Spokane County Water Demand Forecast Model

Model 3.0 & 2013 Forecast Update

Prepared by
Spokane County Water Resources

June 2013

Funding for this project provided by Washington Department of Ecology
Grants G1200126 & G0700149

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Executive Summary

This report describes the update to the Spokane County Water Demand Forecast and Forecast Model. Funding for this project was provided by Washington Department of Ecology Grants G1200126 & 0700149. The Spokane County Water Demand Forecast Model 2.0 (Model 2.0) and Spokane County 2011 Water Demand Forecast (2011 Forecast) was completed in January 2011. The purpose of the update, herein referred to as the Spokane County Water Demand Model 3.0 (Model 3.0) and the 2013 Spokane County Water Demand Forecast (2013 Forecast) was to:

- Utilize the latest demographic data which was recently updated with data from the 2010 Census;
- Add the capability to the water demand model to evaluate the consumptive and non-consumptive components of total water demand; and
- Add the capability to determine how and where return flows reenter the hydrologic system

The update has resulted in a significant change in the water demand forecast and an enhanced understanding of water demand. Before the update the model allowed analysis of how much water left the system at a particular time; with the update we also can determine where it goes, whether lost to evapotranspiration, returned to groundwater or returned to surface water.

The specific methodology and changes to the water demand model are described in the report, but in general, the updated model is now capable of determining whether water is used consumptively, such as with irrigation of plants, or non-consumptively, such as with water that is used to wash vegetables. The water that is used non-consumptively returns to the hydrologic system, either surface water or groundwater, in a specific location. The water demand model is now capable of determining of whether the non-consumptive water returns to groundwater or surface water. It also determines the location of the return. For example, does the water return to the Spokane Valley Rathdrum Prairie (SVRP) aquifer or an aquifer in the Little Spokane River Basin, or does the water return to the Spokane River via the Spokane County Regional Water Reclamation Facility or to Latah Creek via the Latah Creek Wastewater Treatment Facility.

The 2011 Forecast for total water demand for Spokane County was 75.83 billion gallons per year in 2010 and 99.30 billion gallons per year in 2040, a 31% increase. The 2013 Forecast for total water demand for Spokane County is 68.56 billion gallons per year in 2010 and 89.19 billion gallons per year in 2040, a 30% increase. This indicates that a similar growth rate is predicted but the new demographic forecast begins with a smaller base. The report further analyzes changes to specific water use sectors. Of particular note is the change in the self-supplied residential water use sector forecast. The 2011 Forecast indicated a 46.5% increase in self-supplied water use while the 2013 Forecast indicates an 84% increase in self-supplied water use. This is due to changes in the forecasted distribution of housing units in the County; more housing units are forecast outside public water service areas in the new demographic forecast.

The SVRP Aquifer is of particular importance to Spokane County. The SVRP Aquifer provides 73% of the water used in the County and provides a significant amount of water to the Spokane River during low flow times of the year. Analysis of consumptive and non-consumptive water use and return flows give a better understanding of the interaction of water use and the river-aquifer system. The component parts of water use from the SVRP Aquifer are as follows:

- 44% Consumptive
- 22% Returns to Municipal Waste Water Treatment Plants that discharge to the Spokane River
- 18% Returns to ground from irrigation
- 14% Returns to Industrial Waste Water Treatment Plants that discharge to the Spokane River
- 2% Returns to Onsite Septic Systems

Comparison of modeled returns to municipal wastewater treatment facilities and actual flows to treatment facilities as reported to the Washington Department of Ecology indicate good agreement between modeled and actual flows.

Single family outdoor water use is an important component of water demand. It accounts for 26%, or 18.01 billion gallons per year, and is largely a consumptive use. There is an estimated 22,300 acres of single family residential outdoor landscape which is an average of 6,190 ft^2 per residence. For comparison the American Water Works Association Research Foundation did a study that included 14 cities and the average landscaped area was 7,930 ft^2, and the median was 6,930 ft^2 . The rate of return flow from single family residential irrigation was between 11% and 19% between June and September, which is also consistent with other studies that have found that homeowners typically water at or below the calculated theoretical irrigation requirement.

Introduction

This report describes the 2013 update to the Spokane County Water Demand Forecast & Forecast Model. The purpose of the update is three fold: 1) disaggregate total water demand into consumptive and non-consumptive components, 2) determine the location and quantity of non-consumptive use return flows (i.e. return flow to septic vs. waste water treatment plants), and 3) utilize updated demographic data and growth projections completed by the Spokane Regional Transportation Council (SRTC) after the release of the 2010 Census data. The updated model is provided on the accompanying CD.

In January 2011 Spokane County Water Resources completed version 2 of the Spokane County Water Demand Model (Model 2.0) and developed a water demand forecast for Spokane County (2011 Forecast). A full description of Model 2.0 and the 2011 Forecast is presented in *Spokane County Water Demand Forecast Model* (Spokane County, 2011).

Model 2.0 forecasts total water demand for the period 2008 to 2040 for Spokane County. Model 2.0 disaggregates, or separates, water use into sectors and sub sectors. Figure 1 below shows the structure of Model 2.0. This structure allows each sector and subsector to be modeled and forecasted independently. Model 2.0 is also disaggregated spatially, dividing the county into 512 separate units called forecast units. Total water use for each sector and subsector within each forecast unit is calculated. There is no distinction between consumptive and non-consumptive water use. Model 2.0 reports total monthly water demand for each subsector for each month for each forecast unit. So it is possible, for example, to evaluate the demand for publicly supplied single family residences in forecast unit TAZ482 for the month of July. Depending on the analysis the values can be aggregated in any number of ways.

The 2011 Forecast is based on a demographic forecast developed by the SRTC in 2008 for Growth Management Act planning activities of Spokane County and municipalities with in the county. The demographic forecast was for the period 2008-2030 and included population, housing units, and employment.

This report includes the following

- Methodology for disaggregating consumptive and non-consumptive water use and determining the location and quantity of non-consumptive return flows;
- A description of the new demographic forecast and comparison to the previous forecast; and
- Results and analysis of the 2013 Spokane County Water Demand Forecast (2013 Forecast) generated by the Spokane County Water Demand Forecast Model 3.0 (Model 3.0)

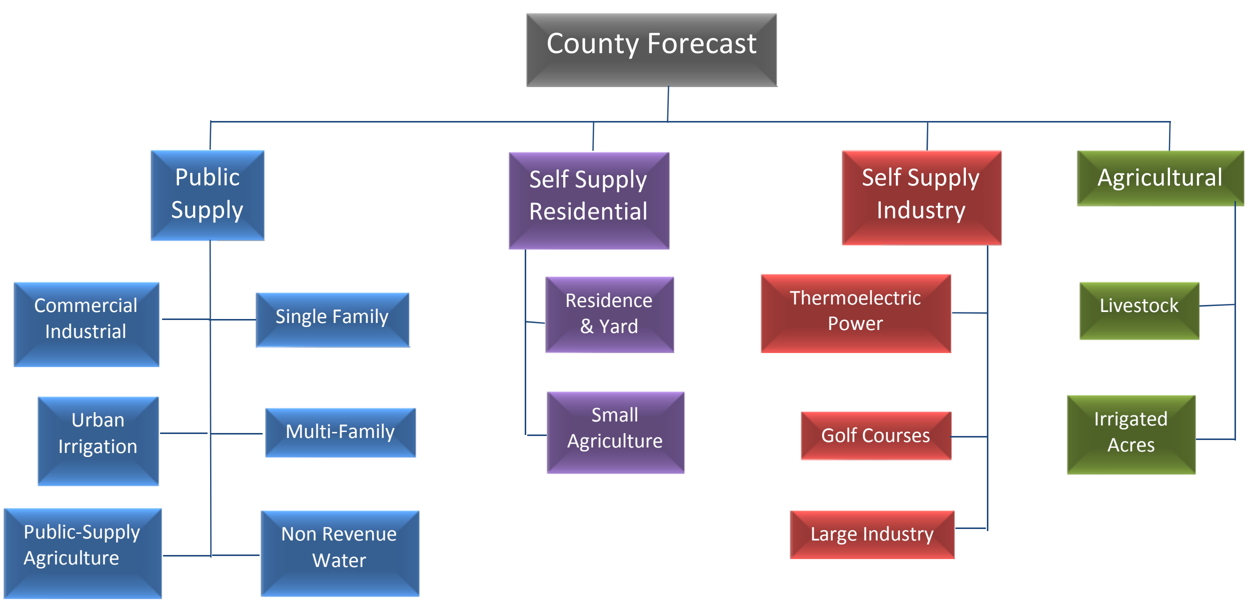


Figure 1—Spokane County Water Demand Model 2.0 Structure

Disaggregation of Consumptive & Non-Consumptive Water Use

Consumptive water use removes water from a local hydrologic system via transpiration by plants and animals, evaporation, water contained within a product or byproduct, etc. Non-consumptive water use does not remove water from the local hydrologic system; water is utilized and then returned back to the local hydrologic system, though not always in the same location from which it was withdrawn, or the same part of the system, i.e. groundwater vs. surface water. Forecasting total water demand is useful in evaluating how much water is needed to support demand, but without the distinction between consumptive and non-consumptive water use the understanding of the impact of water demand on the water resource is incomplete. It is also important to understand how and where the non-consumptive water is returned; for example whether indoor water use returned via an onsite septic system to groundwater or via a waste water treatment plant to a surface water body.

The disaggregation process is begins with dividing each water use sector shown in Figure 1 into consumptive and non-consumptive demand. The approach to disaggregating water demand into consumptive demand and non-consumptive demand is unique for each water use sector and subsector. A description of the approach to each sector and subsector follows.

Publicly Supplied Single Family

Water use in this sector is separated into indoor and outdoor water use. Model 2.0 calculates indoor and outdoor water use separately and then sums them to report the total demand for publicly supplied single family residences for each forecast unit. This allows for treatment of the consumptive and non-consumptive components of indoor and outdoor water use independently. Figure 2 presents a flow chart depicting the disaggregation of publicly supplied single family water use into consumptive and non-consumptive water use

Indoor water use is largely non-consumptive. The percent that is non-consumptive is often in a range between 85% and 95%. The Spokane Valley-Rathdrum Prairie Aquifer Flow Model documented in the United States Geological Survey Scientific Investigations Report 2007-5044, assumes that 95% of indoor water use is non-consumptive (USGS, 2007). Since the percentage can be a range of values the % non-consumptive is a model

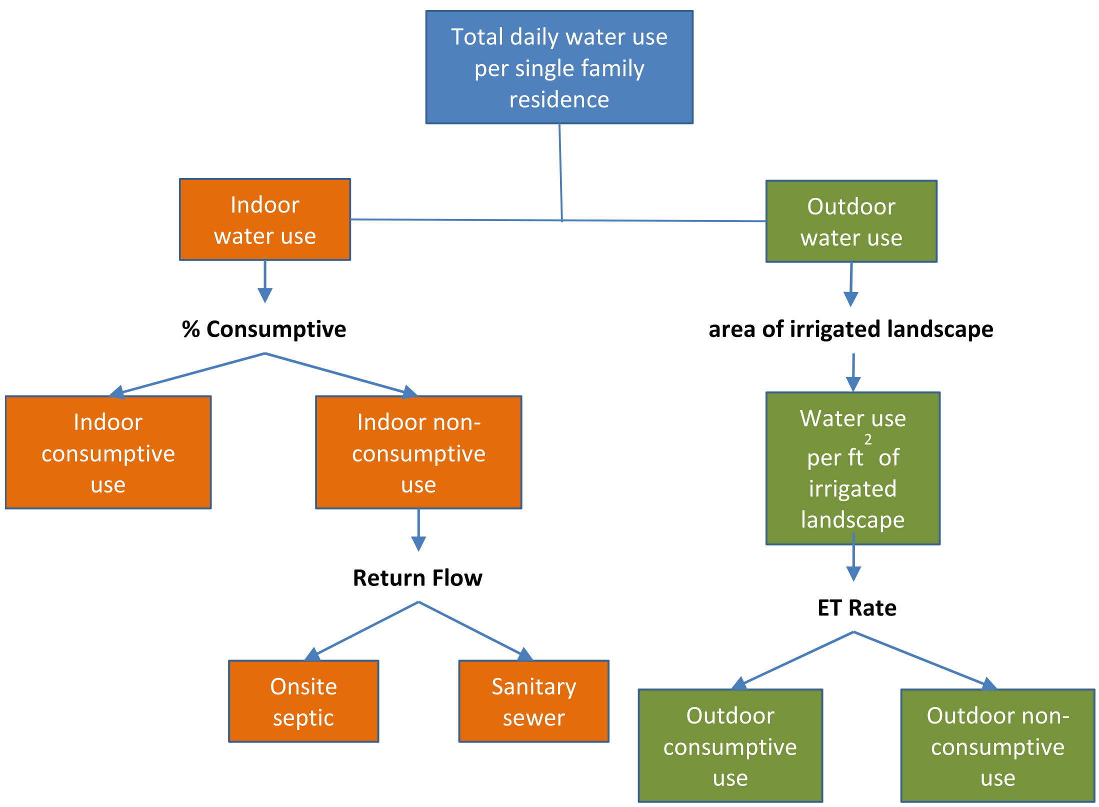


Figure 2—Publicly Supplied Single Family Residential: Disaggregation of Consumptive & Non Consumptive Water Use

input variable, allowing it to be easily changed. Non-consumptive water use is easily calculated by multiplying the total indoor water use by the percent non-consumptive variable that has been input into the demand model. The indoor non-consumptive rate used in the 2013 Forecast presented in this report is 90%, the middle of the range of reported literature values.

Outdoor water use is both consumptive and non-consumptive. Most outdoor water use in this sector is for landscape irrigation with the vast majority of that being for lawns. The econometric model that is used to calculate water use in this sector utilizes model inputs that vary considerably between individual forecast units resulting in a wide range of per residence total outdoor water use depending on the forecast unit. Total daily water demand in the month of July for this sector ranges from 153 gallons per day (gpd) to 6,000 gpd. At the low end of the range there is negligible outdoor water use, while at the high end outdoor water use could be used to irrigate over an acre of landscaping.

Water that is used for landscape irrigation is either used by the plant (transpiration), evaporates, or returns to the groundwater system. Transpiration and evaporation, often combined as evapotranspiration or ET, is consumptive; returns to groundwater is non-consumptive. To disaggregate consumptive and non-consumptive outdoor water use it is necessary to know the volume of water that is applied to a specific area of landscape., i.e. how many gallons are applied to one square foot of landscape. If the volume of outdoor water use per residence and the area of irrigated landscape per residence are known the volume of water per square foot can be calculated. Demand Model 2.0 calculates per residence outdoor water use for each forecast unit, but it does not currently include the area of irrigated landscape per residence for each forecast unit .

To estimate the area of irrigated landscape per residence for each forecast unit in Demand Model 3.0, the following information is used:

1. average size of parcels with single family residences within each forecast unit;
2. average building footprint on each parcel with single family residences; and
3. The percent of the unbuilt area on the parcel that is landscape. For example if a parcel is 4,000 ft^2, and the building footprint accounts for 1,500 ft^2, how much of the remaining area is landscape vs. other types of land cover, such as driveways.

Table 1—Sample Parcel Data Summary

	Parcel Area	Building Foot Print	Unbuilt Area	Landscape Area	% unbuilt landscaped
Average	13,494	1,816	11,677	5,782	58%
Median	10,031	1,733	8,146	4,571	60%
Max	217,454	5,535	213,549	42,381	100%
Min	4,568	686	3,111	0	0%

284 samples; values given in ft^2

The first two pieces of information (parcel size and building footprint) are available from Spokane County Assessor data. The third (percent of unbuilt area that is landscaped) was estimated from data taken from a random sample of single family residential parcels in Spokane County.

The area of irrigated landscape was digitized from an aerial photograph for 284 sample parcels selected at random. The digitized landscape area data along with the building foot print and parcel size allowed the calculation of the percent of the unbuilt area that is landscaped for each sample parcel. Table 1 presents a summary of the sample parcel data.

The average parcel size and building size per forecast unit is known and along with the estimate of the percent of unbuilt area that is landscaped the average area of landscape per forecast unit can be derived. The median value in Table 1, 60% of unbuilt area that is landscaped is used as a default value, but it is incorporated into Model 3.0 as an input variable, so it can be adjusted.

Two pieces of information are needed to separate outdoor water use into consumptive and non-consumptive components: 1) volume of water per square foot of irrigated landscape per residence in each forecast unit, which is described above, and 2) monthly ET rates . Estimating ET rates is complex and there are many different methods that can be used. The monthly ET rates were incorporated into Model 3.0 as an input variable, allowing for easy use of different estimates of ET. ET is reported in inches. The inches are applied to a unit of area, such as a square foot, to determine the volume of water consumed by ET for that area. If there is 1 inch of ET then 0.62 gallons are consumed for every square foot of irrigated landscape. If 2 gallons per square foot are applied then 1.38 gallons per square foot return to the groundwater system.

ET rates utilized in 2013 Forecast are from the Rathdrum Prairie AgriMet Weather Station operated by the United States Bureau of Reclamation. Inches of water per day for several crops, including lawn, are reported for the growing season. The period of record for this station begins April 4, 2008 and it is still currently in operation.

The second aspect of disaggregating consumptive and non-consumptive water use is routing the return flow. Return flows from landscape irrigation are returned to the forecast unit in which it was used. Non-consumptive indoor water use is routed to either an onsite septic system or a sanitary sewer. Onsite septic returns occur in the forecast unit in which it was used. Sanitary sewer returns flows are routed to the waste water treatment plant that serves the forecast unit. In forecast units that are served by multiple waste water treatment plants or have a combination of onsite septic and sanitary sewer, a portion of the forecast unit was allocated to the appropriate return flow location based on sewer connection data.

Publicly Supplied Multifamily Residential

Publicly supplied multifamily residential water use is based on the number of multifamily units in each forecast unit. Model 2.0 calculates indoor and outdoor water use separately and then sums them to report the total demand for publicly supplied multifamily residences for each forecast unit. This allows for treatment of the consumptive and non-consumptive components of indoor and outdoor water use independently.

As with the single family residential sector indoor water use in this sector is largely non-consumptive. Demand Model 3.0 includes an input variable for multifamily indoor water use non-consumptive percent. Ninety percent was used for the 2013 Forecast.

The disaggregation of outdoor water use into consumptive and non-consumptive portions could not be done in the same manner as the single family residential sector. Unfortunately there is not a uniform way in which the number or multifamily units per parcel is recorded by the Spokane County Assessor or other data sources such as gas and electric utilities. The lack of consistent reporting of multifamily units per parcel makes it difficult to estimate the area of landscape per multifamily unit, a necessary component to determine the area to which a specific volume of water was applied. Therefore the separation of multifamily outdoor water use into consumptive and non-consumptive portions is done as a simple percentage. Demand Model 3.0 includes an input variable for multifamily non-consumptive outdoor water use percentage by month. If for example 40% is entered and multifamily outdoor water use for a forecast unit is 100 gpd, 60 gpd would be consumptive and 40 gpd would be non-consumptive. Literature values are available for percent non-consumptive and a range of values can be utilized in the model.

As with the publicly supplied single family residential, the routing of non-consumptive indoor water use is based on whether a forecast unit, or portion of a forecast unit, is served by a sanitary sewer system.

Publicly Supplied Commercial and Industrial

Publicly supplied commercial and industrial water use is based on the number of employees in a certain classification. Model 2.0 calculates indoor and outdoor water use separately and then sums them to report the total demand for publicly supplied commercial and industrial use for each forecast unit. This allows for treatment of the consumptive and non-consumptive components of indoor and outdoor water use independently

A similar approach is used to separate commercial/industrial indoor water use into consumptive and non-consumptive components, though in this sector the percentage can vary between classifications, such as offices vs. industrial. To accommodate this difference Model 3.0 includes percent non-consumptive input variables for each commercial/industrial classification.

The disaggregation of outdoor water use into consumptive and non-consumptive components in this sector was done in a manner similar to the multifamily sector, a straight percentage. This was done for reasons similar to the multifamily sector; it was not possible to estimate the area of irrigated landscape per employee for each classification.

Routing of commercial/industrial non-consumptive return flows is based on whether a forecast unit, or a portion of a forecast unit, is served by a sanitary sewer system.

Self-Supplied Residential & Agricultural

The same approach used for the publicly supplied residential sector is utilized for the residential portion of this sector. The agricultural portion of this sector accounts for livestock that is associated with rural residences. Model 2.0 utilizes a gallon per day (gpd) per animal rate to calculate demand. Disaggregation into consumptive and non-consumptive components is done with a percentage input.

Urban Irrigation & Publicly Supplied Agriculture

A base gpd per acre with a monthly adjustment is used in Model 2.0 to estimate water use for both urban irrigation (parks, schools, cemeteries, etc.) and publicly supplied agriculture. Since the volume of water per unit area is established, ET is the only variable that is needed to disaggregate total water use into consumptive and non-consumptive components. As with single family residential, ET is added as an input variable. The 2013 Forecast utilizes the Rathdrum Prairie AgriMet Station ET data.

Self Supplied Industrial

This sector includes large industrial users such as Kaiser and Inland Empire Paper and it also includes self-supplied golf courses. Self-supplied golf courses are treated in the same manner as publicly supplied golf courses. Large industrial users are included individually and are separated into consumptive and non-consumptive uses based on literature values and available data.

Agricultural

This sector includes irrigated agriculture and livestock. The same approach that is used in the livestock portion of the self-supplied residential and agriculture is used for the livestock portion of the agricultural sector. In Model 2.0 the irrigated agri-

Table 2
Comparison of SRTC 2008 and 2010 Demographic Forecast

		SRTC Forecast		Change			SRTC Forecast		Change
		2008	2010				2008	2010	
Single Family Dwelling Units	2010	162,661	157,330	-5,331	Finance, Insurance, and Real Estate Services	2010	13,928	11,695	-2,233
	2020	179,812	174,075	-5,737		2020	15,954	13,065	-2,889
	2030	199,472	192,845	-6,627		2030	18,181	14,499	-3,682
	2040	219,133	207,270	-11,863		2040	20,409	15,602	-4,807
Multi-Family Dwelling Units	2010	45,596	44,101	-1,494	Medical	2010	28,622	26,901	-1,721
	2020	53,906	53,147	-759		2020	32,261	29,567	-2,693
	2030	62,495	63,045	550		2030	36,795	32,358	-4,437
	2040	71,084	70,652	-432		2040	41,330	34,503	-6,827
Hotel/Motel	2010	7,434	7,597	163	Retail Trade (Central Business District)	2010	7,590	7,267	-323
	2020	8,534	8,423	-111		2020	9,112	7,855	-1,257
	2030	9,612	9,288	-324		2030	10,319	8,470	-1,850
	2040	10,689	9,952	-737		2040	11,527	8,942	-2,584
Industrial	2010	51,862	42,948	-8,914	Students-University	2010	15,474	25,219	9,745
	2020	60,219	49,026	-11,193		2020	17,778	28,330	10,552
	2030	68,901	55,391	-13,510		2030	20,285	31,587	11,302
	2040	77,583	60,282	-17,301		2040	22,792	34,090	11,298
Retail Trade (Non-Central Business District)	2010	58,460	51,303	-7,157	Education Employees	2010	13,315	11,478	-1,838
	2020	68,950	58,280	-10,670		2020	15,370	13,071	-2,300
	2030	78,575	65,587	-12,988		2030	17,573	14,739	-2,834
	2040	88,201	71,202	-16,998		2040	19,777	16,021	-3,756
Services and Offices	2010	29,746	38,762	9,017	University Employees	2010	5,092	6,545	1,453
	2020	36,284	42,801	6,516		2020	5,850	7,088	1,238
	2030	42,622	47,031	4,408		2030	6,673	7,656	984
	2040	48,961	50,281	1,321		2040	7,496	8,093	598

Note: The 2008 SRTC Forecast was through 2030. The 2040 values for the 2008 SRTC Forecast is a linear extrapolation.

culture sector includes and irrigation efficiency factor. Irrigation efficiency is essentially the volume of the total irrigation water that is used consumptively by the crop. Therefore the efficiency rate is used to separate total crop irrigation into consumptive and non consumptive components.

Comparison of Demographic Forecasts

Demographic data is necessary to estimate water demand. The 2011 and 2013 Spokane County Water Demand Forecasts are based on demographic forecasts developed by the SRTC. The SRTC is the federally designated Metropolitan Planning Organization and the state designated Regional Transportation Planning Organization for Spokane County. The SRTC Board includes representatives from county government, small and large municipalities within Spokane County, the private sector, regional transportation entities, and state government. An important function of the SRTC is travel demand modeling and forecasting. As with water demand modeling, demographic data is necessary for travel demand modeling. The SRTC works with a broad range of community partners to develop forecasts that are spatially disaggregated.

The 2011 Forecast was based on the SRTC 2008 Forecast for the period 2008 to 2030. In June 2012 the SRTC released a new forecast for the period 2010 to 2040. Table 2 presents a summary of each forecast and the differences between them. In general the 2010 SRTC Forecast uses lower base values, and forecasts lower growth rates. In 2010 the SRTC also modified the boundaries of the Transportation Analysis Zones (TAZs) largely based on new census block boundaries from the 2010 Census. Model 3.0 uses the new TAZ boundaries.

The two most significant factors in the difference between the SRTC 2008 and 2010 forecasts are:

1. The 2008 SRTC Forecast was done prior to the 2010 decennial census. When the 2010 census was completed and the

Figure 3: Spokane County Water Demand: 2010-2040

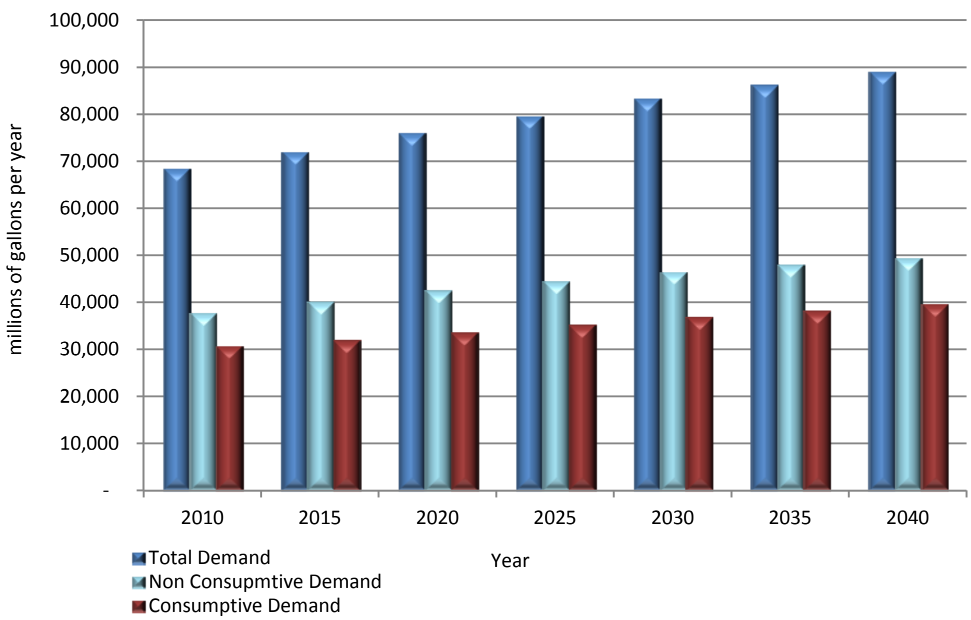


Table 3: Spokane County Total Annual Demand - billon gallons per year

Water Use Sector	2010			2020			2030			2040		
	Total	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*
Public Supply	43.38	25.17	18.21	48.81	28.98	19.83	54.57	32.32	22.25	59.08	34.93	24.15
Self Supply Residential	5.84	2.35	3.49	7.97	3.19	4.78	9.54	3.82	5.72	10.74	4.30	6.44
Industrial-Self Supplied	8.89	8.46	0.42	8.89	8.46	0.42	8.89	8.46	0.42	8.89	8.46	0.42
Agricultural	10.46	1.79	8.67	10.46	1.79	8.67	10.46	1.79	8.67	10.46	1.79	8.67
TOTAL	**68.56**	**37.78**	**30.79**	**76.14**	**42.43**	**33.71**	**83.45**	**46.39**	**37.06**	**89.17**	**49.49**	**39.69**

data was made available new population estimates were available and they indicated a lower population than was previously assumed.

2. One of the main factors in the SRTC Forecast is the population forecast done by the State of Washington Office of Financial Management (OFM). There was a significant difference between the 2007 and 2012 series OFM Forecast.

Spokane County 2013 Water Demand Forecast Results & Analysis

The Spokane County Water Demand Model was used to conduct the following analysis:

- Current and projected consumptive and non-consumptive water demand by sector for the entire county.
- Current and projected consumptive and non-consumptive water demand by sector for areas served by water from the SVRP Aquifer.
- Current indoor water use return flows.
- Current and projected consumptive and non-consumptive water demand by sector for the Spokane County portion of each WRIA within Spokane County.
- Analysis of single family residential outdoor water use.

As described earlier the forecast is based on the SRTC's Horizon 2040 forecast adopted in June 2012 (SRTC, 2012).

The agricultural and self supplied industrial sectors are projected to have no growth in this forecast. In the model these sectors are self supplied and require water rights. Given the approval of new water rights in Spokane County is unlikely, no growth is forecasted. The model, though, can include growth in these sectors as needed.

Spokane County Total Water Demand

Table 3 and Figure 3 present the current and projected annual consumptive and non-consumptive water demand for each water use sector for the 2013 Forecast. Non-consumptive water demand accounts for 55% of total demand, and consumptive demand account for 45%. Total demand is forecasted to grow 30% by 2040.

Table 4: Spokane County Total Water Demand 2011 & 2013 Forecast Comparison

		Public Supply	Self Supply Residential	Industrial Self Supply	Agricultural	Total
2013 Forecast	2010	43.38	5.837	8.89	10.46	**68.56**
	2040	59.10	10.74	8.89	10.46	**89.19**
	% Change	36.3%	84.0%	0.0%	0.0%	**30%**
2011 Forecast	2010	52.27	5.46	7.17	10.53	**75.83**
	2040	73.59	8.00	7.17	10.53	**99.30**
	% Change	40.8%	46.5%	0.0%	0.0%	**31%**

values reported in billions of gallons per year

Table 4 presents both the 2011 and 2013 forecasts for total water demand for 2010 and 2040. The 2011 Forecast has an increase by 2040 of 23.47 billion gallons per year and the 2013 Forecast has an increase by 2040 of 20.63 billion gallons per year. Both are an increase of approximately 30%. The forecasted increase by 2040 in the public supply sector was 40.8% in the 2011 Forecast and 36.3% in the 2013 Forecast. The forecasted increase by 2040 in the self supplied residential sector was 46.5% in the 2011 Forecast and 84% in the 2013 Forecast. While the overall quantity of single family residential units decreased between the 2011 and 2013 forecasts, the number within the self supplied residential sector increased. This is due to the differences in the TAZ boundaries and distribution of single family residential units to each TAZ. In essence more single family residential units are forecasted outside areas served by public water in the 2013 Forecast in comparison to the 2011 Forecast.

SVRP Aquifer Water Demand and Return Flows

The main source of water for Spokane County is the SVRP Aquifer. This resource is utilized both within and outside the geographic boundaries of the aquifer. As a result there are several different water demand and return flow scenarios including:

1) Water from the SVRP Aquifer is used within the geographic boundary of the aquifer and indoor water use is returned to a waste water treatment plant (WWTP) that discharges to the Spokane River.
2) Water from the SVRP Aquifer is used within the geographic boundary of the aquifer and indoor water use is returned to an onsite septic system.
3) Water from the SVRP Aquifer is used outside the geographic boundaries of the aquifer and indoor water use is returned to an onsite septic system.
4) Water from the SVRP Aquifer is used outside the geographic boundary of the aquifer and indoor water use is returned to a WWTP that discharges to the Spokane River.
5) Water from the another aquifer is used outside the geographic boundary of the aquifer and indoor water use is returned to a WWTP that discharges to the Spokane River.

Model 3.0 is structured so that each of these scenarios can be accounted for.

Demand and return flow results presented in this report for the SVRP Aquifer and for each Water Resource Inventory Area (WRIA) take each of the above scenarios into account and re-

Figure 4: SVRP Aquifer Return Flow Scenarios

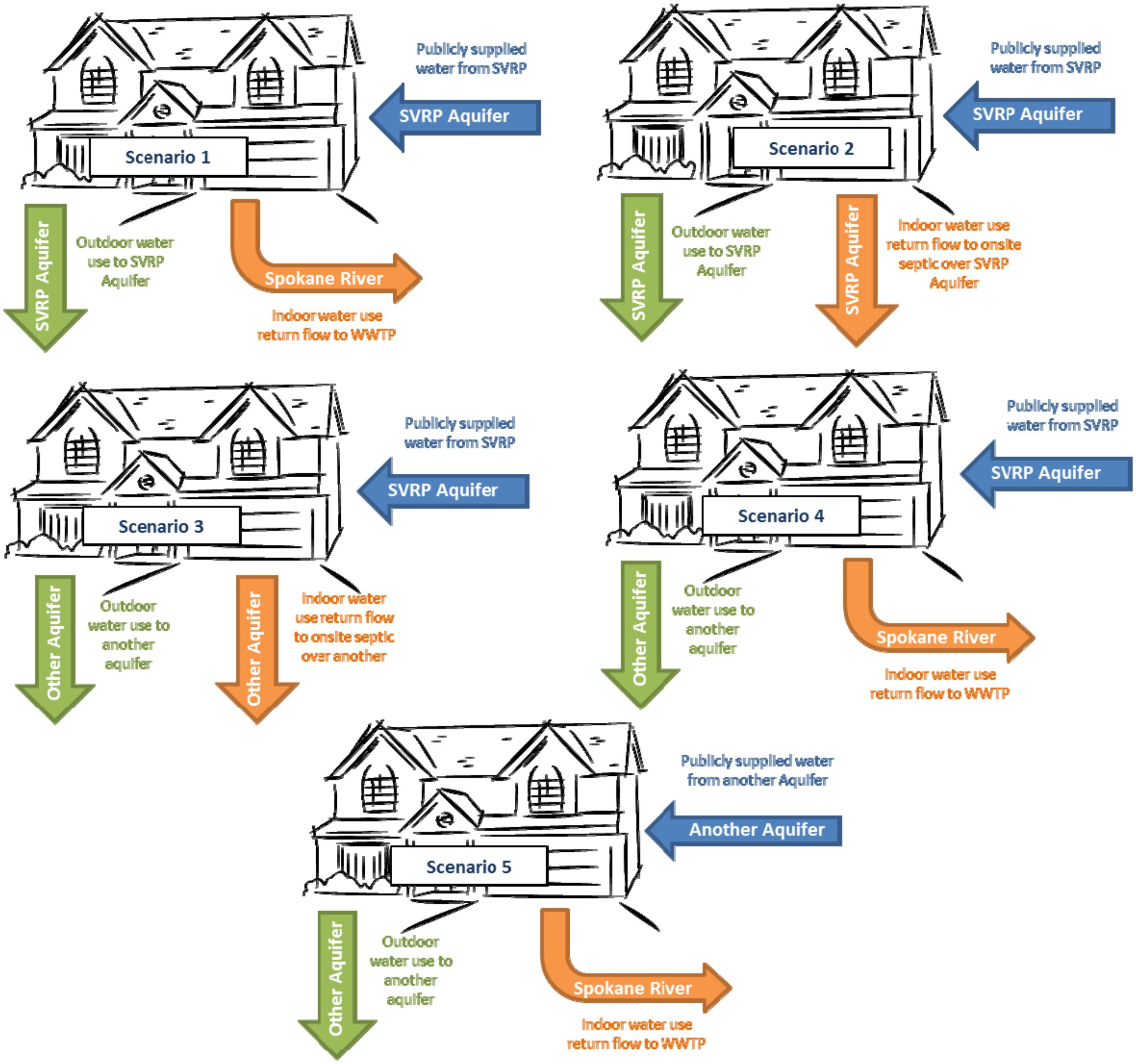
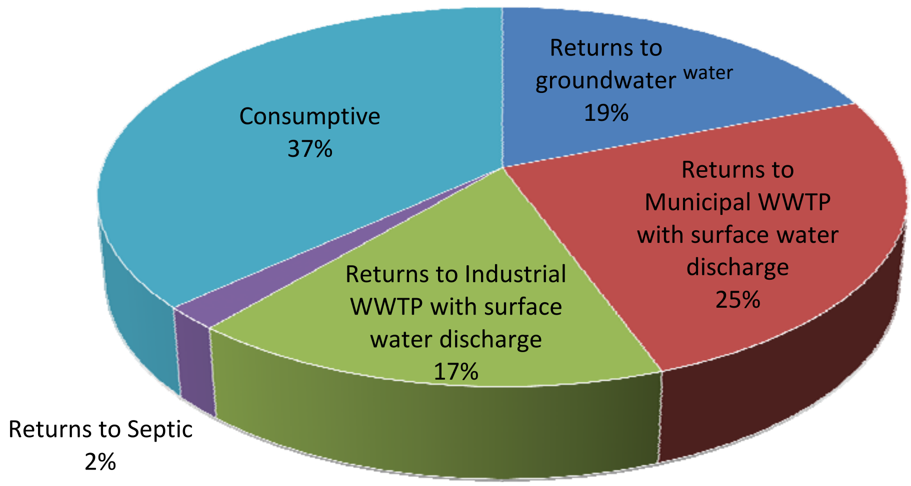


Table 5: SVRP Aquifer Annual Demand - billon gallons per year

Water Use Sector	2010			2020			2030			2040		
	Total	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*
Public Supply	38.70	22.42	16.27	43.15	25.52	17.63	47.90	28.23	19.67	51.64	30.35	21.29
Self Supply Residential	0.04	0.02	0.02	0.05	0.02	0.03	0.06	0.03	0.03	0.07	0.03	0.04
Industrial-Self Supplied	8.78	8.43	0.35	8.78	8.43	0.35	8.78	8.43	0.35	8.78	8.43	0.35
Agricultural	1.88	0.32	1.56	1.88	0.32	1.56	1.88	0.32	1.56	1.88	0.32	1.56
TOTAL	**49.39**	**31.19**	**18.20**	**53.86**	**34.29**	**19.57**	**58.62**	**37.01**	**21.62**	**62.37**	**39.13**	**23.24**

Figure 5: SVRP Aquifer Annual Water Demand & Return Flows

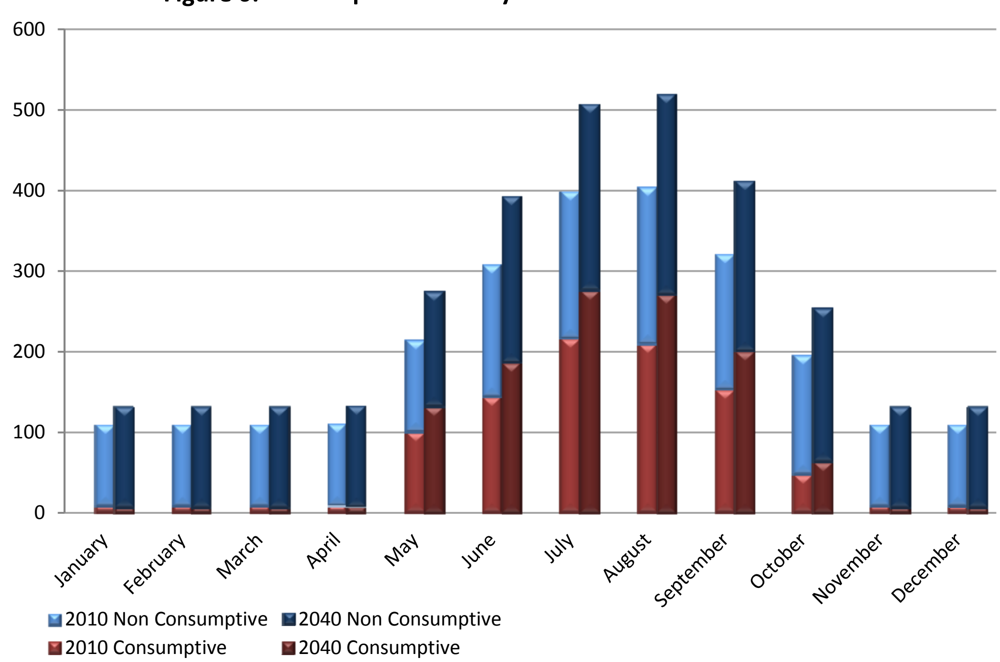


port water demand supplied by the identified water source or basin, and returned to the identified water source or basin. For example, results for WRIA 55 only report water demand supplied by water from WRIA 55 (not the SVRP Aquifer), and return flow that return to areas of WRIA 55 outside the boundaries of the SVRP Aquifer (not onsite septics located within WRIA 55 over the SVRP Aquifer or WWTPs that discharge to the Spokane River).

Table 4 presents the annual water demand from the SVRP Aquifer, both consumptive and non-consumptive, for 2010, 2020, 2030, and 2040 for each water use sector. Water demand from the SVRP Aquifer accounts for 72% of total demand from Spokane County. Total annual demand for the SVRP Aquifer is projected to increase 26%, 4% lower than the projected increase for the County as a whole.

Figure 5 shows the annual distribution of where water withdrawn from the SVRP Aquifer goes. The largest percentage (37%) is consumed, and the second largest (25%) is returned to the Spokane River via municipal waste water treatment plants. Forty two percent of water withdrawn from the aquifer is re-

Figure 6: SVRP Aquifer Monthly Water Demand 2010 & 2040



turned to the Spokane River via waste water treatment plants, either municipal or industrial.

In the Spokane River/SVRP Aquifer system timing is everything. Figure 6 and Table 5 present total monthly demand from

Table 6: SVRP Aquifer Monthly Demand

Month	2010			2040		
	Total	Non Consump	Consump	Total	Non Consump	Consump
January	110	102	8	133	126	7
February	110	102	8	133	126	7
March	110	102	8	133	126	7
April	111	102	9	134	126	8
May	215	115	100	276	143	133
June	309	165	144	394	207	187
July	400	183	217	509	232	277
August	406	195	210	521	249	272
September	322	169	153	413	212	201
October	197	149	48	255	191	64
November	110	102	8	133	126	7
December	110	102	8	133	126	7

the SVRP Aquifer, both consumptive and non consumptive, for 2010 and 2040.

The connection of the Spokane River to the SVRP Aquifer is well documented, and the *Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer* (USGS, 2007) demonstrates that withdrawals from the SVRP Aquifer have an impact on river flows within a very short time frame. This is particularly important during the summer months when demand is high and river flow is low. Analysis with the USGS SVRP groundwater flow model indicates a near 1 to 1 ratio of summer withdrawals from the SVRP Aquifer and flow reductions in the Spokane River. The forecasted increase in total summer withdrawals from the SVRP Aquifer from 2010 to 2040 is 112 cfs. The consumptive portion of the increase is 60 cfs, and the non-consumptive portion is 52 cfs. Approximately 20 cfs of the 52 cfs increase are direct returns to the Spokane River via municipal or industrial waste water treatment plants and 32 cfs are returns to ground.

Table 7: 2010 Total Public Supply Indoor Use Return Flow Modeled vs. Reported

System Name	Modeled	Reported
Total Flow to City of Spokane Facility	26.31	27.1
City of Spokane	24.41	-
Spokane County - North System	1.9	1.72
Spokane County - Valley	8.05	6.8
Liberty Lake Sewer & Water District	1.06	0.73
City of Cheney	0.86	1.17
City of Airway Heights	0.51	0.6
City of Deer Park	0.3	0.27
City of Medical Lake	0.43	0.4
Latah Creek WWTP	0.05	0.04
Septic	5	-
Self Supplied Septic	3.7	

values in million gallons per day

Municipal WWTP Return Flows

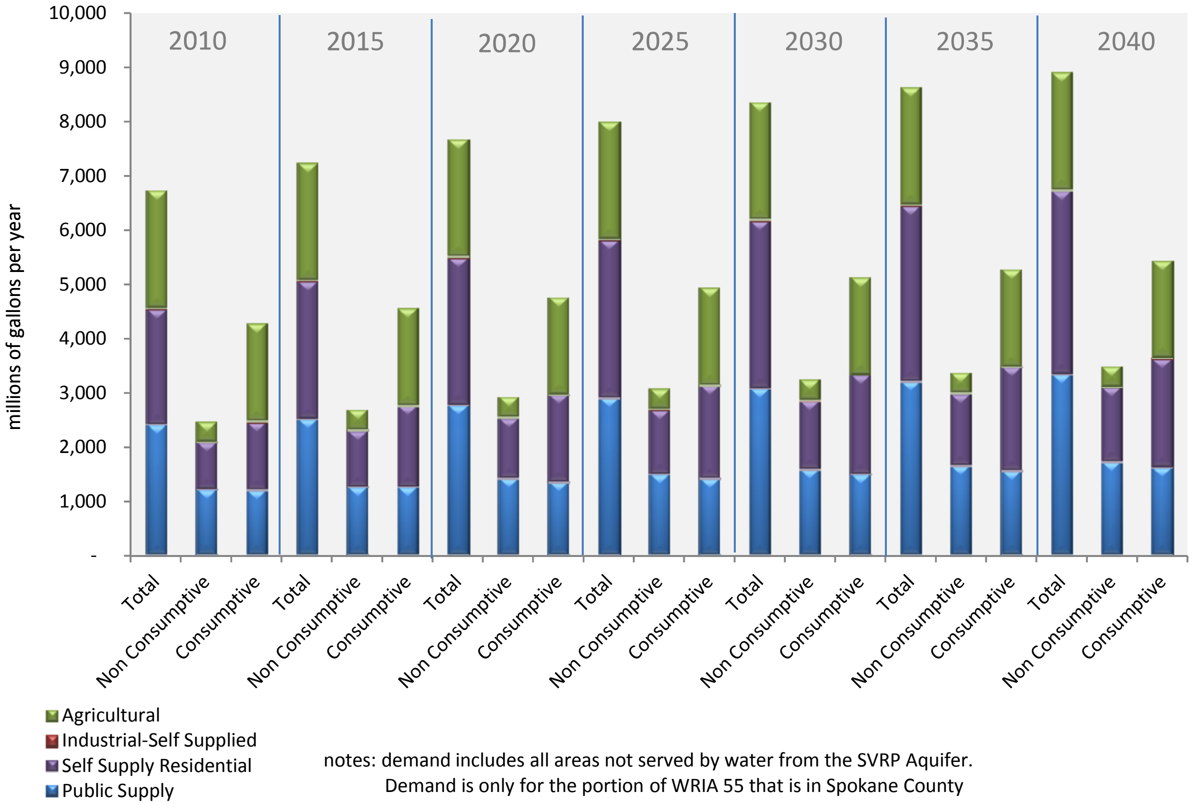
Modeled return flows to municipal WWTPs were compared to actual flows reported by each treatment facility on their discharge monitoring report (DMR) that is submitted to the Washington State Department of Ecology. Summertime flows were utilized so that stormwater that enters a system is minimized. This is especially important for the City of Spokane facility since many areas of the collection system are a combination of storm water and sanitary waste water. In general there was good agreement between the modeled and reported values, but there was a relative percent difference for three facilities that was greater than 30%: Spokane County Valley System, Liberty Lake Sewer and Water District, and City of Cheney.

Modeled values for the Spokane County Valley system were 1.25 MGD greater than reported values. This is likely because more onsite septic systems that will be connected to the system are not yet connected and currently discharge to the ground.

The difference between the modeled and reported values for the City of Cheney was likely due to the variance in flows from Eastern Washington University (EWU). Reported flows at the facility varied from 1.64 in the winter and spring to 0.86 MGD in the summer. The increased amount during the winter and spring is likely due to both increased storm water in the system and increased activity at EWU. It was not possible to separate the influence of EWU from storm water, making a comparison to modeled values difficult.

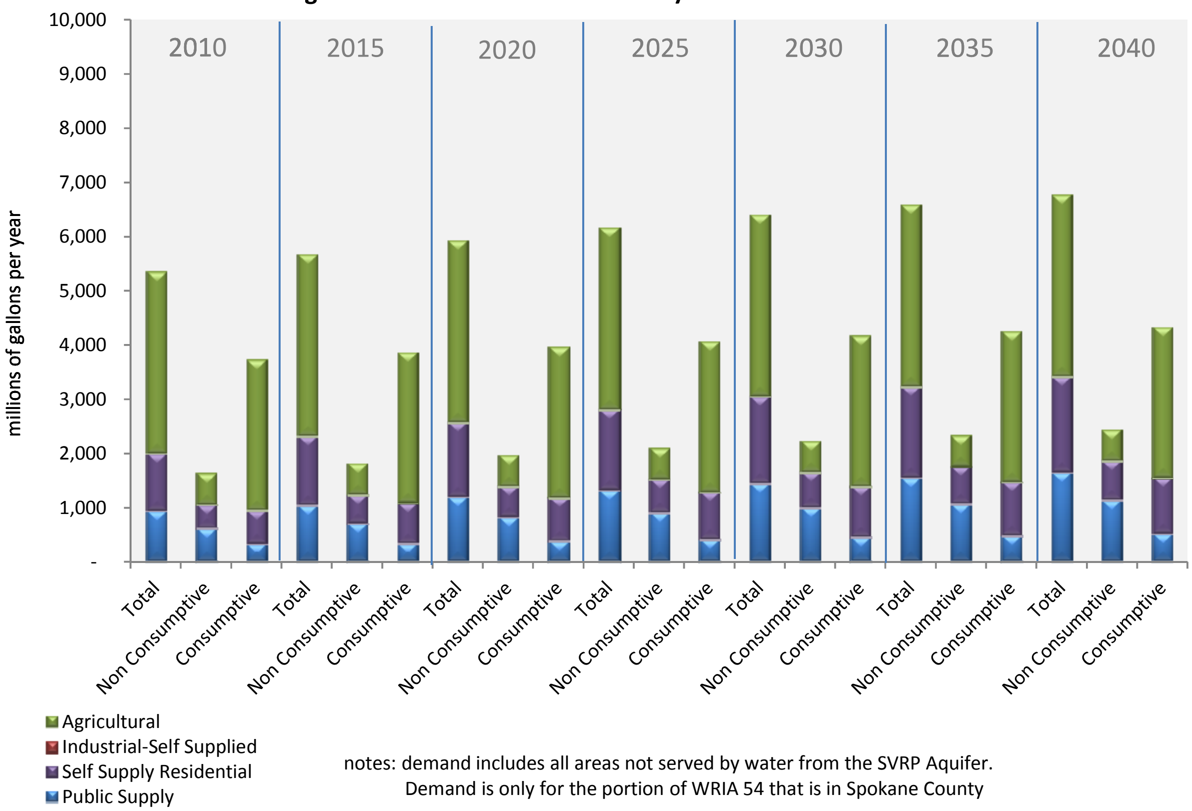
Modeled values for the Liberty Lake Sewer and Water District were higher than reported values. This also occurred in Model 2.0. This is due to the differences between this system and the systems used to develop the single family residential econometric model. Monthly data was not available for the Liberty Lake

Figure 7: WRIA 55 Water Demand by Water Use Sector



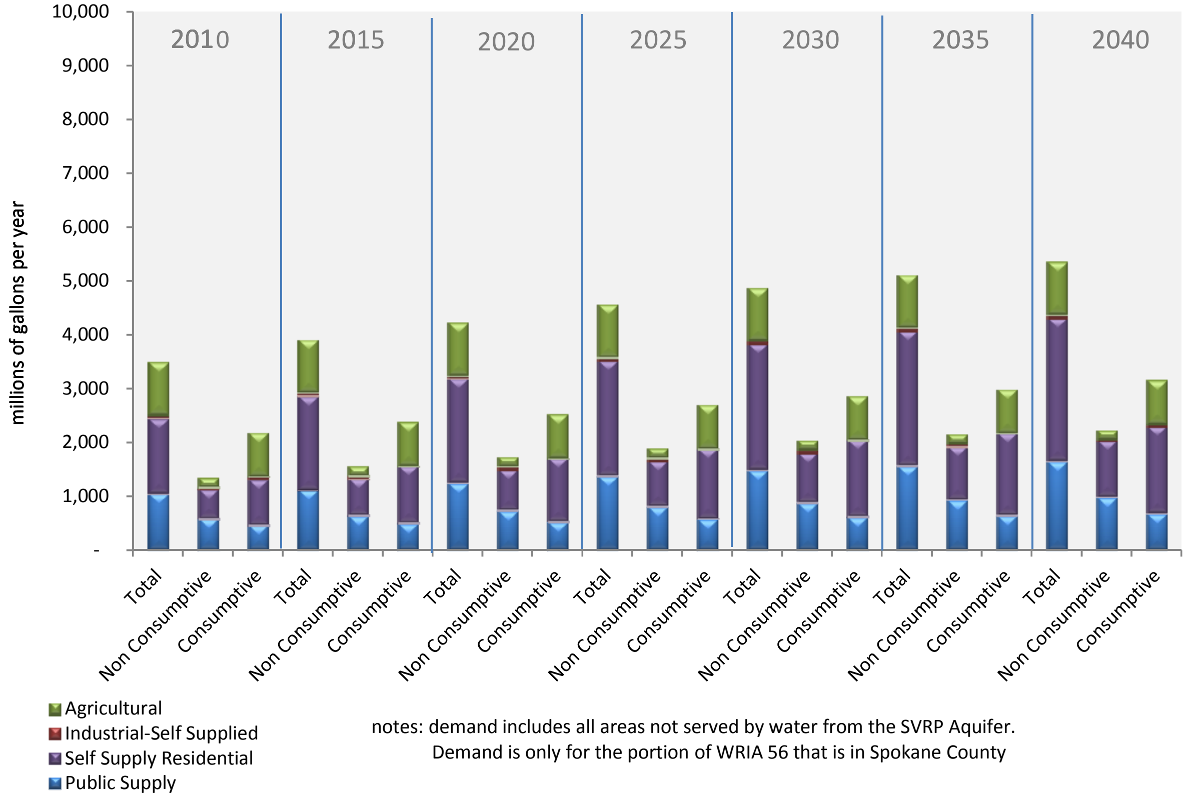
notes: demand includes all areas not served by water from the SVRP Aquifer.
Demand is only for the portion of WRIA 55 that is in Spokane County

Figure 8: WRIA 54 Water Demand by Water Use Sector



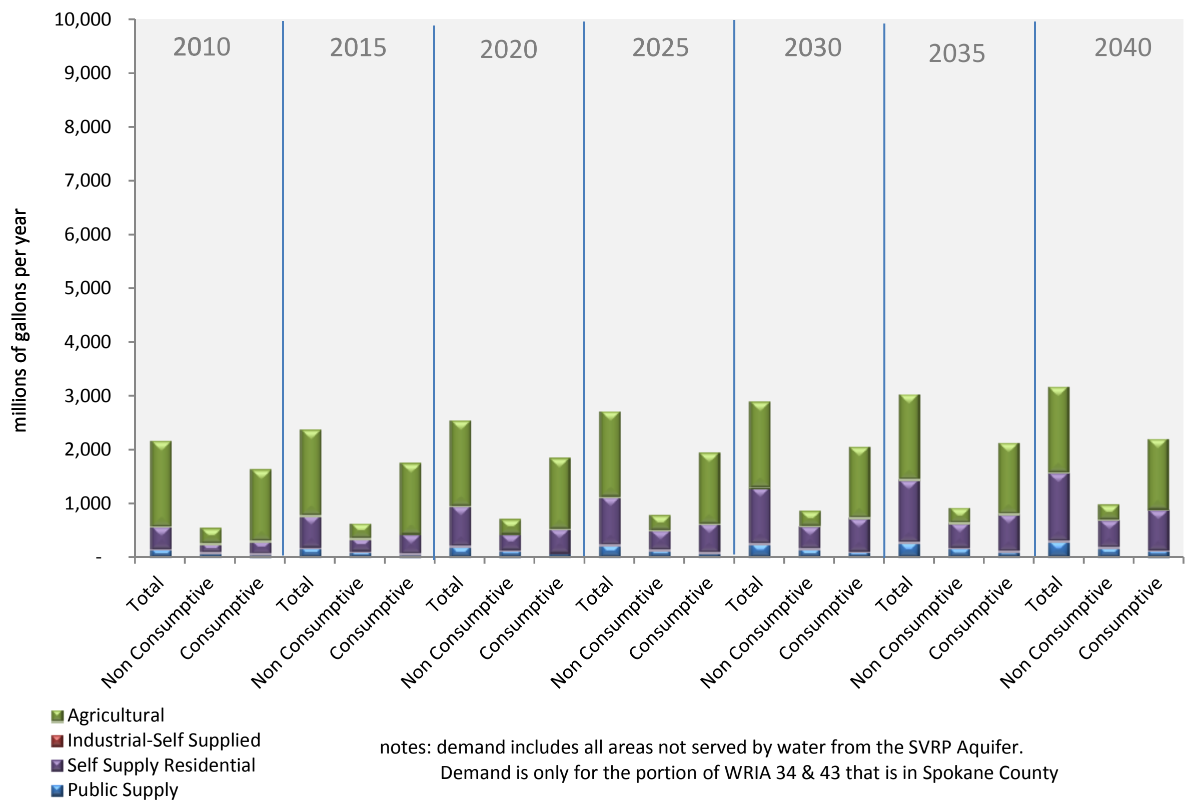
notes: demand includes all areas not served by water from the SVRP Aquifer.
Demand is only for the portion of WRIA 54 that is in Spokane County

Figure 9: WRIA 56 Water Demand by Water Use Sector



notes: demand includes all areas not served by water from the SVRP Aquifer.
Demand is only for the portion of WRIA 56 that is in Spokane County

Figure 10: WRIA 34 & 43 Water Demand by Water Use Sector



notes: demand includes all areas not served by water from the SVRP Aquifer.
Demand is only for the portion of WRIA 34 & 43 that is in Spokane County

Table 8: WRIA 55 Annual Demand - billon gallons per year

Water Use Sector	2010			2020			2030			2040		
	Total	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*
Public Supply	2.41	1.21	1.20	2.77	1.42	1.35	3.08	1.59	1.50	3.35	1.73	1.62
Self Supply Residential	2.13	0.87	1.26	2.72	1.11	1.61	3.10	1.26	1.84	3.39	1.38	2.01
Industrial-Self Supplied	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01	0.02	0.01	0.01
Agricultural	2.16	0.37	1.79	2.16	0.37	1.79	2.16	0.37	1.79	2.16	0.37	1.79
TOTAL	**6.73**	**2.46**	**4.27**	**7.68**	**2.91**	**4.78**	**8.37**	**3.23**	**5.14**	**8.92**	**3.48**	**5.44**

Table 9: WRIA 54 Annual Demand - billon gallons per year

Water Use Sector	2010			2020			2030			2040		
	Total	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*
Public Supply	0.94	0.61	0.33	1.19	0.82	0.37	1.45	1.00	0.45	1.65	1.14	0.51
Self Supply Residential	1.06	0.44	0.62	1.39	0.57	0.81	1.61	0.66	0.94	1.78	0.73	1.04
Industrial-Self Supplied	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural	3.36	0.58	2.78	3.36	0.58	2.78	3.36	0.58	2.78	3.36	0.58	2.78
TOTAL	**5.36**	**1.63**	**3.73**	**5.94**	**1.97**	**3.97**	**6.41**	**2.24**	**4.18**	**6.78**	**2.44**	**4.34**

Table10:WRIA 56 Annual Demand - billon gallons per year

Water Use Sector	2010			2020			2030			2040		
	Total	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*
Public Supply	1.05	0.59	0.47	1.24	0.72	0.52	1.48	0.87	0.61	1.65	0.98	0.67
Self Supply Residential	1.40	0.55	0.85	1.94	0.76	1.18	2.35	0.92	1.43	2.67	1.05	1.62
Industrial-Self Supplied	0.06	0.02	0.04	0.06	0.02	0.04	0.06	0.02	0.04	0.06	0.02	0.04
Agricultural	0.98	0.17	0.81	0.98	0.17	0.81	0.98	0.17	0.81	0.98	0.17	0.81
TOTAL	**3.49**	**1.32**	**2.17**	**4.22**	**1.67**	**2.55**	**4.88**	**1.98**	**2.89**	**5.36**	**2.21**	**3.15**

Table 11: WRIA 34 & 43 Annual Demand - billon gallons per year

Water Use Sector	2010			2020			2030			2040		
	Total	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*	*Total*	*Non Consump*	*Consump*
Public Supply	0.15	0.09	0.06	0.20	0.13	0.08	0.26	0.16	0.10	0.31	0.18	0.12
Self Supply Residential	0.42	0.17	0.25	0.75	0.30	0.45	1.04	0.42	0.62	1.27	0.51	0.76
Industrial-Self Supplied	-	-	-	-	-	-	-	-	-	-	-	-
Agricultural	1.60	0.27	1.32	1.60	0.27	1.32	1.60	0.27	1.32	1.60	0.27	1.32
TOTAL	**2.17**	**0.54**	**1.63**	**2.55**	**0.70**	**1.85**	**2.90**	**0.85**	**2.05**	**3.17**	**0.97**	**2.20**

Sewer and Water District so the water use patterns of this water district are not well represented in the econometric model.

Spokane County Water Demand By WRIA

Approximately 28% of Spokane County water demand is supplied by water not withdrawn from the SVRP Aquifer. Figures 7-10 and Tables 7-10 present the forecasted demand, both consumptive and non-consumptive, for each water use sector for WRIA 54, WRIA 55, WRIA 56, and WRIAs 34& 43.

WRIA 54.

Each WRIA has a unique distribution of water use between sectors. The largest water use component in 2010 in each is:

- WRIA 54– Agricultural
- WRIA 55– Public Supply
- WRIA 56– Self Supplied
- WRIA 34&43– Agricultural

In 2040 the above water use sectors will still be the largest components of total water use in each WRIA with the exception of WRIA 55. By 2040 self-supplied water use will be the most significant component of total water use.

Table12: Irrigated Area Comparison

Study City	Average Irrigated Area (ft^2)
Cambridge, ON	6,998
Waterloo, ON	5,951
Seattle, WA	6,058
Tampa, FL	12,361
Lompoc, CA	4,696
Eugene, OR	6,863
Boulder, CO	6,512
San Diego, CA	5,904
Tempe, AZ	7,341
Denver, CO	7,726
Walnut Valley, CA	10,282
Scottsdale, AZ	4,968
Phoenix, AZ	9,075
Las Virgenes, CA	16,306
Spokane, WA	**6,190**

Single Family Outdoor Residential Water Use

As part of the process of segregating consumptive and non-consumptive water use in Model 3.0 a detailed analysis of single family out door residential water use in Spokane County was conducted. Below are findings of this analysis.

Table 13: Irrigation Application and Return Flow Rates

Month	Application Rate	Net ET	Return Flow Rate
May	0.75	0.86	-14%
June	1.09	0.94	14%
July	1.60	1.41	12%
August	1.60	1.31	19%
September	1.03	0.91	11%
October	0.50	0.00	100%

values in inches per week
Net ET is Lawn ET from the Rathdrum Prairie AgriMet Station less rainfall

The estimated total Spokane County Water Demand in 2010 is 68.56 billion gallons per year. The estimated single family residential outdoor water use demand for 2010 is 18.01 billion gallons per year, or 26% of total demand. During July single family residential outdoor water use is 34% of total demand in July.

There is an estimated 22,300 acres of single family residential landscaped area in Spokane County. The average size of landscaped area per residence is 6,190 ft^2. For comparison, values from the Residential End Uses of Water study published by the AWWA Research Foundation are presented along with the Spokane County average in Table 11 (AWWA, 1999).

Table 12 presents the application rate for each month, the average lawn ET for the years 2008-2012 for the Rathdrum Prairie AgriMet Station, and the percent return flow for each month. The maximum return flow rate is 19% in August. The return flow rate is a function of ET, a value that likely varies significantly over the county. The Rathdrum Prairie AgriMet Station values may under estimate the ET in the southern portion of the county and over estimate it in the northern portion of the county. An investigation of the spatial distribution of lawn ET rates within Spokane County was not in the scope of the project, but as more detailed ET data is available it can be incorporated into the Model.

The 2007 USGS SVRP Aquifer flow model utilized a 40% landscape irrigation return flow rate, which, is more than double the rate estimated from Model 3.0. A lower irrigation return flow rate is supported in other literature as well. The AWWA Residential End Uses of Water concluded:

Homeowners in all participating cities in the study *area irrigated well below the calculated theoretical requirement for the year on average. This suggests that on the whole, homeowners in this study irrigated efficiently when compared with the theoretical requirement for maximum growth of turf grass. (AWWA, 1999)*

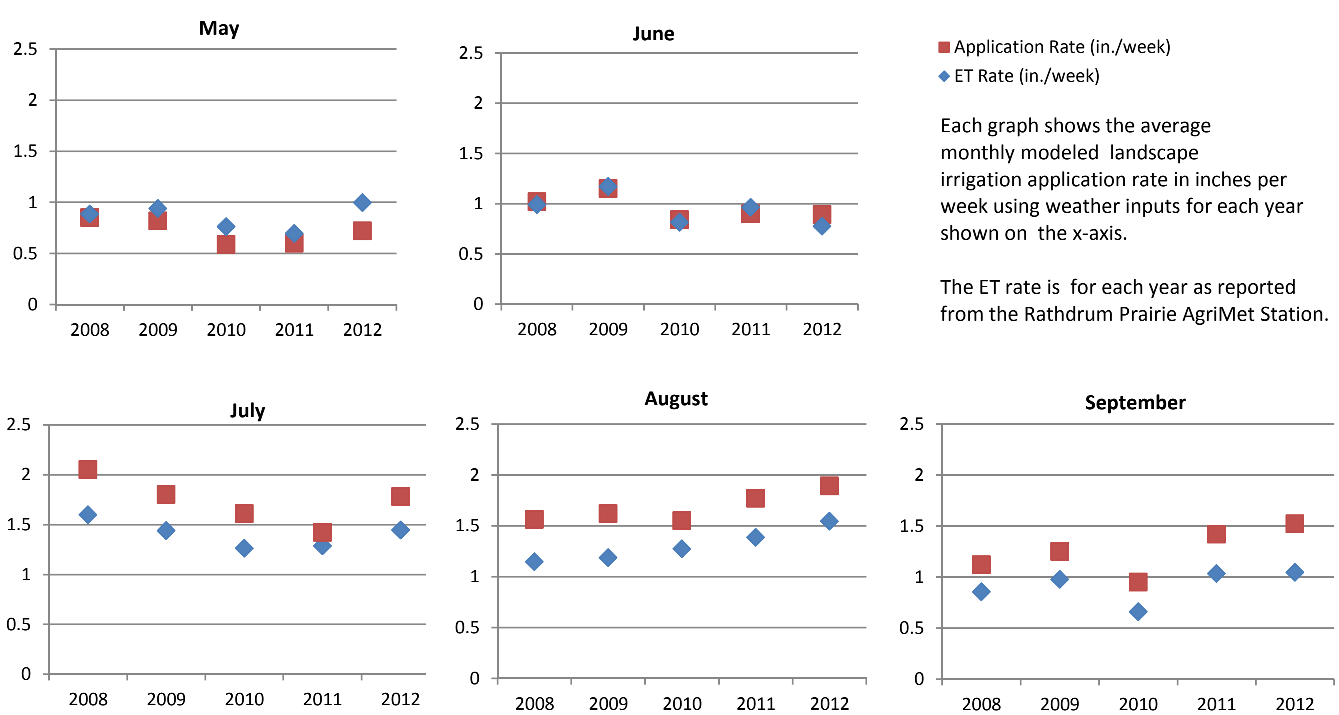
A study conducted by the Utah Department of Natural Resources titled Identifying Residential Water Use concluded the following:

- *Outdoor irrigation practices greatly influence residential water use.*
    - ◊ *Hose irrigation practices apply water under the estimated net irrigation requirement (volume required to maximize growth)*
    - ◊ *Sprinkler systems without control timers water at the estimated net irrigation requirement.*
    - ◊ *Sprinkler systems with timers water close to 44% over the estimated net irrigation requirement.*
- *Estimations from meter reading records indicate that typical residents over irrigate their yards by 18 % of the net irrigation requirement. (Utah Department of Natural Resources, 2001)*

Model 3.0, as did Model 2.0, includes a weather input that impacts single family residential water use. Monthly maximum temperature and monthly total precipitation are entered into the model and it is utilized in the single family econometric model to estimate monthly single family water use. Figure 11 shows the modeled landscape irrigation application rate with 2008 through 2012 weather used as the weather input. Also plotted are the ET rates as reported at the Rathdrum Prairie AgriMet Station. The R^2 of a linear regression of irrigation application rate as a function of ET is 0.81.

The application rates are based on an econometric model that is based on actual weather and reported water use. ET rates were not used in development of the econometric model, but ET rates are a function of weather. The correlation between application rates and ET rates demonstrate the ability of the model to respond appropriately to changes in weather. The correlation also demonstrates that the single family residential water use sector adjusts irrigation application rates in response to changes in ET.

Figure 11: Modeled Irrigation Application Rates compared to actual ET Rates



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