Review of Water Supply Needs in Washington County, Utah

Final Report

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Executive Summary

Washington County, Utah has experienced rapid population growth in the last decade. The factors that have led to this growth--a favorable climate, beautiful scenery and an attractive lifestyle--continue to attract new residents to the area. With expected population growth come concerns about how best to provide water supplies to support new residents and industries.

Several water supply projects have been proposed, including the development of the Virgin River Basin, agricultural conversion, imports, groundwater development, and wastewater reuse, among others. In addition, the Lake Powell Pipeline has been proposed to bring water from the Colorado River to Washington County.

In 1998 the Washington County Water Conservancy District (WCWCD) retained Boyle Engineering to provide an analysis and recommendations regarding potential water supplies for the region. Boyle's recommendations were provided in a report titled *Water Supply Needs for Washington and Kane Counties and Lake Powell Pipeline Study*, hereinafter referred to as the "Boyle Report". Hydrosphere was retained by the Grand Canyon Trust to review the baseline assumptions presented in the Boyle Report and to provide an independent assessment of water supply needs for the area.

Key findings of this study include:

Boyle's projections of future population are too high--Boyle based its estimates of future water needs on population levels projected for the year 2050, at which time Boyle estimates there will be 525,000 residents in the area around St. George. This population estimate is about 60 percent greater than the "buildout" population envisioned by the consolidated development plans of the twelve municipalities (328,000 people). The population estimated by Boyle would require development of considerably more land at higher densities than contemplated by currently accepted development plans.

Boyle's estimates of per-capita water use are too high--Future water use based on more realistic assumptions regarding growth in different sectors would be about 185 gpcd in 2050 (including secondary use). In the alternative analysis presented in this study, secondary water is not considered when accounting for future water demands: we have assumed land irrigated by existing irrigation ditches will be developed, water will be converted to residential uses, and that no new facilities for delivery of secondary water will be converted. This water conversion will depend, among other factors, on the water quality for residential use. Therefore, growth in the secondary sector was not considered in this study.

Boyle’s projections overestimate future water demand--Boyle did not consider the effect of price elasticity, which would further reduce water use. The time path of water

demand in Washington County presented in this study as an alternative scenario, considers both water conservation and price elasticity. An economic/financial model has been developed to account for these variables in the determination of water supply needs. In general, water use per capita will decrease as a result of water conservation and the cost of investment in new water supply projects.

No imported water is required to meet realistic water needs of the region--Because its population estimates and per capita water use estimates are too high, Boyle's estimates of regional water needs in 2050 are more than double more realistic estimates. Using more realistic assumptions this study shows that an ample supply of water is available to support future growth in the region without the need to import water from the Colorado River. In fact, only under high population growth scenarios, which far exceed maximum buildout conditions in Washington County, there would be the need to build the Lake Powell Pipeline Project.

1. Introduction

The objective of this study is to determine the need for the proposed Lake Powell pipeline project as a future water supply source for Washington County, Utah. Washington County has experienced rapid population growth concentrated in urban areas. The in-migration has played an important role in this county's demographic dynamics, in conjunction with a relatively young population, high birth rate, low death rate, and long life expectancy. Climate, recreation opportunities, and high quality of life have been important factors contributing to the high in-migration rates in this part of the state of Utah.

In order to meet increasing water demands in the county, several water supply projects have been proposed. Water development projects include the development of the Virgin River Basin, agricultural conversion, imports, groundwater development, and wastewater reuse, among others. In addition, the Lake Powell Pipeline, a quarter-billion dollar project has been proposed to bring 70,000 AF of water from the Colorado River to Washington County. The proposed pipeline would have considerable environmental impacts. In particular, it would have the potential to introduce additional exotic fish species in the Upper Virgin River basin, which could affect native fish species federally listed as threatened and endangered.

Because of its high monetary and environmental cost, this project would normally be considered for development only after less costly projects. However, a study prepared by the Boyle Engineering Corporation for the Washington County Water Conservancy District and Utah State Division of Water Resources (WCWCD and USDWR, 1998, referred in this study as the "Boyle Report") recommended development of the project in the near-term future (between 2035 and 2040) to provide additional water supply to Washington County.

Many of the assumptions used in the Boyle Report appear to be unrealistic, leading probably to an overestimation of future water needs in Washington County. This study was commissioned by the Grand Canyon Trust to review the assumptions presented in the Boyle Report, and to determine more realistic water supply needs in Washington County for the next 50 years.

Section 2 presents a brief description of the Boyle Report, including its main underlying assumptions. Section 3 presents an analysis of existing population projections, which will be used in this study to determine scenarios of water demands in Washington

County. Section 4 addresses considerations about water use rates in Washington County. Section 5 presents the alternative sources of future water supply in Washington County which are considered as technically, economically, and environmentally feasible to meet increasing water demands in the region, and section 6 analyzes the different water demand scenarios. The assessment of the project need is set out in section 7. The conclusions are summarized in section 8.

This study used an economic/financial model developed by Dr. Tom McGuckin (EnWater Resource Consultants) which accounts for the price elasticity of water use. A detailed description of the model's underlying assumptions is presented in Appendix A.

2. Summary of Boyle Report

In 1998 the Washington County Water Conservancy District (WCWCD) retained Boyle Engineering to provide an analysis and recommendations regarding potential water supplies for the region. Boyle's recommendations were provided in a report titled *Water Supply Needs for Washington and Kane Counties and Lake Powell Pipeline Study*.

Population projections for the Boyle Report were based on the 1988 projections prepared by the Utah Governor's Office of Planning and Budget. Boyle estimated future water needs for the region based on these population estimates. Estimates of future municipal, industrial and secondary demands in Washington County took into consideration population growth and water conservation which was assumed to decrease future demands up to 25% by the year 2050.

Boyle estimated that by 2050 there will be 525,000 people in the area around St. George, a population that is about 60% greater than the "buildout" estimates of population contemplated by the consolidated general plans of the twelve municipalities in the region (328,000 people).

Boyle estimates current per-capita water use in Washington and Kane counties to be 455 gallons per capita per day (gpcd). Boyle assumes that that water use in all sectors, including industrial, commercial and secondary uses (untreated water supplied by existing irrigation ditches within municipal boundaries) will grow in direct proportion to population. Even including conservation savings of 25 percent, Boyle estimates that per capita water use in 2050 would be 340 gpcd.

Based on their estimates of population and per-capita water use rates, Boyle predicts that regional water use will increase from a current level of 34,916 AF/year to 200,619 AF/year in 2050.

Several water development projects were identified and evaluated for meeting future water demands. The Lake Powell Pipeline is identified as one of the water supply projects required to cover water demand needs in Washington County.

3. Population Projections

This study considers several population projection scenarios that are used to determine future water supply needs in Washington County. Following is the description of each scenario as well as their fundamental assumptions. A comparison between the different scenarios is presented at the end of this section.

Two different types of population projections are presented: buildout population estimates and time series or year-by-year population projections. Buildout projections refer to one point in time and represent estimates of ultimate population levels. The determination of these levels are based on the availability of developable lands, land use, zoning, and population limits and associated quality of life. Time series estimates consider a growth rate on a yearly basis, and extend through a considerable period of time. Usually, time series do not include limits to growth. Buildout estimates can be used to validate time series estimates; if maximum population levels achieved through time series estimates exceed ultimate population levels, then they may be overestimating the region's population capacity and should be considered with caution. In other words, time series population estimates must lead to reasonable ultimate populations.

3.1. Description of Population Projection Scenarios

Population projections for Washington County considered in this study include the following aspects:

- Use of most recent population data (Census and projections);
- Consideration of regional buildout conditions in order to maintain quality of life; and
- Availability of developable land, land use, and zoning restrictions.

Two buildout population estimates were used for reference purposes. One such estimate was built up from estimates made in individual municipal general plans (WC, 1997) and buildout projections were obtained from the 1994 Population Management Study for Washington County (WCWCD, 1994).

Two sets of year-by-year population projections are considered:

- Population projections from the 2000 Economic Report to the Governor (Utah Office of Planning and Budget, 1999); and

- 3 population projections from the 1995 Purpose & Need Study for Washington County (WCWCD, 1995).

A brief description of each population projection is presented in the following sections. When available, the main assumptions considered in the elaboration of the projections are summarized. When comparing population estimates, it is important to note that while some correspond to buildout conditions, others are based in growth rates without buildout considerations.

3.1.1. Composite Estimates from Individual General Plans

Composite estimates from individual general plans were considered by the Washington Conservancy District in response to the broad range of population estimates. Table 3.1 presents the population in 1995 and at buildout for each community where data was available.

Table 3.1 - Population Projections from individual general Plans in Washington County

Community	Population (1995)	Population (Buildout)
Ivins	2,000	22,000
Santa Clara	3,200	13,500
Saint George	40,000	130,000
Washington	5,000	40,000
Hurricane	6,000	110,000
La Verkin	2,600	6,600
Toquerville	450	1,000
Virgin	300	370
Rockville	220	
Springdale	300	
Leeds	420	1,500
Hildale	1,600	3,140
Total	62,090	328,110

Source: WC, 1997

3.1.2. Population Management Study for Washington County

The three buildout scenarios presented by the 1994 Population Management Study for Washington County (Table 3.2), take into account the lands in Washington County capable of supporting residential use, as well as different land use and zoning assumptions. Population density limits and associated quality of life is an important consideration. Rapid growth in Washington County has contributed to an increase in prosperity but has also challenged the maintenance of the region's quality of life.

Table 3.2- Washington County Population Projection Summary

Scenario	Total Population
One	142,143
Two	333,332
Three	706,838

The main assumptions underlying each growth scenario, referred to in this study as WCD low, medium, and high scenarios, are summarized in Table 3.3.

Table 3.3- Population Projection Main Assumptions

Scenario	Assumptions
One	• Based on community zoning plans as of October 1993 (Low intensity of growth) • Total area of development: 207,000 acres
Two	• Based on Blooming Hills community (Moderate intensity of growth) • Total area of development: 225,000 acres
Three	• Based on the area from West Black Hills to East Black Hills (High intensity of growth) • Total area of development: 225,000 acres

3.1.3. Utah Office of Planning and Budget (GOPB 1998)

The Utah Governor's Office of Planning and Budget (GOPB) prepared population estimates through the year 2050, for the Utah Division of Water Resources in 1998. The model that determines Utah GOPB population estimates does not rely on historical trends. Instead, the model includes estimated births, deaths, net in/out migration, goods and services provided or anticipated, and projected labor market.

The Demographic and Economic Analysis Section of the Governor's Office of Planning and Budget is responsible for the coordination and staffing of the Utah Population Estimates Committee (1999 Population Estimates for Utah). The UPEC complements and augments the U.S. Bureau of the Census estimates.

The UPEC develops population estimates using a combination of the Component II or school enrollment method, a method based on membership in the Church of Jesus Christ of Latter Day Saints (LDS), and a method based on tax return data from the Internal Revenue Service (IRS).

UPEC population estimates are very close to the ones prepared by the U.S. Bureau of the Census, although there are exceptions from year to year and county to county. While UPEC uses more current birth and death data and draws from local data sources on school enrollment and LDS membership, the Bureau of the Census relies primarily on IRS return data and Medicare, group quarters data, vital statistics, and data on housing units. In general, The Bureau of the Census underestimates population in university-influenced counties, as many in-migrant students do not file tax returns prior to attending college. In counties with small LDS population or where school enrollment is a poor indicator of migration, the UPEC estimates are not very accurate.

According to the Governor's Office of Planning and Budget 1998 Report, growth rates decreased in the late 1990's: 6.7% (1980 - 1997) to 4.7% (1996-1997). This drop in population growth is apparent in the population projections after 2000. UOPB's growth rates continue to drop through 2020, and then rise to 3.68 from 2025 through 2050 (See Table 3.4). These population estimates were used in the Boyle Report to determine future water needs in the region.

3.1.4. Utah Office of Planning and Budget (GOPB 1999)

The 2000 Economic Report to the Governor (January 2000[1]) presents a new set of long term demographic and economic projections for the State of Utah, produced by the Demographic and Economic Analysis Section of the Governor's Office of Planning and Budget (Table 3.5). In this study, we adopted this new set of estimates as they reflect updated information on population growth in Washington County.

3.1.5. Washington County Water Conservancy District

In 1995, the Washington County Water Conservancy District[2] considered three population projections based on different levels of population growth: low, medium, and high. These scenarios will be referred to in this study as WCWCD low, medium, and high scenarios. The low growth scenario assumes that future growth rates will decline as current growth rates are considered non-sustainable. Medium growth is based on a constant growth rate of 6.7% until 1995, followed by a gradual reduction, reaching 2.15% 2040. The high growth scenario assumes a constant growth rate of 6.7% until 2000,

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[1] Data available at the web site: http://www.gvnfo.state.ut.us/dea/Projections/projections.html

[2] Feasibility study of the Lake Powell Pipeline (WCWCD, 1995), also known as the 1995 "Purpose and Need Study."

followed by a gradual reduction, reaching 2.5% in 2035. Population estimates and corresponding growth rates for each scenario are presented in Table 3.6.

Table 3.4- Washington County Population Projections

Year	Utah GOPB 1998 Estimate	Annual % change
1990	49,100(*)	
1995	68,504	6.89
2000	86,222	4.71
2005	106,594	4.33
2010	130,529	4.13
2015	155,015	3.50
2020	177,570	2.75
2025	212,720	3.68
2030	254827	3.68
2035	305269	3.68
2040	365697	3.68
2045	438085	3.68
2050	524803	3.68

Source: Boyle Report, 1998
(*) This figure corresponds to the UOPB 1994 estimate. The April 1 U.S. Census Modified Age, Race and Sex (MARS) population for 1990 is 48,560 (Washington County)

Table 3.5 - Washington County Population Projections GOPB 1999 (2000 provisional baseline)

Year	Population	Annual % change
1980	26,065	
1990	48,560	6.42
2000	83,781	5.61
2005	100,447	3.70
2010	122,272	4.01
2015	144,370	3.38
2020	165,346	2.75
2030	218,198	2.81

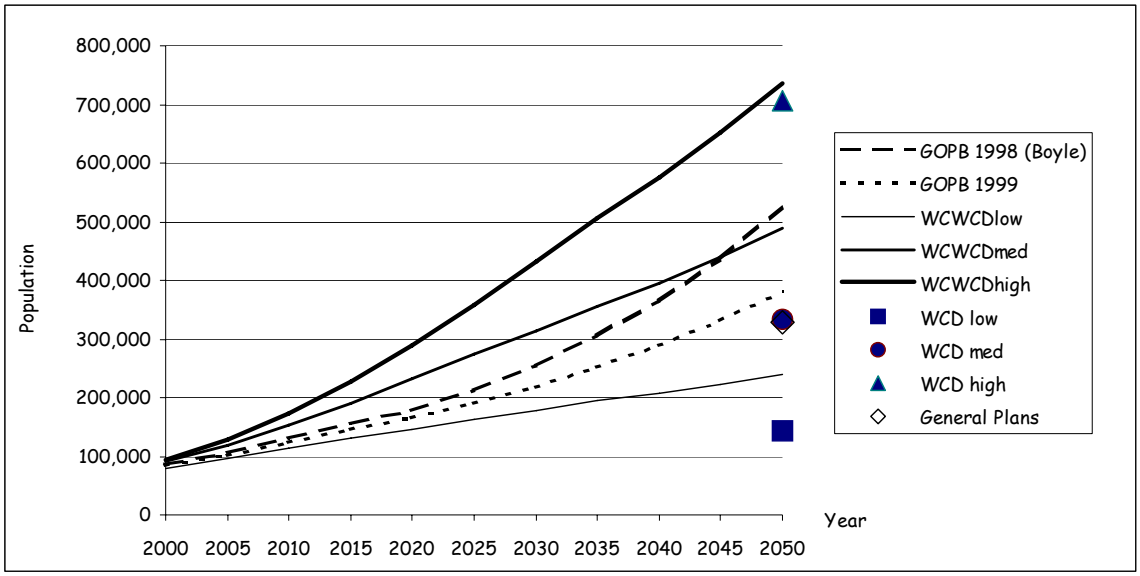
Table 3.6 - Washington County Population Projections (WCWCD, 1995)

Year	Low Growth		Medium Growth		High Growth	
	Population	Annual % change	Population	Annual % change	Population	Annual % change
1990	48,560		48,560		48,560	
1995	67,158	6.70	67,158	6.70	67,158	6.70
2000	80,229	3.62	90,298	6.10	92,880	6.70
2005	96,676	3.80	118,016	5.50	127,269	6.50
2010	112,074	3.00	150,621	5.00	171,119	6.10
2015	128,668	2.80	188,601	4.60	224,176	5.55
2020	144,867	2.40	227,812	3.85	283,398	4.80
2025	160,731	2.10	266,671	3.20	349,799	4.30
2030	175,727	1.80	304,669	2.70	419,480	3.70
2035	190,242	1.60	342,190	2.35	488,658	3.10
2040	203,937	1.40	380,592	2.15	552,872	2.50

3.2. Comparison of Population Projections

Figure 3.1 illustrates the different population scenarios for Washington County referred to above. With the exception of the estimates from the Governor's Office and from the Washington County WCD (1995), population levels correspond to buildout scenarios.

Figure 3.1- Comparison of Population Estimates



Assuming that the population growth rates under the GOPB 1999 scenario remain constant from 2030 through 2050[3], the long-term population projection for 2050 would be about 379,800 in Washington County. This new population projection for 2050 is very close to the medium buildout population level (WCD Med) presented in the 1994 Population Management Study for Washington County and to the population projections from individual general plans in Washington County. Therefore, the GOPB 1999 scenario is considered in this study as the most likely population growth scenario for Washington County.

These population levels are considerably lower than the GOPB estimate of 1998 used in the Boyle Report, which projected a population in 2050 of 524,803. This 1998 estimate is considerably higher than the moderate buildout projections in the 1994 Population Management Study for Washington County. According to the assumptions made for the different buildout scenario in the 1994 study, the peak population of 524,803 from the GOPB in 1998 would require high density development (such as that in central St. George) over the entire area between West Black Hills and East Black Hills. The Boyle

[3] This assumption has been considered in the 1998 estimates from the Demographic and Economic Analysis Section of the GOPB.

Report uses the GOPB estimate of 1998, therefore overestimating future demands for water supply in Washington County.

When generating county population projections, the GOPB adjusts the resident population growth of a city "upward" if "there are (…) amenity (quality of life) advantages relative to other locations."[4] Given that the GOPB doesn't consider limits in population growth in order to preserve the quality of life in a region, it is not surprising that their population estimates are consistently higher than the alternative ones.

On the other hand, population estimates from the general plans at buildout are slightly lower than the GOPB's projections for 2050, and very close to the medium buildout population level (WCD Med) presented in the 1994 Population Management Study for Washington County.

The population projections presented in WCWCD (1995) are substantially higher than the corresponding buildout WCD 1994 scenarios, with the exception of the high estimate.

[4] Procedure for Generating City Population Projections: a Note to the Associations of Governments From GOPB, July 22, 1997

4. Water Use

4.1. Introduction

Estimates of water requirements at some time in the future are made by multiplying the projected population at that point in time by an estimate of per-capita water consumption (expressed in gallons per capita per day (gpcd)) for the same point in time. Average per capita water consumption rates vary across the different water use categories: residential, commercial, institutional, industrial, and secondary use. Secondary water use includes untreated water supplied by existing irrigation ditches within municipal boundaries. These water use categories can be further disagregated in indoor and outdoor use rates.

The next two sections describe (a) the main assumptions in the Boyle Report regarding water use in Washington County and (b) the main assumptions made in this study. The latter includes a comparative analysis between the two approaches.

4.2. Water Use in the Boyle Report

The Boyle Report reported that the municipal and industrial average daily per capita consumption rate in Washington County is 335 gpcd, which is significantly higher than the state average (284 gpcd) and consumption in other cities in the country with similar characteristics (Table 4.1).

Table 4.1 –Representative U.S. Water Use Rates

City	Demand (gpcd)
Albuquerque, NM	250
Phoenix, AZ	175
Tucson, AZ	170
San Antonio, TX	157
Grand Junction, CO	263
Greeley, CO	376
Denver, CO	217
Las Vegas, NV	325
Tacoma, WA	234
Seattle, WA	194

Source: Boyle Report, 1998

The Boyle Report also includes secondary water use in calculating per-capita water demand. When secondary water use is included, the per-capita water use is 455 gpcd.

In calculating future water use, the Boyle Report assumes that the current per-capita water use (455 gpcd) will be reduced by 25% over the next 50 years, to a level of 340 gpcd in 2050.

By aggregating all classes of water use, the Boyle Report assumes that all of these sectors will grow in direct proportion to population growth. This is not the case – commercial and industrial water use typically grow at a slower rate than population. Boyle Report's assumption that secondary water use will grow with population is particularly suspect. Secondary water is an artifact of low-density residential development into agricultural areas. These low-density developments will tend to be re-developed at higher densities to accommodate the population growth that will occur at buildout. The intensive residential development projected to occur in the area is incompatible with maintenance of an extensive system of surface water distribution ditches required to support secondary water uses. Those existing secondary water supplies along with other surface-water supplies for irrigation through ditches will be converted to municipal use as quality considerations allow.

Finally, the Boyle Report does not account for price elasticity, i.e., water demand does not respond to changes in water prices. Changes in water prices result, in this case, from the development of new water supply sources in Washington County.

4.3. Water Use in this Study – Comparative Analysis

This study applies the same water use data as presented in the Boyle Report. However, this study separates the residential water supply use from other public uses. Commercial, municipal, and industrial water uses total 10,845 AF/year. Subtracting this amount from the total publicly supplied water in Washington County leads to a residential use of 18,708 AF/year or 212 gpcd.

The Boyle Report assumed that both residential and non-residential water use grew in proportion to population. The economic/financial model presented in section 7 is based in the assumption that population growth will affect primarily residential water use and that commercial, municipal, and industrial water use will grow at a lower rate than residential water use. Specifically, it is assumed that the increase in demand for commercial, municipal, and industrial water use will constitute about 30% of total growth in water demand.

This study assumes that land irrigated by existing irrigation ditches will be developed and water will be converted to residential uses. This water conversion will depend, among other factors, on the water quality for residential use. Therefore, water demand associated to the secondary sector was not considered in this study.

Finally, this study assumes that water demand in the residential sector is price elastic, i.e., it responds to a change in water price. As new water supply sources are developed in Washington County, water prices increase and, consequently, water use is reduced. Details about price elasticity and demand function used in this study are presented in Appendix A.

In conclusion, lower water use in the commercial, industrial, and municipal sectors, conversion of lands currently irrigated by secondary water supply systems, and consideration of price elasticity result in significantly lower water use rates than the ones used in the Boyle Report. Implications of these assumptions in water demand in Washington County are discussed in section 6.

5. Alternative Sources of Water Supply

The alternative sources of water supply in Washington County considered in this study are summarized in Table 5.1. Water development projects include the development of the Virgin River Basin, agricultural conversion, imports, groundwater development, and wastewater reuse, among others.

Water conservation in Washington County is expected to reduce water demand by 25%. This reduction is to be achieved over a 50-year period, reaching 25% by the year 2050[5]. In this study it was assumed that this water conservation goal would be applicable only to the residential sector. Water conservation in the remaining sectors would reach 5% by 2050. After 2050, water conservation is not expected to occur. However, additional water conservation could take place primarily through the implementation of more aggressive price structures.

The water supply alternatives are taken into account in the economic/financial model described in section 7 and in Appendix A. In addition to the yield, the model takes into consideration the cost and lifetime of each individual project.

[5] See page 30 in Boyle Report

Table 5.1- Future water development projects in Washington County

Name	Description	Yield
Sand Hollow Reservoir	Sand Hollow Reservoir would be located approximately 5.5 miles southwest of Hurricane, with a proposed capacity of 30,000 to 68,000 AF. It would be connected to the Quail Creek system.	12,000 AF/year
North Creek Reservoir	North Creek Reservoir would be located approximately 1.5 miles northeast of the town of Virgin, Utah, with a proposed capacity of 20,000 AF.	4,000 AF/year
Removal of Pah Tempe Springs from the Virgin River	The removal of the high saline springs from the Virgin River would allow a reduction in irrigation demand in Washington Fields. The high irrigation demands are needed to reduce the high salinity by flushing it out of the system. The reduction in demand needs would allow the conversion to sprinkler irrigation systems.	40,000 AF/year
Treatment of Virgin River Water	Purchase of irrigation water rights from Washington Fields by the Washington County Water District.	15,700 AF/year
Lake Powell Pipeline	Construction of a 120 mile long Pipeline from Lake Powell, Arizona, to Washington County, Utah.	70,000 AF/year
Crystal Creek Pipeline	Construction of a 12-13 mile long pipeline to convey water from Crystal Creek to Kolob Reservoir	2,000 AF/year
Groundwater development	Development of groundwater supply in the Virgin River Basin.	16,000AF/year
Wastewater Reuse	Wastewater reuse for limited irrigation of golf courses, parks, and municipal facilities.	10,000 AF within 10 years, 20,000 AF by 2050
Agriculture conversion(a)	Some agriculture land would be converted to residential use and the agricultural consumptive use would be transferred to domestic water supply.	43,460 AF by 2050
Conservation	Implementation of conservation measures, including public education, rate structures and institutional regulations.	25% of residential water demand and 5% of commercial, industrial, and municipal water demand by 2050

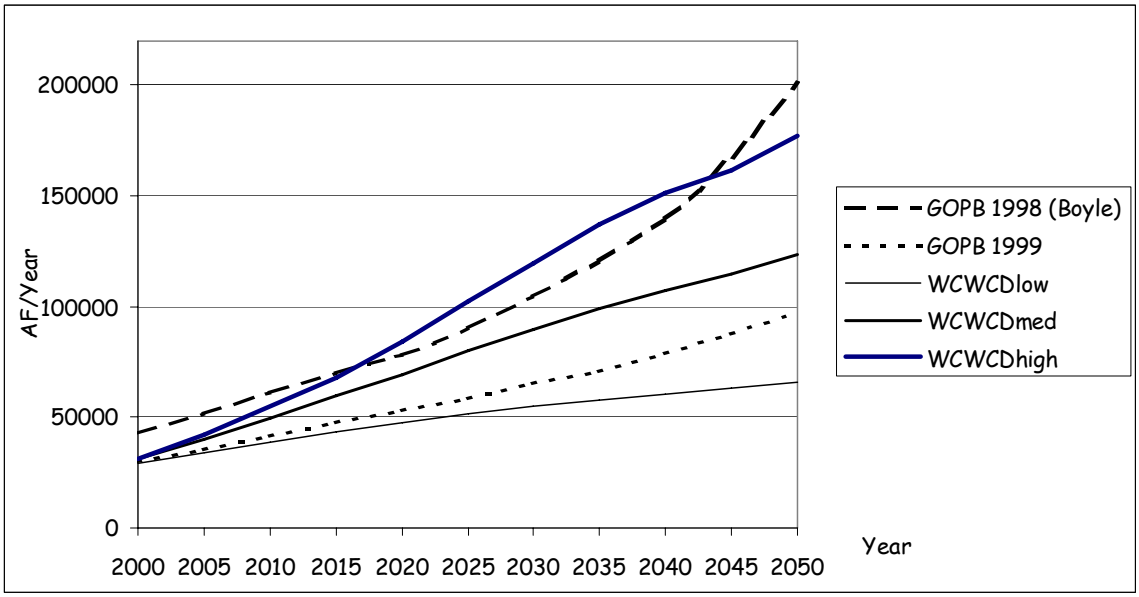
Source: Boyle Report.

(a) The term "agricultural conversion" is used in this study to indicate land transfers and associated transfer in water rights. It should not be confused with the availability of water from agriculture land subject to water conservation (such as the use of sprinklers) for domestic use.

6. Water Demands in Washington County

The water demand estimates in Washington County vary with the population projections considered, assuming a constant water use rate. Given the different population projections discussed above (section 3), Figure 6.1 illustrates the corresponding scenarios for water demand in Washington County through the year 2050.

Figure 6.1- Projected water demand in Washington County (AF/year)



The water demand is a function of a variety of factors and not a linear function of population growth and water use rates, as presented in most management plans. Those factors include economic factors, conservation programs, and the price of water. The determination of the water demand in Washington County developed in this study takes into account both the effect of the implementation of conservation programs, and the effect of price elasticity of water use. The water demand estimates presented in the Boyle Report only consider water conservation and largely overestimate water needs in Washington County (see discussion in section 4.) Therefore, they were not included in the following analysis of water supply project needs.

The economic/financial model presented in the next section, and described in detail in Appendix A, takes into consideration new water supply projects and the water price changes caused by these projects. Changes in water demand result from the combination

of responses to higher prices, increasing conservation rates, and a growing population. Details about the assumption underlying these calculations are presented in following sections and in Appendix A.

7. Project Need

7.1. Economic/Financial Model

In order to account for the effect of increasing cost of water supply in Washington County on the water demand, an economic and financial model of water supply - Washington County Supply Model - was developed. This model estimates water use in Washington County through the year 2050, based on the price elasticity of water use. It considers different population growth scenarios and several water supply projects.

The main assumptions considered in the model are presented in Appendix A. The results of the water supply analysis using this model are presented below.

7.2. Water Supply Projects Not Included in the Model

There are three water supply projects that were not included in the model discussed above. The first is the Ash Creek Project. The second is the reuse of municipal wastewater. Reuse water could be used to irrigate golf courses, parks, and municipal facilities. The third is the available supply stemming from conversion of agricultural land into residential lots.

The Ash Creek project consists of a collection system and a transmission line. The collection system would serve to increase the contribution of several Ash Creek's tributaries to Ash Creek Reservoir. The transmission line would carry the water from Ash Creek to the towns of Toquerville and Hurricane. This project was not considered in this study due its relatively low yield (5,000 AF/year) and large costs. Its unit cost (cost per AF) is considerably higher than the proposed Lake Powell Pipeline.

Reuse has been quantified in the Boyle Report as yielding 6,700 AF in a ten-year period with a maximum of 20,000 AF by 2050. It is assumed that reuse would grow at a conservative rate of 1% to 2% per year. The consideration of reuse in the model would require: (1) an assumption regarding the growth rate of reuse that should be a function of population growth (or water use); and (2) the determination of reuse costs in order to evaluate the effect of price of water in demand reduction. Because reuse costs were not available, this project was not included in the model.

Additional municipal water supplies become available from irrigation water rights appurtenant to land purchased for development. This water supply can constitute the

majority or, in some cases, the totality of the water required by the developed uses. Much of the land that will be developed in Washington County is irrigated land.

About 82,000 AF of water per year (page 3, Boyle Report) are used to irrigate lands in Washington County. The 1995 Purpose and Need Study (WCWCD, 1995) indicates that approximately 60,000 AF would be appurtenant to lands available for development. Assuming that agricultural efficiency is approximately 50% (as reported in the USGS 1995 National Water-Use data files[6]) then, roughly, this water would be available for transfer to municipal uses.

Much of the agricultural water in Washington County has levels of dissolved solids too high for municipal use without previous treatment. Additional site-specific information is required to determine the quantity of each irrigation water supply and the cost of treatment of those supplies. For these reasons we did not include water from developed irrigated lands as a municipal water supply source in the analysis.

It should be noted, however, that agricultural activities, including irrigation, will cease on developed lands. This makes the entire irrigation supply available to supplement river flows at the headgate, measured as the amount diverted for application. Below the point at which all return flows have accrued to the river, the net effect on the river will be quantified by the amount of consumptive use from previous irrigation of the developed lands.

7.3. Results

The need of new water supply projects to meet increasing water demands in Washington County was analyzed using the different population growth scenarios identified in section 3 and the model presented above and in Appendix A. The results of this analysis include: (1) projected population, (2) projected water demand, (3) the time path of water prices, (4) time path of residential use per capita, and (5) the schedule of capital projects. While results (1) and (2) are presented simultaneously for the four different scenarios of population growth, results (3) through (5) are presented individually for each scenario.

7.3.1. Projected Population

The population in Washington County is expected to increase through the year 2050, as illustrated in Figure 7.1. In addition to the time path of population, the buildout population scenarios (WCD low, WCD medium, and WCD high) determined in WCWCD (1994), which are based on land use, zoning and population density (see section 3.1.4), are also presented.

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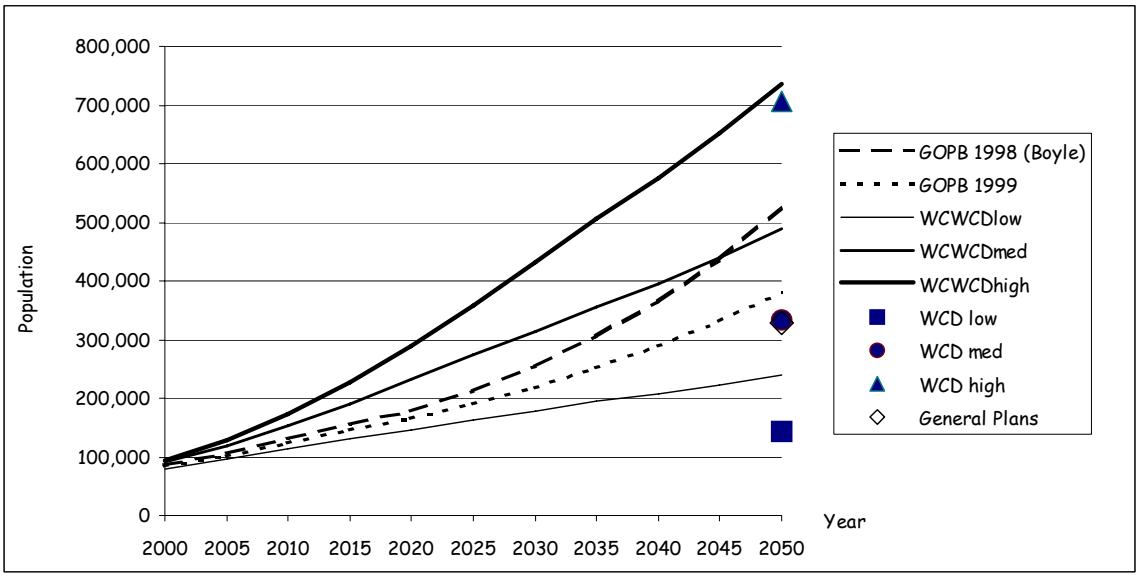
[6] http://water.usgs.gov/watuse/spread95.html

The population projections (WCWCD and GOPB 1999) do not consider buildout conditions, and they exceed the buildout population levels defined by WCWCD (1994). The GOPB 1999 population projections for the year 2050 are the closest to the medium buildout conditions, and therefore can be considered as reasonable. Further considerations regarding population projections require, nevertheless, additional studies that would provide a more realistic and updated reality of possible levels of development.

Figure 7.1- Projected and buildout population in Washington County

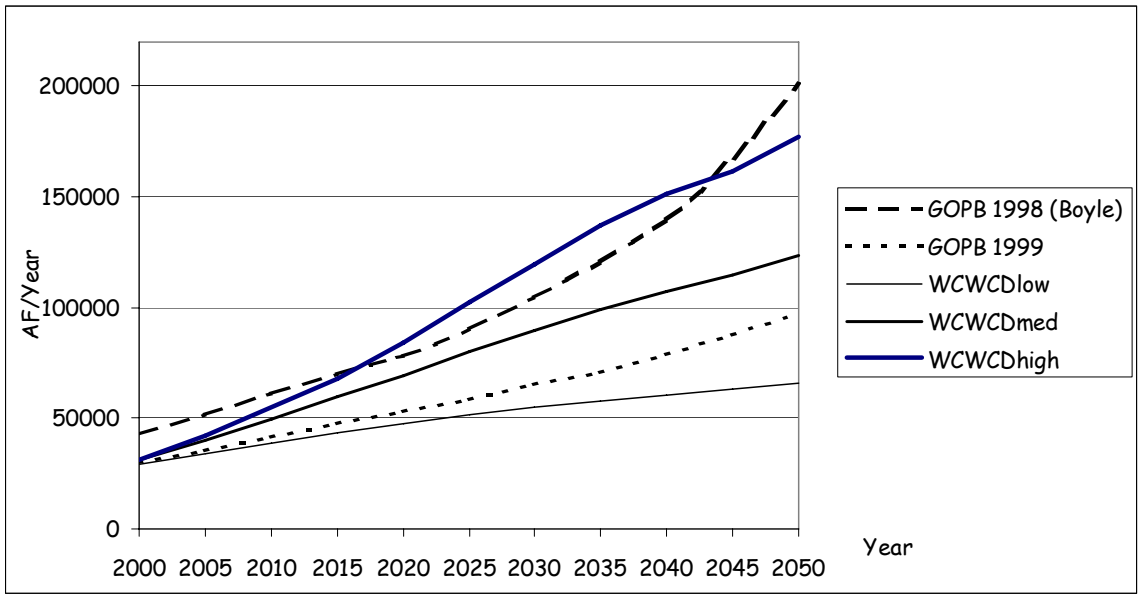


7.3.2. Projected Water Demand

The demand for water supply in Washington County associated to the different population projection scenarios is illustrated in Figure 7.2. As mentioned earlier in this report, water demand scenarios include the effect of water conservation programs. Water conservation is expected to increase up to 25% in the residential sector and 5% in the commercial sector by 2050.

The demand for water supply under the WCWCD high scenario is significantly lower than the projected demand in the Boyle Report. By 2050, the Boyle Report estimates a total demand of 200,619 AF/year (with conservation), while the WCWCD high scenario leads to a total demand of 177,500 AF/year. High population estimates, high per capita water use consumption, and the oversight of the effect of price in water consumption are the main factors that lead to the overestimation of water needs in Washington County in the Boyle Report.

Figure 7.2- Projected water demand in Washington County (AF/year)



7.3.3. Water Prices

The average water prices are a function of two factors: water demand and the cost of new water supply investments. In turn, water demand varies with water conservation (included under all the scenarios considered in this study) and the cost of new water supply investments. Figures 7.3 through 7.6 illustrate the time path of water prices in Washington County for different growth scenarios. To better understand the changes in water prices, the reader should refer to the table (Table 7.1) where the capital projects necessary to meet water demands under each scenario are summarized.

Under the WCWCD low scenario, one single new water supply investment results in a considerable increase in water price. Under this scenario, there is a positive slope in the water price, indicating that the decrease in water use (and therefore the increase in price per capita) resulting from water conservation policies, exceeds the effect of population growth in water prices (other conditions being the same, population growth moves the unit price down).

Under the GOPB 1999, WCWCD medium and high scenarios, a greater number of new water supply projects is needed in order to meet higher water demands. Consequently, increases in water price are significantly higher than under the WCWCD low scenario. The water prices increase substantially as new projects are included in the system. After the introduction of each new water supply project, the water prices decrease significantly. In these cases, the decrease in prices occurs as the effect of high population growth rates

(decrease of the unit average price of water) more than compensates for the effect of conservation policies.

Figure 7.3- Projected water prices in Washington County (average price/1000 gallons): GOPB 1999 scenario

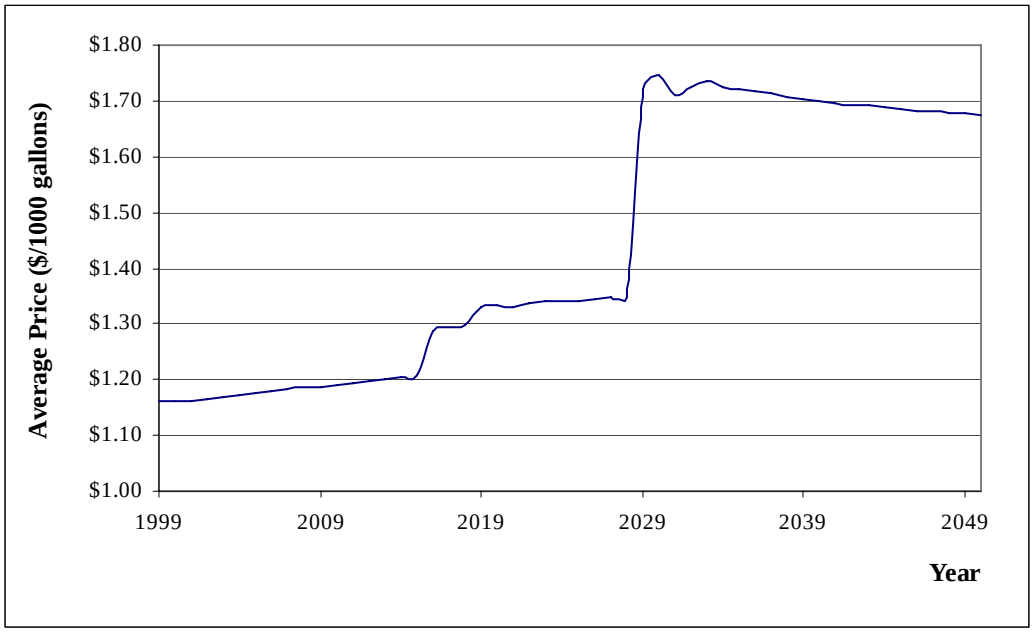


Figure 7.4- Projected water prices in Washington County (average price/1000 gallons): WCWCD low scenario

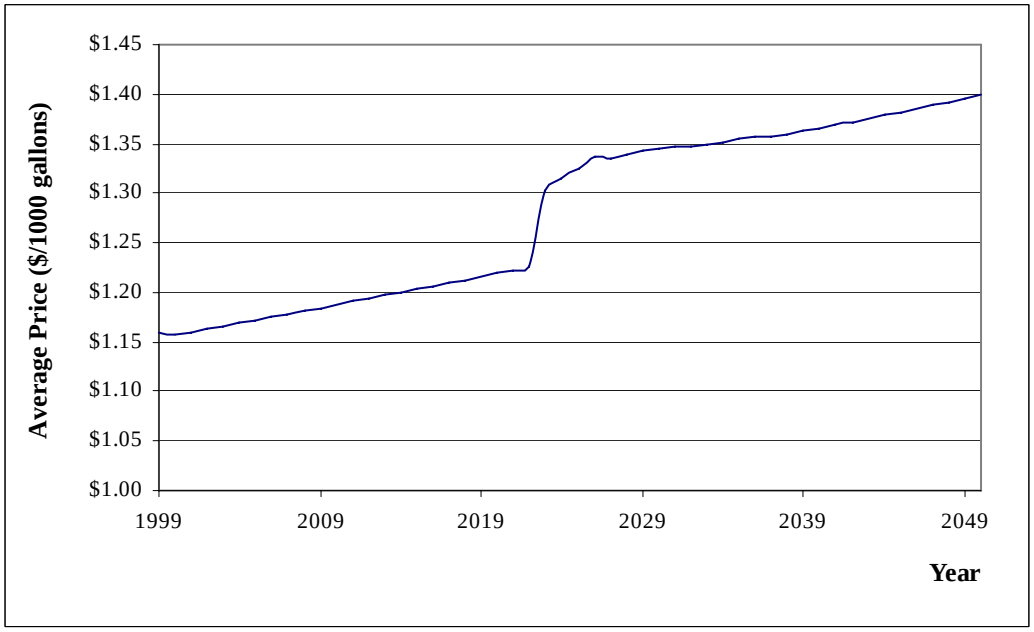


Figure 7.5- Projected water prices in Washington County (average price/1000 gallons): WCWCD medium scenario

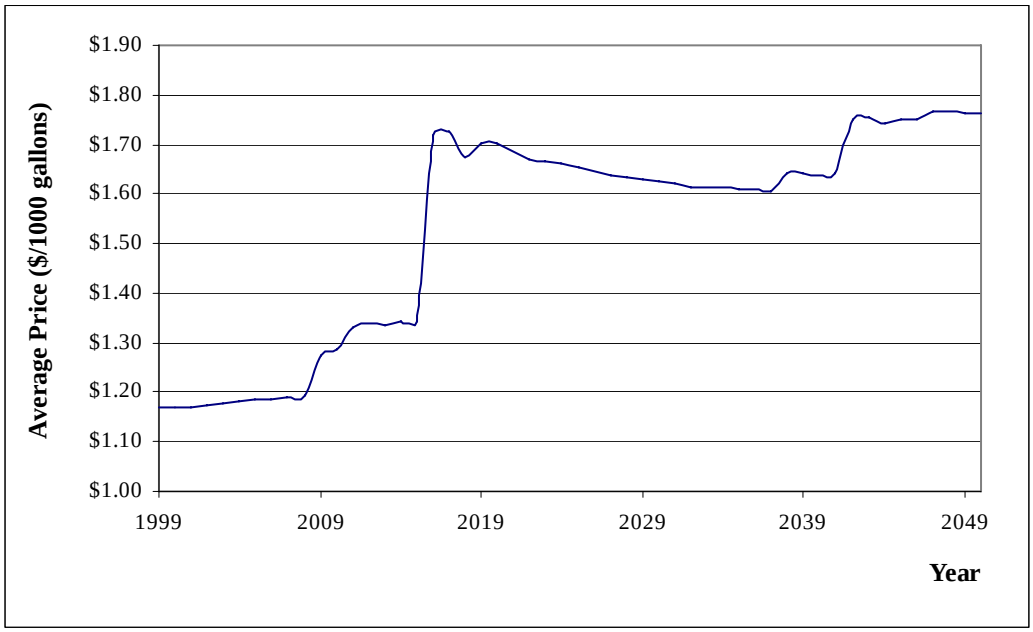
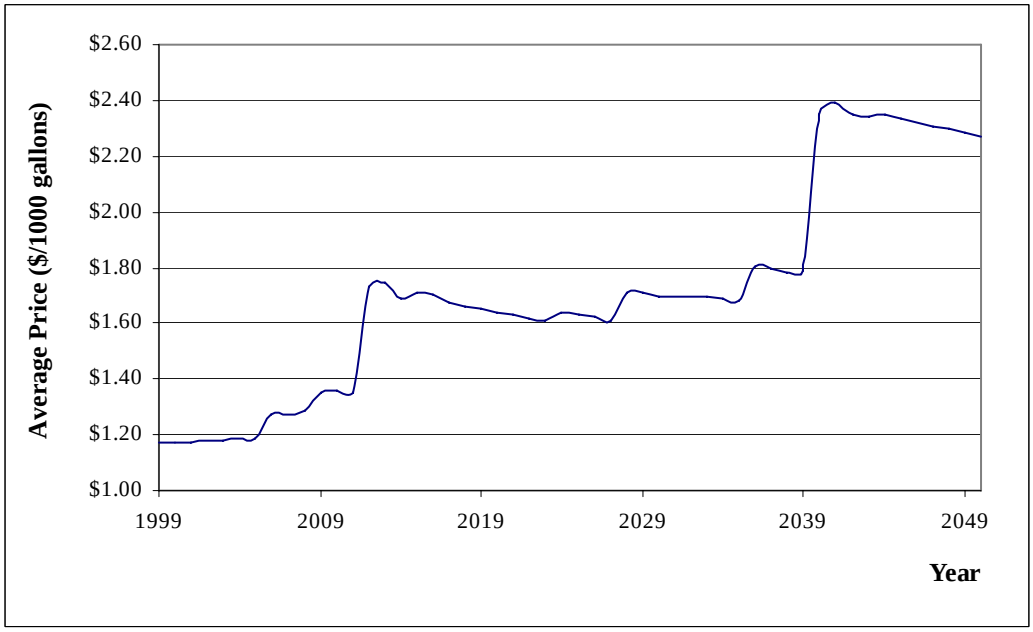


Figure 7.6- Projected water prices in Washington County (average price/1000 gallons): WCWCD high scenario



7.3.4. Residential Use

The time path of residential water use in Washington County is illustrated in figures 7.7 through 7.10. Residential water use is quantified in gallons per capita per day (GPCD). Water use is a function of the price of water and conservation programs. As expected, greater water use reductions occur under the GOPB 1999, WCWCD medium and high scenarios because higher prices result when more new water supply projects are needed to meet increasing demands.

Under the GOPB 1999 scenario, considered in this study as a reasonable population growth scenario in Washington County, groundwater development and the Pah Tempe Springs Project are sufficient to meet future water demands. Figure 7.11 illustrates the time path of water demand and potential supply in Washington County under the GOPB 1999 scenario. Considerable increases in water supply are a result of the introduction of low cost supply projects. Projects with lower supply potential are available at a much higher per unit cost and therefore were not given preference in this study.

Figure 7.7- Projected water residential use in Washington County (gallons per capita per day): GOPB 1999 scenario

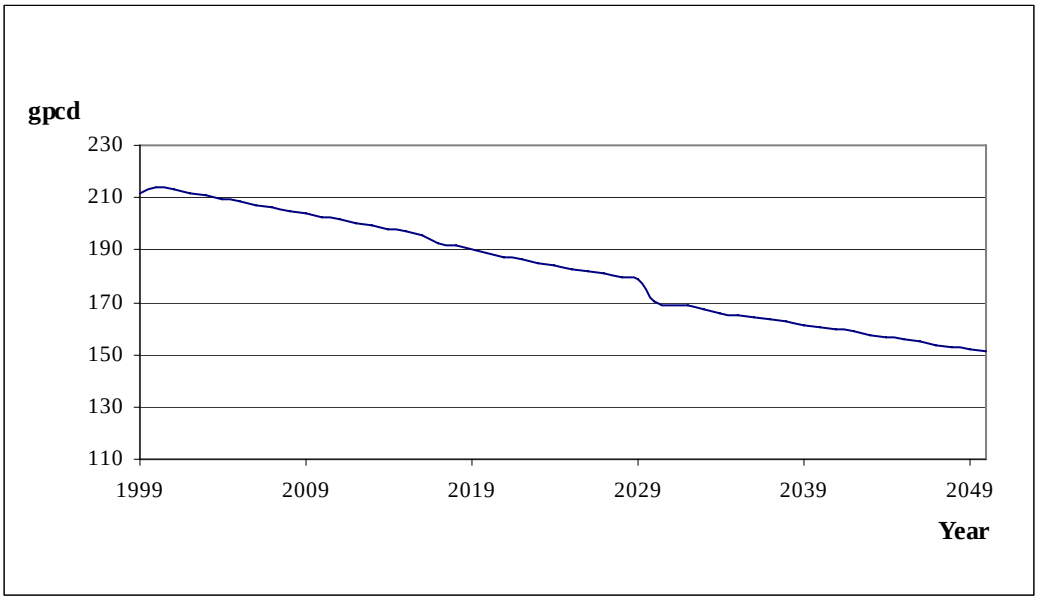


Figure 7.8- Projected water residential use in Washington County (gallons per capita per day): WCWCD low scenario

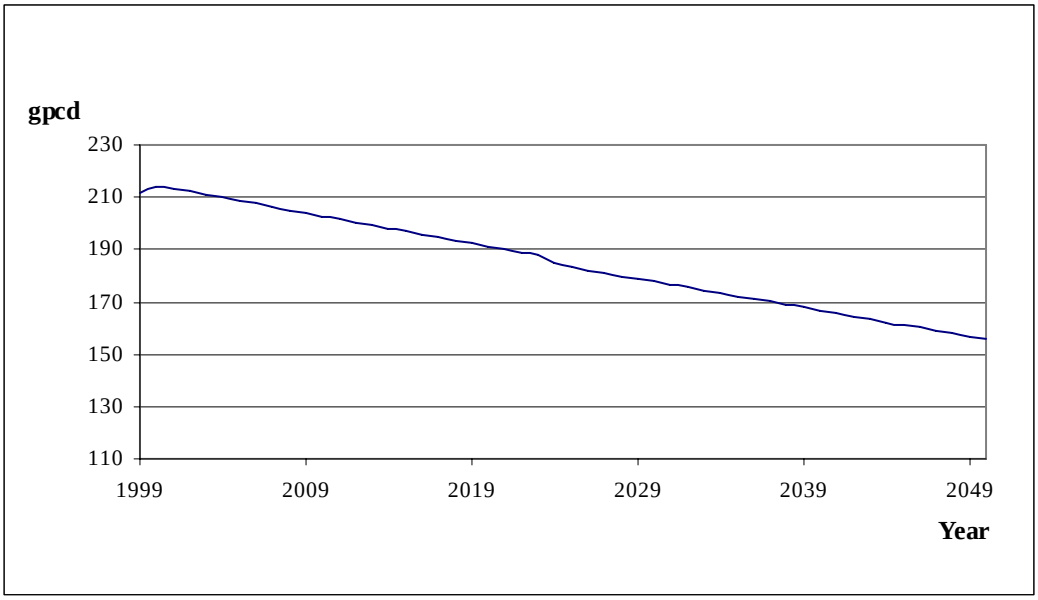


Figure 7.9- Projected water residential use in Washington County (gallons per capita per day): WCWCD medium scenario

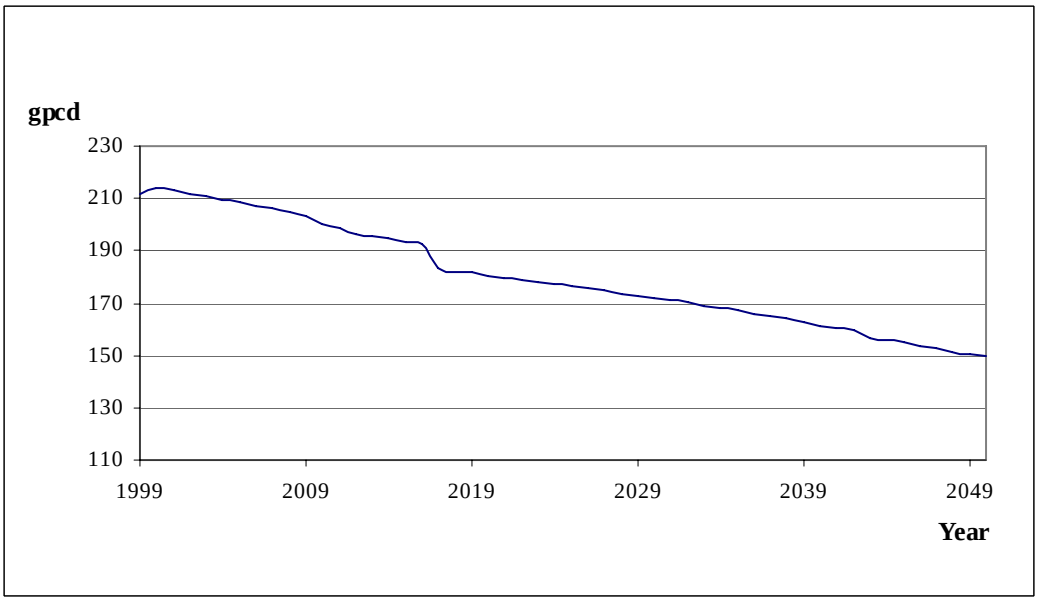


Figure 7.10- Projected water residential use in Washington County (gallons per capita per day): WCWCD high scenario

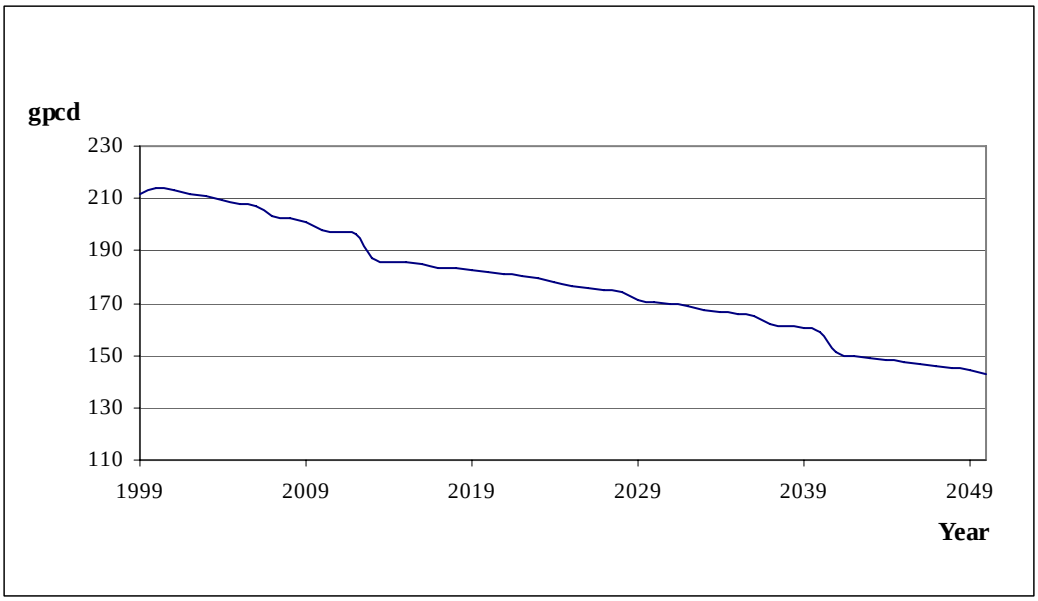
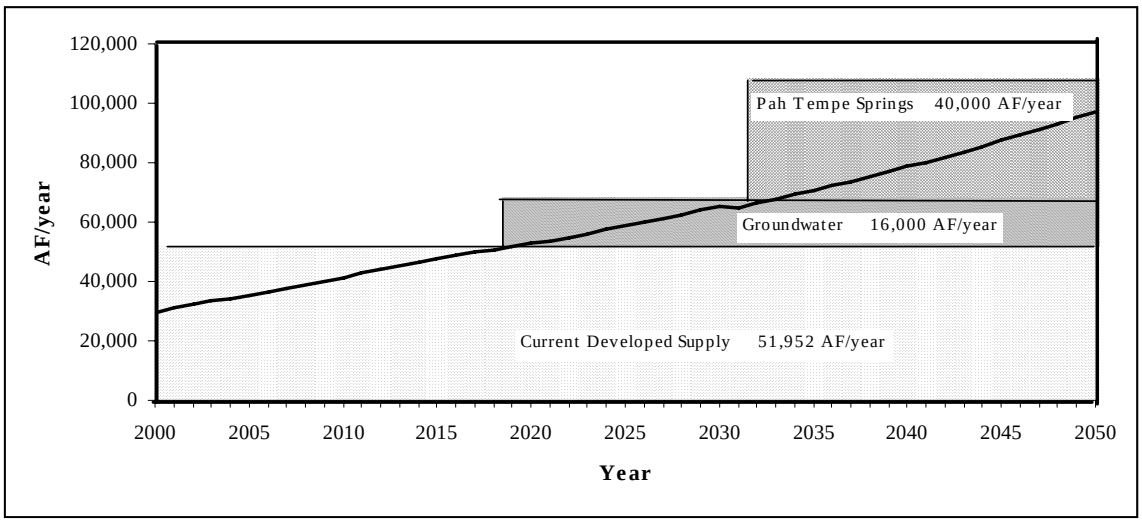


Figure 7.11- Projected demand and potential supply in Washington County (GOPB 1999 scenario)



7.3.5. Capital Projects

For each population growth scenario, the economic/financial model described above determines the need for new water supply investments. Table 7.1 summarizes the results obtained.

As previously mentioned in this study, the model includes conservation goals, but does not consider the potential for wastewater reuse, or the potential for additional water supply resulting from the conversion of current irrigated lands to residential development. Therefore, the model may overestimate the need for additional water supply projects.

Table 7.1- Need for capital projects in Washington County

Project Name	Scenario			
	GOPB 1999	WCWCDlow	WCWCDmed	WCWCDhigh
Groundwater development	X	X	X	X
Pah Tempe Springs R&E	X		X	X
North Creek Reservoir			X	X
Sand Hollow Reservoir			X	X
Crystal Creek Pipeline			X	X
Treatment of V.R. Water				X
Lake Powell Pipeline				X

8. Conclusions

The main conclusions of this study are as follows:

- Population projections, in most cases, reach higher levels than estimated buildout conditions in Washington County by the year 2050. Consequently, water demand estimates based on these population estimates are exaggerated.

- Previous estimates of water supply needs in Washington County do not account for price elasticity of water demand, and may be overestimating the water needs.

- Given the assumptions of the economic/financial model used in this study to evaluate future water supply needs in Washington County, the proposed project (Lake Powell Pipeline) does not constitute a necessity, at least until the year 2050, and then only under the highest growth scenario.

- The level of population used in the Boyle Report by the year 2050, which required the Lake Powell Pipeline, would be 57% higher than the WCD medium buildout scenario estimate.

- The GOPB 1999 population estimate is consistent with the WCD medium scenario and the general plans buildout estimates for Washington County.

- Based on GOPB 1999 population growth scenarios in Washington County, few additional water supply projects would be needed to meet future water needs.

- Additional information regarding population growth scenarios and GIS data is considered important to revise future water demands in Washington County and water supply potential from conversion of agricultural lands, respectively.

9. References

Research Foundation, 1998. Effectiveness of Residential Water Conservation Price and Non-price Programs in Urban Areas in the Western U.S., *American Water Works Association*, December.

WC, 1997. Coordination Plan for Washington County's Urbanizing Region - An Element of the Washington County General Plan.

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REVIEW OF WATER SUPPLY NEEDS IN WASHINGTON COUNTY, UTAH

FINAL REPORT

Prepared for:

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July 2000

Washington County Supply Model

1. Introduction

In order to account for the effect of increasing cost of water supply in Washington County in the water demand, an economic and financial model of water supply - Washington County Supply Model - was developed. The model estimates water use based on the price elasticity of water use, i.e., water use declines as price increases. It allows for the consideration of different population scenarios. The model considers projects in order of unit cost of water, i.e., it uses the cheapest water first.
This appendix summarizes the basic assumptions in the Washington County Supply Model. Some assumptions are based on the case of St. George although they can be considered valid for Washington County.

2. Model Assumptions

2.1. Price of Water

The most basic assumption is that the St. George water utility is non-profit. Thus average price of water charged to customers must equal average cost per unit of production (1000-gallon basis). According to Wayne McArthur (St. George Water and Power Director), total system costs (1998) are $7,240,659 for a delivery of 6 billion gallons. This works out to an average of $1.23 per 1,000 gallons. Mr. McArthur estimated 16,600 residential accounts and 3,500 commercial accounts for St. George. Residential and commercial accounts for Washington County were extrapolated from those in St. George taking into account the total population served by public water supply systems.

2.2. System Costs

System costs are constructed from (variable) treatment cost of $0.62 per 1000 gallons and distribution costs of $13.86 per hookup/month. These costs were derived from water bills in St. George. In the case of the commercial systems, the cost per hookup is $15. Taking into account the number of accounts, the estimated costs almost exactly predicts total system costs.

2.3. Water Use Rates

From the data in the Boyle Report (Table 2-2 p 19), residential consumption in Washington County is 18,708 AF per year for a population of 78,792, which corresponds to 212 GPCD. Commercial water use[1] is 10,845 AF.

For an average of 3 persons per household, the above works to average residential use of 19,330 gallons per month. St. George water utility rates for 17,100 gallons per residential household (monthly) is $1.21/1000 gallons average bill.

2.4. Residential Demand Function

This model uses a slightly modified residential demand function for Las Cruces, New Mexico to represent St. George demand for water. The demand function is obtained from Research Foundation (1998). St. George has approximately the same climate (8 inches of precipitation and hot summer/mild winter temperatures). This residential demand function is as follows:

$$Q = 20.04P^{-0.17}$$

Where Q is residential use per month and P is average price. Based on an average price of $1.21, this function predicts a residential monthly use of 19,330 gallons. This is a constant elasticity demand function with an elasticity of –0.17.

2.5. Water Use, Revenue, and Cost

The model is structured on an annual basis. The essential steps and calculations are described as follows, broken down by the spreadsheets included in the model:

a. **Initial Conditions**: sets initial population and water use amounts. Included in this sheet is a description of rates

b. **Revenue and Use**: total annual use is subdivided into commercial and residential use. Each group grows by an increase in number of accounts. Residential accounts are the growth engine and can be controlled by the annual growth rates. New commercial accounts are a function of residential growth. For every 7 new residential accounts, 3 commercial accounts are added. Use for residential (RU) is controlled by the demand equation. Because of simultaneity problems, the residential price for water is set to the average cost of water for the previous year determined in the **Cost** sheet.

$$P_t = AC_{t-1}$$

[1] Corresponding, in the Boyle Report, to the sum of commercial, industrial, and industrial water use.

$$RU_t = 12\ d(P_t)$$

Where d(P) is residential demand. Commercial use is inelastic and stays at the 1998 amount of 65, 800 gallons per account. Total revenue is calculated for each category by multiplying price times use.

2.6. Water Supply Projects

Capacity Expansion keeps tract of current system capacity and indicates the necessity of adding new capacity. Initial capacity is set to 51,952 AF (Boyle Report, Table 2.1 p18). As Total system use (TSU) increases, it will be limited by available capacity (CAP). Once this capacity constraint is reached, expansion of system supplies (ESS) must be developed from a list of 8 projects presented in the Boyle Report (see Table 3.1.). Because of a four-year lag in construction, a project must be initiated 4 years previous to the expected capacity constraint. New projects are added to capacity using an index number to the 8 listed projects in **Project Supply Curve**. The logic works as follows:

$$CAP_{t+1} = CAP_t + ESS_t$$
$$\text{If } (ESU_{t+4} > CAP_{t+4}) \text{ then } ESS_T > 0 \text{ otherwise } 0$$

In addition to the physical capacity of the system, water rights are purchased on an annual basis to match current use.

The **Project Supply Curve** is designed as a v-lookup table. The 8 projects are listed in increasing average cost order. Annual costs of each project are calculated using a constant repayment function, which includes capital costs along with O&M and other treatment costs. Annual capital costs are calculated from a 5% interest rate and asset life outlined in the Boyle Report for dams, pipes and pump stations (footnote 25 p41). Surface water projects (except for the Treatment of Virgin River) have additional treatment costs of $158 per AF (Boyle Report, p11-p12.).

2.7. Costs

Costs consist of five components: treatment (TC), residential and commercial distribution (RDC and CDC), purchase of new water rights, and new resource costs. The following are the linear cost functions for the first three components:

$$TC = \$0.62\ (TSU)$$

$$RDC = \$13.86\ (\#\ \text{residential accounts}_t)$$

$$CDC = \$15\ (\#\ \text{commercial accounts}_t)$$

New resource costs increase with the addition of new projects and water rights. Costs of new water rights (NWR$) are purchased when total system use exceeds the current inventory of water rights (IWR). It is assumed that the St. George utility purchases water rights outright for $500 (personal communication, Wayne McArthur – director of Water

and Power, St. George Utah). The system is assumed to start with an inventory of 51,952 AF of water rights.

$$\text{If } (TSU_t > IWR_t) \text{ then } NRW_t = TSU_t - IWR_t \text{ otherwise } NRW_t = 0$$

$$IWR_{t+1} = IWR_t + NWR_t$$

$$NWR\$_t = \$500 \text{ x } NRW_t$$

Supply capacity costs (SCC) are initially assumed to be zero but increases with the addition of new projects indexed by the letter i. The annualized cost of the new project (NPC) is added to SCC from the **Project Supply Curve** table (Project) as follows:

$$\text{If } (ESS_t > 0) \text{ then } NPC_t = \text{project(i) otherwise } NPC_t = 0$$

$$SCC_{t+1} = SCC_t + NPC_t$$

Note that a project's cost started the year it started construction. A project's annual costs continue indefinitely (the assumption is that the project is identically replaced after its useful life). Total system costs are the sum of the five components:

$$TSC_t = TC_t + RDC_t + CDC_t + NRW\$_t + SCC_t$$

Average costs are calculated on a 1,000-gallon basis as follows:

$$AC_t = TSC_t/TSU_t$$

2.8. Present Value

Present value is a present value calculation of all system costs over the 50-year horizon.

$$PV = \sum_{t=0}^{50} TSC_t/(1+r)^r$$

The spreadsheet is designed so PV is frozen as a value and can be compared to other scenarios.

Appendix A

WASHINGTON COUNTY SUPPLY MODEL