4 | WATER DEMANDS

INTRODUCTION

A detailed analysis of system demands is crucial to the planning efforts of a water supplier. A demand analysis first identifies current demands to determine if the existing system can effectively provide an adequate quantity of water to its customers under the most crucial conditions, in accordance with federal and state laws. A future demand analysis identifies projected demands to determine how much water will be needed to satisfy the water system’s future growth and continue to meet federal and state laws.

The magnitude of water demands is typically based on three main factors: 1) population; 2) weather; and 3) water use classification. Population and weather have the two largest impacts on water system demands. Population growth tends to increase the annual demand, whereas high temperatures tend to increase the demand over a short period of time. Population does not solely determine demand because different user types use varying amounts of water. The use varies based on the number of users in each customer class, land use density, and irrigation practices. Water use efficiency efforts also impact demands and can be used to accommodate a portion of the system’s growth without increasing a system's supply capacity.

Demands on the water system determine the size of storage reservoirs, supply facilities, water mains, and treatment facilities. Several different types of demands were analyzed and are addressed in this chapter, including average day demand, maximum day demand, peak hour demand, fire flow demand, future demands, and a demand reduction forecast based on the Water Use Efficiency program.

CERTIFICATE OF WATER AVAILABILITY

In accordance with the requirements of the Growth Management Act (GMA), the City of Kent (City) must identify that water is available prior to issuing a building permit. If the property requesting water service is outside of the City limits, a “No Protest of Annexation and Declaration of Covenant” may be required by the City, as identified in the City’s Instructions and Checklist for Certificate of Water Availability. The requirement for providing evidence of an adequate water supply was codified in 1990 under Revised Code of Washington (RCW) 19.27.097 in the Building Code section.

CURRENT POPULATION AND SERVICE CONNECTIONS

WATER USE CLASSIFICATIONS

The City has divided all water customers into ten different classes for billing purposes. For planning purposes, the water customers have been combined into five different groups: 1) single-family residential; 2) multi-family residential; 3) commercial; 4) industrial; and 5) public. The public group includes City of Kent facilities, government, and schools billing classes. The demand analysis that follows will report on the water use patterns of these five user groups.

RESIDENTIAL AND EMPLOYMENT POPULATION SERVED

The residential population within the City limits was 124,500 in 2016, based on estimates from the Washington State Office of Financial Management (OFM). Since the City does not provide water service to all customers within the City limits, the actual population served by the City's water system is smaller. The 2016 residential population served by the City within the water service area is estimated to be approximately 68,157 in 2016, and 69,465 in 2017, as presented in **Chapter 3**.

Because non-residential water use is a significant portion of the City's total water use, the total employment for the water system was calculated to project the future water system demands. The existing and future number of employees working in the water service area were calculated using census tract data available from the Puget Sound Regional Council (PSRC) and data provided by King County. The 2016 employment population served by the City within the water service area is estimated to be approximately 64,755 in 2016, and 65,356 in 2017. The computation of the population served is discussed in **Chapter 3**, along with a more detailed discussion of the City's population and household trends.

EXISTING WATER DEMANDS

WATER CONSUMPTION

Water consumption is the amount of water used by all customers of the system, as measured by the customer's meters. **Table 4-1** shows the historical average number of connections, average annual consumption, and average daily consumption per connection of each customer class for the City from 2011 through 2016. As shown in **Table 4-1**, the City provided water service to an average of 14,907 connections in 2016. Approximately 10,981 connections (74 percent) were single-family residential customers, 1,682 connections (11 percent) were multi-family residential customers, 1,883 connections (13 percent) were commercial customers, 98 connections (less than 1 percent) were industrial customers, and 263 connections (2 percent) were public customers.

Table 4-1
Average Annual Metered Consumption and Service Connections

Year	Customer Class					Totals
	Single-family Residential	Multi-family Residential	Commercial	Industrial	Public	
Average Number of Connections						
2011	10,339	1,674	1,846	97	252	14,207
2012	10,498	1,674	1,849	97	253	14,371
2013	10,631	1,678	1,859	98	253	14,518
2014	10,775	1,681	1,868	98	256	14,678
2015	10,872	1,681	1,874	98	259	14,783
2016	10,981	1,682	1,883	98	263	14,907
Average Annual Consumption (gallons)						
2011	591,332,522	774,421,604	705,851,696	183,370,704	95,741,008	2,350,717,534
2012	598,972,295	813,131,352	708,109,160	149,259,660	92,413,904	2,361,886,371
2013	599,690,973	806,081,452	724,312,336	148,935,776	95,972,888	2,374,993,425
2014	624,470,792	818,546,124	771,937,047	163,497,092	102,842,520	2,481,293,575
2015	642,706,284	838,680,040	809,905,976	168,551,328	115,714,852	2,575,558,480
2016	631,193,966	842,255,480	840,994,352	163,321,312	100,454,904	2,578,220,014
Average Daily Consumption Per Connection (gal/day/conn)						
2011	157	1,268	1,048	5,179	1,043	453
2012	156	1,327	1,047	4,204	1,000	449
2013	155	1,316	1,068	4,178	1,038	448
2014	159	1,334	1,129	4,571	1,102	463
2015	162	1,367	1,184	4,712	1,226	477
2016	157	1,368	1,220	4,557	1,043	474
Average	**157**	**1,330**	**1,116**	**4,567**	**1,075**	**461**

As shown in **Chart 4-1**, the single-family residential class represents approximately 74 percent of all connections, but only 24 percent of total system consumption, as shown in **Chart 4-2**. This is due to the lower consumption per connection of single-family residential customers as compared to other customer types. As shown in **Table 4-1**, single-family residential customers use an average of approximately 157 gallons per day (gpd) per connection, compared to multi-family customers that use an average of approximately 1,330 gpd per connection. Multiple units are typically served by one multi-family residential connection, resulting in additional consumption per connection compared to single-family residential connections. Multi-family residential consumption per connection is similar to the consumption of commercial and public customers that use an average of approximately 1,116 and 1,075 gpd per connection, respectively. Industrial customers use significantly more water with an average of approximately 4,567 gpd per connection. The higher consumption rate per connection of commercial, public, and industrial customers compared to single-family residential customers is expected since these customers include the system’s highest individual water users.

Chart 4-1
2016 Water Connections by Customer Class

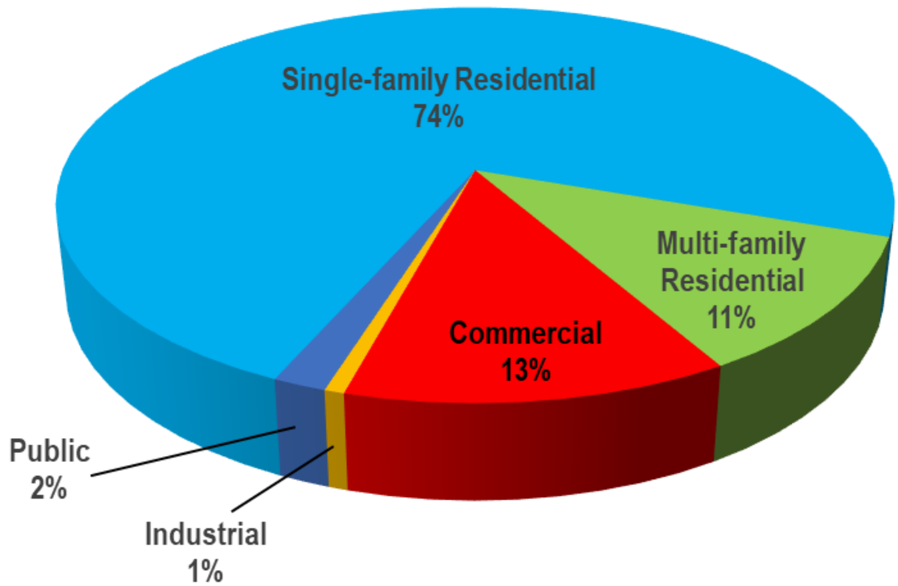


Chart 4-2
2016 Water Consumption by Customer Class

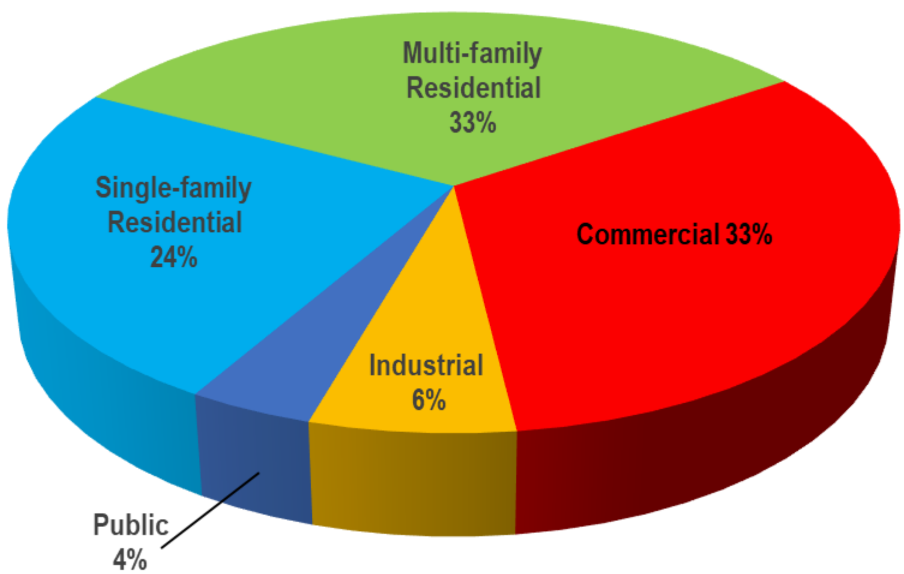


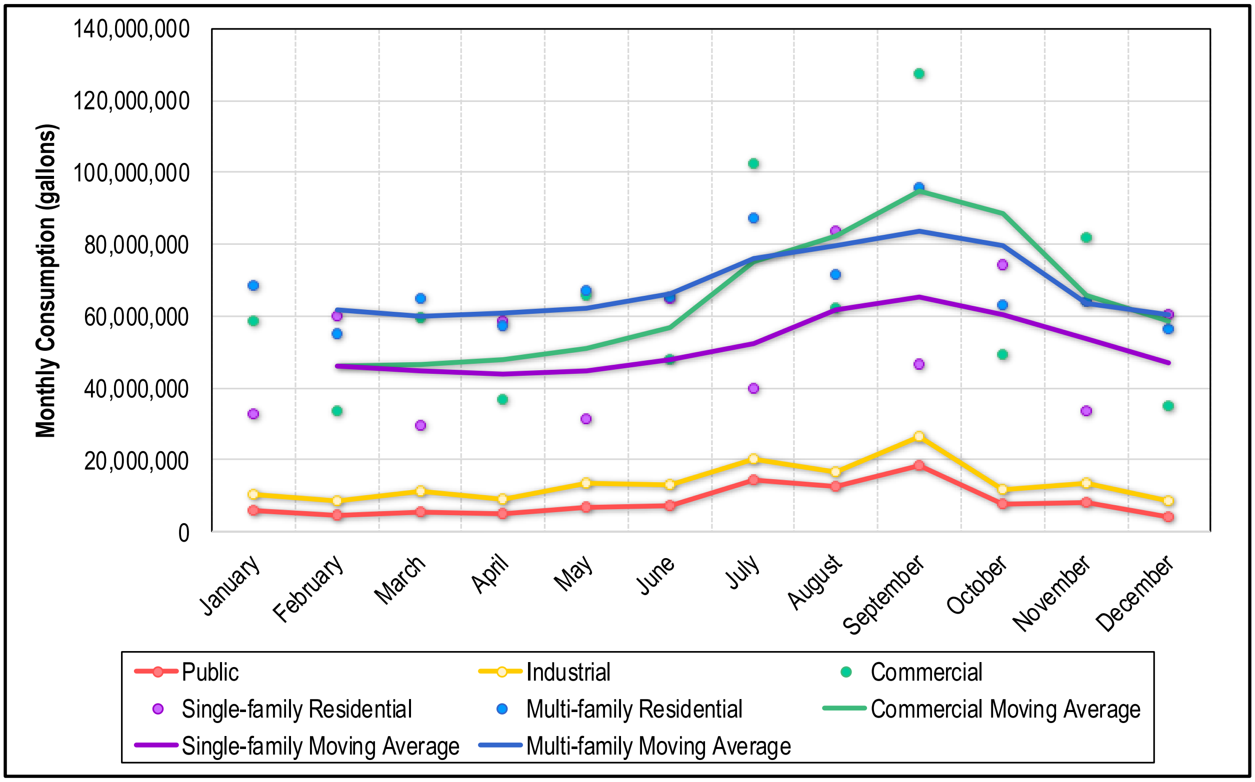
Table 4-2 shows the largest 20 water users of the system in 2016, and their total amount of metered consumption for the year. The total water consumption of these 20 water accounts represented approximately 14.2 percent of the system's total metered consumption in 2016. The list of customer accounts in **Table 4-2** consists of water users from all customer classes except the single-family residential class, with the majority of the largest users considered commercial customers.

Table 4-2
Largest Water Users

Name	Address	Total Annual Consumption (gallons)
Danone Waters of North America	21608 85th Ave. S	52,190,700
Kings Command Foods, LLC	7622 S 188th St.	29,917,512
Air Gas	8008 S 222nd St.	26,700,149
Con Agra Foods	6320 S 190th St.	24,458,243
Aramark Uniform Services	7810 S 228th St.	23,679,523
King County Administration Building	401 4th Ave. N	22,599,339
Rexam Beverage Can Company	1220 2nd Ave. N	21,581,243
Mikron Industries	1136 6th Ave. N	20,869,099
Kent 228	8010 S 228th St.	16,743,603
Alsco	6906 S 204th St.	15,037,301
Northwest Center	22247 76th Ave. S	13,696,796
Oberto Sausage Company	7060 S 238th St.	12,315,895
Danone Waters of North America	21608 85th Ave. S	12,134,867
Boeing Defense and Space Group	20403 68th Ave. S	12,101,205
Smith Brothers Farms	26401 79th Ave S.	11,293,311
Northwest Center	22247 76th Ave. S	10,661,209
Hytek Finishes Co.	8127 S 216th St.	10,401,635
Oberto Snacks, Inc.	7060 S 238th St.	10,211,631
Flow International	23316 64th Ave. S	9,900,442
Hume Investments, Inc.	25246 106th Ave. SE	9,863,787
Largest Water Users Total Consumption		**366,357,488**
Water System Total Metered Consumption		2,578,220,014
Large Water Users Percent of Total Metered Consumption		**14.2%**

Residential demand varies throughout the year, typically peaking in the hot summer months. Other customers often peak at different times or have different peaking factors because their uses and consumption patterns differ. The demand for all customers in the City generally peaks in the summer, as shown in **Chart 4-3**. Residential and commercial consumption have the largest peaks in the summer, as shown in **Chart 4-3**. Industrial and public consumption has less pronounced peaks, but also typically peaks in the summer, as shown in **Chart 4-3**. The City reads public and industrial meters monthly, and most residential and commercial meters every two months as shown in **Chart 4-3**. A two-period moving average trendline is shown for the customer classes that are read every two months to approximate the actual 2016 monthly consumption data. The consumption data are also shown as data points in **Chart 4-3**.

Chart 4-3
2016 Monthly Consumption by Customer Class



WATER SUPPLY

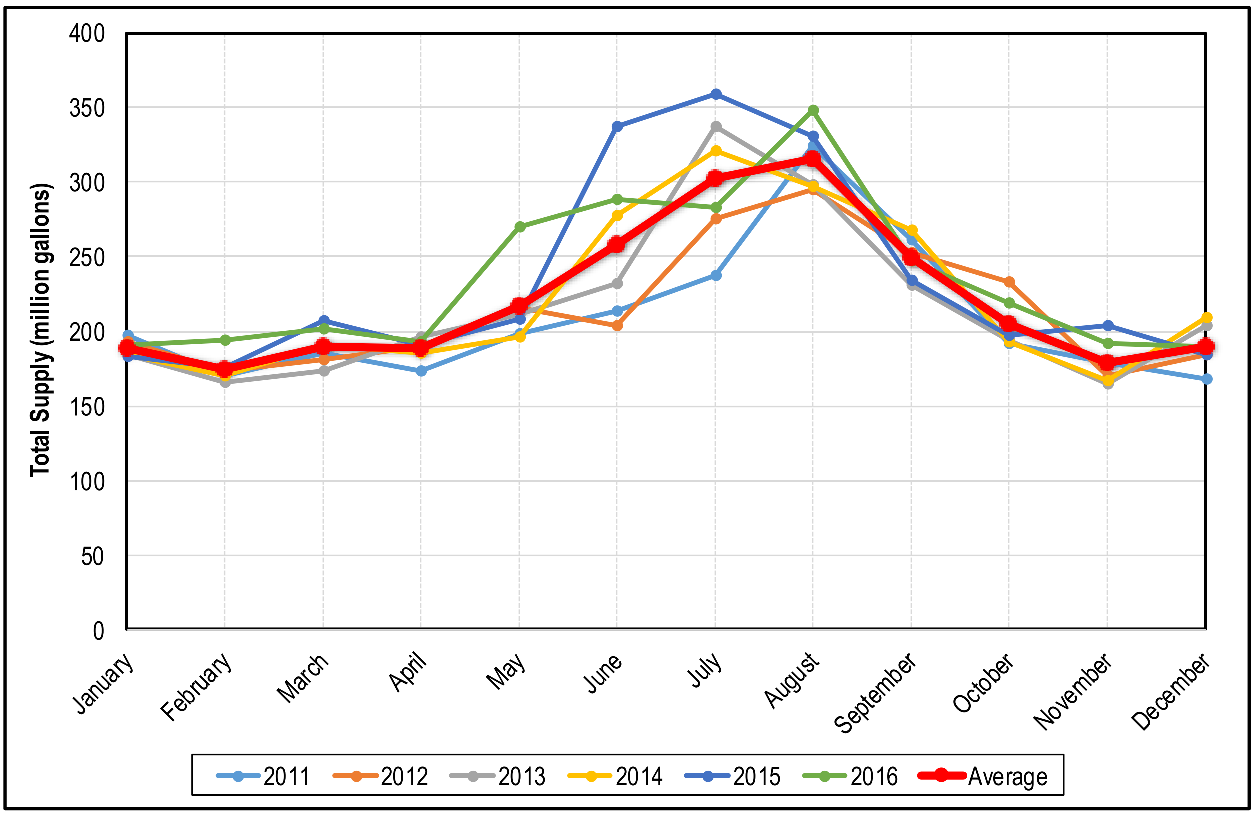
Water supply, or production, is the total amount of water supplied to the system, as measured by the meters at source of supply facilities. Water supply is different than water consumption in that water supply is the recorded amount of water put into the system and water consumption is the recorded amount of water taken out of the system. The measured amount of water supply of any system is typically larger than the measured amount of water consumption, due to non-metered water use and water loss (i.e., distribution system leakage), which will be described more in the **Distribution System Leakage** section. **Table 4-3** summarizes the total amount of water supplied to the system from 2011 through 2016.

Table 4-3
Historical Water Supply

Year	Annual Supply (gallons)
2011	2,498,178,000
2012	2,566,823,000
2013	2,593,245,000
2014	2,659,170,000
2015	2,811,692,000
2016	2,818,790,000

Like most other water systems, the City's water use varies seasonally. **Chart 4-4** shows the historical amount of water supplied to the City's system for each month from 2011 to 2016.

Chart 4-4
Historical Monthly Water Supply



As shown in **Chart 4-4**, water supply increases significantly during summer months, primarily due to irrigation. The City's highest water use typically occurs in July and August. On average, the amount of water supplied during these 2 months is approximately 23 percent of the total supply for the entire year.

Chart 4-5 shows the monthly water supply by source for 2016. In 2016, the majority of water was supplied from the Clark Springs and Kent Springs, with smaller volumes coming from the East Hill Well, and the City of Tacoma's Second Supply Pipeline (SSP) Connection

#1 (240 Zone) and SSP Connection #3 (590 Zone) sources. **Table 4-4** and **Chart 4-6** show the annual water supply by source from 2011 to 2016. In 2016, the City's two primary sources, Clark Springs and Kent Springs, supplied 68 percent of the total supply to the system. The relative volume supplied from each of the City's sources has been similar since 2011, but the volume of water consumed within the City has steadily inclined from 2011 to 2016. This is most likely the result of the 700 new service connections added to the system and the increased usage of water per connection of both commercial and multi-family residential customer classes. **Table 4-4** also presents the system-wide average day demand for 2011 through 2016.

Chart 4-5
2016 Monthly Water Supply by Source

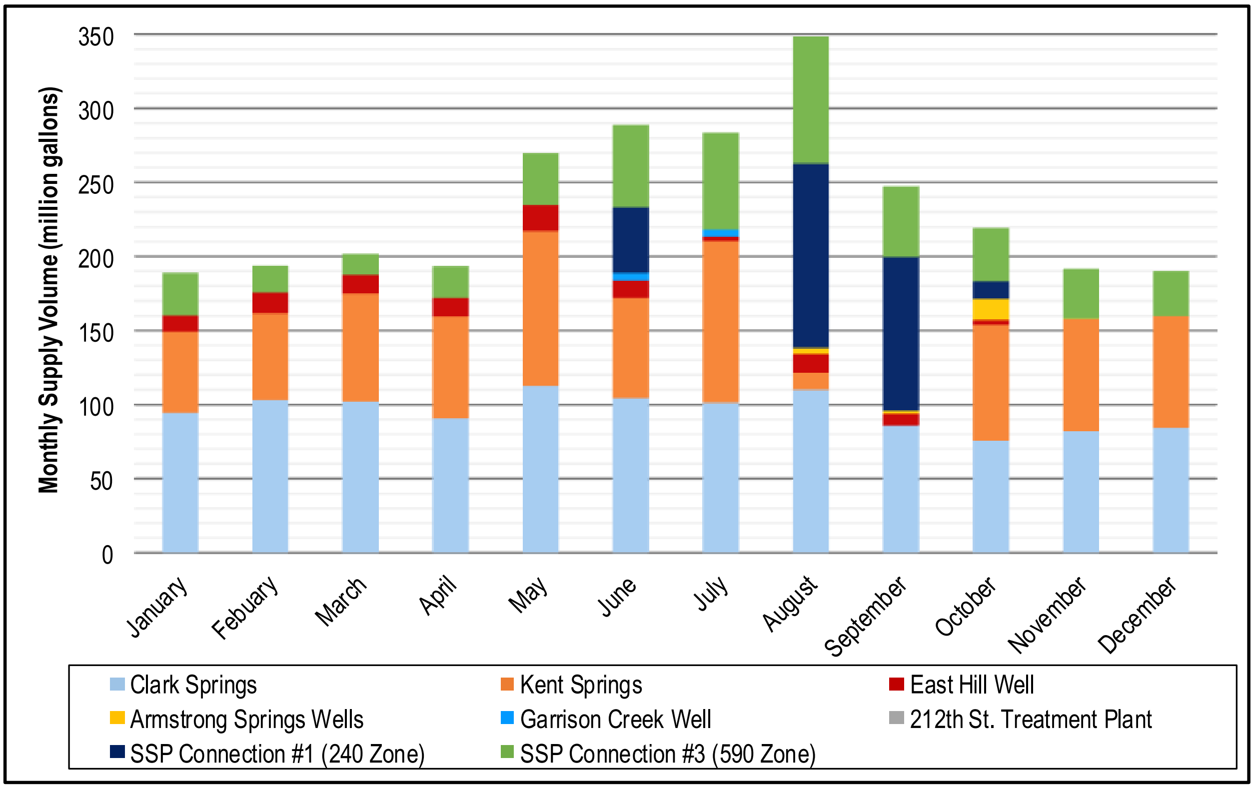


Table 4-4
Historical Supply by Source and System-wide Average Daily Demand

	Annual Supply Volume (MG)												
Year	Clark Springs	Kent Springs	East Hill Well	Armstrong Springs Wells	Seven Oaks Well	Garrison Creek Well	212th St. Treatment Plant	SSP Conn. #1 (240 Zone)	SSP Conn. #3 (240 Zone)	SSP Conn. #3 (590 Zone)	Interties	Net Supply	Average Day Demand (gpm)
2011	1,375.9	743.8	125.5	79.8	0.0	6.4	0.0	0.0	0.0	166.4	0.3	2,498.2	4,753
2012	1,340.8	728.8	228.8	39.0	0.0	0.0	0.0	11.3	0.0	217.8	0.3	2,566.8	4,870
2013	1,297.8	751.5	183.3	88.8	0.0	0.1	0.0	0.0	0.0	271.7	0.2	2,593.2	4,934
2014	1,347.3	822.8	176.2	82.5	0.0	8.1	0.0	16.1	0.0	205.8	0.4	2,659.2	5,059
2015	1,188.3	809.7	158.7	97.5	1.7	17.5	98.7	82.3	0.0	357.2	0.0	2,811.7	5,349
2016	1,146.2	776.8	106.4	21.1	0.0	9.7	0.0	284.2	1.4	472.5	0.5	2,818.8	5,348

Chart 4-6
Annual Water Supply by Source

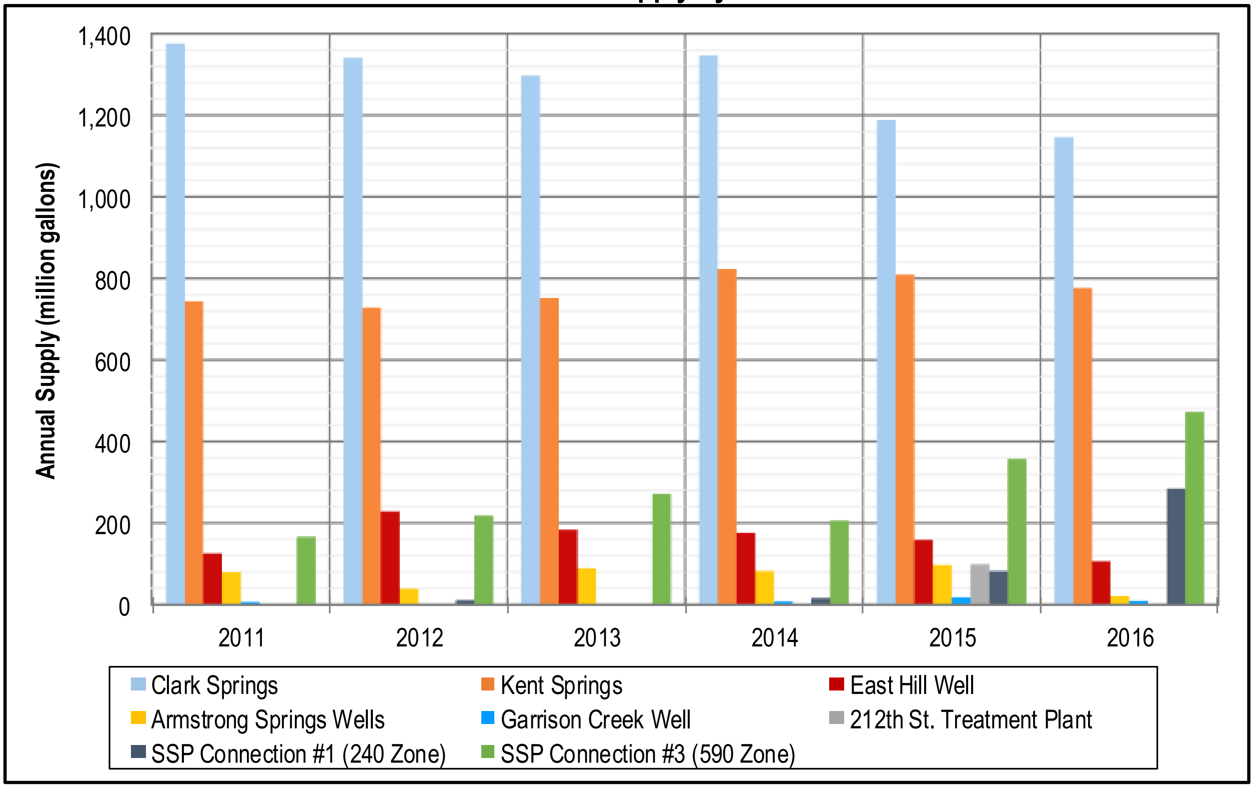


Table 4-5 shows the 2016 demand of each of the City's 13 existing pressure zones. The demands are based on the City's 2016 individual customer meter data. The City's two largest pressure zones, the 240 and 590 Zones, account for approximately 89 percent of the total system demand. **Figure 2-1** in **Chapter 2** presents the City's pressure zones.

Table 4-5
2016 Demands by Pressure Zone

Pressure Zone	2016 Annual Supply (gallons)	Average Daily Demand (gpm)	Percent of Total Demand
240	1,618,150,124	3,070	57.4%
271 Alvord	6,166,085	12	0.2%
308 Hilltop	215,708	0	0.0%
339 Seattle	5,887,243	11	0.2%
354.5	23,848,860	45	0.8%
366 Stetson	1,283,724	2	0.0%
368 Weiland	1,694,095	3	0.1%
416	0	0	0.0%
485	97,852,402	186	3.5%
529	77,623,224	147	2.8%
575	14,531,337	28	0.5%
587	72,225,269	137	2.6%
590	899,311,928	1,706	31.9%
Total	**2,818,790,000**	**5,348**	**100.0%**

Table 4-6 presents the computation of the existing system per capita demand based on 2016 data. As shown in the upper portion of the table, the residential population served by the City's water system in 2016 was approximately 68,157. This population served and the City's total residential water consumption in 2016 (total combined consumption of the single- and multi-family residential customer classes) were used to calculate the existing residential per capita demand of 65 gpd. The lower portion of the table presents the employment population served by the City's water system in 2016, which was approximately 64,755. This population served and the City's total employment water consumption in 2016 (total combined consumption of the commercial, industrial, and public customer classes) were used to calculate the existing employment per capita demand of 51 gpd.

Table 4-6
Existing Per Capita Demand

2016 Residential Population Served	
Calculated 2016 Residential Population Served	68,157
2016 Total Annual Residential Supply (gallons)	
2016 Total Annual Residential Supply (gallons)	1,610,934,886
Existing Residential Per Capita Supply (gal/day/capita)	**65**
2016 Employment Population Served	
Calculated 2016 Employment Population Served	64,755
2016 Total Annual Employment Supply (gallons)	
2016 Total Annual Employment Supply (gallons)	1,207,855,114
Existing Employment Per Capita Supply (gal/day/capita)	**51**

DISTRIBUTION SYSTEM LEAKAGE

The difference between the amount of water supply and the amount of authorized water consumption is the amount of distribution system leakage (DSL). There are many sources of DSL in a typical water system, including water system leaks, inaccurate supply metering, inaccurate customer metering, illegal water system connections or water use, fire hydrant usage, water main flushing, and malfunctioning telemetry and control equipment resulting in reservoir overflows. Several of these types of usages, such as water main flushing and fire hydrant usage, may be considered authorized uses if they are tracked and estimated. Although real losses from the distribution system, such as reservoir overflows and leaking water mains, should be tracked for accounting purposes, these losses must be considered leakage. The Water Use Efficiency (WUE) Rule establishes a DSL standard of 10 percent or less based on a rolling 3-year average.

The City has tracked water usage from flushing main lines and dead-ends since 2011, and many other authorized usage volumes. The amount of DSL in the City's system has been under 10 percent since 2011, as shown in **Table 4-7**. The City will continue to record authorized water usage and improve the reporting of additional authorized water uses. The City will also implement the WUE Program contained in **Appendix E**.

Table 4-7
Distribution System Leakage

Description	Year					
	2011	**2012**	**2013**	**2014**	**2015**	**2016**
Authorized Consumption (MG)						
Metered Customer Use	2,350.7	2,361.9	2,375.0	2,481.3	2,575.6	2,578.2
Public Works Hydrant Meters	31.7	31.7	31.1	62.6	50.7	43.1
Unidirectional & Dead End Flushing	1.8	1.7	3.0	2.0	1.8	1.7
Storm and Sewer Vactor Meters	0.8	0.9	1.8	1.5	1.5	1.2
Routine Maintenance	4.9	5.6	1.9	5.7	1.4	1.5
Other Operations	10.3	5.8	15.4	7.8	7.3	13.3
KSTM Leak	11.0	26.3	11.0	11.0	11.0	11.8
Total Authorized Consumption	**2,411.2**	**2,433.9**	**2,439.2**	**2,571.9**	**2,649.3**	**2,650.8**
Total Supply (MG)						
Gross Supply (Finished Water)	**2,498.2**	**2,566.8**	**2,593.2**	**2,659.2**	**2,811.7**	**2,818.8**
Distribution System Leakage (MG)						
Total DSL Volume	**87.0**	**132.9**	**154.1**	**87.3**	**162.4**	**168.0**
Total DSL Percentage	3.5%	5.2%	5.9%	3.3%	5.8%	6.0%
Rolling 3-Year Average DSL Percentage	**---**	**---**	**4.9%**	**4.8%**	**5.0%**	**5.0%**
Adjusted DSL Percentage[1]	5.9%	8.0%	8.4%	6.7%	8.4%	8.5%

(1) The adjusted DSL percentage is based on the difference between metered consumption and net supply. The calculation does not include the DSL reduction associated with other authorized non-metered consumption.

The annual DSL percentages are applied to the consumption by water use classification as reported in **Table 4-1** to determine the net supply per water use classification. Supply per water use classification for 2011 through 2016 is summarized in **Table 4-8**. The net supply per water use classification is used in the equivalent residential unit (ERU) calculations to determine the number of ERUs for each customer class.

Table 4-8
Average Annual Supply by Customer Class

		Annual Supply (gallons)					
Year	DSL	Single-family Residential	Multi-family Residential	Commercial	Industrial	Public	Total Demand (i.e. Net Supply)
2011	5.9%	628,426,800	823,001,056	750,129,759	194,873,545	101,746,840	2,498,178,000
2012	8.0%	650,944,043	883,685,296	769,550,517	162,210,652	100,432,492	2,566,823,000
2013	8.4%	654,799,968	880,156,834	790,873,492	162,622,327	104,792,379	2,593,245,000
2014	6.7%	669,237,213	877,225,218	827,274,877	175,217,704	110,214,989	2,659,170,000
2015	8.4%	701,631,173	915,572,284	884,160,143	184,004,527	126,323,874	2,811,692,000
2016	8.5%	690,089,763	920,845,123	919,466,321	178,560,588	109,828,206	2,818,790,000

EXISTING EQUIVALENT RESIDENTIAL UNITS

The demand of each customer class can be expressed in terms of ERUs for demand forecasting and planning purposes. One ERU is equivalent to the amount of water used by a single-family residence. The number of ERUs represented by the demand of the other customer classes is determined from the total demand of the customer class and the unit demand per ERU from the single-family residential demand data.

Tables 4-9A and **4-9B** present the computed number of ERUs for each customer class from 2011 through 2016. The demands shown are based on the consumption totals of each customer class and the authorized non-revenue water consumption shown in **Table 4-8**. The average demand per ERU from 2011 through 2016 (6-year average) was 171 gpd, which is slightly less than the average single-family residential demand in the Puget Sound area, which is typically between 200 and 300 gpd.

Table 4-9A
Equivalent Residential Units

Year	Average Number of Connections	Average Annual Demand (gallons)	Demand per ERU (gal/day/ERU)	Total ERUs
Single-family Residential (ERU Basis)				
2011	10,339	628,426,800	167	10,339
2012	10,498	650,944,043	169	10,498
2013	10,631	654,799,968	169	10,631
2014	10,775	669,237,213	170	10,775
2015	10,872	701,631,173	177	10,872
2016	10,981	690,089,763	172	10,981
Multi-family Residential				
2011	1,674	823,001,056	167	13,540
2012	1,674	883,685,296	169	14,251
2013	1,678	880,156,834	169	14,289
2014	1,681	877,225,218	170	14,124
2015	1,681	915,572,284	177	14,187
2016	1,682	920,845,123	172	14,653
Commercial				
2011	1,846	750,129,759	167	12,341
2012	1,849	769,550,517	169	12,411
2013	1,859	790,873,492	169	12,840
2014	1,868	827,274,877	170	13,320
2015	1,874	884,160,143	177	13,700
2016	1,883	919,466,321	172	14,631

Table 4-9B
Equivalent Residential Units

Year	Average Number of Connections	Average Annual Demand (gallons)	Demand per ERU (gal/day/ERU)	Total ERUs
		Industrial		
2011	97	194,873,545	167	3,206
2012	97	162,210,652	169	2,616
2013	98	162,622,327	169	2,640
2014	98	175,217,704	170	2,821
2015	98	184,004,527	177	2,851
2016	98	178,560,588	172	2,841
		Public		
2011	252	101,746,840	167	1,674
2012	253	100,432,492	169	1,620
2013	253	104,792,379	169	1,701
2014	256	110,214,989	170	1,775
2015	259	126,323,874	177	1,957
2016	263	109,828,206	172	1,748
		System-wide Totals		
2011	14,207	2,498,178,000	167	41,099
2012	14,371	2,566,823,000	169	41,396
2013	14,518	2,593,245,000	169	42,102
2014	14,678	2,659,170,000	170	42,815
2015	14,783	2,811,692,000	177	43,567
2016	14,907	2,818,790,000	172	44,854
Average 2011 to 2016			**171**	

The average demand per ERU from 2011 through 2016 of 171 gpd will be used later in this chapter to forecast ERUs in future years based on estimated future demands. This demand per ERU value will also be used to determine the capacity (in terms of ERUs) of the existing system in **Chapter 7**.

PEAK DEMANDS

Average Day Demand

Average day demand (ADD) is the total amount of water delivered to the system in a year divided by the number of days in the year. The ADD is determined from the historical water use patterns of the system and can be used to project future demands within the system. ADD data are typically used to determine standby storage requirements for water systems. Standby storage is the volume of a reservoir used to provide water supply under emergency conditions when supply facilities are out of service. Water production records from the City's wells and spring sources were reviewed to determine the system's ADD. The system's average day demand from 2011 through 2016 is shown in **Table 4-4**.

Maximum Day Demand

Maximum day demand (MDD) is the maximum amount of water used throughout the system during a 24-hour time period of a given year. MDD typically occurs on a hot summer day when lawn watering is occurring throughout much of the system. In accordance with Washington Administrative Code (WAC) 246-290-230, the distribution system shall provide fire flow at a minimum pressure of 20 pounds per square inch (psi) during MDD (i.e., peak day demand) conditions. Supply facilities (e.g., wells, springs, pump stations, interties) are typically designed to supply water at a rate that is equal to or greater than the system's MDD.

One-hour interval water production and reservoir level records from 2016 were reviewed to determine the system's MDD. The City's MDD occurred on Wednesday, August 17, 2016, when temperatures reached approximately 80 degrees Fahrenheit (ºF). As shown in **Table 4-10**, the average demand of the system on August 17, 2016, or MDD, was 11,629 gallons per minute (gpm).

Table 4-10
Maximum Day Demands and Peaking Factors

Peak Demand Data		
Demand Type	**Date**	**Demand (gpm)**
Average Day Demand (ADD)	2016	5,348
Maximum Day Demand (MDD)	August 17, 2016	11,629
Peak Hour Demand (PHD)	August 17, 2016 9:00 PM - 10:00 PM	16,995

Peaking Factors	
Maximum Day Demand/Average Day Demand (MDD/ADD)	2.17
Peak Hour Demand/Maximum Day Demand (PHD/MDD)	1.46
Peak Hour Demand/Average Day Demand (PHD/ADD)	3.18

Peak Hour Demand

Peak hour demand (PHD) is the maximum amount of water used throughout the system, excluding fire flow, during a 1-hour time period of a given year. In accordance with WAC 246-290-230, new public water systems or additions to existing systems shall be designed to provide domestic water at a minimum pressure of 30 psi during PHD conditions. Equalizing storage requirements are typically based on PHD data.

The PHD, like the MDD, is typically determined from the combined flow of water into the system from all supply sources and reservoirs. One-hour interval water production and reservoir level records were reviewed to evaluate the PHD. As shown in **Table 4-10**, the City's PHD, which occurred on August 17, 2016, from 9:00 p.m. to 10:00 p.m., was 16,995 gpm.

Table 4-10 also shows the peaking factors of the water system based on the ADD, MDD, and PHD data. The 2017 ADD was not available at the time of these analyses; therefore, the estimated 2016 ADD was used to estimate the peaking factors of the system. The MDD/ADD demand ratio of 2.17 is within the typical range of 1.2 to 2.5 for most Puget Sound area systems. The PHD/MDD ratio of 1.46 is within the typical range of 1.3 to 2.0 for most Puget Sound area systems. These peaking factors will be used later in this chapter in conjunction with projected ADDs, to project future MDDs and PHDs of the system.

FIRE FLOW DEMAND

Fire flow demand is the amount of water required during firefighting as defined by applicable codes. Fire flow requirements are established for individual buildings and expressed in terms of flow rate (gpm) and flow duration (hours). Fighting fires imposes the greatest demand on the water system because a high rate of water must be supplied over a short period of time, requiring each component of the system to be properly sized and configured to operate at its optimal condition. Adequate storage and supply are useless if the transmission or distribution system cannot deliver water at the required rate and pressure necessary to extinguish a fire.

General planning-level fire flow requirements were established for the different land use categories to provide a target level of service for planning and sizing future water facilities in areas that are not fully developed. The general planning-level fire flow requirement for each land use category is shown in **Table 4-11**. The water system analyses presented in **Chapter 7** are based on an evaluation of the water system for providing sufficient fire flow in accordance with these general planning-level fire flow requirements. The fire flow requirements shown in **Table 4-11** do not necessarily equate to actual existing or future fire flow requirements for all buildings, since this is typically based on building size, construction type, and fire suppression systems provided. Improvements to increase the available fire flow to meet actual fire flow requirements greater than those shown in **Table 4-11** shall be the responsibility of the developer.

Table 4-11
General Planning-level Fire Flow Requirements

Land Use Category	Planning-level Fire Flow Requirement (gpm)	Flow Duration (hours)
Agriculture	1,000	1
Open Space/Greenbelt/Public	1,000	1
Single-Family Residential	1,500	1
Multi-Family Residential	1,500	1
Commercial[1]	3,500	3
Industrial[2]	3,250	4

1 = Includes Mixed-Use, Neighborhood Services, and Urban Center land use types.
2 = Includes King County Industrial and Manufacturing/Industrial Center land use types.

FUTURE WATER DEMANDS

BASIS FOR PROJECTING DEMANDS

Future demands were calculated from the results of the future per capita demand computations shown in **Table 4-6** and the projected population data from **Chapter 3**. Future demand projections were computed with and without water savings expected from implementing WUE measures contained in the City's WUE Program in **Appendix E**.

The calculated future per capita demand of 65 gpd was used for all residential demand projections without savings from WUE measures, and the calculated future per capita demand of 51 gpd was used for all employment demand projections without savings from WUE measures. The per capita demand was reduced to reflect the WUE goals and used as the basis for future water demand projections with implementation of the WUE Program. The City's WUE Program presents goals to reduce the multi-family residential consumption by 1 percent annually and reduce the public agency consumption by 0.5 percent in June through August on an annual basis. The City also has a continued goal to maintain DSL at 6 percent or less each year.

DEMAND FORECASTS AND CONSERVATION

Table 4-12 presents the projected water demand forecast for the City's water system. The actual demand data from 2016 is also shown for comparison purposes. The future ADDs were projected based on residential and employment population estimates for the given years and the estimated demand per capita values from **Table 4-6**. The future MDDs and PHDs shown were computed from the projected ADDs and the existing system peaking factors shown in **Table 4-10**. The future demand projections are also shown with and without estimated reductions in water use from achieving WUE goals.

Table 4-12
Future Water Demand Projections

	Actual	Projected													
Description	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028 (+10 yrs)**	**2038 (+20 yrs)**	**2068 (+50 yrs)**
Water Service Area Population Data															
Residential Population	68,157	69,465	69,653	69,841	70,029	70,259	70,490	70,721	70,952	71,183	71,403	71,622	71,842	74,166	82,705
Employment Population	64,755	65,356	65,956	66,557	67,157	67,530	67,904	68,279	68,655	69,031	69,281	69,529	69,777	77,653	114,053
Demand Basis Data (gal/day/capita)															
Residential ADD without WUE	65	65	65	65	65	65	65	65	65	65	65	65	65	65	65
Employment ADD without WUE	51	51	51	51	51	51	51	51	51	51	51	51	51	51	51
Average Day Demand (gpm)															
Demand without WUE	5,348	5,428	5,458	5,488	5,517	5,541	5,564	5,588	5,612	5,635	5,654	5,673	5,691	6,074	7,745
Demand with WUE		5,410	5,422	5,433	5,445	5,450	5,456	5,461	5,467	5,472	5,473	5,473	5,474	5,849	7,493
Maximum Day Demand (gpm)															
Demand without WUE	11,629	11,803	11,867	11,932	11,997	12,048	12,099	12,150	12,202	12,253	12,294	12,334	12,375	13,208	16,841
Demand with WUE		11,764	11,789	11,814	11,839	11,851	11,863	11,875	11,886	11,898	11,899	11,900	11,901	12,718	16,292
Peak Hour Demand (gpm)															
Demand without WUE	16,995	17,249	17,343	17,438	17,532	17,607	17,681	17,757	17,832	17,907	17,966	18,026	18,085	19,302	24,612
Demand with WUE		17,191	17,228	17,265	17,302	17,319	17,336	17,354	17,371	17,388	17,390	17,391	17,393	18,586	23,810

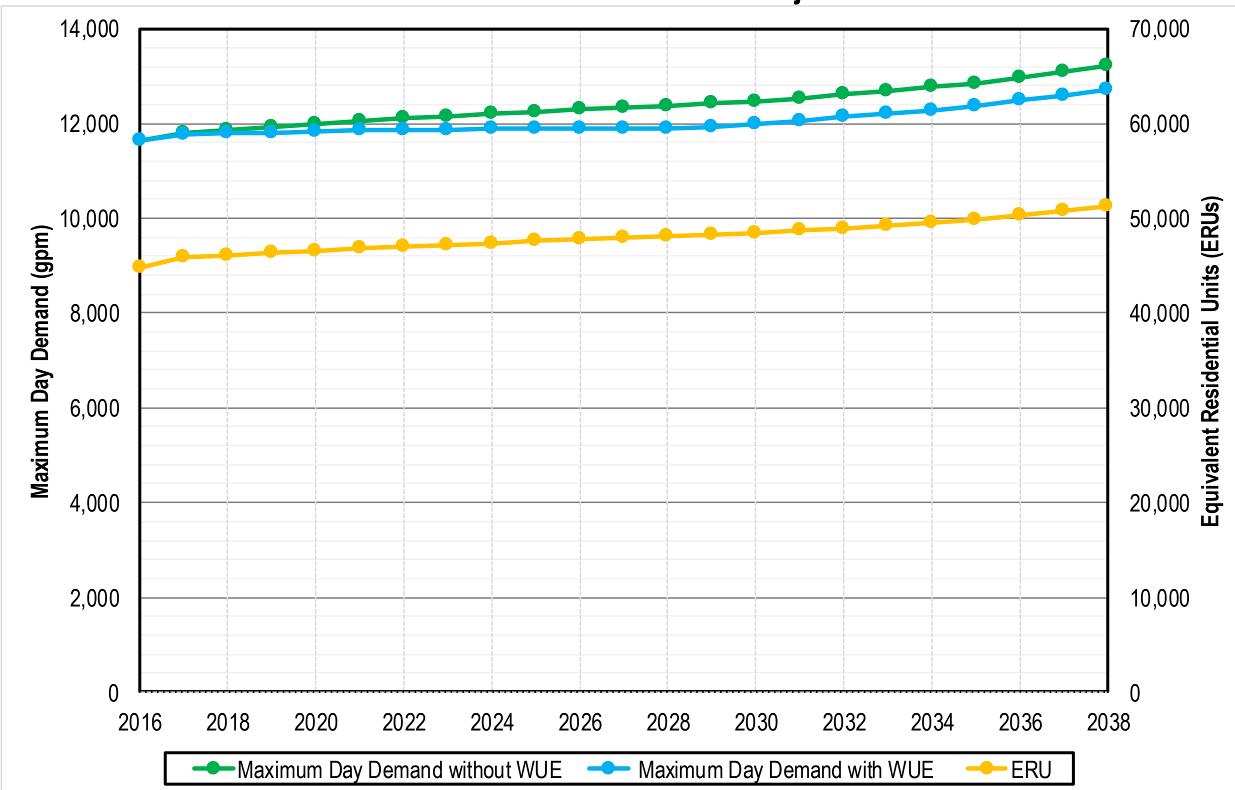
The analysis and evaluation of the existing water system with proposed improvements, as presented in **Chapters 7** and **9**, is based on the 2038 projected demand data without WUE reductions. This ensures that the future system will be sized properly to meet all requirements, whether or not additional water use reductions are achieved. However, the City will continue to pursue reductions in water use by implementing the WUE Program contained in **Appendix E**.

Table 4-13 presents the existing and projected ERUs of the system. The ERU forecasts are based on the projected water demands from **Table 4-12** and the 6-year rolling average demand per ERU that was computed from actual 2011 through 2016 data. The projected water demand and ERU data from **Tables 4-12** and **4-13** are also shown graphically in **Chart 4-7**. **Chart 4-7** will be used in **Chapter 7** to compare demand projections with source of supply availability.

Table 4-13
Future ERU Projections

Description	Actual 2016	Projected 2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028 (+10 yrs)	2038 (+20 yrs)	2068 (+50 yrs)
Demand Data (gpm)															
ADD without WUE	5,348	5,428	5,458	5,488	5,517	5,541	5,564	5,588	5,612	5,635	5,654	5,673	5,691	6,074	7,745
ADD with WUE		5,410	5,422	5,433	5,445	5,450	5,456	5,461	5,467	5,472	5,473	5,473	5,474	5,849	7,493
ERU Basis Data (gal/day/ERU)															
Demand per ERU without WUE	172	171	171	171	171	171	171	171	171	171	171	171	171	171	171
Demand per ERU with WUE		171	171	171	171	171	171	171	171	171	171	171	171	171	171
Equivalent Residential Units (ERUs)															
Total System ERUs	44,854	45,828	46,079	46,330	46,580	46,779	46,978	47,177	47,377	47,577	47,735	47,892	48,049	51,283	65,392

Chart 4-7
Future Water Demand and ERU Projections



CLIMATE CHANGE IMPACTS

The City understands that projections of precipitation patterns due to long-term trends in climate conditions indicate potential impacts to the availability and reliability of drinking water supplies the ability to meet future demands. RH2 has performed a literature review to document climate change projections and estimate their impact on the City's source vulnerability and future demand projections.

CLIMATE CHANGE PROJECTIONS

In 2013, the University of Washington's Climate Impact Group released a report titled *Climate Change Impacts and Adaptation in Washington State*. This report is cited by the Washington State Department of Health (DOH) as a source for their own projections of climate change impacts on drinking water in Washington State.

In summary, this report projects the following major quantitative climatic changes in Washington State pertinent to water system planning.

- The average annual surface air temperature is estimated to increase between 4.3°F and 5.8°F by the end of 2060. This increase depends on projected future greenhouse gas emissions and is relative to the temperatures measured between 1950 and 1999.

- The average number of days with more than 1 inch of precipitation is estimated to increase between 6 and 20 percent by the end of 2060. This increase depends on projected future greenhouse gas emissions and is relative to precipitation records between 1971 and 2000.
- The average April 1st snowpack volume is estimated to decrease between 38 and 46 percent by the end of 2050 for low and medium greenhouse gas emission scenarios. This decrease is relative to the snowpack records between 1916 and 2006.
- The average sea level is estimated to rise between 4 inches and 56 inches by the year 2100. This increase depends on projected future greenhouse gas emissions and is relative to sea level recorded in 2000.

The report also projects the following qualitative impacts specific to water resources management.

- Decreasing summer minimum stream flows and increased potential for more frequent summer water shortages, especially in fully allocated watersheds with little management flexibility.
- Increasing average and peak stream temperatures.
- Widespread changes in streamflow timing and flood risk compared to historical trends.
- Higher rates of water-borne diseases, primarily from increased flooding.

Perhaps the most significant impacts to water purveyors from projected climatic changes would be the projected declining snowpack volume and changes in streamflow timing and summer minimum flows. Effects to streamflow timing vary from basin to basin and depend on the proportion of precipitation that falls as snow versus rain as follows.

- **Rain-Dominant Basins:** In watersheds with warmer winter temperatures where less than 10 percent of winter precipitation falls as snow, streamflow peaks during the winter months and atmospheric warming is projected to have minimal effect on peak streamflow timing in unregulated basins. However, changes in intensity of precipitation could alter reservoir operations and storage availability to accommodate sudden stormwater events that would fill reservoirs. Streamflows in regulated basins may become more extreme despite the availability of reservoir regulation to mitigate these extremes.
- **Mixed Rain and Snow Basins:** Middle elevation watersheds near the current snowline where between 10 percent and 40 percent of winter precipitation falls as snow are the most sensitive to projected atmospheric warming. In these basins, peak streamflow is projected to shift significantly earlier in the season by weeks to months, as wet season precipitation falls as rain instead of snow.
- **Snow-Dominant Basins:** In watersheds with cold winter temperatures where more than 40 percent of winter precipitation currently falls as snow, peak streamflow will shift earlier in the season from early summer to spring as early and late wet season precipitation falls as rain instead of snow. Permanent reduction of glacial ice volume will also affect stream flow in high altitude watersheds.

In the Green River Watershed, which supplies the City of Tacoma and serves as an emergency source for the City of Kent through its Second Supply Pipeline, winters are cool and much of the precipitation falls in the form of snow during winter months[1]. The watershed can most likely be generalized as a "mixed rain and snow basin" or "snow dominant basin." The City of Tacoma would have some ability to mitigate projected shift in peak streamflow timing through operation of the Eagle Creek Reservoir and is preparing for earlier and later peak streamflows. However, the dam is operated to capture extreme winter precipitation volumes, release them safely to the Green River, then drain the reservoir for the next event. If the reservoir captures and releases a greater percentage of the annual volume of precipitation to mitigate flooding, less water would be available for capture and storage for potable supply.

SOURCE VULNERABILITY IMPACTS

The City's water is supplied predominantly by groundwater sources recharged by annual precipitation, and the City's supply appears more resilient against changes in streamflow timing, declining snowpack, and water quality than other water systems that rely on surface water sources. The inherent slow filling, persistent storage, and slow draining characteristics of aquifer replenishment offers some degree of protection against summer water availability if the volume and location of winter precipitation still results in sufficient aquifer recharge. The relationship between precipitation and aquifer recharge is complex and local. Impacts to the City's groundwater sources depend on the precise characteristics of rainfall patterns, surface and subsurface permeability, pathways of infiltration into the aquifer, and locations and volumes of groundwater withdrawal. Urbanization and increased groundwater withdrawals from the source aquifers are significant factors partially or unrelated to changes in precipitation timing and temperature that could negatively impact the reliability of the City's groundwater sources.

It is notable that the University of Washington Climate Impact Group indicated that nearby Tacoma Water's average water supply reliability is expected to decrease (worsen) between 63 percent and 96 percent under projected low and medium greenhouse gas emission scenarios by 2080. This forecasted decrease in reliability is assumed to result from earlier snow melt and decreased summer flows. This forecast also assumes no new sources of supply and no changes to current operating procedures. A system reliability of 100 percent indicates that no water shortage exists; as reliability decreases, the probability of a water shortage occurring increases. The source study indicates Tacoma Water's supply is robust through 2030[2], so the City has some time to further evaluate and mitigate its risk due to changes in surrounding watersheds. The City may consider performing a detailed hydrogeologic study to improve awareness and management of aquifer recharge and withdrawals to mitigate potential changes in rainfall patterns and recharge.

DEMAND IMPACTS

The University of Washington Climate Impact Group reports high confidence that air temperatures will increase over time, but low confidence in how precipitation amounts will

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[1] Tacoma Public Utilities. August 13, 2008. *Green River Watershed Management Plan*, Second Volume.

[2] Vano, J.A., Voisin, N., Cuo, L., Hamlet, A.F., McGuire Elsner, M., Palmer, R.N., Polebitski, A., Lettenmaier, D.P. April 27, 2010. *Climate Change Impacts on Water Management in the Puget Sound Region, Washington State, USA*.

change in time and location. Natural year-to-year variations in precipitation are expected to overprint any incremental changes attributed to climate change processes. There is a clear correlation between temperature, precipitation, and water system demand, but increases in demand are assumed to be caused primarily by the lack of precipitation in the summer and corresponding need for irrigation. Temperature increases alone are expected to have a less significant effect on demand, as most commercial, industrial, and residential uses will not increase solely due to temperature (e.g., showering, laundry, cooking, etc.) As lack of sufficient precipitation is assumed to be the primary driver of summertime demand increases, but there is low confidence in how climate change will impact precipitation patterns and volumes, it is difficult to estimate how climate change could impact demand. As a comparison benchmark, the University of Washington Climate Impact Group noted that Seattle Public Utilities' water system demand is projected to increase by 1 percent in 2025, 2 percent in 2050, and 5 percent in 2075 due to climate change and warming atmospheric temperatures. This increase is relative to demands in 2000.

To predict how demand could be impacted by changes in temperature and precipitation, historic correlations between demand, temperature, and precipitation are helpful. **Chart 4-8** presents the relationship between temperature at Sea-Tac International Airport and the City's total water supplied each month from 2011 to 2016.

Chart 4-8
City of Kent Supply and Sea-Tac International Airport Temperature (2011 through 2016)

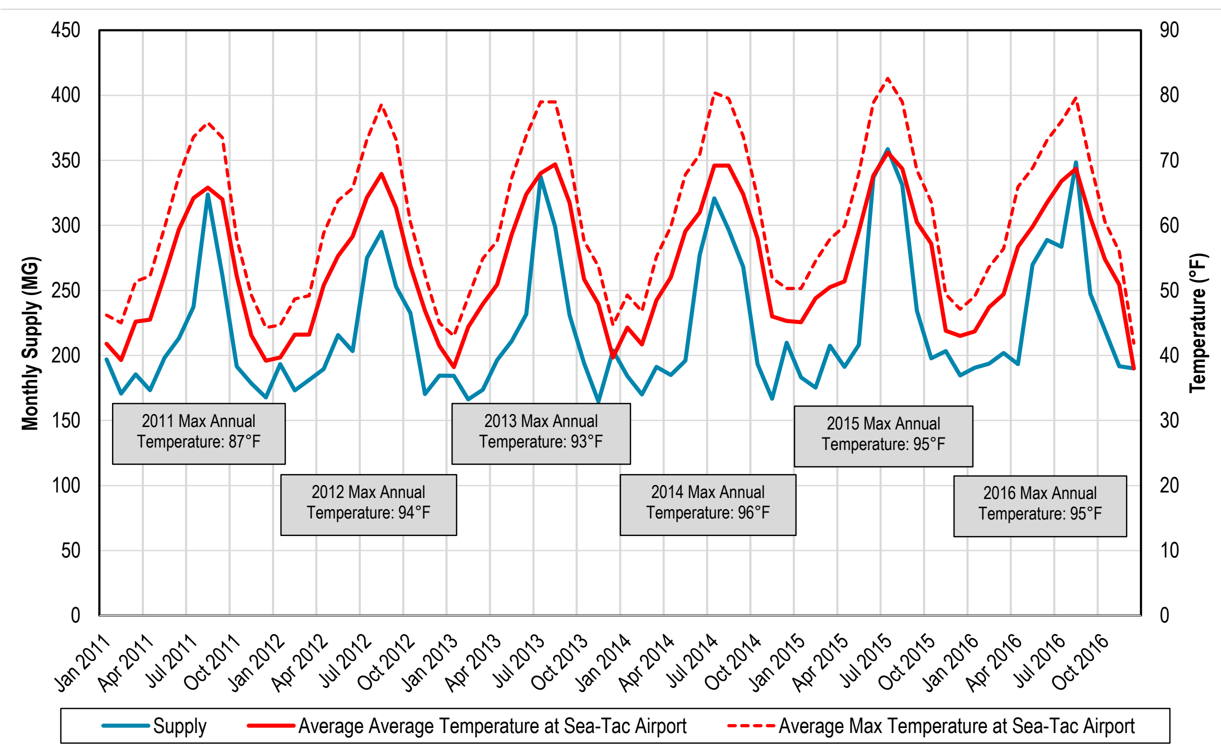

Chart 4-8 illustrates the pattern of summertime supply peaks that correlate with increased temperatures. It should be noted that even though temperature and demand tend to peak at the same time, years with higher maximum annual temperatures do not necessarily have higher water

demands than other years. This reinforces the assumption that, while temperature and demand correlate, increased temperatures alone do not necessarily cause increased demands.

Chart 4-9 presents the relationship between precipitation measured at Sea-Tac International Airport and the City's total water supplied between 2011 and 2016.

Chart 4-9
City of Kent Supply and Sea-Tac International Airport Precipitation 2011-2016

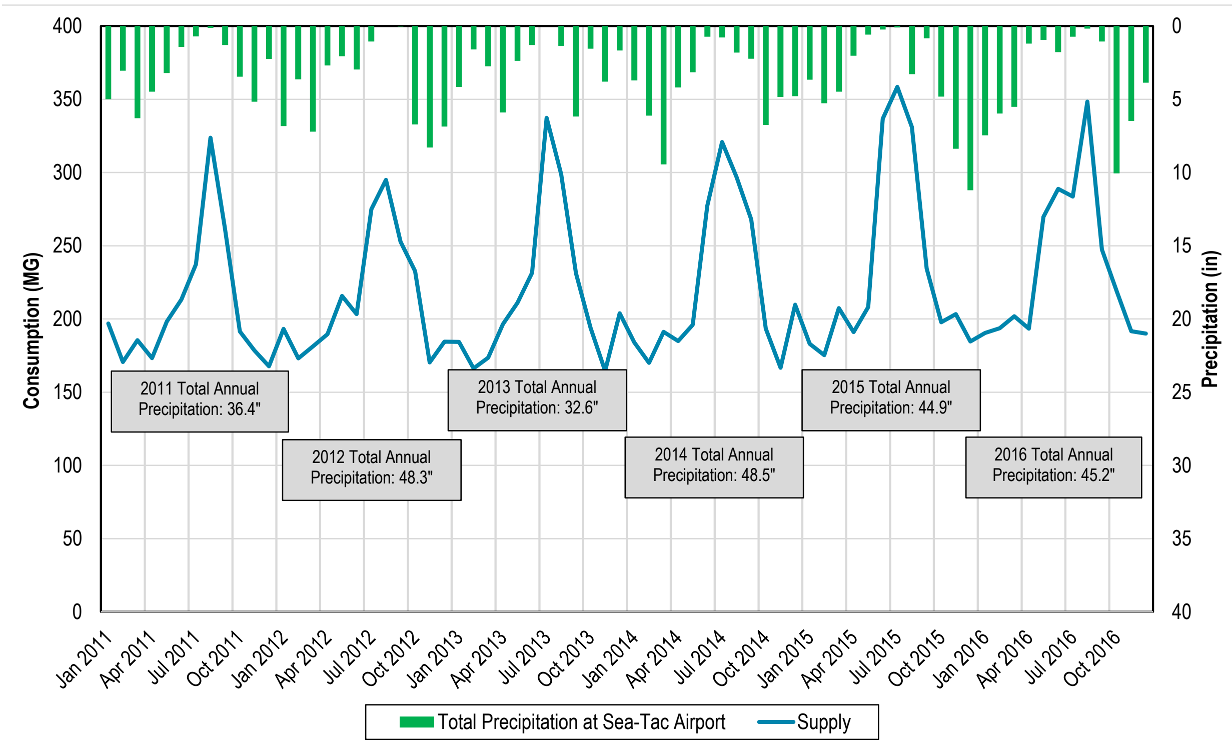

Chart 4-9 illustrates the pattern of summertime supply peaks that correlate with decreased precipitation. There is also some correlation evident year-to-year, as water demands tend to be lower in years with more precipitation and higher in years with less precipitation compared with the years immediately following and preceding (with 2016 as the only exception). Ultimately, the degree to which the City's future water demands will be impacted by climate change are a function of both expected warming and the expected change in precipitation patterns. As climate forecast models improve and changes to precipitation patterns can be forecast with more certainty, the City will further evaluate how demands are impacted by temperature and precipitation. Until that time, the City plans to use the same climate change-related increases that are projected for Seattle Public Utilities on an average day demand basis: a 1 percent increase in 2025; 2 percent in 2050; and 5 percent in 2075. The future demand projections based on these climate change-related increases are shown in **Table 4-14** with the demand projections without estimated reductions in water use from achieving WUE goals or changes in irrigation habits or practices, for reference. The analysis and evaluation of the existing water system with proposed improvements, as presented in **Chapters 7** and **9**, is based on the 2038 projected demand data without WUE reductions and without climate change increases. However, the City will continue to evaluate the projected warming and changes in precipitation patterns and will update the demand projections to include climate change increases in the future as necessary.

Table 4-14
Future Water Demand Projections with Consideration for Climate Change

Description	Actual 2016	2028 (+10 yrs)	2038 (+20 yrs)	2068 (+50 yrs)
Water Service Area Population Data				
Residential Population	68,157	71,842	74,166	82,705
Employment Population	64,755	69,777	77,653	114,053
Average Day Demand (gpm)				
Demand with Climate Change Increase	5,348	5,717	6,121	7,933
Demand without WUE or Climate Change Increase		5,691	6,074	7,745
Maximum Day Demand (gpm)				
Demand with Climate Change Increase	11,629	12,430	13,309	17,249
Demand without WUE or Climate Change Increase		12,375	13,208	16,841
Peak Hour Demand (gpm)				
Demand with Climate Change Increase	16,995	18,166	19,450	25,208
Demand without WUE or Climate Change Increase		18,085	19,302	24,612