



Chapter 3 Water Demand Forecasting

2019 City of Billings Water Master Plan
(Draft)

City of Billings, MT



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Basis of Planning

The purpose of this chapter is to present the data and assumptions used as the foundation for this water system master plan. This chapter includes the following sections:

- ◆ Study Area: meetings were held with water utility staff to establish a study area boundary. This boundary is not a future service area boundary. This boundary is used to establish the limits of population growth for this master plan and to lay out future water infrastructure.
- ◆ Planning Document Review: numerous planning documents were reviewed to understand the population growth predictions and vision for future land use and water use that may impact future water demand estimates. The following data sources were used to spatially allocate future population estimates: Long Range Transportation Plan and associated Traffic Analysis Zones (TAZs), Growth Policy (preferred alternatives presented), and data collected via meetings with engineering staff.
- ◆ Historical and Current Water Demand: data was gathered to help characterize current water customers and their water use including customer type (residential, commercial, etc.), customers by pressure zone, and average day, maximum day, and peak hour usage. These patterns are applied to future demands to evaluate system needs.
- ◆ Future Water Demand Projections: future water demand in the study area is estimated using all the available data described in the sections above.

Study Area Boundary

The study area boundary includes all existing customers and areas that could potentially be served by the water utility through the planning horizon year (2040), it includes the City limits and the City's annexation boundary excluding the Lockwood area, see Figure 3-1. Note that this boundary doesn't indicate a future service area boundary but rather the potential future service areas to be studied in this plan. The study area boundary is approximately 66,000 acres.

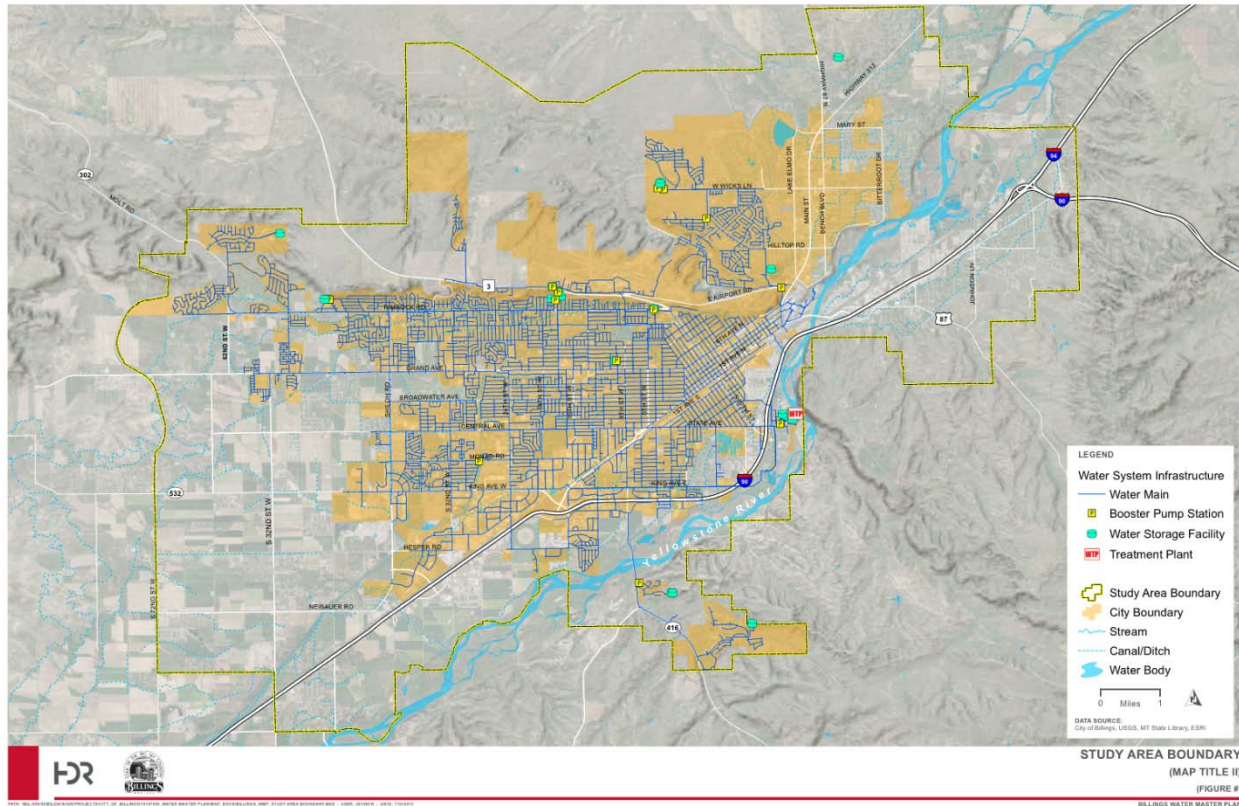


Figure 3-1. Study Area Boundary

Planning Document Review

Planning documents completed over the past 10+ years for the Billings area were reviewed. Since the planning period for some of these documents and neighborhood plans has past, they have minimal applicable information for this 2019 Water Master Plan. In contrast, some of the more recently completed documents provide valuable information for this study, including spatial population and employment growth predictions.

As discussed with City staff, since there isn't an all-encompassing source of population and employment growth estimates that adequately covers the general study area for the water master plan, the project team discussed and evaluated several sources of data and has combined this data into a single map and data set. Where a planning document did not provide guidance, the City's zoning layer was used to assign land use.

Planning Documents

The following planning documents were reviewed to understand and incorporate the City's population growth estimates, the future population distribution around the City and future land use planning.

- ◆ 2016 Growth Policy

- ◆ Billings Urban Area Long Range Transportation Plan (LRTP), 2018
- ◆ Infill Development Policy, Resolution No. 11-19128, 2011
- ◆ Northwest Shiloh Area Plan, 2005
- ◆ One Big Sky Center Concept Plan, 2017 (plus presentation update 2019)
- ◆ City of Billings Annual Action Plan, 2018-19
- ◆ Billings Urban Area, Transportation Improvement Program, FY 2015-2019
- ◆ Downtown Business Association – Strategic Plan, 2018
- ◆ Billings Bypass, Final Environmental Impact Statement, 2014
- ◆ South Billings Master Plan, 2012 (historic growth half the rate of the rest of Billings)

Of these planning documents, the Billings LRTP, the 2016 Growth Policy, and the One Big Sky Concept Plan were used to provide the spatial distribution of projected population.

Billings Urban Area Long Range Transportation Plan (LRTP)

The Billings LRTP provides an inventory of needs and opportunities for transportation elements: streets and highways, public transit and transportation, freight, pedestrians, bicyclists, trails, safety, and security. In addition, and most applicable to this planning effort, the LRTP breaks their study area down into 2,926 Traffic Analysis Zones (TAZ). TAZs represent geographic groupings of population and employment. An individual TAZ is intended to group land uses that have common access to the transportation system (for example, a group of houses that all use local streets to access the same blocks of two collector streets). These zones, shown in Figure 3-2, are used to establish the future population and employment estimates for each TAZ, as shown in Figure 3-3 and 3-4, respectively. The plan estimates an average annual growth rate of 1.5% or 42,000

additional people between 2017 and 2040 in the Billings urban area from approximately 127,000 to 169,000 people.

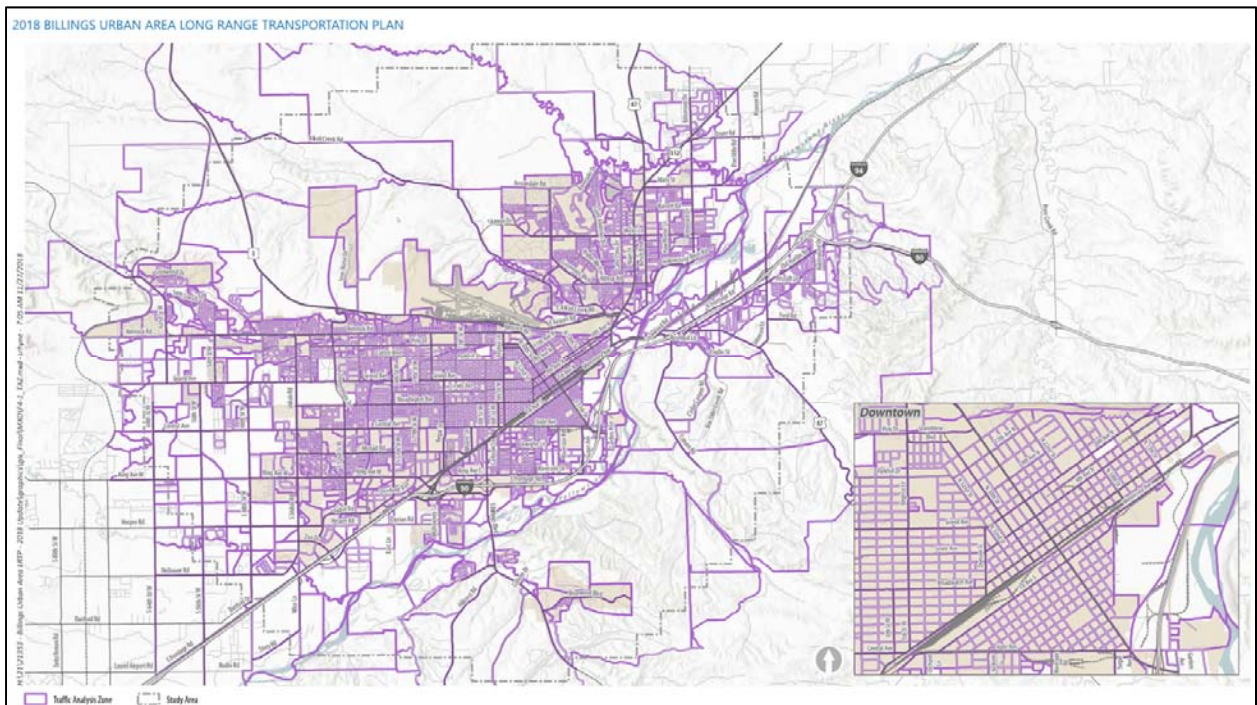


Figure 3-2. Traffic Analysis Zones, L RTP

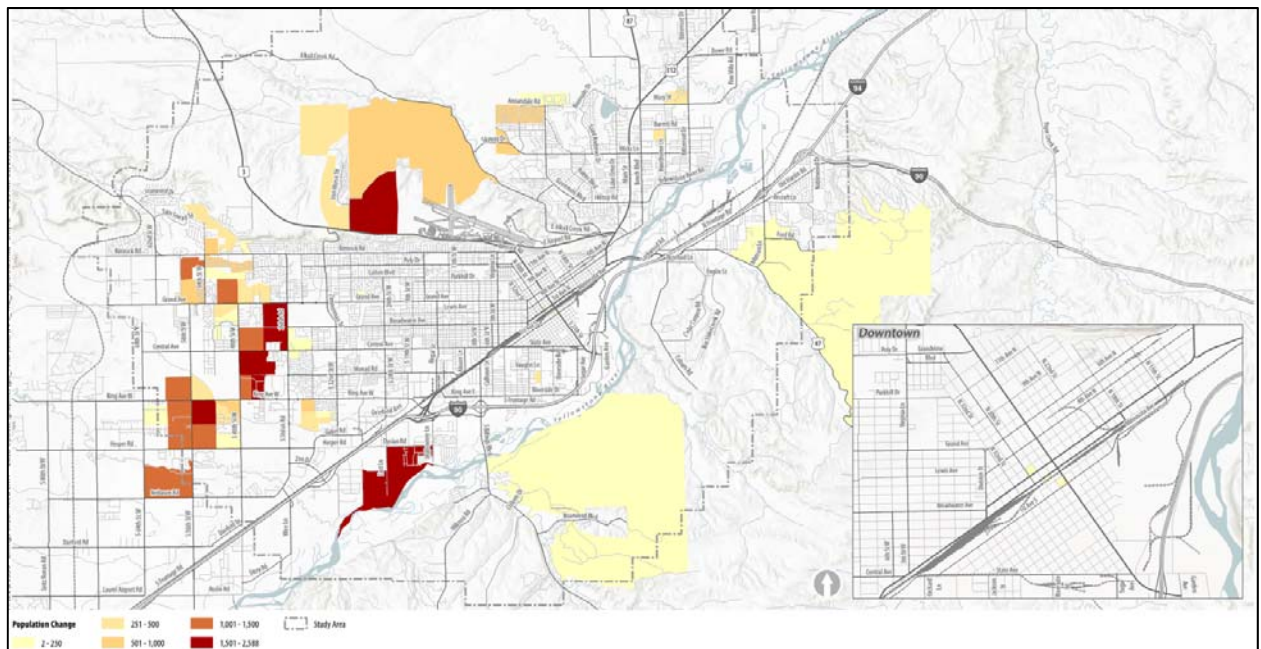


Figure 3-3. Population Growth Estimates, L RTP

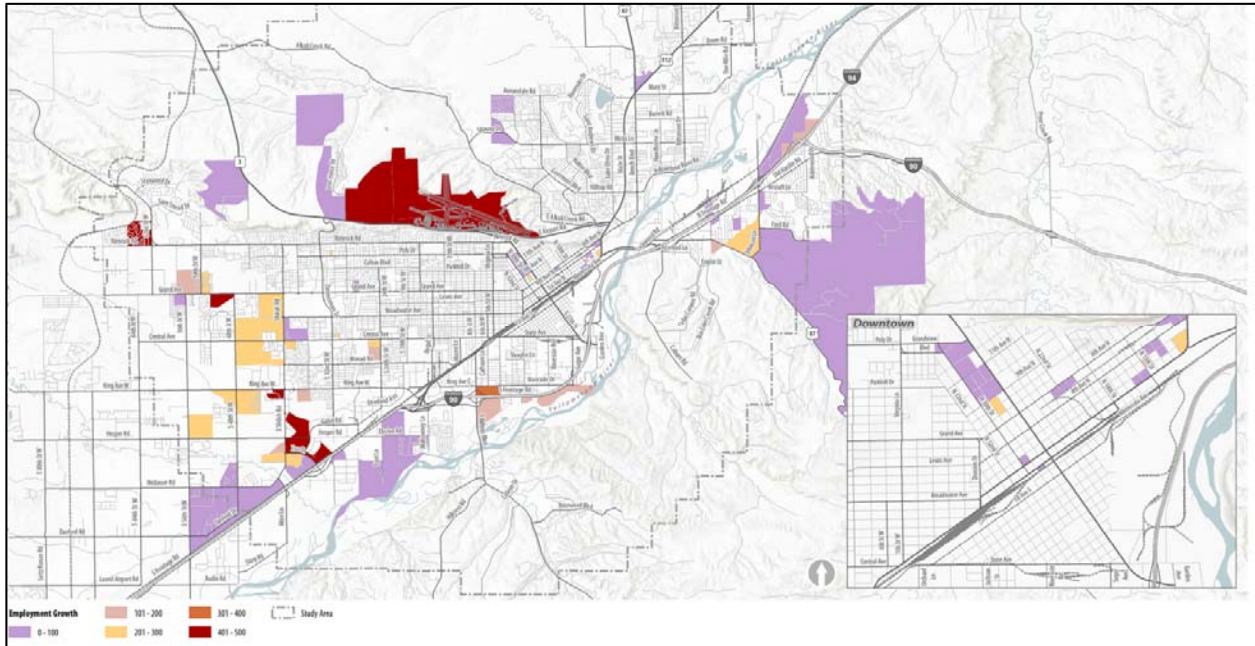


Figure 3-4. Employment Growth Estimates, L RTP

As described in the L RTP and depicted in Figures 3-3 and 3-4, the highest concentrations of population and housing growth are near and north of the airport and on the West End of Billings. This corresponds well to the growth predicted by Billings’ staff and shown on Figure 3-8 with the exception of growth near the airport. The smaller pockets of dense population in the central portion of the Metropolitan Planning Organization (MPO) along Rimrock Road represent the student population at Montana State University Billings and Rocky Mountain College.

2016 Growth Policy

The 2016 Growth Policy serves as a guiding document for land use and infrastructure decisions. The growth policy presented a number of alternatives; this water master plan incorporated the preferred alternatives labeled ‘infill and adjacent land, preferred north, and preferred west’ with some adjustments based on discussions with City staff. The Growth Policy suggests that a reasonable average annual growth rate for planning purposes is 1.5% and predicts an additional 42,000 people by 2035.

One Big Sky Concept Plan

The One Big Sky District is a planned public private partnership to re-develop an area of downtown Billings, and the overall proposed plan is shown in Figure 3-5.

One version of this plan shows 1,000 new dwelling unit total, while the most recent plan shows 1,909 dwelling units. Because the One Big Sky District is still a developing concept, assumptions need to be made for the water master plan regarding the most likely number of new dwelling units by the year 2040. Because some of these new dwelling units will

replace existing dwelling units, and will not be new water demands on the system, a total new dwelling unit number of 1,000 will be used for planning purposes. Similarly, the non-residential plans have been in flux. We have taken the latest estimates presented for Phase 1, and added water demands accordingly. This includes 270,000 SF of commercial office, 440,000 SF of retail, 50,000 SF education space, and 390,000 SF of health care related development.

ONE BIG SKY UPDATE

The One Big Sky District does not currently have further funding and appears unlikely to be moving forward. The demands discussed above will still be included in the master plan to represent residential, commercial and industrial growth in Pressure Zone 1.

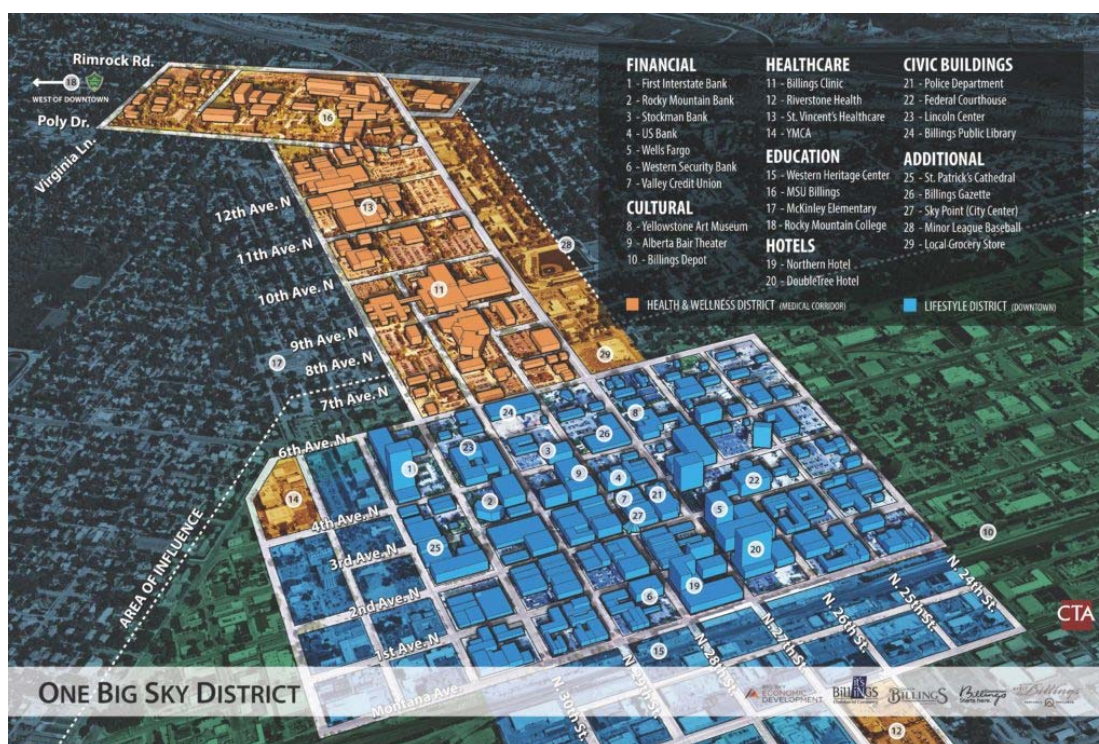


Figure 3-5. One Big Sky District Overview

Inner Belt Loop

The Inner Belt Loop project is a six-mile long stretch of new two-lane road that would connect the Heights to Billings' West End, bringing Wicks Lane overland to the Zimmerman Trail-Highway 3 intersection. The goal of the project is to help boost commercial and residential development in the Heights and reduce traffic along Main Street, particularly where it bottlenecks at MetraPark and Airport Road. Phase I from Wicks Lane to Alkali Creek Road has been constructed. Future phases are currently in the planning stages. At present, there is no plan to install water and sewer in conjunction with the proposed roadway project; however, the figure below shows the pressure zones that could be impacted by development associated with the Inner Belt Loop.

INNER BELT LOOP UPDATE

Although demand projections will not be included in this master plan, an evaluation is included in Chapter 5 for options to provide services for projected growth near the Inner Belt Loop.

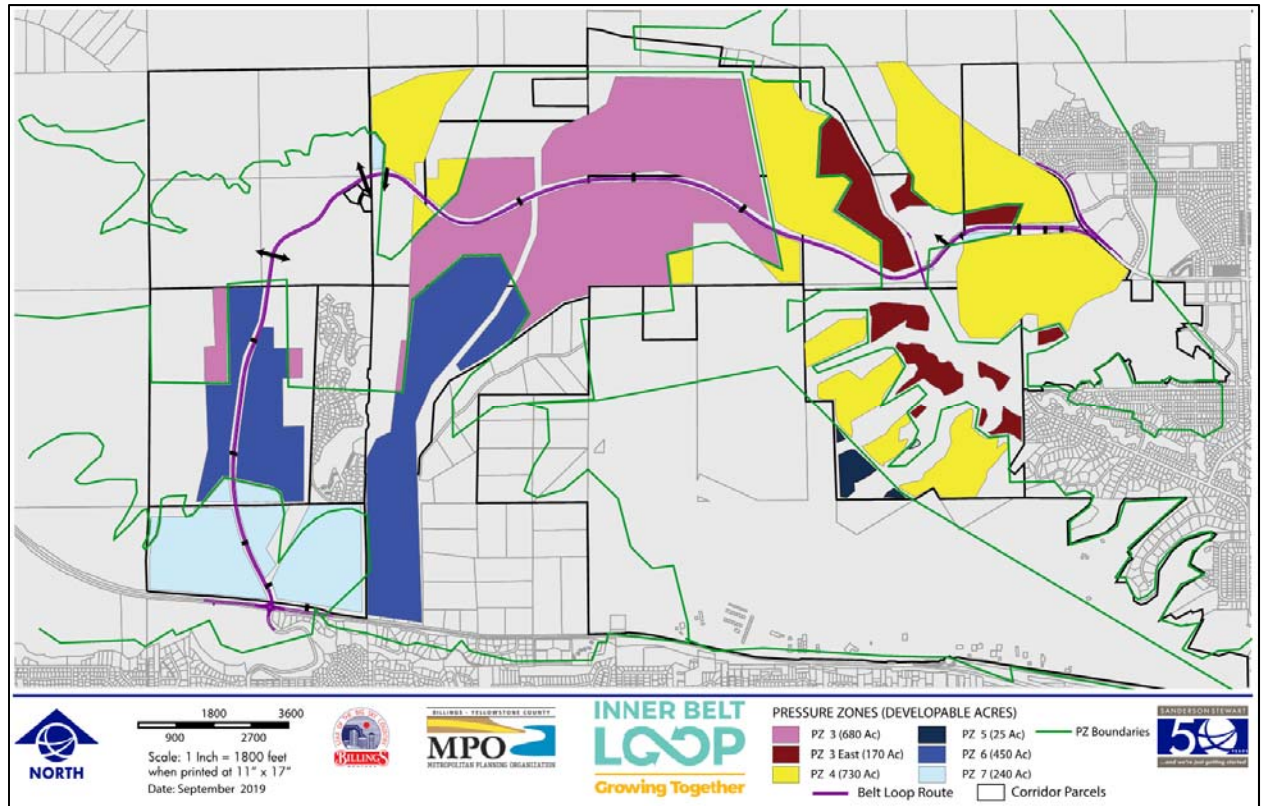


Figure 3-6. Inner Belt Loop and Water Pressure Zones

Future Population Growth and Development

Population growth projections from the LRTP, the 2016 Growth Policy and this water master plan are shown in Figure 3-7 below.



Figure 3-7. Population Projection Comparison

The project team combined the data sources described above to estimate future population growth and allocated it spatially within the study area boundary. An overlay of this information with each of the City’s water system pressure zones provides a spatial assessment of the projected future growth in each zone. This information is summarized herein and shown in Figure 3-9.

Zone 1

Zone 1 includes the City of Billings downtown area and several of the largest single water users in the system such as the Phillips 66 refinery (the City’s largest water customer), Jupiter Sulpher, Billings Clinic, Western Sugar, Yellowstone County Jail, and the Crown Plaza hotel. In addition, Zone 1 includes the proposed One Big Sky District. According to a 3-year average of water demands, Zone 1 has the most demand at an average of 5.5 MGD.

Zone 2

Zone 2 includes an area of high density residential housing south of I-90, near the Elysian Elementary School. This area was identified by the engineering department as an area of high growth. Although the area is currently zoned for commercial and industrial uses, City engineering staff believe the current high density residential housing to the east will continue west. This zoning allows 26 dwelling units per acre. The area near the freeway will likely remain highway commercial and community commercial, and water demands have been added accordingly. Zone 2 demands on average are over 3.1 MGD.

Zone 2 East

Zone 2 East is comprised of the Billings Heights Water District, which owns and operates its own water district with all potable water supplied by the City of Billings. Three developments were identified by the engineering department, as shown on Figure 3-8. In addition, the Billings Heights Water District provided the moderate and high growth



scenarios shown in Table 3-1 and Figure 3-7 below. These projections were extended out to 2040 and the moderate growth scenario values were used in this master plan. According to pumping records, average day demand from 2010 to 2018 is about 2.6 MGD, while the Heights forecasted demand for 2018 is 2.55 MGD.

Table 3-1. Water Demand Projections for Billings Heights Water District

County Water District of Billings Heights		
Water Demand Forecast (Gallons)		
Year	Growth Scenario	
	Moderate	High
2018*	933,184,000	
2019	950,261,300	1,092,880,500
2020	967,651,100	1,120,120,500
2021	985,359,100	1,148,123,500
2022	1,003,391,100	1,176,826,600
2023	1,021,753,200	1,206,247,200
2024	1,040,451,300	1,236,403,400
2025	1,059,491,500	1,267,313,500
2026	1,078,880,200	1,298,996,300
2027	1,098,623,700	1,331,471,200
2028	1,118,728,600	1,364,758,000
2029	1,139,201,300	1,398,877,000
2030	1,160,048,700	1,433,848,900
2031	1,181,277,600	1,469,695,100
2032	1,202,895,000	1,506,437,500
2033	1,224,907,900	1,544,098,400
2034	1,247,323,700	1,582,700,900
2035	1,270,149,8000	1,622,268,400

*Base annual demand developed from 2018 system usage records.
Forecast last updated: 12/19/2018

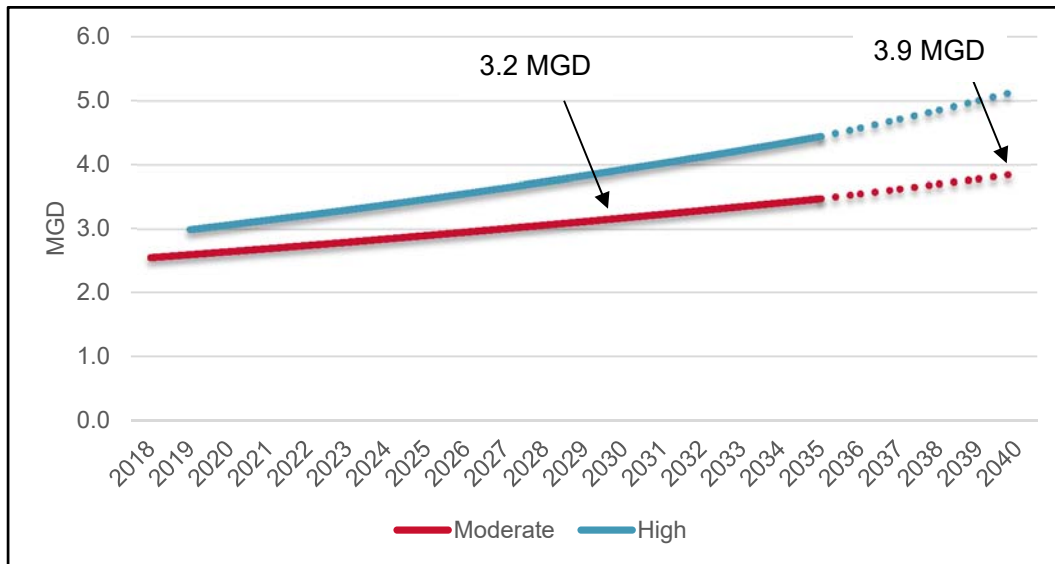


Figure 3-8. Billings Heights Water Demand Projections

Zone 3 South

Zone 3 South includes the Cedar Park area, which has been adding about 1 new home every other year for the last 5 years, and this rate of development is assumed to continue. Zone 3 South has the lowest water demands at 0.012 MGD average over the last 3 years.

Zone 3

Zone 3 is the City's largest pressure zone by area, and has the most potential for growth as development continues moving west toward open developable land. A number of known areas of development have been identified by the engineering department, as well as areas identified in the Growth Policy as the 'West Public Preferred Scenario'. On average over the last 3 years, demands have been almost 3.3 MGD.

Zone 3 East

Zone 3 East is expected to see development identified in the Growth Policy as 'North Public Preferred Scenario'¹, as well as other developing areas identified by the engineering department. For the purposes of this evaluation, Zone 3 East and Zone 4 East (sometimes referred to as Zone 4 North) have been evaluated together because there are currently no customers in Zone 4 East.

¹ Note: The North Public Preferred Scenario was reduced in size after discussions with water department staff because the scenario presented in the growth policy shows growth extending to the west of undevelopable areas. In addition, the West Public Preferred Scenario from the growth policy did not account for the proposed West End Reservoir, so this was added to the map and population was not added for that area.

Zone 4

Zone 4 is roughly bound by the Hi-Line ditch to the south and the Rimrocks to the north, and includes the Yellowstone County Club, and the Copper Ridge Loop area. Developing areas were identified by the planning department, and a small portion of the Growth Policy “West Public Preferred Scenario” is included in this pressure zone.

Zone 4 South, Zone 5, Zone 5 West, Zone 6

Zone 4 South, Zone 5 (City of Billings Municipal Airport), Zone 5 West, and Zone 6 did not have any growth specifically identified through any of the methods above; growth was assumed to be 0.5% per year.

Future Population Growth

As previously discussed, each of the identified developments were compiled into a basis of planning map, and the associated number of dwelling units assigned in accordance with an assumed density value based on discussions with planning staff and available zoning information. For planning purposes, new development is expected to occur at 85% of the maximum allowable density, reserving 15% for right of way and other open land needs.

Population was subsequently calculated by applying the LRTP’s recommended value of 2.23 people per dwelling unit to the additional units identified in each zone. This population added up to an additional 74,000 people or 2.2% average annual growth. The majority of planning documents, as well as historical population growth rates generally state that a growth rate of 1.5% is reasonable to assume for the Billings area. Therefore, the identified development was uniformly scaled back to match the 1.5% annual growth rate of about 48,000 additional people² between 2017 and 2040 as shown in Table 3-2.

Table 3-2. Current and Future Population by Pressure Zone

	Population (TAZ 2017)	2030 Population Estimates	2040 Population Estimates
Zone 1	27,204	27,984	28,662
Zone 2	21,135	26,256	30,705
Zone 2 East	17,163	17,680	18,128
Zone 3	31,317	45,037	56,954
Zone 3 East + Zone 4 East	9,280	11,071	12,627
Zone 3 South	737	745	752
Zone 4	7,754	9,584	11,174
Zone 4 North	1,222	3,145	4,815
Zone 4 South	786	819	848
Zone 5	416	434	449
Zone 5 West	268	279	289
Zone 6	623	649	672
Total	117,670	143,683	166,075

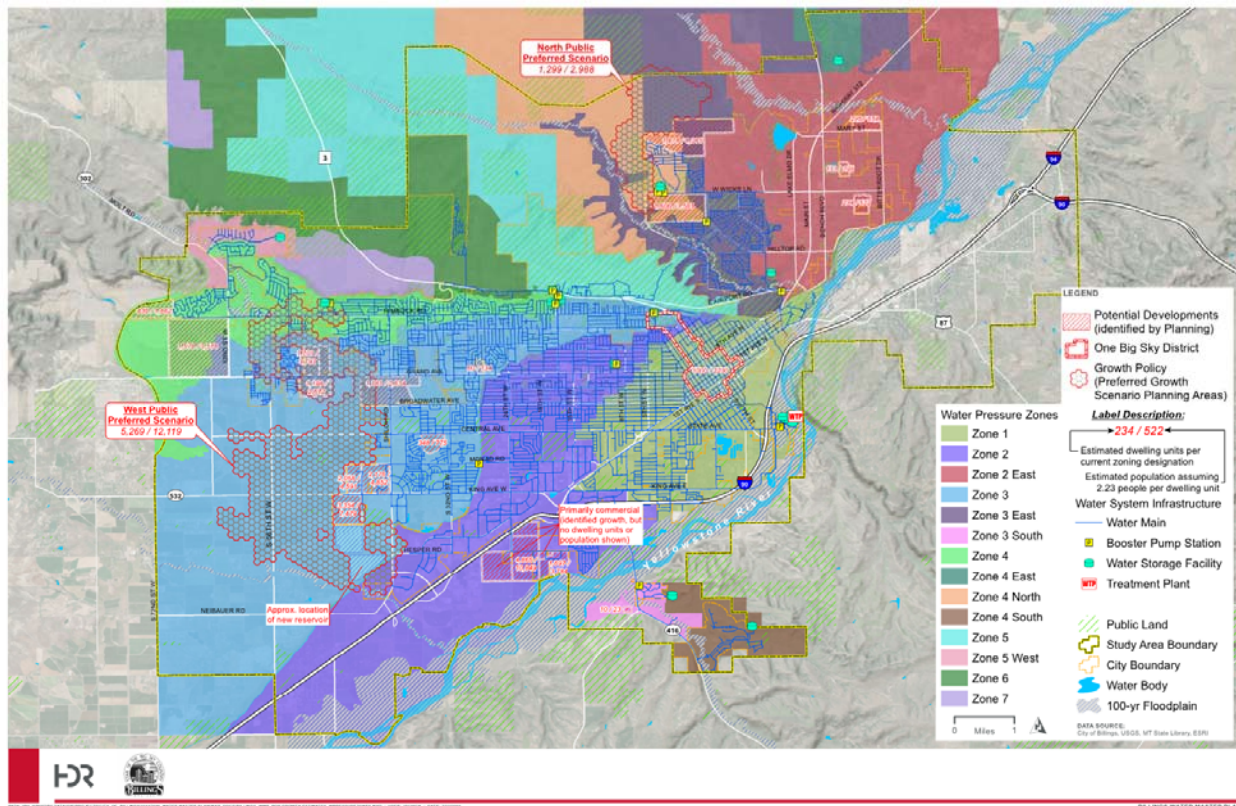


Figure 3-9. 2040 Major Growth Projections Areas

Water Production and Customer Demands

The City of Billings Water Treatment Facility (WTP) produces between 7 and 8 billion gallons of drinking water per year. Figure 3-10 below shows that the difference between the raw water entering the treatment facility and the finished water is about 2 MGD or about 10%, which is typical of a conventional water treatment plant. The difference between the water being pushed out into the system via the High Service Pump Station is about 14% on average greater than the customer meter data. This 14% may include water loss and non-metered water use including street sweeping, construction water, hydrant flushing, theft, meter-inaccuracies, and un-metered parks or other facilities.

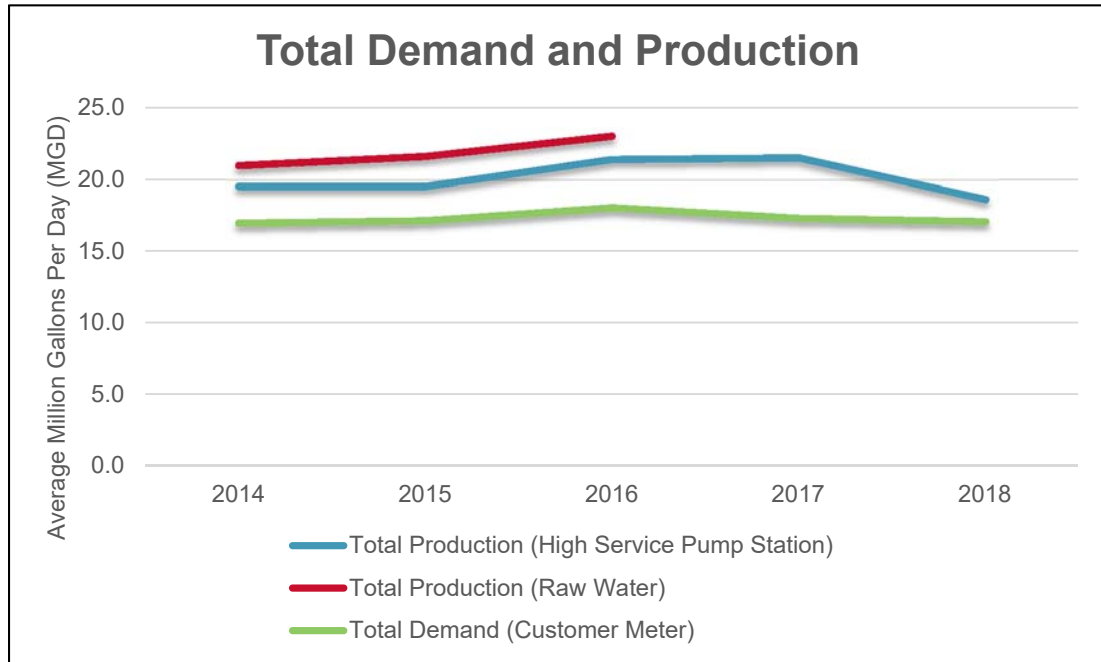


Figure 3-10. System Wide Water Production and Demand

Population and Water Demand from Previous Planning Efforts

The City of Billings has routinely performed water master plans and updates over the years to proactively plan for future water demands and improvements. The following water-related plans were reviewed and some comparisons of future population and water demand estimates derived. These comparisons are summarized and provided in Figures 3-10 through 3-13. The water planning documents reviewed and incorporated herein include: Water and Wastewater Facilities Master Plan (HDR, 2006), Integrated Water Plan Implementation Water Master Plan Update (Morrison Maierle, Inc., 2014), Integrated Water Plan Implementation Water Distribution System Study (Morrison Maierle, Inc., 2014), and the Water/Wastewater Facilities Study (HDR, 1999).

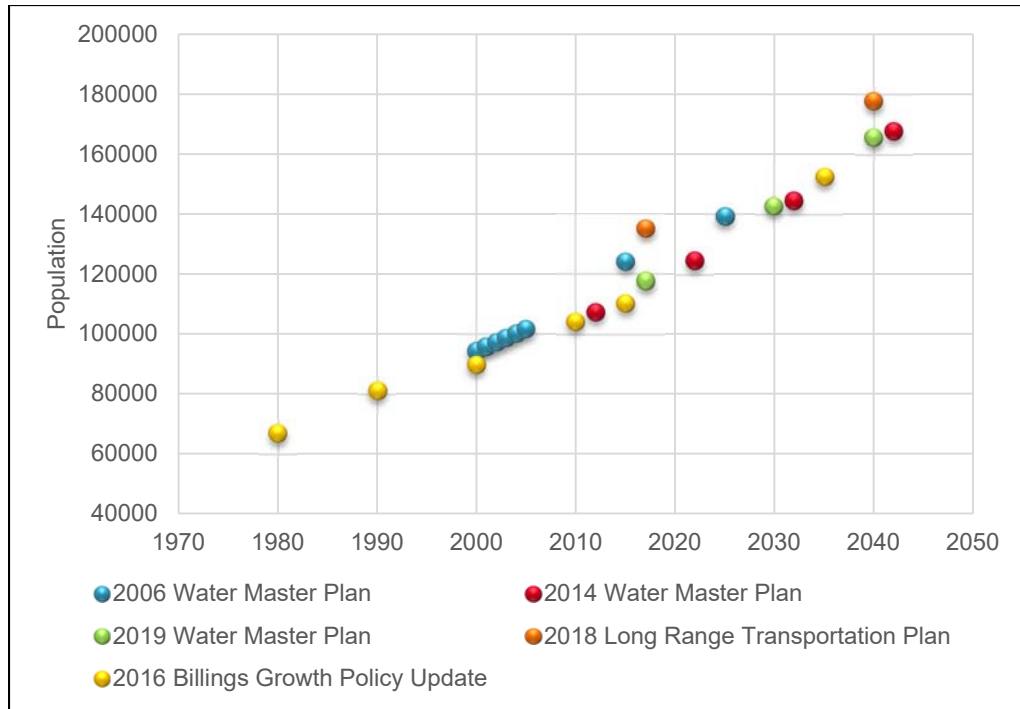


Figure 3-11. Population Estimates Comparison

Notes: While total population estimates vary primarily due to the study area size, the population growth presented in planning documents consistently uses about a 1.5% average annual growth rate over the entire Billings area.

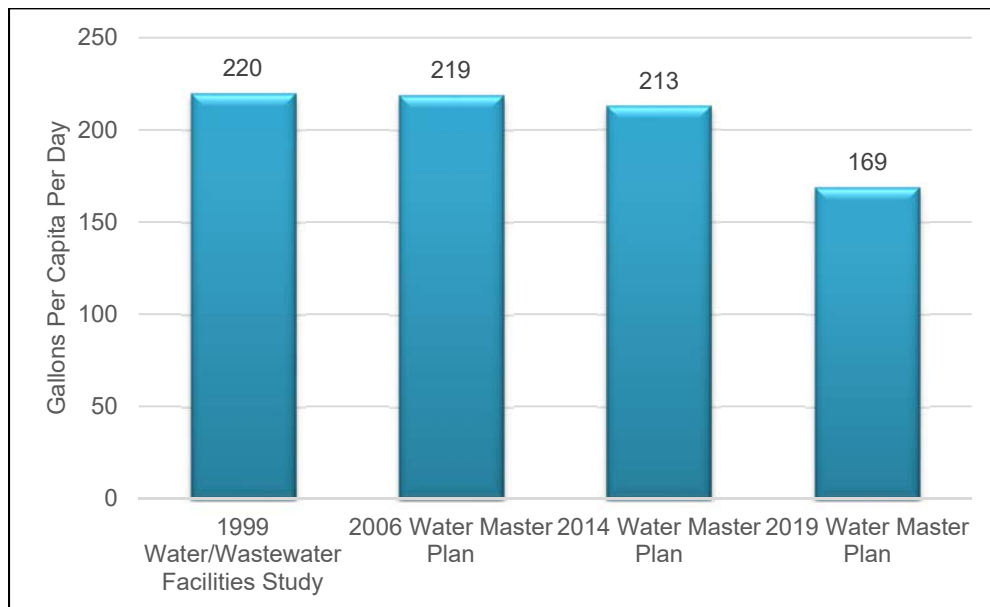


Figure 3-12. Gallons Per Capita Per Day Comparison

Notes:

- 1.) The 2014 Water Master Plan found the 2010-2012 GPCD to be 213, and reported that the GPCD average over the last 10 years was 211; the plan used 215 for analysis purposes.
- 2.) The 2019 Water Master Plan determined GPCD for each pressure zone, which was used to determine future water demand projections. The total customer demand for 2018 (plus 14% for non-revenue water) was divided by the 2017 population, to determine the overall system-wide GPCD of 169.

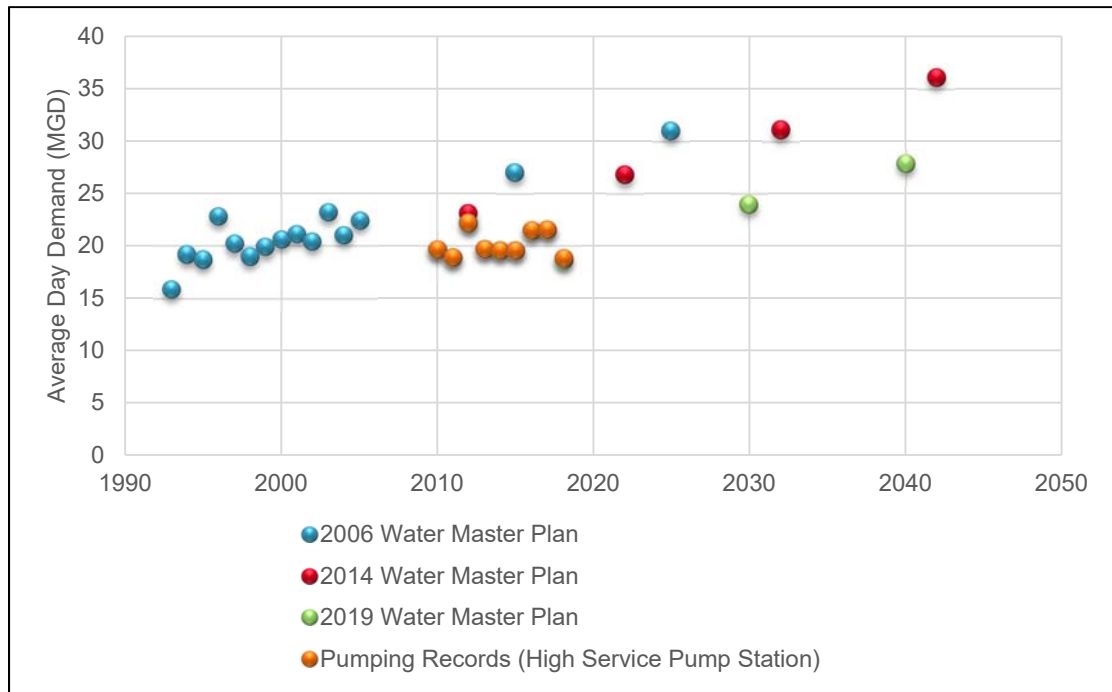


Figure 3-13. Average Day (MGD) Comparison

As population has continued to grow and the City of Billings continues to add new water customers, the average day demands have remained relatively stable, hovering around 20 MGD since the 1990s. It is interesting to note that this finding has been observed across the country and is due to a variety of reasons including socioeconomics, water efficient fixtures and landscaping, reductions in leakage, rate structures that incentivize conservation, a general trend towards increased multi-family housing, and overall public awareness for water resource management and conservation.

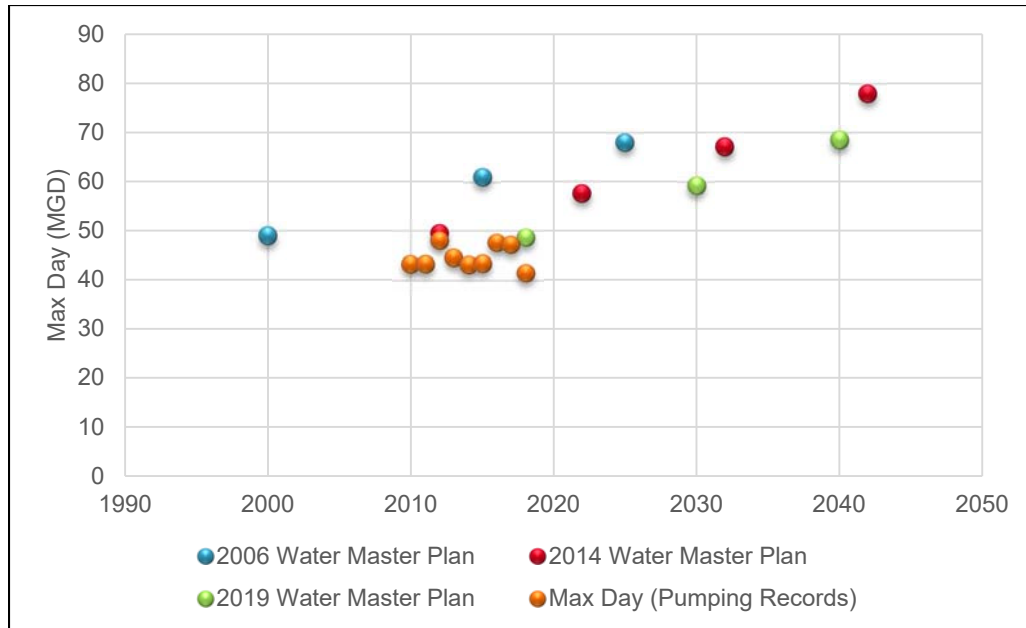


Figure 3-14. Max Day (MGD) Comparison

Notes:

- 1.) The 2014 Water Master Plan used a maximum day peaking factor of 2.85 for the parks and 1.25 for industrial customers, and 2.2 for all other demands.
- 2.) The 2019 Water Master Plan uses a maximum day to average day ratio of 2.78 which takes into account actual max day production at the High Service Pump Station, compared to customer demand data.

While average day demands predicted for 2030 and 2040 are lower than previous plans, the maximum day demands projected in this master plan are consistent with previous studies.

Water Production by Pressure Zone

An important element of this master plan is the City’s desire to examine water production and demand by pressure zone. Table 3-3 shows the water production by pressure zone for the last eight years. This water is delivered to customers through the distribution pipe network and moved around the system via a series of booster stations and water storage reservoirs. The delivery system for the City’s water system is schematically shown in Figure 3-15.



Table 3-3. Pumping by Pressure Zone, 2010 – 2018, Million Gallons per Day (MGD)

Zone	Description	2010	2011	2012	2013	2014	2015	2016	2017	2018
Zone 1	HSPS Zone 1 - Leavens - Willett	6.96	6.43	5.19	4.76	5.15	5.11	4.71	4.85	4.82
Zone 2	HSPS Zone 2 West + Willett - Cedar Park - Briarwood - Volker - Staples Z3 - Staple Z4*	3.23	2.56	4.45	4.02	4.21	3.23	4.25	4.14	4.27
Zone 2 East	HSPS Zone 2E - Walter Z3	2.15	2.12	2.85	2.71	2.45	2.65	3.56	3.61	2.11
Zone 3	Staples Z3 + Voelker + Leavens - Chapple	3.75	4.12	5.29	4.63	4.55	4.90	5.02	5.01	4.22
Zone 3 + 4 East	Walter Z3 – Fox + Terrace Estates	1.49	1.61	1.94	1.58	1.42	1.54	1.69	1.72	1.39
Zone 3 South	Cedar Park	0.02	0.02	0.03	0.03	0.02	0.02	0.03	0.02	0.02
Zone 4	Chapple + Staples Z4 - Waldo - Ironwood	1.64	1.62	1.87	1.48	1.31	1.56	1.56	1.56	1.31
Zone 4 North	Fox	0.08	0.11	0.14	0.13	0.11	0.14	0.18	0.19	0.16
Zone 4 South	Briarwood	0.15	0.15	0.20	0.15	0.14	0.16	0.17	0.17	0.15
Zone 5	Waldo - Christensen	0.06	0.04	0.07	0.06	0.05	0.07	0.06	0.06	0.04
Zone 5 West	Ironwood	0.00	0.00	0.00	0.00	0.03	0.04	0.05	0.05	0.06
Zone 6	Christensen	0.11	0.12	0.17	0.12	0.11	0.12	0.14	0.13	0.11
	Total (MGD)	19.65	18.89	22.18	19.68	19.56	19.55	21.42	21.53	18.65

*Note: If Walter is pumping from Zone 1, then Zone 1 is equal to High Service Zone 1 minus Leavens minus Willett.



Table 3-4 shows the average day and maximum day production, then the ratio of maximum to average day for the past 8 years. The ratio has consistently been about 2.25 for the system overall. However, when we remove the Billings Heights Water District and compare actual peak day production measured at the High Service Pump Station, and compare it to average day customer demands, we get a peaking factor of 2.78.

Table 3-4. Average Day, Maximum Day, and Peaking Factor

Year	Average Day Production (mgd)	Max Day Production (mgd)	Water Peaking Characteristics (Maximum Day to Average Day Ratio)
2010	19.65	43.25	2.20
2011	18.89	43.28	2.29
2012	22.18	47.97	2.16
2013	19.68	44.53	2.26
2014	19.56	43.12	2.20
2015	19.54	43.38	2.22
2016	21.42	47.53	2.22
2017	21.53	47.14	2.19
2018	18.65	47.97	2.57

To provide another metric for the ongoing management of water usage in the City, the gallons per capita per day (gpcd) value for each pressure zone was derived. The gpcd was determined by averaging the last three year’s (2016-2018) of customer data and calculating the 2018 trend line for the last five years. To conservatively plan to meet projected water demands, the greater of these two values was used, and subsequently unitized by dividing the total gallons per pressure zone by the 2017 population for each zone³. A non-revenue water factor of 14% was added. As shown in Table 3-5, the gpcd varies by pressure zone for a variety of reasons including lot size, newer vs. older fixtures, socioeconomics, etc. For example, a large portion of Zone 3 South is Blains Mobile Home Court which includes relatively small homes on small lots, suggesting a lower than average gpcd value would be appropriate.

It should be noted that gallons per capita per day (gpcd) is based on the total water usage (all land uses types) in each zone divided by the estimated population in that zone. Given the wide variation in customer type and usage per zone, gpcd should not be used as a basis for comparing water use efficiency by zone. Gpcd per zone is used herein as a baseline of current usage so that future demands by land use type can be incrementally incorporated in the pressure zone analysis.

³ 2017 population numbers contained in the Traffic Analysis Zones data in the 2018 Long Range Transportation Plan.

Table 3-5. Gallons Per Capita Per Day by Pressure Zone

Pressure Zone	Gallons Per Capita Per Day ¹
Zone 1	232
Zone 2	170
Zone 2 East	170
Zone 3	120
Zone 3 + 4 East	101
Zone 3 South	20
Zone 4	232
Zone 4 North	143
Zone 4 South	145
Zone 5	121
Zone 5 West	195
Zone 6	466

Notes:

These values were increased by 14% to account for non-revenue water.

Zone 2 East gpcd was calculated using the self-reported total gallons for 2018 divided by the 2017 population according to the TAZ.



Projected Water Demands

To estimate future water demands, future population growth was spatially allocated according to developments identified by City of Billings engineering staff, and future growth identified in the 2016 Growth Policy. Population growth is anticipated to occur at about 1.5% per year. The gcpd factors for each pressure zone were applied to the predicted future populations to determine future water demands. Maximum day demands were determined by using the 2.78 peaking factor, and peak hour demands are 3.4 times average day. This projected population and demand information is summarized in Table 3-6.

Table 3-6. Future Water Demand Estimates

	2017 Population	Existing Average Day (MGD) ²	2018 Max Day (MGD)	2018 Peak Hour (MGD)	2030 Population Estimate	2030 Average Day (MGD)	2030 Max Day (MGD)	2030 Peak Hour (MGD)	2040 Population Estimate	2040 Average Day (MGD)	2040 Max Day (MGD)	2040 Peak Hour (MGD)
Zone 1	27,204	5.54	15.38	18.84	27,984	6.64	18.43	22.58	28,662	6.80	18.87	23.11
Zone 2	21,135	3.15	8.73	10.70	26,256	4.47	12.41	15.20	30,705	5.23	14.51	17.77
Zone 2 East1	17,163	2.56	7.10	8.69	17,680	3.18	8.82	10.81	18,128	3.90	10.82	13.26
Zone 3	31,317	3.28	9.12	11.17	45,037	5.39	14.95	18.31	56,954	6.81	18.90	23.16
Zone 3 East	9,280	0.82	2.29	2.80	11,071	1.12	3.11	3.81	12,627	1.28	3.55	4.35
Zone 3 South	737	0.01	0.04	0.04	745	0.01	0.04	0.05	752	0.01	0.04	0.05
Zone 4	7,754	1.58	4.37	5.36	9,584	2.22	6.16	7.55	11,174	2.59	7.19	8.80
Zone 4 North	1,222	0.15	0.42	0.52	3,145	0.45	1.25	1.53	4,815	0.69	1.91	2.34
Zone 4 South	786	0.16	0.43	0.53	819	0.12	0.33	0.40	848	0.12	0.34	0.42
Zone 5	416	0.08	0.23	0.28	434	0.05	0.15	0.18	449	0.05	0.15	0.19
Zone 5 West	268	0.07	0.20	0.24	279	0.05	0.15	0.19	289	0.06	0.16	0.19
Zone 6	623	0.11	0.30	0.37	649	0.30	0.84	1.03	672	0.31	0.87	1.06
Total	117,904	17.5	48.6	59.6	143,683	24.0	66.6	81.6	166,075	27.9	77.3	94.7

Notes:

The source of the Zone 2 East water demand predictions is the Billings Heights provided information.
3-year Average (2016, 2017, 2018) of customer demand data

