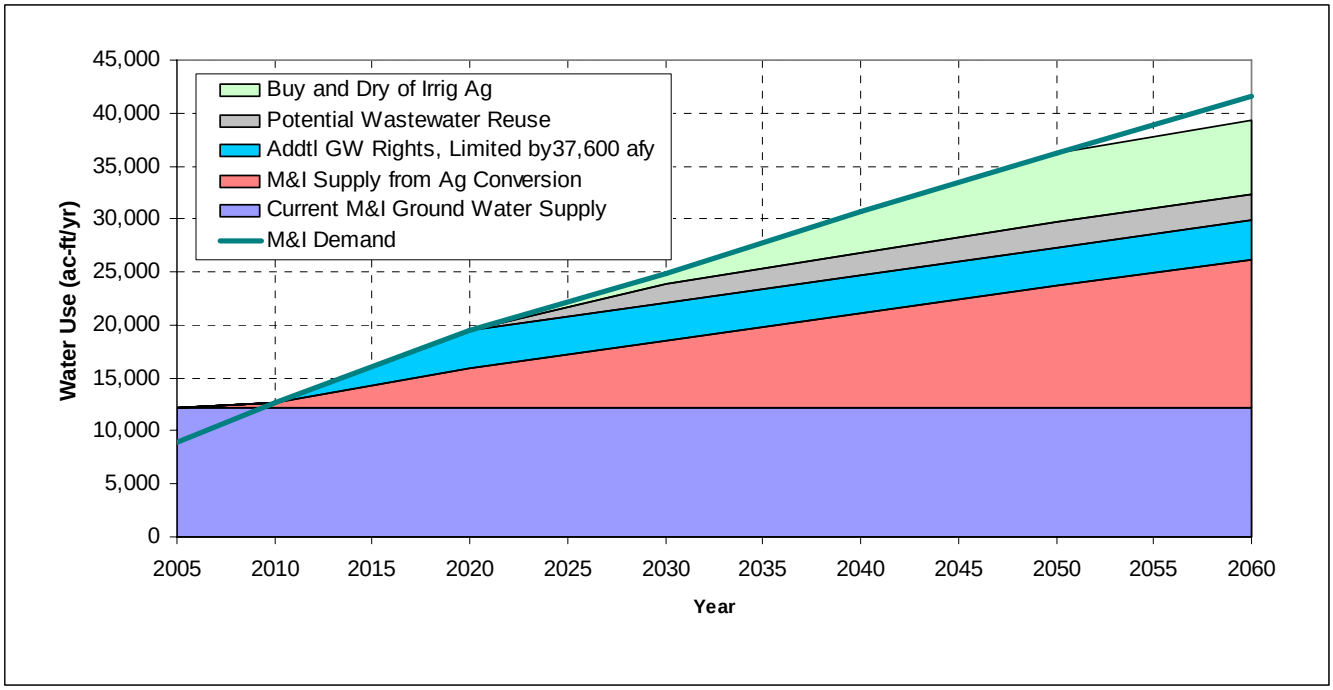
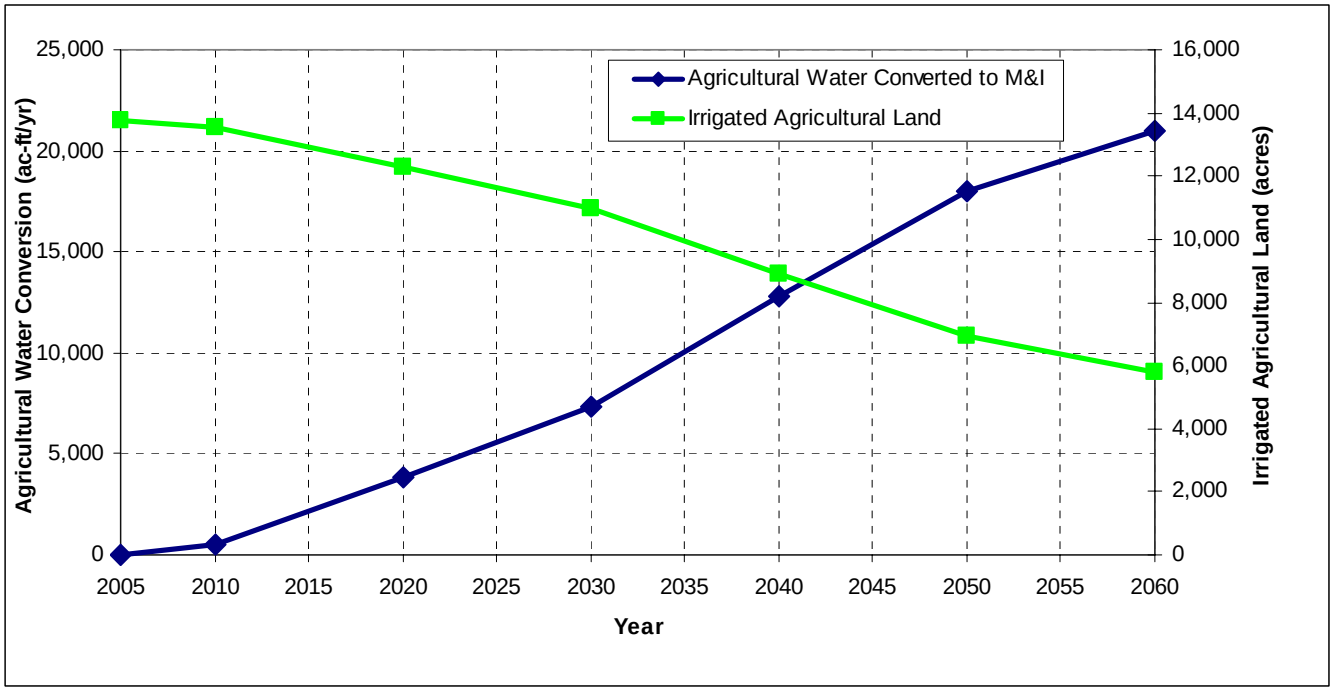


Figure 6-13
Agricultural Conversions to Meet Projected M&I Demand



6.2.3 KCWCD No Action Alternative

The LPP would not be constructed or operated under the No Action Alternative. The KCWCD could use existing supplies and implement future water development projects including new ground water production, converting agricultural water rights to M&I water rights as a result of urban development in agricultural areas, and developing water reuse/reclamation.

6.2.3.1 Assumptions

The following assumptions were made in developing the No Action Alternative for KCWCD. Conditions that would allow water supply development are incorporated into the assumptions where applicable.

- Existing M&I reliable annual supply of approximately 4,040 ac-ft per year would continue (culinary plus secondary water).
- Reliable annual yield of existing supply is estimated using Division of Water Resources reliable culinary supply plus reliable secondary supply (estimated as 2005 secondary water use) as described in **Chapter 4**.
- Projected maximum water demands are based on Utah GOPB (2008) population projections, per capita water use, and conservation assumptions (including 31 percent reduction in total M&I per capita water use from 2005 through 2060) as described in **Chapter 3** (per capita water use would decrease as water conservation measures are implemented and practiced).
- The four ground water basins have approximately 8,100 ac-ft available to KCWCD for future development through development of additional ground water up to the sustainable yield of the aquifer.

- Up to 20 percent of 2005 estimated agricultural water use could be converted to M&I use as a result of urban development if projected demands exceed available supply from other alternative water supplies.

- Water reclamation and reuse could be developed as needed to meet future demands.

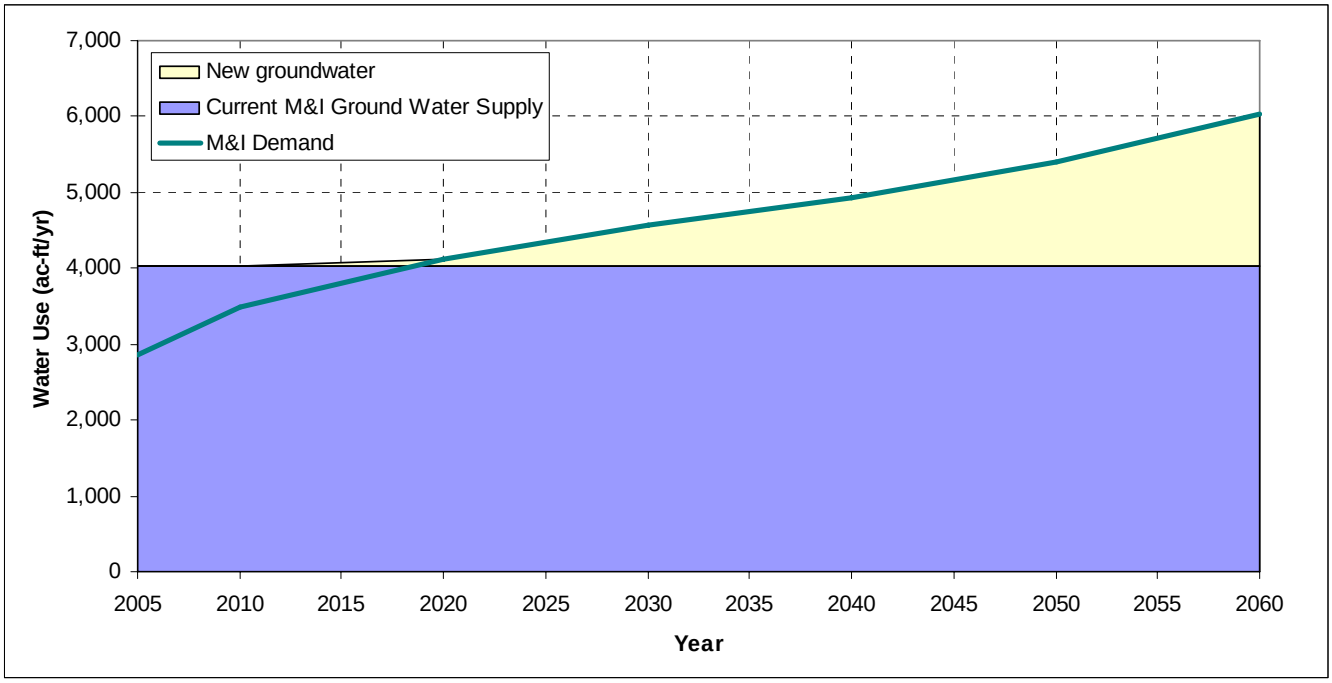
6.2.3.2 Water Supply and Demand

Existing water supplies (4,040 ac-ft per year) and 1,990 ac-ft per year of new ground water under the No Action Alternative would meet projected M&I water demand of 6,030 ac-ft per year within the KCWCD service area through 2060 (**Figure 6-14)**. The total potential water supply for KCWCD is about 12,140 ac-ft per year (4,040 ac-ft per year existing culinary plus secondary supply, and 8,100 ac-ft per year potential for additional ground water development up to the assumed sustainable ground water yield) without agricultural conversion to M&I supply or the Lake Powell Pipeline. Short-term ground water overdrafts and proposed storage projects (e.g., Jackson Flat Reservoir) would provide reserve water supply to meet demands during drought periods and other emergencies.

Table 6-7
KCWCD No Action Alternative Data

Item	Amount (ac-ft/yr)
2060 Demand	**6,030**
Existing Supplies	
Culinary Supply	3,540
Secondary Supply	500
Future Supplies	
New Ground Water Production	8,100
Agricultural Water Conversion	2,710
Total Supplies	**14,850**
Unmet Demand	**0**

Figure 6-14
KCWCD No Action Alternative – Supply and Demand



6.3 Summary

Results of Phase 1 of the LPP Water Needs Assessment are summarized in **Table 6-8**.

Table 6-8
Summary of the LPP Water Needs Assessment

Description	WCWCD	CICWCD	KCWCD
Existing (2005) M&I Reliable Supply	83,900	12,150	4,040
Existing (2005) M&I Demand	46,740	8,960	2,870
Existing (2005) Unmet Demand	0	0	0
Existing (2005) Surplus	37,160	3,190	1,170
2060 Demand without Conservation	316,400	48,180	8,580
2060 Demand with Conservation	265,770	41,590	6,030
2060 Conservation Savings/Supply	50,630	6,590	2,550
2060 Unmet Demand	**181,870**	**29,440**	**1,990**
2060 Additional Supply from Likely Projects	25,100[1]	17,960[2]	10,810[3]
2060 Unmet Demand	**156,770**	**11,480**	**0**
Water Supply Available from LPP	70,000	11,480	0
2060 Unmet Demand	**86,770**	**0**	**0**
2060 Additional Supply from Possible Projects	16,890[4]	0	0
2060 Unmet Demand	**69,880**	**0**	**0**

Notes:
[1] Likely projects for WCWCD include Quail Creek Reservoir Exchange, Ash Creek Pipeline, Crystal Creek Pipeline, Maximize Existing Wastewater Reuse, and Agricultural Conversion associated with M&I development. See **Table 6-2** for timing and water supply for each of the projects.

[2] Likely projects for CICWCD include: Agricultural water conversion from developed land, Agricultural water conversion from "buy and dry", and Local ground water rights. See **Table 6-3** for timing and water supply for each of the projects.

[3] Likely projects for KCWCD include: Agricultural Water Conversion and Local ground water rights. See **Table 6-4** for timing and water supply for each of the projects.

[4] Possible projects for WCWCD include future wastewater reuse. See **Table 6-2** for timing and water supply for future wastewater reuse.

There are a number of factors that introduce significant uncertainty into the results of this water needs assessment. These include:

- Population forecasts for a period exceeding 50 years are highly speculative, particularly given past difficulties with accurately forecasting population growth in Southwest Utah. Actual population will be driven by many factors that cannot be accurately forecasted. The most defensible forecast has been used for this study.
- Actual future conservation efforts may exceed or fall short of the goals assumed in Phase 1 of this study. Phase 2 will further investigate reasonable conservation assumptions by evaluating the potential for implementing specific conservation measures in the study area.
- Sustainable yield for the Cedar Valley ground water basin has not been determined definitively; the assumed sustainable yield significantly affects the need for and timing of alternate sources of supply.
- The rate at which urban development occurs over areas of existing irrigated agriculture will affect the rate at which agricultural supplies are converted to M&I supplies without buy and dry programs. This in turn would affect the timing of other new supplies including the Lake Powell Pipeline.

- The mix of culinary and secondary water use at present was assumed to continue into the future. Complex economic factors, outdoor landscaping practices, and regional and local water use policies could substantially affect the ratio of secondary water use to total water use.
- Advanced water treatment processes (e.g. reverse osmosis) are assumed to be financially and environmentally prohibitive with regard to providing culinary water from local surface waters. Technological breakthroughs in treatment processes or brine disposal methods could make advanced water treatment feasible for Southwestern Utah in the future, making it possible to develop additional local water resources.

These and other uncertainties affect the reliability of the water supply and demand estimates used in this report. Assumptions other than those made in this report could be reasonable based on alternate assumptions of future growth, hydrology, community values, political influences, etc. Despite these uncertainties, the methods and assumptions used in this water needs assessment were selected to be the most defensible methods and assumptions possible given available information, and the results are considered to be usable for long-range regional water supply planning purposes.

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