Lake Powell Pipeline Study

WATER NEEDS ASSESSMENT

Draft

March 2011





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Water Needs Assessment

March 2011

DRAFT

Prepared for:

Utah Division of Water Resources

Prepared by:

MWH
BUILDING A BETTER WORLD

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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**.

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.

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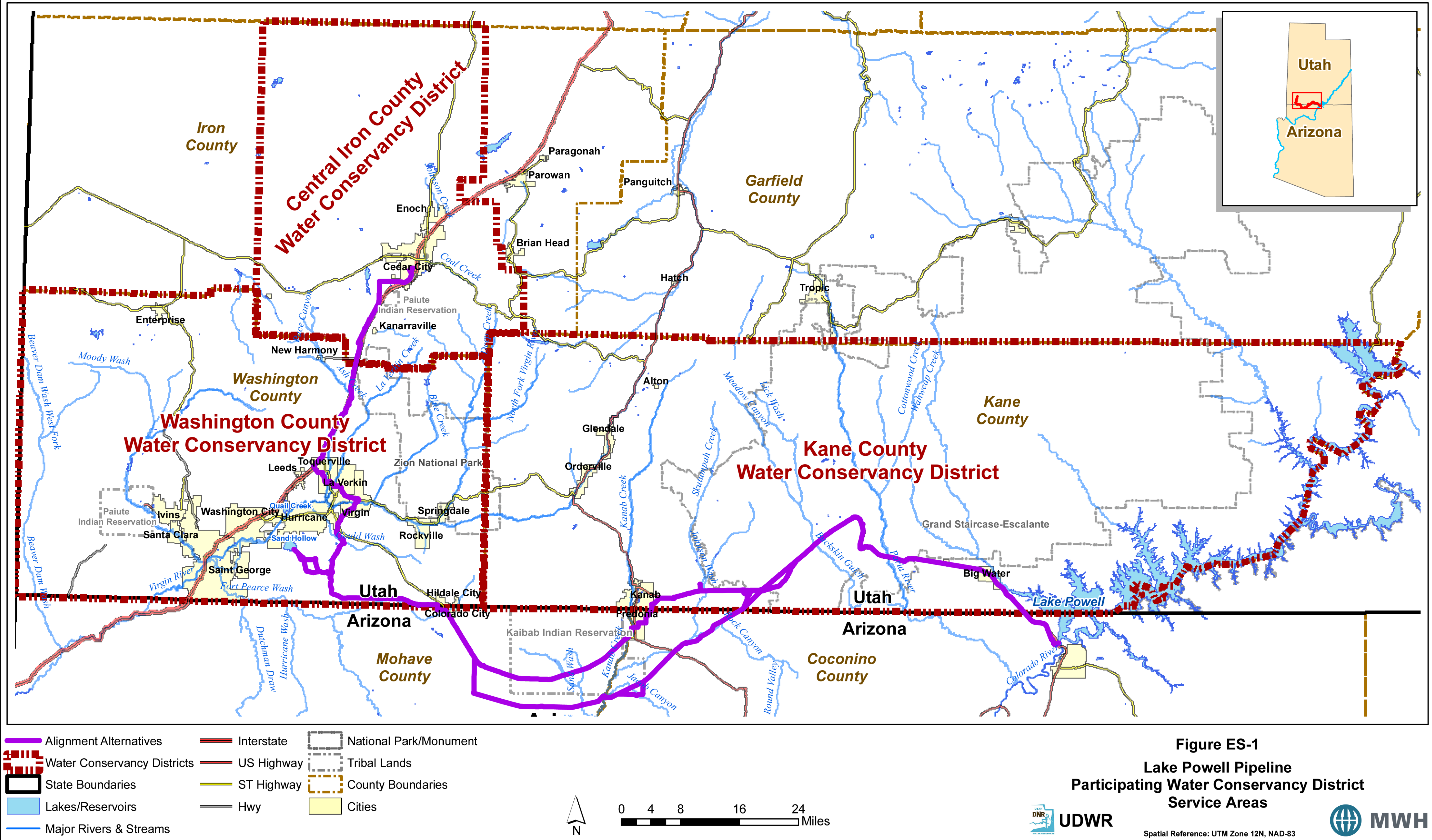

Figure ES-1

Lake Powell Pipeline
Participating Water Conservancy District Service Areas

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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 –** 69,000 acre-feet per year (ac-ft/yr)
- **CICWCD –** 13,000 ac-ft/yr
- **KCWCD –** 4,000 ac-ft/yr

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
- Determine the potential secondary and reuse water demand and supply

The Water Needs Assessment was prepared by MWH Americas, Inc. under contract to the State of Utah. It partially fulfills the project objectives outlined in Study Plan 19, Water Supply and Climate Change, approved by the Federal Energy Regulatory Commission in their January 21, 2009 Study Plan Determination.

ES-2 Water Demand Forecast

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
- Portion of KCWCD service area that could be served with water from the LPP

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 2009 per capita use rates for culinary (potable) and secondary (nonpotable) water, reduced by assumed future conservation.
- Water conservation programs for each district were developed through a detailed evaluation of potential measures and local involvement.
- 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 2009 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.

Total annual municipal and industrial (M&I) water demand forecasts were developed for the 2009 to 2060 study period for the three Districts using population projections, 2005 comprehensive M&I water use information, 2009 per capita water use estimates, and an assumed conservation savings based on feasible water conservation programs. 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-2.1 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 January 2008 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.**

Population data reflects permanent residents only. Each of the districts has a high proportion of non-permanent residents who are not counted in these figures. Temporary population includes seasonal residents, tourists and other visitors, and college students. Although these non-permanent residents are not included in population values, their water use is included in the total water use values used to compute per capita use rates. This can significantly inflate per capita use estimates for the study area.

Table ES-1 Population Projections

District	Parameter[2]	Year							2005 to 2060 AGR
		2009	2010	2020	2030	2040	2050	2060	
WCWCD	Pop.	159,880	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.	42,858	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.	6,705	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).
(2)Pop. = GOPB population projection; AGR = annual growth rate.

ES-2.2 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 and 2009 Utah Governor's Water Conservation Team (GWCT) water use rates provided by the Utah Division of Water Resources (DWRe). Per capita water use rates for 2009 were determined as follows.

- **WCWCD –** 2009 GWCT culinary per capita use data for the 6 largest cities in Washington County was extrapolated to the entire county based on the ratio between water use in the six largest cities vs. the entire county in the 2005 M&I Water Use Report by DWRe. Secondary per capita water use was assumed to be the same in 2009 as in 2005.
- **CICWCD –** 2005 culinary and secondary water per capita use rates reported in the M&I Water Use Report by DWRe were reduced by 4 percent to account for assumed conservation savings of 1 percent per year.
- **KCWCD –** 2009 culinary and secondary water per capita use rates were the same as the rates for 2005 reported in the M&I Water Use Report by DWRe. This assumes that conservation or other factors did not significantly affect per capita water use in KCWCD between 2005 and 2009.

Results 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 2009 Per Capita Water Use

District	Culinary (gpcd)	Secondary (gpcd)	Total (gpcd)
WCWCD	242.0	52.3	294.3
CICWCD	213.0	20.8	233.8
KCWCD	345.7	74.5	420.3
Source: GWCT 2010, DWRe 2006c; DWRe 2007a; DWRe 2007b; DWRe 2009bb.			

The per capita use rates (calculated as total water use divided by total permanent population) reported in **Table ES-2** are higher than the values often reported for other similar U.S. cities. Several factors contribute to relatively high water use rates in the southwest Utah region.

- Many communities only report residential water use, which is not affected by commercial or industrial uses that can vary greatly between communities. Values used for this project include total water use in all sectors divided by the permanent population, to be consistent with previous data reported by DWRe.
- The population values used to compute per capita water use do not include the significant impact of the large number of non-permanent residents in the region.
- Water use values include both culinary (potable) and secondary (non-potable) sources. Many communities only report culinary water use.
- The growing season in southwestern Utah is long and summers are hot, particularly in WCWCD, increasing the need for outdoor irrigation water.

ES-2.3 Conservation

Conservation has been a cornerstone of water resources management in the WCWCD and CICWCD service areas for many years. Both agencies have state-accepted conservation plans. WCWCD adopted a conservation plan before it was required by the State, and has been a leader in implementing effective conservation measures since the mid-1990s. WCWCD and CICWCD have staff dedicated to developing and implementing conservation programs in cooperation with their member entities, regional agencies and universities.

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

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.

St. George has an active conservation program that includes many of the conservation measures promoted by WCWCD.

CICWCD's conservation programs have been primarily focused on public education and awareness, with the following components implemented from 2000 to 2009.

- Public education which includes presentations on water conservation at local schools, annual information booths at festivals, and an informative web site containing water conservation tips.

- Revisions to zoning ordinances made through the Iron County Planning Commission that encourage water conservation.
- Participation in the Environmental Protection Agency (EPA) WaterSense Partnership program, which has a goal to promote water efficiency and enhance the market for water efficient products, programs, and practices.
- Implementation of the Master Gardener Program that trains interested community members in all aspects of the horticulture field. Strong emphasis on water-wise landscaping.
- Implementation of the Water-Efficient Landscape Check-up program that is designed to recognize and showcase water efficient landscapes in Iron County.
- Participation in the Utah Water-wise Plant Tagging program that encourages local nurseries to place tags on plants that are water-wise to assist the population in identifying water-wise plants for use in their home landscapes.

The conservation programs in Cedar City encourage water conservation through customer education on outside watering and irrigation restrictions, and new water rate structures. The following programs have been implemented in Cedar City:

- Public education which provides information via television, radio (Slow the Flow Program) and printed material in monthly newsletters and the annual Consumer Confidence Report.
- Performance of annual water audits to detect leakage and unaccounted-for-water.
- Time-of-day Watering Ordinance that does not allow outside irrigation with culinary water between 8:00 AM and 6:00 PM.
- Water audits for culinary and pressurized irrigation water system customers used to identify and recommend specific water conservation measures.
- Increasing block rate structures to discourage excessive water use. The price of water increases as usage increases.
- Large irrigation users are classified and required to have a separate irrigation meter/connection to the City's pressurized irrigation system.

Enoch City has been executing conservation programs such as developing a secondary water source, installing a demonstration garden for efficient water use, requiring time-of-day watering ordinances, and using a water pricing structure. Enoch approved a secondary system that will serve 150 homes in two subdivisions. The City also implemented a water education program that distributed conservation information via newsletters, radio and television.

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. 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.

Future per capita water use for the study period was based on the 2009 per capita water use summarized in **Table ES-2** reduced by an assumed conservation percentage. The percent reduction applied to the 2009 per capita water use was based on feasible conservation plans developed for each District and the

State of Utah's conservation goal of achieving 25 percent reduction in per capita water use statewide by 2050 relative to 2000 per capita use.

The historical conservation achieved toward meeting the State's goal in the WCWCD and CICWCD service areas was estimated based on historical water use data collected from a variety of sources, and climatological data provided by DWRe. This analysis estimated conservation savings beginning in 2000, but it is recognized that conservation programs were effectively reducing per capita water use prior to 2000. For WCWCD five sources of water use data were evaluated for CICWCD seven sources of water use data were evaluated. All water use data were analyzed along with evapotranspiration data to consider the effects weather may have had on water use in a particular year.

A water conservation model was prepared for each District to evaluate potential benefits from a wide variety of conservation measures. The model simulated water savings at the end-use level (e.g., individual appliances) for existing and proposed conservation measures selected by groups of local water suppliers and conservation planners. A preferred conservation program was selected by the stakeholder group for each District based on local conditions and the desire to achieve the State's water conservation goal. **Table ES-3** summarizes the results of the conservation analysis. For KCWCD, the most ambitious conservation program evaluated in the model generated 16 percent conservation savings by 2050. It was assumed that KCWCD would adopt the necessary measures to achieve the State's goal of 25 percent savings by 2050.

Table ES-3 Summary of Water Conservation Analysis

	WCWCD	CICWCD	KCWCD
Historical 2000-2009 conservation savings (%)	13	9	0
Remaining conservation savings needed to meet State goal by 2050 (%)	12	16	25
Number of conservation measures in selected program	14 existing, 11 new	3 existing, 18 new	0 existing, 12 new
Projected 2009-2050 conservation savings (%)	15.9	16.3	25
Projected 2009-2060 conservation savings (%)	17.9	17.0	31

ES-2.4 Demand Projections

Total M&I projected water demands were estimated for the Districts using the GOPB population projections and the 2009 M&I per capita use rates reduced by the estimated conservation percentages. The projected water demands were calculated as the population projections multiplied by the per capita water use with conservation. 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** and **Tables ES-4** and **ES-5** indicates that total M&I demand for WCWCD would increase from 52,710 ac-ft/yr in 2009 to 232,830 ac-ft/yr in 2060. The demand forecast for CICWCD shown in **Figure ES-3** and **Tables ES-6** and **ES-7** indicates that total M&I demand for CICWCD would increase from about 11,220 ac-ft/yr in 2009 to 39,770 ac-ft/yr in 2060. The demand forecast for KCWCD shown in **Figure ES-4** and **Table ES-8** indicates that total M&I demand for KCWCD would increase from about 3,160 ac-ft/yr in 2009 to 5,850 ac-ft/yr 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-9.**

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

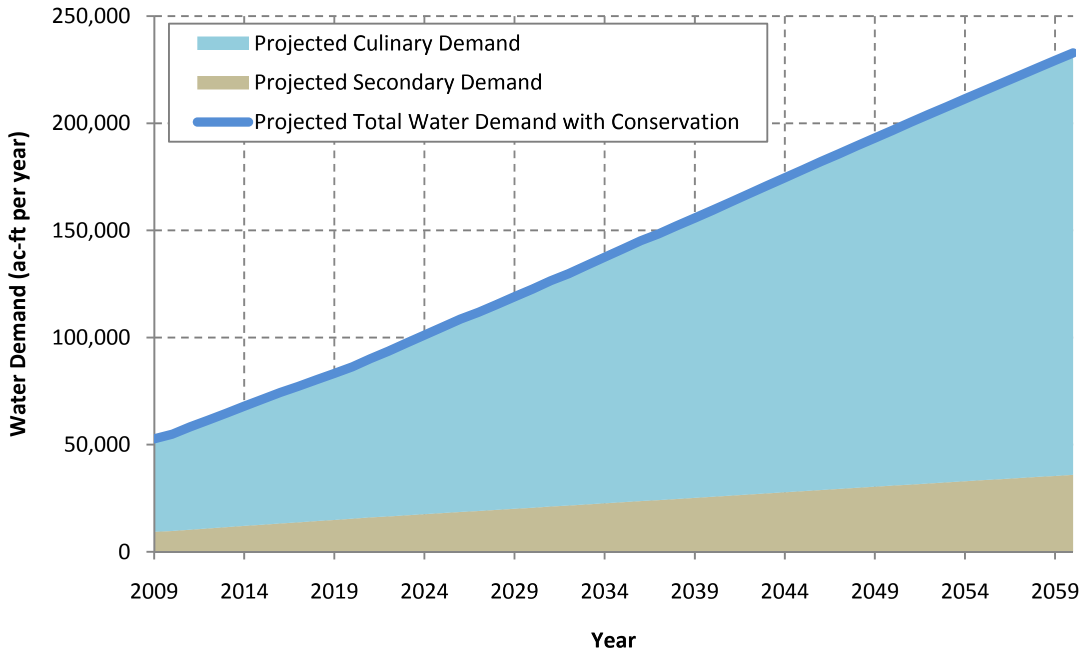


Table ES-4 WCWCD Total M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation from 2009	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)
2009	159,880	294.3	0%	294.3	52,710	0	52,710
2010	168,080	294.3	1%	291.6	54,900	0	54,900
2020	279,860	294.3	6%	275.4	86,340	0	86,340
2030	415,510	294.3	10%	263.4	122,610	0	122,610
2040	559,670	294.3	14%	254.3	159,400	0	159,400
2050	709,670	294.3	16%	247.5	196,780	0	196,780
2060	860,380	294.3	18%	241.6	232,830	0	232,830

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

Table ES-5 WCWCD Culinary and Secondary M&I Water Demand Forecast

Year	Culinary Projected Water Demand (ac-ft/yr)	Secondary Projected Water Demand (ac-ft/yr)	Total Projected Water Demand (ac-ft/yr)
2009	43,340	9,370	52,710
2010	45,130	9,770	54,900
2020	70,860	15,480	86,340
2030	101,990	20,620	122,610
2040	133,663	25,740	159,400
2050	165,840	30,940	196,780
2060	196,870	35,960	232,830

Table ES-6 CICWCD M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation from 2009	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)
2009	42,860	233.8	0%	233.8	11,220	0	11,220
2010	45.360	233.8	3%	226.1	11,490	500	11,990
2020	61.240	233.8	12%	206.7	14,180	3,500	17,680
2030	78,560	233.8	14%	200.6	17,650	5,000	22,650
2040	98,830	233.8	16%	197.1	21,830	6,500	28,330
2050	123,020	233.8	16%	195.5	26,940	7,000	33,940
2060	150,940	233.8	17%	193.8	32,770	7,000	39,770

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

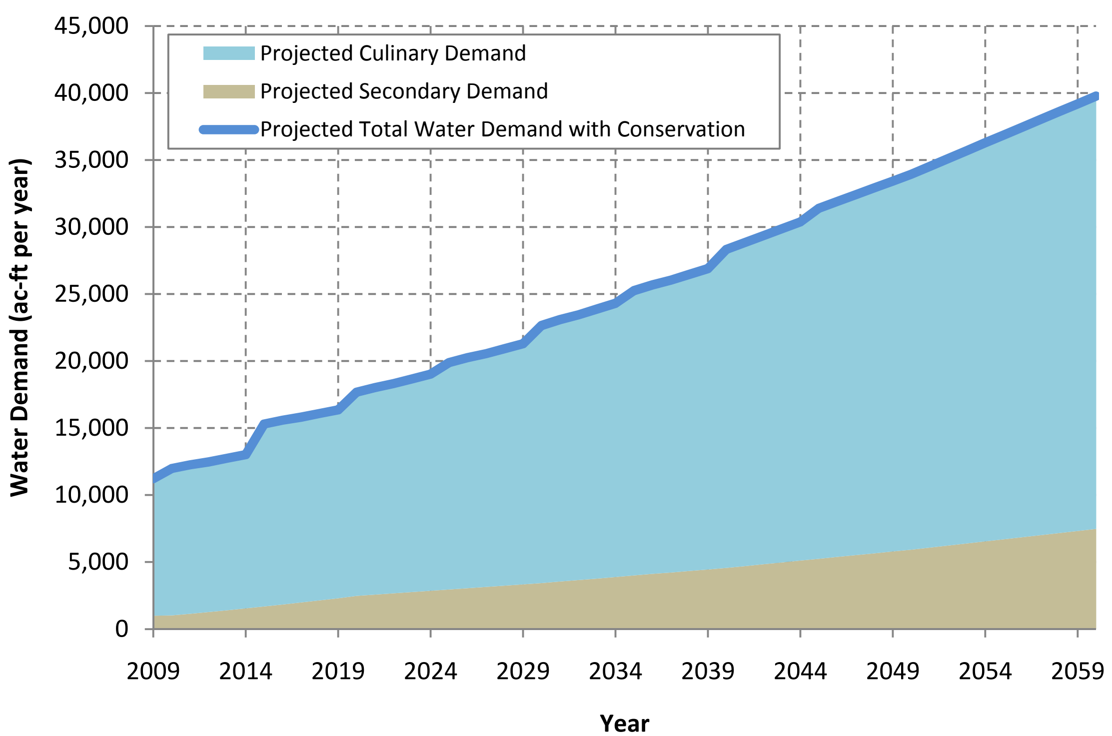


Table ES-7 CICWCD Culinary and Secondary M&I Water Demand Forecast

Year	Culinary Projected Water Demand (ac-ft/yr)	Secondary Projected Water Demand (ac-ft/yr)	Total Projected Water Demand (ac-ft/yr)
2009	10,220	1,000	11,220
2010	10,970	1,020	11,990
2020	15,200	2,480	17,680
2030	19,210	3,440	22,650
2040	23,760	4,570	28,330
2050	28,010	5,930	33,940
2060	32,290	7,480	39,770

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

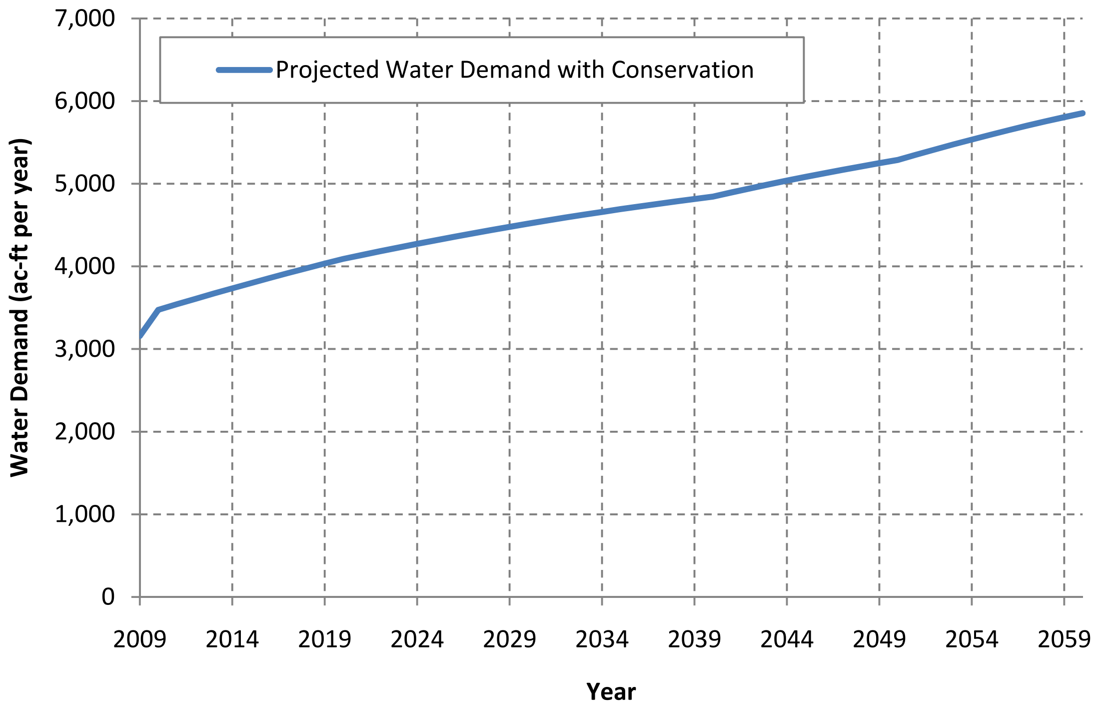


Table ES-8 KCWCD M&I Water Demand Forecast

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)
2009	6,700	420.3	0%	420.3	3,160	0	3,160
2010	6,890	420.3	1%	417.7	3,230	250	3,480
2020	8,750	420.3	7%	392.1	3,840	250	4,090
2030	10,390	420.3	13%	366.4	4,270	250	4,520
2040	12,030	420.3	19%	340.8	4,590	250	4,840
2050	14,270	420.3	25%	315.2	5,040	250	5,290
2060	17,280	420.3	31%	289.6	5,600	250	5,850

[1] Reasonably foreseeable demand 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.

Table ES-9 KCWCD Subbasin M&I Water Demand Forecast

Subbasin	Projected Water Demand (ac-ft/yr)						
	2005	2010	2020	2030	2040	2050	2060
East Fork Virgin River	490	550	660	730	790	870	980
Kanab Creek	1,940	2,430	2,860	3,160	3,400	3,720	4,130
Johnson Canyon	90	100	120	140	150	170	190
Wahweap Creek	280	320	380	430	460	510	570

ES-3 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 Water 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-3.1 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 originating 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-10**. Existing secondary M&I water supplies for WCWCD consist of the Toquerville Secondary Water System, the Gunlock to Santa Clara Pipeline, water in Washington Fields, and reuse water produced by the St. George wastewater treatment plant and reuse plant.

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 eight municipalities in Washington County (St. George, Washington, Ivins, Hurricane, LaVerkin, Santa Clara, Toquerville, and Leeds). 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-10 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	22,600	0
Sand Hollow Ground Water	3,000	0
Kolob Reservoir	2,000	0
Meadow Hollow Reservoir	200	0
Crystal Creek Pipeline	2,000	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
Existing Wastewater Reuse	0	3.900
Total	33,550	6,560

Notes:
[1]Source of data: (WCWCD 2006; WCWCD 2007c; DWRe 2009b, DWRe 2011), 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 and all other entities, is approximately 74,560 ac-ft/yr of potable supply and 7,450 ac-ft/yr of secondary supply (DWRe 2007a; DWRe 2009b). Reliable supply for surface water sources was calculated for a 90 percent reliability level (i.e., maximum surface water shortage of 10 percent in any given year that would be made up with ground water supply). The source of the Sand Hollow Ground Water supply is leakage from Sand Hollow Reservoir. WCWCD has determined that this supply will be considered a reserve or emergency supply for use only during a severe drought, facility outage, or other emergency. For this reason 3,000 ac-ft/yr of the total reliable yield is shown in Table ES-10. Uncertainties associated with future climate changes, population growth, aging infrastructure, and other factors result in the need for prudent planning as mitigation against unforeseen water shortages. The resulting total reliable existing and near-term supply for Washington County is approximately 82,110 ac-ft/yr.

Table ES-11 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.

Secondary water demand can only be significantly increased by extending dedicated secondary water distribution systems into areas of new development. All WCWCD entities have water master plans that envision expanding existing secondary systems as new development occurs. Secondary water supply from wastewater reuse and Virgin River diversions can be developed only if substantial reservoir storage is available. Reclaimed water that is generated year-round must be stored for use during the outdoor landscaping irrigation season. Virgin River water that is only available for diversion and few weeks during the year must also be stored for use during the entire irrigation season. Proposed Warner Valley Reservoir (45,000 ac-ft) would serve this purpose.

Water quality issues will influence the potential for use of several of the potential future projects. For example, elevated levels of total dissolved solids in Virgin River water from agricultural conversions associated with new 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-11 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(1)	3,830	0
Maximize Existing Wastewater Reuse(2)	0	7,300
Agricultural Conversion from Development(3)	0	10,080
Lake Powell Pipeline	69,000	0
Potential Future Wastewater Reuse(4)	0	27,620
Total Potential Yield from Future Projects	72,830	45,000

(1) Ash Creek Pipeline yields 3,830 ac-ft/yr based on a 90% reliability level.

(2)The maximum capacity of the existing reuse treatment plant is 7,800 ac-ft/yr, but this supply can only be used to meet secondary demands during the irrigation season (April through October) and currently there is no storage capacity resulting in the loss of any supplies that are not used by the end of a given month. Thus the usable supply is 50% of the plant capacity, or 3,900 ac-ft/yr. It was assumed that storage facilities would be implemented and the reuse plant would be run at full capacity of 11,200 ac-ft/yr. Therefore an additional 7,300 ac-ft/yr could be developed.

(3)The estimated supply is 12,880 ac-ft/yr with 90% reliability (DWRe 2011). However, it was estimated that approximately 2,800 ac-ft/yr of this supply is currently in use and has been accounted for in the 7,450 ac-ft/yr of reliable secondary supply.

(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). However, the amount of this potential reuse that could actually be used as secondary supply would be limited by demand and storage constraints. It is assumed that the proposed Warner Valley Reservoir (45,000 ac-ft/yr) would provide storage for additional reuse water and water from the agricultural conversion from development. As a result there would be approximately 27,620 ac-ft/yr of storage available for all future reuse water supplies.

ES-3.2 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/yr. 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/yr of potable supply (3,800 ac-ft from springs and 7,560 ac-ft from wells) and 800 ac-ft/yr 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/yr (USGS 2005). Future water use scenarios for this report were developed using an assumed sustainable yield of 37,600 ac-ft/yr. 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-12**. 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.

CICWCD, Cedar City and Enoch City have plans for expanding secondary water systems into areas of existing and new development, making it possible to develop and use poorer quality sources of water to meet non-potable demands.

Table ES-12 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/yr
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.
Lake Powell Pipeline	13,000	CICWCD has requested 13,000 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	41,090-61,090	Includes all potential sources

ES-3.3 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 2009b).

Total reliable potable supply in Kane County including water rights owned by KCWCD is about 3,540 ac-ft/yr and reliable secondary supply is about 500 ac-ft/yr, for a total reliable water supply of approximately 4,040 ac-ft/yr (DWRe 2006c; DWRe 2009b; 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. Existing reliable water supplies for the East Virgin River basin, the Kanab Creek basin, the Johnson Canyon basin, and the Wahweap Creek basin are shown in **Table ES-13**.

Table ES-13 KCWCD Existing Reliable Supplies

Subbasin	Potable	Secondary	Total
East Fork Virgin River	582.9	262.0	844.9
Kanab Creek	2,320.3	234.9	2,555.2
Johnson Canyon	96.3	0.0	96.3
Wahweap Creek	542.9	0	542.9
Total	3542.4	496.9	4039.3

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/yr is outlined in **Table ES-14.** However, ground water permits have been issued for a total of over 150,000 ac-ft/yr, 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-14.**

Table ES-14 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/yr
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 4,000 ac-ft from LPP, which 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	100-4,100	

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

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.

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-4 Water Resources Planning

Integrated water resources plans were developed for each of the Districts using 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.

ES-4.1 WCWCD Integrated Water Resources Plan

The information used to develop the integrated water resource plan for WCWCD is summarized in **Table ES-15** and the results are shown in **Figure ES-5.** The difference between the projected 2060 demand of 232,830 ac-ft/yr and existing and near term projects, which include existing supplies and Ash Creek Pipeline, is 115,000 ac-ft/yr. 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 69,000 ac-ft/yr, existing and planned supplies cannot meet demand after 2041. WCWCD has not determined how these potential shortages will be addressed.

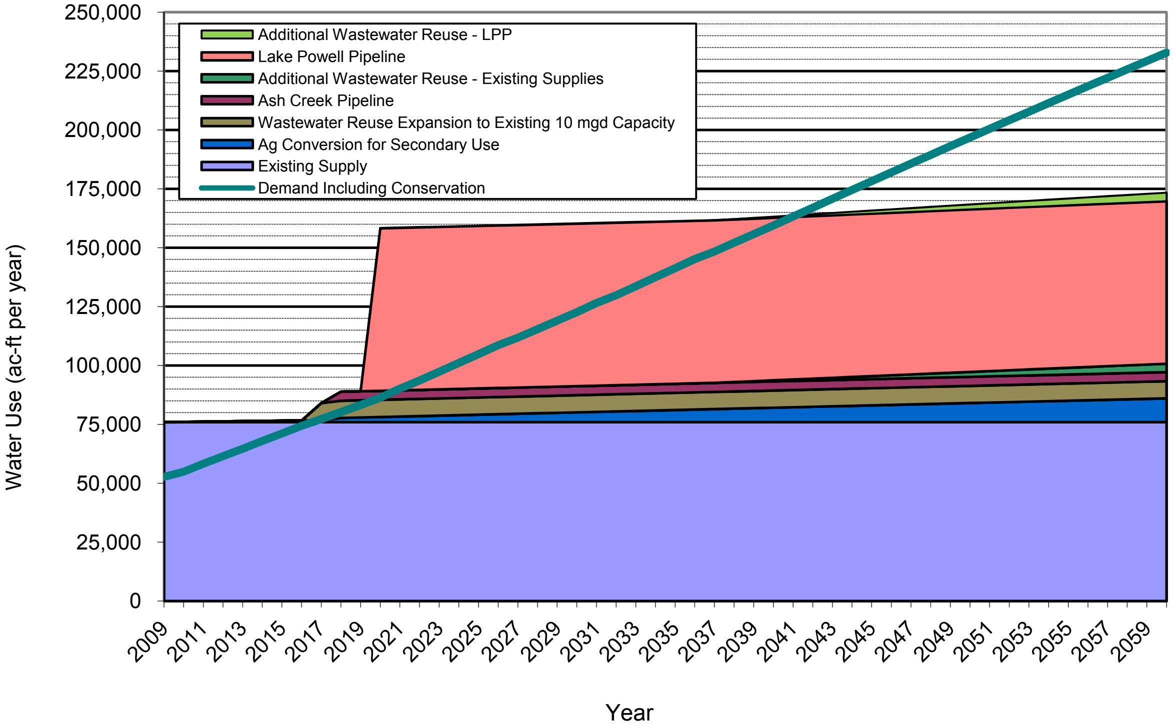
The need and timing for new water supplies in WCWCD is highly dependent on the ability to develop and use poor quality water sources to meet secondary demands.

Table ES-15 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	75,990[1]	Culinary and Secondary		-	Combined culinary and secondary supply.
Future Supplies					
Agricultural Conversions from Development	10,080[2]	Secondary	Begin when needed; phase in over time	2010	Consists of multiple projects and water rights changes. Linear annual increase to meet secondary demand; requires Warner Valley Reservoir.
Warner Valley Reservoir	-	Secondary	Need for secondary sources	2017	Storage needed for reuse and Virgin River water.
Maximize Existing Wastewater Reuse Capacity of 10 mgd	7,300[3]	Secondary	Begin when needed; phase in over time	2017	Treatment capacity and distribution system can be phased as needed to meet secondary demand; requires Warner Valley Reservoir.
Ash Creek Pipeline	3,830[4]	Culinary	When needed	2018	Culinary supply indirectly by supplying secondary supply grade water to offset current culinary use.
Lake Powell Pipeline	69,000	Culinary	When needed	2020	Can be used to meet culinary and/or secondary supply as needed. 69,000 ac-ft/yr used in 2060.
Future Wastewater Reuse	7,230[5]	Secondary	When needed	2037	Phased in as needed to meet secondary demand; requires Warner Valley Reservoir.

Notes
[1]Includes WCWCD reliable water supply from DWRe M&I Water Use Reports for 2005 (62,650 ac-ft/yr culinary plus 7,450 ac-ft/yr secondary), existing wastewater reuse (3,900 ac-ft/yr based on demand and capacity restrictions), and water supply from the Crystal Creek pipeline (2,000 ac-ft/yr).
[2]The estimated supply is 12,880 ac-ft/yr with 90% reliability (DWRe 2011). However, it was estimated that approximately 2,800 ac-ft/yr of this supply is currently in use and has been accounted for in the 7,450 ac-ft/yr of reliable secondary supply. It was assumed that agricultural conversions from development will be developed moderately until Warner Valley Reservoir is available for storage.
[3]The water reuse plant recently constructed in St. George has a total capacity of 11,200 ac-ft/yr. Two of three filters have been installed to date (current capacity of 7,800 ac-ft/yr), with 3,400 ac-ft/yr 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. It was assumed that storage facilities would be implemented and the reuse plant would be run at full capacity of 11,200 ac-ft/yr. Therefore an additional 7,300 ac-ft/yr could be developed.
[4] Ash Creek Pipeline yields 3,830 ac-ft/yr based on a 90% reliability level.
[5]The maximum potential future wastewater reuse (33,910 ac-ft/yr) would be greater than the amount given, but the actual amount was limited by secondary demand. Approximately 50% would be derived from existing supplies and 50% would be derived from LPP supplies.

Figure ES-5 WCWCD Supply and Demand – Total



ES-4.2 CICWCD Integrated Water Resources Plan

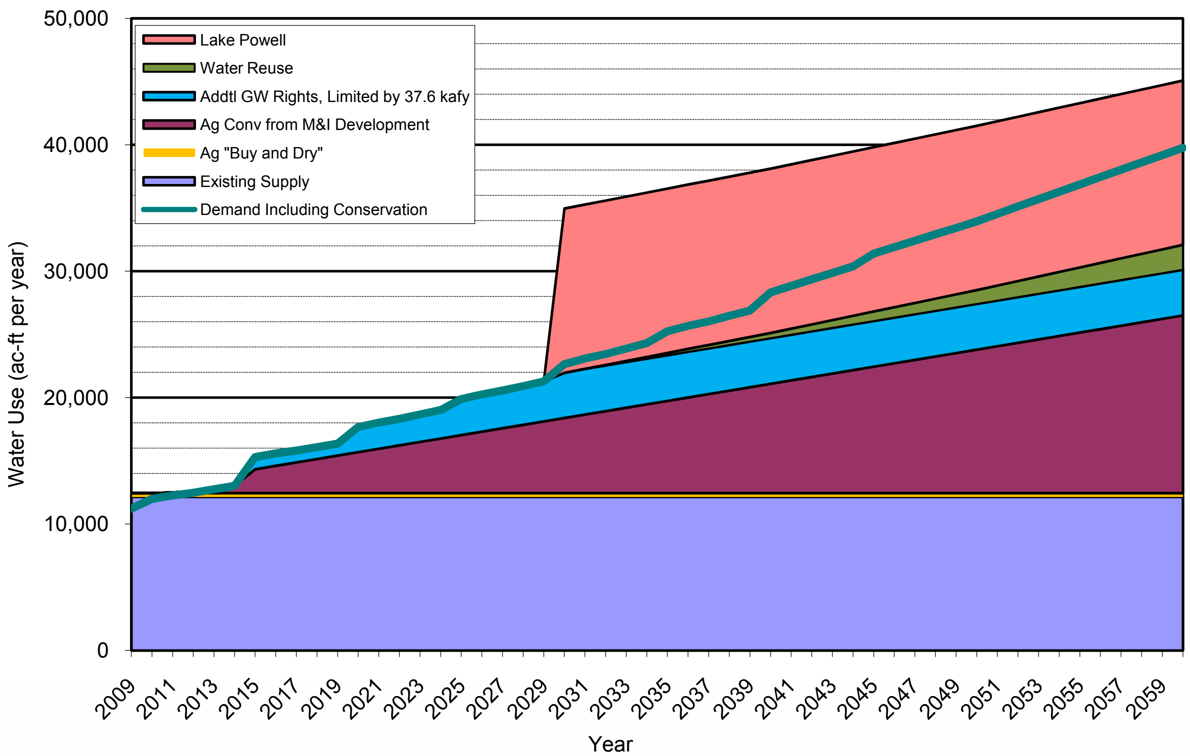
The information used to develop the integrated water resource plan for CICWCD is summarized in **Table ES-16**, and the results are shown in **Figure ES-6**. The difference between the projected 2060 demand of 39,770 ac-ft/yr and the existing supply of 12,160 ac-ft/yr is 27,610 ac-ft/yr. The CICWCD integrated 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 7,670 ac-ft/yr is shown in **Table ES-16** and **Figure ES-6**. 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 2030. 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. Due to the closed basin conditions in Cedar Valley, wastewater reuse can become a significant source of new supply only after the LPP imported water is brought into the basin.

Table ES-16 CICWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)	Type of Supply (Culinary or Secondary)	Date Needed	Comments
Existing Supplies	12,160	Culinary and Secondary	-	Combined culinary and secondary supply
Assumed Sustainable Basin Yield	37,600	-	-	
Future Supplies				
Agricultural Conversion from buy and dry of existing agricultural rights	300	Secondary	2009	Enoch City purchased approximately 300 ac-ft/yr of supply from buy and dry of agricultural water rights in 2008.
Agricultural Conversion (due to development over irrigated lands)	14,060	Culinary and Secondary	2011	Based on timing of expansion of development onto irrigated lands.
Development of Existing Local Ground Water Rights	3,610	Culinary and Secondary	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/yr
Lake Powell Pipeline	7,670	Culinary	2030	Implement when needed for culinary water use.
Wastewater Reuse	1,970	Secondary	2031	Implement when needed as last priority due to water quality constraints.

Figure ES-6 CICWCD Supply and Demand



ES-4.3 KCWCD Integrated Water Resources Plan

The information used to develop the integrated water resource plan for KCWCD is summarized in **Table ES-17**, and the results are shown for each of the four subbasins in **Figure ES-7** through **Figure ES-10**. The difference between the projected KCWCD 2060 demand of 5,850 ac-ft/yr and the existing supply of 4,040 ac-ft/yr is 1,810 ac-ft/yr. 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 out of convenience. Tapping into the pipeline would add a reliable supply to the KCWCD 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-17 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	850	2,560	100	540	Combined culinary and secondary supply.
Future Supplies					
New Ground Water (Amount and Year Needed)	130	1,580	90	30	Phase in as needed. For all subbasins, this is the only Future Supply needed to meet demand.
	2046	2012	2009	2056	
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-7 KCWCD Supply and Demand – East Fork Virgin River

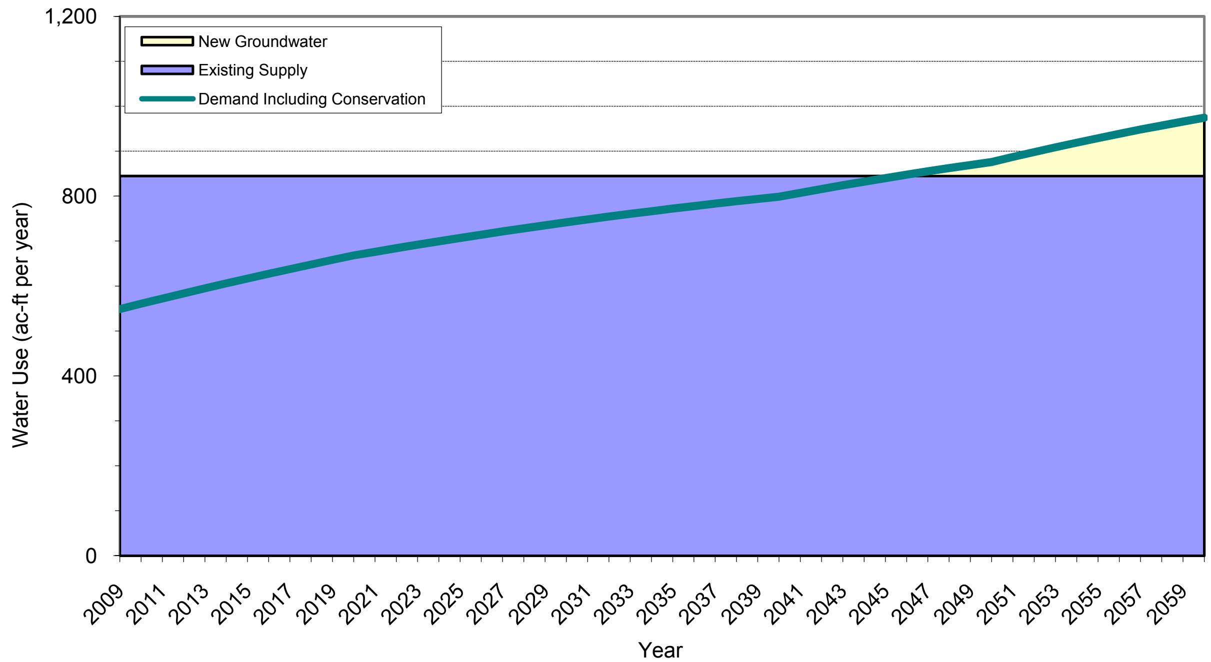


Figure ES-8 KCWCD Supply and Demand – Kanab Creek

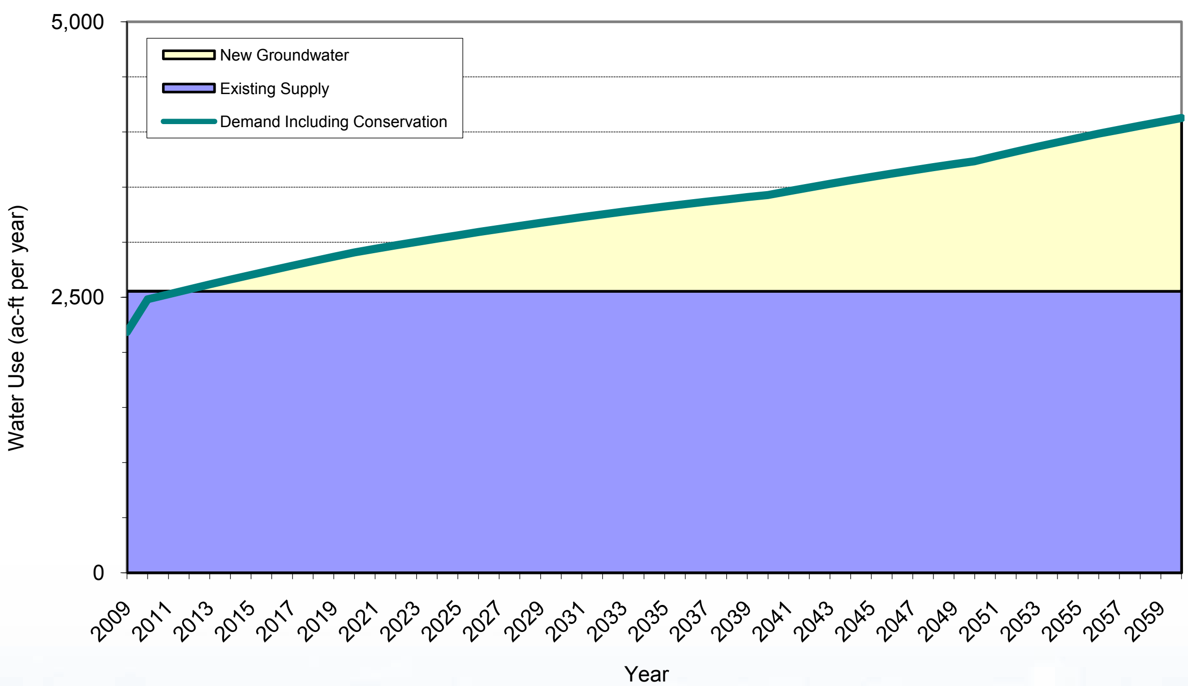


Figure ES-9 KCWCD Supply and Demand – Johnson Canyon

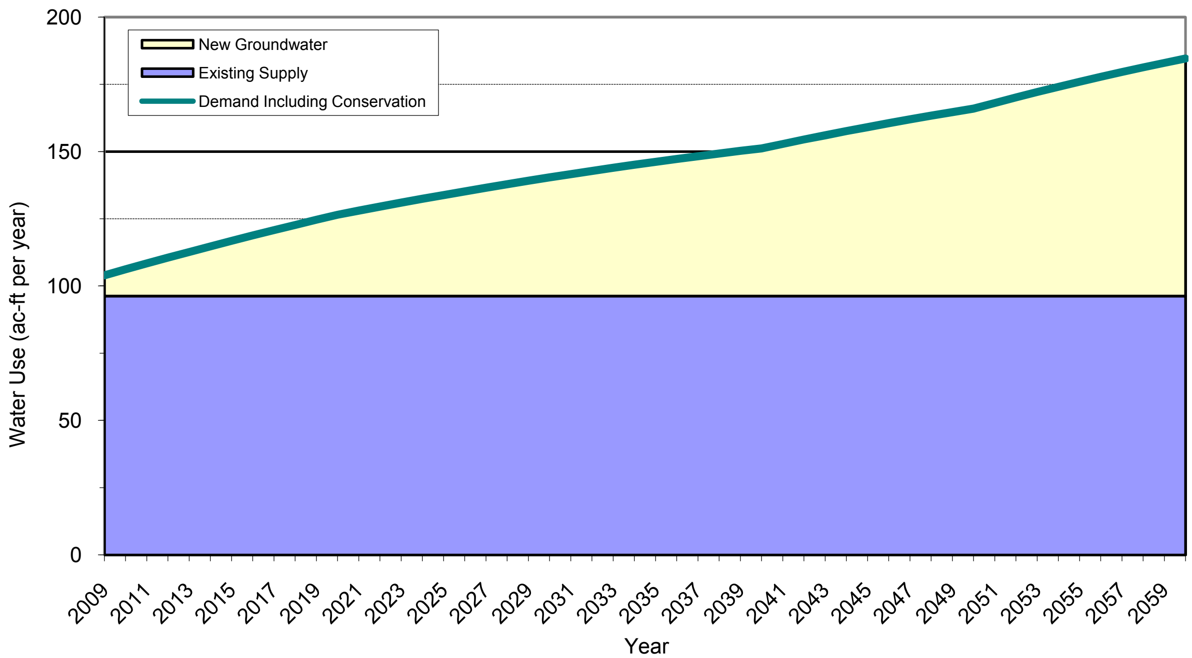
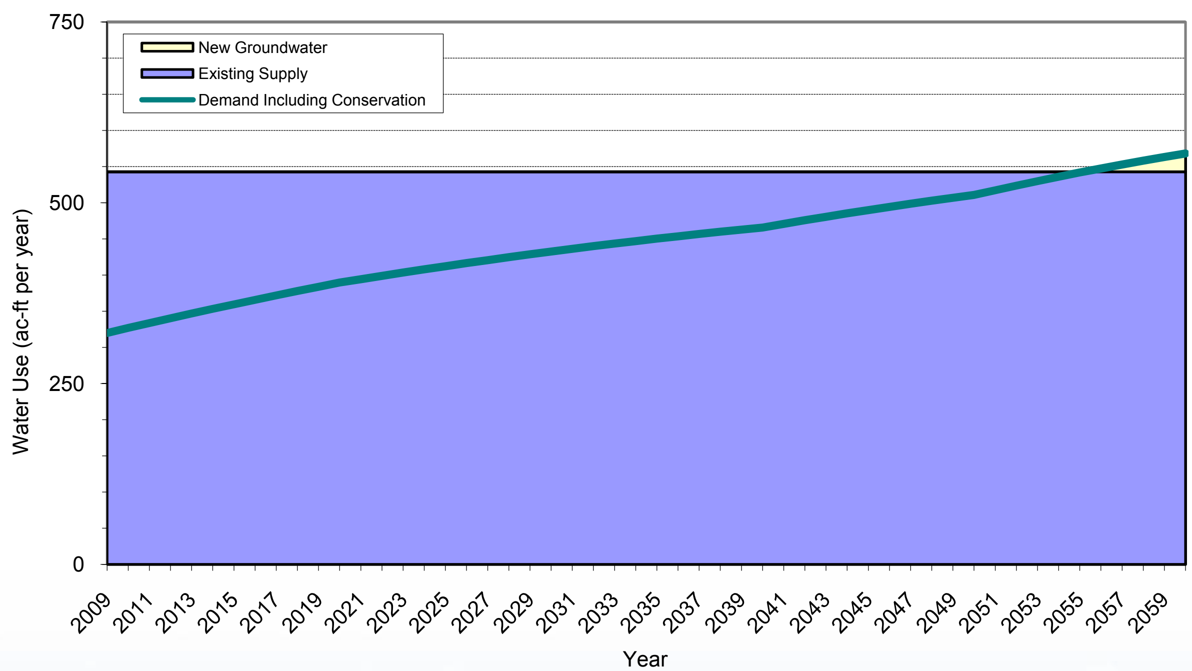


Figure ES-10 KCWCD Supply and Demand – Wahweap Creek



ES-5 Summary

Results of the LPP Water Needs Assessment are summarized in **Table ES-18**.

Table ES-18 Summary of the LPP Water Needs Assessment

Description	WCWCD	CICWCD	KCWCD
Existing (2009) M&I Reliable Supply	75,990	12,160	4,040
Existing (2009) M&I Demand	52,710	11,220	3,160
Existing (2009) Unmet Demand	0	0	0
Existing (2009) Surplus	23,280	940	880
2060 Demand without Conservation	283,630	46,530	8,380
2060 Demand with Conservation	232,830	39,770	5,850
2060 Conservation Savings/Supply	50,800	6,760	2,530
2060 Unmet Demand	**156,840**	**27,610**	**1,810**
2060 Additional Supply from Likely Projects	21,210[(1)]	19.640[(2)]	10,810[(3)]
2060 Unmet Demand	**135,630**	**7,970**	**0**
Water Supply Available from LPP	69,000	13,000	0
2060 Unmet Demand	**66,630**	**0**	**0**
2060 Additional Supply from Possible Projects	7,230[(4)]	0	0
2060 Unmet Demand	**63,020**	**0**	**0**

Notes:
[(1)]Likely projects for WCWCD Ash Creek Pipeline, Maximize Existing Wastewater Reuse, and Agricultural Conversion associated with M&I development.
[(2)]Likely projects for CICWCD include: Agricultural water conversion from developed land, Agricultural water conversion from "buy and dry," and Local ground water rights.
[(3)]Likely projects for KCWCD include: Agricultural Water Conversion and Local ground water rights.
[(4)]Possible projects for WCWCD include 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 this study. A conservation analysis conducted by Maddaus Water Management evaluated 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 and the timing and strategy of the State Engineer in managing this limited resource 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 existing mix of culinary and secondary water use was assumed to change in the future. Complex economic factors, outdoor landscaping practices, and regional and local water use policies will probably affect the ratio of secondary water use to total water use substantially.

- 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. 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 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 –** 69,000 acre-feet per year (ac-ft/yr)
- **CICWCD –** 13,000 ac-ft/yr
- **KCWCD –** 4,000 ac-ft/yr

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; and
- 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 was conducted in two phases. Phase 1 consisted 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 were conducted. This report incorporates the Phase 1 and Phase 2 work into a comprehensive Water Needs Assessment.

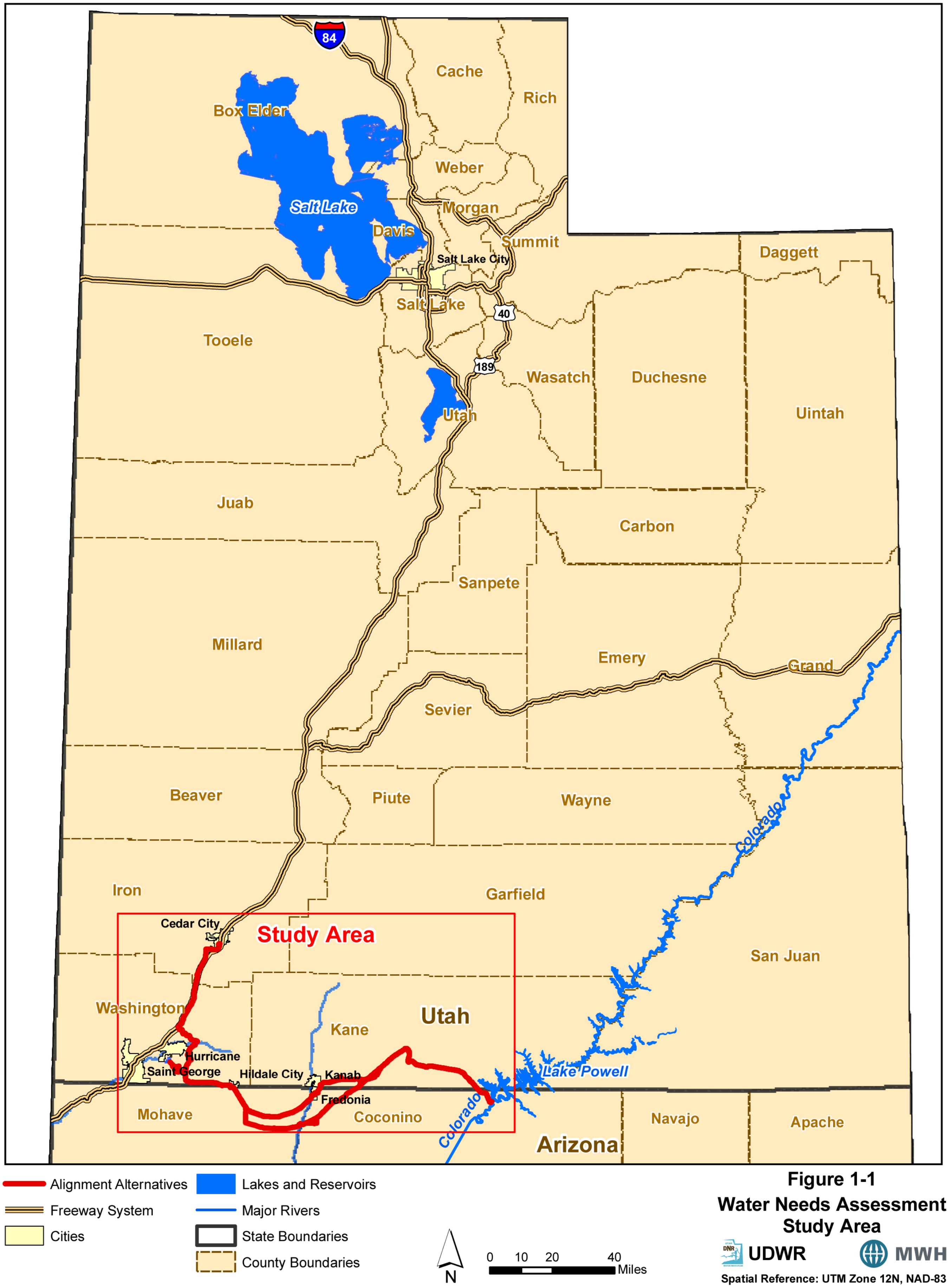


Figure 1-1
Water Needs Assessment
Study Area

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.

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 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 –** 69,000 ac-ft/yr
- **CICWCD –** 13,000 ac-ft/yr
- **KCWCD –** 4,000 ac-ft/yr

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) was based on existing information in 2008 with limited new data collection to avoid duplicating previous work and meet the project schedule. The final water needs assessment (Phase 2) was based on additional data collection and analyses, particularly for assessments of conservation and water reuse.

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

Phase 1 consisted of activities associated with developing feasibility-level water demand projections to assist with the alternative screening analysis. Phase 2 consisted 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.

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.

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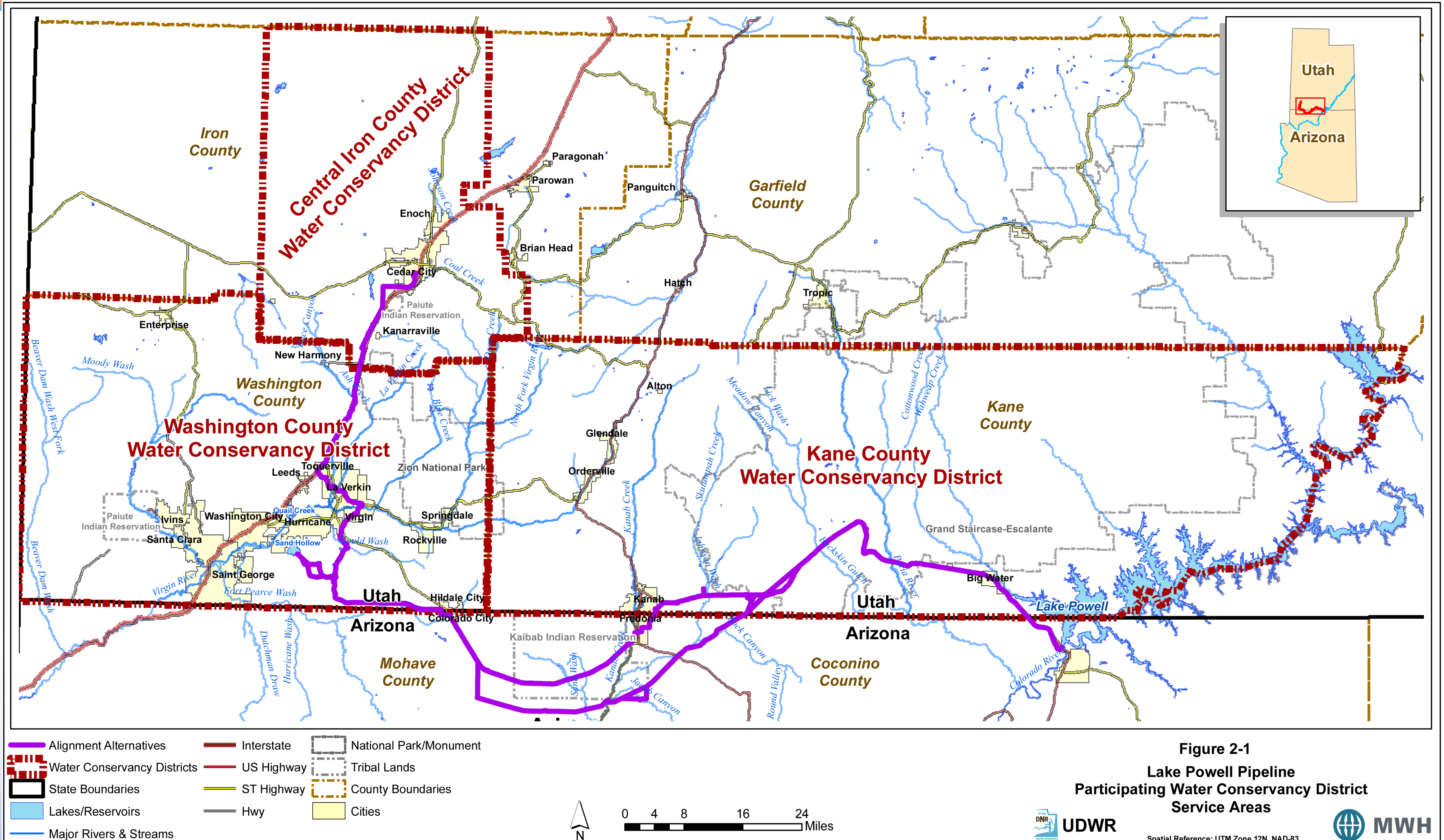

Figure 2-1
Lake Powell Pipeline
Participating Water Conservancy District Service Areas

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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.

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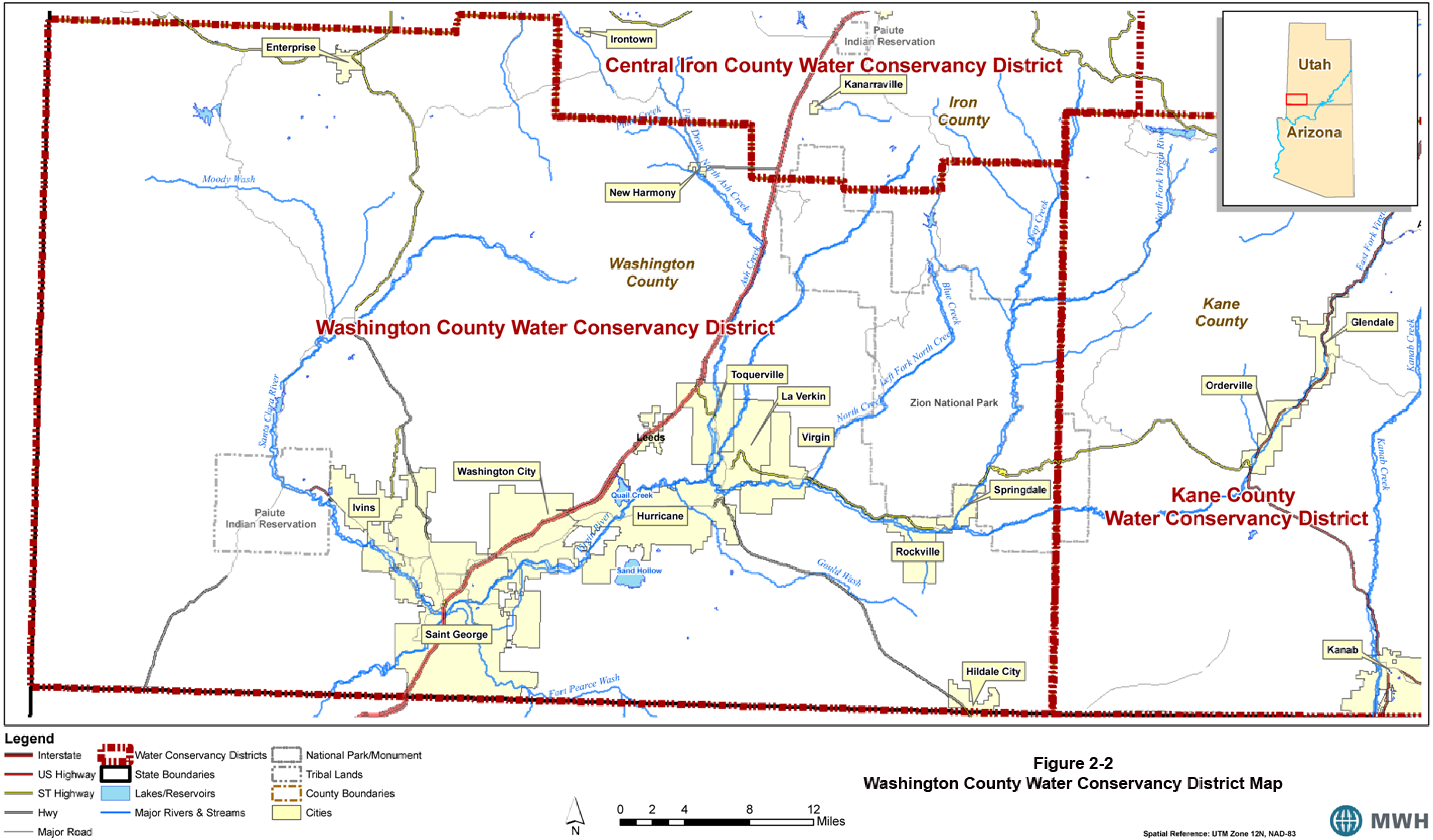

Figure 2-2
Washington County Water Conservancy District Map

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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 separately 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 4** 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

2.1.2 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 2009 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.

The 2009 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.

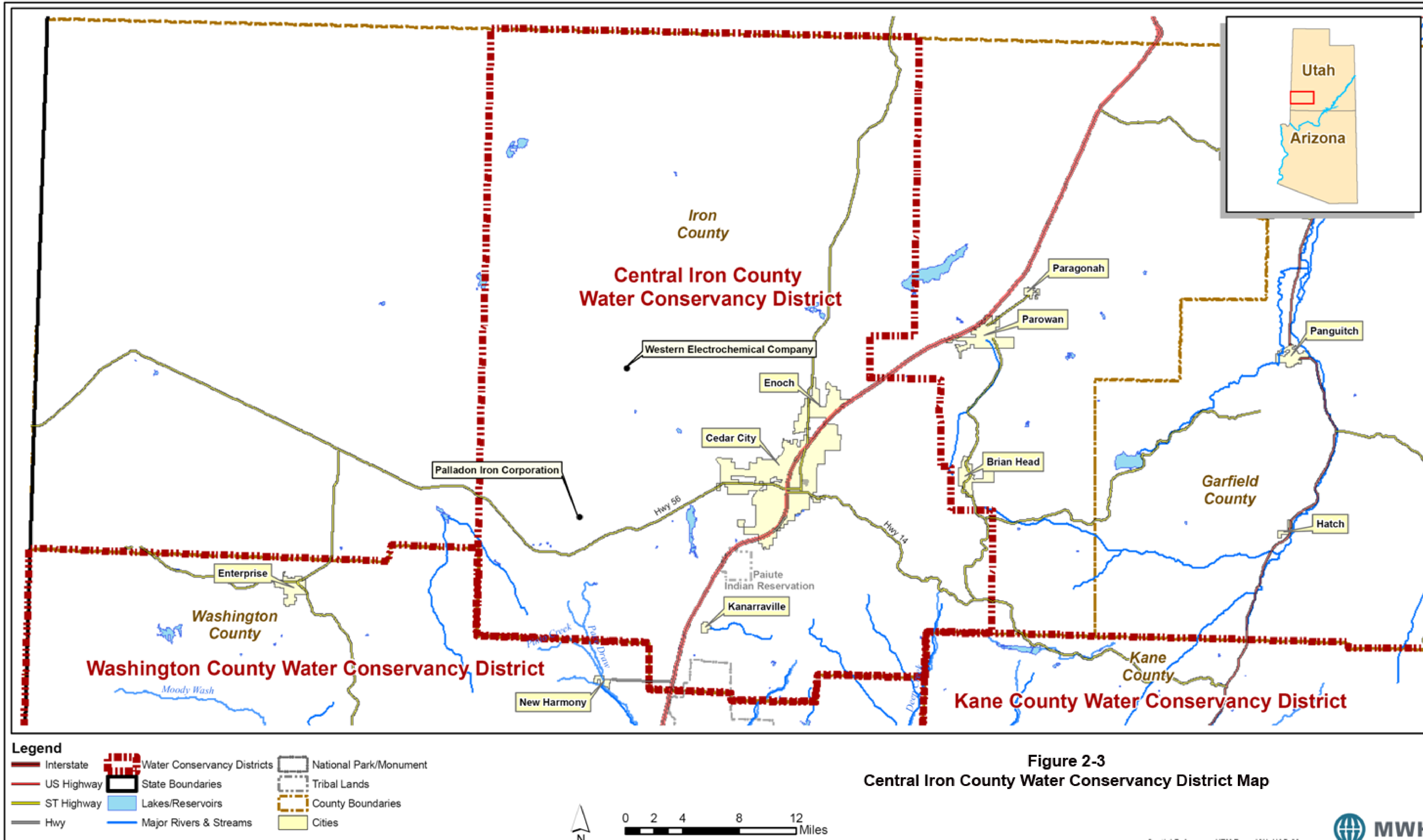


Figure 2-3
Central Iron County Water Conservancy District Map

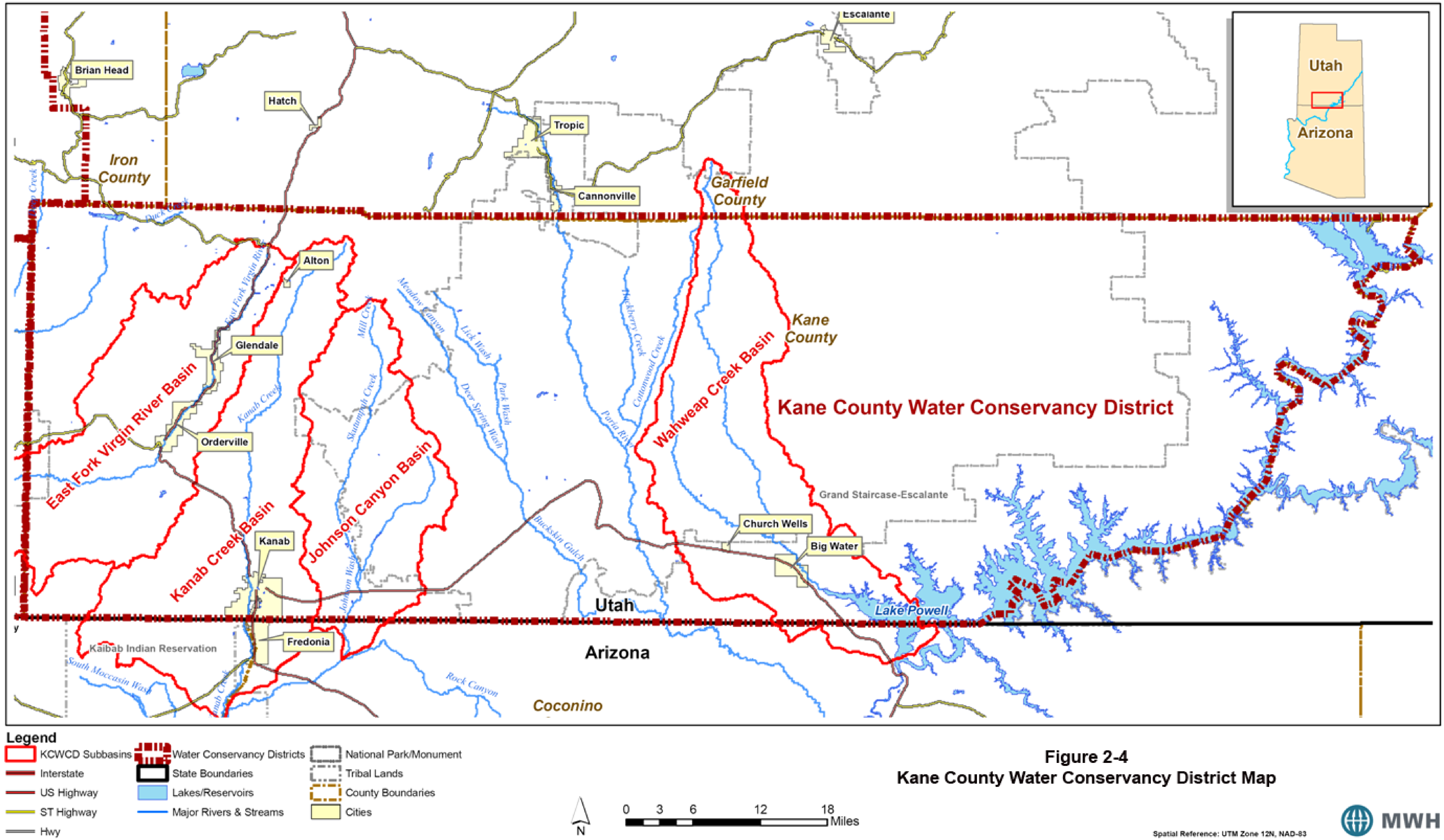


Figure 2-4
Kane County Water Conservancy District Map

2.2 Population Data

2.2.1 Population Projections

Population projections from 2008 through the year 2060 were obtained from the GOPB for the counties within the Districts' service area boundaries (GOPB 2008). GOPB publishes population forecasts sanctioned for use by State agencies and others for planning purposes. 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 (2009) was estimated by an interpolation between 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 for 2010. The 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 2009b). 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 is not included in the GOPB population projections, was 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:

$$\text{Annual Visitors} = (\text{\# of hotel rooms}) \times (\text{occupancy rate}) \times (\text{average people per room}) \times 365 \text{ days per year}$$

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 2009 population as was estimated using an interpolation between 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 for 2010.
- 2009 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 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 for municipal and industrial water use categories was based on 2005 water use data from the DWRe draft municipal and industrial water supply and use reports (DWRe 2006c; DWRe 2007a; DWRe 2009b; DWRe 2007b), reduced by assumed conservation between 2005 and 2009. 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. For WCWCD, data from the Governor's Water Conservation Team (GWCT) (DWRe 2009a) was used to determine culinary per capita water use data in 2009. 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 were 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 –** Culinary per capita water use in 2009 for the six largest cities in Washington County was taken from GWCT data provided by DWRe. The ratio of the six cities use to total Washington County use (from the Kanab Creek/Virgin River M&I Water Supply and Use Report) for 2005 (DWRe 2009b) was used to estimate total Washington County culinary use in 2009. Secondary per capita use for 2005 for Washington County as reported in the Kanab Creek/Virgin River Basin M&I Water Supply and Use Report was assumed to be representative of secondary per capita water use for the WCWCD for 2009. 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 in 2005 for all the public community water systems within Iron County was taken from 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. To compute 2009 per capita water use, 2005 per capita use was reduced by the percentage of assumed conservation between 2005 and 2009.
- **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 2009 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/yr (DWRe 2009b). 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/yr 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).

Future per capita water use (i.e., 2009 to 2060) was based on the 2009 per capita water use with an assumed percent reduction for conservation. These data were assumed to be the best available data for the following reason: they are the most recent data available for each District, consistent data are 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 savings, 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 their uncertainty.

2.4 Methodology for Determining Projected Conservation

Projected conservation for the three Districts was based on water conservation studies performed by MWH and its subconsultant Maddaus Water Management, in close cooperation with each District. Results of the conservation studies were compared to the State's water conservation goals. The conservation goals described in this report were applied to total M&I per capita water use (culinary plus secondary use).

Studies of potential future water savings due to implementation of conservation programs were performed for each District independently. The studies included collecting billing data to analyze actual water use at the customer level; selecting potential conservation measures suitable for the community; creating a model to analyze water use and conservation savings for each measure; combining selected measures into comprehensive water conservation programs; and coordinating with the communities in the selection of conservation measures and the overall desired program. The conservation model was prepared by Maddaus Water Management based on extensive experience with conservation programs in other communities, published information on conservation measure effectiveness, and locally specific information provided by the water users. There conservation programs were developed for each District, and the local stakeholders selected the program they felt was most reasonable for their conditions. The water conservation model was used to forecast conservation savings and water use reductions from 2009 through 2060.

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 was 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). 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. The forecasted conservation savings from the proposed conservation programs developed by Maddaus Water Management were compared to the State's conservation goals to assure that the goals would be met.

The historical conservation achieved in the WCWCD and CICWCD service areas has been based on historical water use data collected from a variety of sources, and climatological data provided by DWRe. Annual per capita water use data were analyzed to determine trends in water use, in some cases considering net evapotranspiration data as an indicator of annual weather conditions. For WCWCD, five sources of water use data were analyzed and for CICWCD seven different sources were analyzed. Per capita water use data were compared for years with similar net Et values to estimate changes in water use due to conservation efforts. Water use trends were analyzed to determine whether the annual rates of reduction in per capita water use were relatively similar amongst the different sources. Evaluation of these trends was used to select a typical percent reduction in water use per year between 2000 and 2009 for each District.

2.5 Water Demand Forecast

Total projected water demand (i.e., ac-ft/yr) was determined for the three Districts for the period from 2009 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 2009 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 2009.

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 that were 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, 2009b) 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 10 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 yields 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. WCWCD also utilizes secondary water and reuse water to meet outdoor water demands. The expansion of WCWCD's secondary water system would also provide an additional water supply. 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. CICWCD is considering expanding its secondary water system and developing a reuse water treatment plant within its community. This additional water supply would increase the water supply available to meet demands in the future.

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 Existing 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 and from interviews withwater conservation coordinators and water resources planners at the various entities. No effort was made to field-verify the implementation of specific conservation measures described in the water conservation plans.

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 for this 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**. 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.

For the conservation assessment performed by MWM several meetings were conducted to collect water use data, reuse data, and existing conservation program information. The initial meetings were conducted in February 2008 to collect water use data and reuse data from each of the Districts and the major cities within their service area. After the assessment of the water use data, Water Efficiency Working Group meetings were conducted in April 2010 and August 2010 to discuss current water use and review conservation measures currently implemented. MWM presented several potential conservation measures that could be considered for implementation in each community and the stakeholders screened the potential conservation measures to a short list of specific conservation measures that were further evaluated in the conservation assessment. The conservation coordinators and water resource planners in each entity selected the preferred conservation program in a workshop with MWM.

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 show 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 (GOPB 2007b) along with the GOPB 2008 projections.

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

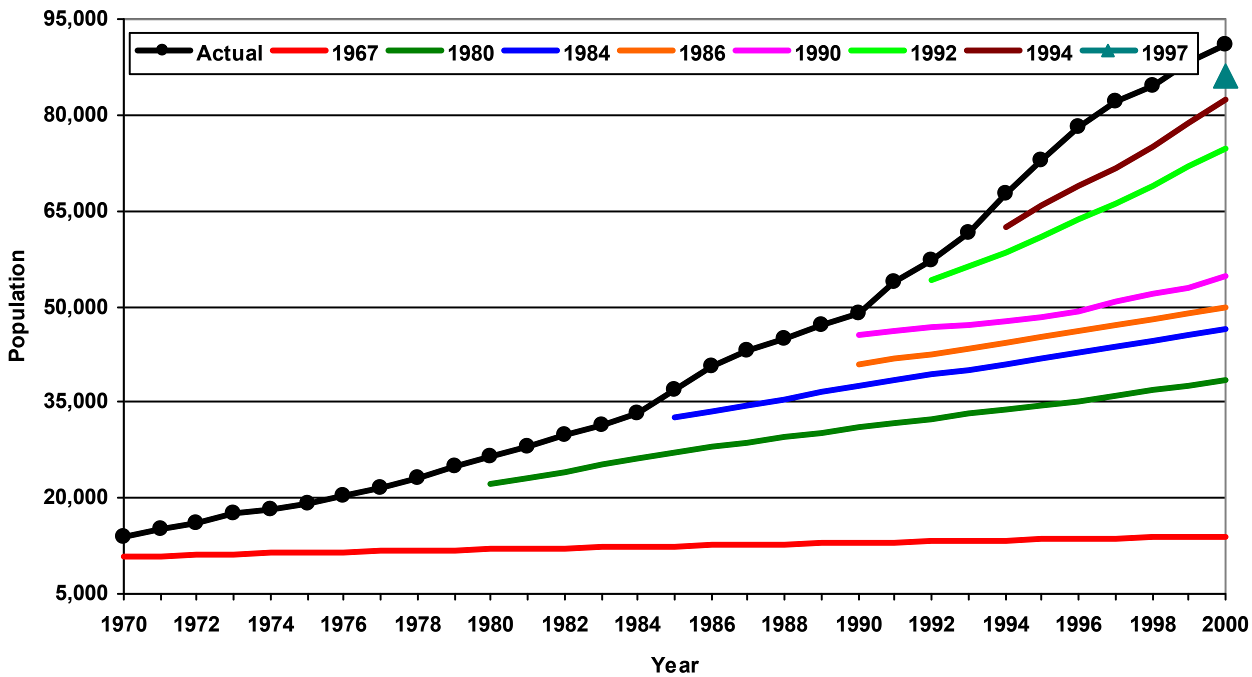


Table 3-1 Population Projections for WCWCD

District/ City	Parameter[2]	2009	2010	2020	2030	2040	2050	2060	2005 to 2060 AGR
WCWCD	Pop.	159,880	168,078	279,864	415,510	559,670	709,674	860,378	-
	AGR	-	5.00%	5.10%	3.95%	2.98%	2.37%	1.93%	3.48%
Ivins	Pop.	9,754	10,477	17,436	25,886	34,867	44,213	53,602	-
	AGR	-	7.15%	5.09%	3.95%	2.98%	2.37%	1.93%	3.74%
La Verkin	Pop.	5,004	5,162	8,592	12,756	17,182	21,787	26,413	-
	AGR	-	3.11%	5.09%	3.95%	2.98%	2.37%	1.93%	3.27%
Hurricane	Pop.	15,341	16,381	27,287	40,512	54,568	69,193	83,887	-
	AGR	-	6.56%	5.10%	3.95%	2.98%	2.37%	1.93%	3.66%
St. George	Pop.	80,796	84,245	140,268	208,254	280,507	355,703	431,239	-
	AGR	-	4.18%	5.10%	3.95%	2.98%	2.37%	1.93%	3.39%
Santa Clara	Pop.	8,660	9,325	15,532	23,061	31,062	39,387	47,751	-
	AGR	-	7.40%	5.10%	3.95%	2.98%	2.37%	1.93%	3.77%
Washington	Pop.	21,366	22,858	38,285	57,050	77,011	97,793	118,818	-
	AGR	-	6.75%	5.16%	3.99%	3.00%	2.39%	1.95%	3.71%

[1]Source of population projections is GOPB (2008), except for the 2009 population, which are estimated population data using the DWRe municipal and industrial water supply reports (DWRe 2009b) for 2005 and GOPB (2008) 2010 projections.
[2]Pop. = GOPB population projection; AGR = annual growth rate.

Figure 3-2 WCWCD Population Projection Range

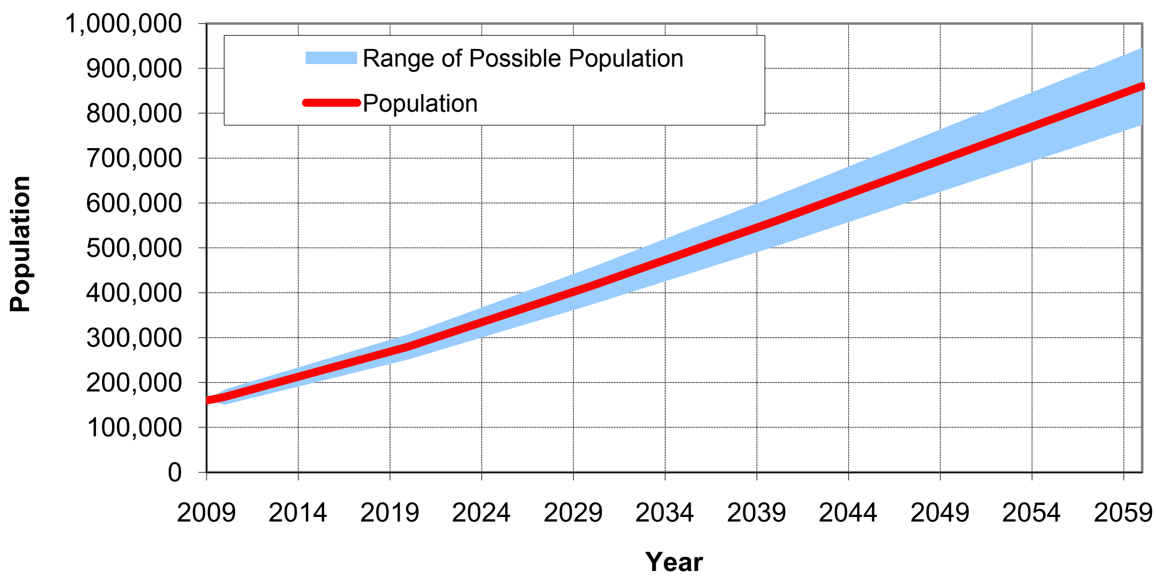
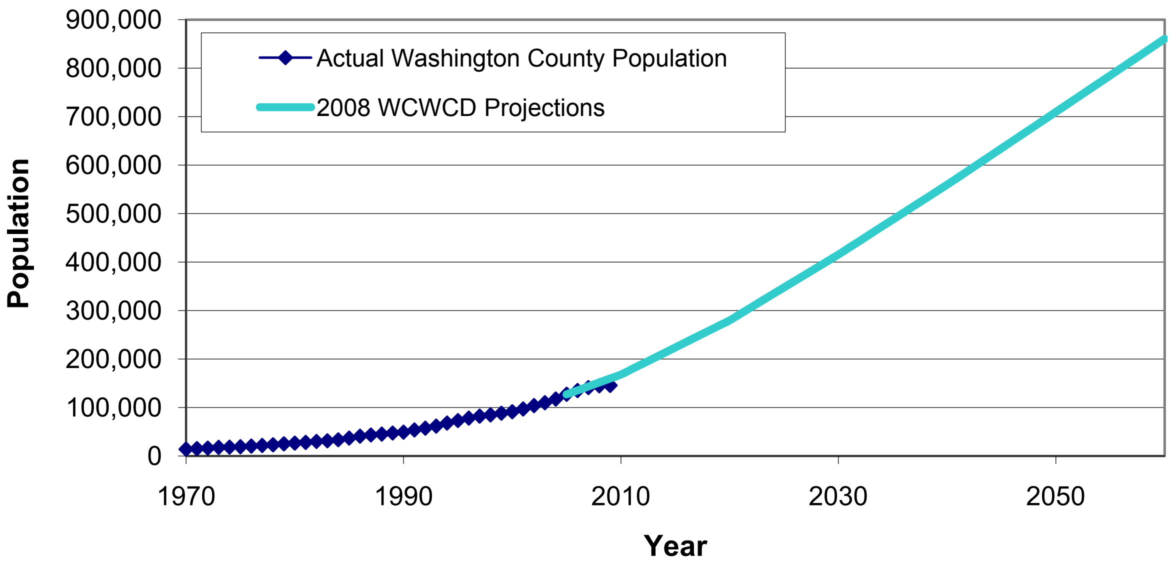


Figure 3-3 WCWCD Historical Population and 2008 Population Projections (GOPB 2007b)



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 show 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 four 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)

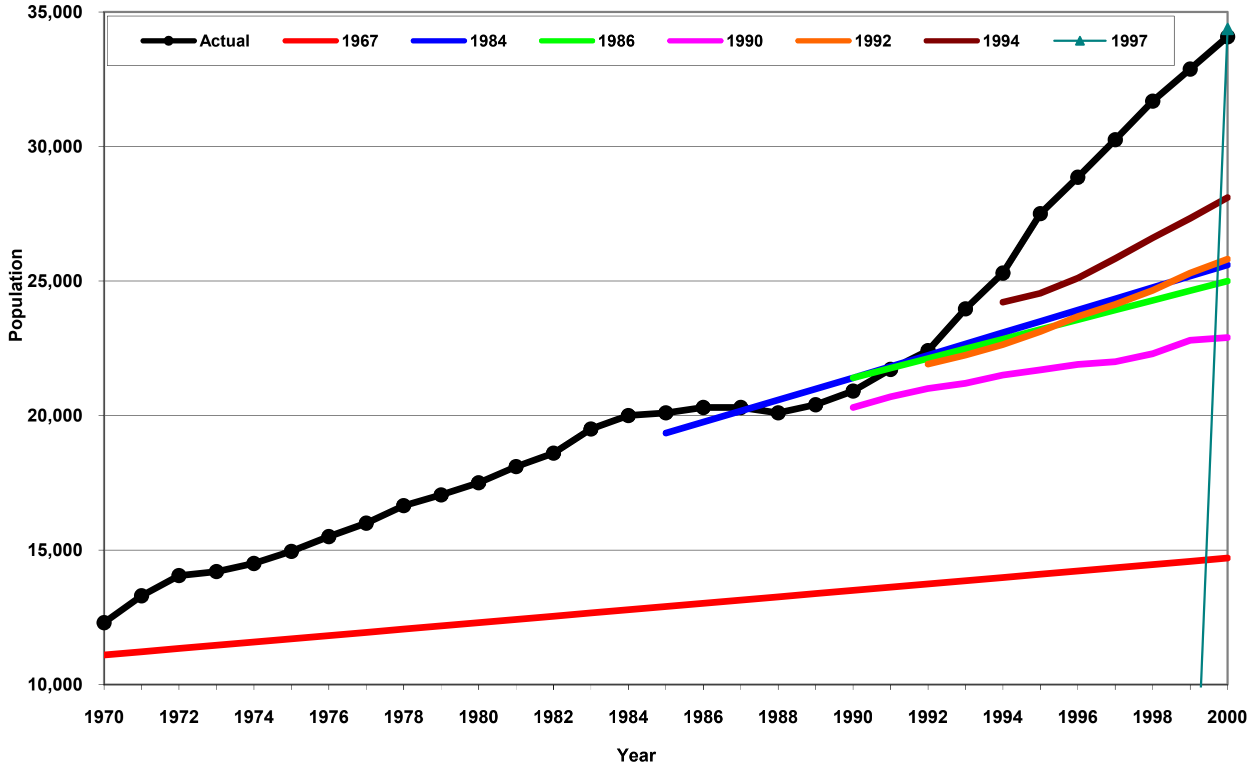


Table 3-2 Population Projections for CICWCD

District/ City	Parameter(2)	Year 2009	2010	2020	2030	2040	2050	2060	2005 to 2060 AGR
CICWCD Total	Pop.	42,858	45,358	61,236	78,563	98,833	123,020	150,936	-
	AGR	-	5.67%	3.00%	2.49%	2.30%	2.19%	2.05%	2.77%
Cedar City	Pop.	28,726	29,907	40,376	51,799	65,165	81,113	99,516	-
	AGR	-	4.03%	3.00%	2.49%	2.30%	2.19%	2.04%	2.59%
Enoch City	Pop.	5,222	5,302	7,157	9,181	11,551	14,379	17,642	-
	AGR	-	1.52%	3.00%	2.49%	2.30%	2.19%	2.05%	2.33%

(1)Source of population projections is GOPB (2008), except for the 2009 population, which are estimated population data using the DWRe municipal and industrial water supply reports (DWRe 2007a) for 2005 and GOPB (2008) 2010 projections.
(2)Pop. = GOPB population projection; AGR = annual growth rate.

Figure 3-5 CICWCD Population Projection Range

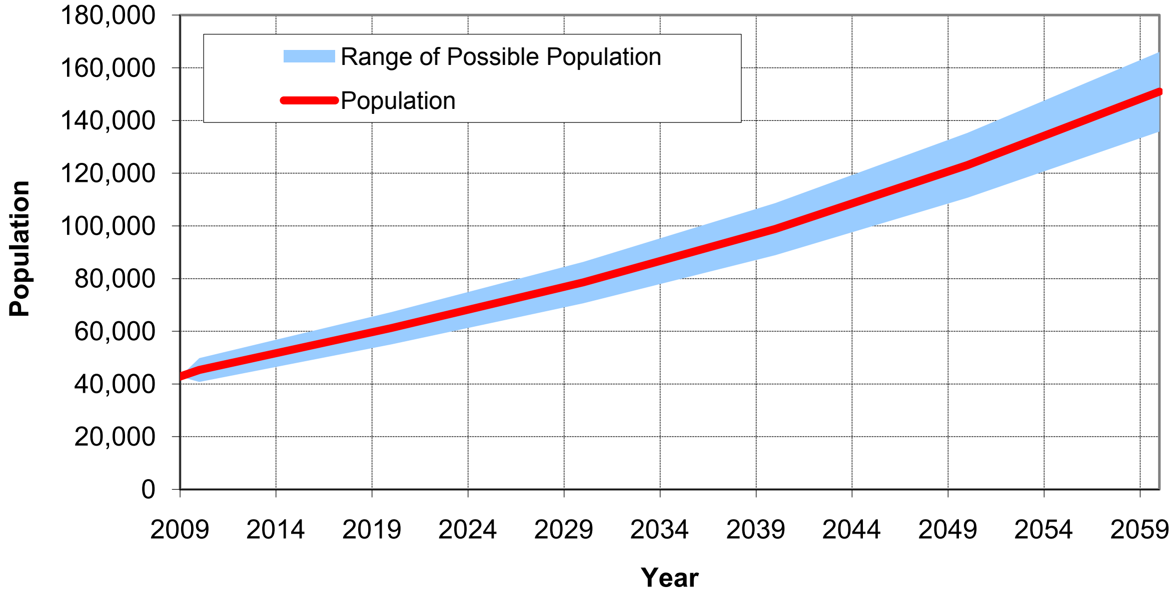
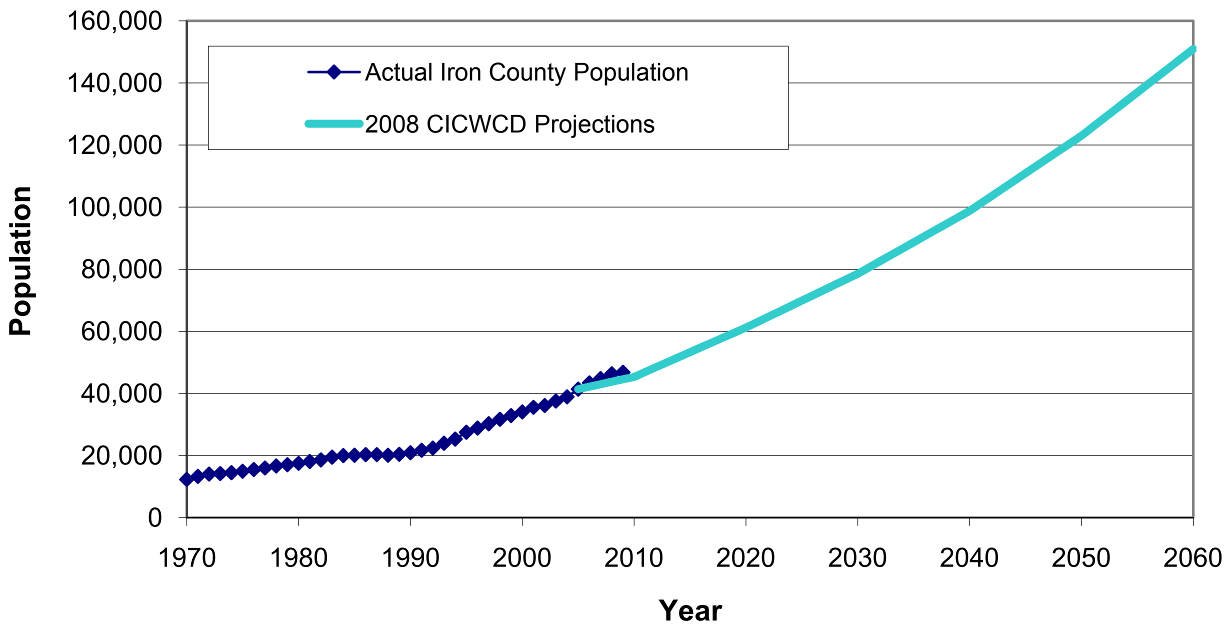


Figure 3-6 CICWCD Historical Population and 2008 Population Projections (GOPB 2007b)



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 3-9** displays the historical GOPB population estimates (2007b) along with the GOPB 2008 projections.

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

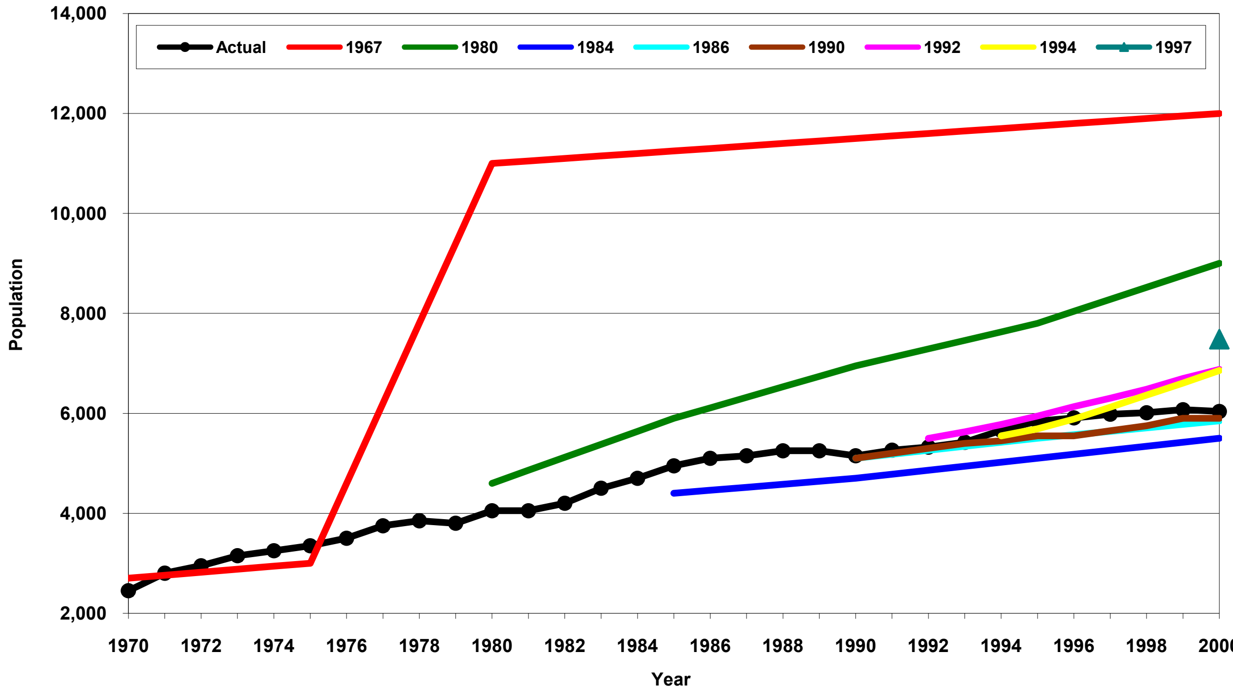


Table 3-3 Population Projections for KCWCD and Kanab

District/City	Parameter(2)	Year 2009	2010	2020	2030	2040	2050	2060	2005 to 2060 AGR
KCWCD	Pop.	6,705	6,893	8,746	10,394	12,034	14,267	17,276	-
	AGR	-	2.77%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Kanab	Pop.	3,988	4,100	5,202	6,182	7,157	8,485	10,275	-
	AGR	-	2.77%	2.38%	1.72%	1.47%	1.70%	1.91%	1.94%

(1)Source of population projections is GOPB (2008), except for the 2009 population, which are estimated population data using the DWRe municipal and industrial water supply reports (DWRe 2006c; DWRe 2007b; DWRe 2009b) for 2005 and GOPB (2008) 2010 projections.
(2)Pop. = GOPB population projection; AGR = annual growth rate.

Figure 3-8 KCWCD Population Projection Range

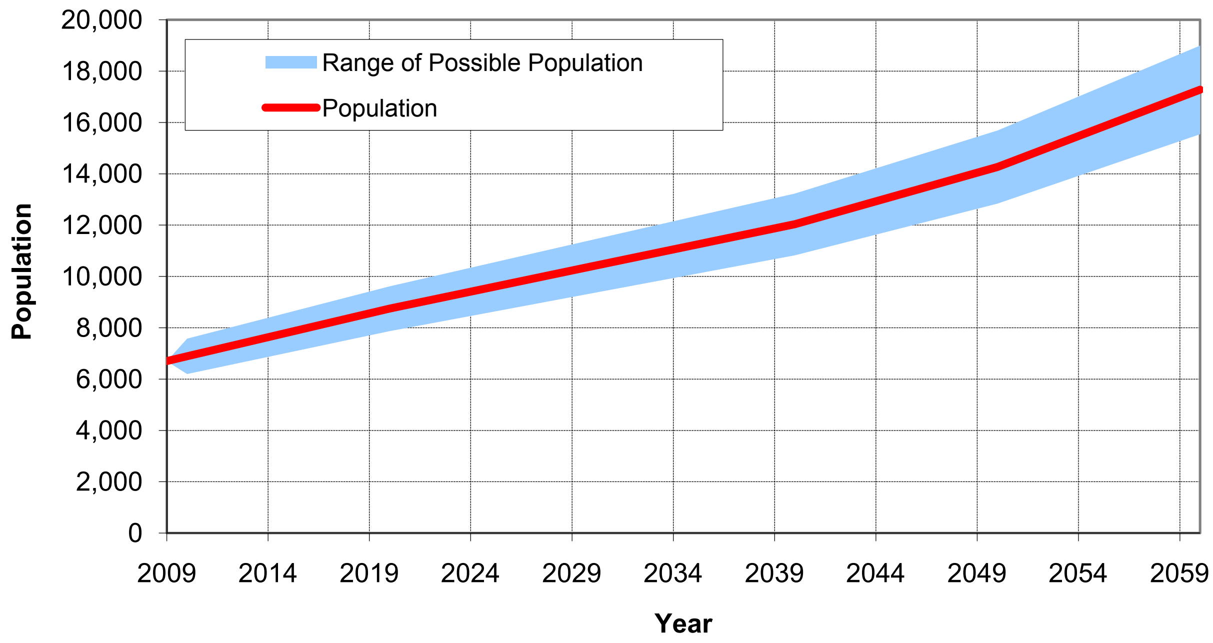
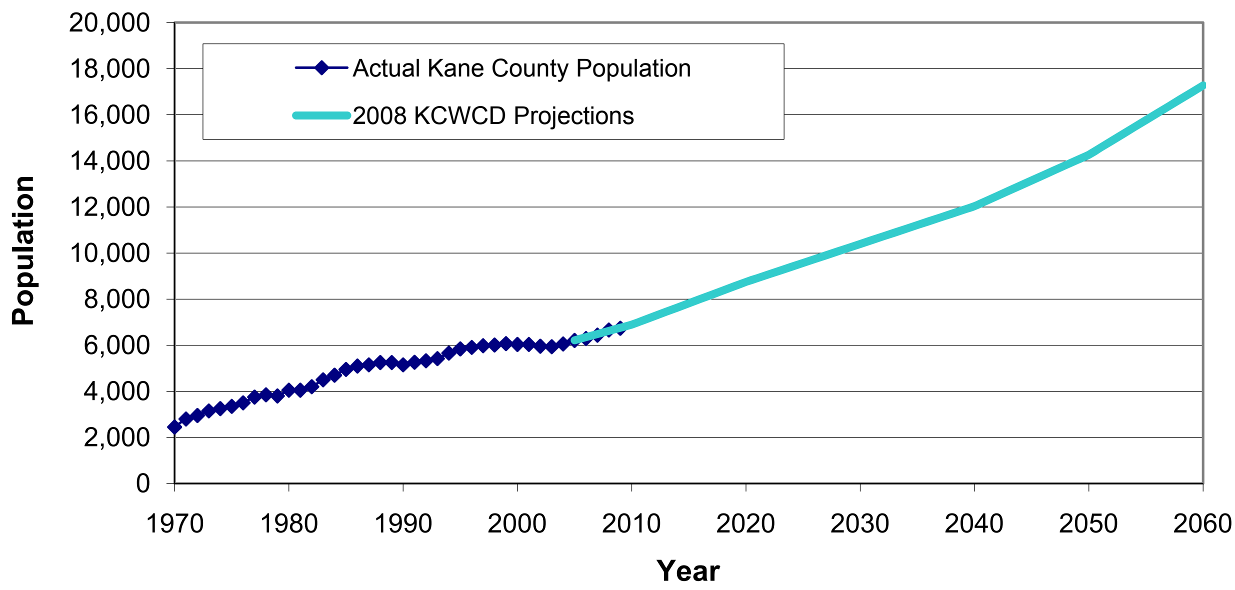


Figure 3-9 KCWCD Historical Population and 2008 Population Projections (GOPB 2007b)



3.1.1.4 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
		2009	2010	2020	2030	2040	2050	2060	
East Fork Virgin River	Pop.	1,165	1,198	1,521	1,807	2,092	2,481	3,004	-
	AGR	-	2.83%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Kanab Creek	Pop.	4,639	4,769	6,050	7,191	8,325	9,870	11,952	-
	AGR	-	2.76%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Johnson Canyon	Pop.	221	227	288	342	396	470	569	-
	AGR	-	2.71%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%
Wahweap Creek	Pop.	680	699	887	1,054	1,220	1,447	1,752	-
	AGR	-	2.74%	2.38%	1.73%	1.47%	1.70%	1.91%	1.94%

(1)Source of population projections is GOPB (2008), except for the 2009 population, which are estimated population data using the DWRe municipal and industrial water supply reports (DWRe 2006c; DWRe 2007b; DWRe 2009b) for 2005 and GOPB (2008) 2010 projections.
(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 three 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 B 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 smaller non-permanent population.

3.1.3.1 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.		

3.1.3.2 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.

3.1.3.3 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 are 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 are countywide data and are 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 are 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

Cities in southwestern Utah 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).
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
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 in terms of water use by type (culinary and secondary) and category (residential, commercial, etc.) for each District. Additionally, the data have been verified by the DWRe during yearly field surveys between the DWRe and the water providers. The 2005 water use data were used as a basis for estimating 2009 water use data used to start the future water use forecasts. 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, presence of golf courses, and amount of industrial and institutional use relative to residential use. 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 17.3 percent in WCWCD, 8.9 percent in CICWCD, and 17.7 percent in KCWCD.

Table 3-10 WCWCD[1, 2] 2005 Per Capita Water Use (gpcd)

Water Use Categories	Culinary	Secondary	Total
Residential – Indoor	71.9	0.0	**71.9**
Residential – Outdoor	97.4	15.8	**113.3**
Commercial	61.4	9.5	**70.9**
Institutional	15.5	26.0	**41.5**
Industry/Stock Water	3.7	1.0	**4.7**
Total	**250.0**	**52.3**	**302.3**

Notes:
(1)WCWCD water use was assumed to be the water use for all of Washington County except Enterprise.
(2)Source: DWRe 2009b.

Figure 3-10 WCWCD 2005 Per Capita Water Use

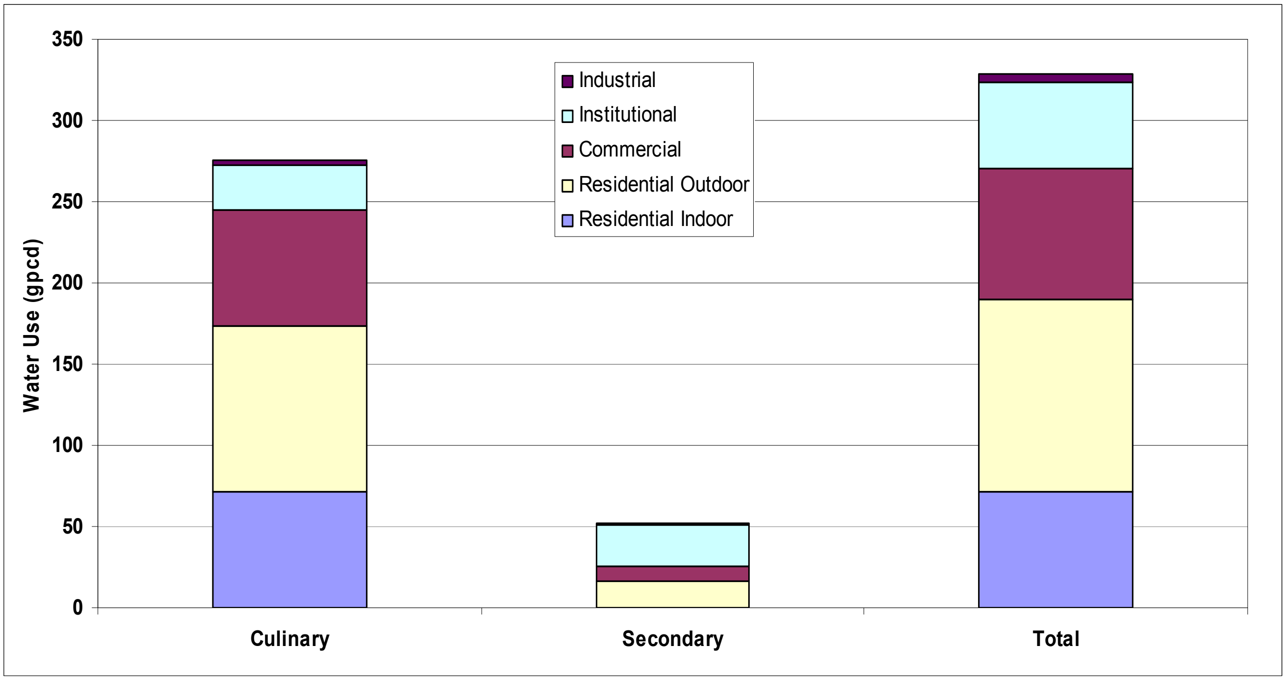


Table 3-11 CICWCD[1, 2] 2005 Per Capita Water Use (gpcd)

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

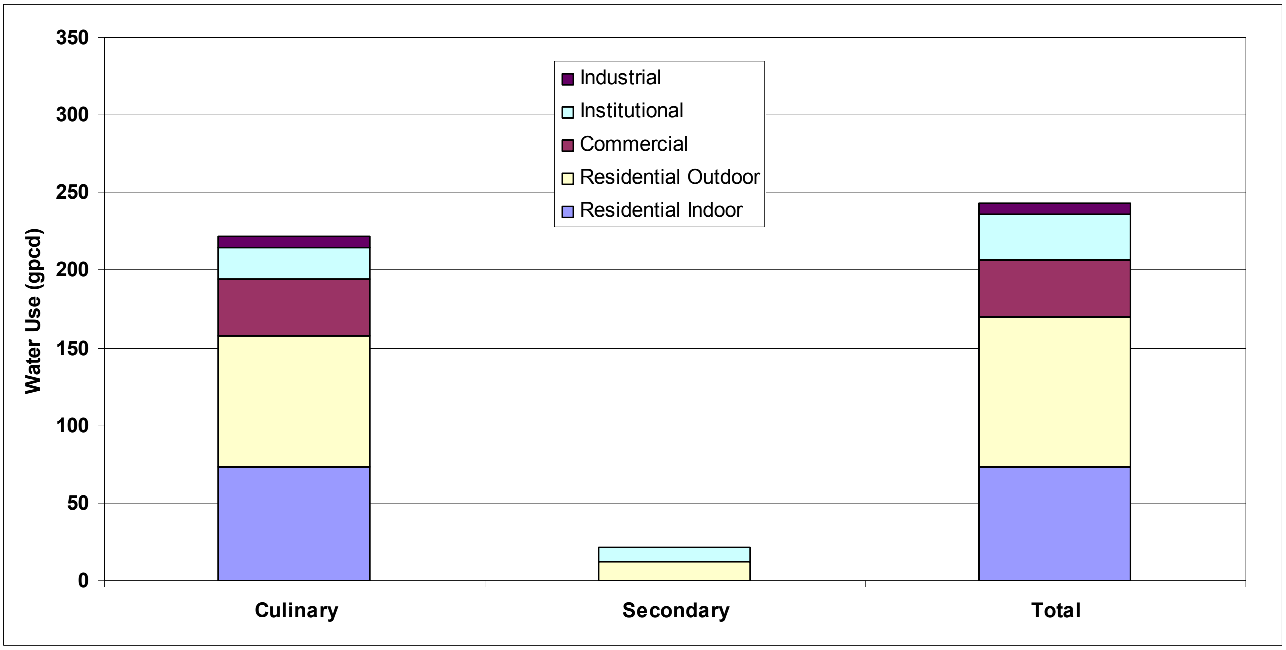


Table 3-12 KCWCD[1, 2] 2005 Per Capita Water Use (gpcd)

Water Use Categories	Culinary	Secondary	Total
Residential – Indoor	76.2	0.0	**76.2**
Residential – Outdoor	91.8	60.8	**152.6**
Commercial	68.5	0.0	**68.5**
Institutional	102.8	13.8	**116.5**
Industry/Stock Water	6.4	0.0	**6.4**
Total	**345.7**	**74.5**	**420.3**

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 2009b; DWRe 2007b.

Figure 3-12 KCWCD 2005 Per Capita Water Use

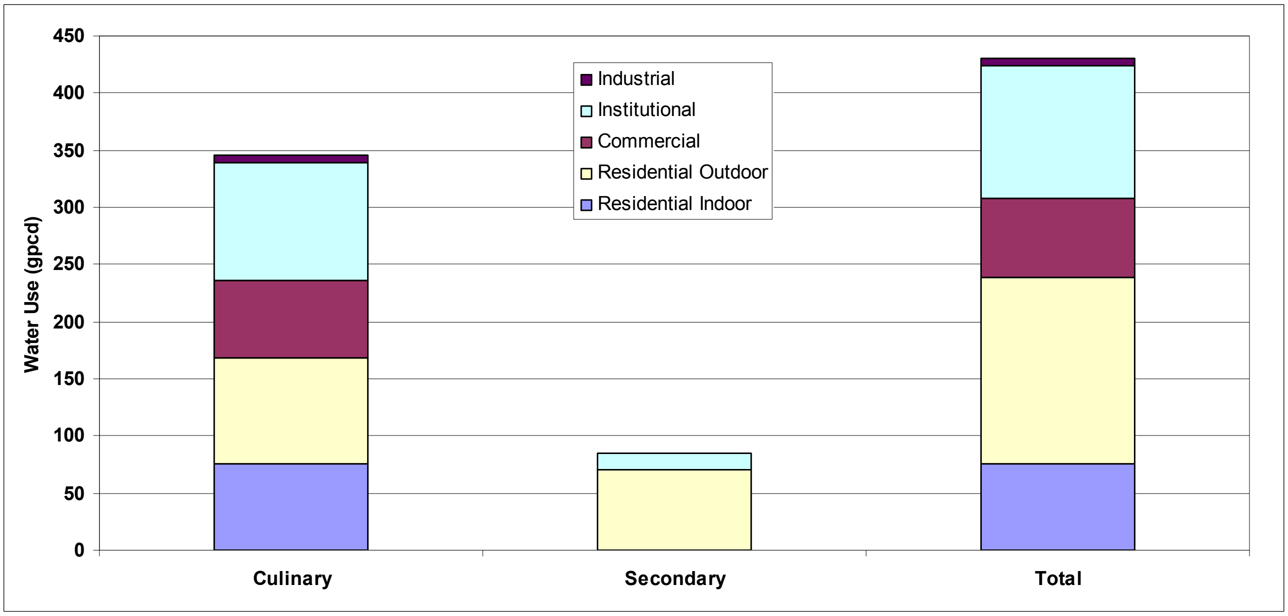


Table 3-13 2005 Per Capita Water Use (gpcd) for Major Cities in Study Area

Entity	Culinary	Secondary	Total
Hurricane City	215.0	86.1	**301.0**
Ivins City	164.2	10.5	**174.7**
La Verkin City	120.6	53.1	**173.7**
Santa Clara City	218.9	1.5	**220.4**
St. George City	290.1	33.6	**323.7**
Washington City	219.5	50.9	**270.4**
Cedar City	231.5	15.8	**247.4**
Kanarraville	408.9	145.8	**554.7**
Kanab City	383.1	16.6	**399.7**
Source: DWRe 2006c; DWRe 2007a; DWRe 2009b; 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	39%	61%
CICWCD	43%	57%
KCWCD	33%	67%

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	68% (61%)	32% (39%)
CICWCD	71% (70%)	29% (30%)
KCWCD	49% (54%)	51% (46%)

(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 is significant as 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 2009b) 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 2009b)	2005	302
	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 2009b)	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 2009b)	2005	420
	Kanab CFP (Alpha Engineering 2006)	2005	410(5)
	DWRe Kanab Creek/Virgin River Basin Plan (DWRe 1993)	1990	321(2, 6)

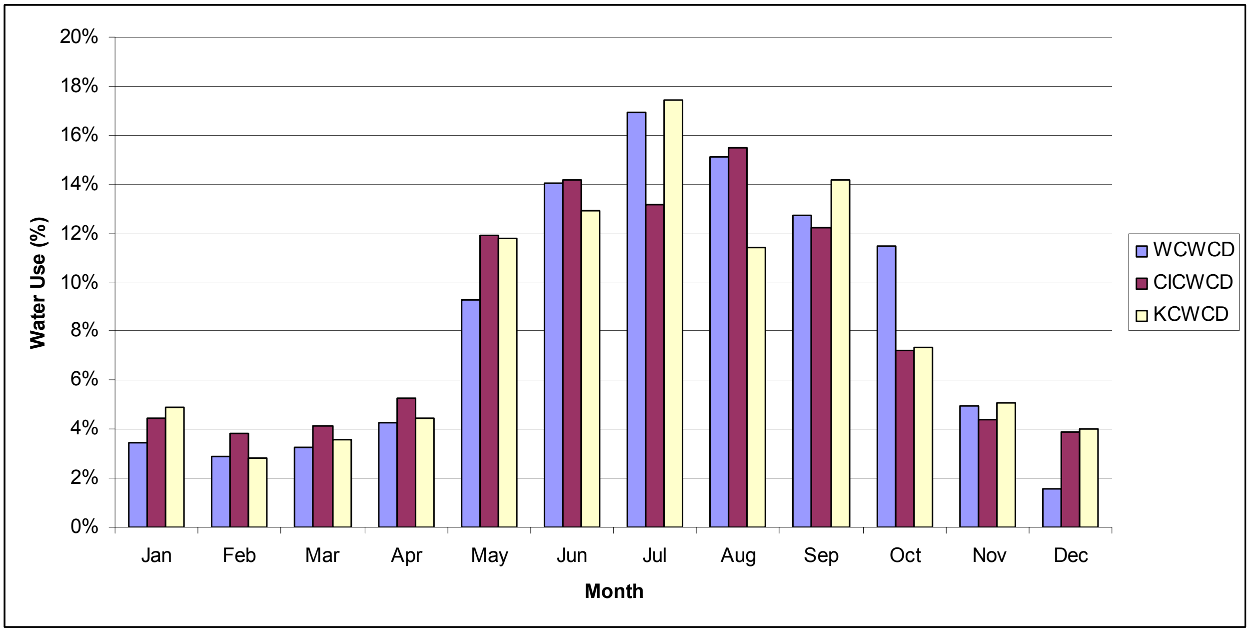
(1)Calculated as total water use divided by permanent population plus an estimate of secondary residence population based on county property tax assessment. Includes culinary and secondary water use.
(2)Includes culinary water use only but not secondary water use.
(3)The Washington County average per 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, are 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 (April 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 March, November, and December.

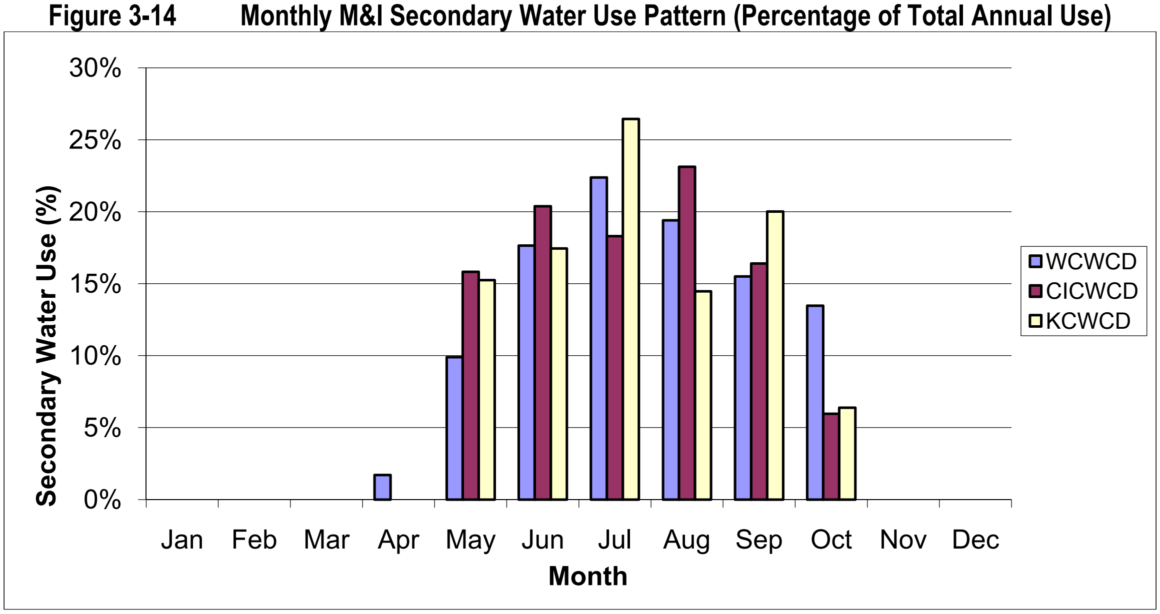
Monthly water use patterns were used to determine monthly variations in secondary water use demands in order to determine the portion of available secondary supply that could be used by the Districts. Monthly secondary demand would need to be great enough to fully utilize potential secondary supply if 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; Cedar City, 2006; Alpha Engineering, 2006.

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



3.2.5 2009 Per Capita Water Use

Water demand forecasts were started with 2009 water use, based on computed per capita use rates. The methods of computing 2009 per capita use rates varied for each District, and are described below.

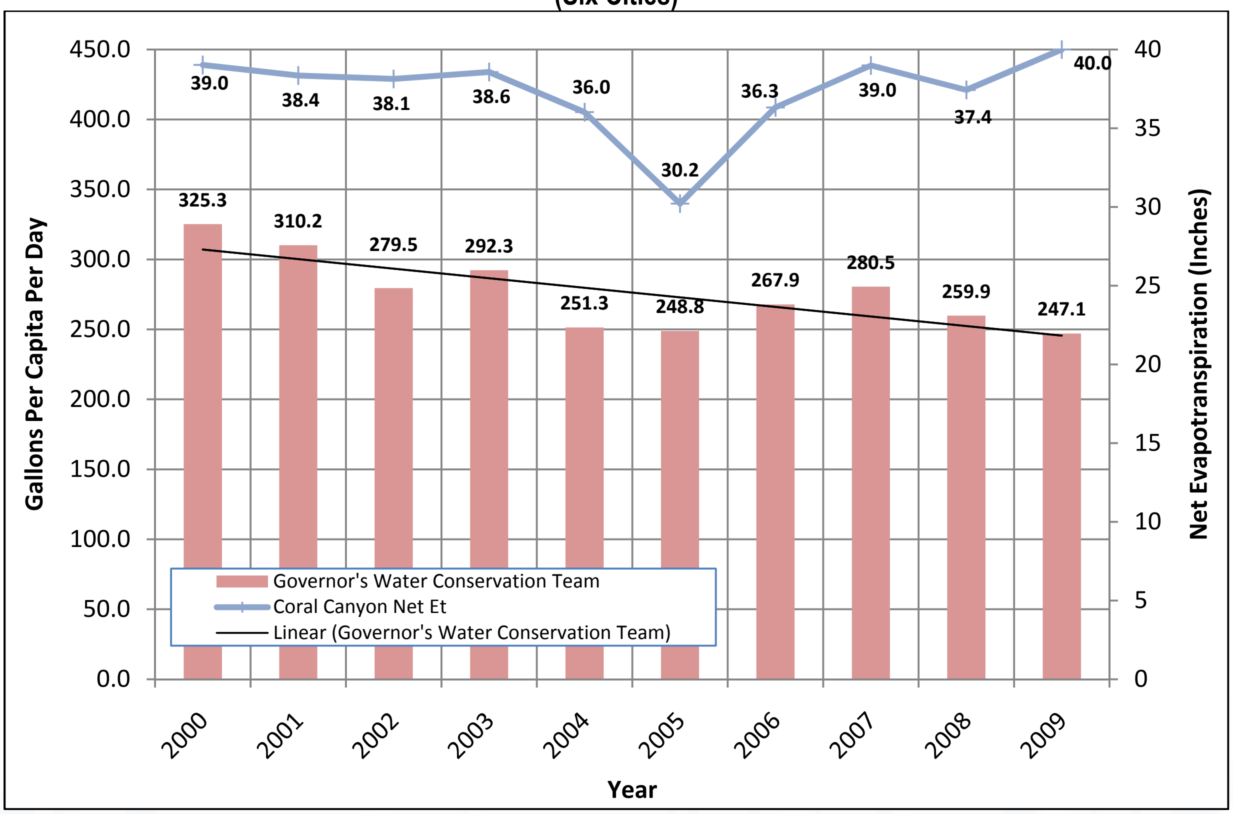
3.2.5.1 WCWCD

The Governor's Water Conservation Team (DWRe, 2009) collected culinary water use data for the 6 major cities in Washington County between 2000 and 2009. This data was verified by DWRe staff, and was recommended for use in this study. Annual culinary per capita water use for the 6 cities is shown in **Figure 3-15**. Because data was available only for the 6 cities, the ratio of the 6 cities culinary water use to total Washington County culinary water use in 2005 was used to estimate the total Washington County culinary water use in 2009. The secondary per capita water use was assumed to remain the same from 2005 to 2009, based on conversations with DWRe staff. The 2009 per capita water use values used in this analysis are shown in **Table 3-17**.

Table 3-17 WCWCD 2009 Per Capita Water Use

Water Type	Per Capita Water Use(gpcd)
Culinary	242.0
Secondary	52.3
Total	294.3

Figure 3-15 Utah Governor's Water Conservation Team – Culinary Per Capita Water Use for WCWCD (Six Cities)



3.2.5.2 CICWCD

2009 per capita water use was computed by reducing the measured 2005 per capita water use described previously by the amount of conservation assumed to occur between 2005 and 2009. The method of estimating historical conservation water savings is described in the following section. Based on this analysis, it was estimated that water use in Central Iron County decreased by about four percent between 2005 and 2009 (one percent per year). Reducing the 2005 per capita water use values by four percent yielded the values in **Table 3-18**.

Table 3-18 CICWCD 2009 Per Capita Water Use

Water Type	Per Capita Water Use (gpcd)
Culinary	213.0
Secondary	20.8
Total	233.8

3.2.5.3 KCWCD

2009 per capita water use was assumed to be the same as the 2005 data presented in the M&I Water Use Reports and summarized in **Table 3-12**. As described in **Section 3.2**, it is assumed that little or no water conservation savings have been realized in Kane County over the 2005-2009 period.

3.3 Conservation

For Phase 1 of the LPP WNA, the historical conservation achieved for the WCWCD and CICWCD service areas were based on the Utah Division of Water Resources (DWRe) documentation of 12 percent reduction in per capita water use achieved statewide between 2000 and 2005. The remaining goals were set at 13 percent reduction to be achieved from 2005 to 2050.

For Phase 2 of the WNA, the estimates of historical conservation achieved in the WCWCD and CICWCD service areas were updated based on historical water use data collected from a variety of sources, and climatological data provided by DWRe. For WCWCD five sources of water use data were evaluated and for CICWCD seven sources of water use data were evaluated. All water use data were analyzed along with evapotranspiration (Et) data to help determine the effects regional weather may have had on water use in a particular year. Methods and results of the historical conservation analysis are described in **Chapter 5**.

Each of the districts conducted an evaluation of potential future conservation programs that could be adopted to reduce future per capita water use and meet the State's conservation goal. The conservation evaluation was performed by Maddaus Water Management and MWH, and is described in **Chapter 5**. The result of the evaluation was selection of a conservation program for each district that consisted of a suite of measures to at least meet the goal for achieving 25% per capita water use reduction from 2000 to 2050.

Based on the analysis of historical conservation achieved, the following reductions in per capita use were assumed for the Districts to calculate future M&I per capita water use.

- **WCWCD –** A 13 percent reduction in per capita water use was estimated for WCWCD from 2000 to 2009. An 18 percent reduction in per capita water use was computed from 2009 to 2060 based on the conservation program selected by WCWCD. The total conservation savings between 2000 and 2050 is projected to be 29 percent, exceeding the State's goal of 25 percent.
- **CICWCD –** A 9 percent reduction in per capita water use was estimated for CICWCD from 2000 to 2009. A 17 percent reduction in per capita water use was computed from 2009 to 2060 based on the conservation program selected by CICWCD. The total conservation savings between 2000 and 2050 is projected to be 26 percent, meeting the State's goal of 25 percent.
- **KCWCD –** Kane County has not achieved any significant conservation over the 2000 to 2009 period, and as a result, KCWCD should attempt to achieve 25 percent reduction from 2009 to 2050 based on the state's goal. The conservation program adopted for KCWCD is capable of achieving a 25 percent reduction in per capita water use from 2009 to 2050, and a _31 percent reduction from 2009 to 2060. The conservation program assumed for Kane County is not capable of meeting the State's statewide conservation goal, but is considered the most extensive program that is reasonable and achievable for this community.

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 3-19**, with conservation reported as percent reduction in per capita water use relative to the 2009 per capita water use described in **Section 2.4**. As described in the Methods section, conservation was assumed to increase according to the modeled savings from the adopted conservation measures from 2009 to 2060.

Table 3-19 Conservation Schedule for LPP Districts

Year	Water Conservation Percentage (Relative to 2009 per capita Water Use)		
	WCWCD	CICWCD	KCWCD
2010	1%	2%	1%
2020	6%	11%	7%
2030	10%	14%	13%
2040	14%	16%	19%
2050	16%	16%	25%
2060	18%	17%	31%

3.4 Projected Water Demand

Total water demand in the Districts is comprised of culinary and secondary water demands. The projected total water demand was calculated and was broken down into a projected secondary water demand and culinary water demand.

3.4.1 Total 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 from new industries. Water demand forecasts for total municipal and industrial (M&I) water demand were developed for each District for the period from 2009 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 computed conservation savings described in the previous section for the 2009 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.

3.4.2 Culinary and Secondary Water Demand

As described previously, total water demand in the Districts is comprised of culinary and secondary water demands. The total combined water demand in 2060 was calculated based on the population forecasts and per capita use rates. 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. However, other factors such as typical residential lot size, development density, number of people per household, improvements in plumbing fixtures, improvements in appliance efficiency, drought, and global climate change will have an influence.

Future secondary water demand will be affected by some of the same factors that will affect culinary water use, 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 secondary water lines, and thus deliveries are limited by the location and capacity of the secondary 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). Since secondary water is untreated, its use in urban areas is limited to landscape watering and other outdoor uses. 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.

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 are considered reliable due to the thorough validation process that was followed, reliable data for previous years are not available with enough frequency to assess possible trends in use by Districts 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 total secondary water use demands were developed based on outdoor water use projections. Currently outdoor water use is comprised of secondary water and culinary water. For example, the M&I Water Use Report shows that in 2005 in WCWCD approximately 49 percent of culinary water was used outdoors. (Combined culinary and secondary outdoor water use was about 62 percent of total water use.) It was assumed that the ratio of outdoor culinary water use to total culinary water use would decrease over time as secondary water would be developed to meet outdoor demands.

It was also assumed that 48 percent of the future conservation savings would result from a reduction in outdoor water use, based on the MWM conservation model. This would be due to variables such as smaller lots, less turf in all new residential developments, and conservation measures targeting outdoor water use. For example, in 2060 WCWCD would save approximately 50,805 ac-ft of water per year if the 18 percent reduction in per capita water use is applied (calculated by multiplying the 2060 population of 860,378 by the 2009 per capita water use of 294.3 gpcd by 18 percent reduction and converting this value to ac-ft/yr). Of the 50,805 ac-ft/yr it was assumed approximately 24,387 ac-ft of outdoor water use per year would be reduced. This reduction in outdoor water use would be applicable to secondary water use and culinary outdoor water use.

The ratio of secondary water use to total water use was assumed to increase throughout the study period. For example, in 2005 in WCWCD the secondary demand comprised about 17 percent of total water use (52.3 gpcd divided by 302.3 gpcd). It was assumed that by 2060 this would increase to 28 percent of total water use. The 2005 secondary demand value applies to current secondary uses in WCWCD such as various parks, golf courses, agriculture, etc. It was assumed that by 2060 all parks, golf courses, public buildings etc. would use secondary water for outdoor irrigation. This does not include secondary water that may potentially replace outdoor culinary water use.

An assumption was made that outdoor watering with culinary water would continue in existing developed areas since most developed areas would not be retrofitted with parallel secondary systems. New developments however, were assumed to have secondary systems in place. It was assumed that by 2020 the districts would develop their secondary water systems and all new development after 2020 would utilize secondary water for 25 percent of its outdoor water use.

Although the mix of culinary versus secondary water use is assumed to shift, 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's 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/yr to these two tribes.
- Western Electrochemical Company (WECCO) is an industrial user in the CICWCD 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/yr for Palladon and 1,500 ac-ft/yr 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 3-20**.

Table 3-20 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
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/yr (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 3-21 summarizes the reasonably foreseeable additional commercial, industrial and institutional future water demands added to the population-based projections described in the previous sections.

Table 3-21 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/yr every 5 years
	WECCO	1,500	Increasing from 2020 to 2040 by 500 ac-ft/yr 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 for WCWCD are shown in **Table 3-22** and **Table 3-23** and plotted for WCWCD in **Figure 3-16**.

Table 3-22 WCWCD Total M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation From 2009	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)
2009	159,880	294.3	0%	294.3	52,710	0	52,710
2010	168,080	294.3	1%	291.6	54,900	0	54,900
2020	279,860	294.3	6%	275.4	86,340	0	86,340
2030	415,510	294.3	10%	263.4	122,610	0	122,610
2040	559,670	294.3	14%	254.3	159,400	0	159,400
2050	709,670	294.3	16%	247.5	196,780	0	196,780
2060	860,380	294.3	18%	241.6	232,830	0	232,830

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

Table 3-23 WCWCD Culinary and Secondary M&I Water Demand Forecast

Year	Culinary Projected Water Demand (ac-ft/yr)	Secondary Projected Water Demand (ac-ft/yr)	Total Projected Water Demand (ac-ft/yr)
2009	43,340	9,370	52,710
2010	45,130	9,770	54,900
2020	70,860	15,480	86,340
2030	101,990	20,620	122,610
2040	133,663	25,740	159,400
2050	165,840	30,940	196,780
2060	196,870	35,960	232,830

Water demand forecasts for total M&I water use are shown in **Table 3-24** and **Table 3-25** and plotted for CICWCD in **Figure 3-17**. Total M&I water demand for CICWCD in the year 2060 would be approximately 39,770 ac-ft/yr.

Table 3-24 CICWCD M&I Water Demand Forecast

Year	Population	Base Per Capita Use (gpcd)	Assumed Conservation from 2009	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)
2009	42,860	233.8	0%	233.8	11,220	0	11,220
2010	45.360	233.8	3%	226.1	11,490	500	11,990
2020	61.240	233.8	12%	206.7	14,180	3,500	17,680
2030	78,560	233.8	14%	200.6	17,650	5,000	22,650
2040	98,830	233.8	16%	197.1	21,830	6,500	28,330
2050	123,020	233.8	16%	195.5	26,940	7,000	33,940
2060	150,940	233.8	17%	193.8	32,770	7,000	39,770

(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 WCWCD Total M&I Water Demand Forecast

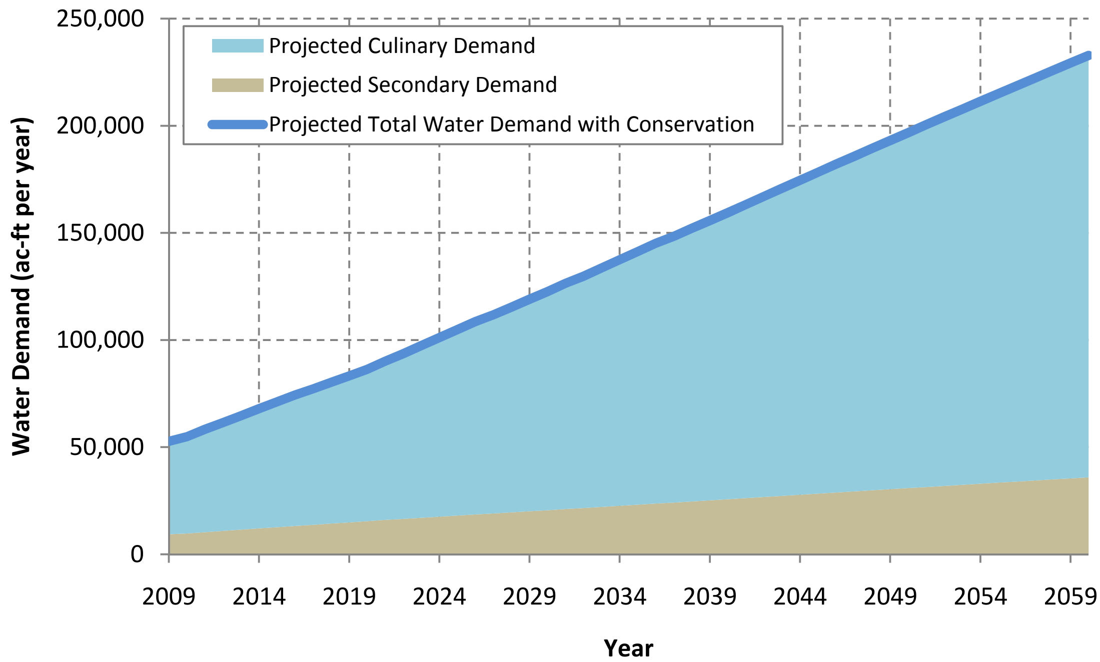


Table 3-25 CICWCD Culinary and Secondary M&I Water Demand Forecast

Year	Culinary Projected Water Demand (ac-ft/yr)	Secondary Projected Water Demand (ac-ft/yr)	Total Projected Water Demand (ac-ft/yr)
2009	10,220	1,000	11,220
2010	10,970	1,020	11,990
2020	15,200	2,480	17,680
2030	19,210	3,440	22,650
2040	23,760	4,570	28,330
2050	28,010	5,930	33,940
2060	32,290	7,480	39,770

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

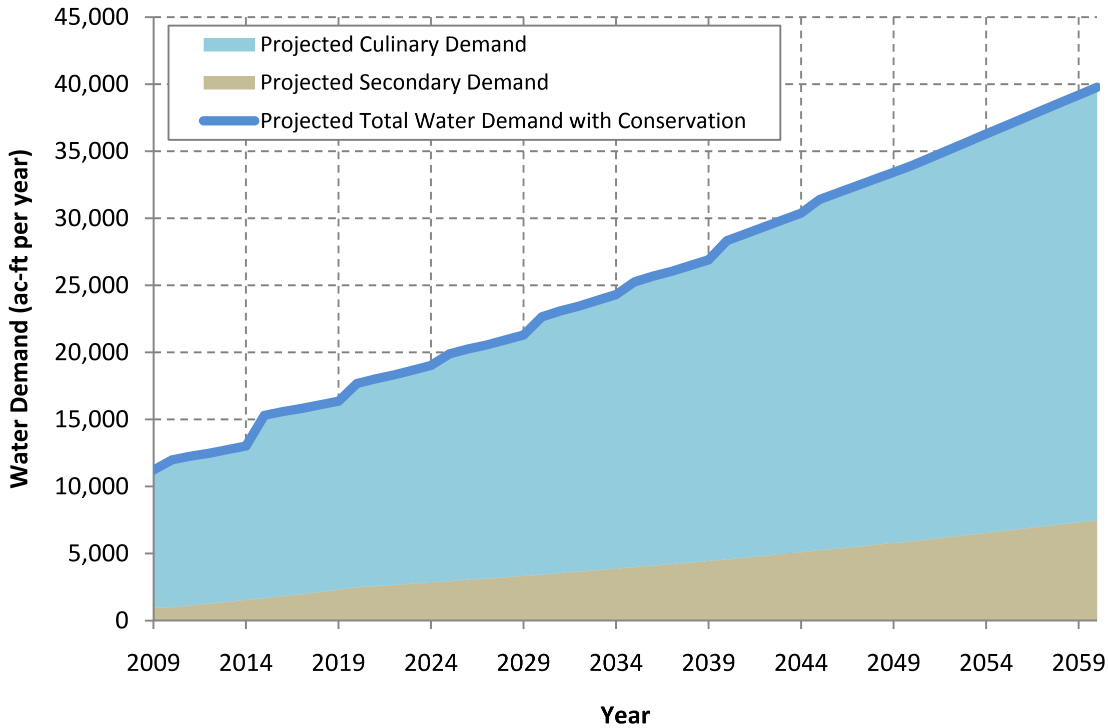


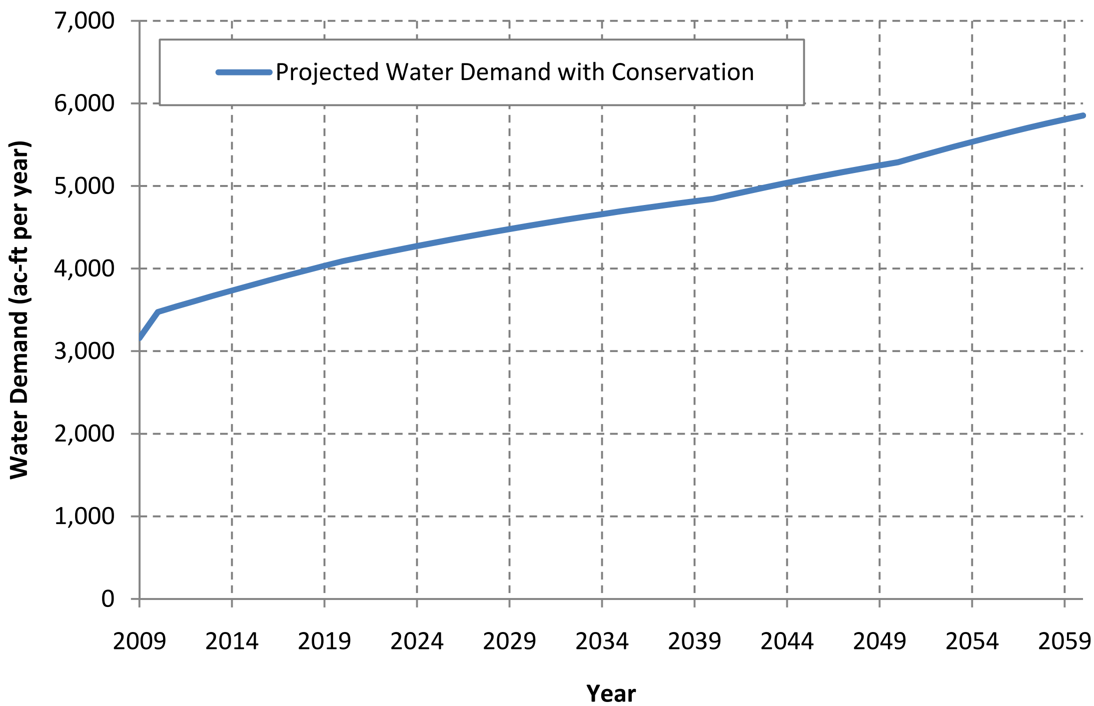
Table 3-26 KCWCD M&I Water Demand Forecast

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)
2009	6,700	420.3	0%	420.3	3,160	0	3,160
2010	6,890	420.3	1%	417.7	3,230	250	3,480
2020	8,750	420.3	7%	392.1	3,840	250	4,090
2030	10,390	420.3	13%	366.4	4,270	250	4,520
2040	12,030	420.3	19%	340.8	4,590	250	4,840
2050	14,270	420.3	25%	315.2	5,040	250	5,290
2060	17,280	420.3	31%	289.6	5,600	250	5,850

(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.

Water demand forecasts for total M&I water use are plotted for KCWCD in **Figure 3-18**. Total M&I water demand for KCWCD in the year 2060 would be approximately 5,850 ac-ft/yr.

Figure 3-18 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 3-19** through **Figure 3-22**. The approximate total M&I water demands for each of the subbasins in the year 2060 would be:

- East Fork Virgin River Subbasin – 970 ac-ft/yr
- Kanab Creek Subbasin – 4,130 ac-ft/yr
- Johnson Canyon Subbasin – 190 ac-ft/yr
- Wahweap Creek Subbasin – 570 ac-ft/yr

Figure 3-19 East Fork Virgin River Total M&I Water Demand Forecast

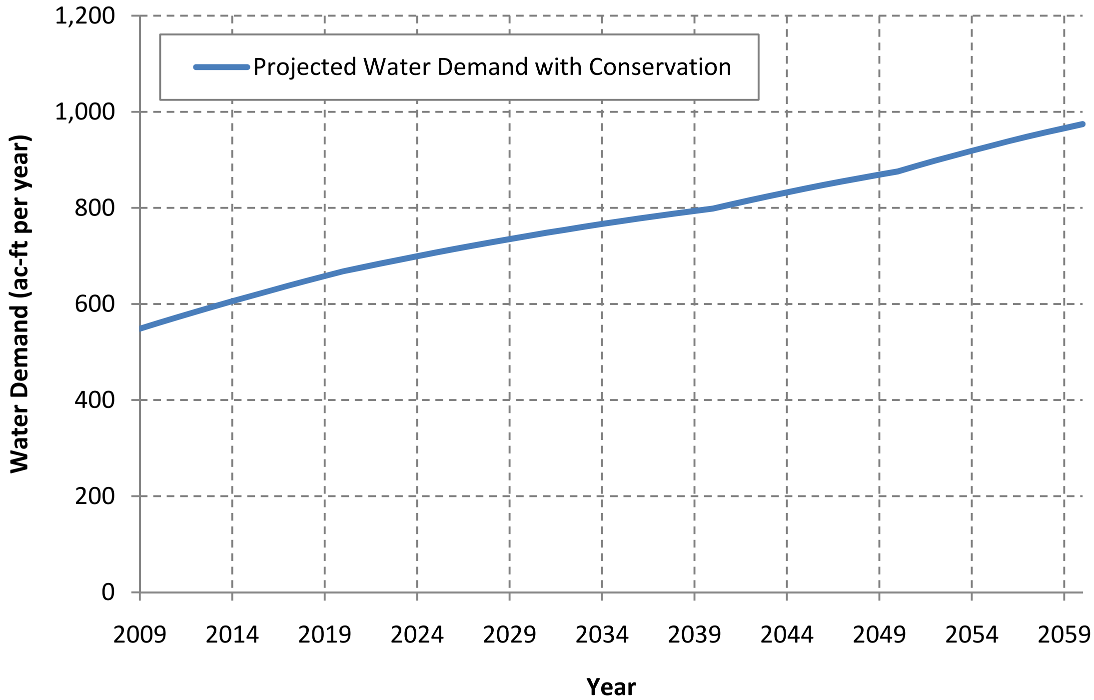


Figure 3-20 Kanab Creek Total M&I Water Demand Forecast

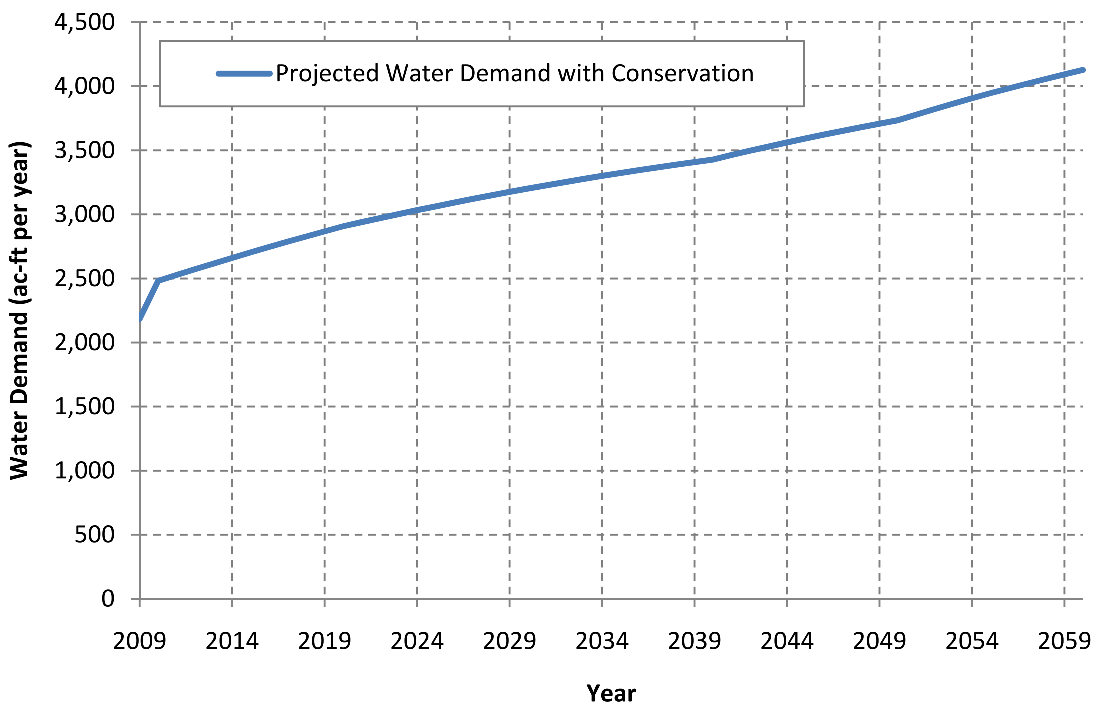


Figure 3-21 Johnson Canyon Total M&I Water Demand Forecast

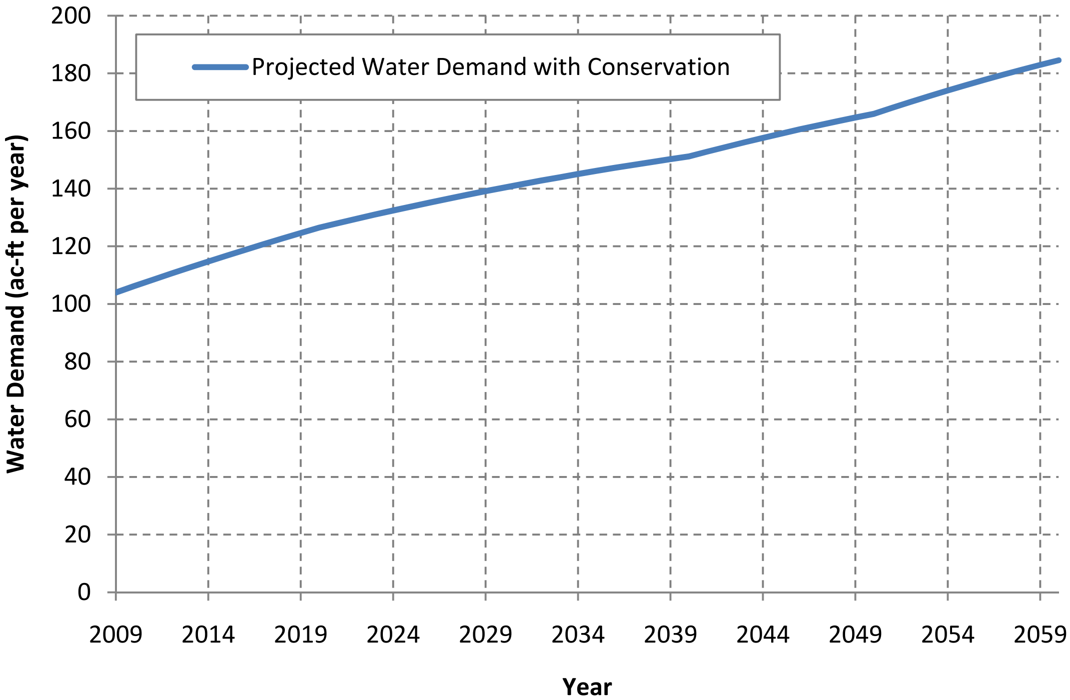
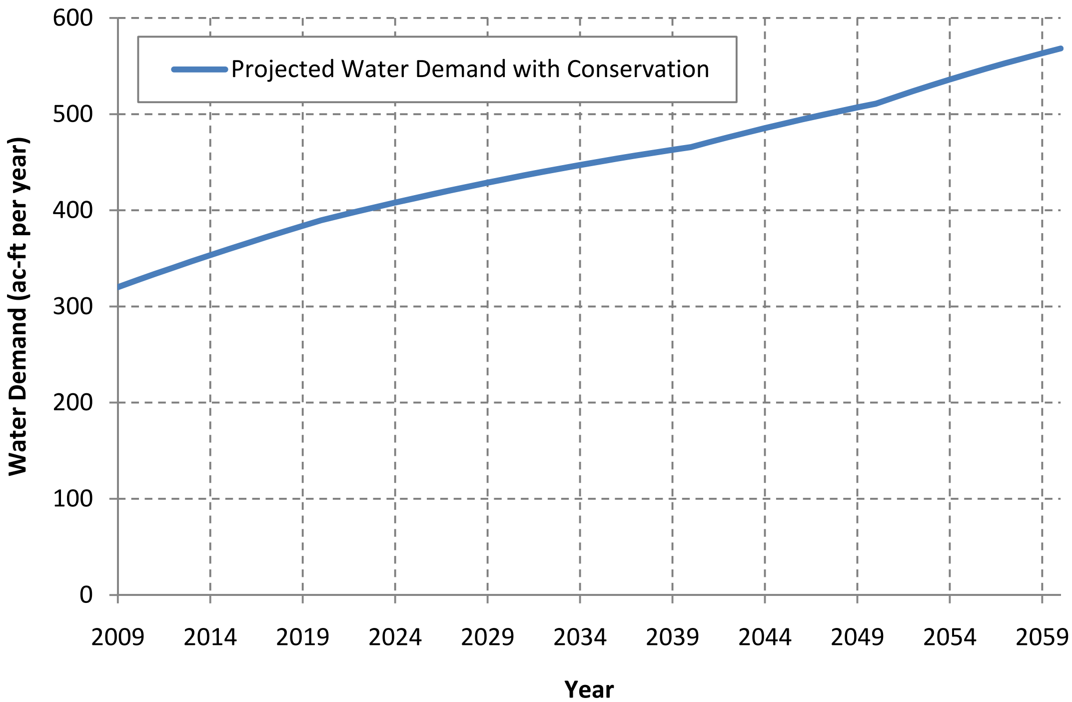


Figure 3-22 Wahweap Creek Total M&I Water Demand Forecast



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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 2009b; 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 2009b) 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 2009b). 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.

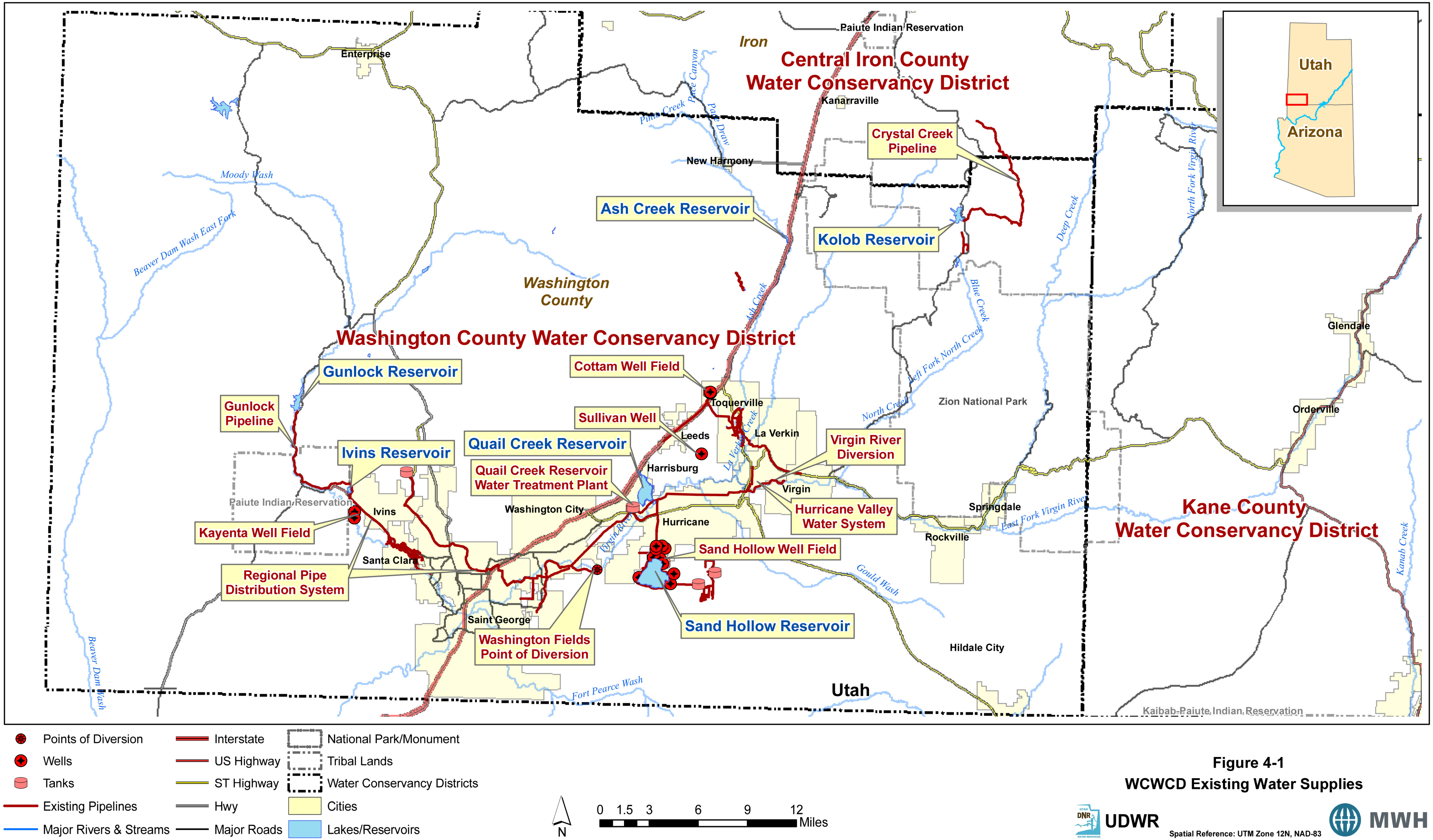

Figure 4-1
WCWCD Existing Water Supplies

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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 16,900 ac-ft/yr (90 percent reliability) of raw water for culinary uses to the communities of St. George, Hurricane, La Verkin and Washington (DWRe 2011). 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 22,600 ac-ft/yr (90 percent reliability). The existing reliable yield of surface water from Sand Hollow Reservoir was estimated to be 5,700 ac-ft/yr with 90 percent reliability (the difference between the total reliable yield of the Quail Creek/Sand Hollow reservoir system, 22,600 ac-ft/yr, and Quail Creek Reservoir, 16,900 ac-ft/yr).

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/yr (DWRe 2009b).

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 2009b).

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 4.1.5.1**.

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/yr, which includes 7,000 ac-ft/yr associated with recharge from Sand Hollow Reservoir and approximately 1,000 ac-ft/yr 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/yr from Sand Hollow ground water wells. As a result, there would be no new yield from additional Sand Hollow wells.

WCWCD is concerned over the reliability of future surface water supplies due to factors such as climate change and demand hardening (i.e., less flexibility during drought periods as per capita use rates decrease). Although the District does not currently have a formal emergency reserve water supply policy, it is prudent to have a reserve supply for use in critical drought periods. WCWCD will hold 5,000 ac-ft/yr of the Sand Hollow well field yield as reserve supply, leaving 3,000 ac-ft/yr for use to meet annual demands.

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/yr. 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/yr (less than originally expected following recent pump tests) (WCWCD 2008a).

Crystal Creek Pipeline. WCWCD recently constructed 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/yr (WCWCD 2008a). This water is 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.

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/yr (DWRe 2009b).

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. It is considered part of the Sand Hollow well field system. 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/yr (DWRe 2009b).

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 if necessary.

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	22,600	0
Sand Hollow Ground Water	3,000	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
Crystal Creek Pipeline	2,000	0
Gunlock to Santa Clara Pipeline	0	2,500[2]
Toquerville Secondary Water System	0	160
Existing Wastewater Reuse	0	3.900
Total	**33,550**	**6,560**

Notes:
(1)Source of data: WCWCD 2006; WCWCD 2007c; DWRe 2009b, DWRe 2011, 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/yr. 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/yr in 2005 (DWRe 2009b). 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/yr (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 74,560 acre feet per year (DWRe 2009b). **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[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 Department[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**

Water Supplier	Reliable Potable Water Supply (ac-ft/yr)			
	Springs	Wells	Surface	Total(1)
Washington County WCD(7, 9)	0.0	3,750.0	41,700	**33,540**
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**	**42,198.0**	**62,648.7**

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 22,590 ac-ft/yr. Kolob Reservoir yields 2,000 ac-ft/yr. Meadow Hollow Reservoir yields 200 ac-ft/yr. The Sand Hollow recovery wells (surface water influenced, hence the classification) yield 3,000 ac-ft/yr. All stated reservoir/surface supplies based on 90% 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.
(8)Source: DWRe 2009b.
(9)WCWCD surface water supply includes the original amount from DWRe 2009b plus 2,000 ac-ft/yr from Crystal Creek Pipeline, built after the DWRe 2009b report.

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 are considered reliable due to the significant validation process followed, reliable data for previous years are 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 2009b).

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.

In Washington County there is a secondary water distribution system that is owned by WCWCD and operated by St. George. Secondary water and reuse water are intermixed and blended in the secondary system to provide secondary water to several entities. The secondary system serves St. George, Ivins, Santa Clara, and Hurricane. The water sources and infrastructure for this secondary system are described below.

4.1.4.3 WCWCD and St. George Secondary System

St. George has a wastewater treatment plant, reuse plant, and an extensive secondary distribution system. Each component of the St. George infrastructure is described below.

St. George Wastewater Treatment Plant

The St. George wastewater treatment plant uses extended aeration for its treatment process and produces Type II effluent. The average BOD is 2.13 mg/L and the average TSS is 1.69 mg/L.

The existing capacity of the WWTP is about 17 mgd. The capacity could be increased to approximately 25 mgd with increased efficiency. Roughly 9 mgd is treated annually with minimal fluctuations throughout the year (approximately ½ mgd). Typically treatment increases slightly in the winter and decreases in the summer. To accommodate future growth, the facility could be duplicated for a future capacity of 40 mgd.

The wastewater effluent is either discharged to the Virgin River or treated by the reuse plant.

St. George Reuse Treatment Plant

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 reuse plant was not built 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 to deliver 2,000 ac-ft of water annually to the Tribe.

The wastewater treatment plant typically produces good quality water which results in an increased efficiency for the reuse plant. Type I effluent is produced and can be used for secondary purposes where human exposure is likely. The average water quality of the reuse effluent in comparison to the Utah's water quality limits are displayed in **Table 4-3** below.

Table 4-3 Water Quality of St. George Reuse Effluent and Utah Water Quality Limits

Constituent	Reuse Effluent(1)	Utah Constituent Limit(2)
Turbidity (NTU)	0.5-0.8	2
pH	7.7	6-9
Residual Chlorine (mg/L)	1.7-2.4	>1
E Coli (#/L)	1	0
BOD (mg/L)	2.0-2.6	10
TSS (mg/L)	1.3-2.4	5

Notes:
(1)Barnum 2008.
(2)DWRe 2005.

The reuse plant utilizes filtration and chlorination for its treatment processes.

Demand for this secondary supply only exists during the irrigation season; as a result the reuse plant is shut down in the winter for about 3 to 4 months (approximately November through February). It is typically restarted in April or March. When the reuse plant is not operating in the winter the wastewater effluent is discharged to the Virgin River.

The plant is designed for 10 mgd capacity (11,200 ac-ft/yr). The current capacity of the reuse plant is approximately 7.0 mgd (7,840 ac-ft/yr). About 3.5 mgd is treated per filter and currently only 2 filters are used. There is space for a third filter for future growth. If the filters are pushed, roughly 12 mgd (13,440 ac-ft/yr) could be treated with all three filters being used.

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. Approximately 801 million gallons (2,460 ac-ft) were treated annually as of 2007 (Barnum 2007).

Existing Secondary Sources

Secondary water and reuse water are intermixed and blended in the secondary irrigation system. The reuse water originates from the St. George reuse plant. The secondary water is supplied by Gunlock and Ivins Reservoirs, local wells, and local springs. Wells that feed the secondary system are the Sunbrook #1 and #2 wells, and the Mathis, Moores, and Frie wells. All of these wells are located around the Sunbrook golf course. Sunbrook #1 supplies irrigation water to the Sunbrook golf course. The other 4 wells provide secondary supply to the parks and softball fields along the secondary water line going north towards the Ledges area. A third Sunbrook well was recently drilled, and will replace Sunbrook #2 that is no longer producing water.

Springs in western Washington City supply water for a private secondary system called the Sandburg System. The Sandburg System serves 3 schools, 2 parks, and a ball field in northeast St. George and western Washington City.

Springs located northeast of downtown called the East/West City Springs feed a small ditch system in downtown St. George. This system primarily serves residential customers.

All existing secondary sources and existing infrastructure in Washington County are displayed in **Figure 4-2**.

Existing Infrastructure

Most of the secondary water delivery system is pressurized and interconnected with the exception of the small ditch system in downtown St. George and the Sandburg system mentioned above. The network of distribution lines within the system runs from Gunlock Reservoir to Washington Fields as can be seen in **Figure 4-2**.

As mentioned in **Section 4.1.3.4**, 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. Ivins Reservoir stores some of the reuse water. There are 2 small tanks near Ivins Reservoir on the secondary water distribution system for pump stations. 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. One part of the WCWCD/St. George delivery system extends to the Shivwits Band and Ivins City.

Existing Secondary Customers

The St. George 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. The Shivwitz Band sells secondary water to the Bloomington Country Club and will sell secondary water to the Sun River Golf Course (Barnum 2009).

Several churches, golf courses, parks, and schools are also served by the secondary system. **Figure 4-3** displays the location of the existing customers in the Washington County area. Approximately eight golf courses, ten parks, sixteen schools, six churches and eight subdivisions, an RV park, the St. George WWTP, and the city power yard are all supplied with secondary water.

- **Golf Courses:**
  - Ledges Golf Course
  - Entrada at Snow Canyon Country Club
  - Dixie Red Hills Golf Course
  - Sunbrook Golf Course
  - Southgate Golf Course
  - Bloomington County Club Golf Course
  - St. George Golf Club
  - Green Spring Golf Course
- **Parks:**
  - Canyons Softball Field
  - Wallace B. Mathis Memorial Park
  - Bluff Street Park
  - Brooks Nature Park
  - Worthern Park
  - J.C. Snow Park
  - Tonaquint Park and Cemetery
  - Bloomington Park
  - Fields at Little Valley
  - 2450 East Park

- **Schools:**
  - Snow Canyon Preschool
  - Snow Canyon High School
  - Snow Canyon Middle School
  - Washington County School District
  - Dixie College
  - East Elementary
  - Dixie Middle School
  - Dixie High School
  - Tonaquint Intermediate School
  - Bloomington Hills Elementary
  - Desert Hills High School
  - Sunrise Intermediate School
  - Little Valley Elementary
  - Pine View Middle School
  - Sandstone Elementary
  - Pine View High School
- **Subdivisions:**
  - Lily White
  - Sun Country Meadows South
  - Meadow Creek Estates
  - Terra Cotta
  - Bloomington Hills North
  - Bloomington Hills South
  - Estates at Hidden Valley
  - Bloomington Ranches
- **Churches:**
  - 2 LDS Churches
  - LDS Seminary
  - LDS Tabernacle
  - Temple Square, Temple Apartments
  - Grace Episcopal Church
- **Other:**
  - City Power Yard
  - Temple View RV Park
  - St. George WWTP

Two private ditch companies also provide water in the WCWCD service area. Bloomington Water provides water to residential lots in St. George that back up to the St. George golf course and additional homes southwest of golf course. Cottonwood Irrigation supplies water to Dixie State College.

Figure 4-2 WCWCD Owned and St. George Secondary Sources and Existing Infrastructure

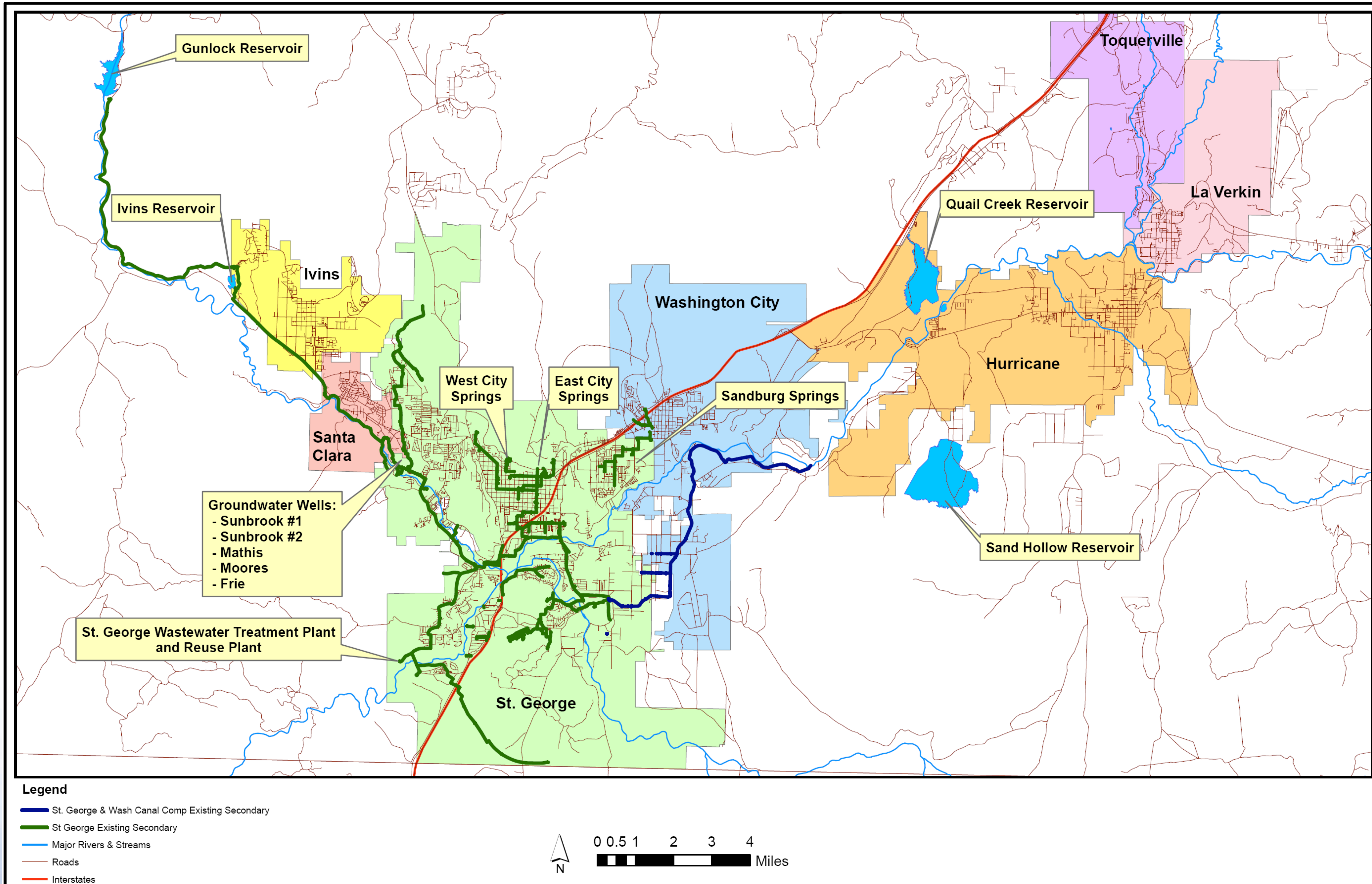

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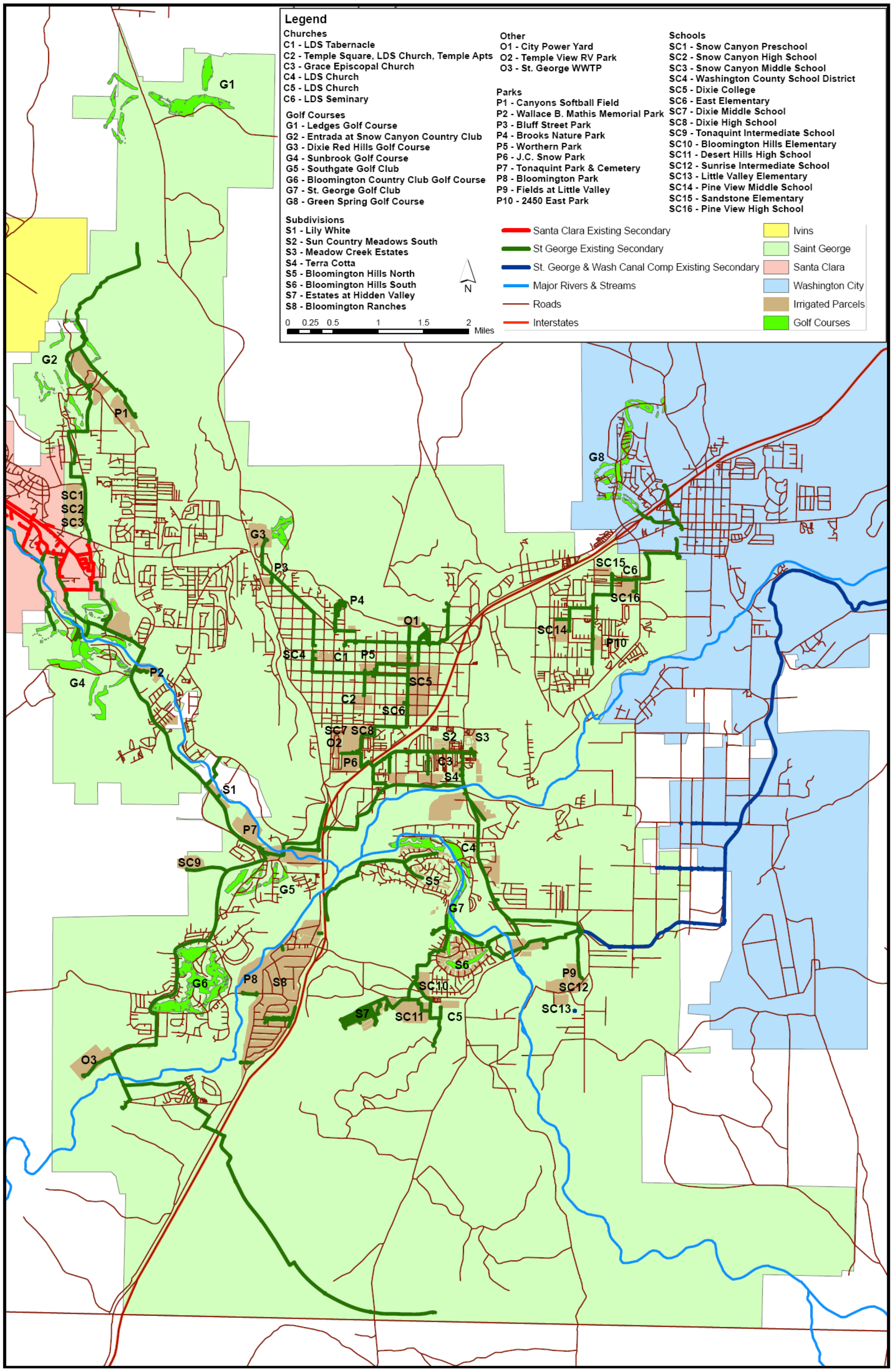
Figure 4-3 WCWCD and St. George Potential Secondary Infrastructure and Customers



Secondary Water Rates

The secondary customers are charged based on a water rate structure. The City mixes the inexpensive supply from Gunlock Reservoir with the more expensive reuse water. Some of the private golf courses have a contract rate. Secondary rates were estimated at about 70 percent of culinary rates, in order to provide motivation for customers to use secondary supply. There have not been any problems with water rights for reuse water since secondary water can be used anywhere within the WCWCD service area.

4.1.4.4 Hurricane City Secondary System

Hurricane City, Hurricane Canal Company and WCWCD are considering piping the existing flood irrigation system to help provide sufficient irrigation flows during years of drought and maximize usage of irrigation water. Contingent upon the flow of the Virgin River, WCWCD has agreed to deliver 12,000 to 15,000 ac-ft of water per year to the Hurricane Canal Company (Alpha 2007b). The existing pressurized irrigation system is currently being fed by the Hurricane City 3 MG reservoir as shown in **Figure 4-4**.

4.1.4.5 Ivins City Secondary System

Ivins City currently does not own an irrigation water distribution system. The Ivins Irrigation Company owns a network of irrigation pipes in disrepair and poor condition within the City. It is not likely the City will take ownership of or maintain the irrigation company's holdings. If Ivins City were to purchase the irrigation company it would only be to acquire additional water rights (Alpha 2006). Ivins City has required new developments to install dry secondary lines for a future secondary system. The existing secondary infrastructure is shown in **Figure 4-5**.

4.1.4.6 La Verkin City Secondary System

In February 2007 La Verkin acquired 2,650 ac-ft of water rights and a secondary water system from the La Verkin Bench Canal Company. The original pressurized irrigation distribution system was installed around 1980 and uses Virgin River water. The existing facilities are being used at or near capacity. It was estimated by the City that there is an excess capacity in water shares and no excess capacity in distribution (Alpha 2007a). The existing secondary infrastructure is shown in **Figure 4-6**.

4.1.4.7 Santa Clara City Secondary System

Santa Clara City does not have its own secondary system. The Santa Clara Canal Company is a private company owned by local property owners with most water rights owned by local farmers. The city owns some water rights and has an agreement to use their system. A park and cemetery are connected to the secondary system. There is an existing secondary system for home owners in the southern portion of the City as can be seen in **Figure 4-7.**

4.1.4.8 Washington City Secondary System

Washington City owns and operates a secondary irrigation system within the "old" section of town north of the Virgin River, which is displayed in **Figure 4-8**. The secondary system is comprised of several subsystems differentiated by irrigation districts, which utilize several different sources of secondary water. The irrigation system infrastructure consists of a network of small, unconnected low pressure ditches, pipes, gates, and valves. If a new pressurized irrigation system is implemented none of the existing infrastructure will be usable. Since the City does not have a pressurized secondary water system a complete new distribution network would have to be constructed.

Figure 4-4 Existing Hurricane Secondary Infrastructure

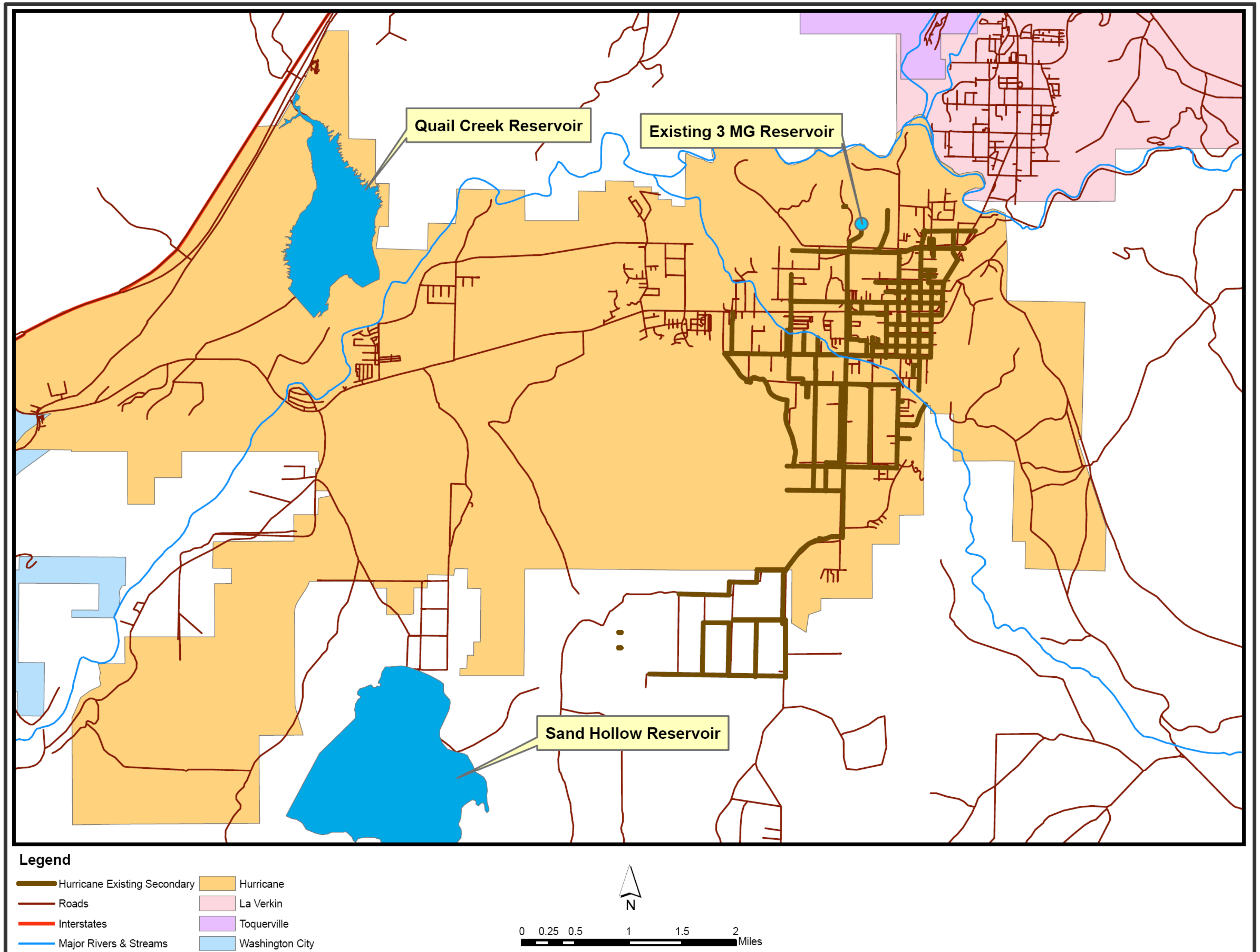


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Figure 4-5 Existing Ivins Secondary Infrastructure

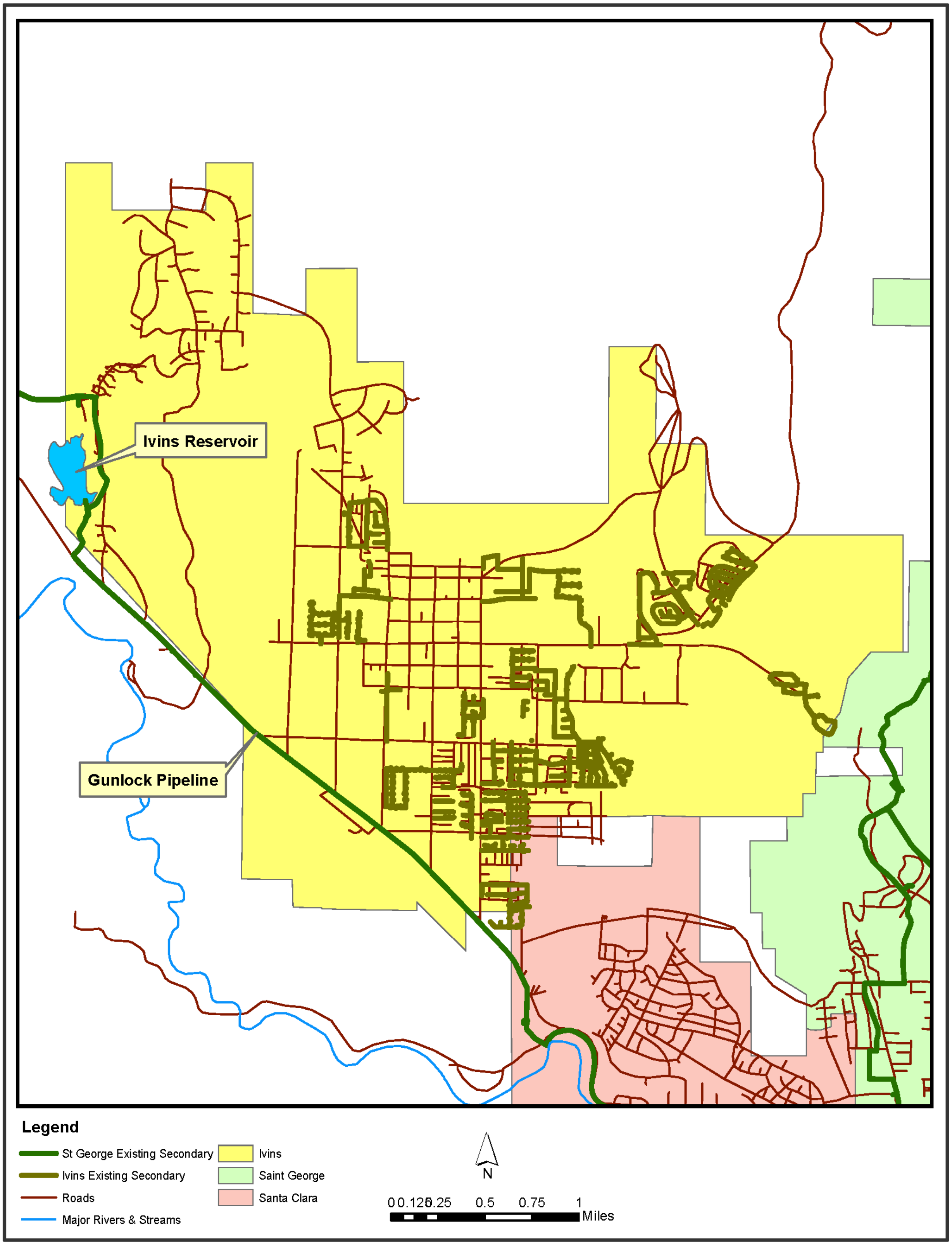


Figure 4-6 Existing La Verkin Secondary Infrastructure

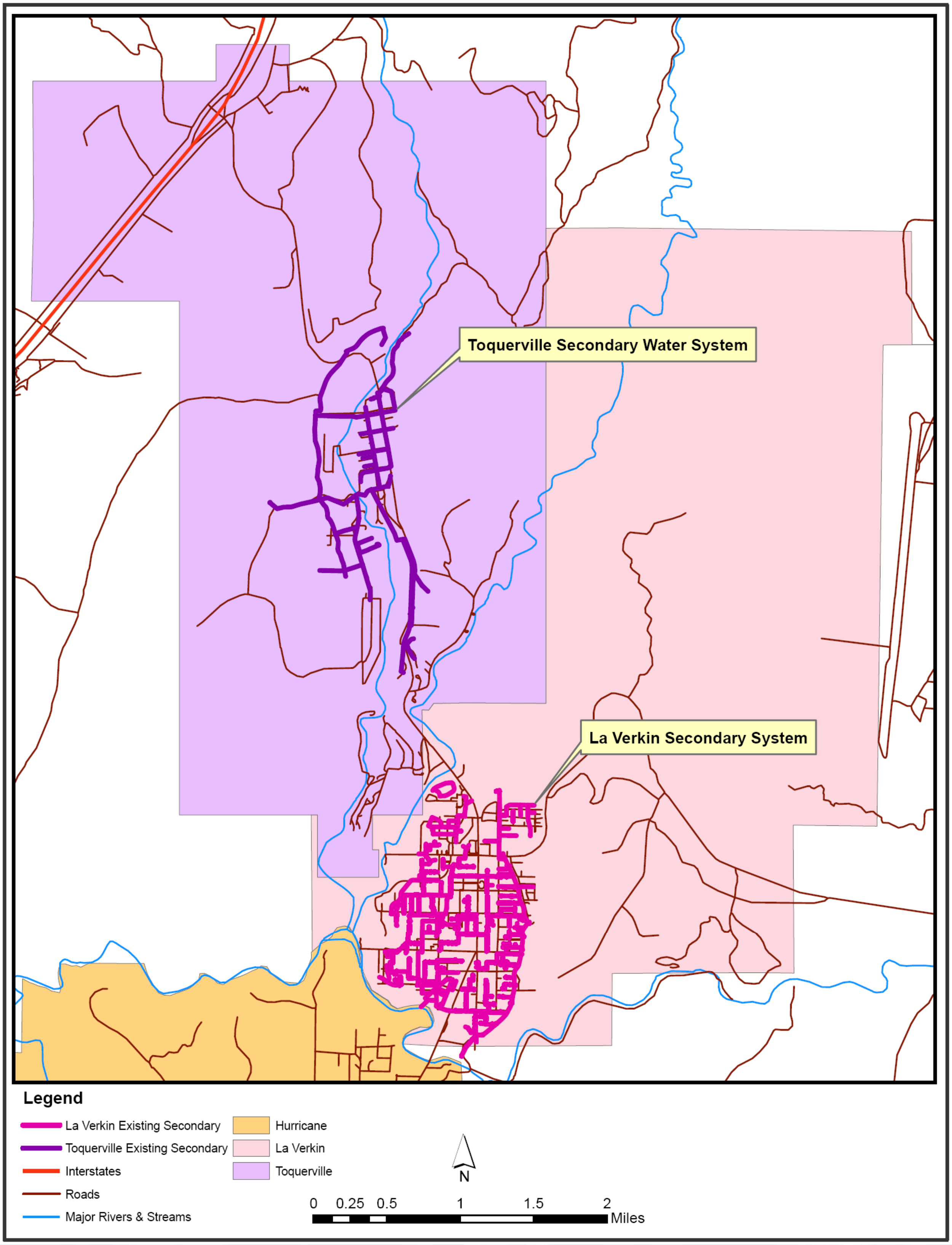


Figure 4-7 Existing Santa Clara Secondary System

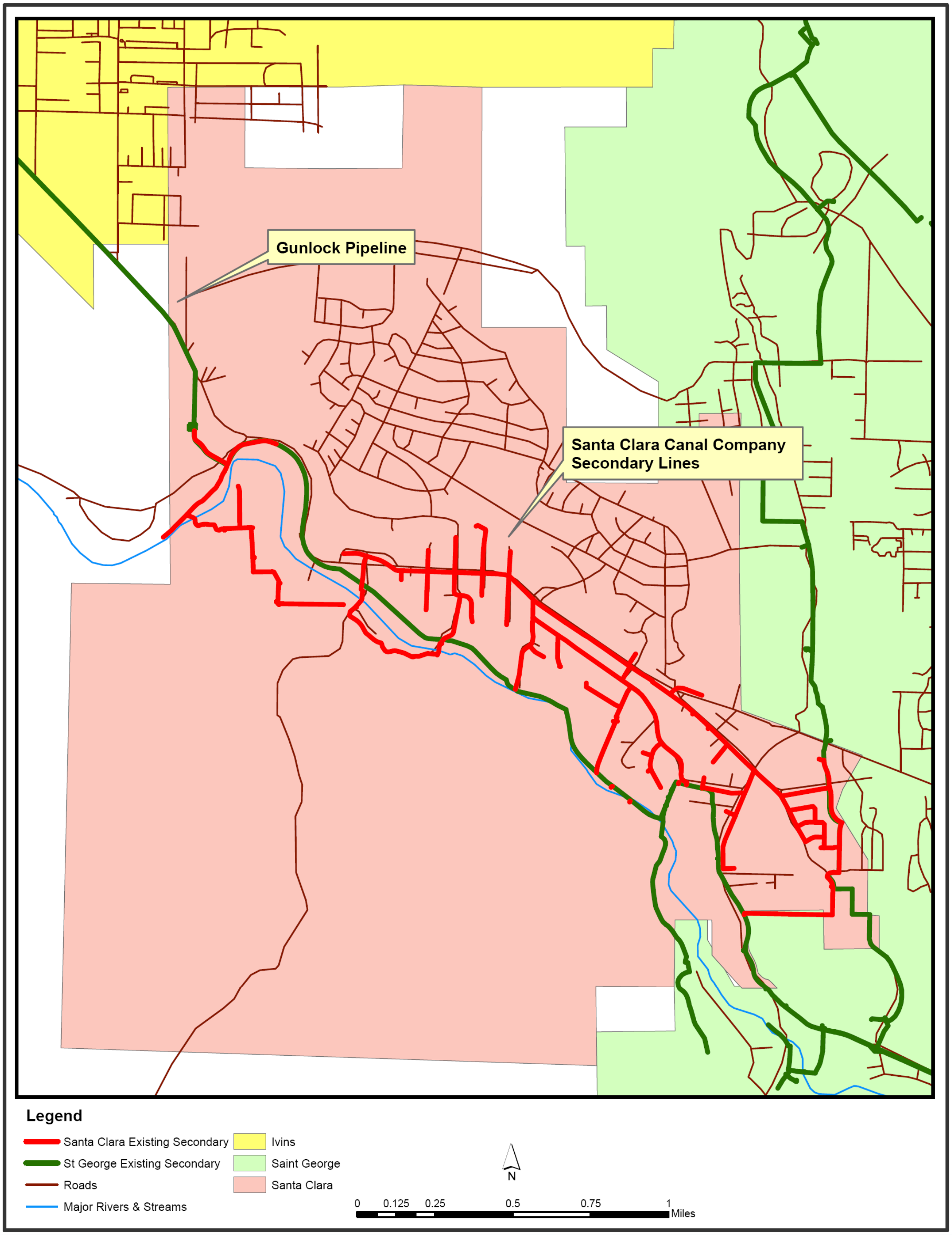
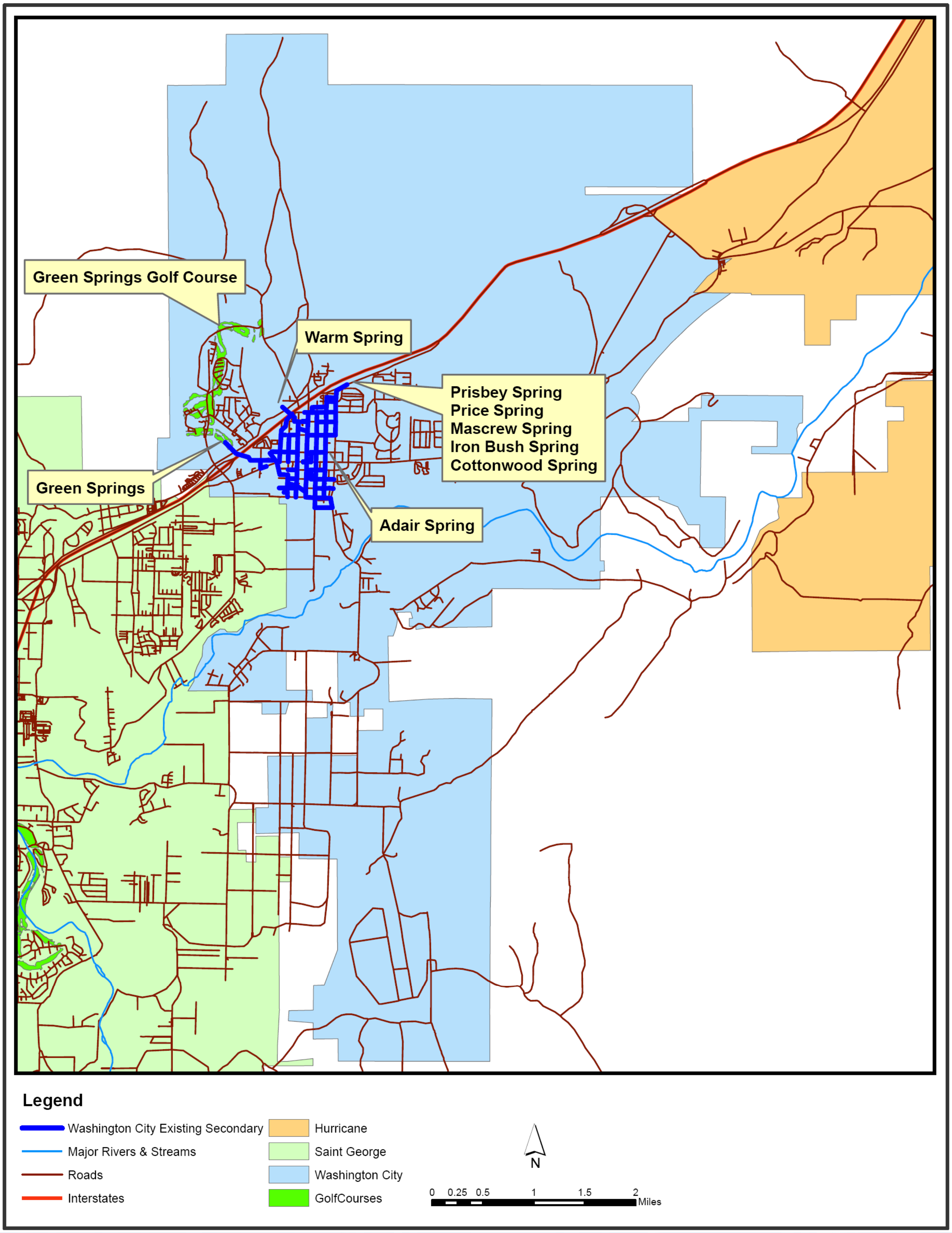


Figure 4-8 Existing Washington City Secondary System



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 4-9** 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/yr, 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 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/yr 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/yr was assumed for the existing yield in **Section 4.1.3.2**.

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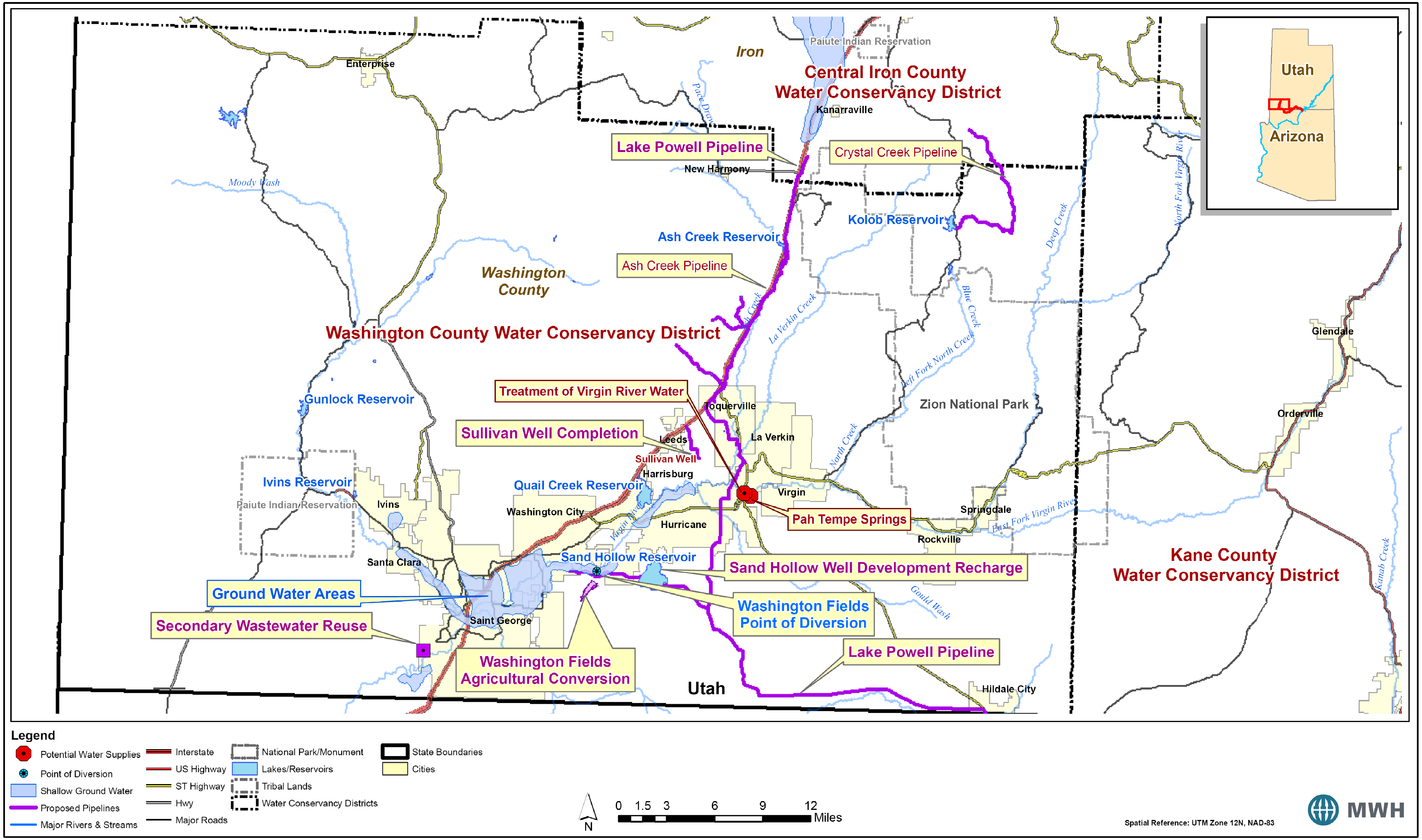
Figure 4-9 WCWCD Existing and Future Water Supplies



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4.1.5.3 Secondary Water Supplies

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). Using the indoor water use projections in **Section 3.4.2** and assuming 76 percent of the WCWCD service area's wastewater would be treated by the St. George WWTP and accounting for a 15 percent loss in the system there would theoretically be approximately 45,100 ac-ft of reuse water available to meet secondary demands in 2060. 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.

Another limitation to the reuse water supply is lack of storage. With limited storage for reuse supplies, if reuse supplies exceed secondary demand, the unused water is lost. Warner Valley Reservoir is proposed to store reuse water, and to store other secondary water including water from the Washington Fields Diversion that will be converted from agricultural use to secondary M&I use. It is estimated that Warner Valley Reservoir would have a storage capacity of about 45,000 ac-ft. Of that 45,000 ac-ft approximately 10,080 ac-ft would be used in 2060 to store secondary water. This would result in 34,900 ac-ft/yr available for storage of reuse water in 2060. Currently WCWCD does not have future planned storage other than Warner Valley Reservoir. Subsequently for this assessment, it was assumed that storage would be the limiting factor in the amount of reuse water that would likely be developed.

Existing reuse supplies are approximately 3,900 ac-ft/yr, which is half of the St. George wastewater reuse plant existing capacity (7,800 ac-ft/yr) due to storage limitations. The reuse treatment plant could be expanded by an additional 3,400 ac-ft/yr up to the capacity of 11,200 ac-ft/yr. The additional 3,400 ac-ft/yr of additional reuse capacity plus half of the existing capacity currently not used (3,900 ac-ft/yr) could potentially be utilized for the first phase of reuse expansion assuming storage would be implemented. This would result in 7,300 ac-ft/yr of additional yield from the maximization of the current St. George reuse plant.

Additional reuse beyond the existing 10 mgd (11,200 ac-ft/yr) reuse plant capacity was limited by the projected storage available for reuse (32,600 ac-ft in Warner Valley Reservoir). Any additional reuse beyond the existing 10 mgd capacity would require new reuse treatment facilities.

Currently reuse water has better water quality (approximately 1,200 ppm TDS) than the Virgin River water (approximately 2,500 ppm TDS) and would actually improve secondary water quality. But over time wastewater reuse has the potential to degrade local surface and ground water quality due to an increase in total dissolved solids and other constituents in the return flows.

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.

4.1.5.4 Potential Secondary Water Systems

WCWCD and the several cities within the WCWCD service area have considered developing secondary systems in their communities to offset culinary water use. The Regional Water Supply Agreement executed by the cities and WCWCD requires the cities to extend secondary water systems into all areas of new development. The following sections discuss the potential for further development of the secondary systems in the Washington County study area.

4.1.5.5 WCWCD and St. George Secondary System

Future Treatment: The St. George reuse treatment plant was designed with three filter bays. Due to funding limitations only two filters were installed. A grant has been requested from the Bureau of Reclamation to install the third filter. If the grant is approved the filter will be installed. If the grant is not approved, then the installation of the third filter will be delayed until funds are available.

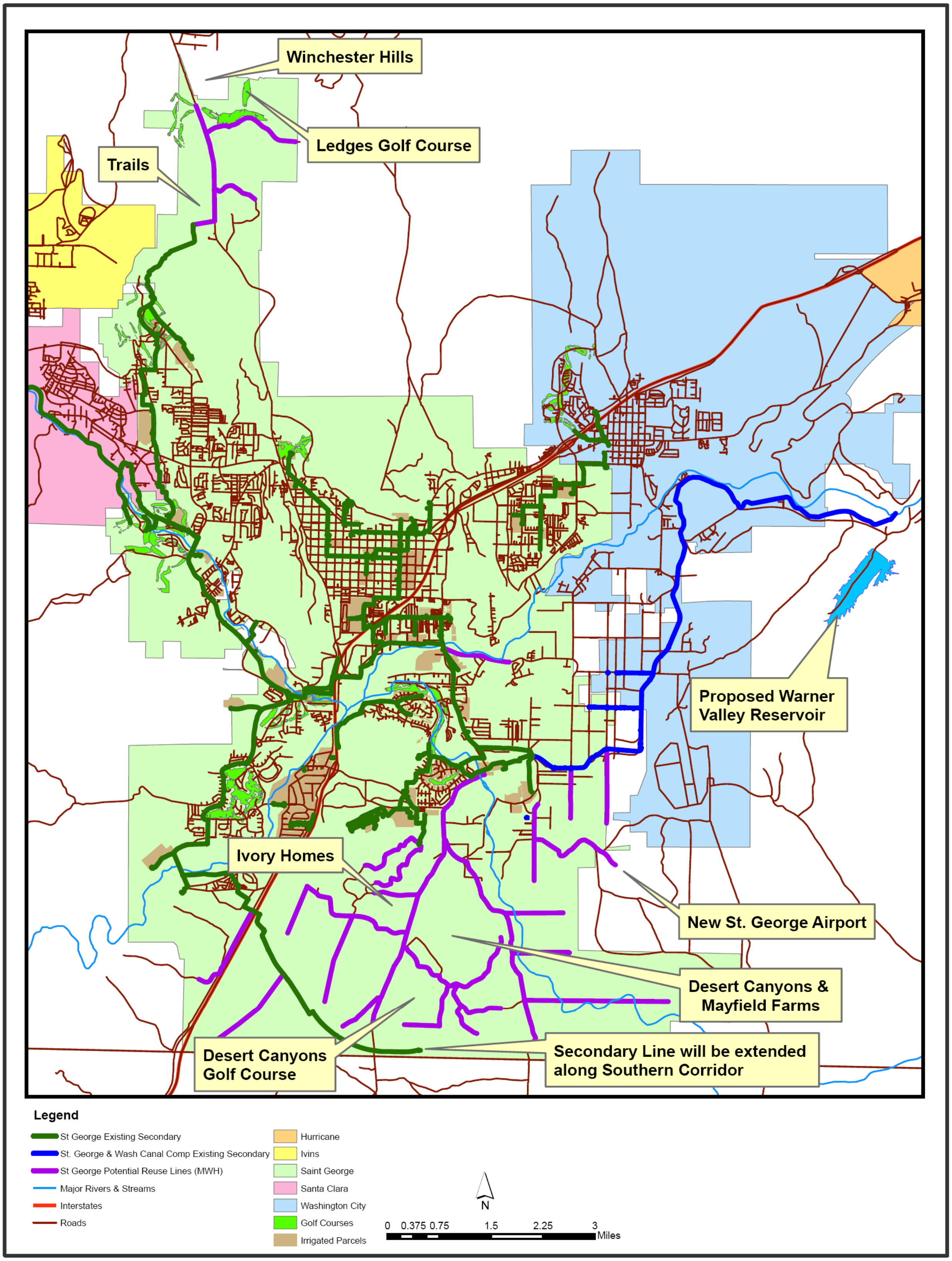
Future Infrastructure: Currently part of the reuse line extends southeast from the treatment plant along the Southern Corridor to the intersection of River Road. As the Southern Corridor is extended to the east, St. George plans to extend the reuse line. In order to provide reuse water east of River Road a pump station must be installed. The timing of the installation will be determined by development in the area to be served but should be within the next three years (Barnum 2008).

The Ledges development has the right to use secondary/reuse water for irrigation of its golf course and common areas. However, the development is obligated to install three pump stations to deliver the water. The City will participate in the upsizing of these pumps. It is anticipated that the pump stations will be installed in approximately five years.

Future reuseable water would be stored in the proposed Warner Valley Reservoir (approximately 45,000 ac-ft total capacity). The Warner Valley Reservoir would be owned by WCWCD and would store water produced from agricultural conversions and reclaimed effluent. Reuse water would have a higher priority since it has better water quality than the Virgin River water. 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.

Since it is probable that future developments will have secondary lines, the locations of future secondary lines were estimated conceptually for this assessment based on areas of potential development, which can be seen in **Figure 4-10**.

Figure 4-10 WCWCD and St. George Potential Secondary Infrastructure and Customers



Future Secondary Customers: Potential/secondary water customers include any future developments. For the past 4 years an ordinance has been pending that will require all new development to have a separate secondary system. It was assumed for this study that this ordinance will be passed by 2020 and that all new development would have separate secondary water supply lines where feasible. Other future developments that could potentially be served by the secondary system are displayed in **Figure 4-4** and listed below:

- **Desert Canyons –** The developers have committed but there is not an ordinance.
- **Desert Canyon Golf Course**
- Mayfield Farms – They have already put in the secondary infrastructure and are financially vested.
- **New St. George City Airport**
- **Ivory Homes –** The developers have agreed to use a secondary system and the area is currently under construction. Existing homes have secondary taps, but no trunk line to connect to yet.
- **Winchester Hills –** Unincorporated area that would like to get secondary water. Since Winchester Hills is in unincorporated Washington County and currently does not have plans to be annexed by St. George it probably wouldn't receive secondary water from St. George.
- **Ledges –** They are expected to use secondary water once the Ledges branch is completed to the north.
- **Trails –** Is near Ledges and is expected to have secondary water once the Ledges branch is completed to the north.
- **Washington Fields –** There is an 18 inch pressurized pipe for new development

4.1.5.6 Hurricane City Potential Secondary System

In August 2007 a Concept Master Plan for the Hurricane Area Pressurized Irrigation System was prepared to assess the feasibility of a pressurized irrigation system in the Hurricane Valley area. The concept master plan evaluated the existing Hurricane Canal Company infrastructure and prepared a proposed secondary system, which is displayed in **Figure 4-11**.

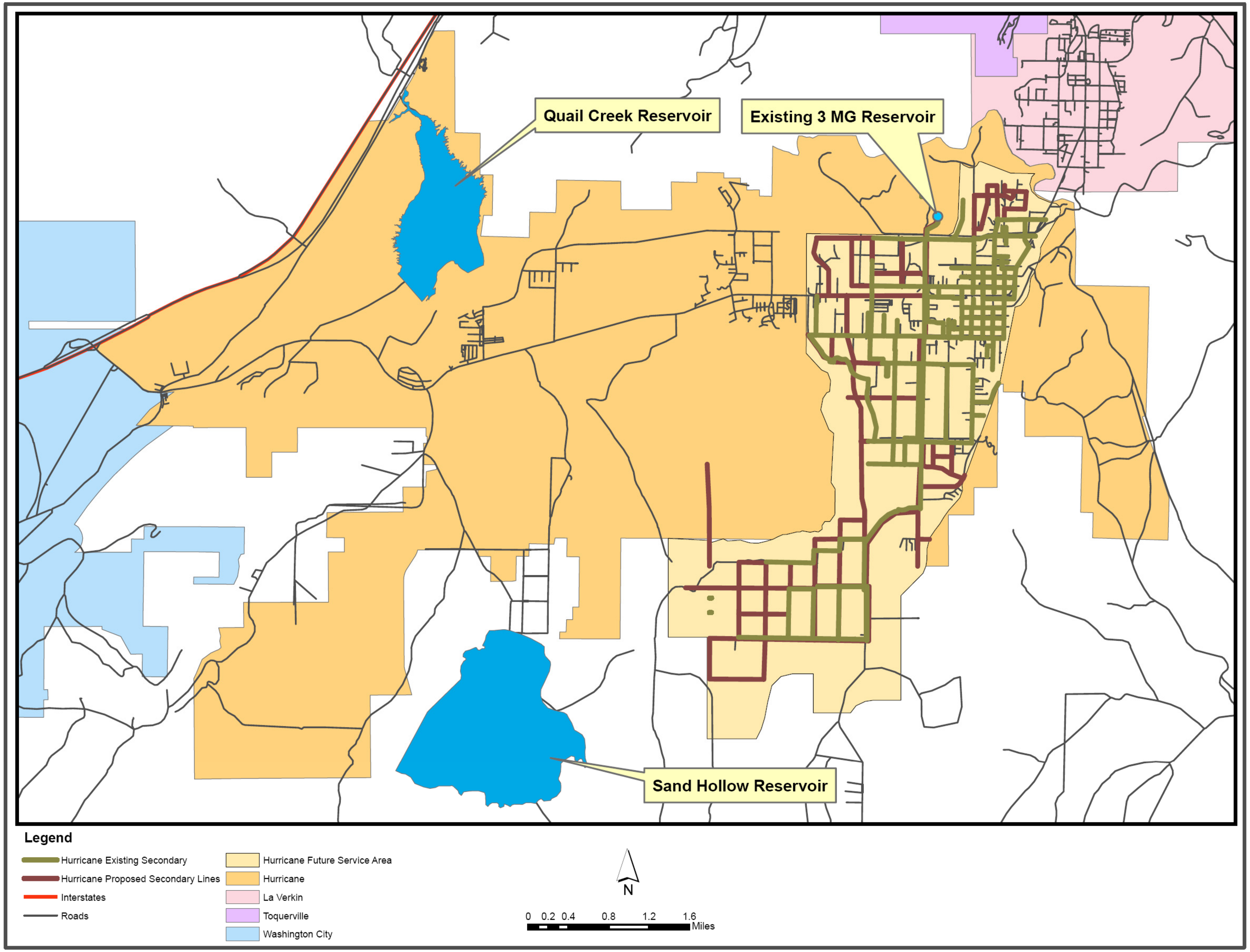
For additional storage it has been proposed to construct another 3 MG reservoir adjacent to the existing reservoir. The secondary piping infrastructure would be comprised of 6" to 24" diameter pipe and sections of existing pipe. It is anticipated that future development would be required to construct irrigation lines to provide secondary irrigation.

4.1.5.7 Ivins City Potential Secondary System

An Irrigation Capital Facilities Plan was prepared for Ivins City in September 2006 (Alpha 2006). The Irrigation CFP addresses water irrigation needs with current and build-out conditions.

Potential Secondary Water Supply Sources: Ivins City currently owns 349 ac-ft of irrigation water shares attributable to the Ivins Irrigation Company, St. George Clara Field Canal Company, and the Santa Clara Field Canal Company. The City anticipates access to additional irrigation water from WCWCD as part of the Water Pooling Agreement. The costs will be passed onto the water users in Ivins City (Alpha 2006).

Figure 4-11 Hurricane Potential Secondary Infrastructure



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Future Infrastructure: Ivins City would need to construct and operate a new irrigation system that would likely tap into the WCWCD/St. George secondary pipeline that runs along Highway 91. There is an existing tap for future use at the intersection of 200 West and Old Highway 91. Secondary water would fill proposed irrigation water tanks.

The City has estimated what irrigation system improvements would be needed in the future and has divided them into three projects:

- **Initial Irrigation Improvements:** Installing a network of irrigation pipe that will provide service to areas that currently have dry irrigation systems installed.
- **Central Ivins Irrigation Improvements:** Extending the irrigation pipe network to areas that do not have a dry irrigation system installed.
- **Future Improvements:** Installation of additional irrigation pipe to the remainder of the city, primarily areas that are currently undeveloped.

Ivins had a preliminary future irrigation system designed and modeled, which is displayed in **Figure 4-12**. The pipe sizes in the system range from 6 inches to 12 inches with pressure-reducing valves to regulate the pressures between zones. In the Master Plan a buildout population of 35,789 was used to design the secondary system. This buildout population would be reached a little after 2040 according to GOPB populations used in this study. Using the City's projected buildout the City will need approximately 146,217 linear feet of irrigation pipe as reported in the Master Plan. This system would eventually need to be expanded to meet the secondary demands in 2060.

4.1.5.8 La Verkin City Potential Secondary System

The City of La Verkin had a Capital Facilities Plan and Development Impact Fee Analysis prepared in March 2007. The CFP discusses the existing secondary water system and future secondary system demands. The CFP prepared a preliminary cost estimate for additional facilities needed currently and at buildout. It was assumed that property owners would supply and install all distribution infrastructure within their respective developments including water lines, pressure reducing valves, valves and fittings (Alpha 2007). The area for future development is 731 acres and is displayed in **Figure 4-13**. The buildout population used in the CFP to analyze the secondary system was 15,570. This buildout population would be reached after 2030 according to GOPB populations used in this study. This system would eventually need to be expanded to meet the secondary demands in 2060.

4.1.5.9 Toquerville City Potential Secondary System

As mentioned in **Section 4.1.3.4**, Toquerville has a secondary system and is currently using approximately a third of its capacity. For this assessment, it was assumed that by 2060 the existing secondary system will be used to full capacity.

Figure 4-12 Ivins Potential Secondary Infrastructure

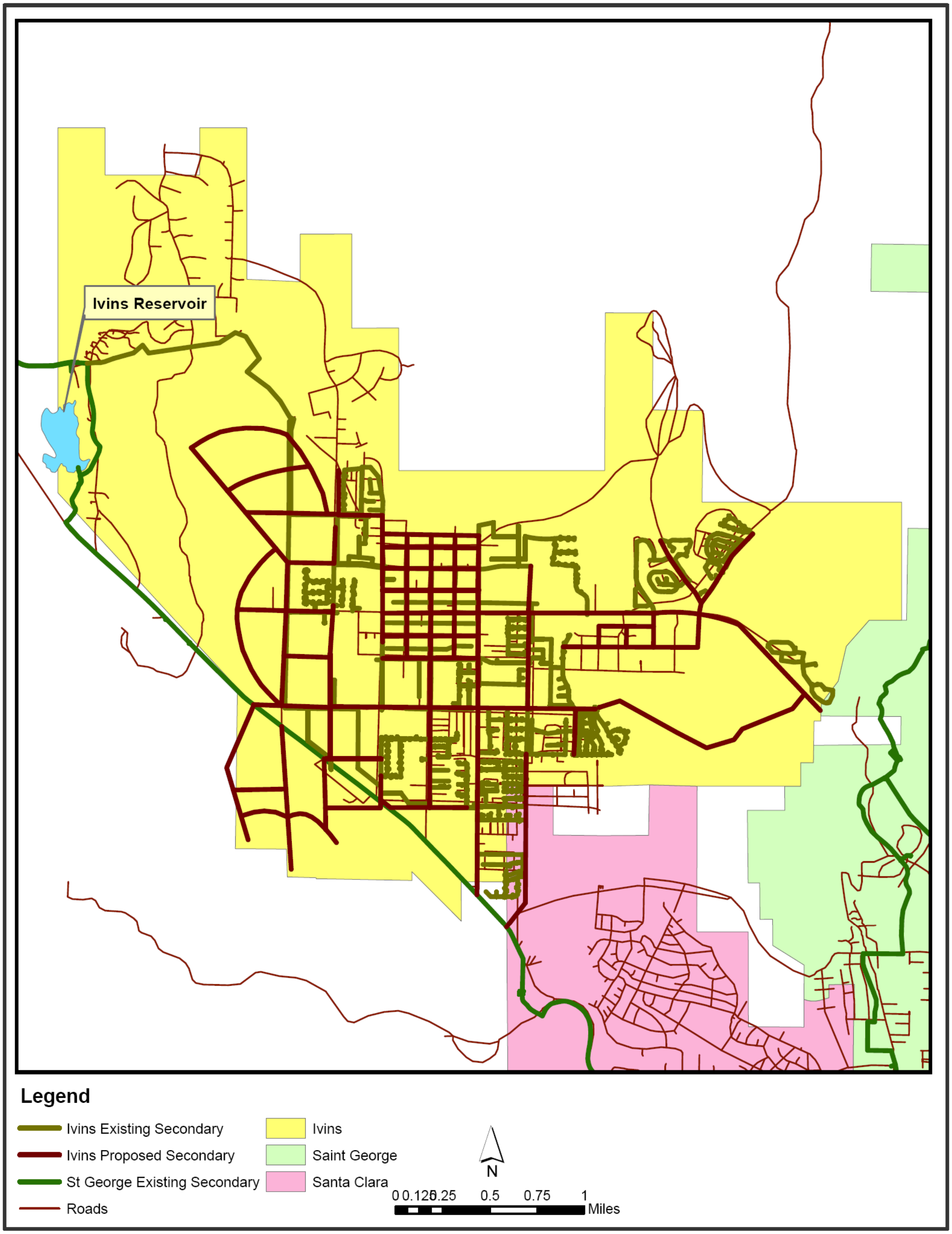
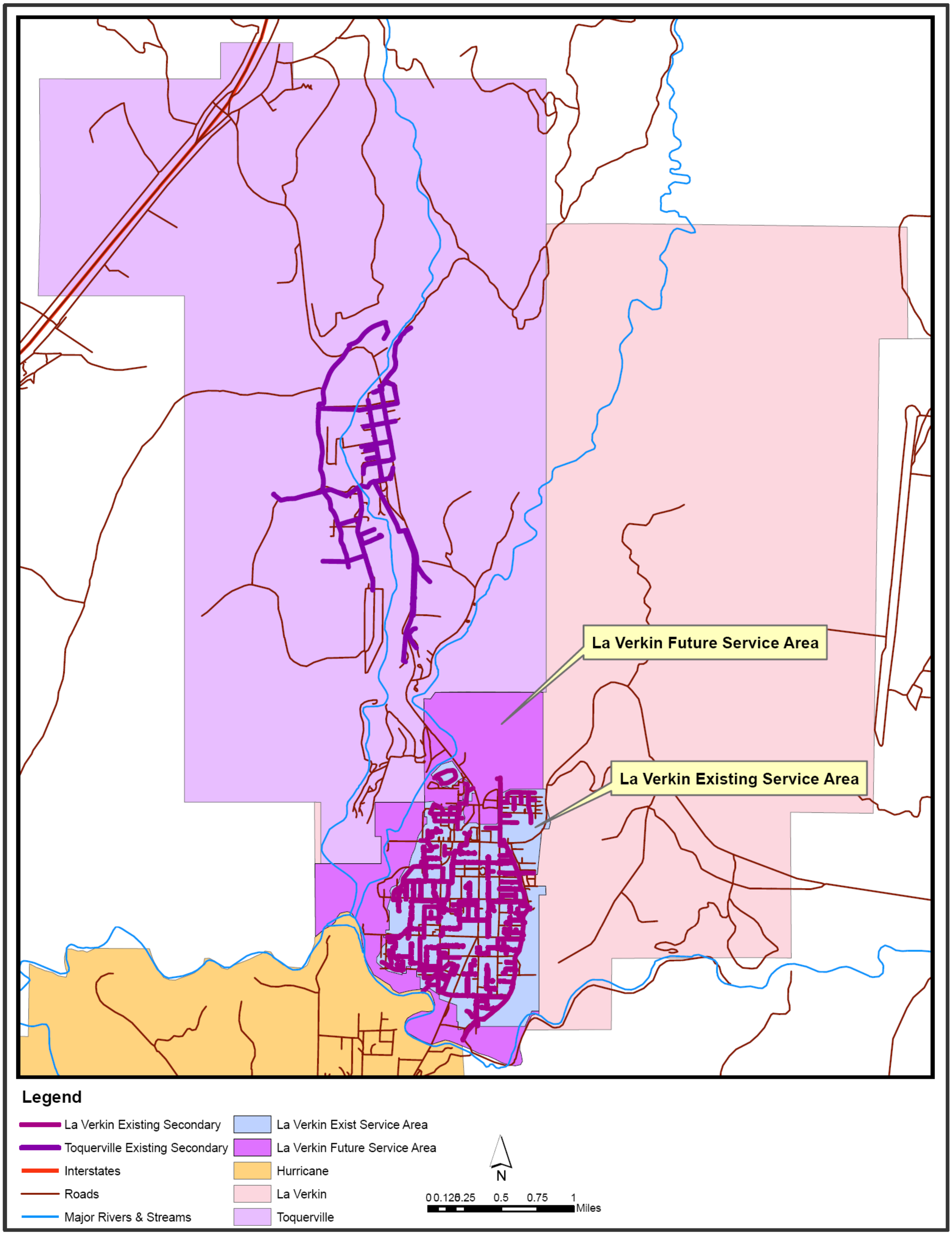


Figure 4-13 La Verkin Potential Secondary Infrastructure



4.1.5.10 Washington City Potential Secondary System

In 2005 Washington City prepared a Secondary Water Master Plan. The master plan discusses existing secondary infrastructure, estimates potential demand through 2025, analyzes the existing pressurized secondary irrigation system, and projects system requirements for future growth. This master plan was prepared before the St. George reuse plant was constructed and therefore may not be representative of Washington City's currently secondary plans. Potential future secondary system infrastructure is shown in **Figure 4-14**.

In the Secondary Water Master Plan Washington City considered water resource recovery facilities (WRRFs) also known as scalping plants in conjunction with their wastewater system improvements. The location for the future water resource recovery facility would be in the industrial park, which is the common collection point for all domestic wastewater north of the river just before it flows into St. George. The reuse water would be directly tied into the pressurized irrigation system and would fill reservoirs that would float online.

Washington City has a secondary water storage facility located east of the city yard with a storage capacity of 250,000 gallons. Since the facility is not located at an elevation that would produce a gravity flow system, the City assumes the current capacity as zero (Sunrise 2005).

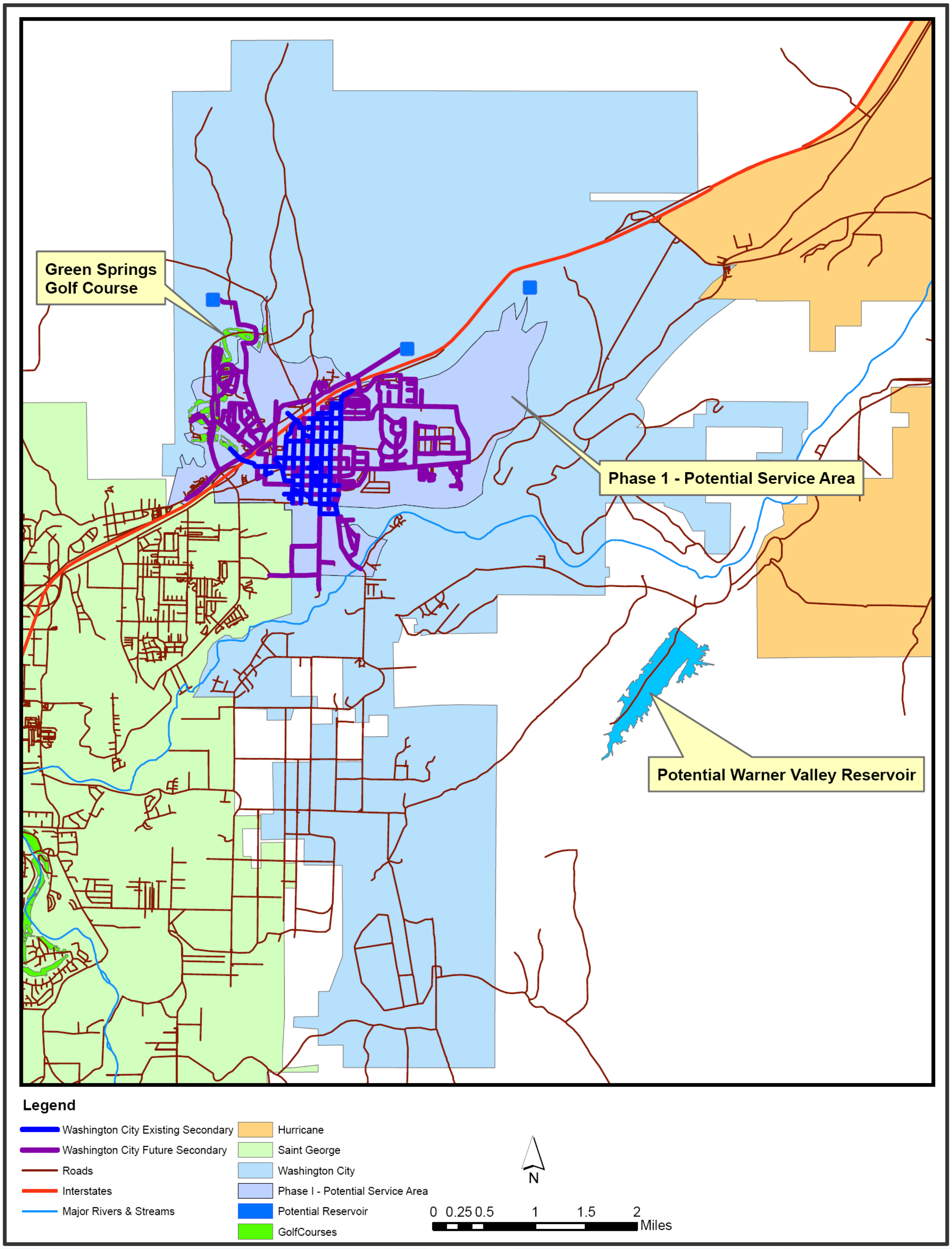
The City owns 2,700 ac-ft/yr of irrigation water rights in which several springs are the water sources as described in **Section 4.1.4.8** (Sunrise 2005). Washington City defined a potential service area for existing secondary sources. It is an area within the old section of town, north of the river, west of the black ridge, and east of Green Springs Drive. In addition to this potential service area in the old section of town the Secondary Water Master Plan identifies an additional 17,000 acres of developable land inside of the proposed annexation boundaries of Washington City. A four-point analysis was conducted for the 17,000 acres of developable land mentioned above. For the majority of the land it was assumed 20 percent of a developed acreage would be irrigated.

Although the Secondary Water Master Plan was completed and discusses the development of a secondary system within Washington City the secondary system is not economically feasible at this time (Shaw 2008). In October 2006 the City adopted an ordinance requiring all new development within the city to provide a network of dry secondary lines (Shaw 2009). Through this ordinance the City is positioning itself to develop secondary water use in the future.

4.1.5.11 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.

Figure 4-14 Washington City Future Infrastructure



The "duty of water" for irrigated agricultural land ranges from 3 to 6 ac-ft/yr per acre of irrigated land (DWRi 2008), and was assumed to be an average of 4.5 ac-ft/yr 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/yr 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 dependent on many factors including strength of the agricultural economy, water demand, growth rate, and location of M&I development within the WCWCD.

Table 4-4 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 4-4**. 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/yr (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).

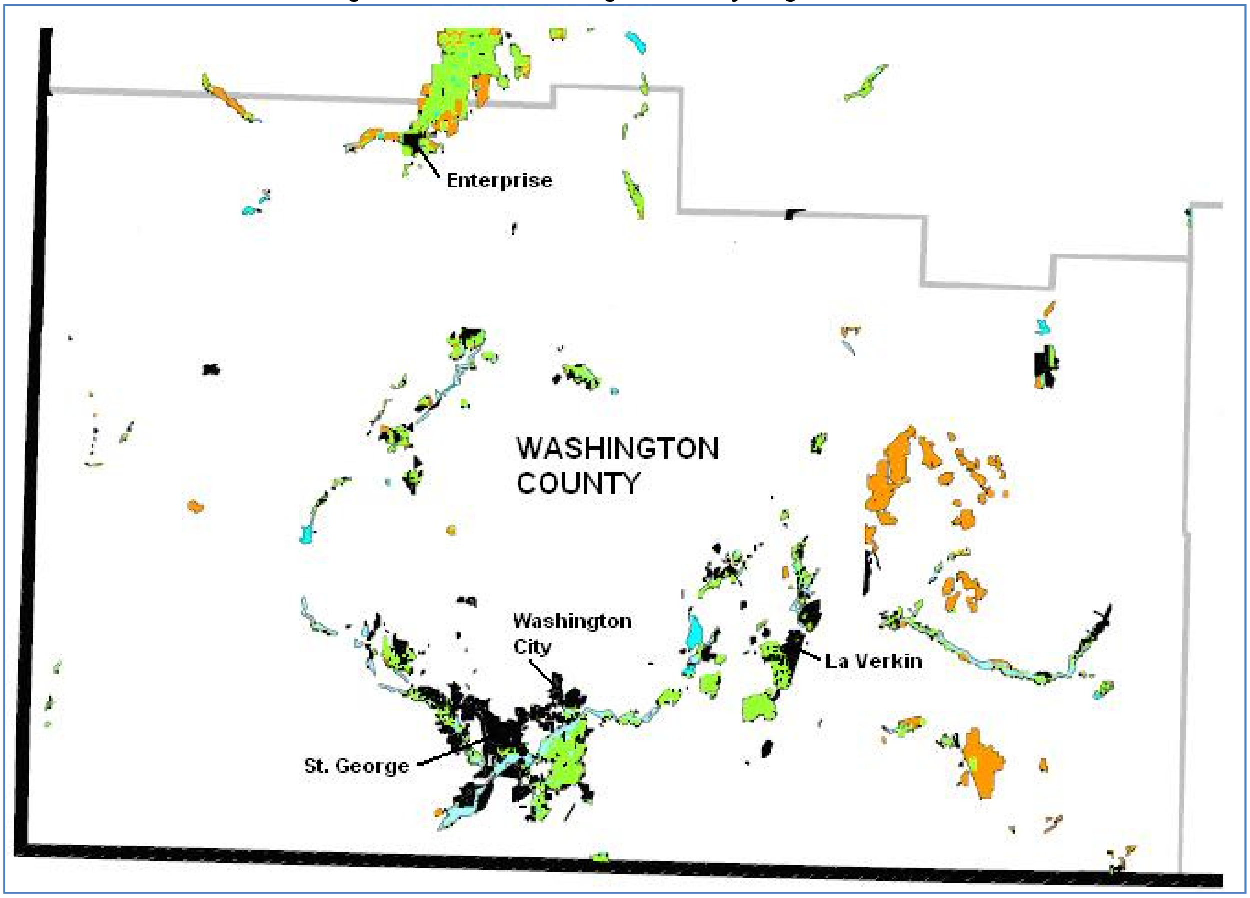
Table 4-4 Etimated Irrigated Agricultural Lands for Washington County

Area	Irrigated Agricultural Land (Acres) Per Year		
	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 4-15 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.

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.

Figure 4-15 Washington County Irrigated Lands



Source: Modified from (DWRe 1999)
Map Color Code: Green = Irrigated Cropland, Orange = Non-Irrigated Cropland, Blue = Water, Black = Urban

DWRe (2011) performed a modeling analysis of the Virgin River basin which included an estimate of the Washington Fields agricultural water that could be converted to M&I use without impacting existing agricultural water users. The study estimated that 12,880 ac-ft/yr could be converted for secondary M&I purposes with a 90 percent reliability. This value includes some existing irrigation supplies that have already been converted. Using the M&I Water Use Report data for existing secondary water supplies, it was estimated that about 2,800 ac-ft/yr of Washington Fields was included in the 12,880 ac-ft/yr value. Thus the remaining irrigation water available for conversion to secondary M&I use is about 10,080 ac-ft/yr.

In the future, water from agricultural conversions made at the Washington Fields area could be stored in proposed 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 two parts untreated Lake Powell water and one 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 because of environmental, technical, and economic feasibility issues. In particular, this would be very expensive water to use of purposes of urban landscape irrigation. 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 would be 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/yr of the total 13,290 ac-ft/yr 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

4.1.5.12 Additional Conveyance 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.

4.1.5.13 *Warner Valley Reservoir*

WCWCD has plans to construct Warner Valley Reservoir as a storage vessel for regional secondary water supplies. Although the site has been selected, the final capacity will be determined after further analysis. A capacity of 45,000 ac-ft has been assumed based on previous planning work by WCWCD. WCWCD plans to fill the reservoir with Virgin River water diverted at the Washington Fields Diversion and reclaimed water from the St. George reuse plant. Water from the reservoir would be delivered to secondary water distribution systems in Washington County. The purposes of the reservoir are to: (1) firm the yields from Virgin River diversions which can be made only during the short part of the year when high flows are occurring; and (2) facilitate use of reclaimed water, which is generated year-round, throughout the urban landscaping irrigation season. Warner Valley Reservoir is planned for construction in the 2017-2020 timeframe, and would probably be prior to completion of the LPP. The reservoir project has not been through the design or environmental permitting processes.

4.1.5.14 *Lake Powell Pipeline*

WCWCD has requested the delivery of 69,000 ac-ft of water per year from the LPP project. In order for the WCWCD to fully develop the 69,000 ac-ft they will need to utilize existing storage facilities or 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 their potential technical and environmental challenges, 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/yr. 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 4-16**. Streamflow exceedance information for the same location and period of record is summarized in **Table 4-5** and **Figure 4-16**, which shows the frequency of various streamflow values. For example, **Table 4-5** and **Figure 4-17** 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 4-5 Virgin River below Washington Fields – Percent Exceedance for Daily Streamflow, 1940-2006 (DWRe 2008)

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 4-16 Daily Streamflow for Virgin River below Washington Fields (DWRe 2008)

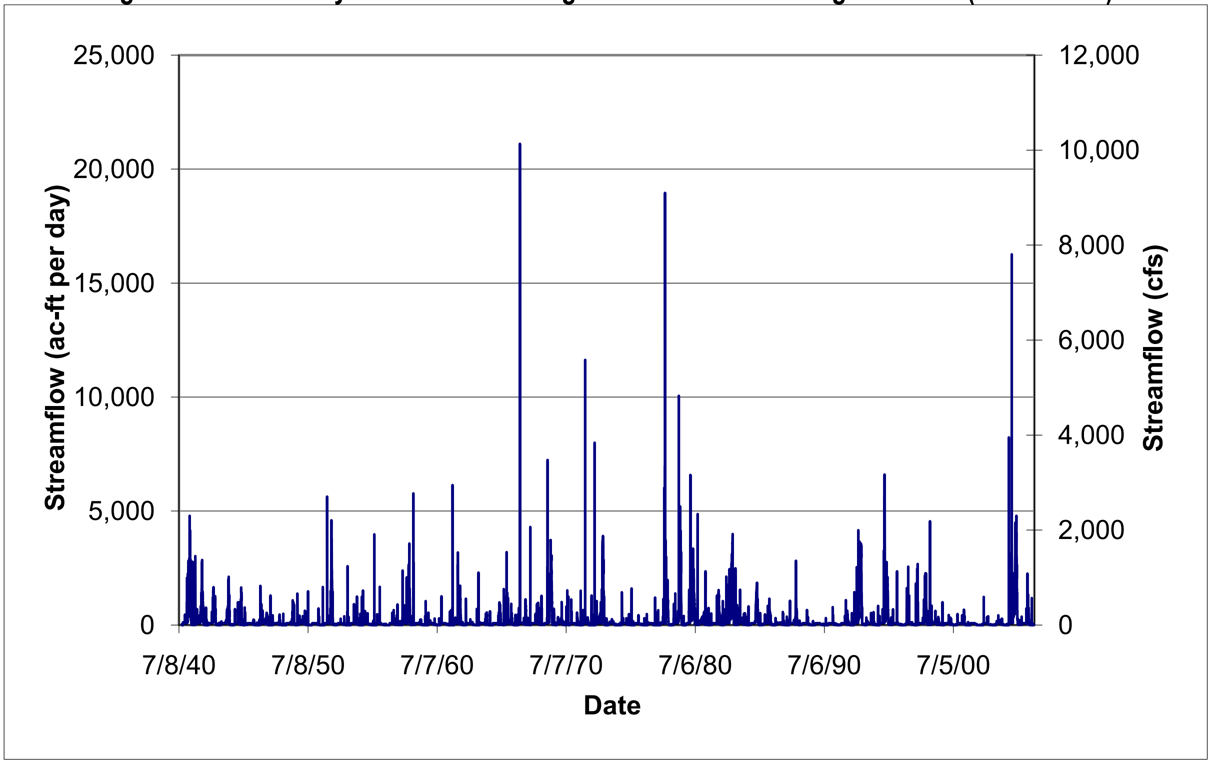
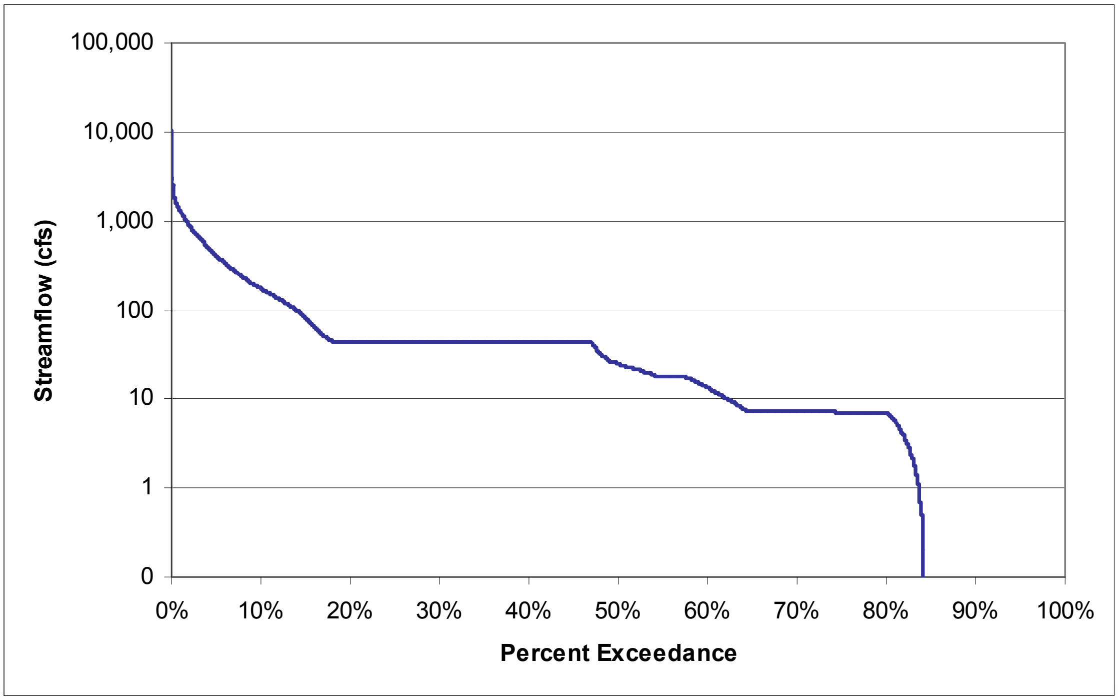


Figure 4-17 Virgin River below Washington Fields Flow Exceedance Curve (DWRe 2008b)



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 4.1.5.11**, 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 be feasible only as the last source of supply when all other options are exhausted, and only subject to availability of storage in Warner Valley Reservoir. 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 challenging.

4.1.6.2 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 2009b). 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 2009b), 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/yr, 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 4-6 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 4-6 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(1)	3,830	0
Maximize Existing Wastewater Reuse(2)	0	7,300
Agricultural Conversion from Development(3)	0	10,080
Lake Powell Pipeline	69,000	0
Potential Future Wastewater Reuse(4)	0	27,620
Total Potential Yield from Future Projects	72,830	45,000

(1) Ash Creek Pipeline yields 3,830 ac-ft/yr based on a 90% reliability level.
(2)The maximum capacity of the existing reuse treatment plant is 7,800 ac-ft/yr, but this supply can only be used to meet secondary demands during the irrigation season (April through October) and currently there is no storage capacity resulting in the loss of any supplies that are not used by the end of a given month. Thus the usable supply is 50% of the plant capacity, or 3,900 ac-ft/yr. It was assumed that storage facilities would be implemented and the reuse plant would be run at full capacity of 11,200 ac-ft/yr. Therefore an additional 7,300 ac-ft/yr could be developed.
(3)The estimated supply is 12,880 ac-ft/yr with 90% reliability (DWRe 2011). However, it was estimated that approximately 2,800 ac-ft/yr of this supply is currently in use and has been accounted for in the 7,450 ac-ft/yr of reliable secondary supply.
(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). However, the amount of this potential reuse that could actually be used as secondary supply would be limited by demand and storage constraints. It is assumed that the proposed Warner Valley Reservoir (45,000 ac-ft/yr) would provide storage for additional reuse water and water from the agricultural conversion from development. As a result there would be approximately 27,620 ac-ft/yr of storage available for all future reuse water supplies.

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.

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 4-18**.

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 4-7** 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 4-18 CICWCD Existing Water Supplies

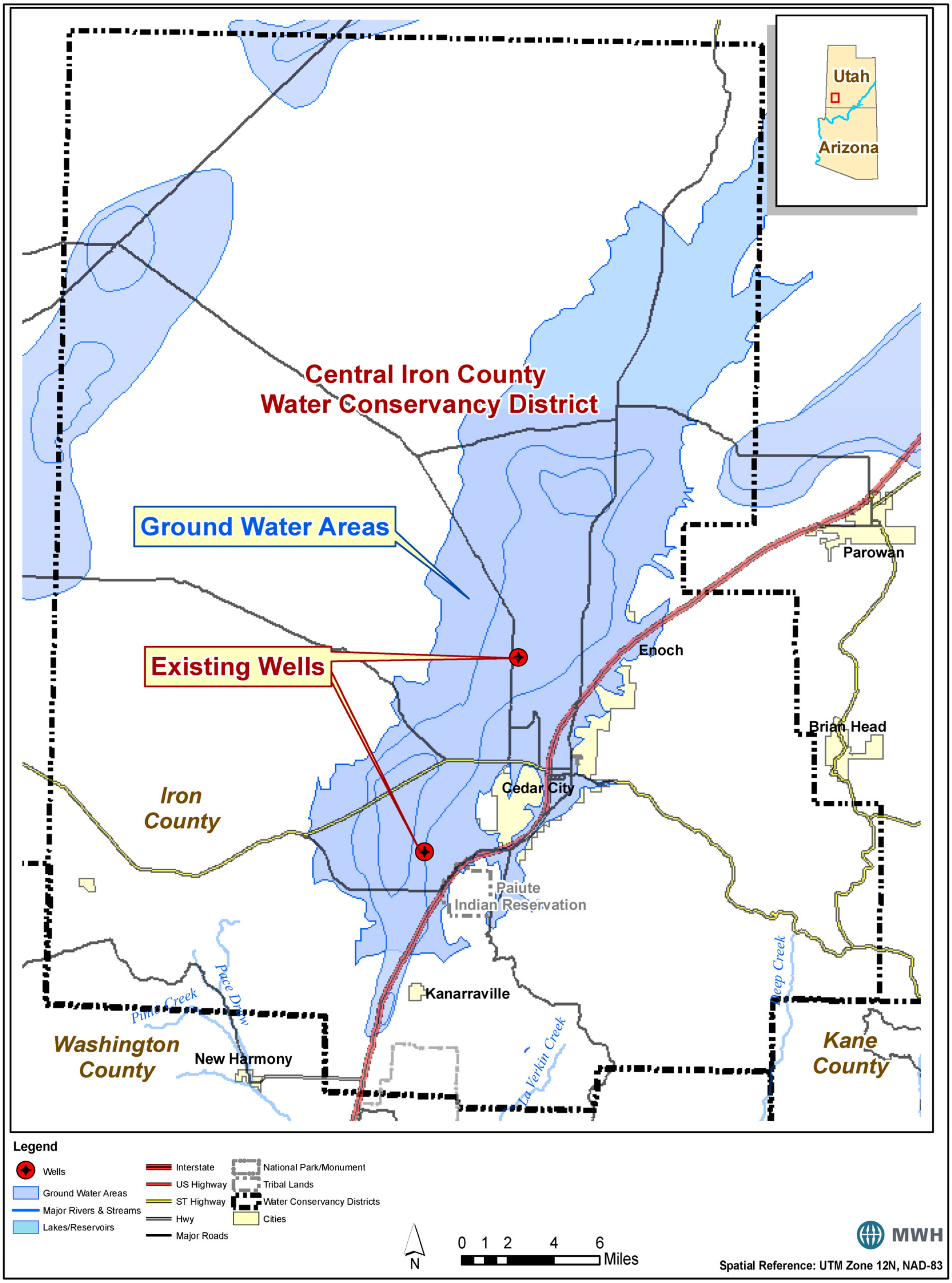


Table 4-7 Existing and Proposed CICWCD Water Rights for Source Development

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.

4.2.3.1 Existing Potable Water Systems

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 2009b). **Table 4-8** 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 the CICWCD portion of Iron County, total reliable potable water supplies are 11,360 ac-ft/yr (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 2009b).

4.2.3.2 Existing Secondary Water Systems

Secondary water use in the CICWCD portion of Iron County 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 (DWRe 2007a; DWRe 2009b). 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, in which secondary M&I water is supplied to some parts of the city using a pressurized irrigation system.

4.2.3.2.1 Cedar City

In the Draft Water System Master Plan Update for Cedar City, UT Brown and Caldwell evaluated Cedar City's secondary water system and assessed the feasibility of implementing a pressurized secondary irrigation system. For the evaluation, the existing irrigation system facilities were reviewed, two improvement alternatives were assessed, and a secondary water supply from a wastewater scalping plant was considered.

Cedar City Wastewater Treatment Plant

The Cedar City Regional Wastewater Treatment Facility serves Cedar City, Enoch City, and the surrounding communities. It was constructed in 1996 and is located approximately 8 miles northwest of Cedar City. The treatment plant performs secondary treatment utilizing a nitrifying trickling filter process, which provides biological treatment of BOD and partial treatment of nitrogen. The treated effluent is applied to 640 acre land application site owned by a local farmer (Dupont 2008).

Existing Secondary System

The Cedar City secondary irrigation system is comprised of a single transmission main, two supply wells, and a booster station. The transmission main is 12-inches in diameter and runs parallel to I-15 from the existing pump station at the old wastewater treatment plant site at the northern end of the City to the storage reservoir at the southern end of the City (**Figure 4-19**). There are also two smaller pipelines that branch off the main pipeline (6-inch and 10-inch diameter).

There are two existing water storage facilities. The Leigh Hill Reservoir is an existing storage reservoir at the southern end of the City. It has been reconstructed and has a capacity of approximately 100 ac-ft. The second storage facility is a pond owned by Cedar Ridge Golf Course with a storage volume of approximately 4.6 ac-ft.

Existing Secondary Sources

Two wells provide water for the existing secondary irrigation system, the Cemetery Well and the Northfield Well. The Cemetery Well is located near the southwestern corner of the cemetery and has a maximum production capacity of 1,400 gpm. The Northfield Well is located north of the City and has a maximum production capacity of 900 gpm. The Cedar Ridge Golf Course uses water from the Cemetery Well. Both sources can provide water to Leigh Hill Reservoir.

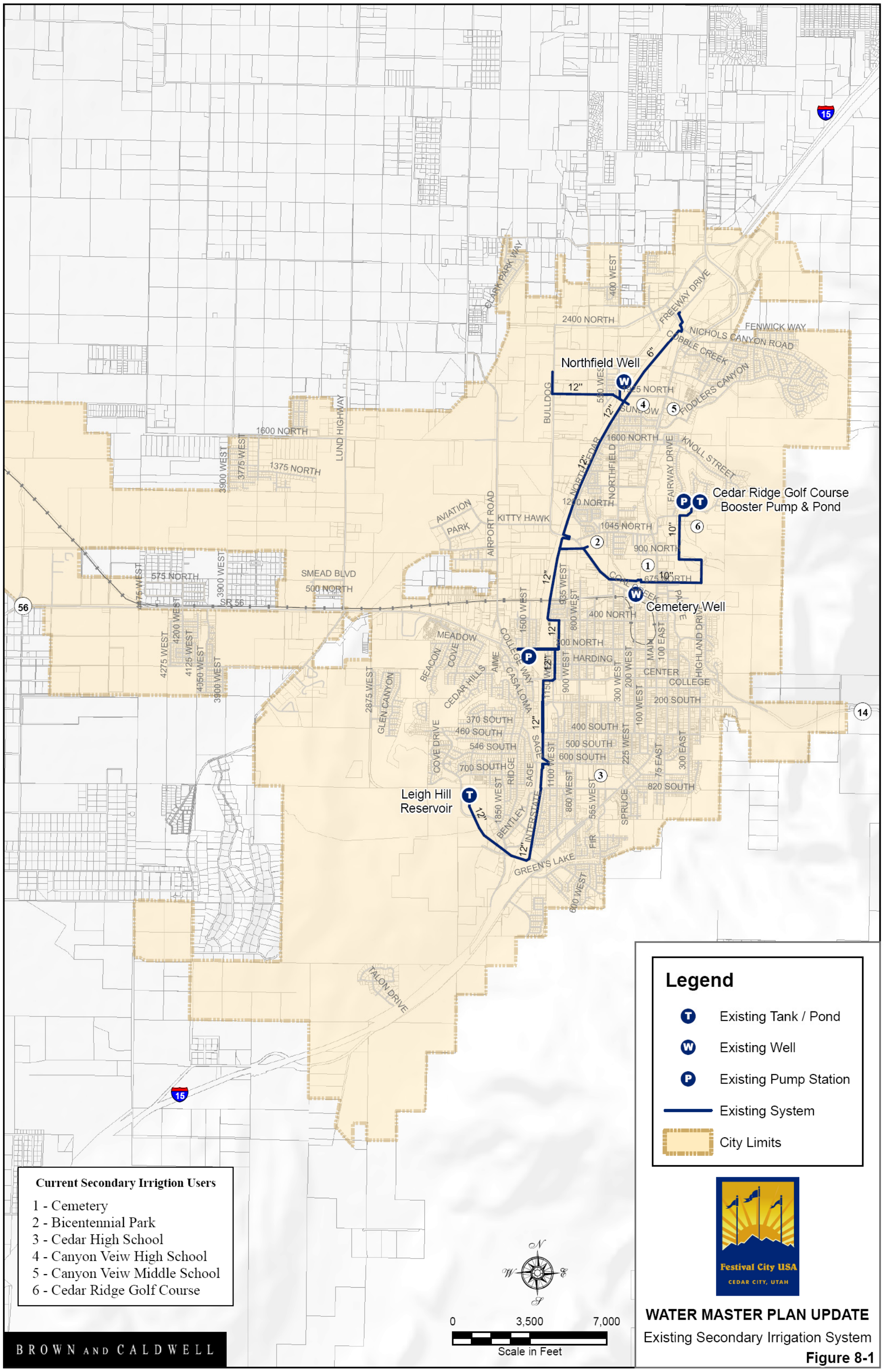
Cedar City also has water rights for surface water from Coal Creek that could be used for irrigation purposes. The City owns shares in five irrigation companies that are supplied by Coal Creek.

Existing Secondary Customers

Based on Cedar City's water production records, in 2007 the Cemetery Well produced 452 ac-ft while the Northfield Well produced 247 ac-ft. The water was supplied to six customers:

- The Cemetery
- Cedar Ridge Golf Course
- Bicentennial Park softball and soccer fields
- Canyon View High School
- Canyon View Middle School
- Cedar City High School

Figure 4-19 Cedar City Secondary Irrigation System



The Southern Utah University is connected to the system now that Leigh Hill Reservoir is complete and will begin using the secondary water. The amount of water use at each site in 2007 is listed in **Table 4-8** below.

Table 4-8 Cedar City Secondary Irrigation Use in 2007

Location	Net Area Served (ac)	Average Yearly Use (ac-ft)
Cemetery and Bicentennial Ball Fields	50	140.2
Golf Course (including Pond)	150	381.2
Cedar High School	65	95.1
Canyon View High School and Canyon View Middle School	40	82.3
Total	**305**	**698.8**

Note:
Values taken from Cedar City Corporation Annual Water Report from 2007. Number may be slightly reduced since they do not include water discharged into Coal Creek.

4.2.3.2.2 Enoch City

The Enoch City Water Master Plan discusses the current secondary system, and plans to expand the secondary system (Nolte 2007). Enoch City has a secondary system that provides service to 169 connections, which serve approximately 66 acres. The City is able to meet the secondary water demands with its current secondary sources and water rights. It does however need to develop additional storage requirements.

The City is currently drilling another well to add to the secondary system. The well is expected to produce 400 gpm. **Figure 4-20** shows the layout of the existing secondary system.

Figure 4-20 Enoch City Secondary System

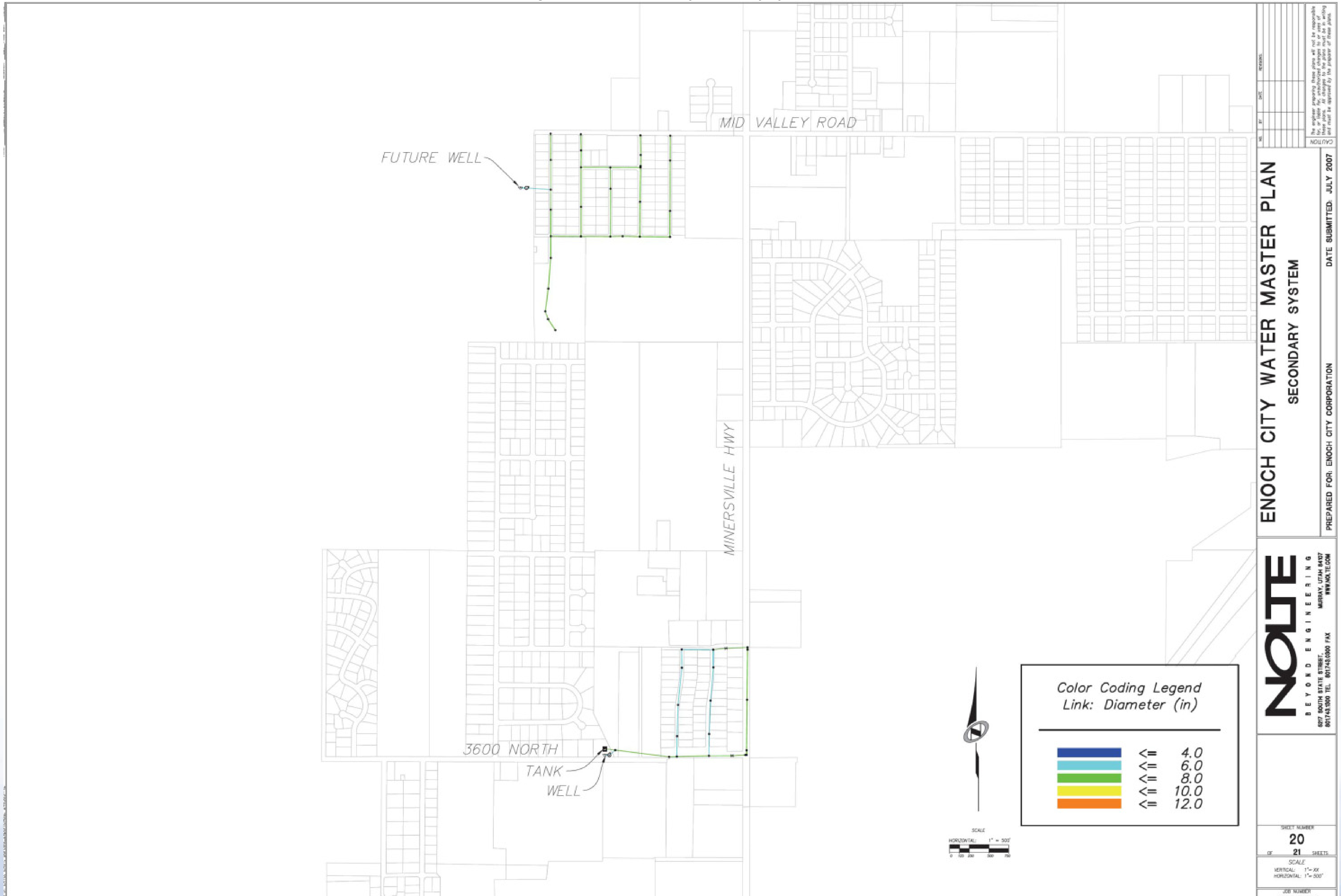


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Table 4-9 Reliable Potable Water Supplies – Iron County

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) and DWRe, 2009b (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/yr) but is lower than the highest estimate of annual basin recharge (42,000 ac-ft/yr). The 37,600 ac-ft/yr 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/yr 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/yr of potable water use plus 800 ac-ft/yr of secondary use) (DWRe 2007a, DWRe 2009b). 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 is 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/yr strictly on the basis of water right seniority, municipal entities would be affected. **Table 4-10** 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 4-10 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[1, 2] (ac-ft)	Water Rights Curtailed by Seniority[3] (ac-ft)	Water Rights after Curtailment in 2005[3] (ac-ft)
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/yr.

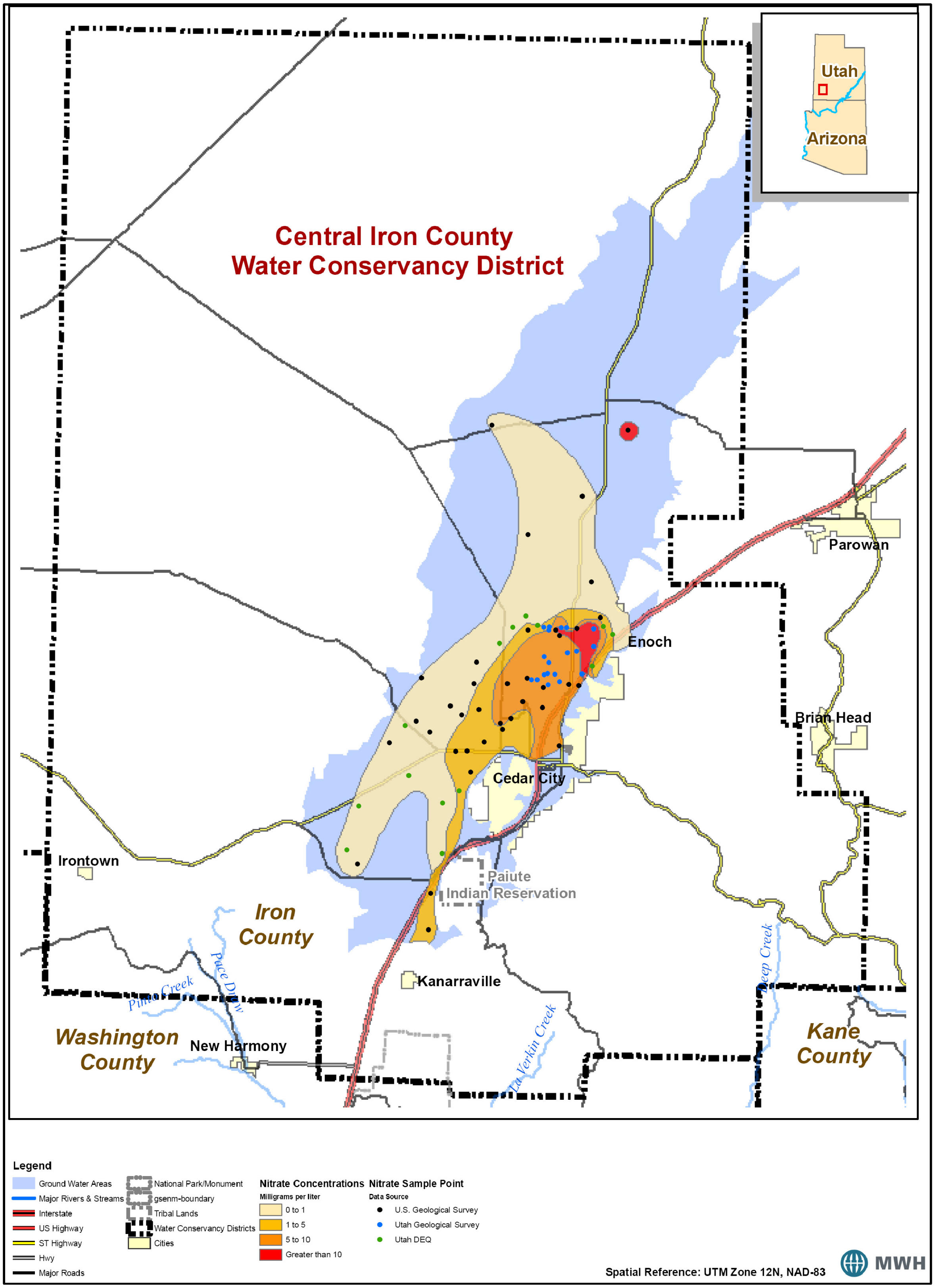
4.2.4.2 Cedar Valley Aquifer Water Quality Considerations

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 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 4-21** shows the spatial distribution for nitrate during the sampling period.

Figure 4-21 Iron County Nitrate Concentrations (USGS 2005)



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.

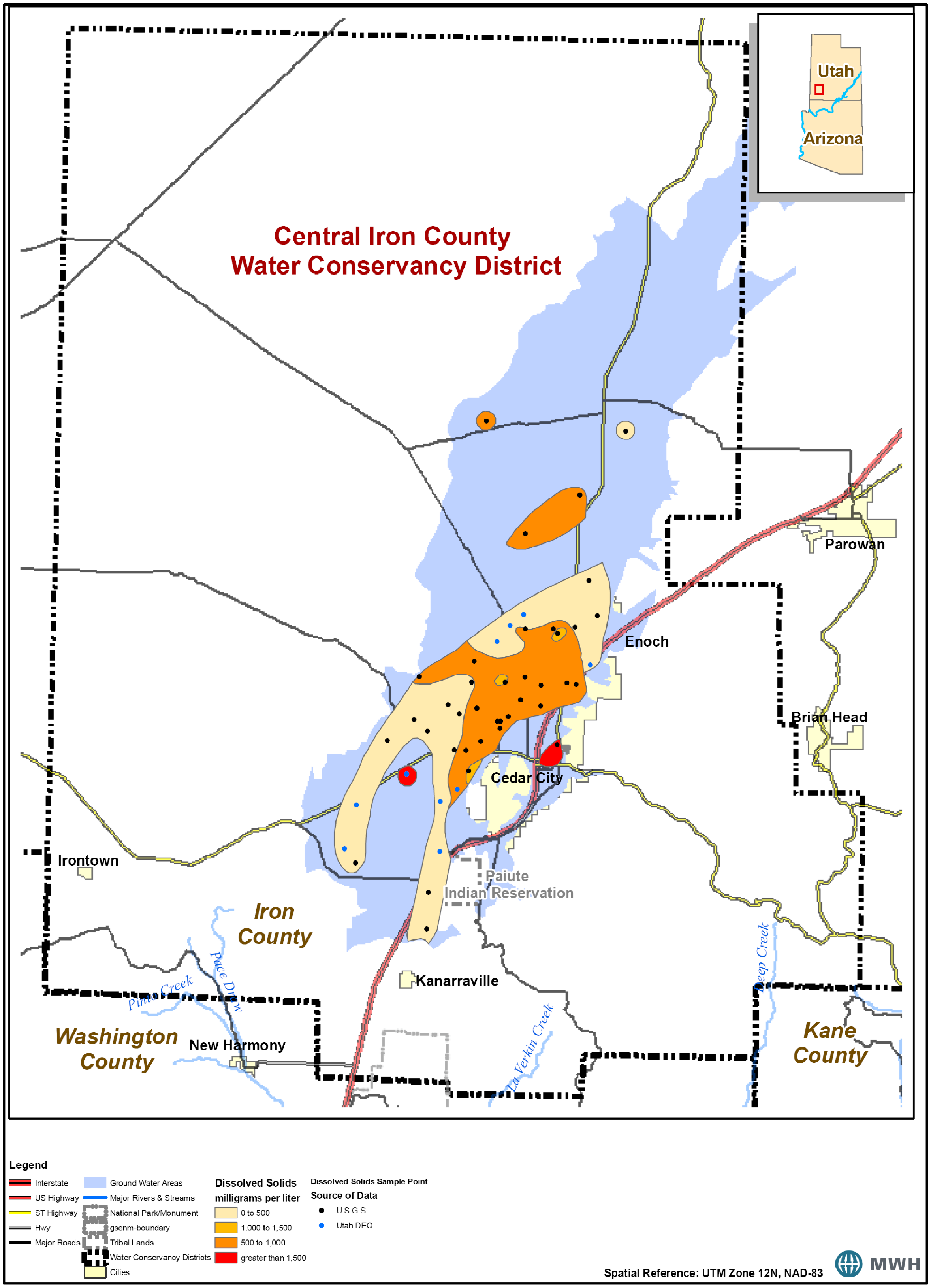
During 1976-1996 fields near the wastewater treatment plant located northeast of the Cedar City airport were irrigated with wastewater effluent. During the USGS study in 1999-2001 wells in the vicinity of the irrigated fields were sampled and analyzed for nitrate including the nitrogen-15 and oxygen-18 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 4-21** 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 4-22** 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.

Figure 4-22 Iron County Total Dissolved Solids Concentrations



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.

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.

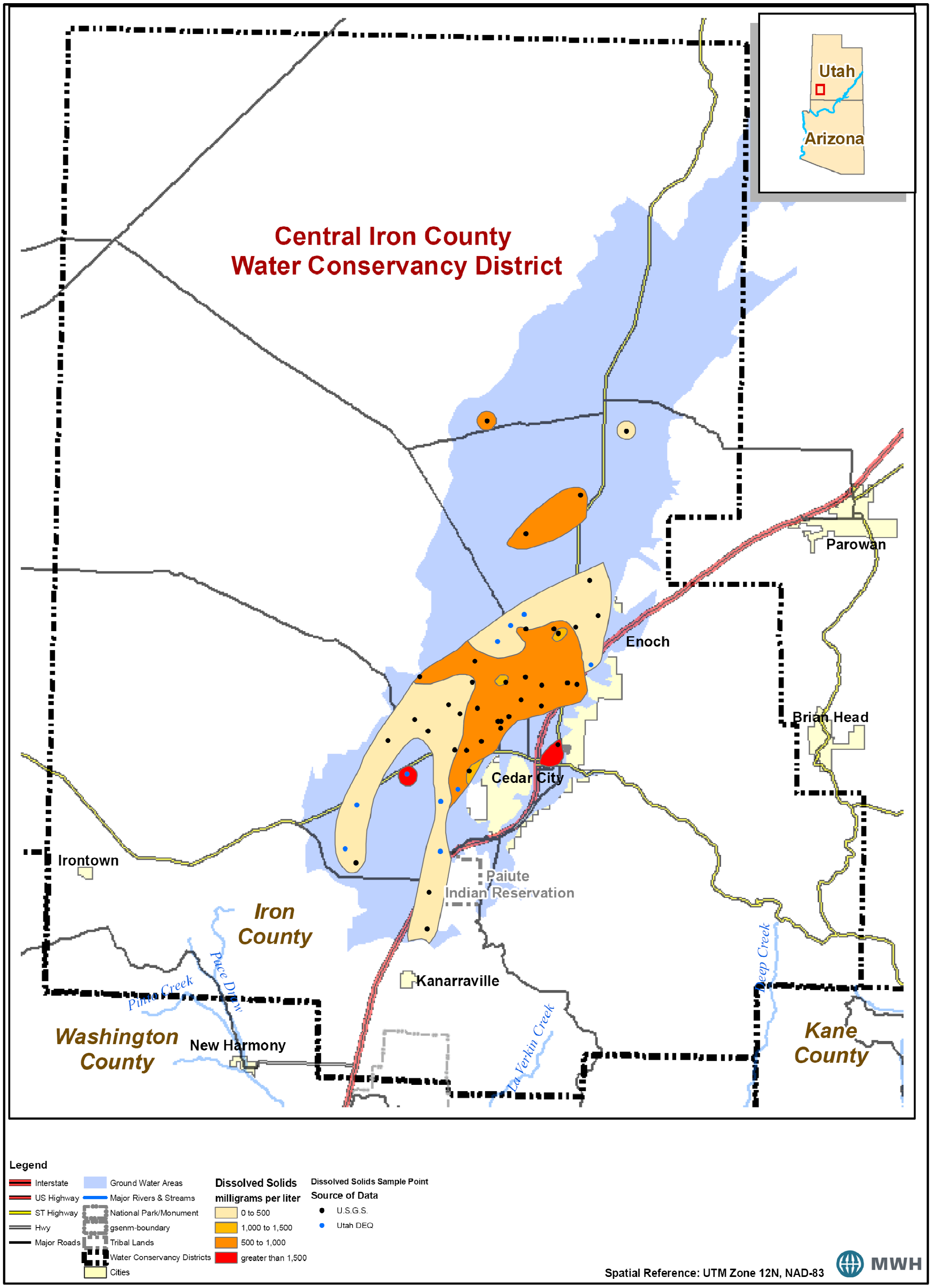
While the cities will continue to enhance their own water portfolios through acquisition of ground water rights associated with new development, they recognize that with the Cedar Basin sustainable yield issues other sources of supply will be needed. There is a growing willingness to cooperate regionally 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/yr from the LPP to assist in meeting its future needs.

Figure 4-23 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.

Figure 4-23 CICWCD Future Water Supplies



At present, the only imported water project currently anticipated by CICWCD is the LPP. CICWCD is currently requesting 13,000 ac-ft/yr 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.

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 cannot 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

Existing secondary water systems are limited in the CICWCD areas. As described above, 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.

4.2.5.3.1 Cedar City

The feasibility of implementing a secondary system was evaluated in the Water System Master Plan Update for Cedar City. Two secondary system infrastructure alternatives were evaluated. The first alternative is a Partial City System that would expand the existing secondary water system to offset large culinary demands with secondary water supply where possible, and provide secondary water for outdoor irrigation in new developing areas. The second alternative is a City-wide System that would expand the secondary system into all areas within the City limits. Since the City-wide system would incorporate the

Partial City System, it was assumed the Partial City System would be implemented first, and then the City-wide System would be added.

Partial City System

The Partial City System would continue to serve current customers and would deliver secondary water to all City parks and schools not currently served by the system. It would also require all new developments to install secondary lines and use secondary water. The Water System Master Plan estimates an average yearly demand of 2,880 ac-ft/yr for the Partial City System.

Most areas included in the Partial System would be served by gravity flows. The areas that are higher in elevation would require booster pumps to provide adequate pressure. A new reservoir would also be needed at the north end of the City with a storage capacity of 3 ac-ft for new residential development. The reservoir would be supplied by Enoch South Well which would require new infrastructure. To regulate pressures within the system two pressure reducing valves (PRV) would also be needed.

City-Wide System

The City-Wide System would serve all current customers as well as all other areas within the City limits. The improvements mentioned for the Partial System would be required along with additional supply sources and facilities. The Water System Master Plan estimates an average yearly demand of 4,920 ac-ft/yr without undeveloped areas. If undeveloped areas are included, the City-Wide System would have an average yearly demand of 6,600 ac-ft/yr. Additional water sources could be provided by purchasing existing wells and water rights, and/or acquiring shares in irrigation company stock that divert water from Coal Creek. It was assumed the additional water needs would be supplied from Coal Creek.

A pump station is being designed to deliver water to Leigh Hill Reservoir. The booster pumps needed for the Partial System would be upgraded to meet a higher demand. Existing developed areas would need to be retrofitted and secondary pipelines would need to be installed. An existing pipeline from the reservoir would need to be increased from 12-inch diameter to 16-inch diameter. The proposed layout for the Partial City System and the City-wide System are displayed in **Figure 4-24**.

4.2.5.3.2 Enoch City

Enoch City has plans to increase the size of the secondary system to serve the entire City in the future. The City has sufficient water sources and water rights to meet the secondary requirements. The future secondary water supply will come from Coal Creek and/or existing secondary wells. The City is currently drilling another well to add to the secondary system. The well is expected to produce 400 gpm and will increase the source capacity to serve 500 total connections (Nolte 2007).

The secondary water storage will need to be increased to meet future system requirements. This could be accomplished with secondary ponds or storage tanks with the secondary system expansion. Two alternatives are considered for the secondary system in the Enoch City Water Master Plan. The first alternative assumed that all storage will be located in the southwest part of the City where there are several existing secondary ponds. The second alternative assumes that the existing water steel storage tanks will be replaced with other storage facilities and the storage tanks will be used for secondary storage. The two alternatives are shown in **Figure 4-25** and **Figure 4-26**.

Figure 4-24 Cedar City City-Wide Secondary System Master Plan

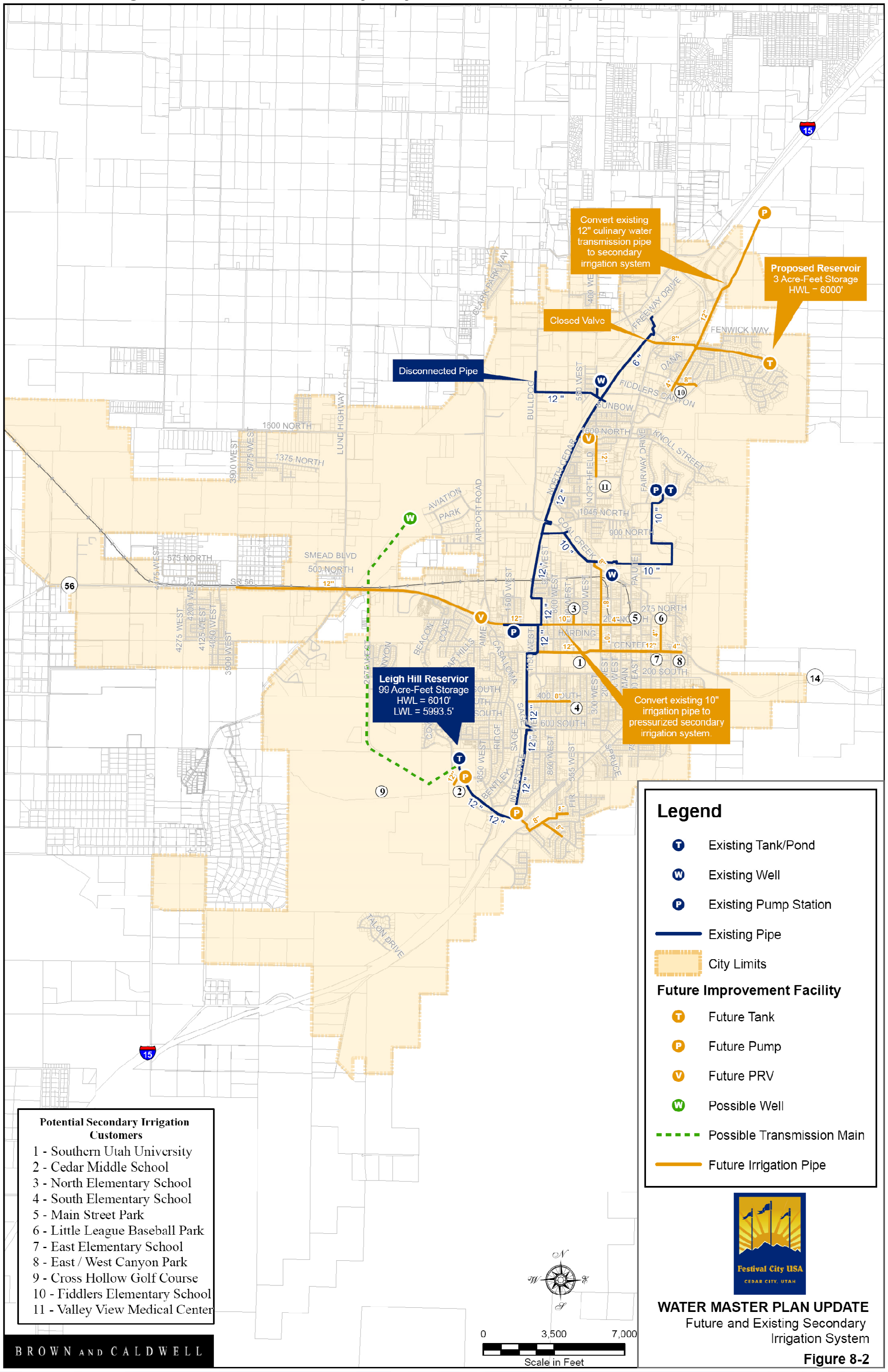


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Figure 4-25 Enoch City Proposed Secondary System – Alternative 1

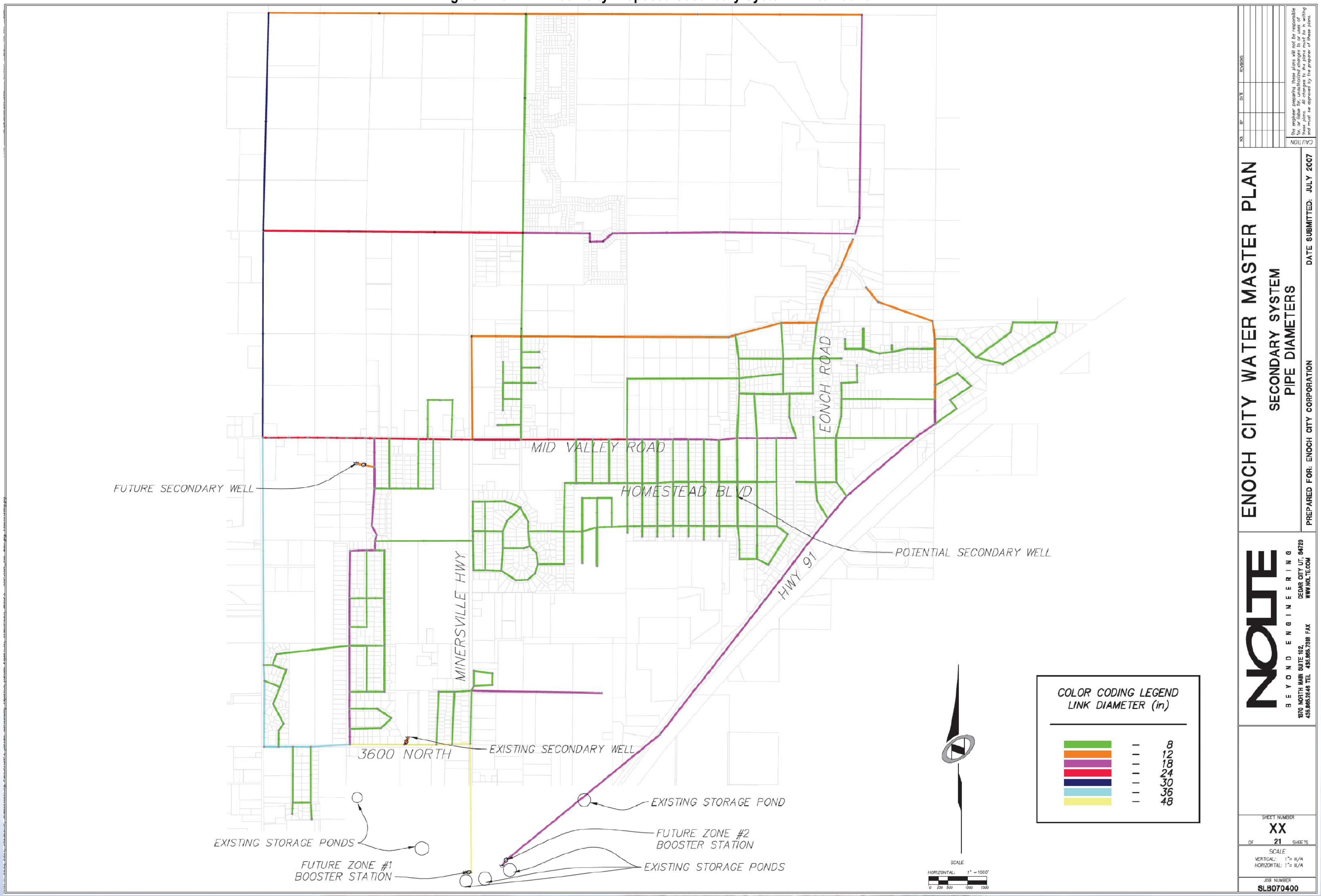
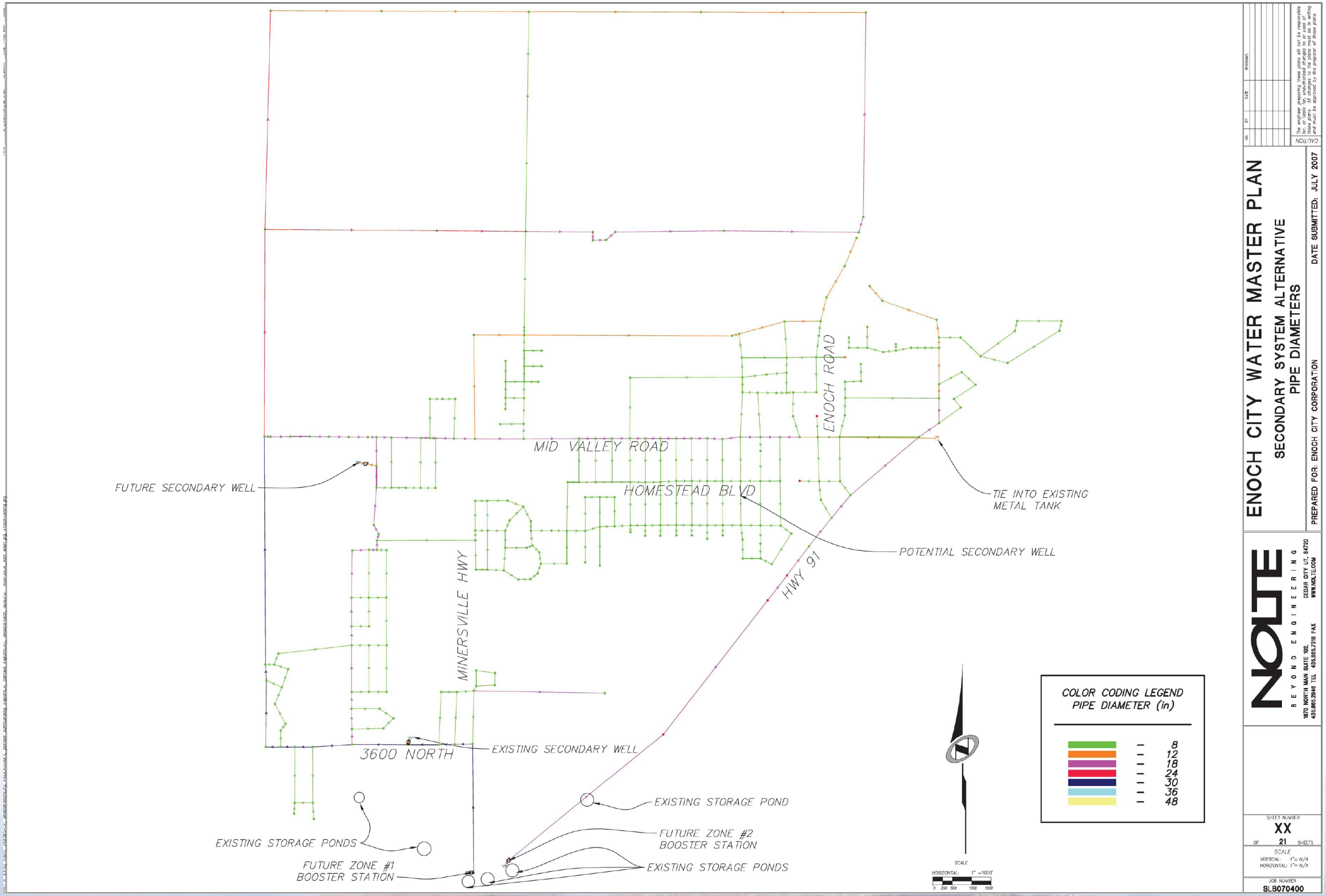


Figure 4-26 Enoch City Proposed Secondary System – Alternative 2



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.

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 plant could potentially be reused. The Cedar City regional wastewater treatment plant treated about 2,600 ac-ft/yr 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).

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.

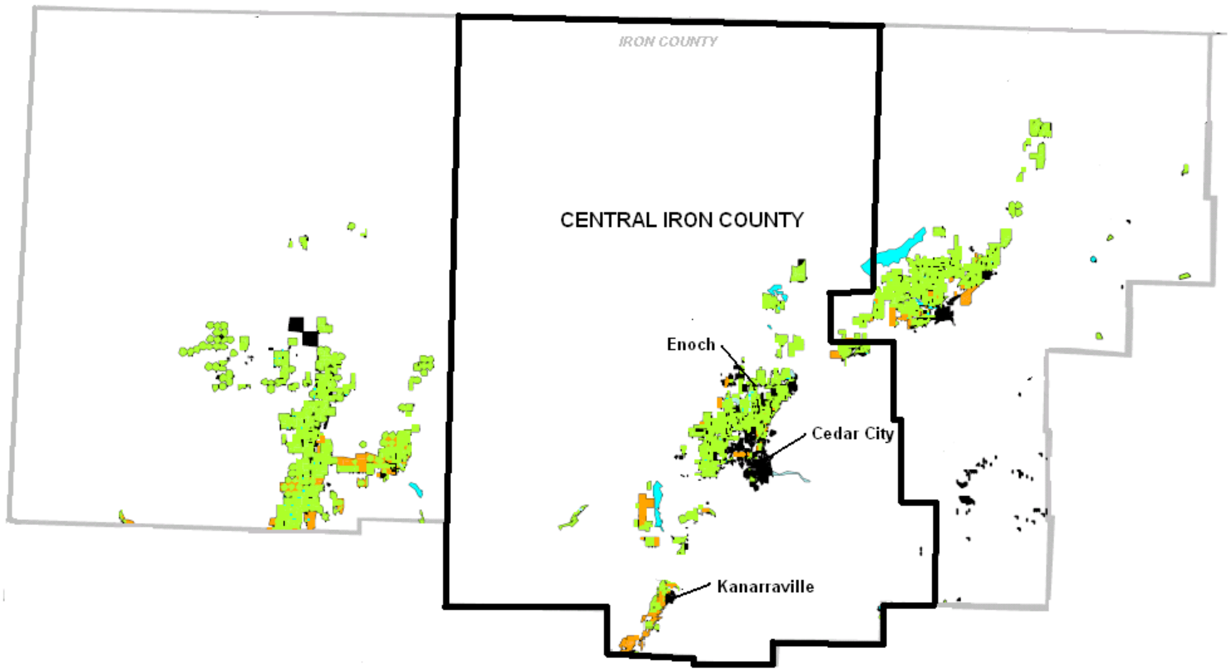
Using the assumptions described above, the maximum potential reuse supply in 2060 would be approximately 7,420 ac-ft/yr if water was imported from outside Cedar Valley Aquifer, and 5,940 ac-ft/yr if demands were fully met with supplies originating from the Cedar Valley Aquifer. The actual amount of reuse would also be restricted by monthly demand for secondary water generated through reuse. Because water use varies by month, as discussed in **Chapter 3**, the monthly supply of reuse water available for secondary supply also varies. The monthly pattern from **Figure 3-1** was used to calculate monthly influent to the wastewater treatment plant, based on predicted annual water demand. The resulting maximum potential for reuse supply in 2060 was calculated to be about 3,000 ac-ft/yr 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/yr 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. It is noted that because of the closed basin in Cedar Valley, ground water quality will continue to degrade even without water reclamation and reuse.

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 4-27** 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 projections 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 4-27 Iron County Water-Related Land Use



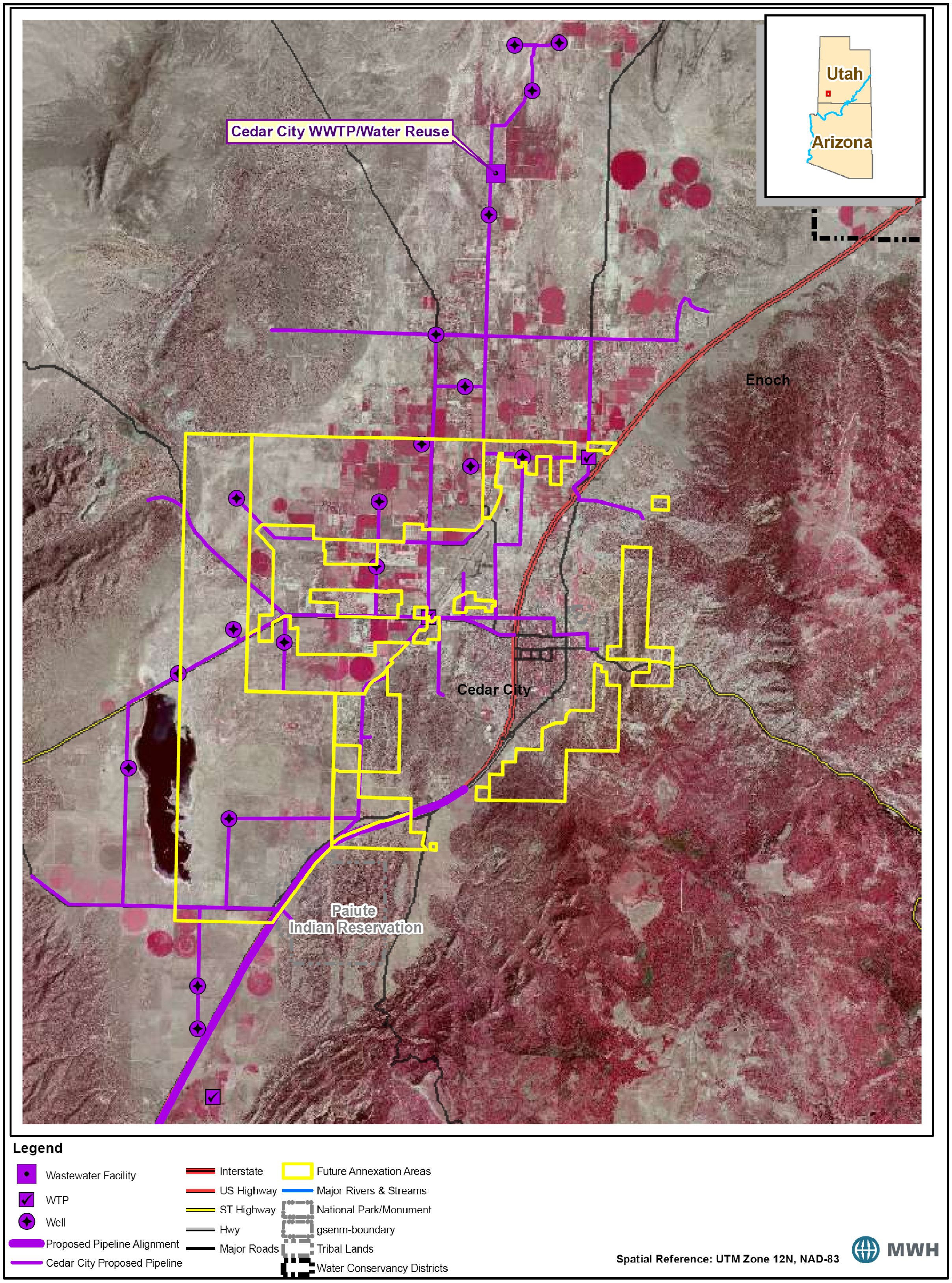
Source: Modified from DWRe, 1999.
Notes: Map Color Code: Green = Irrigated Cropland, Orange = Non-Irrigated Cropland, Blue = Water, Black = Urban

Figure 4-28 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/yr. 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.

Figure 4-28 Cedar City Annexation Areas and Existing Irrigated Lands



A conversion of approximately 14,060 ac-ft/yr 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 recently acquired a portion of the potential agricultural water rights conversions. According to Enoch City, approximately 900 ac-ft/yr of additional ground water rights supply were acquired between 2005 and 2008 (Brough 2008). Of the 900 ac-ft/yr of additional supply, approximately 300 ac-ft/yr was acquired through buy and dry of agricultural land and the remaining 600 ac-ft/yr 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/yr 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/yr 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.

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/yr 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/yr 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/yr.

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/yr of new supply through "buy and dry," as shown in **Table 4-11** (assumed 4.0 ac-ft/yr 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 4-11 Estimates 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/yr 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/yr 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/yr 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/yr. 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/yr (11,060 ac-ft/yr of ground water pumping rights as shown in **Table 4-12,** plus 4,710 ac-ft/yr 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 above to be about 12,160 ac-ft/yr (11,360 ac-ft/yr reliable potable supply plus 800 ac-ft/yr reliable secondary supply). Based on these values, entities within the CICWCD service area could develop an additional 3,610 ac-ft/yr 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.

Table 4-12 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/yr
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.
Lake Powell Pipeline	13,000	CICWCD has requested 13,000 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	**41,090-61,090**	**Includes all potential sources**

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 ac-ft/yr. 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 13,000 ac-ft/yr 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. The pipeline will deliver water to a new 120 ac-ft raw water storage reservoir feeding a new water treatment plant, which will feed water to the existing culinary water distribution system.

4.2.5.9 *Summary of Future Water Supplies*

Table 4-12 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.

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 2009b).

Figure 4-29 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 4-13** 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/yr, which includes Kane County minus Fredonia, AZ and National Park Service Bullfrog Recreation Site. Reliable secondary supply for Kane County is 497 ac-ft/yr (DWRe 2009b; DWRe 2006c). The total reliable supply for KCWCD is 4,039 ac-ft/yr (3,542 ac-ft/yr reliable supply plus 497 ac-ft/yr secondary supply).

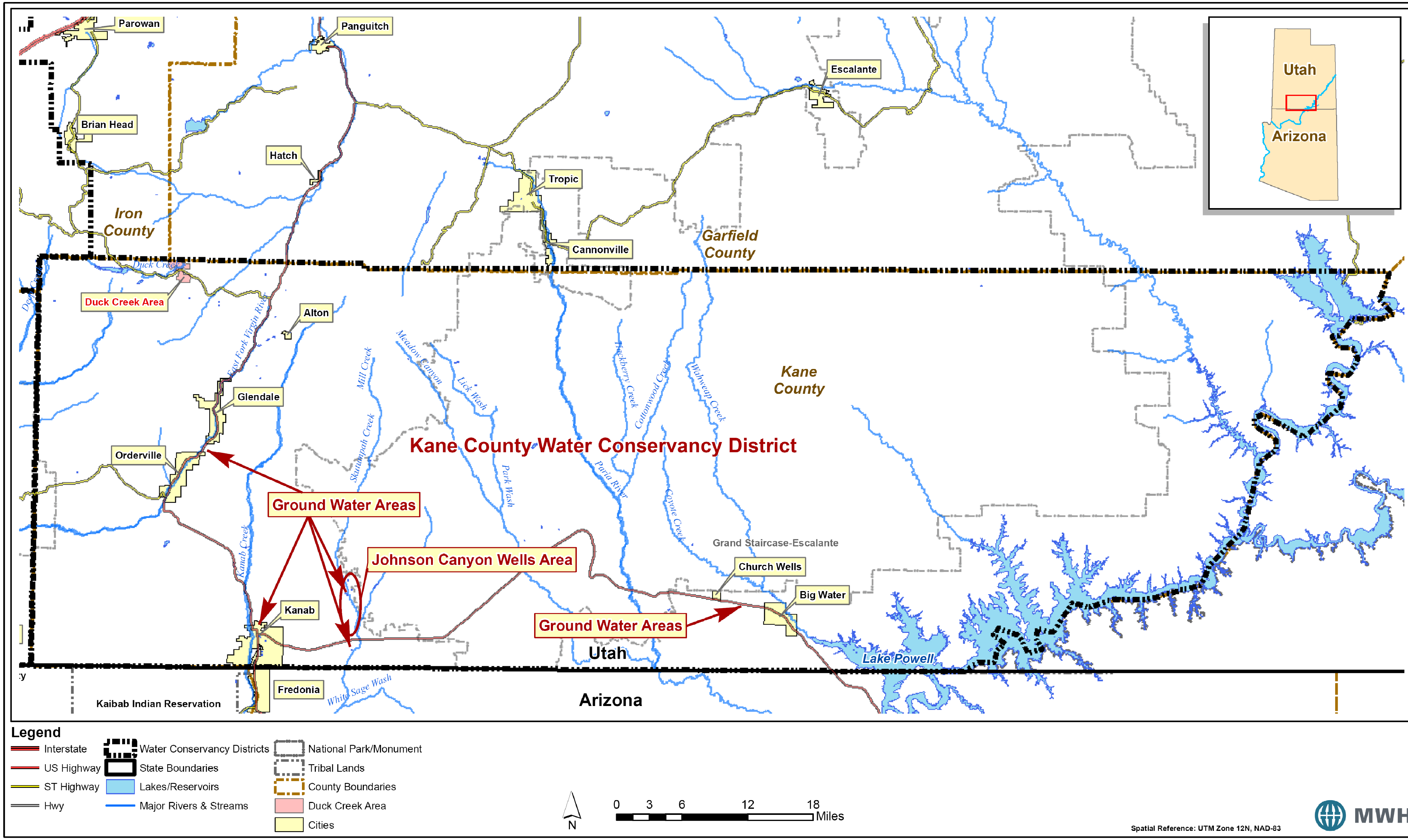
Table 4-13 Reliable Potable Water Supplies – Kane County

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, Arizona(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 dependent on the final pipeline alignment selected during future phases of the study.
(3)Two wells, one with 50 ac-ft/yr capacity and the other with 60 ac-ft/yr capacity (updated from DWRe 2009b)
(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, Arizona, 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.
(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.

Sources: *DWRe, 2009b; **DWRe, 2006; ***DWRe, 2007b.

Figure 4-29 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 4-14**. The total reliable water supply for the basin is the combined culinary and secondary supply of 845 ac-ft/yr (DWRe 2009b). Annual total potable use for 2005 was 295 ac-ft/yr or 51 percent of the reliable potable water supply.

Table 4-14 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 4-15**. The total reliable water supply for the basin is the combined culinary and secondary supply of 3,481 ac-ft/yr (DWRe 2009b). Annual total potable use for 2005 was 1,530 ac-ft/yr 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 4-15 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 4-16**. The total reliable water supply for the basin contains only potable supply totaling 96.3 ac-ft/yr (DWRe 2009b). Annual total potable use for 2005 was 37 ac-ft/yr or 38 percent of the reliable potable water supply.

Table 4-16 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 4-17**. The total reliable water supply for the basin contains only potable supply totaling 543 ac-ft/yr (DWRe 2006c). Annual total potable use for 2005 was 188 ac-ft/yr or 35 percent of the reliable water supply.

Table 4-17 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 4-18**. 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/yr 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/yr). 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/yr (1,400 ac-ft/yr in the East Fork Virgin River subbasin, 25,300 ac-ft/yr in the Kanab Creek subbasin, 20,400 ac-ft/yr in the Johnson Creek subbasin, and 12,400 ac-ft/yr in the Wahweap subbasin). Total ground water use from the four subbasins was approximately 5,600 ac-ft/yr in 2005 (3,100 ac-ft/yr M&I ground water pumping and 2,500 ac-ft/yr agricultural pumping). Thus well users could increase their production by approximately 53,900 ac-ft/yr 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/yr reported in **Table 4-18** 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 4-18 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 2009b)
(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 2009b)
(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, Arizona water use was included to get an accurate estimate of the amount of water available for development.
(6)Ten 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 was used to calculate agriculture well withdrawal for each subbasin.

KCWCD is currently constructing Jackson Flat Reservoir south of Kanab. Jackson Flat Reservoir is 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/yr) 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 4-30**.

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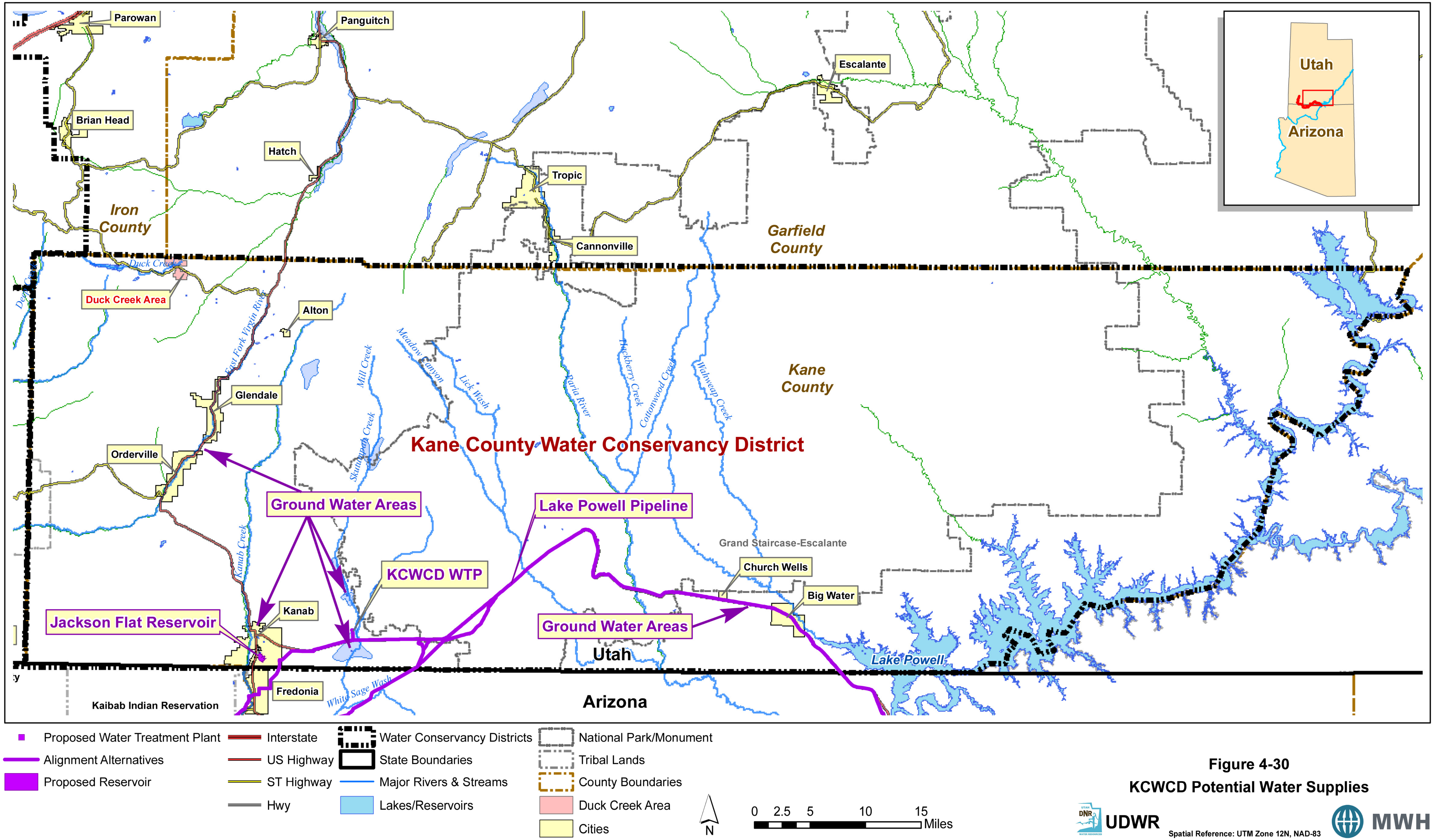

Figure 4-30
KCWCD Potential Water Supplies

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KCWCD has requested delivery of 4,000 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. Originally a larger supply was required by KCWCD from the LPP. KCWCD would be allowed 4,000 ac-ft/yr 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/yr. Any amount of LPP water 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/yr 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.

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 2009b). Irrigated agricultural acreage in 2007 and the associated agricultural water use (based on an agricultural diversions estimate of 4.0 ac-ft/yr per acre of irrigated land for East Fork Virgin River Basin and 5.0 ac-ft/yr per acre for Kanab Creek and Johnson Canyon Basins) are shown in **Table 4-19.** 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 4-19** indicates that there is a total of 13,550 ac-ft/yr 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/yr of water supply available to M&I from existing irrigated agricultural.

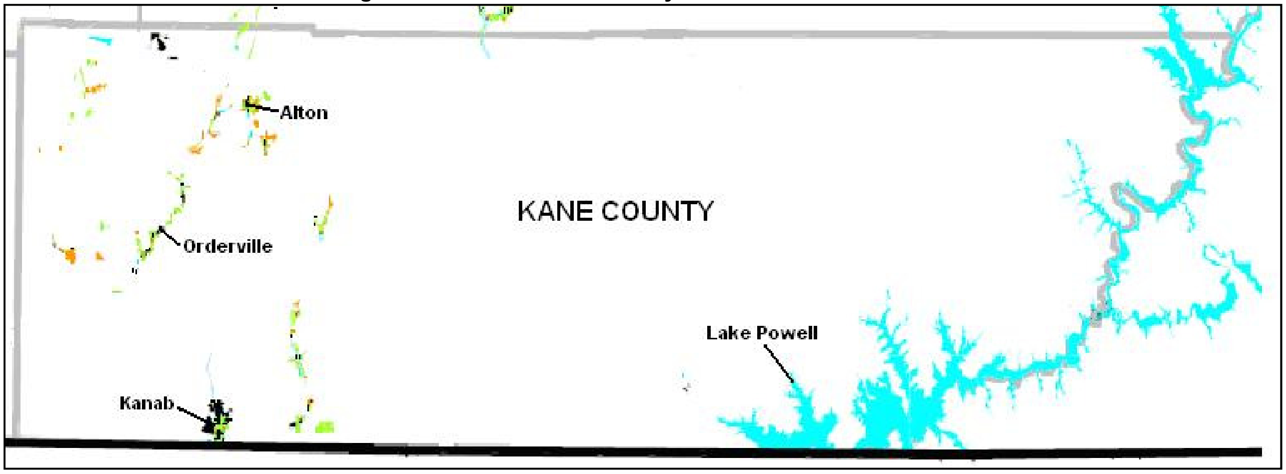
Table 4-19 Kane County Subbasins – 2007 Estimated Agricultural Water Use

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

(1)Source of irrigated land data: DWRe (2007d)
(2)Based on assumed agricultural water diversions of 4.0 ac-ft/yr per acre of irrigated agricultural land for East Fork Virgin River Basin and 5.0 ac-ft/yr 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 4-31 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 4-31 Kane County Water-Related Land Use



Source: Modified from DWRe, 1999.
Notes: 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 4-20 summarizes the potential developable supplies to meet future demands in the KCWCD service area. KCWCD previously owned approximately 30,000 ac-ft/yr 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 4-20 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/yr
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	0-4,000	KCWCD has requested 4,000 ac-ft from LPP 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**	**100-4,100**	

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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, their recent effectiveness in reducing per capita water use rates, and conservation programs adopted for future implementation. 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**.

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 even for communities that have not achieved the statewide average 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, commercial, 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. WCWCD has led the way in implementing conservation practices in Utah and the Southwest U.S. for over 15 years.

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). Focused conservation activities began with the first Water Fair in 1995. 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). WCWCD is currently (2010) in the process of updating its conservation plan again.

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 Current 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 (USEPA) 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 organizes 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 program began in 1995.

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.

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.

Irrigation Controller 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, aid in water management, 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. The Toquerville Secondary Water System was the first open ditch system to be connected to a piped system.

In 2007, Governor John Huntsman, Jr., signed the legislation designating a state-wide water week, declaring the first full week in May as Water Week. In cooperation with the City of St. George, the District organizes a garden fair, facility tours, and a water walk. Using these events and activities, the District promotes the importance of water and helps educate people on the importance of conservation.

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; 2008b)

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.

Category	Title	Description
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.
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 several 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).

Hurricane adopted a water rate structure to encourage conservation. This is summarized below.

Block	Consumption (gallons)	Rate Within Pressurized Irrigation Zone ($/gal)	Rate Outside Pressurized Irrigation Zone ($/gal)
Base rate		$13.50	$13.50
1	0-5,000	$0.80/1,000 gal	$0.80/1,000 gal
2	5,001-10,000	$0.85/1,000 gal	$0.85/1,000 gal
3	10,001-20,000	$1.90/1,000 gal	$0.90/1,000 gal
4	20,001-30,000	$2.05/1,000 gal	$1.05/1,000 gal
5	30,001-40,000	$2.20/1,000 gal	$1.20/1,000 gal
6	40,001-60,000	$2.40/1,000 gal	$1.40/1,000 gal
7	60,001 and above	$2.60/1,000 gal	$1.60/1,000 gal

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).

Santa Clara adopted a water rate structure to encourage conservation. This is summarized below.

Block	Consumption (gallons)	Rate Within Pressurized Irrigation Zone ($/gal)
Base rate		$22.25
1	0-9,000	In base rate
2	9,001-16,000	$0.82/1,000 gal
3	16,001-23,000	$1.02/1,000 gal
4	23,001-30,000	$1.37/1,000 gal
5	30,001-45,000	$1.72/1,000 gal
6	45,001-60,000	$2.17/1,000 gal
7	60,001 and above	$2.67/1,000 gal

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 Historical Conservation Savings

An analysis of the effect of historical conservation practices on reduction in per capita water use was performed. The purposes of this analysis were to determine WCWCD's progress toward meeting the State's goal of 25 percent water use reduction between 2000 and 2050 and to set a target for future water conservation programs.

The historical conservation achieved in the WCWCD service area was based on an assessment of historical water use data collected from five sources of water use data. These sources are summarized in **Table 5-3**. Historical per capita water use data is comprised of two parts: actual water use and population. Different data sources use different information to derive these two parameters, which makes comparing results challenging.

Table 5-3 Summary of Sources of Historical Water Use Data for WCWCD

Data	Sources				
	Utah Water Use Program (DWRi 2009)	M&I Supply and Use Reports (DWRe 2009b)	Utah Governor's Water Conservation Team Water Use Data (DWRe 2009a)	10-Years of Water Conservation Report and Updated Water Use Data (WCWCD)	Production and Consumption Data (Cities)
Water Use					
Culinary vs. Secondary	Combined Culinary and Some portion of Secondary	Culinary and Secondary (Separated)	Culinary	Combined Culinary and Secondary	Culinary and Secondary (Separated)
Production vs. Consumption	Combined Production and Consumption	Consumption	Consumption	2000 to 2008 Consumption, 1995 to 1999 Not Specified	Production and Consumption (Separated)
Years of Record	1990 to 2008	1997, 2002, 2005	2000 to 2008	1995 to 2008	2007 to 2008
Population					
Source	Provided by Cities	GOPB	GOPB numbers modified by DWRe to reflect population served by water suppliers	1995 to 1999 Provided by Cities, 2000 to 2008 GOPB	GOPB
Permanent Residents vs. Permanent and Non-permanent Residents	Not specified	Permanent Residents	Permanent Residents	Permanent Residents	Permanent Residents

For purposes of this analysis, all reductions in water use were attributed to active or passive conservation. Conventional active water conservation efforts include programs such as public education programs, installation of efficient water fixtures in new buildings, replacement of old water fixtures, and implementation of efficient irrigation programs. However, reduction in regional per capita water use can also result from changes in housing density, housing types, landscaping, lot sizes, climate, water pricing, drought policies, regional economic conditions (e.g., recessions), percentage of non-permanent residents, hotel occupancy, and CII uses. Because the State of Utah conservation goal does not differentiate among active or passive conservation, this analysis counts all water use reduction against the 25 percent goal.

Evapotranspiration (Et) data were also analyzed to help determine the effects weather may have had on water use in a particular year. High Et in hot and dry years typically results in increased water demands for outdoor irrigation. The opposite is true for wet and cool years when water use can decline. In arid Southern Utah this is a particularly important aspect of overall water use.

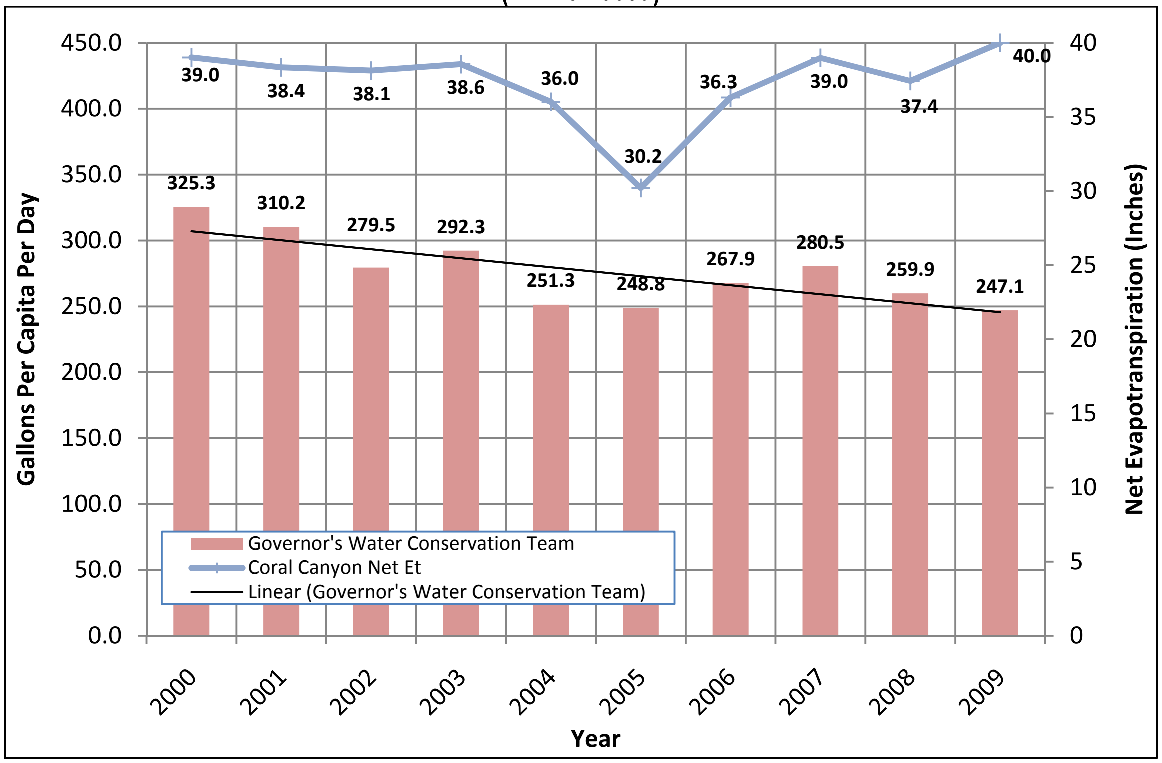
Based on the five sources of water use data reviewed, the Governor's Water Conservation Team data for the 6 largest cities in Washington County appeared to be the most reliable in determining the historical water conservation achieved in the WCWCD service area since 2000. This is shown in **Figure 5-1**. The data were analyzed in several different ways.

- The percent conservation achieved from 2000 to 2007 was computed since both years have net Et values of 39 inches. The culinary water use reduced from 325 gpcd in 2000 to 281 gpcd in 2007, which is a 14 percent reduction or about 2 percent per year. Extrapolated to 2009 this would be a total culinary water use reduction of 18 percent.
- A 5-year moving average of culinary water use was computed for years starting in 2000 through 2005. The 5-year moving average declined from 290 gpcd to 261 gpcd, an average of 2.1 percent per year. Applied to the 2000-2009 period, this results in an estimated culinary water use reduction of 19 percent.
- A linear regression was fit to the 10 years of data. The regression line decreases from 308 gpcd to 246 gpcd, a total of 20 percent or 2.2 percent per year.

All of the methods of analysis give similar results, with culinary water use in WCWCD's 6 largest cities declining 18-20 percent between 2000 and 2009. DWRe estimated that the secondary water use of 52 gpcd remained relatively constant over this period. Water use in areas outside the 6 largest cities probably showed smaller declines due to less aggressive conservation measures and less change in housing stock and development type. In addition, the economic recession may be responsible for water use reduction in the last two years that may not be representative of long-term changes. As a result, the overall real water conservation savings for WCWCD from 2000 to 2009 was estimated to be two-thirds of the values computed from the GWCT culinary data, or 13 percent. This results in a remaining conservation goal of 12 percent from 2009 through 2050 based on the State's goal of 25 percent by 2050 (about 0.3 percent per year).

Projected future water conservation savings for WCWCD were estimated based on a water conservation analysis conducted for the District by Maddaus Water Management (2010).

Figure 5-1 Utah Governor's Water Conservation Team Culinary Per Capita Water Use for WCWCD (6 Cities) (DWRe 2009a)



5.2.4 Future Goals and Water Conservation Programs

Projected future water conservation savings were determined through a detailed water conservation study conducted for WCWCD by Maddaus Water Management (MWM, 2010c). This analysis reviewed recent water use data at the customer level (billing data), evaluated existing water conservation measures, considered potential future water conservation measures based on experience in other parts of the country, developed alternative conservation programs, and worked with WCWCD to select a likely program to be implemented in the future. The analysis of potential conservation measures was performed using a conservation model developed by MWM that analyzes water use at the end-use level (e.g., individual appliances and fixtures) and includes information on individual unit water savings, year of implementation, unit costs to customers and the utility, market penetration, and other factors. Meetings with local water user representatives were held to discuss results and select a preferred conservation program.

Stakeholders selected Program B from among three alternatives considered. This program consists of all existing conservation measures currently being implemented by WCWCD and the cities in Washington County, and additional measures considered feasible for this area based on local conditions, development types, cost and public acceptance. **Table 5-4** lists all the measures considered, and indicates those included with preferred Program B. All programs include anticipated savings from enforcement of current plumbing codes, which require use of low-flow plumbing fixtures in new homes and remodels.

Table 5-4 Conservation Measures Selected for Programs

No.	Measure Name	Program A	Program B	Program C
W1	Promote Green Buildings		X	X
W2	Twenty Gallon Challenge		X	X
W3	Financial Incentives for Irrigation Upgrades	X	X	X
W4	ND Require New Landscape and Irrigation Requirements	X	X	X
W5	Smart Irrigation Controller Rebates	X	X	X
W6	Turf Removal			X
W7	Regulate Water Softeners			X
W8	Distribute Retrofit Kits		X	X
W9	Toilet Leak Detection	X	X	X
W10/11	Washer Rebates			X
W12	High Efficiency Toilet (HET) Rebates	X	X	X
W13	Single Family Water Surveys	X	X	X
W14	Multifamily Surveys			X
W15	Multifamily Washer Rebate (Intensive)		X	X
W16	ND Require Hot Water on Demand/Structured Plumbing Program			X
W17	ND Require Multi Family Submetering on New Accounts			X
W18	Garbage Disposal SF			X
W19/34	Public Information Program	X	X	X
W20	Conservation Pricing	X	X	X
W21	New Home Award Programs (Patterned after WaterSense)		X	X
W22	Efficient Outdoor Use Education and Training Programs	X	X	X
W23	Rotating Sprinkler Nozzle Rebates		X	X
W24	CII Surveys			X
W25	CII Rebates to Replace Inefficient Equipment			X
W26	Replace Restaurant Spray Nozzles	X	X	X
W27	Award Programs for Water Savings by Businesses		X	X
W28	High Efficiency Urinal Rebate (<0.25 gallon)			X
W29	Focused Water Audits for Hotels/Motels		X	X
W30	School Building Retrofit		X	X
W31	Irrigation Water Surveys		X	X
W32	Artificial Turf Sports Fields		X	X
W33	ND Require Irrigation Designers/Installer be Certified	X	X	X
W35	Train Landscape Maintenance Workers	X	X	X
W36	ND Prohibit Once through Cooling, Non-Recycling Fountains, Water Wasting Fixtures and Practices	X	X	X
W37	Real Water Loss Reduction		X	X
	TOTAL NUMBER OF MEASURES*	**14**	**25**	**37**
*Totals include consolidated measures W10/11 and W19/34, each of which counts as two measures in the total.				

The initial conservation analysis by MWM had most of the conservation measures starting very early in the project implementation period. Further discussions with WCWCD resulted in spreading implementation of the selected measures over 25 years, beginning in 2010. The MWM model analyzed water savings from 2007 to 2037. Savings between 2007 and 2009 were small and were discounted when making water demand forecasts. Results were extrapolated to 2060 assuming the computed annual savings for the last 10 model years of 2027-2037 continued through 2060.

Table 5-5 summarizes the water savings and percent conservation assumed with the selected conservation program. The percent conservation by 2050 is 15.9 percent, which exceeds the target of 12 percent to meet the State's conservation goal. The conservation savings shown in **Table 5-5** were factored into the demand projections used to compare future supply and demand in **Chapter 6**.

Table 5-5 Projected Water Savings and Conservation from WCWCD Conservation Program

Year	Total Water Savings (ac-ft/yr)	Cumulative Percent Conservation
2010	454	0.9
2020	5,249	6.4
2030	12,740	10.5
2040	22,250	13.6
2050	32,970	15.9
2060	45,078	17.9

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 and hired a conservation coordinator in 2008. 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, and the City updated its water conservation plan in 2009 as part of Cedar City's Water System Master Plan Update. To reduce the City's per capita water use the conservation plan recommends implementing conservation methods such as public education, continuing their annual water audit program, and implementing non-promotional pricing (Cedar City 2009).

Enoch City created a water conservation plan in 1999 and updated it in 2007 as part of the City's Water Master Plan. Several water conservation methods being implemented are new water pricing structures, watering restriction schedules, secondary water systems, and a water efficient demonstration garden. These methods and others will be discussed in further detail below (Enoch City 2007).

5.3.2 Current Conservation Program

5.3.2.1 Central Iron County Water Conservancy District

CICWCD's conservation methods from 2000 to 2009 have primarily been focused on public education and awareness. A public education program was initiated by CICWCD in which CICWCD gave several 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.

In 2008 CICWCD hired a conservation coordinator to further develop the conservation efforts in the district. Since then the district has partnered with the EPA to promote programs, products and practices pertaining to water efficiency. The district also offers a Master Gardener Program that trains participants in water-wise landscaping. To encourage efficient landscaping in the community, CICWCD has a Water-Efficient Landscape Check-up program that recognizes and showcases water efficient landscapes in the County. The Utah Water-wise Plant Tagging program is also implemented to assist the public in identifying water-wise plants. See **Table 5-6** for a list of conservation programs CICWCD implemented from 2000 to 2009 (CICWCD 2005, CICWCD 2009).

Table 5-6 CICWCD Conservation Programs for 2000-2009 (CICWCD 2005, CICWCD 2009)

Category	Title	Description
Public Education	Presentations	Presentations on water conservation at a Water Fair for a local Middle School.
	Annual Information Booth	Information booth at the annual Live Stock and Heritage Festival. Purpose of booth is to provide community with water conservation information.
	Web Site	Informative web site containing water conservation tips and resources. Also provides the public with information about upcoming workshops and programs.
Zoning Ordinances	Conservation Oriented Zoning Ordinances	CICWCD is working with Iron County Planning Commission on revising zoning ordinances to encourage water conservation
Conservation Education and Certification	Water-Efficient Landscape Check-up	Program is designed to recognize and showcase water efficient landscapes in Iron County. Program also provides tips for those interested in water-wise landscaping.
	EPA WaterSense Partner	Partnership program sponsored by the Environmental Protection Agency (EPA). Goal is to promote water efficiency and enhance the market for water efficient products, programs, and practices.
	Master Gardener Program	Program trains interested community members in all aspects of the horticulture field. Strong emphasis on water-wise landscaping. Program also provides strong, educated volunteer basis.
Water-Wise Plant List and Tagging (State Program)	Utah Water-wise Plant Tagging	Encourage local nurseries to participate in this free state wide program. Tags are placed on plants that are water-wise to assist the population in identifying water-wise plants for use in their home landscape.

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 5-7**). The 2004 Cedar City conservation plan incorporated three programs: system water audits and leak detection, public information, and non-promotional pricing. Since the completion of the plan in 2004 the City has been implementing all three programs. One of the City's goals was to reduce the unaccounted for water loss to less than 10 percent of the total production. To reach this goal the City performed water audits as well as a leak detection and repair program. In the 2009 water conservation report the City indicated that it reached its UFW goal (6.2 percent).

Cedar City performed customer water surveys and large landscape conservation incentives to encourage conservation. A daytime water restriction ordinance was also adopted to improve irrigation efficiency by restricting outside watering from the culinary system between the hours of 8:00 am to 6:00 pm during the summer. The City's public education efforts have included an annual Consumer Confidence Report, monthly newsletters, and the State's "Slow the Flow" campaign.

In 2005 the City Council enacted the non-promotional water pricing, customer water survey, and large landscape conservation incentive measures under City Council Resolution No. 05-0126. Through the resolution, an inclining block rate structure was established with the intent to encourage water conservation. The offering of water audits to culinary and pressurized irrigation water system customers as a public service was also mandated by the resolution. The audits are offered to identify and recommend specific water conservation measures. In addition, the resolution classified large irrigation users which are now required to have a separate irrigation meter/connection to the City's pressurized irrigation system.

Table 5-7 Cedar City Water Conservation Programs (Cedar City 2004, Brown and Caldwell 2009)

Category	Title	Description
Public Education	Printed Material	Water conservation information in the annual Consumer Confidence Report and monthly newsletters.
	Slow the Flow Program	The campaign provides water conservation information via television and radio.
Reduce Unaccounted for Water loss	Water Audits, Leak Detection and Repair	Perform annual water audits to detect leakage and unaccounted-for water.
Ordinances	Time-of-day Watering Ordinance	No outside irrigation with culinary water between 8:00 AM and 6:00 PM
Water Audits	Culinary System and Irrigation System Water Audits	Water audits offered to culinary and pressurized irrigation water system customers to identify and recommend specific water conservation measures.
Non-Promotional Water Pricing	Increasing Block Rate Structure	An increasing block rate structure to discourage excessive water use. 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 number of customers it can serve.
	Classification of Large Irrigation Users	Large irrigation users are classified and required to have a separate irrigation meter/connection to the City's pressurized irrigation system.

To discourage excessive water use, Cedar City implemented new water rate structures in 2001, which was before the City Council Resolution was put into effect. High water use is penalized with price increases. There are different rate structures for residential users, non-residential users, and large irrigation users. According to the 2004 conservation plan 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 5-8** and **Table 5-9**.

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 5-10**.

Table 5-8 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 5-9 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 5-10 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 and updated it in 2007 as part of the City's Water Master Plan. Enoch City has been implementing conservation programs such as developing a secondary water system, requiring time-of-day watering ordinances, and implementing a water pricing structure. In 2002, Enoch City and the Utah State University Extension Service installed a 1.5 acre landscape demonstration garden (Enoch City 2007). The City approved a secondary system that will serve 150 homes in two subdivisions. The City also implemented a water education program that distributes conservation information via newsletter, radio, and television.

5.3.3 Historical Conservation Savings

A per capita water use and historical conservation savings analysis was performed for CICWCD. The purposes of this analysis were to determine CICWCD's progress toward meeting the State's goal of 25 percent water use reduction between 2000 and 2050 and to set a target for future water conservation programs.

The historical conservation achieved in the CICWCD service area was based on an assessment of historical water use data collected from seven sources of water use data. These sources are summarized in **Table 5-11**. Evapotranspiration (Et) data were also analyzed to help determine the effects weather may have had on water use in a particular year.

Table 5-11 Summary of Sources of Historical Water Use Data for CICWCD

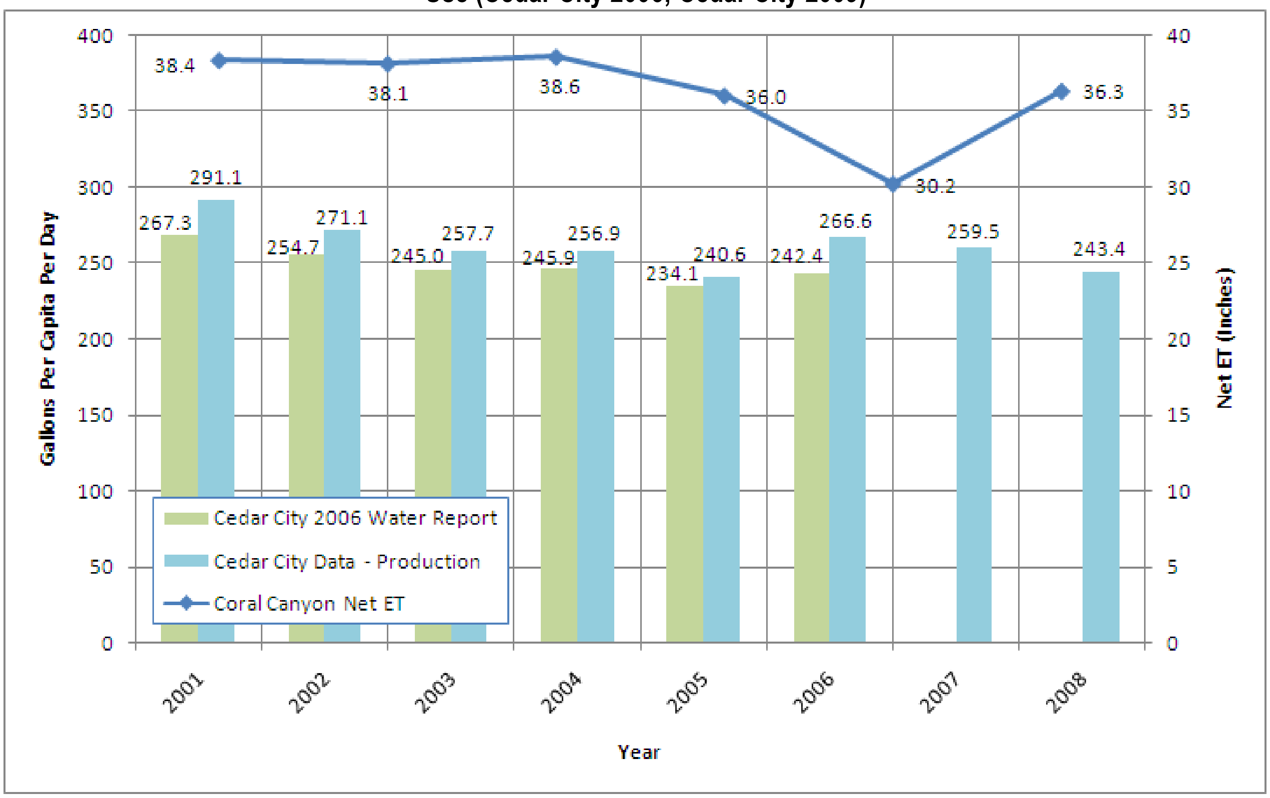
Data	Sources						
	Utah Water Use Program (DWRi)	M&I Supply and Use Reports (DWRe)	Cedar City 2006 Water Use Report	Cedar City Water Conservation Plan	Cedar City Water System Master Plan	Enoch City Water Master Plan	Production and Consumption Data (Cities)
Water Use							
Culinary vs. Secondary	Combined Culinary and, Some portion of Secondary	Culinary and Secondary (Separated)	Culinary and Secondary (Separated)	Not specified	Not specified	Not specified	Culinary and Secondary (Separated)
Production vs. Consumption	Combined Production and Consumption	Consumption	Not specified	Not specified	Production and Consumption (Separated)	Consumption	Production and Consumption (Separated)
Years of Record	1990 to 2008	2002, 2005	2001 to 2006	1994 to 2003	1997, 2007	1995 to 2006	2001 to 2008
Population							
Source	Provided by Cities	GOPB	Provided by City	Not specified	Not specified	Not specified	GOPB

Annual per capita water use data were analyzed for Cedar City and Enoch City from the seven different sources by comparing trends in water use with net Et values. Per capita water use data were compared for years with similar net Et values to estimate changes in water use due to conservation efforts. Different sources of data were compared when the time frames of available data overlapped. Water use trends were analyzed to determine whether the annual rates of reduction in per capita water use was relatively similar amongst the different sources.

Decreases and increases in per capita water use are observed for years with similar net Et values in the seven data sets provided, which makes it challenging to estimate percent conservation achieved from 2000 to 2009. However, it appears that there is general decreasing trend in per capita water use over time. Based on overall similarities in rates of reduction in per capita water use for the Cedar City 2006 Water Use Report and the Cedar City production data, these data sets are considered reliable in representing water use for Cedar City. See **Figure 5-2**. An estimate of 1.2 percent per year reduction in per capita water use is assumed, based on the comparison of the Cedar City 2006 Water Use Report and the Cedar City production data.

Conservation savings in Cedar City are probably greater than the average savings throughout the CICWCD area, because conservation programs in Cedar City are more aggressive and because other passive factors affecting water use reduction (e.g., amount of new building, smaller lot sizes, economic factors) are probably more influential in Cedar City than in Central Iron County as a whole. As a result, it is estimated that there was a 1.0 percent per year rate of reduction in per capita water use from 2000 to 2009 in the CICWCD service area. Based on these results, a 9 percent reduction in per capita water use is calculated from 2000 to 2009. This results in a remaining conservation goal of 16 percent from 2009 through 2050 based on the state's goal of 25 percent by 2050 (about 0.4 percent per year).

Figure 5-2 Cedar City 2006 Water Use Report and Cedar City Production Data Culinary Per Capita Water Use (Cedar City 2006; Cedar City 2009)



5.3.4 Future Goals and Water Conservation Programs

Projected future water conservation savings were determined through a review of currently proposed water conservation measures by CICWCD, Cedar City and Enoch City, and through a detailed water conservation study conducted for CICWCD by Maddaus Water Management (MWM, 2010). The following sections describe proposed conservation measures and the quantitative conservation analysis.

5.3.4.1 CICWCD

To achieve the per capita water reduction goals, CICWCD has proposed recommendations for future conservation methods. The Water Management and Conservation Plan for CICWCD lists several water conservation programs for future implementation. A water conservation demonstration garden will exhibit water-wise plants and irrigation methods. In addition to the garden, CICWCD will host water-wise landscaping classes and large water user workshops to educate professionals and homeowners on the 7 Xeriscape principles. The district will also offer training programs for professionals to gain a Qualified Water Efficient Landscaper (QWEL) certificate or to be eligible for recognition as a WaterSense Irrigation Partner (CICWCD 2009). To reduce indoor water use, CICWCD will start an ultra low flush toilet replacement program and will offer water audits to residential, commercial and industrial water users. A list of current and future water conservation programs CICWCD's conservation coordinator is preparing and programs listed in the district's Water Management and Conservation Plan is below (CICWCD 2005, CICWCD 2009).

- Public Information and Education Campaign
- Information Booths at festivals
- Web Site – Conservation Tips
- Master Gardener Program
- Utah Water-wise Plant Tagging (State Program)
- EPA WaterSense Partnership
- Qualified Water Efficient Landscaper (QWEL) training program
- 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-efficient Landscape Check-ups
- 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 scheduled for implementation. Since the City reached its UFW goal within the past 5 years it will not continue the leak detection and repair program. However, as a maintenance measure the City will continue to perform annual audits and monitor customer billing for significant changes in customer usage. The City also plans to further develop its water conservation education campaigns to educate its residents on proper water use and conservation methods. Possibilities for public education include increasing communication about conservation information, employing someone to develop its public education efforts, and creating a xeriscape demonstration garden. To ensure that water pricing is promoting conservation, the rates should be periodically reviewed. If necessary, the rates could be adjusted (Cedar City 2009). 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 2004 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

The Water System Master Plan Update also recommends several methods to ensure the conservation plan is implemented (Brown and Caldwell 2009):

- Establish a timeline for the implementation and evaluation of the conservation program effectiveness.
- Discuss and adopt a conservation plan every 5 years at a City Council meeting with provisions for public comment.
- Deliver the conservation plan to the City leaders, Iron County and the media.
- Include a drought/emergency component to the conservation plan.
- Enoch City

5.3.4.3 Enoch City

Enoch City proposed three conservation goals in its Conservation Plan that include reducing consumption by 25% by the year 2050; adopting a conservation-oriented rate structure while maintaining a financially viable water system; and promoting xeriscaping for landscapes, open spaces and yards.

The conservation plan describes several recommended conservation measures Enoch City could implement to reach its conservation goals. Public information programs could be implemented to inform water users about conservation methods. The programs could include poster contests, T-shirt design contests, presentations, advertisements, and printed education materials. The City could develop a consumer education program which could incorporate distributing water conservation kits including leak detection dye tablets and shower and faucet flow restrictors. Schools could work with a conservation coordinator to administer water education programs. Treated wastewater could be reclaimed for landscape irrigation and industrial processes. High water users could be approached with specific water conservation plans for their faculties. Enoch could offer indoor and outdoor water surveys for single family and multi family residential customers. Landscape planning through education about xeriscaping could also promote water conservation. A rebate program could encourage residents to use high-efficiency appliances. The City's website could also display useful information about water conservation methods or links to other useful sites.

Enoch City plans on implementing the following conservation programs in order to meet its conservation goals:

- 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
- City Facilities Re-Landscaping
- Water-Wise Landscape Awards
- Member Agency Assistance Program

- Water Conservation Plan Update
- Efficient use of surface water to reduce groundwater pumping.

The City recognizes that a part-time and/or full time person may be needed to implement public information programs, conduct leak detection and repair, and to coordinate the water conservation programs.

To track water conservation progress, the City will compare monthly water supply data for each category of usage after the first year, compare water supplied data and metered data to identify any leaks in the system, and add more conservation measures if necessary.

5.3.4.4 Conservation Analysis

A similar analysis was conducted for CICWCD as was described for WCWCD in **Section 5.2.4** (MWH 2010a). This analysis reviewed recent water use data at the customer level (billing data), evaluated existing water conservation measures, considered potential future water conservation measures based on experience in other parts of the country, developed alternative conservation programs, and worked with CICWCD to select a likely program to be implemented in the future. The analysis of potential conservation measures was performed using a conservation model developed by MWM that analyzes water use at the end-use level (e.g., individual appliances and fixtures) and includes information on individual unit water savings, year of implementation, unit costs to customers and the utility, market penetration, and other factors. Meetings with local water user representatives were held to discuss results and select a preferred conservation program.

Stakeholders selected Program B from among three alternatives considered because it appears to optimize the cost of implementing conservation measures without going past the point of diminishing returns. This program consists of all existing conservation measures currently being implemented by CICWCD and the cities in Central Iron County, and additional measures considered feasible for this area based on local conditions, development types, cost and public acceptance. **Table 5-12** lists all the measures considered, and indicates those included with preferred Program B. All programs include anticipated savings from enforcement of current plumbing codes, which require use of low-flow plumbing fixtures in new homes and remodels.

Table 5-12 Conservation Measures Selected for Programs

No.	Measure Name	Program A – Continue Existing Program	Program B – Expand Existing Program	Program C – Implement All Measures
C1	Promote Green Buildings		X	X
C2	Twenty Gallon Challenge – Web Based Water Use Calculator		X	X
C3	Financial Incentives for Irrigation Upgrades			X
C4	ND Graduated Impact Fee for New Landscape and Irrigation		X	X
C5	Smart Irrigation Controller Rebates		X	X
C6	Turf Removal			X
C7	Distribute Retrofit Kits			X
C8	Toilet Leak Detection		X	X
C9	Washer Rebates Efficient Machines			X
C10	High Efficiency Toilet (HET) Rebates			X

No.	Measure Name	Program A – Continue Existing Program	Program B – Expand Existing Program	Program C – Implement All Measures
C11	Single Family Water Surveys I		X	X
C12	Multifamily Washer Rebate		X	X
C13	Efficient Dishwasher Rebates			X
C14	Public Information Program	X	X	X
C15	Conservation Pricing		X	X
C16	Efficient Outdoor Use Education and Training Programs	X	X	X
C17	Rotating Sprinkler Nozzle Rebates		X	X
C18	CII Surveys			X
C19	Replace Restaurant Spray Nozzles		X	X
C20	Focused Water Audits for Hotels/Motels		X	X
C21	School Building Retrofit		X	X
C22	Irrigation Water Surveys		X	X
C23	Xeriscape Demonstration Gardens	X	X	X
C24	Train Landscape Maintenance Workers		X	X
C25	Real Water Loss Reduction		X x x	X
TOTAL NUMBER OF MEASURES*		**3**	**18**	**25**
Note: Measure C23 combined with measure C14 for analysis.				

Table 5-13 shows the water savings projected from the conservation measures in Program B. The 2009-2050 savings of 16 percent meet the State's conservation goal when combined with nine percent savings from 2000 to 2009. Program B includes measures that are not currently in the conservation plans for CICWCD, Cedar City and Enoch City. Based on the conservation model analysis, these communities will have to expand their conservation programs in order to meet the State's conservation goal. The conservation savings in **Table 5-13** were used to forecast future water demand for CICWCD.

Table 5-13 Projected CICWCD Conservation Savings

Year	Conservation Savings Relative to 2009 (percent)
2010	1.6
2020	10.7
2030	14.0
2040	15.5
2050	16.3
2060	17.0

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 Current 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 5-14** and **Table 5-15**.

Table 5-14 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 5-15 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 5-16** lists the conservation programs in greater detail (KCWCD 2007).

Table 5-16 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 conservation based on four levels of water shortages or reduction in supply from drought or equipment failure. 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 5-17** (Kanab City 2004).

Table 5-17 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 estimate 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, increased from 1997 to 2005 by 30 percent while the permanent population has decreased by 2 percent. This is shown in **Figure 5-3**. 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 gpcd, 291 gpcd, and 273 gpcd respectively.

Subsequent data from water billing records collected by Maddaus Water Management (MWM 2010b) found that residential culinary water use in 2007 was 181 gpcd. If secondary residential water use remained at 85 gpcd as it was in 2002 and 2005, the total residential water use was 266 gpcd. There was a 6 percent reduction in residential per capita water use from 1997 to 2007.

The water use data collected for 2007 by MWM showed a total culinary per capita water use of 408 gpcd. This is much higher than the residential use rate, and indicates that commercial and industrial water use is an important contributor to the overall high 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 5-3 Kane County Average Per Capita Water Use from 1997 to 2005 (DWRe 2000a; 2006b, 2008)

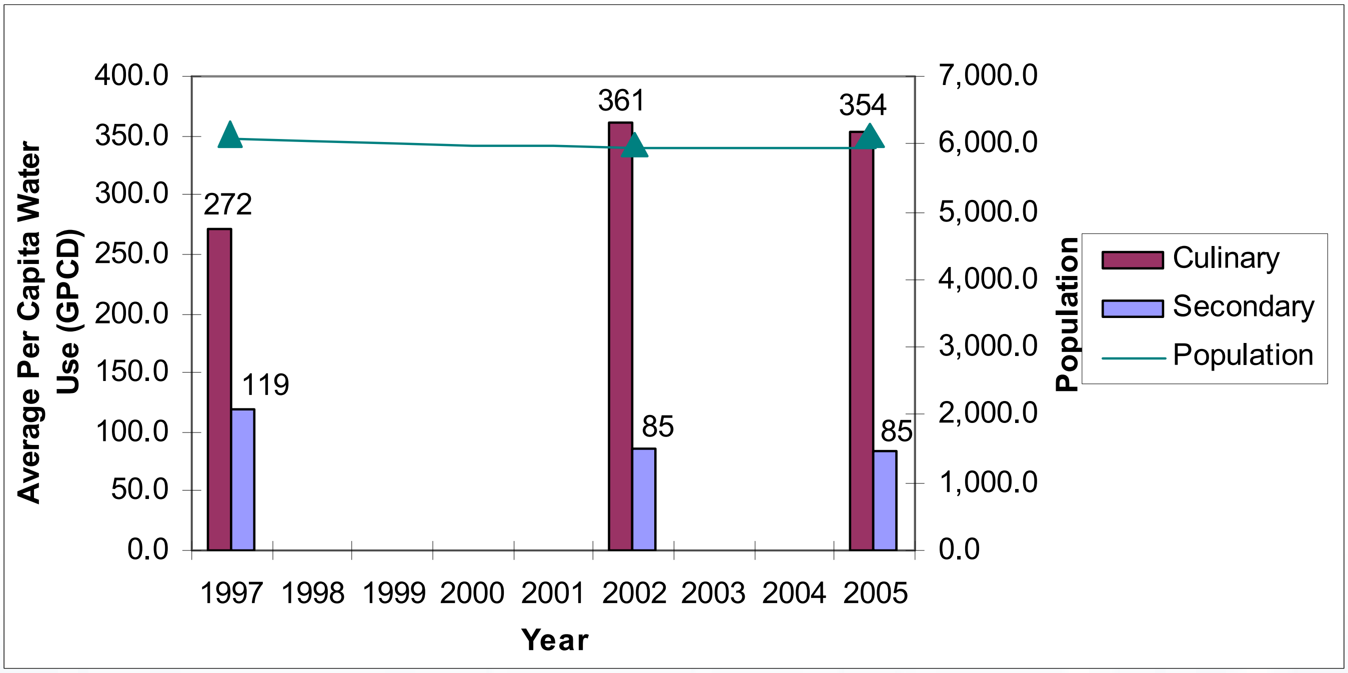
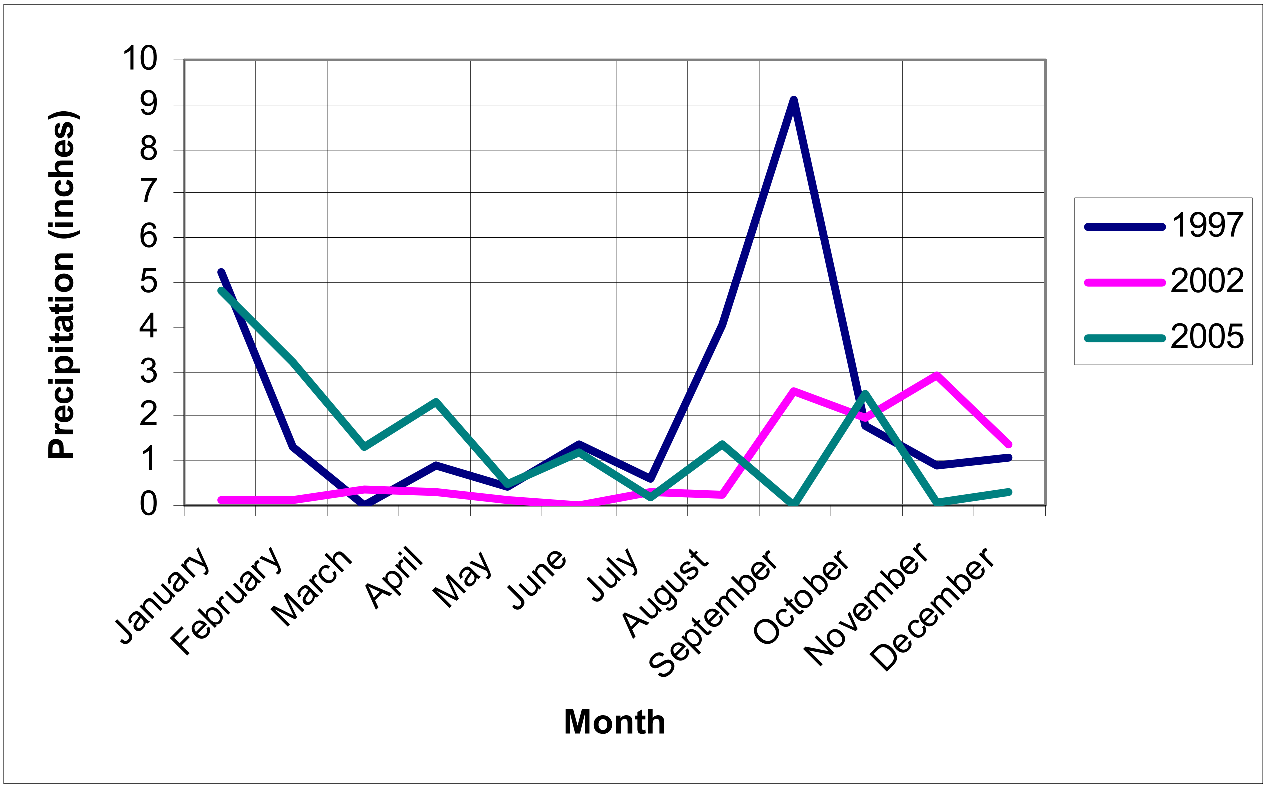


Figure 5-4 shows monthly precipitation for the years for which water use data were plotted in **Figure 5-3**.

Figure 5-4 Monthly Precipitation in Kanab for 1997, 2002, and 2005 (WRCC 2007b)

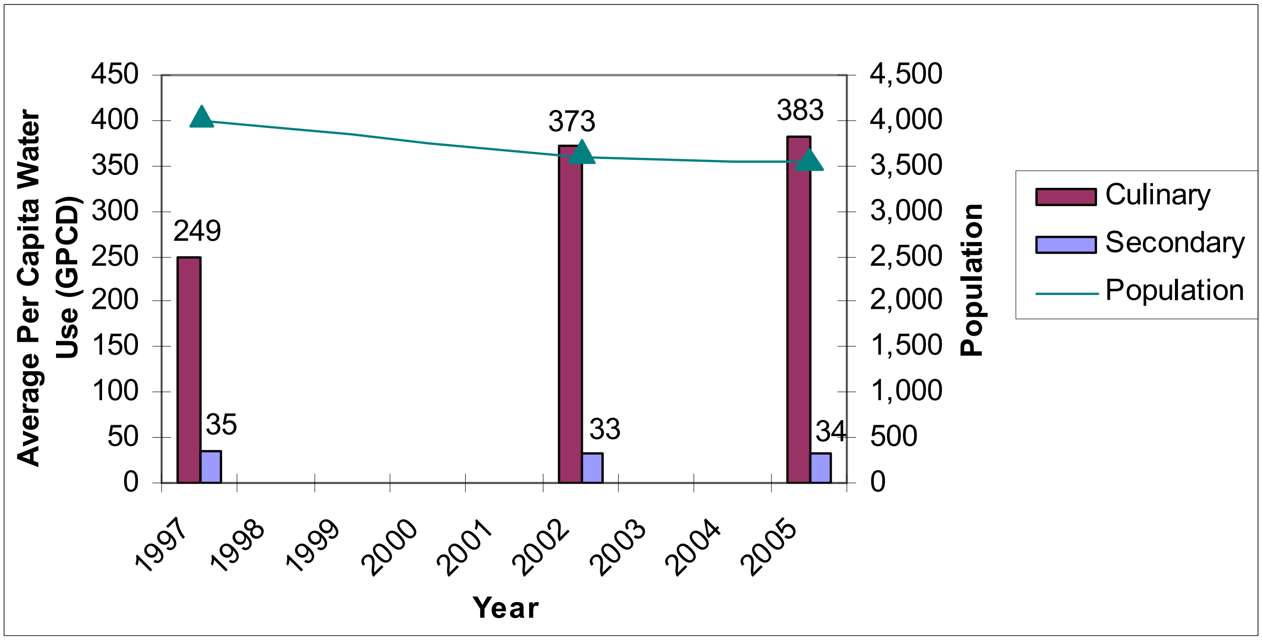


In 1997 the later months of the summer, July and August, had a high amount of precipitation compared to the years 2002 and 2005. The per capita water use was also the lowest that year, in comparison to the other two years recorded. The precipitation for the summer of 2002 was minimal in comparison to 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. The trend of high precipitation correlated with low per capita water use and vice versa as 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 5-5**. 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 5-5 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 2009 time period. Therefore, to meet the statewide conservation target, Kane County's conservation goal is 25 percent reduction in per capita water use from 2009 to 2050. Based on direction from DWRe to extend conservation through 2060 using the same rate of reduction as in DWRe's current goal, the total conservation goal through 2060 is 31%.

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 5-18**.

MWM (2010b) performed an analysis of potential conservation measures and programs for KCWCD. The same list of measures was initially considered as was described for WCWCD (**Section 5.2.4**), but fewer measures were considered to be appropriate for KCWCD due to differences in community and development characteristics. As with the other MWM analyses, Program C consisted of all the potentially feasible conservation measures for the KCWCD area. The MWM model estimated Program C savings by 2050 of 16 percent. Compared to the target of 25 percent, this suggests that achieving the State's conservation goal will be challenging for KCWCD. For purposes of the water needs assessment, it was assumed that KCWCD would implement sufficient conservation measures to achieve the 25 percent reduction in overall water use mandated by the State.

Table 5-18 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 Comparison of Water Rate Structures in the Lake Powell Pipeline Study Area

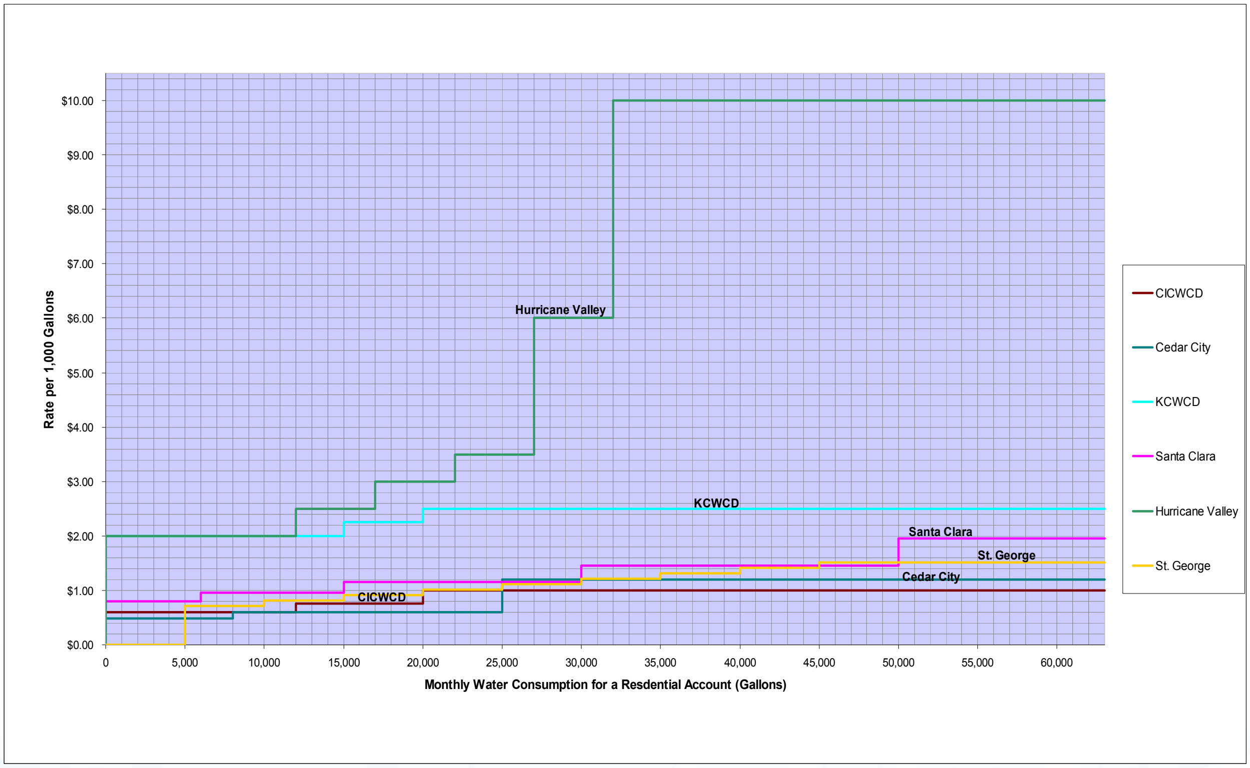
To encourage the reduction of water consumption, many cities are adopting inclining block-rate structures. Block rate structures consist of fixed amounts of water sold at a unit price. Increased block rate structures are based on the idea that consumers will use less water if the unit rate of water increases 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 5-6 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.

Figure 5-6 Increasing Block Rate Structures for Residential Customers in the Lake Powell Pipeline Service Area



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.

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 statewide during the period 2000 to 2005. The water districts and water agencies in Washington, Iron, and Kane Counties have each played a role in reducing water use by creating and implementing water conservation plans.

WCWCD has been a leader in water conservation for many years. It developed its water conservation program in 1996 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 a review of historical water use, conservation savings from 2000 to 2009 were estimated to be 13 percent. WCWCD's conservation goal as adopted for this Water Needs Assessment study is therefore a 12 percent reduction in total per capita water use from 2009 to 2050. A feasible conservation program was developed for WCWCD that provided 16 percent conservation savings by 2050 and 18 percent by 2060. It was assumed that this program would be implemented when forecasting future water demand.

Based on review of historical water use, historical water savings in the CICWCD planning area were estimated to be 9 percent from 2000 to 2009. For purposes of the Water Needs Assessment study, CICWCD and Cedar City were given minimum goals of 16 percent reduction in per capita water use relative to 2009 water use by 2050 to meet the State's conservation target. A feasible conservation program was developed for CICWCD that provided 16 percent conservation savings by 2050 and 17 percent by 2060. It was assumed that this program would be implemented when forecasting future water demand.

It was not possible to demonstrate positive water conservation savings in the KCWCD study area for the 2000-2009 period. Thus for purposes of the Water Needs Assessment study, KCWCD's conservation goal is 25 percent reduction in per capita water use by 2050 relative to 2009 water use. When extrapolated to 2060 that results in a reduction in per capita water use of 31 percent compared to 2009. Review of potentially feasible conservation measures indicated that under normal assumptions it will be difficult to achieve the conservation target. However, for purposes of this study it has been assumed that participation in the LPP project will necessitate aggressive conservation measures on the part of KCWCD communities that will be successful in meeting the State's conservation goal.

Chapter 6 – Water Resources Planning

6.1 Integrated Water Resources Plans

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 resource 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 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** provides breakouts of culinary and secondary demands and supplies.
- **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 cannot 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.
- **Lake Powell Pipeline Supplies.** For the analysis in this section, LPP requests have been adapted as potential LPP supplies for each District (69,000 ac-ft/yr for WCWCD, 13,000 ac-ft/yr for CICWCD, and 4,000 ac-ft/yr for KCWCD).

6.2 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 232,830 ac-ft/yr and existing supplies is about 115,000 ac-ft/yr. 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.

Water reuse up to the existing St. George reuse plant capacity is listed as the first increment of future secondary supply. Although detailed cost estimates have not been completed at this level of analysis, it is assumed the unit cost for this project is less than the unit cost of the LPP. The existing reuse plant in St. George has a total capacity of 11,200 ac-ft/yr, with a current effective annual yield of 3,900 ac-ft/yr. This leaves 7,300 ac-ft/yr of available supply to be developed to meet secondary water demands. The existing reuse supply is limited to 3,900 ac-ft/yr because of seasonal fluctuations in demand and lack of storage for reuse water. It is assumed that all of the reuse plant capacity will be available for secondary supply after Warner Valley Reservoir is constructed.

Additional reuse plant expansion beyond the St. George reuse plant capacity would be implemented as another source of secondary supply. The volume of effluent available in 2060 will greatly exceed the existing reuse plant capacity of 11,200 ac-ft/yr, but a plant expansion could be implemented when the demand for secondary water exists. As shown in **Table 6-2** supplies from an expanded reuse plant would be phased in over time to meet demand. Other factors that will help determine the rate of developing 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.

The Ash Creek Pipeline Project is listed as the first source of future culinary water 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. The yield of the pipeline will be 3,830 ac-ft/yr.

Besides the LPP, one other sources of water is available to WCWCD to meet total water demands, agricultural water conversions from M&I development (10,080 ac-ft/yr). This potential project has substantial feasibility or economical constraints that make the Lake Powell Pipeline a more viable option as a culinary M&I supply. Agricultural conversions and future wastewater reuse have water quality constraints, making them most cost-effective to meet secondary demands. All of these projects require Warner Valley Reservoir to be available at a capacity of about 45,000 ac-ft for seasonal storage. For planning purposes, it is assumed that Warner Valley Reservoir can be permitted, designed, and constructed in about 6 years, prior to the LPP. For the integrated water resources plan, Warner Valley Reservoir was expected to be in service by 2017. This is conservative for purposes of determining the timing of the need for the LPP.

Sources of new secondary water assume comparable demand for non-culinary grade water. Developing this future demand requires implementation of the separate secondary water distribution systems in WCWCD cities described in **Chapter 4**.

The Lake Powell Pipeline 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).

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	22,590	0
Sand Hollow Ground Water	3,000	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
Crystal Creek Pipeline	2,000	0
Gunlock to Santa Clara Pipeline	0	2,500[3]
Toquerville Secondary Water System	0	160
Existing Wastewater Reuse	0	3,900
Future Project		
Ash Creek Pipeline	3,830	0
Maximize Existing Wastewater Reuse[4]	0	7,300
Agricultural Conversions from Development[5]	0	10,080
Lake Powell Pipeline	69,000	0
Potential Future Wastewater Reuse	0	27,620[6]
Total	**106,370**	**51,400**

[1]Source of data: WCWCD 2006; WCWCD 2007c; DWRe 2009b. 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 3,900 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. It was assumed that storage facilities would be implemented and the reuse plant would be run at full capacity of 11,200 ac-ft/yr. Therefore an additional 7,300 ac-ft/yr could be developed.

[5] The estimated supply is 12,880 ac-ft/yr with 90% reliability (DWRe 2011). However, it was estimated that approximately 2,800 ac-ft/yr of this supply is currently in use and has been accounted for in the 7,450 ac-ft/yr of reliable secondary supply.

[6] 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). However, the amount of this potential reuse that could actually be used as secondary supply would be limited by demand and storage constraints. It is assumed that the proposed Warner Valley Reservoir (45,000 ac-ft/yr) would provide storage for additional reuse water and water from the agricultural conversion from development. As a result there would be approximately 27,620 ac-ft/yr of storage available for all future reuse water supplies..

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	75,990(1)	Culinary and Secondary		-	Combined culinary and secondary supply.
Future Supplies					
Agricultural Conversions from Development	10,080(2)	Secondary	Begin when needed; phase in over time	2010	Consists of multiple projects and water rights changes. Linear annual increase to meet secondary demand; requires Warner Valley Reservoir.
Warner Valley Reservoir	-	Secondary	Need for secondary sources	2017	Storage needed for reuse and Virgin River water.
Maximize Existing Wastewater Reuse Capacity of 10 mgd	7,300(3)	Secondary	Begin when needed; phase in over time	2017	Treatment capacity and distribution system can be phased as needed to meet secondary demand; requires Warner Valley Reservoir.
Ash Creek Pipeline	3,830(4)	Culinary	When needed	2018	Culinary supply indirectly by supplying secondary supply grade water to offset current culinary use.
Lake Powell Pipeline	69,000	Culinary	When needed	2020	Can be used to meet culinary and/or secondary supply as needed. 69,000 ac-ft/yr used in 2060.
Future Wastewater Reuse	7,230(5)	Secondary	When needed	2037	Phased in as needed to meet secondary demand; requires Warner Valley Reservoir.

Notes

(1)Includes WCWCD reliable water supply from DWRe M&I Water Use Reports for 2005 (62,650 ac-ft/yr culinary plus 7,450 ac-ft/yr secondary), existing wastewater reuse (3,900 ac-ft/yr based on demand and capacity restrictions), and water supply from the Crystal Creek pipeline (2,000 ac-ft/yr).

(2)The estimated supply is 12,880 ac-ft/yr with 90% reliability (DWRe 2011). However, it was estimated that approximately 2,800 ac-ft/yr of this supply is currently in use and has been accounted for in the 7,450 ac-ft/yr of reliable secondary supply. It was assumed that agricultural conversions from development will be developed moderately until Warner Valley Reservoir is available for storage.

(3)The water reuse plant recently constructed in St. George has a total capacity of 11,200 ac-ft/yr. Two of three filters have been installed to date (current capacity of 7,800 ac-ft/yr), with 3,400 ac-ft/yr 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. It was assumed that storage facilities would be implemented and the reuse plant would be run at full capacity of 11,200 ac-ft/yr. Therefore an additional 7,300 ac-ft/yr could be developed.

(4) Ash Creek Pipeline yields 3,830 ac-ft/yr based on a 90% reliability level.

(5)The maximum potential future wastewater reuse (33,910 ac-ft/yr) would be greater than the amount given, but the actual amount was limited by secondary demand. Approximately 50% would be derived from existing supplies and 50% would be derived from LPP supplies.

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., Ash Creek Pipeline 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 existing culinary supply is partially used to meet secondary demands from 2013 to 2018 until its full yield is needed to meet culinary demands.

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** and **Figure 6-2** show that the shortage is in culinary and 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
- 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)
- Additional water reuse

Figure 6-1 WCWCD Supply and Demand – Culinary

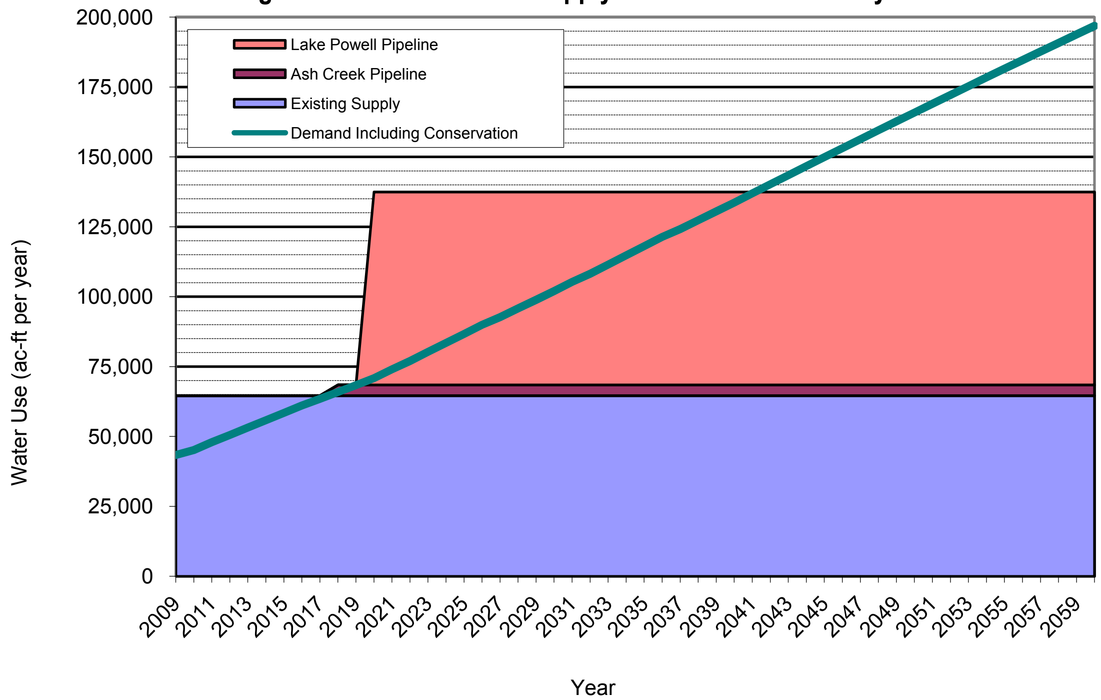


Figure 6-2 WCWCD Supply and Demand – Secondary

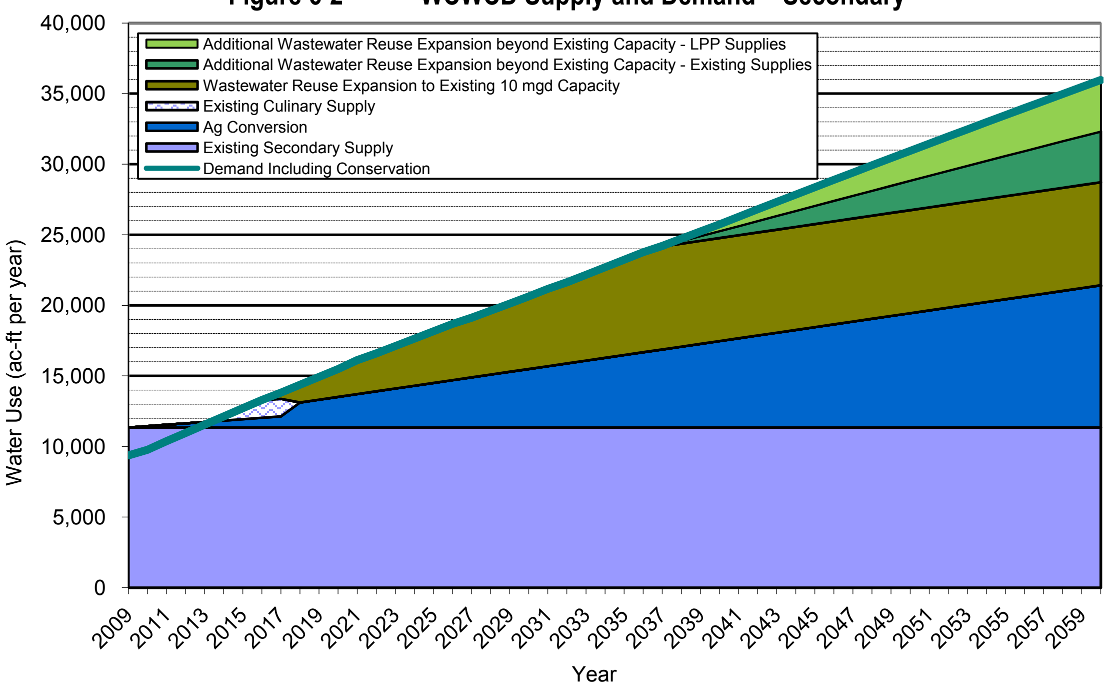
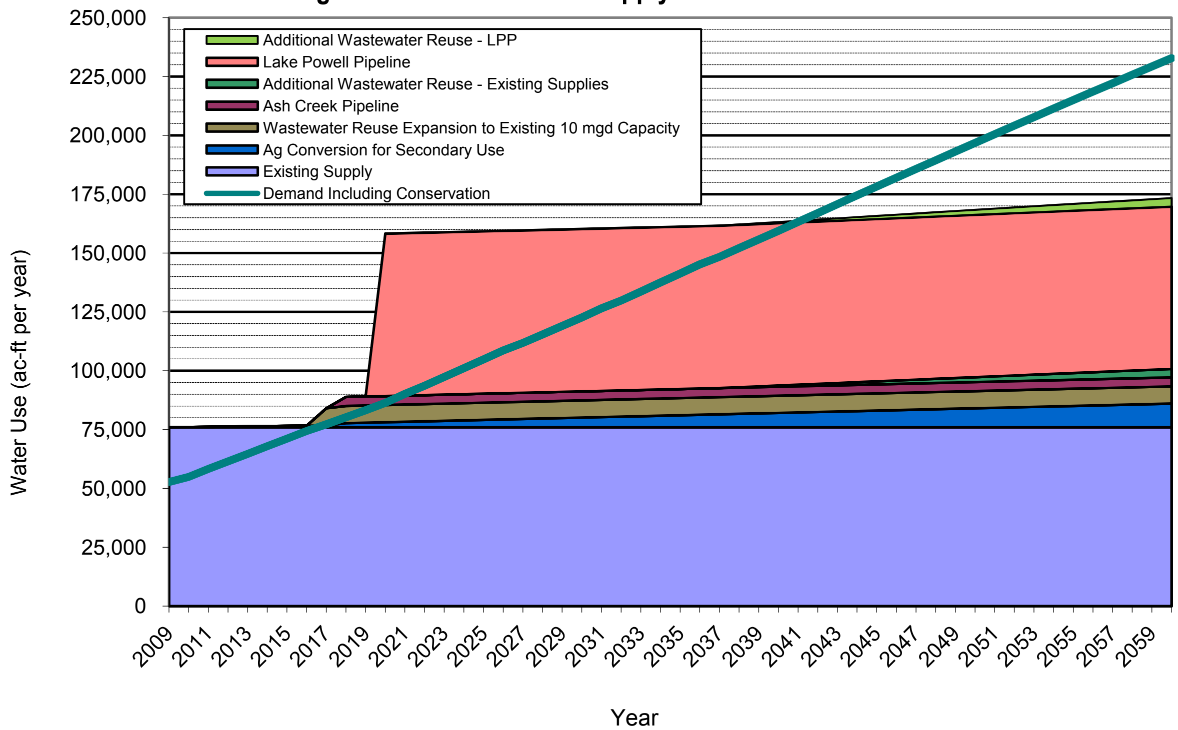


Figure 6-3 WCWCD Supply and Demand – Total



6.3 CICWCD Integrated Water Resources Plan

Future water resource development requirements in the CICWCD service area will be strongly determined by three factors that cannot 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/yr 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/yr, 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.

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 39,770 ac-ft/yr and the existing supply of 12,160 ac-ft/yr is 27,610 ac-ft/yr. 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 partially meet demands.

CICWCD has requested 13,000 ac-ft/yr 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 2030, 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. 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/yr.

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

- acquiring agricultural water rights in developable areas before development actually occurs; or
- overdrafting the ground water basin on a short-term basis with the intention of replacing the overdrafted water with imported LPP water in the future.

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

The maximum supply needed from LPP by 2060 is 7,670 ac-ft/yr. 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, or reduce the amount of M&I transferred from existing agricultural users.

Table 6-3 CICWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr)	type of supply (culinary or secondary)	Date Needed	Comments
Existing Supplies	12,160	Culinary and Secondary	-	Combined culinary and secondary supply
Assumed Sustainable Basin Yield	37,600	-	-	
Future Supplies				
Agricultural Conversion from buy and dry of existing agricultural rights	300	Secondary	2009	Enoch City purchased approximately 300 ac-ft/yr of supply from buy and dry of agricultural water rights in 2008.
Agricultural Conversion (due to development over irrigated lands)	14,060	Culinary and Secondary	2011	Based on timing of expansion of development onto irrigated lands.
Development of Existing Local Ground Water Rights	3,610	Culinary and Secondary	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/yr
Lake Powell Pipeline	7,670	Culinary	2030	Implement when needed for culinary water use.
Wastewater Reuse	1,970	Secondary	2031	Implement when needed as last priority due to water quality constraints.

Figure 6-4 through **Figure 6-6** show 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/yr the LPP would be needed in 2030.

Figure 6-4 CICWCD Supply and Demand – Culinary

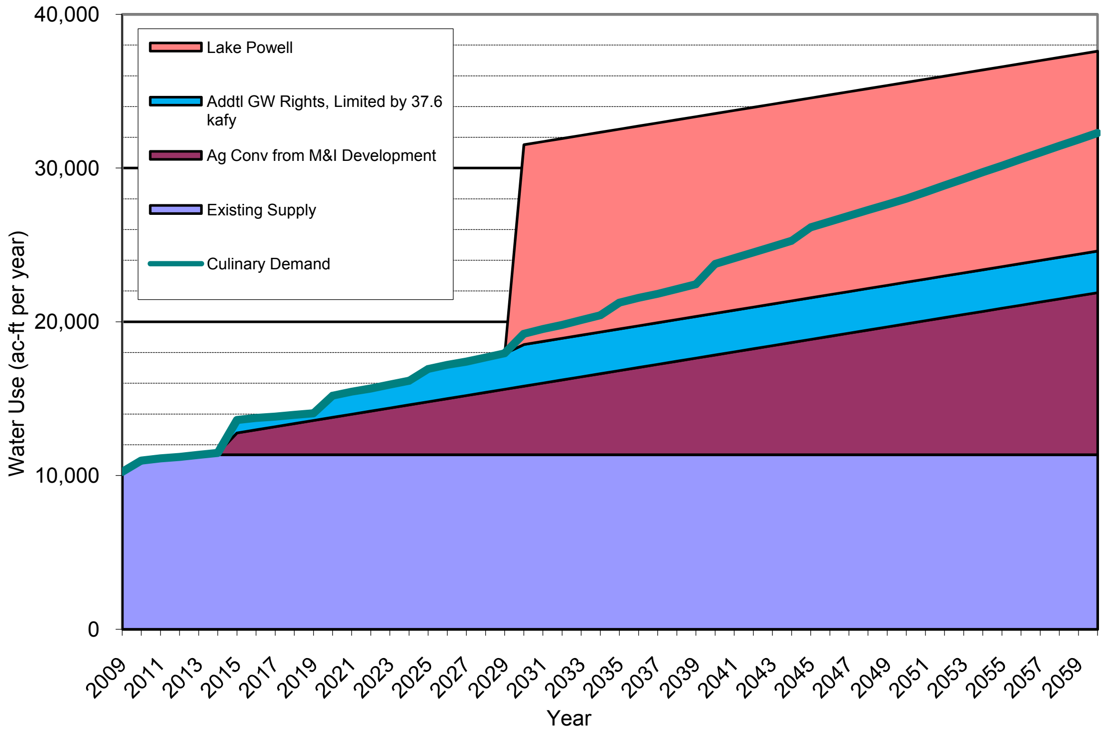


Figure 6-5 CICWCD Supply and Demand – Secondary

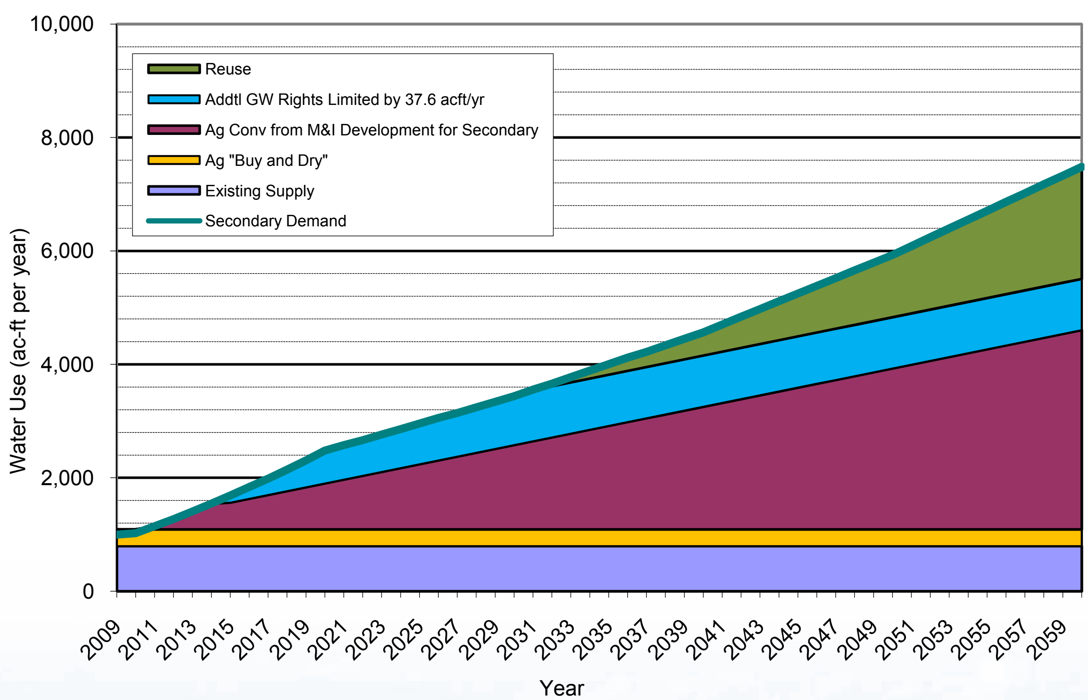
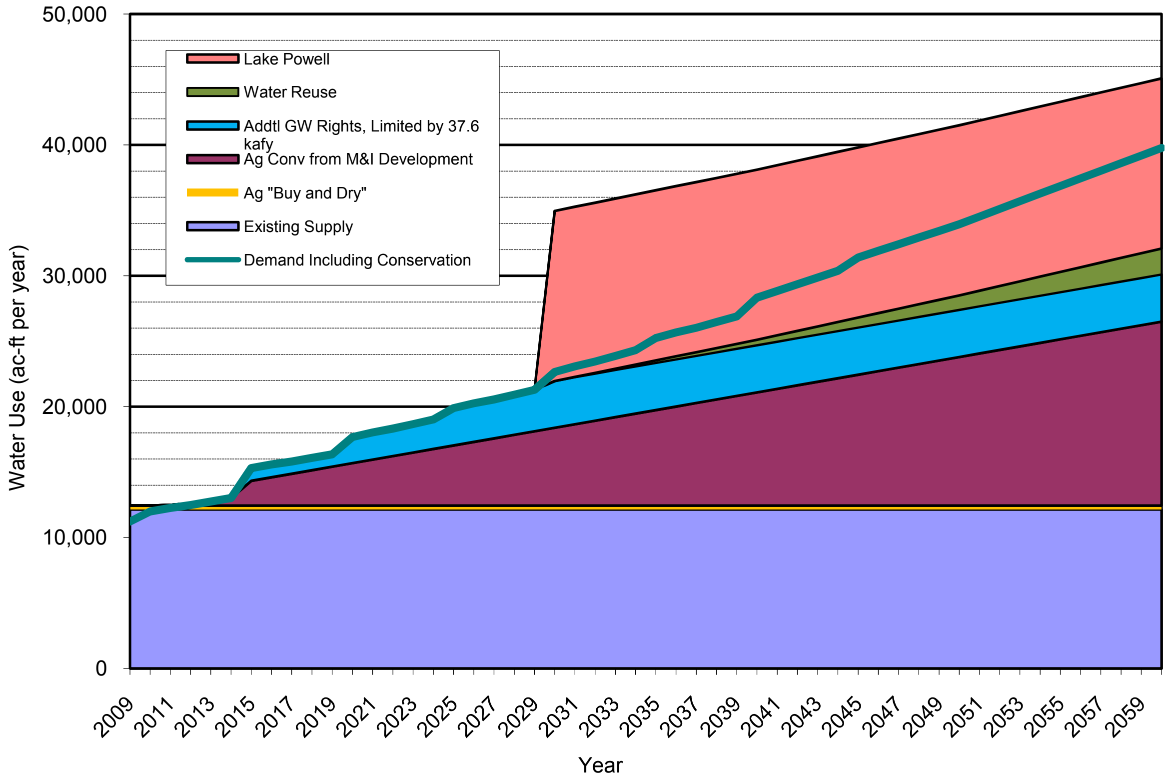


Figure 6-6 CICWCD Supply and Demand – Total



6.4 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 5,850 ac-ft/yr and the existing supply of 4,040 ac-ft/yr is 1,810 ac-ft/yr. 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.

Table 6-4 KCWCD Integrated Water Resources Plan Data

Supply Source	Average Annual Yield in 2060 (ac-ft/yr) East Fork Virgin River	Kanab Creek	Johnson Canyon	Wahweap Creek	Comments
Existing Supplies	850	2,560	100	540	Combined culinary and secondary supply.
Future Supplies					
New Ground Water (Amount and Year Needed)	130	1,570	90	30	Phase in as needed. For all subbasins, this is the only Future Supply needed to meet demand.
	2046	2012	2009	2056	
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 4,000 ac-ft/yr from LPP.

Notes:
[1]Lake Powell Pipeline would not be needed in the planning horizon.

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 4,000 ac-ft/yr in LPP supply. This imported water source is considered to be the last priority compared to the feasible local water development projects.

Figure 6-7 through **Figure 6-10** 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 6-7 KCWCD Supply and Demand – East Fork Virgin River

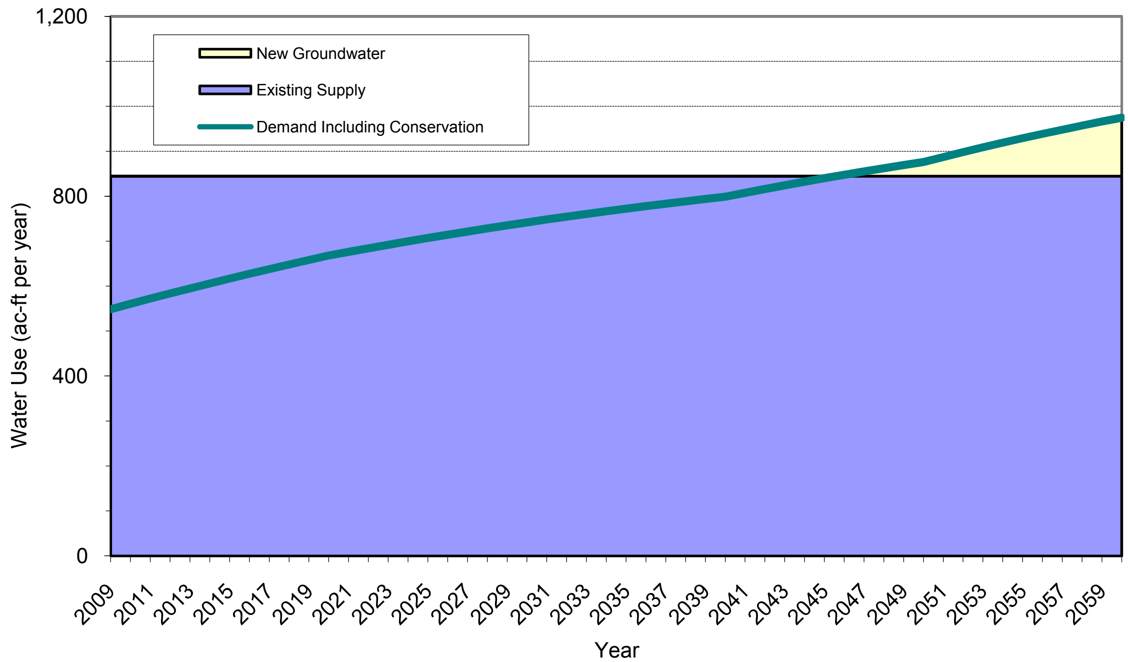


Figure 6-8 KCWCD Supply and Demand – Kanab Creek

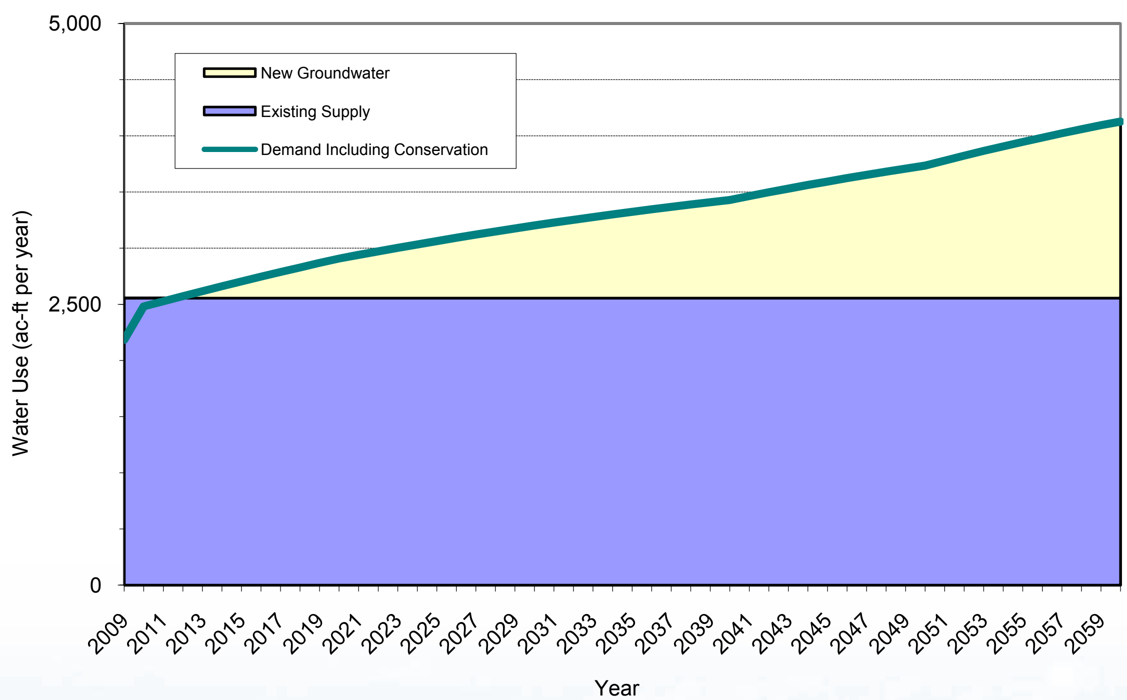


Figure 6-9 KCWCD Supply and Demand – Johnson Canyon

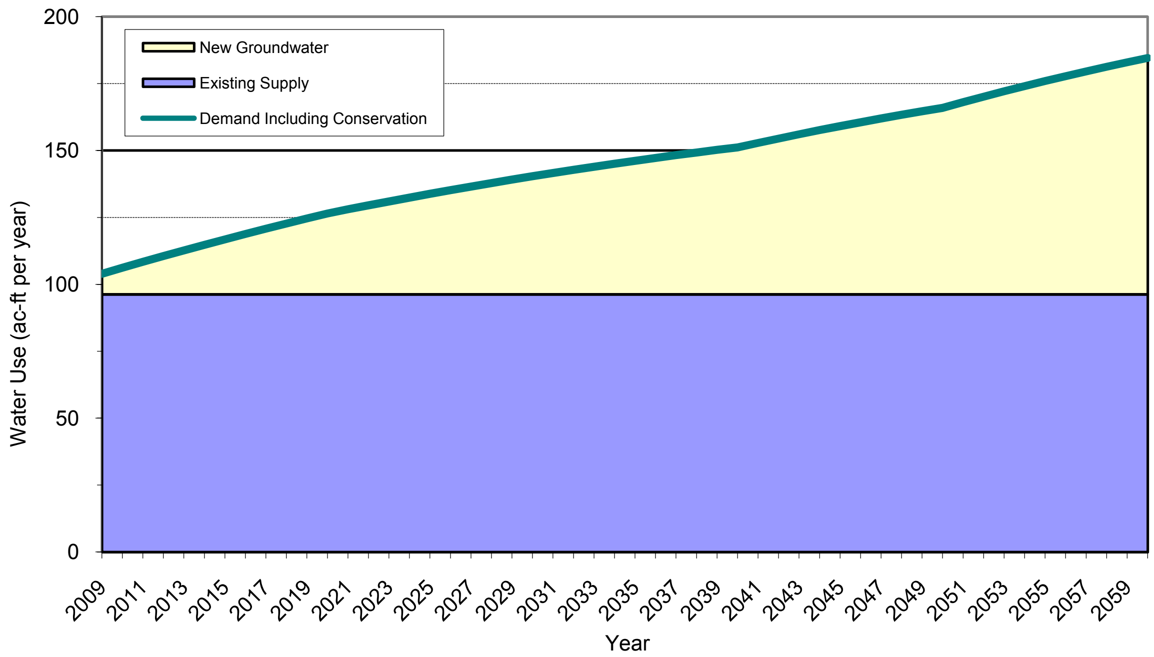
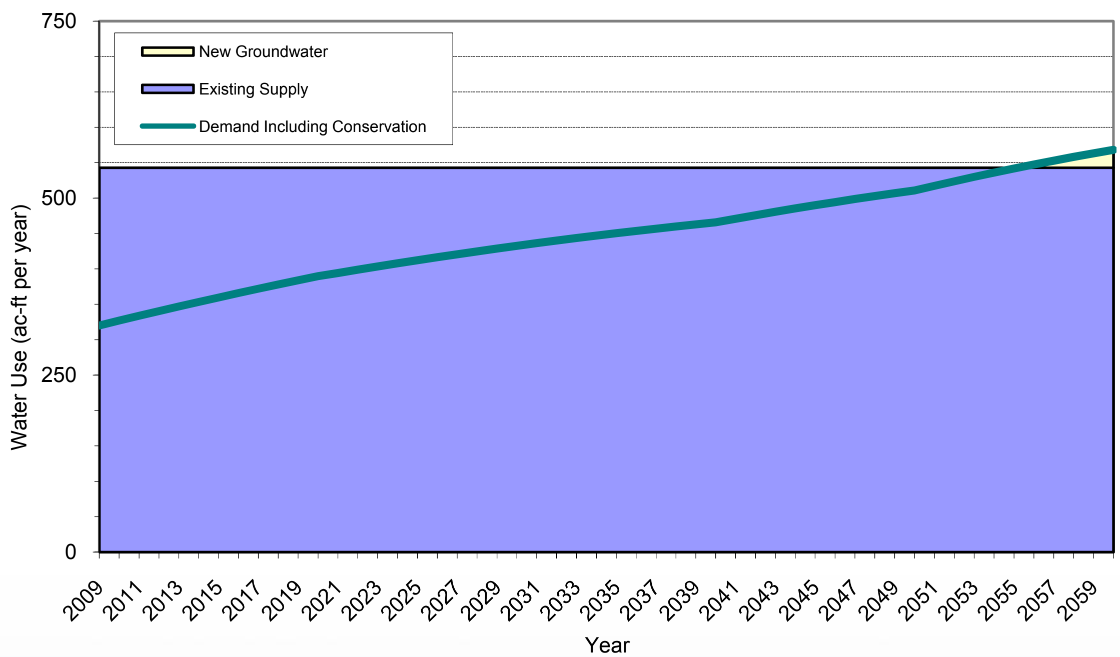


Figure 6-10 KCWCD Supply and Demand – Wahweap Creek



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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

BOD	Biochemical oxygen demand
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
Et	Evapotranspiration
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
MCL	Maximum contaminant level
mgd	Million gallons per day
mg/l	Milligrams per liter
MWM	Maddaus Water Management
NEPA	National Environmental Policy Act
RWSA	Regional Water Supply Agreement
SITLA	Utah State Institutional Trust Lands Administration
SWAT	Smart Water Applied Technology
TDS	Total dissolved solids
TMDL	Total Maximum Daily Load
TSS	Total suspended solids
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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