Water Management and Conservation Plan

September 2021

CITY OF BEND

GSI Water Solutions, Inc.

Cover Photos (clockwise from top-left): WaterWise landscaping (City of Bend); aerial view of Bend looking West (City of Bend); Prowell Springs, Bend Municipal Watershed (Patrick Griffiths).

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Abbreviations and Acronyms

ADD	average day demand
MDD	maximum day demand
MMD	maximum monthly demand
NRW	non-revenue water
BMW	Bend Municipal Watershed
USFS	U.S. Forest Service
TID	Tumalo Irrigation District
OAR	Oregon Administrative Rule
ORS	Oregon Revised Statute
City	City of Bend
Avion	Avion Water Company, Inc.
Roats	Roats Water System, Inc.
UGB	Urban Growth Boundary
IWSMP	Integrated Water System Master Plan
WMCP	Water Management and Conservation Plan
WQA	winter-quarter average
cfs	cubic foot per second
SWIP	Surface Water Improvement Project
AMI	advanced metering infrastructure
SCADA	supervisory control and data acquisition
DSS	decision support system
SUP	special use permit
WARS	water availability reporting system
gpm	gallons per minute
gpcpd	gallons per capita per day
WFF	Water Filtration Facility

1. Municipal Water Supplier Plan Elements

This section satisfies the requirements of OAR 690-086-0125.

This rule requires a list of affected local government to whom the Plan was made available, and a proposed date for submittal of an updated Plan.

1.1 Introduction

The City of Bend (City) is located along the Deschutes River in the eastern foothills of the scenic Cascade Range. Vibrant economic growth and extensive outdoor recreation opportunities continue to draw new residents and businesses, increasing the demand for water within the City. The City operates a public drinking water system that supplies water to its customers using surface water from the Bend Municipal Watershed (BMW), and groundwater from the Deschutes Regional Aquifer to meet seasonal demand. The City recognizes the value of these dual water sources and actively seeks opportunities to protect and conserve its water supply for the benefit of its customers and the entire Deschutes River Basin. Effective water management and dedicated implementation of conservation measures can reduce water consumption, delay the need to develop additional water supplies, and reduce the volume of new water needed for municipal purposes.

Two private water utilities, Avion Water Company, Inc. (Avion) and Roats Water System, Inc. (Roats) serve areas within the City limits and Urban Growth Boundary (UGB) under franchise agreements with the City. As a result, the City's water service population is estimated to be 67,187, approximately 75% of the population of the City of Bend UGB population. The City's water service population is likely higher due to the daily influx of commuters and visitors for recreation and tourism. Irrigation needs also increase summer water demand.

In 2002, the Oregon Water Resources Commission adopted administrative rules requiring mitigation for the impacts of pumping under new groundwater permits (OAR 690-507). Two of the City's permits for groundwater use (G-18123 and G-18124) require the City to provide mitigation as part of the Deschutes Basin Groundwater Mitigation Program, and the City has an approved incremental mitigation plan for each permit. The City continues to develop water use under these permits.

This Water Management and Conservation Plan has been developed in conjunction with the City of Bend's Integrated Water System Master Plan (IWSMP).

1.2 Plan Requirement

This Water Management and Conservation Plan (WMCP or Plan) fulfills the requirements of Oregon Administrative Rules (OAR) Chapter 690, Division 86, effective as of December 2018.

The City completed its first WMCP in August 1998. The City has submitted two updated WMCPs to the Oregon Water Resources Department (OWRD) since that time. The most recent update was submitted on January 3, 2011. OWRD issued a final order approving the City's current WMCP on June 30, 2011. Consistent with that order, the City also submitted a WMCP Progress Report in June 2016 describing the City's water use and progress on water conservation measures. The 2011 final order required the

City to submit an updated WMCP within 10 years of approval of the WMCP and no later than December 29, 2020.

1.3 Plan Organization

The Plan is organized into the following five sections, each addressing specific requirements of OAR Chapter 690, Division 86. Section 2 is a self-evaluation of the City's water supply, water use, water rights, and water system. The information developed for Section 2 provides the foundation for the sections that follow. Sections 3 through 5 describe how the City can improve its water conservation and water supply planning efforts. The Plan also includes appendices with supporting information.

Section	Requirement
Section 1 – Municipal Water Supplier Plan Elements	*OAR 690-086-0125*
Section 2 – Municipal Water Supplier Description	*OAR 690-086-0140*
Section 3 – Municipal Water Conservation Element	*OAR 690-086-0150*
Section 4 – Municipal Water Curtailment Element	*OAR 690-086-0160*
Section 5 – Municipal Water Supply Element	*OAR 690-086-0170*

1.4 Affected Local Governments

OAR 690-086-0125(5)

The following governmental agencies may be affected by this WMCP:

- Deschutes County

Thirty days before submitting this WMCP to OWRD, the City made the draft Plan available for review by the affected local government entities listed above along with a request for comments related to consistency with the local government's comprehensive land use plan. The letter requesting comments and any comments received are included in **Appendix A**.

1.5 Plan Update Schedule

OAR 690-086-1025(6)

The City anticipates submitting an update of this Plan within 10 years of the final order approving this Plan. As required by OAR Chapter 690, Division 86, a progress report will be submitted within 5 years of the final order.

1.6 Time Extension

OAR 690-086-0125(7)

The City is not requesting an extension of time to implement metering or a benchmark established in a previously approved Plan.

2. Municipal Water Supplier Description

This section satisfies the requirements of OAR 690-086-0140.

This rule requires descriptions of the water supplier's water sources, service area and population, water rights, and adequacy and reliability of the existing water supply. The rule also requires descriptions of the water supplier's customers and their water use, the water system, interconnections with other water suppliers, and quantification of water loss.

2.1 Terminology

The following terminology is used in this WMCP.

Demand refers to the quantity of water delivered to a distribution system from a water treatment plant, wholesale supplier, or groundwater well. By definition, production equals system demand. Demand includes metered consumption (for example, residential, commercial, industrial, public, and irrigation customers), unmetered public uses (firefighting, hydrant flushing, other), and water lost to leakage and other factors. The City uses the American Water Works Association's (AWWA) M36 methodology for evaluating water system efficiency. The term demand, as used in this document, is equivalent to the AWWA's "water supplied." See **Exhibit 2-1** for a matrix showing the water balance table with terms and components used to describe water production, consumption, and loss in a water system, through the standards of AWWA's M36 methodology.

Authorized consumption is equal to metered water use and unmetered, authorized water use (e.g., system flushing), both billed and unbilled. Note that exhibits and descriptions of monthly or seasonal consumption only consider metered water use, as certain unmetered water uses are only estimated on an annual basis. Due to the low volume of unmetered water uses, metered water use is sufficiently similar to authorized consumption to make monthly and seasonal comparisons across years.

Demand minus authorized consumption equals **water loss.** Water loss is equal to the sum of apparent and real losses. **Apparent losses** include unauthorized consumption and meter inaccuracies, among other loss types; **real losses** include leakage on transmission and distribution mains up to the point of customer metering.

Non-revenue water (NRW) is the volume of water supplied that is unbilled and does not produce revenue, equal to real and apparent losses plus unbilled authorized consumption.

Generally, demand and consumption in municipal systems are expressed in units of million gallons per day (mgd), but also may be expressed in cubic feet per second (cfs) or gallons per minute (gpm). One mgd is equivalent to approximately 1.55 cfs or 694 gpm. For annual or monthly values, a quantity of water is typically reported in million gallons (MG). Water use per person (per capita use) is expressed in gallons per capita per day (gpcd).

The following terms are used to describe specific values of system demand:

- **Average day demand (ADD)** equals the total annual demand divided by 365 days.

- **Maximum day demand (MDD)** equals the highest system demand that occurs on any single day during a calendar year. It is also called the one-day MDD or peak-day demand.
- **Monthly demand** equals the total volume of water produced in a month.
- **Maximum monthly demand (MMD)** equals the highest demand that occurs over a single month of a calendar year.
- **Maximum operational demand** equals the four-hour rolling average maximum demand during the year.
- **Peaking factors** are the ratios of one demand value to another. The most common and important peaking factor is the ratio of the MDD to the ADD.

Exhibit 2-1. AWWA M36 Water Audit Matrix

<table>
<tr><td rowspan="10">Volume from Own Sources (Adjusted for known errors)

Water Imported</td><td rowspan="10">System Input Volume</td><td>Water Exported</td><td colspan="3">Billed Water Exported</td><td>Revenue Water</td></tr>
<tr><td rowspan="9">Water Supplied</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Authorized Consumption</td><td>Billed Metered Consumption (water exported is removed)</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption</td><td>Unbilled Metered Consumption</td><td rowspan="8">Non-Revenue Water (NRW)</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="5">Water Losses</td><td rowspan="3">Apparent Losses</td><td>Unauthorized Consumption</td></tr>
<tr><td>Customer Metering Inaccuracies</td></tr>
<tr><td>Systematic Data Handling Errors</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Transmission and/or Distribution Mains</td></tr>
<tr><td>Leakage and Overflows at Utility's Storage Tanks</td></tr>
<tr><td>Leakage on Service Connections</td></tr>
</table>

2.2 Water Sources

OAR 690-086-0140(1)

The City's primary water sources are surface water from the BMW and groundwater from the Deschutes Regional Aquifer.

2.2.1 Surface Water

The City's surface water intake is approximately 11.5 miles west of the city limits; on Bridge Creek, just above its confluence with Tumalo Creek. A 1926 agreement between the U. S. Forest Service (USFS) and the City created the BMW, and subsequent USFS plans recognize and designate municipal use as the highest and best use of the watershed. The BMW lies within the Deschutes National Forest, which is managed by the USFS. In addition, the USFS has issued several special use permits to the City that require significant environmental analysis and provide clear communication channels between signatories, control human activity, and protect water quality through regulations, restrictions, and ongoing monitoring.

The City's surface water system was developed in the 1920s and expanded in the 1950s as an unfiltered, gravity-flow system. Surface water provides approximately half of the City's annual water supply; groundwater provides the other half. The surface water supply is diverted at the Heidi Lansdowne Intake Facility located on Bridge Creek, which contains the combined flows from Bridge Creek and natural springs in the BMW from the Middle Fork of Tumalo Creek that are conveyed into Bridge Creek. Surface water is diverted from Bridge Creek and then conveyed approximately ten miles to the City's Outback Facility, where it is treated using membrane filtration. In 2016, the City upgraded the surface water intake and replaced the original transmission mains with a single pipe. The City's diversion is currently limited to a maximum of 18.2 cfs by Special Use Permit (SUP) BEN1178 issued by the USFS.

2.2.2 Groundwater

The City appropriates groundwater from the Deschutes Regional Aquifer using 20 active wells and associated water rights. The City's records show that groundwater levels in the City's wells are stable. Water levels in the Deschutes Regional Aquifer fluctuate in response to climate cycles, but there is no long-term trend.

2.3 Interconnections with Other Systems

OAR 690-086-0140(7)

The City's drinking water system has an emergency interconnection with Avion. The interconnection with Avion, constructed in 2003, is at the intersection of 27th Street and Bear Creek Roads. The City has yet to convey water through this interconnection except for flow-testing purposes and does not intend to rely on Avion to supply water to the City's customers.

The City previously maintained interconnections with Roats that allowed Roats to serve water to the Juniper Utility service area. In 2018, the City completed a sale of the Juniper Utility service area and associated infrastructure to Avion and Roats.

2.4 Water Supply Contracts

The City has a wholesale water supply contract to purchase water from Avion. Under this contract, Avion provides wholesale water service to the Bend Municipal Airport *only*. The airport is a small, isolated water system that is not connected to the main City system. The City has a well available for redundancy and fire protection, but normal demand is met with water supplied by Avion.

The City also has agreements to provide water to Tetherow, a resort adjacent to the Bend UGB, and to The Tree Farm, a rural residential development approved by Deschutes County adjacent to the City of Bend UGB to the West.

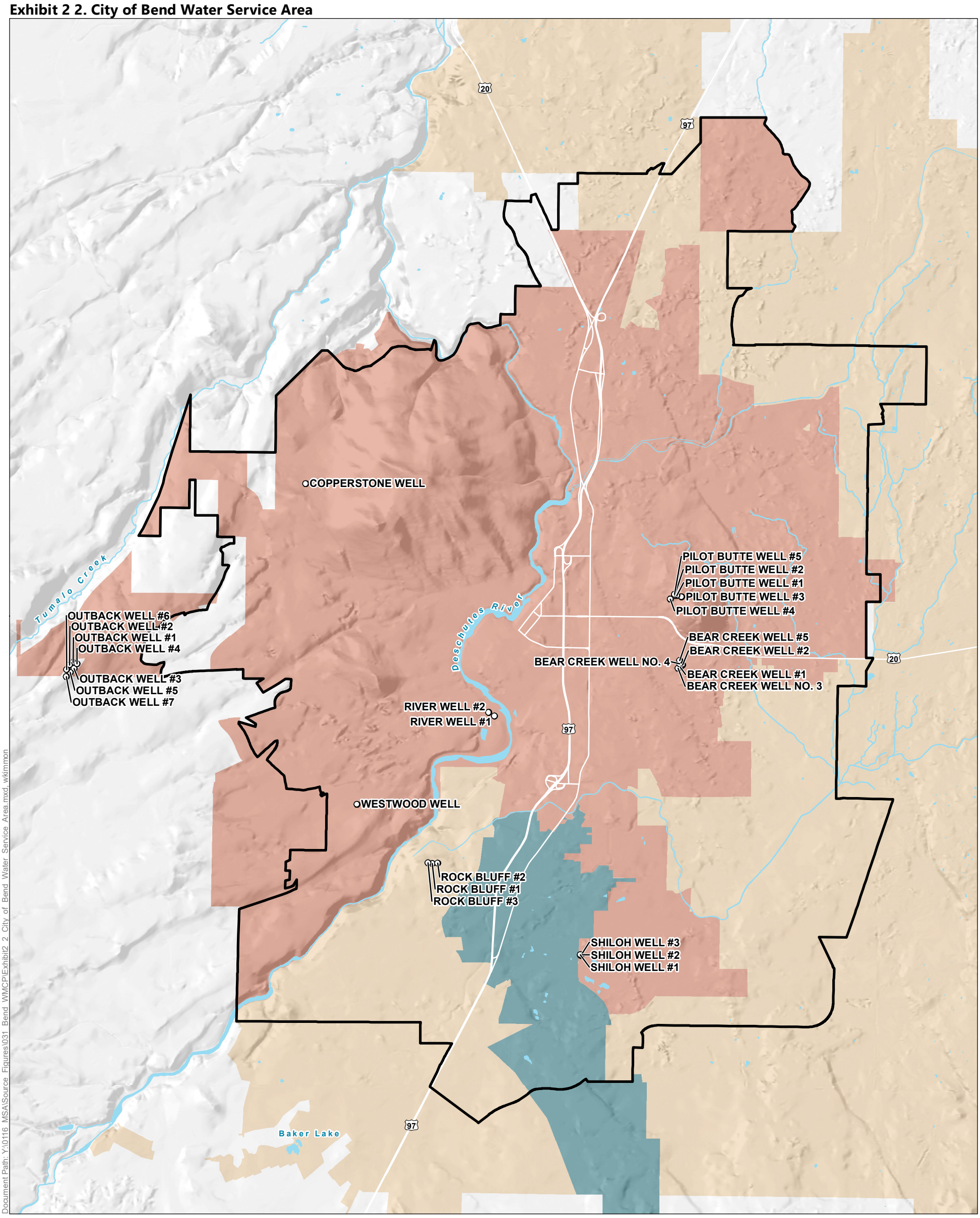
2.5 Intergovernmental Agreements

The City does not have any intergovernmental cooperation agreements regarding the provision of water to the City. The City and Tumalo Irrigation District (TID) have entered into an intergovernmental agreement to improve communication and cooperation and to set forth the structure of an approach and potential future projects that will enhance streamflows in Tumalo Creek.

2.6 Current Service Area Description and Population

The City's current service area appears in **Exhibit 2-2**. For purposes of making demand projections for this WMCP, the area shown is also the projected future service area. The City's service area includes most of the area within the City's current UGB, as well as the Tetherow and Tree Farm developments on the City's west side. The two private water utilities, Avion and Roats, serve water both outside and within the UGB in areas not served by the City's water system, primarily on the City's south and east sides. According to 2019 billing data, the City's water system had an average of approximately 25,826 meters billed each month (i.e., meters in active use), serving residential and non-residential customers. The City's 2019 estimated service area population is 68,379, based on the Portland State Population Research Center estimated population of 91,385, less 23,615 service population for Avion and Roats combined within the City of Bend, plus 609 service population in Tetherow (91,385- 23,615+ 609), which equates to approximately 75 percent of the UGB population. This number likely does not accurately capture increases in service population caused by an influx of temporary residents, which include both daily commuters and a year-round tourist population. The City estimates that the daytime influx of employees and tourists combined is approximately 50,000 per day, with some seasonal variation.

Exhibit 2 2. City of Bend Water Service Area



Date: November 16, 2020
Data Sources: City of Bend, OSIP

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2.7 Demand

OAR 690-086-0140(4)

The City's demand consists of the volume of water pumped from the City's groundwater wells and the volume of surface water treated and placed into the distribution system.

2.7.1 Historical Water Demand

Exhibit 2-3 presents the volumes produced annually from 2014 through 2019, broken down by groundwater and surface water sources. The dip in surface water production that occurs from 2015 through 2016—and associated increase in groundwater demand—is due to planned reductions of surface water use during construction activities for the City's Surface Water Improvement Project (SWIP). During this time, the City replaced the main transmission pipelines that conveyed water 10 miles from the Heidi Lansdowne Intake Facility to the City's Outback Facility, where the City also constructed a new state-of-the-art membrane Water Filtration Facility (WFF) to meet new drinking water regulations. The City also rebuilt the intake structure with new features to control and measure the rate of flow into the Bridge Creek intake along with state-of-the-art monitoring and fish screening. The original transmission lines from the intake ran at full capacity (as they were not designed to hold pressure when off). When turbidity was above limits or when water was not needed to meet customer demand, unused water was returned to Tumalo Creek near the Outback Facility. This practice ended with completion of the SWIP in 2016.

Exhibit 2-3. Historical Water Demand, 2014 through 2019

Year	Surface Water (MG)	Groundwater (MG)	Total (MG)	ADD (mgd)	MMD (MG)	MDD (mgd)	MDD Date	Peaking Factor (MDD:ADD)	June – Sept Reference ET Less Precipitation (inches)
2014	2024	2207	4231	11.6	686.5	24.4	7/16/2014	2.10	21.08
2015	953	3575	4528	12.4	723.5	26.5	7/3/2015	2.13	20.42
2016	1818	2704	4522	12.4	719.1	25.8	8/19/2016	2.09	19.78
2017	2988	1736	4723	12.9	788.1	28.0	8/3/2017	2.17	23.44
2018	2566	2230	4796	13.1	794.0	28.2	8/9/2018	2.14	22.35
2019	2721	1599	4320	11.8	686.8	26.1	8/7/2019	2.20	18.95
Average	2068	2490	4559	12.5	742.2	26.6	7/26	2.13	21.00

Notes
ET = evapotranspiration
MG = million gallons
mgd = million gallons a day
ADD = average daily demand
MDD = maximum daily demand

Exhibit 2-4 displays the City's ADD and MDD trends from 2014 through 2019. From 2014 through 2018, the ADD increased from 11.6 mgd to 13.1 mgd, with an average of 12.5 mgd. For the same period, the MDD increased from 24.4 mgd to 28.2 mgd, with an average of 26.6 mgd. Both ADD and MDD declined slightly in 2019. Compared with data reported in the previous WMCP, the ADD has increased slightly and MDD has decreased slightly. During periods of hot and dry weather, there tends to be an increase in water use for irrigation, resulting in higher MDD values. Similarly, during wet and

cool periods, the MDD tends to decrease. Economic conditions also play a role. The City's MDD decreased from 29.2 to 21.3 between 2008 and 2012, a period that coincided with both economic recession and cooler, wetter weather. In contrast, 2013 through 2018 coincided with warmer, drier weather and increased growth. The influence of these factors is also complicated by the City's long-term investments in advanced metering infrastructure (AMI) and supervisory control and data acquisition (SCADA) that have helped the City to more carefully and precisely manage the use of water; and by changes in the water service population, including the sale of the Juniper Utility service area to Avion and Roats. As a result, short-term influences on authorized consumption may mask longer trends toward reduced per capita consumption.

Exhibit 2-4. Average Day and Maximum Day Demand, 2014 through 2019

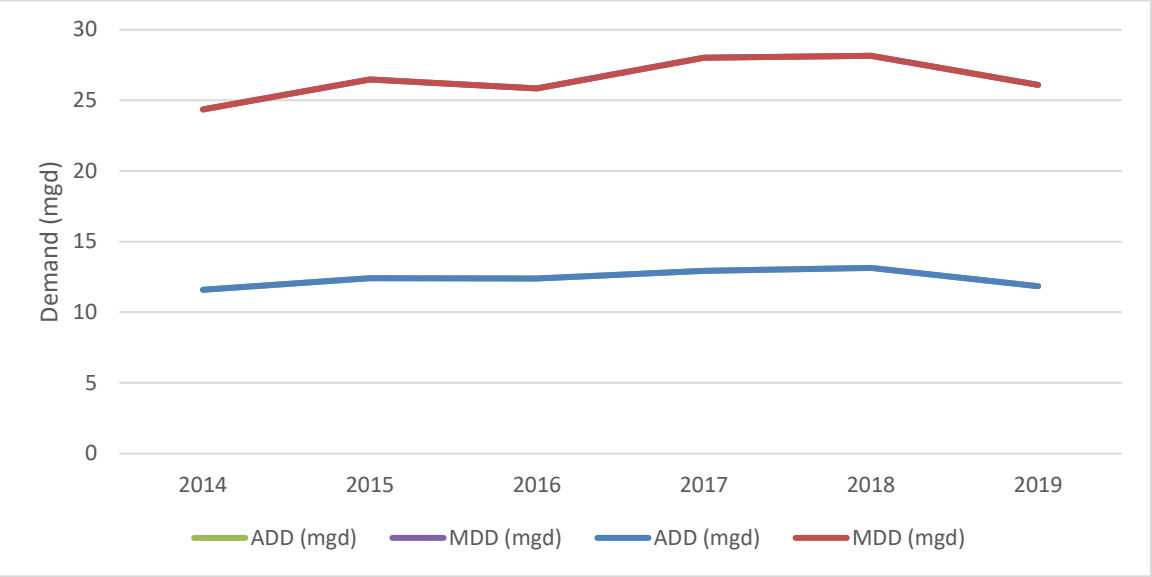


Exhibit 2-5 graphically represents the ratio of the MDD to ADD, which are the peaking factors presented in Exhibit 2-3, for the years 2014 through 2019. The peaking factor ranged from 2.09 to 2.20, with an average of 2.14. This is slightly lower than the most recently reported average peaking factors in the WMCPs for the Cities of Prineville and Redmond, which are 2.3 (2007 through 2015) and 2.5 (2006 through 2011), respectively. For use in projecting future demand in Section 5 of this WMCP, a peaking factor of 2.14 was used, following the City's 2020 IWSMP. In general, the City's peaking factor showed little variation from 2014 through 2019.

Exhibit 2-5. Maximum Day to Average Day Peaking Factor, 2014 through 2019

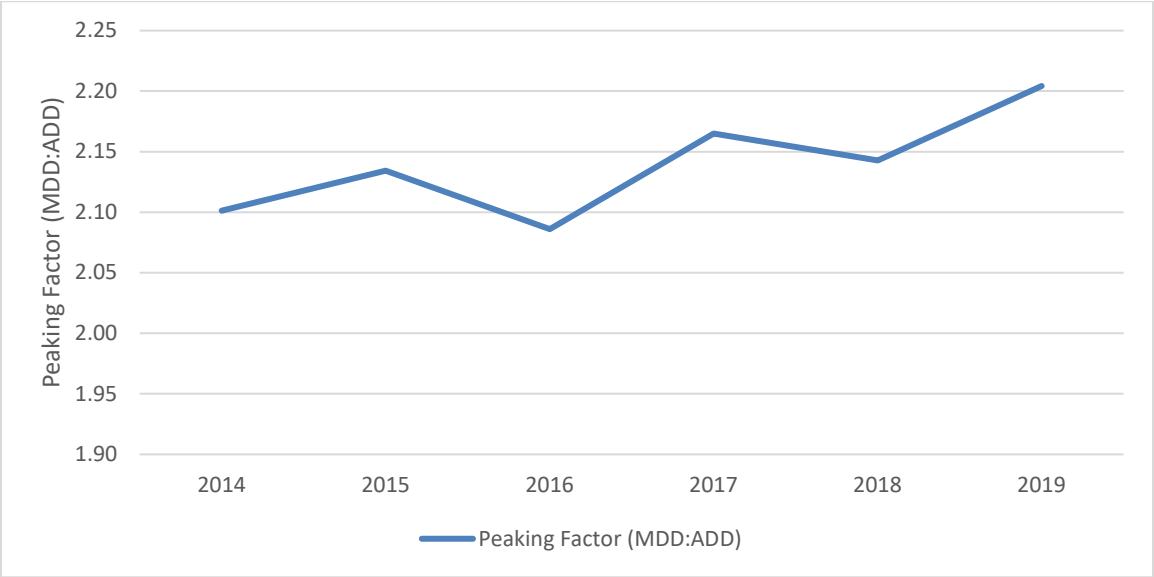
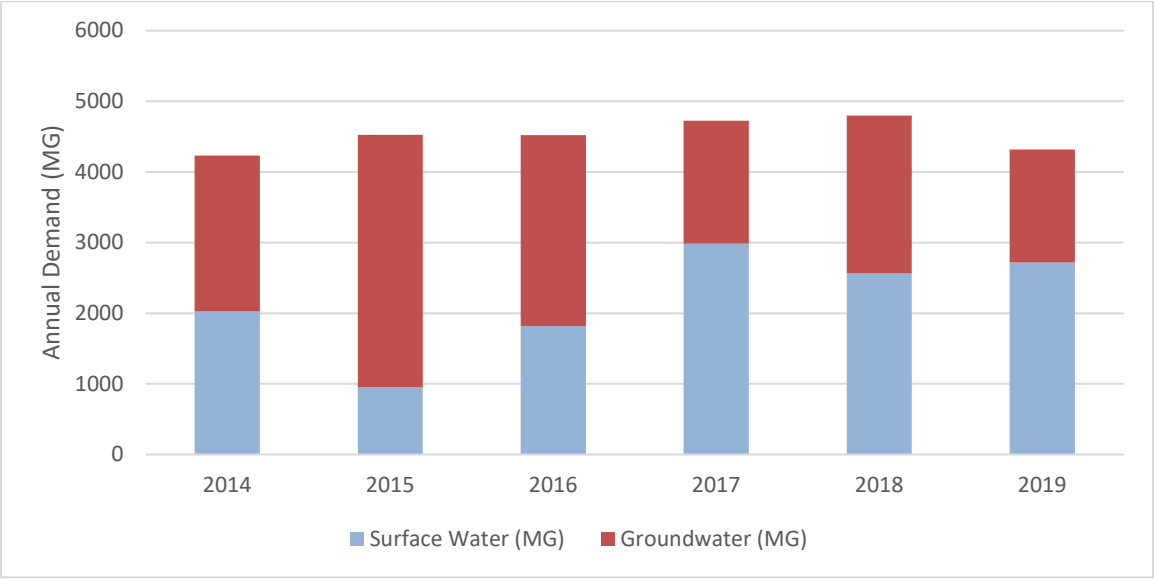


Exhibit 2-6 illustrates the annual demand for surface water and groundwater. On average from 2014 through 2019, the City's demand was made up of 55 percent groundwater and 45 percent surface water. However, this number was skewed by planned temporary reductions in surface water usage during replacement of raw water pipelines and addition of the WFF as part of the SWIP. The data from 2017 through 2019, when the City diverted a little more than half of its water supply from surface water, are likely more representative of anticipated groundwater and surface water usage.

Exhibit 2-6. Annual Demand of Surface Water and Groundwater, 2014 through 2019



Surface water is used year-round to meet the City's base water demand, and groundwater is used when surface water supplies are insufficient to meet demand. **Exhibit 2-7** illustrates the monthly demand volumes from 2014 through 2019. After completion of the SWIP, surface water provided nearly all of the water supply during the winter months, while groundwater generally augmented supply during the

peak seasons. However, due to work on the SWIP, the City temporarily relied more heavily on groundwater from 2015 through 2016. The data also show the shutdown of the City's WFF from April through early June 2018 for emergency maintenance of the City's chlorine contact basin reservoir.

Exhibit 2-7. Monthly Surface Water and Groundwater Demand, 2014 through 2019

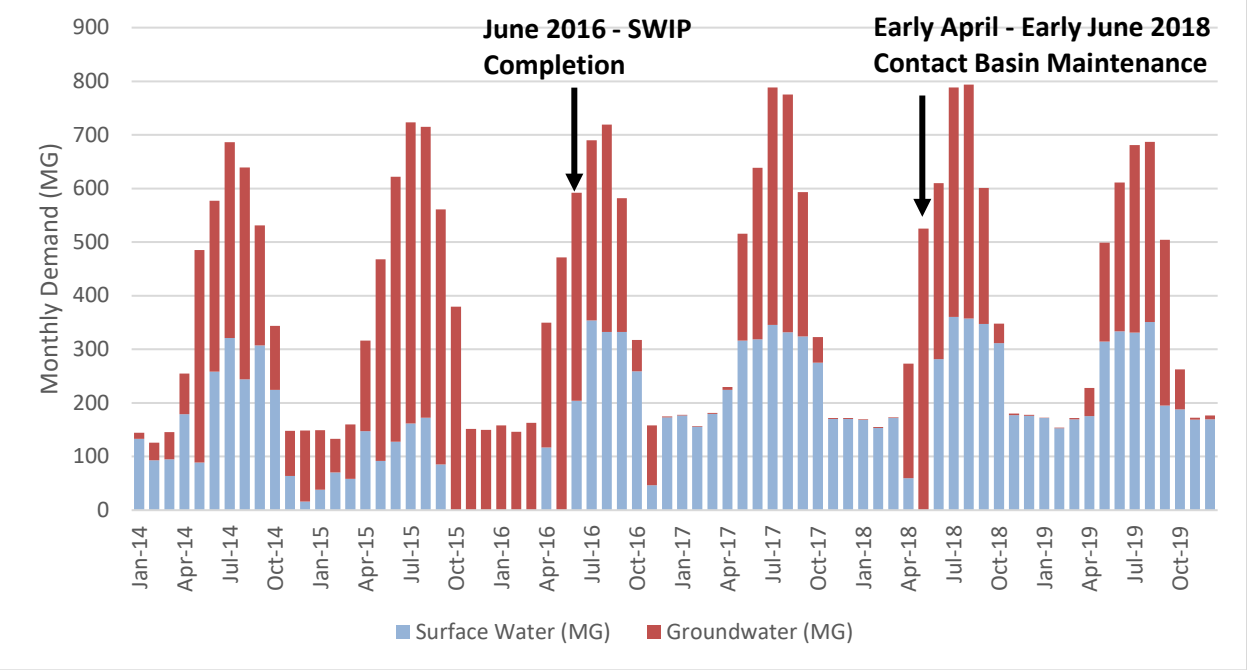
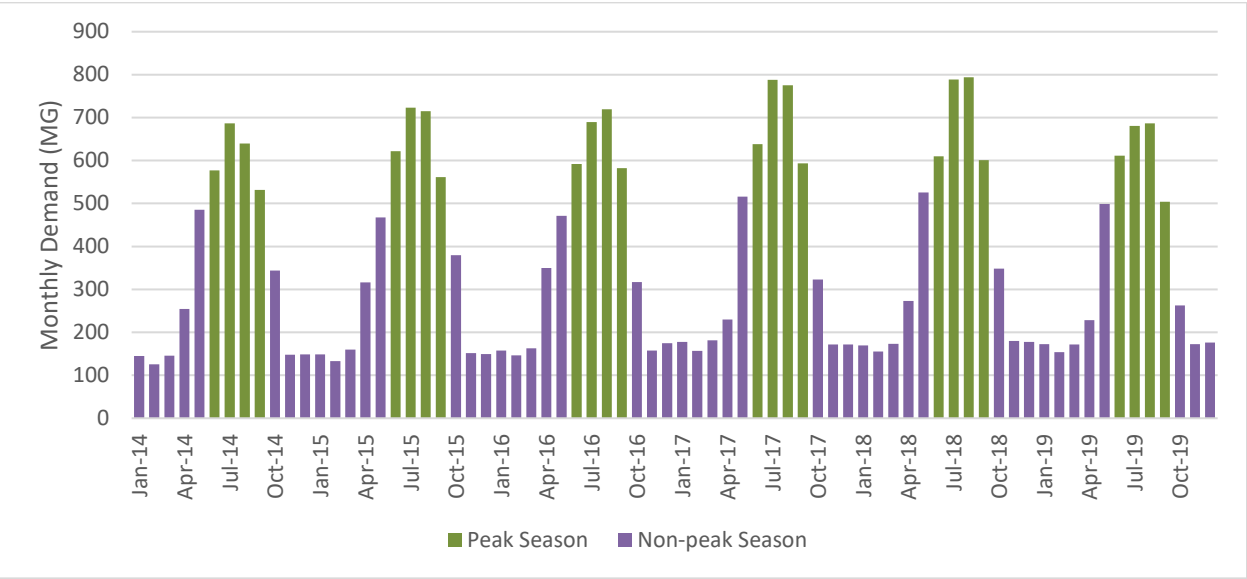


Exhibit 2-8 shows total monthly demand, with the peak season of June through September in green and the non-peak season in purple. The average monthly demand was 654.6 MG during the peak season and 237.7 MG during the non-peak season. The MMD averaged 733.0 MG and these peaks occurred in July (2014, 2015, 2017) and August (2016, 2018, 2019).

Exhibit 2-8. Monthly and Seasonal Demand, 2014 through 2019



2.7.2 Per Capita Demand

Exhibit 2-9 shows the estimated per capita demand within the City's water service area. The average and maximum day per capita demand represent use by all customer categories. Because the per capita demand includes all water use from both residential and non-residential uses, the calculated per capita demand values exceed the amounts of water actually used by a typical individual. Therefore, although per capita demand may show year-to-year trends, the evaluation of per capita demands benefits from additional context, including consideration of customer mix, climate, rainfall, economic conditions, and fluctuations in hotel or hospital occupancy or in large commercial and industrial uses. For example:

- The Bend Economic Development Department estimates that the average daily population increase from tourism and job commuters is approximately 50,000 people.
- Bend hosts a regional medical center with 250 beds.
- There are more than 25 breweries and distilleries in Bend.
- Evapotranspiration data presented in Exhibits 2-3 and 2-9, along with information presented in Section 2.8, provide additional context, as the largest use of water remains seasonal use for outdoor irrigation.

While this allows for consideration of year-to-year trends within the City, per capita demand is generally not a suitable metric to compare water demand across communities.

Exhibit 2-9. Average and Maximum Day per Capita Demand, 2014 through 2019

Year	Service Population	ADD (mgd)	MDD (mgd)	Per capita ADD (gpcd)	Per capita MDD (gpcd)	June – Sept Reference ET Less Precipitation (inches)
2014	59,744	11.6	24.4	194	408	21.08
2015	60,673	12.4	26.5	204	436	20.42
2016	62,901	12.4	25.8	197	411	19.78
2017	64,905	12.9	28.0	199	432	23.44
2018	67,187	13.1	28.2	196	419	22.35
2019	68,379	11.8	26.1	173	382	18.95
Average	63,965	12	26	194	415	21.00

Notes
ADD = average daily demand
ET = evapotranspiration
gpcpd = gallons per capita per day
MDD = maximum daily demand
MG = million gallons
mgd = million gallons a day

2.8 Customer Characteristics and Use Patterns

Authorized consumption is equal to the metered and certain unmetered water uses within the system. All customers are metered; however, authorized water use for activities such as fighting fires and system maintenance are not always metered by the City. Maintenance use and water used for water quality purposes, such as system flushing, are tracked informally by City operations staff. To obtain a more accurate determination of water loss, the City has developed a Water Loss Control Program to calculate

and track unbilled authorized consumption as part of its AWWA M36 Water Audit Program, as further described in Section 3.

The City currently has five key customer categories: single-family, multi-family, commercial, irrigation-only, and hydrant meters. In 2019, 90 percent of meters were single-family or multi-family, and the remaining 10 percent were commercial or irrigation-only. Hydrant meters made up 0.6 percent of meters. Residential customers include single-family and multi-family accounts, and non-residential customers include commercial and irrigation-only account categories.

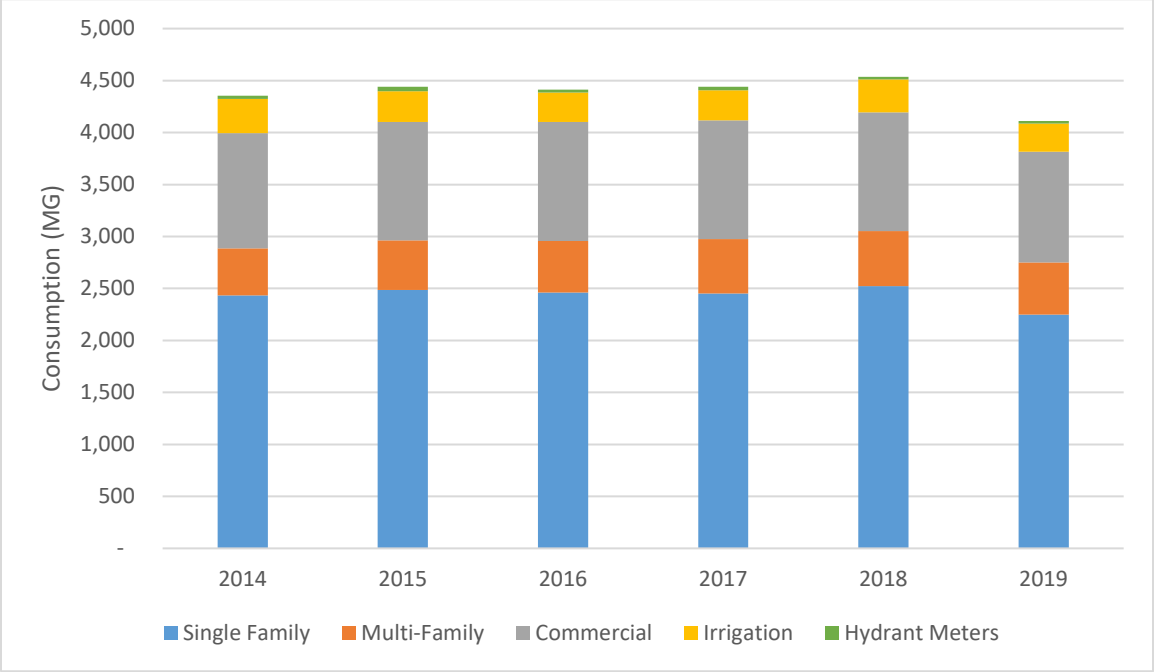
Understanding the characteristics of customers within the system is important when analyzing water use and forecasting future demand and consumption patterns. **Exhibit 2-10** shows the number of meters by customer category from 2016 through 2019. The numbers do not include meters from the Juniper Utility service area, which was sold to Roats and Avion in 2018. The City's irrigation-only account category includes meters providing water for seasonal outdoor irrigation only to locations such as parks and school fields as well as irrigated landscapes owned by the City and larger home owners' associations. Prior to the completion of the previous WMCP in 2011, the City created a Hydrant Meter Program, which requires temporary meters when using hydrants for non-emergency purposes. Hydrant meters measure and charge for water use for temporary uses, including construction and dust abatement. A single hydrant meter box can be used at multiple job sites for different purposes over a season. Although the number of meters and authorized consumption are reported in the same way as other customer categories, the hydrant meter category is not readily comparable to other categories for this reason.

Exhibit 2-10. Number of Meters by Customer Category, 2016 through 2019

Year	Single Family	Multi-Family	Commercial	Irrigation-Only	Hydrant Meters	Total
2016	20,649	1,569	2,124	359	61	24,762
2017	20,658	1,597	2,141	359	56	24,811
2018	21,017	1,631	2,169	371	57	25,245
2019	21,540	1,671	2,184	374	57	25,826

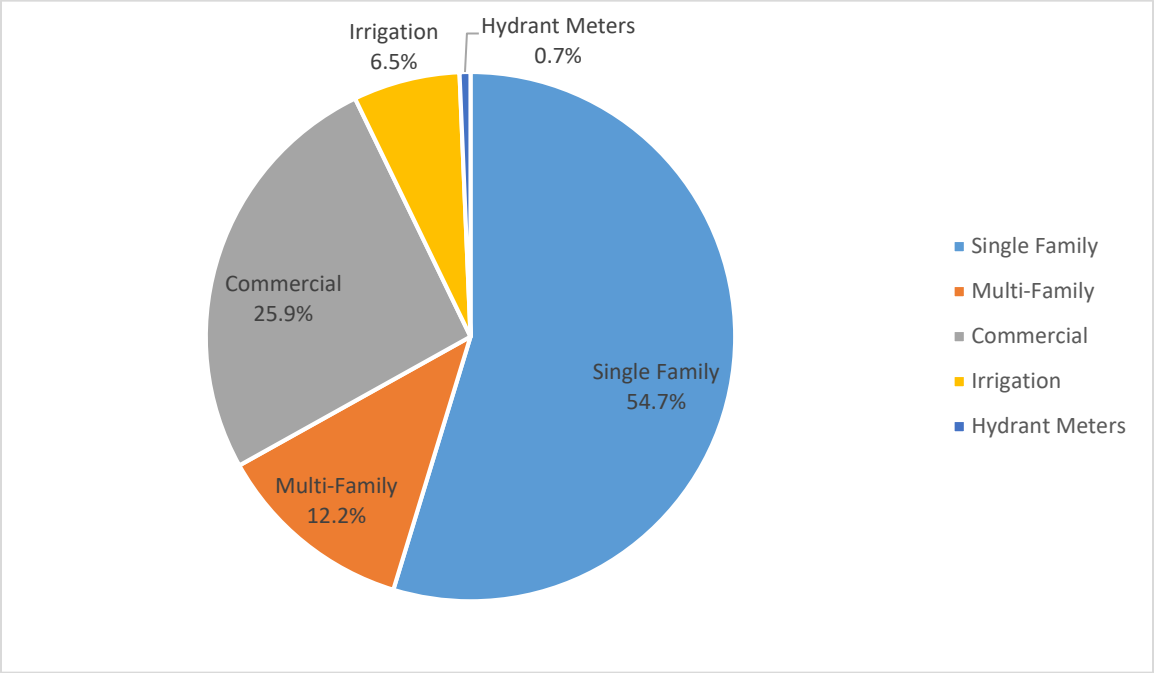
The annual metered consumption by customer category from 2014 through 2019 is shown in **Exhibit 2-11**.

Exhibit 2-11. Annual Consumption by Customer Category, 2014 through 2019



The percent of total water used by each customer category in 2019 is illustrated in the pie chart in **Exhibit 2-12**. Residential use comprised 67.3 percent of consumption; non-residential comprised 32.7 percent of use.

Exhibit 2-12. Percent Annual Consumption by Customer Category, 2019



The monthly consumption by customer category from 2014 through 2019 is shown in **Exhibit 2-13**. Consumption during the peak season is typically higher than during the non-peak season. For single

and multi-family residential meters, and especially irrigation-only meters, seasonal water use will mostly reflect outdoor water use for irrigation of landscaping. For commercial and hydrant meters, differences in seasonal water use may not reflect indoor and outdoor (irrigation) water use, but rather other seasonally correlated activities. For example, water use for industrial cooling or use of hydrants for dust suppression activities during construction season would also likely increase during the summer and decrease during the winter. However, seasonal fluctuations in the City's water use will also reflect differences in service population during the summer and winter seasons.

2019 peak season water use was 4.7 times higher than non-peak-season water use for single family residential connections (due to outdoor landscape watering associated primarily with large residential lots), 2.1 times higher for multi-family connections (most which have combined indoor and outdoor uses on the meter and typically smaller areas for landscape), and 2.7 times higher for commercial connections.

These ratios suggest that conservation efforts focused on reducing outdoor use by single-family homes and certain commercial customers with large landscape water use, may help to address peak-season demand (See **Exhibit 2-13**).

Exhibit 2-13. Monthly Consumption by Customer Category, 2014 through 2019

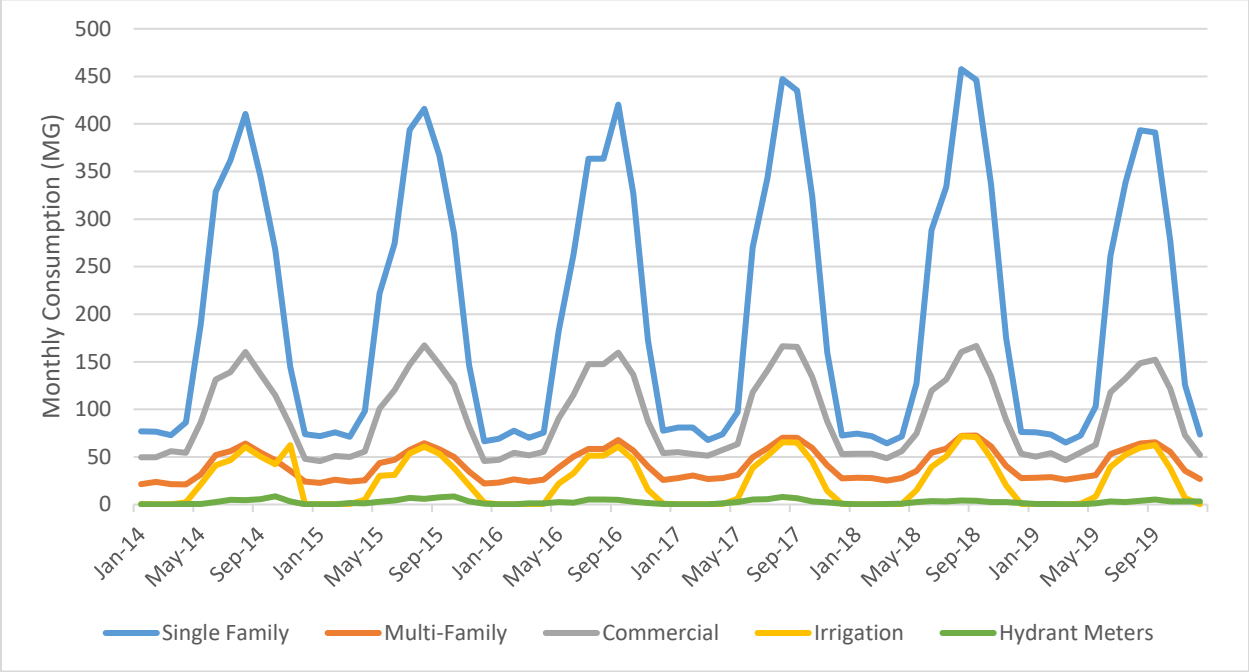


Exhibit 2-14 shows the City's annual water consumption by customer category. **Exhibit 2-15** compares the City's annual consumption to that of 2009 in the previous WMCP. The City's customer categories have changed, therefore only the residential and non-residential categories are compared. Due to the change in the categorization of residential and non-residential accounts—some commercial accounts from 2009 were reclassified as multi-family when that category was created in 2013—and the sale of the Juniper Utility service area to Avion and Roats, it is difficult to compare data from 2009 and 2019. The first full year that customer categories existed as they do now was 2014.

Exhibit 2-14. Water Consumption by Customer Category (MG), 2014 through 2019

Year	Single Family	Multi-Family	Commercial	Irrigation-Only	Hydrant Meters	Total
2014	2,433	452	1,110	328	31	4,354
2015	2,487	475	1,139	295	43	4,439
2016	2,461	495	1,146	283	28	4,413
2017	2,453	521	1,145	287	35	4,441
2018	2,523	531	1,140	318	26	4,537
2019	2,250	502	1,065	268	27	4,113

Exhibit 2-15. Comparison of Water Consumption by Customer Category (MG), 2009 and 2019

	Accounts			Consumption (MG)		
Year	Residential	Non-Residential	Total	Residential	Non-Residential	Total
2009	19,033	3,211	22,244	2,551	1,639	4,190
2019	23,211	2,614	25,826	2,752	1,361	4,113
% Change	18%	-23%	14%	7%	-20%	-2%

Note
MG = million gallons

2.9 Water Loss

OAR 690-086-0140(9)

For the purposes of this WMCP, water loss is equal to the difference between annual demand ("water supplied," according to M36 methodology) and authorized consumption, excluding unmetered consumption, and represents the sum of unmetered consumption (e.g., hydrant flushing and distribution system flushing), system leakage, and inaccuracies of measurement at production (i.e., demand) meters and customer meters. When this difference is divided by the demand value, water loss is expressed as a percentage of total demand. The OWRD administrative rules for WMCPs set a water loss goal of 10 percent or less (OAR 690-086-0150(4)(e).

Exhibit 2-16 presents the annual water loss for 2014 through 2019. Water loss has remained below 10 percent since 2008 and averaged 4.7 percent from 2014 through 2019.

Beginning in 2013, the City began using the AWWA M36 Water Audit Methodology to conduct annual water audits. This comprehensive methodology has been adopted as an industry-wide best practice and provides the most up-to-date analysis of the City's water distribution system efficiency and accuracy. In addition to real losses (system leakage, overflows), the M36 Water Audit Methodology estimates apparent losses, which include unauthorized consumption, customer metering inaccuracies, and systematic data handling errors. The reporting worksheets for 2014 through 2019 and performance

indicators for 2019 are presented in **Appendix B**, and provide additional information about the source of water loss and estimates of avoidable loss.

The annual demand totals shown in **Exhibit 2-18** differ from those shown in Exhibit 2-2 and used for other calculations involving demand. The numbers used in the City's water audits, summarized in **Exhibit 2-17**, include pumping from the Hole Ten wells, which were sold to Roats in 2016 along with the Juniper Utility service area. Production from Hole Ten ceased to be accounted for as part of the City's system in January 2017. The numbers used in Exhibit 2-2 and elsewhere include pumping from the City's current water sources only.

Exhibit 2-16. City of Bend Estimated Water Loss, 2014 through 2019

Year	Annual Demand/ Water Supplied (MG)	Authorized Consumption (MG)	Water Loss (MG)	Water Loss (%)	Apparent Losses (MG)	Real Losses (MG)
2014	4,461	4,371	90	2.0%	44	46
2015	4,746	4,455	291	6.1%	45	246
2016	4,727	4,449	278	5.9%	45	232
2017	4,746	4,453	294	6.2%	45	248
2018	4,793	4,549	244	5.1%	46	198
2019	4,370	4,119	251	5.7%	42	209
Average	**4,640**	**4,399**	**241**	**5.2%**	**45**	**197**

Notes
[1] Third-party verification to the M36 audit process in 2015 improved the utility department's systematic data handling and reporting practices, which may be responsible for the difference between 2014 and other years.
MG = million gallons

2.10 Water Rights

OAR 690-086-0140(5)

2.10.1 Summary of Water Rights

The City holds six surface water rights that authorize a total use of up to 36.123 cfs (23.3 mgd) from Tumalo Creek and Bridge Creek for municipal purposes: four certificates, one transfer and one permit. **Exhibit 2-17** summarizes the City's surface water rights. In addition, the City holds 12 groundwater rights that authorize the use of groundwater at a rate of up to 68.2 cfs (44.1 mgd). Six certificates and three permits authorize the use of water for municipal purposes, Certificate 85526 authorizes the use of water for Domestic and Municipal use, and Certificates 94101 and 85411 authorize the use of water for Quasi-municipal use. In total, the City holds nine certificates and three permits. **Exhibit 2-18** summarizes the City's groundwater rights. The exhibit includes the source, priority date, completion date (if applicable), and maximum instantaneous rate of water diverted to date for each water right.

Exhibit 2-17. City of Bend Surface Water Rights

Application	Permit	Certificate or Transfer Number	Source(s)	Priority	Completion Date	Authorized Rate (cfs)	Authorized Volume (AF)	Maximum Diverted to Date (cfs)	Notes	Average Annual Demand (MG)					Average Monthly Demand (MG)					Average Daily Demand (MG)				
										2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
Tumalo Creek Decree		85526	Tumalo Creek or its Tributaries	Senior to all other rights on Tumalo Creek	N/A	6	N/A	18.2	4/15 through 9/15 only.	953	1,818	2,988	2,566	2,721	79.4	151.5	249.0	213.9	226.7	2.61	4.97	8.19	7.03	7.45
Tumalo Creek Decree		31411	Tumalo Creek	8/5/1900	N/A	2	821.7																	
				9/1900		4.5																		
				6/1/1907		0.02																		
Tumalo Creek Decree		31665	Tumalo Creek	9/1900	N/A	1.314	328.14																	
				4/28/1905		0.186																		
				6/1/1907		1.103																		
Tumalo Creek Decree		B-112	Tumalo Creek, Crater and Little Crater Creek, Three Spring Branches	9/1900	10/1/2038	1.62	1923.5		4/1 through 10/31 only. Total diversion under this right is limited to 2.43 cfs in April and October; 3.23 cfs from 5/1 through 5/15 and 9/16 to 9/30; and 5.99 cfs from 5/16 through 9/15.																
				6/1/1907		0.39																		
				10/29/1913		Varies (2.43 - 5.99)																		
S-67983	S-49823	85713	Bridge Creek	12/12/1983	N/A	12.2		12.2	Authorized source is Bridge Creek, "with any deficiency in the available supply from Bridge Creek to be made up by appropriation from an unnamed tributary to Middle Fork of Tumalo Creek and Tumalo Creek." Extension pending for undeveloped portion.																
S-67983	S-49823		Bridge Creek	12/12/1983	10/1/1999	2.8		0																

* Demand data measured at Bridge Creek intake

Exhibit 2-18. City of Bend Groundwater Rights

Application	Permit	Certificate or Transfer Number	Priority	Completion Date	Source(s)	Authorized Rate (cfs)	Authorized Volume (AF)	Maximum Diverted to Date	Notes	Average Annual Demand (MG)					Average Monthly Demand (MG)					Average Daily Demand (MG)				
										2015	2016	2017	2018	2019	2015	2016	2017	2018	2019	2015	2016	2017	2018	2019
G-4677	G-4435	94100	11/8/1968	N/A	Outback Well 3 Outback Well 4 Bear Creek Well 2 Pilot Butte Well 4 Outback Well 5 Outback Well 6 Shiloh Well	7.75		7.75		3,249	2,273	1,173	1,712	1,100	270.8	189.4	97.7	142.7	91.7	8.90	6.21	3.21	4.69	3.01
G-8695	G-8565	94101	12/22/1978	N/A	Westwood Well Pilot Butte Well 4 Shiloh Well	0.94		0.94																
G-8695	G-8565	85411	12/22/1978	N/A	Westwood Well	1.51		1.51																
G-5644	G-4946	85412	10/13/1971	N/A	River Well 1 River Well 2 Pilot Butte Well 2 Copperstone Well	7.57		7.57																
G-5644	G-4946	85413	10/13/1971	N/A	River Well 1 River Well 2 Pilot Butte Well 1 Bear Creek Well 1 Bear Creek Well 2	4.87		4.87																
G-12226	G-11380	85414	9/7/1990	N/A	Outback Well 1 Outback Well 2 Outback Well 3 Outback Well 4 Bear Creek Well 1 Airport Well 2*	10		10																
G-5644	G-4946	85415	10/13/1971	N/A	River Well 1 River Well 2	2.7		2.7																
G-5644	G-4946	68702	10/13/1971	N/A	River Well 1 River Well 2	0.9		0.9																
G-11942	G-11379	85559	6/30/1989	N/A	Rock Bluff Well 1 Rock Bluff Well 2 Rock Bluff Well 3	4.16		4.16		110	204	194	114	270	9.1	17.0	16.2	9.5	22.5	0.30	0.56	0.53	0.31	0.74
G-11942	G-11379		6/30/1989	10/1/1998	Rock Bluff Well 1 Rock Bluff Well 2 Rock Bluff Well 3 Pilot Butte Well 3	3.84		2.35	Extension of time pending.2.35 cfs utilized prior to 2005.																
G-13097	G-18123		8/27/1992	4/26/2027	Bear Creek Well 3 Bear Creek Well 4 Bear Creek Well 5 Shiloh Well Outback Well 7	12	3,223	3.01	209.5 mitigation credits assigned (maximum annual volume of 419 AF)	216	227	369	404	229	18.0	18.9	30.7	33.6	19.1	0.59	0.62	1.01	1.11	0.63
G-13098	G-18124		8/27/1992	4/26/2027	Pilot Butte Well 3 Pilot Butte Well 4 Pilot Butte Well 5 Shiloh Well Outback Well 7	12	3,223	3.01	608.95 mitigation credits assigned (maximum annual volume of 1,217.9 AF)																

* Although Airport Well 2 is included in Certificate 85414 and in this exhibit, it is now used exclusively for fire-flow events only as a backup to the water supplied by Avion. The well does not provide water to the City's municipal water system.
**Demand data are measured at well head; however, several wells are on multiple water rights so the data are consolidated.
AF = acre-feet MG = million gallons N/A = not applicable or available

2.10.2 Surface Water

The City's six surface water rights authorize the use of up to a total of 36.1 cfs (23.3 mgd) from the Tumalo Creek watershed. While the maximum rate of the City's combined surface water rights is 36.1 cfs, due to seasonal limitations, sharing of priority dates with other water users on Tumalo Creek, and seasonal low flows, the reliable rate of the City's water rights is significantly lower than 36.1 cfs. Furthermore, under the terms of the City's SUP (BEN1178) authorizing operation of the surface water system on USFS lands, the City's diversion is currently limited to 18.2 cfs (11.8 mgd). The current SUP expires in 2037.

The City's surface water rights are evidenced by four certificates, one permit, and one transfer.

The amount of water available to satisfy the City's surface water rights is a function of water right priority date (seniority) and stream flow. The City's most senior surface water right is Certificate 85526, which authorizes the use of up to 6.0 cfs from Tumalo Creek. The certificate evidencing this water right does not provide a date of priority, but states instead that the "right is senior to all other rights on Tumalo Creek." The City acquired this water right as the result of a judgment of the Deschutes County Circuit Court in a case between the City of Bend and the Deschutes County Municipal Improvement District.[1]

The City holds two additional surface water right certificates for the use of water from Tumalo Creek: Certificate 31411, which authorizes the use of up to 6.52 cfs; and Certificate 31665, which authorizes the use of up to 2.603 cfs. Both rights originated as multiple decreed rights for irrigation. The City acquired the lands to which the rights were appurtenant and transferred the water rights to municipal purposes. As a result, these certificates each have multiple priority dates and a different maximum authorized rate associated with each date, corresponding to the priority dates of TID's decreed water rights. These rights also carry an annual volume limitation and a season of use limitation stemming from their origins as irrigation water rights.

The City's most junior municipal water right is Certificate 85713, which authorizes the use of up to 12.2 cfs from Bridge Creek and an unnamed tributary of Middle Fork Tumalo Creek. This certificate was issued as the result of the partial perfection of Permit S-49823, which authorized the use of up to 15.0 cfs. The remaining 2.8 cfs portion of Permit S-49823 continues to be in the water right development process as a permit. A permit extension is pending for Permit S-49823.

Finally, the City holds a water right evidenced by Transfer B-112. Under this transfer, the maximum authorized rate of diversion from Tumalo Creek varies by season from 2.43 cfs to 5.99 cfs. The right also has an annual volume limitation and a season of use because it was originally an irrigation right. Transfer B-112 changed the place of use, point of diversion, and character of use of two certificates for irrigation and domestic use. On August 7, 2019, OWRD approved an extension of time allowing the City to complete this transfer by October 1, 2038.

[1] *City of Bend vs. Deschutes County Municipal Improvement District,* August 11, 1926. Circuit Court of the State of Oregon for Deschutes County. Judge D.R. Parker. Oregon Water Resourced Department Order Volumes 1M-153.

The City's water right Transfer B-112 includes Crater Creek and Little Crater Creek as sources. Crater Creek was constructed between 1913 and 1914 to augment Tumalo Creek flows via the Crater Creek ditch, which drains the southern slope of Broken Top. The water is conveyed to the headwaters of Middle Fork Tumalo Creek. The diversion is operated by the TID.

2.10.3 Groundwater

Discussion of the City's groundwater rights benefits from a brief summary of groundwater regulations in the Upper Deschutes Basin over the past three decades. In 1993, the U.S. Geological Survey and OWRD initiated a study on the groundwater in the Deschutes Basin upgradient from Lake Billy Chinook. One of the conclusions of the study is that there is a direct hydraulic connection between groundwater and surface water within the study area.[2] As a result of this conclusion, OWRD determined that groundwater appropriations in the study area would interfere with existing surface water rights (including instream water rights) and would measurably reduce flows needed for scenic waterways in the Deschutes Basin. Under the Scenic Waterway Act (ORS 390.835) OWRD could only approve new groundwater permits if qualifying mitigation were provided.

In 2002, the Deschutes Basin Groundwater Mitigation Program was established to create a mechanism for water users to provide mitigation for impacts to scenic waterway flows and senior water rights, while allowing additional appropriations of groundwater in the Deschutes Ground Water Study Area. The Mitigation Program is authorized by Oregon Revised Statute (ORS) 537.746 and is established in OWRD's administrative rules (OAR Chapter 690, Divisions 505, 521, and 522).

All nine of the City's groundwater right certificates and one permit, and the undeveloped portion of G-11379, predate the establishment of the Deschutes Basin Groundwater Mitigation Program. The City refers to these as "Tier 1" groundwater rights. These more senior groundwater rights do not require mitigation under OWRD's Mitigation Program. The City's two most junior groundwater right permits, G-18123 and G-18124, were issued after the establishment of OWRD's mitigation program and are referred to as "Tier 2" groundwater rights.

The City has a total of 44.2 cfs of Tier 1 groundwater rights, of which 40.4 cfs have been certificated. One Tier 1 water right, G-11379, remains in the permit development phase, with 3.84 cfs remaining undeveloped after a partial perfection in 2009. The City submitted an extension application for the remaining undeveloped 3.84 cfs in 2003 and an addendum in 2018. In the 2018 addendum, the City identified that a total of 6.51 cfs was developed prior to June 29, 2005; therefore there is a 1.49 cfs undeveloped portion of the permit (8 cfs permit – 6.51 cfs developed prior to 6/29/2005 = 1.49 cfs undeveloped portion of the permit). This 1.49 cfs undeveloped portion of the permit is subject to fish persistence conditions that will be recommended by Oregon Department of Fish and Wildlife (ODFW).

Permits G-18123 and G-18124 each have a priority date of August 27, 1992, and each authorizes water use at a rate of up to 12.0 cfs and an annual volume of up to 3,223 acre-feet. OWRD determined that each permit has a total mitigation obligation of 1,611.5 mitigation credits based on an estimated consumptive use coefficient of 50 percent. To date, the City has assigned 209.5 and 608.95 mitigation

[2] Gannett, M. W. (2001). Ground-water hydrology of the upper Deschutes Basin, Oregon (No. 4162). US Department of the Interior, US Geological Survey.

credits to permits G-18123 and G-18124, respectively, allowing pumping of up to a total of 1,636.9 acre-feet per year.

2.10.4 Aquatic Resource Concerns

OAR 690-86-140(5)(i) requires identification of any streamflow-dependent species listed by a state or federal agency as sensitive, threatened, or endangered that are present in the source, and listing of the source as water quality limited and the water quality parameters for which the source was listed, and any designation of the source as being in a critical groundwater area.

The City's water supply comes from both groundwater and surface water. Groundwater in the Deschutes Basin is not an OWRD-designated Critical Groundwater Area or Groundwater Limited Area. The City's surface water sources in the BMW are within the Tumalo Creek watershed. **Exhibit 2-19** shows the listed fish species that occur in Bridge Creek and Tumalo Creek. Bridge Creek is within the Upper Tumalo Creek Watershed Unit (WU). The Upper Tumalo Creek WU is listed on Oregon Department of Environmental Quality's (DEQ) 303(d) list of impaired water bodies for water temperature. The Lower Tumalo Creek WU is listed on DEQ's 303(d) list of impaired water bodies for temperature and flow modification. Crater Creek and Little Crater Creek are not 303(d) listed and do not provide habitat for listed fish.

Exhibit 2-19. Listed Native Fish Species Occurring in Bridge and Tumalo Creeks[1]

Species	Evolutionarily Significant Unit (ESU)	Federal Listing	State Listing
Inland Columbia Redband Trout (*Oncorhynchus mykiss gairdneri*)	Range-wide	N/A	Sensitive – Vulnerable

Notes
[1] Native fish species occurring in Bridge and Tumalo Creeks listed as Sensitive, Threatened, or Endangered under the Oregon or Federal Endangered Species Acts.

2.10.5 Assessment of Water Supply

OAR 690-086-0140(3)

As previously described, the City's water supply is provided by its surface water and groundwater rights. The City holds water rights authorizing use of up to approximately 68.2 cfs (44.1 mgd) of groundwater from the Deschutes Regional Aquifer, and the City's surface water supply from the BMW is currently limited to 18.2 cfs (11.8 mgd) based on the City's SUP. The City's existing water right capacity is sufficient to meet its current peak water demand. The City's surface water supply may be further limited by stream flow, the requirement to share water supply with water users of similar priority date, surface water quality events, and system capacity.

1. Surface Water

Flows in Tumalo Creek are influenced by snow melt. Flows typically peak during May and June and are lowest during September. According to OWRD's Water Availability Reporting System (WARS), the 80 percent exceedance of the natural stream flow in Tumalo Creek is 51.8 cfs in September. In recent dry years, the calculated 7-day rolling average flow has occasionally dropped below 50 cfs.

The amount of water available to satisfy the City's surface water rights is a function of water right priority date (seniority) and stream flow, as further described below. **Exhibit 2-20** shows the maximum rate of Tumalo Creek water rights by priority date for the Tumalo Creek water right holders (which share several priority dates) during the month of July.

Exhibit 2-20. Maximum Rate of Tumalo Creek Natural Flow Water Rights (cfs)

Priority Date	City of Bend	Tumalo Irrigation District (TID)	State of Oregon Instream Water Right (measured at gage USGS 14073520)
Unrestricted	6.00		
8/5/1900	2.00	5.02	0.81
9/1900	7.43	35.19	11.47
4/28/1905	0.19	3.71	0.60
5/27/1907		0.52	0.08
6/1/1907	1.51	12.22	1.96
10/29/1913[1]	5.99	136.00	
12/8/1961		Tumalo Reservoir Storage	7.80
12/12/1983	15.00		
10/11/1990[2]			32.00
Maximum Diversion[3]	36.11	183.42	32.00

Notes

[1] The maximum authorized rate under the City's 1913 water right is limited to no more than 5.99 cfs in combination with the 1900 and 1907 water rights included in Transfer B-112. TID's 1913 water right, together with the amount secured under other water rights for the same lands, is limited to no more than 1/32.4 cfs per acre at the point of diversion. Exhibit 2-20 shows the maximum rate allowed under each priority, regardless of joint limitation.

[2] Instream water rights with priorities senior to 1990 are designated to replace a portion of the 1990 instream water right created pursuant to ORS 537.341.

[3] The maximum rate for each entity takes into account all joint limitations on each users' water rights.

Most of the City's surface water rights were originally irrigation water rights that the City acquired for municipal purposes. As a result, these rights continue to have a seasonal limitation and an annual volume limitation. The City's surface water rights authorize the use of up to 36.1 cfs during the irrigation season and 21.0 cfs during the remainder of the year. During the irrigation season, several of the City's water rights share priority dates with other irrigation water rights held by TID and instream water rights held by the State of Oregon created through Allocations of Conserved Water from TID's canal piping efforts. In practice, the required instream water right downstream of TID's Tumalo Feed Canal diversion—which varies depending on the total flow of Tumalo Creek—is met or exceeded throughout the irrigation season. Over the course of the 214-day irrigation season in 2019, with approximately 5 cfs of TID instream leases, the instream flow at USGS gage 14073520 below TID's diversion did not drop below 18.4 cfs, which is well in excess of the flow required by the leases and instream water rights. As a result, there was no need to "distribute water" in 2019 to ensure the instream water right was being satisfied.

The City's previous WMCP included a discussion of the vulnerability of the City's surface water supply to high-turbidity events during periods of high runoff or forest fires. The City's WFF, completed in 2016, employs membrane filtration, removing silt and other particles that cause turbidity from water diverted at the Bridge Creek intake, limiting supply interruptions during periods of high turbidity. The City is also evaluating the potential for a pre-sedimentation basin to further reduce the impact of high-turbidity events on the WFF.

In summary, the City's surface water rights have been reliable up to the maximum rate of 18.2 cfs authorized by the USFS SUP (BEN 1158) in recent years. There has been no need for water distribution among the water right holders on Tumalo Creek; the established instream water rights below TID's Tumalo Feed Canal have consistently been met or exceeded. Despite this recent streamflow reliability, in 2018 and 2019, the WFF was temporarily unavailable, due to planned and unplanned maintenance and lightning strikes. As the City continues to learn more about potential risks to the uninterrupted operation of the WFF, it will be possible to identify and mitigate events that compromise the reliability of the surface water system. For the purposes of this WMCP and the City's IWSMP, the City assumed a conservative firm yield of 6,600 gpm (14.7 cfs) from the surface water system, which is the yield that is achievable with one of the WFF's current filter racks offline.

2. Groundwater

As described above, the City holds nine water right certificates and three permits for the use of groundwater.

The City's wells develop the Deschutes Regional Aquifer, located in the Deschutes Formation. The permeable geology underlying the Deschutes Basin, combined with the large annual precipitation in the Cascade Range, results in a large aquifer system that is highly productive. The Deschutes Formation consists of a variety of highly permeable volcanic and sedimentary deposits that are between 4 million years old to 7.5 million years old. The Deschutes Formation is up to 2,000 feet thick in places. Groundwater flows from the recharge areas in the Cascade Range and Newberry Volcano towards the discharge area near the confluence of the Deschutes, Crooked, and Metolius Rivers. The aquifer is highly transmissive and supports most of the region's water supply wells, with some that can produce more than 2,000 gpm. The aquifer developed by the City's wells appears to be a reliable and sustainable source of supply.

Certificates 85414 and 85559 and Permit G-11379 have static water level conditions that may reduce the water available under the water rights if a well listed on the right displays a total static water level decline of 25 feet or more over any period of years. At the basin scale, fluctuations in the groundwater levels generally follow climate cycles, with periods of high groundwater levels generally corresponding to high precipitation and lower water levels corresponding to low precipitation. This effect dampens going eastward and away from the recharge area. Additionally, it is possible that any extension of time for the 1.49 cfs portion of Permit G-11379 not developed prior to 2005 will include fish persistence conditions that limit the City's access to water under the extended permit.

The City's groundwater permits, G-18123 and G-18124, require mitigation under the Deschutes Basin Groundwater Mitigation Program. The need to mitigate for the use of water under these permits limits their reliability to some extent. The administrative rules implementing the Mitigation Program are

scheduled to expire on January 2, 2029, but may be extended.[3] The City will be able to maintain the mitigation established before that date, but it is unclear how, or if, mitigation can be established if the administrative rules are not extended beyond 2029. Permits G-18123 and G-18124 both have development deadlines of April 26, 2027. Regardless of the timeline for the City to develop the full rate of Permits G-18123 and G-18124, the City can only make proof on (certificate) the water rights with a volume equal to the volume for which mitigation credits have been provided, which may require the City to seek extensions of time to complete development of the permits. The availability of mitigation credits is also a limiting factor in the reliability of water supply under Permits G-18123 and G-18124. In general, the mitigation credits assigned to Permits G-18123 and G-18124 were created through instream transfer of existing surface water rights in the name of irrigation districts. It is unclear to what extent mitigation credits will continue to be made available from this source. However, as detailed in Section 5 of this WMCP the City's demand projections indicate that the City may need to apply for a new groundwater right within the next 10 years.

2.11 System Description

OAR 690-086-0140(8)

The City operates a public drinking water system (Public Water System Identification Number 4100100) that supplies water to its customers from both surface and groundwater sources. **Exhibit 2-25** provides a schematic of the City's existing distribution system. **Exhibit 2-26** provides a map of the City's existing surface water diversion and conveyance system in the Tumalo Creek watershed. The surface water supply originates from Tumalo Creek and Bridge Creek, approximately 11.5 miles west of the City at the Heidi Lansdowne Intake Facility. Tumalo Creek water is conveyed through two parallel transfer pipes to a canal flowing to Bridge Creek. The water is diverted at the Intake Facility and raw water is conveyed approximately 10 miles via a pipeline to the City's Outback Facility. After treatment at the WFF and disinfection at the Outback Facility with the addition of chlorine, the water flows through the chlorine contact basin and Outback Reservoir 1 and Reservoir 2. Two finished water transmission pipes transmit water from the Outback Facility to the City's distribution system. The groundwater supply originates from 20 active wells associated with water rights.

The City's distribution system comprises nearly 450 miles of pipe, 15 storage reservoirs, and 6 pump stations, as well as associated appurtenances such as control valves, pressure-reducing valves, isolation valves, meters, and fire hydrants. The system has six primary pressure zones serving customers ranging in elevation from approximately 3,530 feet to 4,170 feet above mean sea level. Summary information for the wells, reservoirs, pipelines, and pump stations is presented in **Exhibits 2-21, 2-22, 2-23,** and **2-24**, respectively.

[3] ORS 537.746 directs the Water Resources Commission to repeal the rules for the Deschutes Basin ground water study area effective September 27, 2002, on January 2, 2029.

Exhibit 2-21. Summary of Pipeline Sizes

Diameter (inches)	Miles
1 to 6	63.8
8	208.8
10 to 14	118.6
16 to 18	38.5
24 to 36	9.7
Total	**439.3**

Exhibit 2-22. Summary of Reservoirs

Reservoir	Volume (MG)	Material
Awbrey Reservoir	5.00	Concrete
College Reservoir #1 (South)	0.5	Steel
College Reservoir #2 (North)	1.0	Steel
Contact Basin Reservoir (Outback Facility)	1.5	Steel
Outback Reservoir #1	2.0	Steel
Outback Reservoir #2	3.0	Steel
Outback Reservoir #3	3.6	Steel
Overturf Reservoir East	1.5	Steel
Overturf Reservoir West	1.5	Steel
Pilot Butte Reservoir #1	1.5	Steel
Pilot Butte Reservoir #2	1.0	Steel
Pilot Butte Reservoir #3	5.0	Concrete
Rock Bluff Reservoir #1	1.5	Steel
Tower Rock Reservoir	1.0	Steel
Westwood Reservoir	0.5	Steel

Exhibit 2-23. Summary of Existing Wells Associated with Water Rights for Bend's Municipal System

Well	Flow
Bear Creek Well 1	1050
Bear Creek Well 2	1100
Bear Creek Well 3	Not Yet Constructed
Bear Creek Well 4	Not Yet Constructed
Bear Creek Well 5	Not Yet Constructed
Copperstone Well	950
Outback Well 1	800
Outback Well 2	950
Outback Well 3	1050
Outback Well 4	1150
Outback Well 5	1050
Outback Well 6	1100
Outback Well 7	1300
Pilot Butte Well 1	750
Pilot Butte Well 2	Not Operational
Pilot Butte Well 3	900
Pilot Butte Well 4	1150
Pilot Butte Well 5	Not Yet Constructed
River Well 1	1800
River Well 2	1900
Rock Bluff Well 1	750
Rock Bluff Well 2	800
Rock Bluff Well 3	800
Shiloh Well 3	1200
Westwood Well	700
Airport Well 2*	240

* Although Airport Well 2 is included in Certificate 85414 and in this exhibit, it is now used exclusively for fire-flow events only as a backup to the wholesale water supply from Avion. The well does not provide water to the City's municipal water system.

Exhibit 2-24. Summary of Existing Pump Stations

Pump Station	Flow[1] (gpm)	Total Capacity	Firm Capacity[2]
Awbrey Pump 1	1,200	3,600	2,400
Awbrey Pump 2	1,200		
Awbrey Pump 3	1,200		
College Pump 1	1,100	2,200	1,100
College Pump 2	1,100		
Murphy Road Pump 1	300	1,500	1,200
Murphy Road Pump 2	300		
Murphy Road Pump 3	300		
Murphy Road Pump 4	300		
Murphy Road Pump 5	300		
Scott Street Booster Pump 1	1,000	3,000	2,000
Scott Street Booster Pump 2	1,000		
Scott Street Booster Pump 3	1,000		
Tetherow Pump 1	120	3,220	2,520
Tetherow Pump 2	300		
Tetherow Pump 3	700		
Tetherow Pump 4	700		
Tetherow Pump 5	700		
Tetherow Pump 6	700		
Westwood Pump 1	275	2,275	1,375
Westwood Pump 2	550		
Westwood Pump 3	900		
Westwood Pump 4	550		

Notes

[1] Flow rates indicate typical flow rates based on available SCADA data and model results if available; otherwise they are based on pump curves which may or may not be accurate.

[2] Firm capacity is defined as the total installed capacity remaining with the largest pump at a facility out of service.

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Exhibit 2-25. City of Bend Water System Schematic

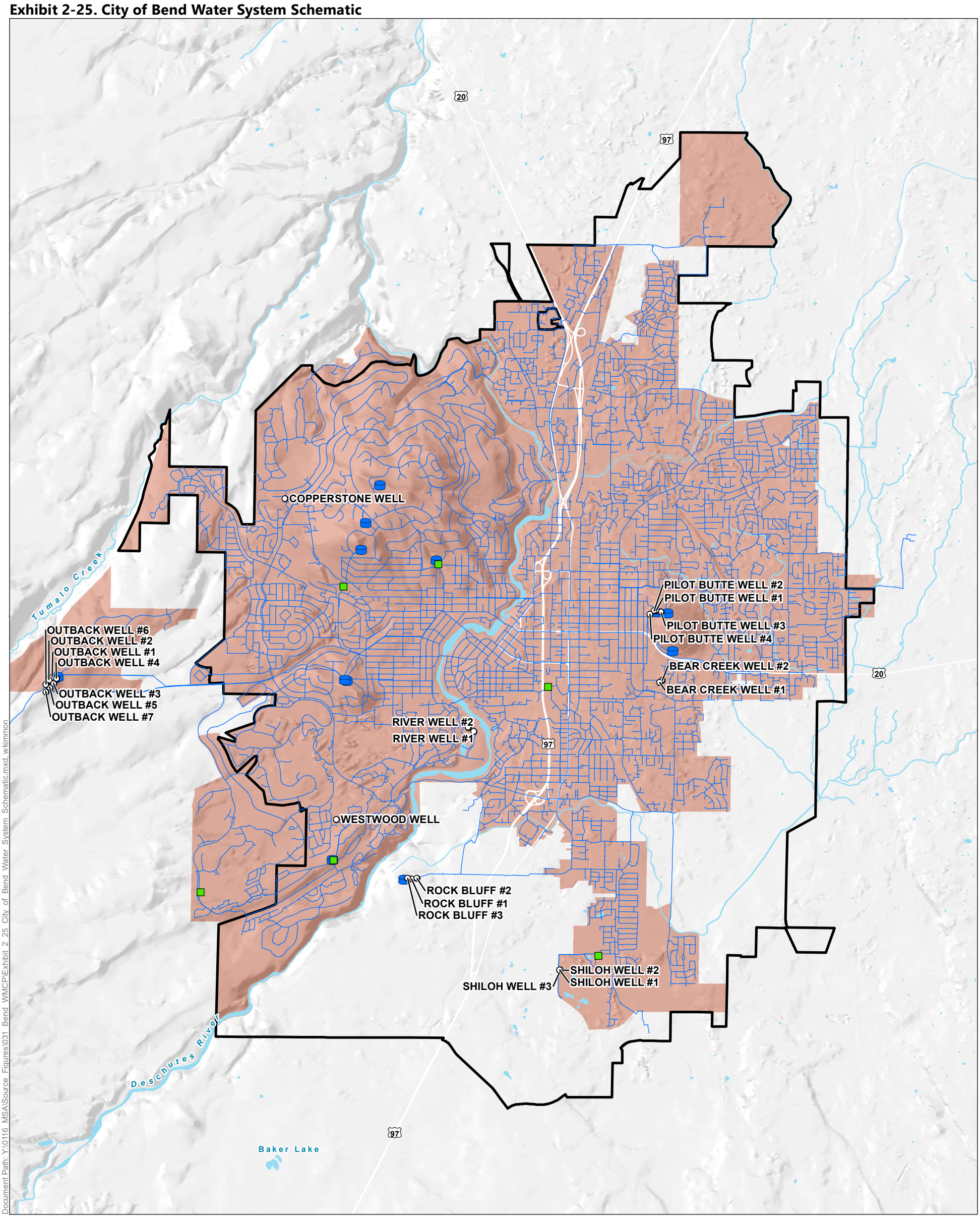

Exhibit 2-26. Bend Municipal Watershed and Bridge Creek Intake

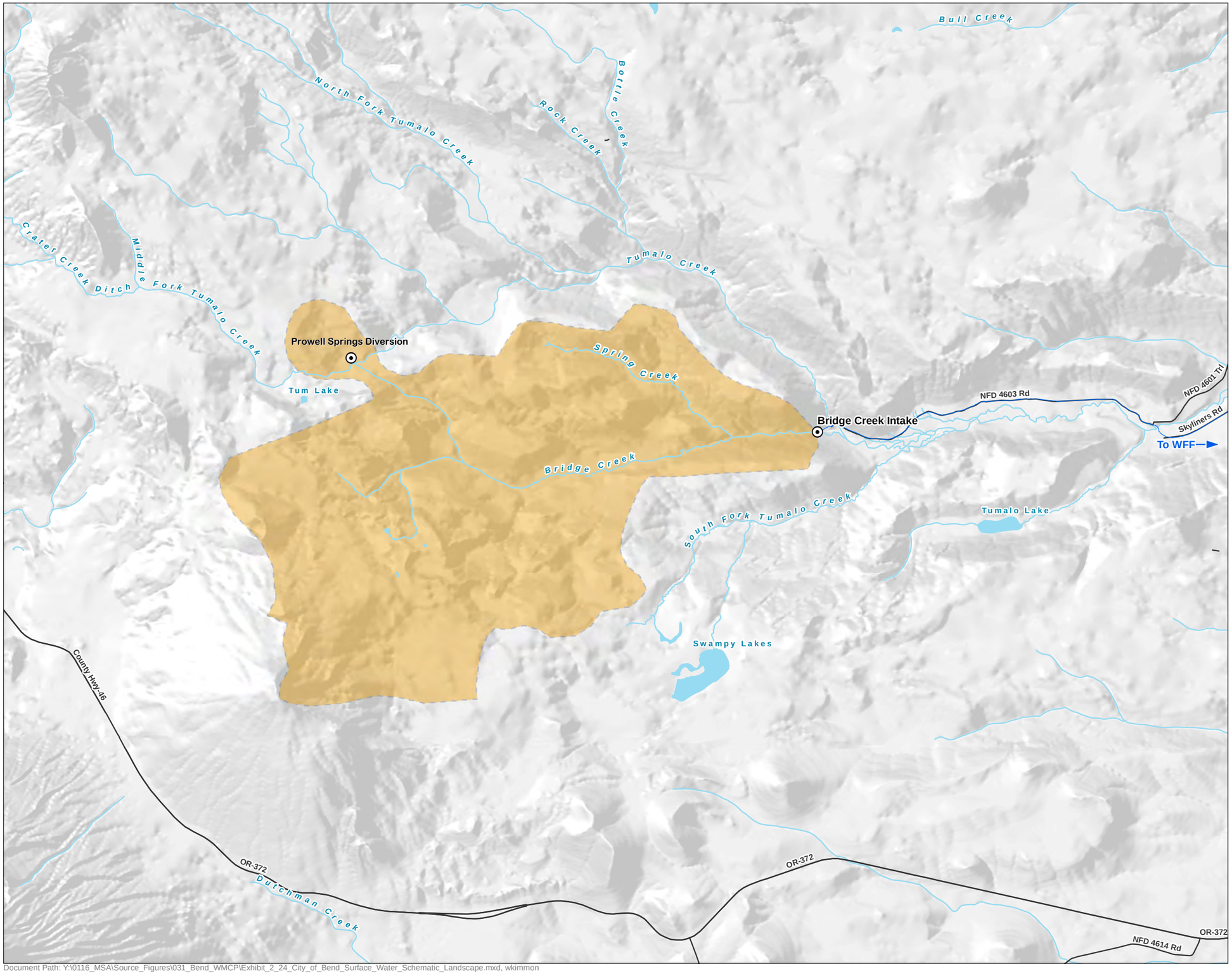

EXHIBIT 2-26
City of Bend
Bend Municipal Watershed

2021 Water Management and Conservation Plan

LEGEND

- POD
- City of Bend Municipal Watershed
- Pipe
- Major Road
- Watercourse
- Waterbody

Note: Land ownership is not shown, but nearly all lands shown within the extent of the map are within the Deschutes National Forest.

N

0 2,000 4,000
Feet

Date: October 28, 2020
Data Sources: City of Bend, OSIP

GSI Water Solutions, Inc.

Document Path: Y:\0116_MSA\Source_Figures\031_Bend_WMCP\Exhibit_2_24_City_of_Bend_Surface_Water_Schematic_Landscape.mxd, wkimmon

3. Water Conservation Element

This section addresses the requirements of OAR 690-086-0150(1) – (6). This rule requires a description of specific required conservation measures and benchmarks, and additional conservation measures implemented by the City.

3.1 Progress Report

OAR 690-086-0150(1)

OAR 690-086-0150(1) requires the water conservation element of a municipal WMCP to include a progress report on the conservation measures that were scheduled for implementation in the prior WMCP. The City previously submitted WMCPs to OWRD in 1998, 2004, and 2011, with the most recent WMCP approved by OWRD in a final order dated June 30, 2011. In addition, the City submitted a required WMCP Five-Year Progress Report to OWRD in June 2016, and OWRD issued a letter on August 12, 2016 stating that its review found no deficiencies. **Exhibit 3-1** shows (1) the required and additional conservation measures required by OAR 690-086-0150(4)-(5) that were included in the approved 2011 WMCP,[4] (2) the City's five-year water conservation benchmarks established for each conservation measure in the approved 2011 WMCP, and (3) the City's current status of each water conservation benchmark. Please note that benchmarks marked as "IMPLEMENTED" may also be associated with continuing programs that have been successfully implemented, but are continuing.

[4] OWRD updated some rules in December 2018, which are reflected in the exhibit.

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Exhibit 3-1. Conservation Measures and Benchmarks

Sub-section Requirement	2011 Benchmark	2020 Progress Summary
OAR 690-086-150 (4) A description of the specific activities, along with a schedule that establishes five-year benchmarks, for implementation of each of the following conservation measures that are required of all municipal water suppliers:		
(a) An annual water audit that includes a systematic and documented methodology for estimating any un-metered authorized and unauthorized uses	Develop and implement an annual Water Audit Program within the next 5 years; as part of this effort, develop a method to calculate and track unbilled authorized consumption, which may include development of additional measurement methodology, to more accurately determine revenue and non-revenue water.	**IMPLEMENTED[1].** The City successfully developed and implemented an annual Water Audit Program in 2013. Since then, annual water audits utilizing the AWWA M36 reporting methodology have been conducted. In 2015, the City hired an external water loss control expert to perform a third-party validation of the 2015 M36 Water Audit results consistent with Water Research Foundation parameters for third-party reviews. The City formed a Water Loss Control Team in 2016 to review, evaluate, and implement recommendations from annual M36 Water Audits. Authorized unbilled water use for flushing, water quality testing, and reservoir cleaning and draining are tracked. The City's water loss in 2019 was 5.7 percent and averaged 4.7 percent from 2014 through 2019 according to the M36 Water Audit.
	Reorganize and update customer classes and service codes, as well as work towards equipping all water meters with automated metering infrastructure (AMI) meters.	**IMPLEMENTED.** AMI technology was completely implemented by 2013. Staff continue to manage the City's AMI infrastructure and customer water use data. Customer classes and service codes were last updated in 2015 through the latest rate modernization effort and included the addition of a multi-family customer class (MF).
(b) If the system is not fully metered, a program to install meters on all un-metered water service connections.	Continue to install meters at all new service connections.	**IMPLEMENTED.** All new water services are equipped with water meters and fully AMI.
(c) A Meter Testing and Maintenance Program	Continue to replace all existing meters with the new AMI standard within the next 5 years.	**IMPLEMENTED.** AMI implementation completed in 2013. All new water service meters are fully AMI.
	Use improved technology when upgrading or replacing existing source meters during the next 5 years.	**IMPLEMENTED.** All new production water meters are mag meter type with the highest metering accuracy rate available. Five older model production meters were replaced in 2015.
(d) A rate structure under which customers' bills are based, at least in part, on the quantity of water metered at the service connections	Continue to bill customers based, in part, on the quantity of water metered.	**IMPLEMENTED.** All customers are billed based on quantity of water consumed.
	Reduce the base quantity allowance from 4 CCF to zero CCF within the next 5 years.	**IMPLEMENTED.** The City eliminated the base quantity allowance (4 ccf) in 2015 with its rate modernization effort.
(e) If the annual water audit indicates that system leakage exceeds 10 percent, a regularly scheduled and systematic program to detect leaks in the transmission and distribution system using methods and technology appropriate to the size and capabilities of the municipal water supplier;	Continue to conduct leak detection surveys to monitor changes in pipe integrity over time.	**IMPLEMENTED.** Leak detection is not required of the City since leakage is well below the 10 percent threshold. However, staff conduct supply side leak detection annually as part of its commitment to reducing non-revenue water and system leakage.
	Continue to monitor customer consumption records for evidence of leaks and to work cooperatively with customers when leaks are discovered.	**IMPLEMENTED.** Customer water use is monitored by utility and billing staff. Notifications of constant consumption are made to the customer. Beginning in 2017, The City's customer engagement software was implemented as a new means of constant consumption notification and customer communication.
	Install AMI data technology at all of its meters, which will record hourly consumption and radio transmit that information to the City. This "real-time" information will help the City find and address leaks in the system on the customer side of the meter.	**IMPLEMENTED.** AMI implementation completed in 2013.

Sub-section Requirement	2011 Benchmark	2020 Progress Summary
(f) A public education program to encourage efficient water use and the use of low water use landscaping that includes regular communication of the supplier's water conservation activities and schedule to customers	Continue to provide water efficiency and conservation outreach information to the public using print materials, radio, and video.	**IMPLEMENTED.** The City continues to offer customers a wide variety of educational information through such means as a conservation website (waterwisetips.org), a three-part series of WaterWise Guides, public workshops on low-water landscape methods, and regular news/media releases emphasizing the importance of reducing water waste and using water efficiently.
	Continue to update the website and outreach materials as needed.	**IMPLEMENTED.** Regular updates to the City's Utility Department and water conservation websites are made by Utility Department staff. The City's website underwent a complete redesign in 2016 to update graphics and improve navigation.
	Explore the potential for development of cost-share partnerships between the City's three water utilities: water, stormwater, and wastewater. The water and stormwater utilities have the potential to jointly hire an employee that can serve both programs.	**IMPLEMENTED.** The Utility Program Compliance Specialist job description was created in 2015 to address dual program needs for enforcing stormwater and water use regulations, and that position was filled soon thereafter. In 2017, the City added a 0.5 FTE Utility Program Compliance Specialist to the Water Conservation Program.
OAR 690-086-150 (5) If the Municipal Water Supplier serves a population greater than 1,000 and proposes to expand or initiate diversion of water under an Extended Permit for which resource issues have been identified under OAR 690-086-0140(5)(i), or if the Municipal Water Supplier serves a population greater than 7,500, a description of the specific activities, along with a schedule that establishes five-year Benchmarks, for implementation of each of the following measures; or documentation showing that implementation of the measures is neither feasible nor appropriate for ensuring the efficient use of water and the prevention of waste		
(a) A system-wide leak repair or line replacement program to reduce system leakage to 15 percent and if the reduction of system leakage to 15 percent is found to be feasible and appropriate, to reduce system leakage to 10 percent	As stated in Leak Detection and Repair under OAR 690-086-0150(4), continue to conduct leak detection surveys to monitor changes in pipe integrity over time.	**IMPLEMENTED.** System leakage is below 15 percent (water loss was 5.7 percent in 2019). However, City staff continue to conduct leak detection surveys.
	Continue to monitor customer consumption records for evidence of leaks.	**IMPLEMENTED.** System leakage is below 15 percent (Water loss was 5.7 percent in 2019). However, City staff continue to monitor customer consumption records for evidence of leaks using AMI.
(b) Technical and financial assistance programs to encourage and aid residential, commercial, and industrial customers in implementation of conservation measures;	Continue efforts to develop and maintain WaterWise partnerships with large use customers during the next 5 years.	**IMPLEMENTED.** The Large Landscape Program pairs water conservation staff with owners of large landscapes to manage irrigation efficiently. The science-based program is data driven and utilizes a combination of AgriMet weather data, GIS spatial data, hourly AMI water use data, and the latest water budget calculation best management practices. Under the Large Landscape Program, the City has partnered with such entities as: Bend Metro Parks and Recreation District, Bend-La Pine Schools, Housing Works, Shevlin Center Owners Association, and Oregon State Parks: Pilot Butte State Park.
	Continue to distribute toilet tank leak detection dye tablets, shower timers, and related items to customers during the next 5 years.	**IMPLEMENTED.** These are available year round at various City events, the WaterWise Kiosk in City Hall, and at Utility Department offices. Staff also distribute approximately 300 indoor water conservation kits annually.
	Conduct cost analysis aimed at the creation of cost-effective rebate programs within the next 5 years.	**IMPLEMENTED.** Staff utilized the Alliance for Water Efficiency (AWE) Tracking Tool to evaluate the cost-effectiveness of various conservation measures until recently. In 2019 through 2020, the City conducted a Water Conservation Program Water Savings and Cost-effectiveness Analysis, which analyzed several rebate programs. This effort is detailed in Sections 3.3 and 3.5.2.
	Develop a pilot program for creation of water budgets for targeted customer groups, based on evapotranspiration data.	**IMPLEMENTED.** Water budgets continue to be a key landscape water efficiency performance indicator. Water budgets are now calculated for all customers participating in the Sprinkler Inspection Program (described in Section 3.5.1) and the Large Landscape Program to identify the greatest conservation potential.

Sub-section Requirement	2011 Benchmark	2020 Progress Summary
	Continue to fund and promote the use by all customers of the AgriMet weather station and its website, including a pilot project to place real time evapotranspiration data on the City website for use in creation of outdoor water use budgets.	**IMPLEMENTED.** The AgriMet Bend weather station continues to be funded in part by the City of Bend. Due to software incompatibilities, the City was unable to auto-populate its water conservation website with ET data from AgriMet. However, the website link is not necessary given that the AgriMet weather station is still able to supply real-time weather data to signal-based irrigation controllers.
(c) Supplier financed retrofitting or replacement of existing inefficient water using fixtures, including distribution of residential conservation kits and rebates for customer investments in water conservation;	Continue to pursue greater irrigation efficiency of its existing City-owned landscapes and all new landscapes so they will meet the latest Engineering Standards and Specifications, which includes the use of smart irrigation controller technology, xeriscaping principles, and other sustainable landscape practices.	**IMPLEMENTED.** The City's Engineering Standards and Specifications were revised to improve irrigation efficiency in City-owned landscape projects going forward. This standard promotes an increased level of water efficiency in the landscape based on national standards for using smart irrigation technology and drip irrigation where possible and limiting the use of lawn and overhead irrigation to functional areas. Site improvements were also made to over 15 Utility Department facilities including new landscaping, new irrigation systems, and new irrigation controllers with remote access capabilities.
	Study the cost effectiveness of implementing a toilet rebate replacement or incentive program based on the new voluntary federal HET standard.	**IMPLEMENTED.** Within the past 10 years, staff evaluated a High-Efficiency Toilet (HET) rebate program with the AWE Water Conservation Tracking Tool. Initial findings showed that the rebate was not a cost-effective conservation measure based on the Tracking Tool inputs. However, the City's 2020 Water Conservation Program Water Savings and Cost-effectiveness Analysis (detailed in Section 3.3) indicated that a toilet rebate was cost-effective.
	Become an EPA WaterSense Program partner and make related information available through its web links, bill stuffers, and other methods.	**IMPLEMENTED.** The City is now an EPA WaterSense Partner, member of Alliance for Water Efficiency, Irrigation Association, and Oregon Landscape Contractors Association.
	Provide a list of qualifying toilets that meet the various flush standards along with the creation of a toilet efficiency fact sheet.	**IMPLEMENTED.** A link to EPA WaterSense approved devices is located on the City's water conservation website.
(d) Adoption of rate structures, billing schedules, and other associated programs that support and encourage water conservation;	As stated in Unit-based Billing Program under OAR 690-086-0150(4), continue to bill customers based, in part, on the quantity of water metered.	**IMPLEMENTED.** A new rate structure went into effect on July 1, 2015. This eliminated the remaining 4 ccf monthly allowance and based sewer charges on winter quarter average water use.
	Reduce the base quantity allowance from 4 CCF to zero CCF within the next 5 years.	**IMPLEMENTED.** A new rate structure went into effect on July 1, 2015. This eliminated the remaining 4 ccf monthly allowance and based sewer charges on winter quarter average water use.
	Continue to send monthly bills and to provide water efficiency and conservation information to the public with periodic bill stuffers and electronic messaging with related conservation information and links to the City's conservation website.	**IMPLEMENTED.** A variety of public education and communication tools are utilized by water conservation staff including monthly utility bill newsletters, social media, City website, press releases, attending public events, and more.
(e) Water reuse, recycling, and non-potable water opportunities; and	During the next 5 years, continue to look for opportunities to increase the use of recycled water.	**IMPLEMENTED.** The City currently sends approximately one-half of its recycled water to an area golf course. The other one-half is placed in recharge ponds that help recharge the Deschutes Basin Aquifer.
(f) Any other conservation measures identified by the water supplier that would improve water use efficiency.	Within the next 5 years, evaluate adoption of modified irrigation restrictions based on time of day (hours that promote efficient water use).	**IMPLEMENTED.** Approved irrigation hours and days have been incorporated into the Bend Code. These may be revised based on information resulting from the City's IWSMP, which is currently under development.

Sub-section Requirement	2011 Benchmark	2020 Progress Summary
	Continue to implement current landscape standards through related approval processes during the next 5 years.	**IMPLEMENTED.** New City-owned and public landscapes will follow the Engineering Standards and Specifications. This document outlines standards that contractors and City staff must follow regarding landscape and irrigation work. Private development projects follow Bend Development Code, which is currently under review.
	Continue to seek appropriate partnership opportunities based on current project priorities, budget, and staff time.	**IMPLEMENTED.** Staff continue to seek new partnerships to advance water conservation efforts in the community. This includes partnership with large customers such as the local school district, local parks district, state parks, churches, and homeowners' associations. Staff also seek public education partnerships with Oregon State University Extension Service, Central Oregon Community College, Central Oregon Builders Association, and more.
	Continue to look for coordination opportunities to more efficiently communicate and implement related programs.	**IMPLEMENTED.** The Water Conservation Program manager oversees the coordination of water efficiency efforts throughout the City. Staff regularly seek input on how to best deliver services in the most cost-effective manner.
	Continue to implement the Hydrant Meter Program and related fill station.	**IMPLEMENTED.** The Hydrant Meter Program continues to be instrumental in reducing non-revenue water. A total inventory of 94 AMI hydrant meters was recorded as of 2018. Each includes an AMI transmitting unit to ensure all hydrant water usage is tracked for billing and water auditing purposes.
	During the next 5 years, work with the City Council and the City's Engineering Department to develop capital improvement and conservation budgets to identify which conservation measures to fund and implement.	**IMPLEMENTED.** Within the past 10 years, staff evaluated the cost-effectiveness of water conservation measures with the AWE Water Conservation Tracking Tool. However, the City recently analyzed water conservation measures in greater detail through its 2020 Water Conservation Program Water Savings and Cost-effectiveness Analysis (detailed in Section 3.3) as part of its IWSMP process to identify cost-effective water conservation measures to fund and implement over the next 20 years.

Notes

[1] Please note that benchmarks marked as "IMPLEMENTED" may also be associated with continuing programs that have been successfully implemented, but are continuing.

AMI = advanced metering infrastructure
AWWA = American Water Works Association
ccf = 100 cubic feet
ET = evapotranspiration
EPA = U.S. Environmental Protection Agency
FTE = full-time equivalent
GIS = geographic information system
HET = high-efficiency toilet
OAR = Oregon Administrative Rule

3.2 Use and Reporting Program

OAR 690-086-0150(2)

The City's Water Measurement and Reporting Program complies with the measurement and reporting standards in OAR Chapter 690, Division 85.

The City currently measures surface water entering the distribution system at the Heidi Lansdowne Intake Facility using a mag meter. The City's AMI infrastructure enables the City to record surface water diversion hourly. The City measures groundwater entering the distribution system wellheads using mag meters with AMI and the SCADA system and records groundwater use continuously.

Each year, the City submits monthly water use measurements to OWRD for the previous water year (October 1 to September 30). The City's water use records can be found here: https://apps.wrd.state.or.us/apps/wr/wateruse_query/

3.3 Other Current Water Conservation Measures

OAR 690-086-0150(3)

The City implements numerous water conservation measures, which are described in the progress report in Section 3.1 as well as in Sections 3.4 through 3.6. The following section provides detail on individual conservation measures evaluated as part of the Water Savings and Cost-effectiveness Analysis, described in greater detail in a report in **Appendix C.**

- Sprinkler Inspection Program for single family customers
- Water Waste Prevention Program
- Large Landscape Program
- Meter Testing and Maintenance Program now utilizes AMI
- Customer Leak Detection Program
- Utility bill newsletters
- Educator resources about water conservation
- Water Conservation Program Water Savings and Cost-effectiveness Analysis in 2020 (see below)

2020 Water Conservation Program Water Savings and Cost-effectiveness Analysis

As part of the effort to update the City's IWSMP and WMCP, in 2020 the City conducted a Water Conservation Program Water Savings and Cost-effectiveness Analysis using the Maddaus Water Management, Inc., Decision Support System (DSS) Model. The City used the DSS model to evaluate different water conservation programs consisting of conservation measures that can be pursued over the next 20 years; dependent upon City Council concurrence and funding in future City budgets.

The DSS Model output and additional post-model analysis shows that the program preferred by City staff (Program C), consisting of a combination of indoor and outdoor conservation measures, could reduce MDD by 5.1 mgd (7.89 cfs) by 2040. The City conducted this analysis in coordination with development of an updated IWSMP and this WMCP update. The measures comprising the program consist of two existing measures (outdoor water surveys provided through the Sprinkler Inspection Program and indoor water conservation kits), new outdoor water conservation incentives, new indoor and outdoor water conservation ordinances, and the Water-efficient Toilet Rebate Program. The annual and maximum-day water savings, estimated cost of implementation, and estimated avoided infrastructure costs based on these water savings are summarized in **Exhibit 3-2.** The avoided infrastructure cost of approximately $21,000,000 is equal to the cost of constructing three new wells and one 4-MG reservoir (which would not need to be constructed if 5.1 mgd in water savings in a MDD scenario is realized). The impact of the estimated water savings is discussed in greater detail in Section 5.

Exhibit 3-2. Summary of Water Conservation Program Water Savings, Costs, and Avoided Infrastructure Costs

Maximum Day Water Savings in 2040 (mgd)	5.1
Total Water Savings (2020–2040) (MG)	7,939
Estimated Cost of Implementation through 2040	$ 11,071,052
Avoided Infrastructure Cost	$ 21,000,000

Notes
MG = million gallons
mgd = million gallons per day

Conservation measures in Program C are summarized in **Exhibit 3-3. Appendix C** includes the documentation for the City's analysis, including additional tables describing the Water Conservation Program, descriptions of approach, methods and assumptions, and estimated water savings and costs of implementing that program.

Exhibit 3-3. Water Savings and Cost-effectiveness Analysis Measures

Water Savings and Cost-effectiveness Analysis Measures Included	Water Savings and Cost-effectiveness Analysis Measure Summary Description
Retrofit on Resale	Require installation of WaterSense-approved fixtures in conjunction with any construction that requires a permit or in the course of resale of the property: lavatory faucets that flow at no more than 1.0 gpm (public restrooms are 0.5 gpm), kitchen faucets no more than 1.8 gpm, showerheads no more than 1.5 gpm, urinals no more than 0.125 gpf, and toilets no more than 1.28 gpf. Work with the real estate industry to require a certificate of compliance be submitted to the City that verifies that a qualified inspector has inspected the property and efficient fixtures were either already there or were installed before close of escrow.
High Efficiency Toilet Rebate	Provide customers a rebate for replacing a toilet that uses 1.6 gpf or more with an EPA WaterSense-approved Ultra-High Efficiency Toilet (UHET) that uses 1.28 gpf or less. For single family, multi-family, and commercial customers.
Free Faucet Aerators and Showerheads	Provide free water-efficient showerheads (1.5 gpm) and faucet aerators (1.5 gpm for bathrooms and kitchens) to single family, multi-family, and commercial customers by mail upon customer request or as a prize for signing up for WaterSmart. (This is an existing water conservation measure; these fixtures are distributed in the indoor water conservation kits.) *This is currently a WMCP measure with an associated benchmark.*
Indoor Plumbing Fixture Ordinance	Require developers to install the following WaterSense approved in new developments: lavatory faucets that flow at no more than 1.0 gpm (public restrooms are 0.5 gpm), kitchen faucets no more than 1.8 gpm, showerheads no more than 1.5 gpm, urinals no more than 0.125 gpf, and toilets no more than 1.28 gpf. Work with the real estate industry to require a certificate of compliance be submitted to the City that verifies that the property has been inspected and water-efficient fixtures were installed before close of escrow.
Landscape and Irrigation Ordinance	Develop and enforce Water Efficient Landscape Design Standards. Standards specify that new development projects and renovations of existing units subject to design review be landscaped according to water-efficient best management practices including, appropriate plant selection and placement, efficient irrigation systems, and smart irrigation controllers. The ordinance could require certification of landscape professionals.

Water Savings and Cost-effectiveness Analysis Measures Included	Water Savings and Cost-effectiveness Analysis Measure Summary Description
Outdoor Water Surveys	Provide free landscape water surveys to existing single family and multi-family residential customers upon request and to high water use single family and multi-family customers identified by the City. The City provides a customized report (a water budget generated using WaterSmart Software) to the customer on how to save water. Water budgets will be updated annually based on lots square footage and weather. No devices will be given away as part of this program. (This is an existing water conservation measure; these surveys are provided under the Sprinkler Inspection Program and the Large Landscape Program.) *This is currently a WMCP measure with an associated benchmark.*
Weather-based Irrigation Controller Rebate	Provide a rebate of $100 for the purchase of a WaterSense approved weather-based irrigation controller. These controllers have on-site weather sensors or rely on a signal from a central weather station that modifies irrigation times at least weekly.
Pressure Regulation Rebate	Provide a $100 rebate for the installation of an in line pressure regulator. This device is meant to regulate the incoming service pressure to the entire property affecting indoor and outdoor end uses, such as faucets, showers, clothes washers, and irrigation.
Drip Irrigation Kits	Offer free drip irrigation kits to single family residential customers.
Rotating Sprinkler Nozzles Rebate	Provide rebates to replace standard spray sprinkler nozzles with high-efficiency nozzles. Rebates will be $4 per nozzle up to a maximum purchase of 20 nozzles.
Pressure Regulating Sprinkler Bodies Rebate	Rebate customers $3 per pressure regulating sprinkler body Rainbird PRS/Hunter PR40 or similar to regulate pressure at the sprinkler head on individual irrigation zones.

Notes
EPA = U.S. Environmental Protection Agency
gpf = gallons per flush
gpm = gallons per minute
UHET = ultra-high-efficiency toilet

3.4 Required Conservation Measures

OAR 690-086-0150(4)(a-f)

3.4.1 Annual Water Audit

In 2013, the City began using the AWWA M36 Water Audit and Loss Control Program methodology to conduct annual water audits and has been refining its processes each year to improve its score, which reflects strengths of the water auditing accounting system. In 2015 and 2019, the City hired an external water loss control expert to perform a third-party validation of the M36 Water Audit results consistent with Water Research Foundation parameters for third-party reviews. The AWWA M36 Water Audit methodology provides the most up-to-date analysis of the City's water distribution system efficiency and accuracy. In addition to unmetered uses and real losses (e.g., system leakage, overflows, evaporation), the M36 Water Audit Methodology includes in its estimate of non-revenue water such factors as customer metering inaccuracies and systematic data handling errors.

Since 2016, the City has had in place a Water Loss Control Team that conducts annual water audits to review, evaluate, and implement recommendations from annual M36 Water Audits. The reporting worksheets and performance indicators for these water audits (from 2015 through 2019) are presented in **Appendix B**, and provide additional information about the source of water loss and estimates of avoidable loss. The City's water loss in 2019 was 5.7 percent and averaged 4.7 percent from 2014 through 2019 according to the M36 Water Audit, as shown in **Exhibit 2-16**. The M36 audit recommendations included addressing real losses from system leakage and improving some meter accuracy, so the City implemented a Supply Meter Testing Plan for Water Operations staff to implement into routine operations.

Five-Year Benchmarks

- The City will continue to conduct annual water audits utilizing the AWWA M36 Water Audit methodology.
- The City will consult with an external water loss control expert to perform a third-party validation of the M36 Water Audit results at least once in the next 5 years.
- The City will assess annual audit results as part of an evaluation of potential system and operational improvements.

3.4.2 System-wide Metering

The City's water system is fully metered and fully converted to AMI. The City completed conversion of its water system to AMI in 2013 and all new water service connections have AMI meters. The City's previous investments in AMI have allowed the City to leverage water use data.

The benefits the City has realized from AMI include the following:

- The collection of hourly water use data has enhanced the City's supply-side and customer-side leak-detection capabilities.
- Access to detailed customer water use data has improved the City's ability to target

conservation measures for individual customers and groups of customers.

- An improved understanding of customer water use patterns across different customer categories has enhanced the City's ability to project future water demands.

Five-Year Benchmarks

- The City will continue to install AMI meters on all new water connections.
- The City will investigate the feasibility of adding AMI meters to detects on fire flow connections, related fire systems, and bypass vaults.

3.4.3 Meter Testing and Maintenance

Production meters for the City's surface water and groundwater sources are nearly all mag meters accurate to within 0.5 percent. The production meters are connected to the City's SCADA system and are tested annually. Source meters are verified through draw down and fill exercises on reservoirs and validated by third-party consultants. Each year, the City tests production meters and all customer meters 3 inches and larger following AWWA's M36 Water Audit and Loss Control guidelines. The City is developing a program to expand annual meter testing to the City's 1.5- to 2-inch customer meters.

The City samples a percentage of customer meters 1 inch and smaller for annual testing. The City typically replaces small customer meters when they reach a metered volume of 300,000 cubic feet or 2,200,000 gallons, roughly corresponding to a 20-year lifespan. Recently, the City has begun installing electromagnetic meters on customer connections of 1 inch and smaller. The accuracy of electromagnetic meters is maintained through the 20-year guaranteed lifespan of the meter eliminating decline in meter accuracy over time. In 2019, the City contracted with a third party to verify the meter accuracy data recorded by City staff.

Five-Year Benchmarks

- The City will continue to develop a standardized production Meter Verification Program.
- The City will continue to test all customer meters 3 inches and larger annually.
- The City will develop a formal annual testing and Meter Replacement Program for 1.5-inch to 2-inch customer meters.
- The City will complete development of a Small Meter Testing and Replacement Program (3/4-inch and 1-inch meters) aligning with AWWA's M36 Water Audits and Loss Control Program standards. The program will allow gradual transition to use of new electromagnetic meters as adopted in City of Bend Standards and Specifications.[5]

[5] https://www.bendoregon.gov/government/departments/community-development/private-development-engineering-division/standards-and-specifications

3.4.4 Water Rate Structure

The City's rate structure is based, in part, on the quantity of water metered at each service connection. The City has a base rate, which is contingent on meter size. It also has a volumetric rate based on the volume of water consumed, which currently applies uniformly to all customer classes. This current rate structure has been in place since July 2015, replacing a 4 ccf (1 ccf = 100 cubic feet) monthly allowance that provided little financial incentive to conserve water. The new rate structure also was changed to calculate sewer charges based on the volume of potable water used indoors (and assumed to go to the sewer system). The proxy for determining indoor water use uses the summed average of all metered water use during December, January, and February, which is referred to as winter-quarter-average (WQA). The new sewer rate methodology provides an additional financial incentive to increase indoor water use efficiency. In addition, sewer rate calculations for multi-family customers changed to per-dwelling unit-based charges instead of the flat sewer rate that was previously in place, resulting in greater incentive to conserve water indoors for these facilities.

In late 2020, the City will complete an update to a new utility billing software that will make it more feasible for the City to implement a new rate structures in the future, if desired. In the coming years, the City plans to explore implementation of a new rate structure, such as tiered rates, water budget-based rates, or another approach aimed at reducing peak-season demand. The City reads customers' meters and bills customers monthly.

Exhibit 3-4 presents the City's current residential and non-residential water rates for customers inside and outside of city limits.

Exhibit 3-4. City of Bend Water Rates for Residential and Non-Residential Customers, as of July 1, 2020

	Inside City		Outside City	
Meter Size (inches)	**Base Rate**	**Usage Rate**	**Base Rate**	**Usage Rate**
3/4	$23.60	$1.96 / 100 cu ft	$35.41	$2.94 / 100 cu ft
1	$27.15		$40.72	
1 1/2	$35.93		$53.89	
2	$46.50		$69.75	
3	$74.74		$112.12	
4	$106.46		$159.71	
6	$194.57		$291.85	
8	$300.32		$450.49	
10	$423.75		$635.63	
12	$568.27		$852.41	

Note
cu ft = cubic foot

Five-Year Benchmarks

- The City will continue to bill customers based on the existing uniform rate structure, which charges customers based on the volume of water they consume.
- The City will complete implementation of an updated utility billing system, which will provide the administrative feasibility to change rate structures in the future.
- The City will continue to review existing customer categories and rate classes as part of the City's annual rate review process to promote efficiency and equity.

3.4.5 Water Loss Analysis

The City's water loss in 2019 was 5.7 percent and averaged 4.7 percent from 2014 through 2019, according to the AWWA M36 Water Audit. As described under Annual Water Audit in Section 3.4.1 above, the City conducts annual AWWA M36 Water Audits, which consist of the most up-to-date best management practices for conducting water audits.

OWRD requires the development and implementation of a Leak Detection Program when system water losses exceed 10 percent. The City's water losses are less than 10 percent, but the City has maintained its Distribution System Leak Detection Program since 2004. In 2018, the City surveyed more than 25 miles of water mains for hidden leaks and surveyed all water mains in streets scheduled to be paved in 2018 and 2019. The survey identified and then repaired 16 water main leaks that were estimated to be losing a total of 42 gpm. In 2017, a distribution system leak detection contractor surveyed approximately 25 miles of water mains and located three leaks that were estimated to be losing a total of 2.25 gpm. In 2016, a leak detection contractor surveyed approximately 19 miles of water mains and located 17 leaks that were estimated to be losing a total of 33 gpm.

Although customer leaks (leaks that occur on the downstream, customer side of the meter) are considered metered demand, ongoing customer leak detection is possible with the City's AMI metering infrastructure software to identify and notify customers of potential leaks downstream of the water meter. More than 13,000 leak alerts were sent to customers in 2019. This is known as the Customer Leak Notification Program.

The City has also correlated pipeline replacement with street maintenance activities to minimize redundant construction costs and loss of service. A majority of the City's delivery mains are ductile iron pipe. Replacements and new lines will continue to use ductile iron pipe, which has a greater lifespan and lower leak potential than galvanized steel pipe. In 2018 and 2019, City Staff surveyed 38 miles of water main. A total of 13 leaks were repaired in the distribution system, which accounted for an estimated 36 MG annually.

Five-Year Benchmarks

- The City will continue its efforts to minimize water loss by continuing the Distribution System Leak Detection Program and completing an annual Leak Detection Report as part of the City's M36 Water Audit Program.
- The City will evaluate the feasibility of developing a more formal pipe replacement program to identify and replace aging and failing pipe segments on an annual basis as outlined in the City's Capital Improvement Plans, to be adopted in late 2020 or early 2021.

3.4.6 Public Education

The City implements a comprehensive Public Education Program that promotes water conservation, which includes the following:

- **Website Content:** The City has web pages promoting indoor and outdoor water conservation at WaterWisetips.org. The site provides a comprehensive list of resources for customers on water use efficiency and current with seasonal events and program offerings. In addition, customers can report water waste, request free indoor conservation kits, and evaluate their water use through the City's customer engagement software.

- **WaterWise Guides:** The City created three WaterWise publications. The WaterWise Guides (Landscape, Irrigation, Streetscape) contain water efficiency, horticultural, and maintenance information specific to the Central Oregon landscape. The WaterWise Landscape Guide provides photos and information on how to plan, design, install, and maintain a beautiful Bend WaterWise landscape. The WaterWise Irrigation Guide covers irrigation design basics as well as technical tips for landscape professionals. The WaterWise Streetscape Guide focuses exclusively on street-side landscaping, offering example landscape plans, plant lists, and step-by-step instructions aimed to keep irrigation water from running off onto pavement. Guides are available at nearly 20 local garden centers, nurseries, libraries, at City facilities, and online on the City's WaterWise Program webpage.[6]

- **Annual Outdoor Water Conservation Campaign:** The City conducts an outdoor water conservation media campaign annually from April through October to coincide with peak seasonal water demands. The City plans to formalize the public outreach of seasonal water conservation messages under a Seasonal Advisory Alert messaging. Seasonal Advisory Alert messages are intended to heighten awareness regarding seasonal outdoor landscape and irrigation water use efficiency and to inform water customers of the potential for higher-than-normal water demands and/or the need to pay close attention to their irrigation consumption to help manage peak season water use. The WaterWise Program will issue Seasonal Advisory Alerts and may request that all water users strive for increased efficiency and or voluntary reductions in outdoor water use. The request may include a summary of the current water supply situation and the reasons for the requested reductions, including programmatic goals or incentives that may be available.

  In declaring a Seasonal Advisory Alert, the City may do the following:

  - Contact local media outlets and request that the public be informed about the need to use water efficiently during the peak season of April through October.
  - Create and post prepared public service announcements, including conservation tips, on the City's web page and social media outlets.
  - Provide customer notifications on water bills, through utility bill inserts, or through the

[6] https://www.bendoregon.gov/government/departments/utilities/conservation/waterwise-guides

City's customer engagement portal, potentially including reference to AMI data.

- **Conservation Connection Newsletter:** The WaterWise Program sends a quarterly newsletter to more than 150 local green industry contractors, irrigators, architects, and designers. The newsletter keeps the industry informed on local issues that affect the green industry with a focus on reducing outdoor water use.

Workshops and Events

- **WaterWise Garden at Hollinshead Park:** The City's WaterWise Program partnered with Oregon State University Extension Service, Central Oregon Master Gardeners Association, and Bend Parks and Recreation to develop a water conservation demonstration garden at Hollinshead Park. This historic park has served as an excellent location for multiple WaterWise workshops addressing topics such as drip irrigation and low-water landscape transformation.
- **WaterWise Workshops Professional Series:** The City proactively engages green industry contractors to provide continuing education opportunities and to support the State's landscape and irrigation contractor certification programs administered through the Oregon Landscape Contractors Board.
- **WaterWise Water Waste Prevention Program:** The City provides technical assistance to customers to help them reduce water waste, provides a one-page Water Use Analysis that identifies water and financial savings potential of reducing waste outdoors, and encourages customers to use its WaterSmart Software to track daily water use and receive water use notifications. The City also enables community members to report water waste through a "Report Waste" online form on the City's Water Waste Prevention Program web page.
- **Educator Resources:** The City offers educational materials for middle school students, classroom presentations accompanied by field trips to water facilities, and a lending library with free resources for educators. The City's website describes these resources, provides flyers and guides, and includes videos about the City's water facilities and the importance of working together to care for local water resources.
- **Additional Activities:** The City promotes water conservation through utility bill newsletters, press releases, social media, and public events.

Five-Year Benchmarks

- The City will continue to update its educational resources for customers and the landscape industry through the City's WaterWise website, workshops, and related educational outreach activities.
- Formalize seasonal public outreach efforts under the Seasonal Advisory Alert Program.

3.5 Additional Conservation Measures

OAR 690-086-0150(5)

OAR 690-086-0150(6) requires municipal water suppliers (1) that serve a population greater than 1,000 and propose to expand or initiate the diversion of water under an *extended permit* for which resource issues have been identified, or (2) if the population served is greater than 7,500, to provide a description of the specific activities, along with a five-year schedule to implement several additional conservation measures. The City serves a population of greater than 7,500.

3.5.1 Technical and Financial Assistance

The City provides technical and financial assistance to customers through a variety of means, including the following:

- **Indoor Water Conservation Kits:** The City offers indoor water conservation kits, which include a showerhead with the U.S. Environmental Protection Agency's (EPA's) WaterSense label, two bathroom faucet aerators, a shower timer, a dual-spray kitchen faucet aerator, toilet leak detection dye tabs, plumber's tape, and installation instructions. Multi-family and apartment complex owners are eligible for a more customized combination of indoor water conservation items. Since the City began offering the kits in 2016, it has distributed approximately 300 kits annually, with an estimated 85 percent going to single family residential customers and 15 percent going to multi-family residential customers.

- **Sprinkler Inspection Program:** The City has a Sprinkler Inspection Program that offers free outdoor water surveys for single family residential customers. Sprinkler inspections include a visual check to pinpoint any problems with the irrigation system, tests to measure how much water the irrigation system delivers, tests for irrigation system pressure, and soil sampling to determine root depth and soil type. Program participants receive a customized inspection report with a water budget and recommended watering schedule, as well as recommendations and tips to make their irrigation system more efficient. Customers are either recruited into the Sprinkler Inspection Program (i.e., targeted) by the City based on high outdoor water use when compared to lot size, or they can request sprinkler inspections. **Exhibit 3-5** presents the number of sprinkler inspections the City has provided since the program began in 2015.

  Exhibit 3-5. Inspections Provided by the Sprinkler Inspection Program, 2015-2019

Year	Total Inspections	Targeted	Requested
2015	64	N/A	64
2016	189	65	124
2017	211	78	133
2018	165	89	76
2019	165	98	67
Total	794	330	464

- **Large Landscape Program:** The City has a Large Landscape Program that offers free outdoor water audits to customers with large landscapes (of approximately 1 acre or more). Typical program participants include multi-family residences, commercial establishments, City-owned landscapes, schools, parks, homeowners' associations, and churches. City conservation staff meet with landscape owners to inspect irrigation systems, develop detailed irrigation water budgets, track actual water use to compare with the water budget, and identify cost-effective

improvements to increase landscape water efficiency. The Large Landscape Program is data driven and utilizes a combination of AgriMet weather data, GIS spatial data, hourly AMI water use data, and a customized water budget to guide water management throughout the season. The program also introduces customers to the City's customer engagement software, which provides water use data to aid customers' water management decisions.

- **Home Water Use Report:** In 2020 the City entered a pilot project to evaluate the extent to which providing customers with a Home Water Use Report, a tool available through the City's customer service software, would result in reductions in water use. The Home Water Use Report delivers a summary of the customer's monthly water use alongside a comparison to the water use of customers of comparable homes. The City's pilot project provides the Home Water Use Reports to a group of high water users and a control group of average water users to evaluate the effectiveness of the reports on various types of water users.
- **WaterWise Demonstration Garden:** In 2017, the City established a WaterWise demonstration garden at Hollinshead Park, which was a collaborative effort with Oregon State University Extension, the Master Gardeners Association, and Bend Parks and Recreation Department. The WaterWise demonstration garden includes low-to-moderate water use landscape plants and examples of water-efficient irrigation techniques that work well in Central Oregon. The City's water conservation staff designed and installed the four-station irrigation system. The four different irrigation techniques featured are inline drip irrigation, point source irrigation with drip emitters, pressure regulating tree bubblers, and an overhead application showcasing high-efficiency sprinkler nozzles. The WaterWise demonstration garden is open to the public to enable water customers to learn about ways to make their landscape and irrigation system more water efficient, and it serves as an excellent location for water conservation workshops.

Five-Year Benchmarks

- The City will continue the Large Landscape Program.
- The City will continue to offer the Sprinkler Inspection Program to its residential customers during the irrigation season.
- The City will continue to evaluate the feasibility and effectiveness of the use of Home Water Use Reports as a customer outreach and awareness tool.

3.5.2 Supplier Financed Retrofit or Replacement of Inefficient Fixtures

As described under 3.5.1, the City offers free indoor water conservation kits that include technical assistance items and the following water efficient fixtures to replace existing inefficient fixtures: an EPA WaterSense-labeled showerhead, two bathroom faucet aerators, and a dual-spray kitchen faucet aerator.

In 2019, the City financed irrigation efficiency improvements for more than 15 existing City Utility Department landscapes, which included installing new irrigation systems, new irrigation controllers with remote access capabilities, and landscaping that is more water efficient. In addition, the City will continue to upgrade all new City-owned landscapes to meet the low-water specifications detailed in the City's Engineering Standards and Specifications document, which the City updated and City Council

adopted in 2017. The Engineering Standards and Specifications document applies to all City-owned and public landscapes, and promotes an increased level of water efficiency in the landscape. The City will continue to upgrade City-owned landscapes as additional changes are made to the Engineering Standards and Specifications document.

As described in Section 3.3, the City used a Water Savings and Cost-effectiveness Analysis to help identify a potential water conservation program that includes measures that could be pursued over the next 20 years, dependent upon City Council concurrence and funding in future City budgets. The potential water conservation program identified a number of potential new supplier-financed measures to replace inefficient fixtures, such as a high-efficiency toilet rebate, weather-based irrigation controller rebate, pressure reducing valve rebate, rotating sprinkler nozzles rebate, pressure-regulating sprinkler bodies rebate, and free drip irrigation kits.

Five-Year Benchmarks

- The City will continue to offer free indoor water conservation kits that include water-efficient faucet aerators and a showerhead.
- The City will implement new supplier-financed measures to replace inefficient fixtures identified in the Water Savings and Cost-effectiveness Analysis to the extent the measures are approved by City Council and funded in future City budgets.

3.5.3 Rate Structure and Billing Practices that Encourage Conservation

As described under Section 3.4.4, the City's rate structure is based, in part, on the quantity of water metered at each service connection. The City has a base rate based on meter size and a usage rate based on the volume of water consumed, applicable to all customer classes. This current rate structure has been in place since July 2015. In late 2020, the City will complete conversion of its utility billing software to a system with more robust capabilities, which will make it feasible for the City to implement a new rate structure, if desired. In the coming years, the City plans to explore implementation of a new rate structure, such as tiered rates, water budget-based rates, or another approach aimed at reducing peak-season demand.

Five-Year Benchmarks

- The City will continue to bill customers monthly based, in part, on the volume of water consumed.
- The City will investigate the feasibility of increasing tiered water rates based on water budgets to promote water conservation and to provide consistent revenue to meet operational, financial, and rate objectives set by the City Council.

3.5.4 Water Reuse, Recycling, and Non-potable Opportunities

The City's wastewater treatment facility is located over 8 miles northeast and downhill from Bend. It is finalizing the capability to produce high quality reclaimed water suitable for reuse for irrigation. The City previously delivered a small portion of its reclaimed water to Pronghorn Resort located downhill from the Reclamation Facility. At this time, the WPCF permits on file with DEQ for operation of the water

reclamation facility require the City's treated wastewater, to be discharged to seepage ponds for return to the Deschutes Basin Aquifer.

Five-Year Benchmark

- The City will continue to consider feasible opportunities to use reclaimed water from its water reclamation facility.

3.5.5 Other Conservation Measures

Now that the City has updated its Engineering Standards and Specifications document, it is reviewing the Bend Development Code for opportunities to require more water-efficient landscaping standards in private development projects.

The City continues to develop and maintain partnerships that advance water conservation efforts. The City has partnerships with large customers, including the local school district, local parks district, state parks, churches, and homeowner associations. The City has public education partnerships with groups such as with Oregon State University Extension Service, Central Oregon Community College, and Central Oregon Builders Association. The City has also worked with the Transportation and Mobility's landscape department to upgrade controllers in City-owned right of way landscapes through the Large Landscape Program.

To continue to stay informed about the latest water conservation standards and technologies, the City is an EPA WaterSense Partner and is a member of the Alliance for Water Efficiency, Irrigation Association, and Oregon Landscape Contractors Association.

The City has been evaluating current and potential water savings from water conservation measures in an effort to maximize the cost-effectiveness of its Water Conservation Program. Since 2016, the City has been utilizing the Alliance for Water Efficiency Water Conservation Tracking Tool to quantify savings of existing conservation measures. As described in Section 3.3, the City conducted a Water Savings and Cost-effectiveness Analysis in 2020 as part of the IWSMP and WMCP efforts. The City used this analysis to identify a cost-effective Water Conservation Program that included a number of additional measures that, if implemented, may result in significant water savings and avoided infrastructure cost of $21,000,000 over 20 years. The conservation measures include outdoor and indoor conservation measures and accompanying rebates for new efficient equipment. The outdoor measures will focus on reducing the peak demands of irrigation season through water efficiency standards and specifications for new development. The outdoor rebates will provide the incentive for conversion to high-efficiency devices improving program participation. The indoor measures will focus on reducing the baseline water use by specifying high-efficiency indoor devices in homes and businesses. Indoor measures will also be coupled with rebates to incentivize the conversion to more efficient devices.

In addition, the City of Bend Code has irrigation regulations in place in an effort to increase water use efficiency and spread customer demand over the course of the day and week. No irrigation is allowed between 9 a.m. and 5 p.m. Customers with even addresses must irrigate on even days and with odd addresses must irrigate on odd days. Zero sprinkler overspray and runoff is allowed.

Five-Year Benchmarks

- The City will begin a code alignment and update process with the goal of increasing efficiency of outdoor water use through adoption of best management practices to promote irrigation efficiency in various related sections of the City of Bend Code and engineering specification documents.
- The City will explore the feasibility of updating and aligning indoor water use efficiency and related best management practices and other code improvements that will increase the water use efficiency inside of homes and businesses using nationally recognized standards that will work in Bend.
- Over the next five years City staff will work with City Management and the City Council to identify which of the new measures identified in the Water Conservation Program Water Savings and Cost-effectiveness Analysis (described in Section 3.3) to fund and implement.

3.6 Water Conservation Benchmarks Summary

A summary of the City's 5-year water conservation benchmarks by measure is presented in **Exhibit 3-6**.

Exhibit 3-6. Summary of 5-Year Water Conservation Benchmarks

Conservation Measures	Five-Year Benchmarks
Annual Water Audit	• The City will continue to conduct annual water audits utilizing the AWWA M36 Water Audit Methodology. • The City will consult with an external water loss control expert to perform a third-party validation of the M36 Water Audit results at least once in the next five years.
System-wide Metering	• The City will continue to install AMI meters on all new water connections.
Meter Testing and Maintenance	• The City will continue to develop a standardized production Meter Verification Program. • The City will continue to test all meters 3 inches and larger annually. • The City will develop a formal annual Testing and Meter Replacement Program for 1.5-inch to 2-inch meters. • The City will complete development of a Small Meter Testing and Replacement Program (3/4-inch and 1-inch meters) aligning with AWWA's M36 Water Audits and Loss Control Program standards. The program will allow gradual transition to use of new electromagnetic meters as adopted in the City of Bend Standards and Specifications.
Water Rate Structure	• The City will continue to bill customers based on the existing uniform rate structure, which charges customers based on the volume of water they consume. • The City will complete implementation of an updated utility billing system, which will provide the administrative feasibility to change rate structures in the future. • The City will continue to review existing customer categories and rate classes as part of the City's annual rate review process to promote efficiency and equity. • The City will investigate the feasibility of increasing tiered water rates based on water budgets to promote water conservation and to provide consistent revenue to meet operational, financial, and rate objects set by the City Council.

Conservation Measures	Five-Year Benchmarks
Water Loss Analysis	• The City will continue its efforts to minimize water loss by continuing the Distribution System Leak Detection Program and completing an annual Leak Detection Report as part of the City's M36 Water Audit Program. • The City will evaluate the feasibility of developing a pipe replacement program to identify and replace aging and failing pipe segments on an annual basis as outlined in the City's Capital Improvement Plans, to be adopted in late 2020 or early 2021.
Public Education	• The City will continue to update its educational resources for customers and the landscape industry through the City's WaterWiseTips.org website, workshops, and related educational outreach activities.
Technical and Financial Assistance	• The City will continue the Large Landscape Program. • The City will continue to offer the Sprinkler Inspection Program to its residential customers during the irrigation season. • The City will continue to evaluate the feasibility and effectiveness of the use of Home Water Use Reports as a customer outreach and awareness tool.
Supplier Financed Retrofit or Replacement of Inefficient Fixtures	• The City will continue to offer free indoor water conservation kits that include water-efficient faucet aerators and a showerhead. • The City will implement new supplier financed measures to replace inefficient fixtures identified in the Water Savings and Cost-effectiveness Analysis to the extent they are approved by City Council and funded in future City budgets.
Rate Structure and Billing Practices that Encourage Water Conservation	• The City will continue to bill customers monthly based, in part, on the volume of water consumed. • The City will investigate the feasibility of moving from uniform rates, to tiered water rates based on water budgets to promote water conservation and to provide consistent revenue to meet operational, financial, and other rate objectives set by the City Council.
Water Reuse, Recycling, and Non-potable Opportunities	• The City will continue to consider feasible opportunities to use reclaimed water from its water reclamation facility.
Other Conservation Measures	• The City will begin a code alignment and update process with the goal of increasing efficiency of outdoor water use through adoption of best management practices to promote water use efficiency in various related sections of City of Bend codes and specification documents. • The City will explore the feasibility of updating and aligning indoor water use efficiency and related best management practices and other code improvements that will increase the water use efficiency inside of homes and businesses using nationally recognized EPA WaterSense standards that will work in Bend. • Over the next five years City staff will work with City Management and the City Council to identify which of the new measures identified in the Water Conservation Program Water Savings and Cost-effectiveness Analysis (described in Section 3.3) to fund and implement.

Notes
AWWA = American Water Works Association
EPA = U.S. Environmental Protection Agency

4. Water Curtailment Element

This section satisfies the requirements of OAR 690-086-0160. This rule requires a description of past supply deficiencies and current capacity limitation. It also requires inclusion of stages of alert and the associated triggers and curtailment actions for each stage.

4.1 Introduction

Curtailment planning is the development of proactive measures to reduce demand during supply shortages as the result of prolonged drought or system failure from unanticipated events, including fire, lightning strikes, flooding, landslides, earthquakes, and contamination, mechanical or electrical equipment failure, or events not under control of the City (for example, localized or area-wide power outages and intentional malevolent acts).

4.2 History of System Curtailment Episodes

OAR 690-086-0160(1)

Within the last decade, the City has not experienced water shortages resulting from system failure related to catastrophic events, mechanical or electric equipment failure, or insufficient flows in Tumalo Creek. Over this period, during brief interruptions to the City's surface water supply from turbidity events, lightning strikes, and planned and unplanned maintenance, the City has increased its reliance on its groundwater sources. The City's new membrane filtration plant has also nearly eliminated the need for the City to shut down its surface water treatment due to high turbidity during high-flow events. The City is currently able to use its groundwater rights to meet water demands. Future groundwater use may be limited by system (well) capacities and groundwater restrictions in the Deschutes Study Area. The City's previous curtailment plan included four stages. The City has regularly issued service announcements when there are forecasts for below-normal streamflows and above-normal temperatures. The City initiated Stage 1 water shortage alerts in 2015, 2020, and 2021 when the Governor declared a drought emergency for Deschutes County.

The City also has experienced occasional short-duration interruptions to normal service delivery as a result of pipe or water main breaking, lightning striking wells, and other mechanical or electrical malfunctions of its water supply and delivery system. In these events, the City has relied on its unaffected water sources, either surface water or groundwater, during the service interruption.

4.3 Curtailment Stages and Initiating Conditions

OAR 690-086-0160(2) and (3)

The City's curtailment plan includes three curtailment stages to be invoked in the event of a water supply shortage. These stages are of increasing severity and could be initiated and implemented in progressive steps or a later stage could be implemented directly. The plan includes both voluntary and mandatory measures, depending upon the cause, severity, and anticipated duration of the shortage. The goal of the City's curtailment plan is to describe the potential actions under each stage of alert that

will provide the greatest assurance of maintaining emergency fire flows and potable water supplies for human consumption.

Stages of curtailment are therefore centered on a declining trend in system storage and a failure to maintain a minimum of 20 psi throughout the City's distribution system, as well as minimum levels of storage for fire flow in one or more reservoirs for extended periods of time. The reservoir level required for fire flow varies by reservoir, with some reservoirs having a greater amount of storage available for flexibility in meeting short-term demands. Other curtailment triggers are centered on water quality considerations for human consumption.

Exhibit 4-1 presents a summary of the potential initiating conditions for the three curtailment stages. Initiation of a curtailment stage is based on the specific circumstances of the actual event. The decision to implement curtailment will also consider the knowledge and judgment of City staff members familiar with the water system. Staff members may evaluate such considerations as assessments of the extent of system damage or contamination, duration of repair, costs, fire hazards, and weather forecasts.

In addition to the curtailment stages described below, the City also issues Seasonal Advisory Alerts. Seasonal Advisory Alert messages are intended to heighten awareness regarding seasonal outdoor landscape and irrigation water use efficiency and to inform water customers of the potential for higher-than-normal water demands and/or the need to pay close attention to their landscape and irrigation consumption to help manage peak-season water use. This program is described in more detail in Section 3.4.6.

Exhibit 4-1. Summary of Potential Initiating Conditions for Curtailment Stages 1 through 3

Curtailment Stage	Potential Initiating Conditions	Potential Triggers
Curtailment Stage 1: Potential Water Shortage Alert	• Minor damage to the distribution system. • Mechanical or electrical failure at source supplies. • Extensive periods of high water demand. • Planned reduction in supply capacity resulting from extended disruption in supply chain for chlorine or other water treatment chemicals.	• Over any period of 3 days, a declining trend in storage and failure to recover in one or more reservoirs above the operational level required to maintain minimum fire flows.
Curtailment Stage 2: Serious Water Shortage Alert	• Significant damage to water source supplies and/or distribution system. • A credible threat against key utility infrastructure. • Threat of fire to the Bend Municipal Watershed utility infrastructure.	• Over any period of 5 days, a declining trend in reservoir storage and failure to refill one or more reservoirs above operational level required to maintain fire flows.
Curtailment Stage 3: Severe Water Shortage Alert	• Extensive damage to water supply or distribution infrastructure. • Contamination of water sources. • Fire in the Bend Municipal Watershed.	• Failure to refill more than one storage reservoir above level required to maintain fire flows for a period of 7 days or more. • Loss of multiple sources of supply or significant distribution infrastructure leading to loss of system pressure and/or reservoir storage.

4.4 Curtailment Plan Implementation

OAR 690-086-0160(4)

4.4.1 Stage 1: Potential Water Shortage Alert

Stage 1 of the City's Curtailment Plan will activate a program to reduce nonessential water use as needed. Activation of Stage 1 may include (1) reiterating communication under the City's Seasonal Advisory Alert public outreach program, which requests voluntary water use reductions, and (2) any mandatory direction to specific customer groups, geographic areas, or pressure zones regarding reductions in water use. Potential initiation conditions include minor damage to the distribution system, mechanical or electrical failure at source supplies, extensive periods of high water demand, or disruption in the supply chain for chlorine or other chemicals required for water treatment. These and other conditions may cause one or more of the City's reservoirs to operate below required fire flow storage for extended periods of time. The City may activate Stage 1 curtailment if over any period of 3 days, there is a declining trend in reservoir storage and the one or more reservoirs cannot be refilled to a level greater than that required to maintain fire flows.

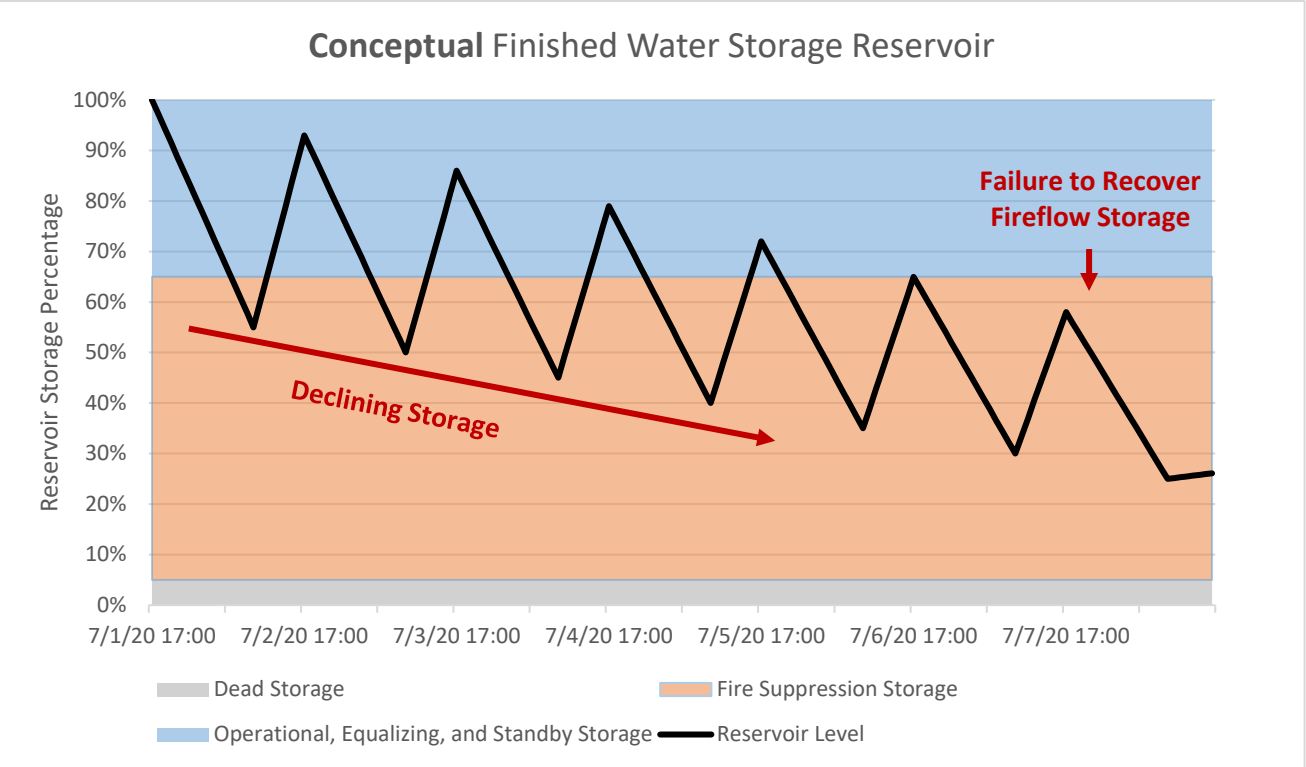
Elements of Stage 1 may include the following:

- Prohibiting the use of water that would impede the City's ability to meet the requirements of the Safe Drinking Water Act.
- Temporary reductions to, or prohibition of, landscape irrigation.
- Temporary prohibitions on filling swimming pools or ponds; operating water features; and washing sidewalks, driveways, and patios.

The purpose of Stage 1 curtailment actions is to reduce water demands in a specific area or throughout the City in order to prevent further declines in reservoir storage, and to allow reservoir storage to recover to a volume greater than that required to maintain minimum fire flows.

Exhibit 4-2 provides a conceptual example of a declining storage trend and failure to recover fire flow storage and minimum system pressure requirements.

Exhibit 4-2. Conceptual reservoir storage operation over the course of one week during periods of high demand, illustrating a pattern of declining storage and a failure to recover fire flow storage.



4.4.2 Stage 2: Serious Water Shortage Alert

Stage 2 of the City's Curtailment Plan will activate a program to eliminate all nonessential water use. Activation of Stage 2 may include activities listed in the Stage 1: Potential Water Shortage Alert, as well as any mandatory direction to specific customer groups, geographic areas, or pressure zones regarding reductions in water use. Potential initiating conditions include a fire in the Bend Municipal Watershed that poses a threat to the City's water supply infrastructure, a credible threat against key utility infrastructure, or significant damage to water supply or distribution infrastructure. These and other conditions may cause one or more of the City's reservoirs to operate below required fire flow storage for extended periods of time, or to drop significantly during a short period of time. The City may activate Stage 2 curtailment if over any period of 5 days, there is a declining trend in reservoir storage and the one or more reservoirs cannot be refilled to a level greater than that required to maintain fire flows.

Elements of Stage 2 may include the following:

- Prohibition of landscape irrigation.
- Prohibiting the use of water that would impede the City's ability to meet the requirements of the Safe Drinking Water Act.

Enforcement of mandatory water use restrictions will occur through the City's Code Enforcement Division.

The purpose of Stage 2 curtailment actions is to reduce water demands in a specific area or throughout the City in order to prevent loss of system pressure, further declines in reservoir storage, and to allow reservoir storage to recover to a volume greater than that required to maintain minimum fire flows.

4.4.3 Stage 3: Severe Water Shortage Alert

Stage 3 of the City's Curtailment Plan will activate a program intended to limit water use to that necessary for human consumption and sanitation needs. Activation of Stage 3 may include activities listed in the Stage 2: Serious Water Shortage Alert, as well as any mandatory direction to specific customer groups, geographic areas, or pressure zones regarding reductions in water use. Potential initiating conditions include a fire in the Bend Municipal Watershed resulting in damage to the City's surface water supply infrastructure, extensive damage to other water supply or distribution infrastructure, or contamination of multiple water sources.

In addition to significant emergencies impairing the City's ability to provide water. High demand conditions during supply interruptions may cause one or more of the City's reservoirs to operate below required fire flow storage for extended periods of time, or to drop significantly during a short period of time. The City may activate Stage 3 curtailment if:

- Failure to refill more than one storage reservoir above level required to maintain fire flows for a period of 7 days or more.
- Loss of supply leading to rapid loss of system pressure and/or reservoir storage.

If the event renders water in the system unsafe to drink, the City will activate the appropriate response protocols in accordance with the City's Emergency Management Plan, Wildfire Preparedness Plan, and/or National Incident Management System.

Under Stage 3, the City may prohibit all water uses except those necessary for human consumption and sanitation needs.

The purposes of Stage 3 curtailment is to maintain system pressure of 20 psi, potable water supply for human consumption and sanitation needs and, to the extent possible, to return reservoir storage to levels required for fire flow.

4.5 Authority and Enforcement

The City Manager is authorized to determine the need for water curtailment and to declare a water curtailment stage under Bend Municipal Code 14.20.040. Plan provisions will remain in effect until the City Manager terminates the curtailment requirement. Actions may be applied to the entire system, or only to those customer categories, geographic areas, or pressure zones that are directly affected by any water supply shortage. The City Manager is responsible for execution of the curtailment plan provisions after a water curtailment stage is declared.

4.6 Notifications of Curtailment

The City has several communication channels for relaying important information about a supply shortage, including voluntary or mandatory measures. The City may rely on social media, local

television, radio, and print media; strategically located sandwich boards or road signs; and the City of Bend's website to communicate with customers on an ongoing basis about a supply shortage. Notices and other forms of communication may include a description of the current water situation, the reason for the requested conservation measures, and a warning that mandatory restrictions may be necessary if voluntary measures are not sufficient to achieve water-use reduction goals.

4.7 Drought Declaration

In the event the Governor of Oregon declares a drought emergency in Deschutes County, the City's conservation and curtailment elements of this WMCP meet the requirements of ORS 536.720. If the City is within a drought area declared by the Governor, the City will consider whether mandatory or voluntary curtailment measures are needed to meet system demands and the stage of curtailment that should be initiated. Regardless of whether curtailment is needed, the City will encourage customers to conserve and use water efficiently as part of their regular Seasonal Advisory Alerts and other WaterWise Program efforts.

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5. Municipal Water Supply Element

This section satisfies the requirements of OAR 690-086-0170.

This rule requires descriptions of the City's current and future service area and population projections, demand projections for 10 and 20 years, and the schedule for when the City expects to fully exercise its water rights. The rule also requires comparison of the City's projected water needs and the available sources of supply, an analysis of alternative sources of water, and a description of required mitigation actions.

5.1 Delineation of Service Area

OAR 690-086-0170(1)

The City's existing water system serves the current UGB, excluding those areas served by Avion and Roats, as shown in **Exhibit 2-2**. The City also serves water to the Tetherow destination resort and the Tree Farm rural residential development outside the UGB to the west. As part of the City's IWSMP, the City developed a 20-year forecast of growth within the City's existing service area that considers customer category (single family residential, multi-family residential, commercial). The City does not anticipate changes to the footprint of the service area during the 10-year term of this WMCP.

5.2 Population Projections

OAR 690-086-0170(1)

The City's water service area population for 2018 was estimated using the method described in Section 2. Future populations (2018 to 2040) within the City's service area rely on the Coordinated Population Forecast for Deschutes County as the basis for population projections.[7] The City assumed that the proportion of the UGB population within the City's water service area would remain constant at approximately 75 percent. The City's projected water service area population in 2030 and 2040 is summarized in **Exhibit 5-1**. These projections equate to an average annual growth rate (AAGR) of 2.52 percent from 2018 through 2030 and 2.18 percent from 2030 to 2040.

Exhibit 5-1. Projected Water Service Area Population, 2030 and 2040

Year	Population
2018	67,187
2030	92,681
2040	115,272

[7] Portland State University. Population Research Center; Chun, Nicholas; Rancik, Kevin; Haggerty, Rhey; Ollinger, Joshua; and Rynerson, Charles, "Coordinated Population Forecast for Deschutes County, its Urban Growth Boundaries (UGB), and Area Outside UGBs 2018-2068" (2018). Oregon Population Forecast Program. 39.
https://archives.pdx.edu/ds/psu/26643

These population projections were not used to develop the City's water demand forecasts. As described in detail below, demand forecasts were developed on the basis of land-use planning and customer meter data.

5.3 Demand Forecast

OAR 690-086-0170(3)

OAR 690-086-0170(3) requires water demand projections for 10 and 20 years and, at the option of the Municipal Water Supplier, longer periods. Future water demand projections for 2030 and 2040 were developed for the City's IWSMP using City planning data for existing and future housing units, AMI data for customer demand information, and water production data. The City has also included water demand projections for 2041 and 2050 in this WMCP. As described in greater detail in Section 5.4, demand projections for these years are pertinent to the City's evaluation of the need for access to water under Permit G-11379, for which an extension application is currently pending, and the potential need for a new water right. The City projected demands for 2041 and 2050 by extending the average annual growth rate from 2030 through 2040.

The City's water demands vary throughout the day, particularly during the peak season. For the purposes of these projections, the City's "maximum operational demand" is the maximum 4-hour rolling average rate of the City's groundwater and surface water production. The use of the 4-hour rolling average demand reduces the impact of brief and anomalous spikes in source water demand. The City's maximum operational demand is approximately 17 percent higher than the City's MDD. Typically, during an MDD scenario, the City's demands are higher than the daily average during the night, peak during the morning hours, and then fall during the afternoon. **Exhibit 5-2** shows the City's maximum 4-hour rolling average demand on August 11, 2018, the date on which the maximum operational demand occurred in 2018. This pattern reflects, in part, the City's regulations regarding landscape irrigation, which restrict irrigation to the hours of 5 p.m. to 9 a.m. and encourage irrigation from 7 p.m. to 6 a.m. The City projected that the maximum operational demand will grow at the same rate as the City's MDD.

Exhibit 5-2. Four-hour Rolling Average Demand on August 11, 2018, Including Maximum Operational Demand of 50.8 cfs

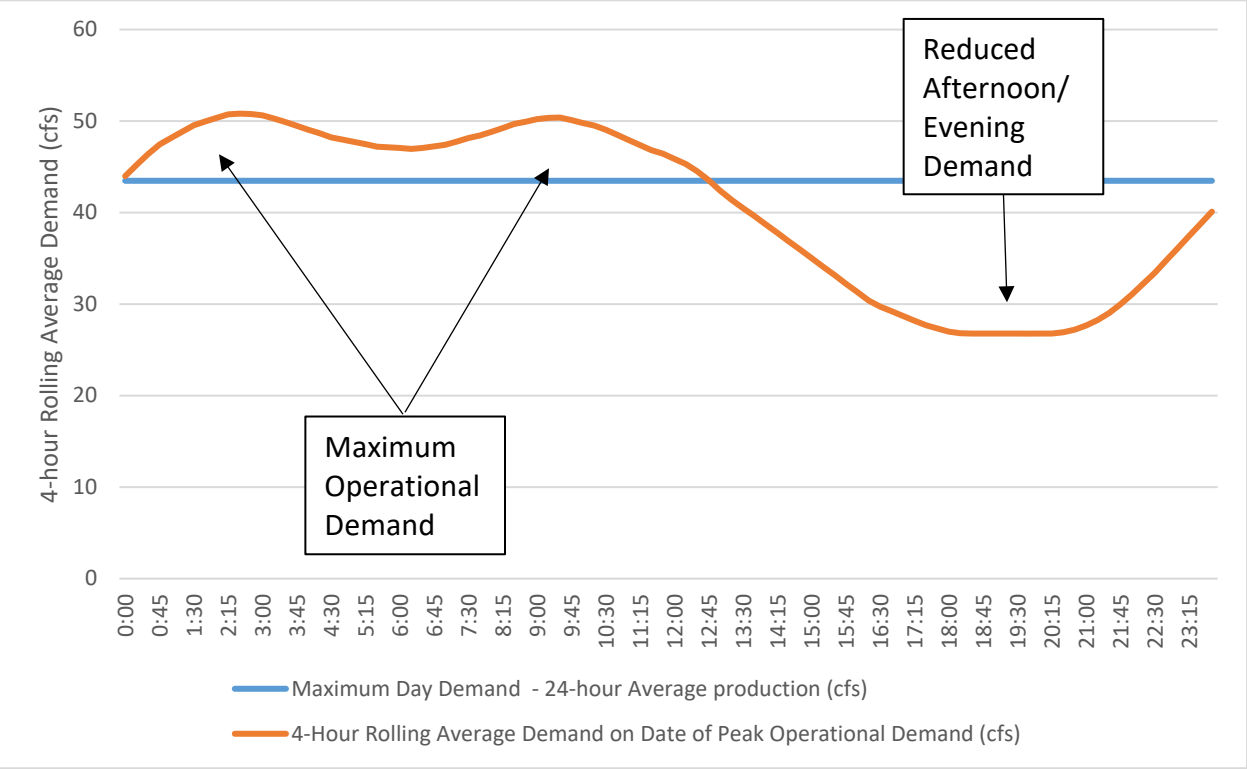


Exhibit 5-3 below shows the 2018 actual and 2030 and 2040 projected ADD, MDD, and maximum operational demand, along with the associated average annual growth rate for the City's water demand. The growth rates for MDD and ADD are slightly different, due to differences in the forecasted growth of different customer categories during the forecast period. For example, the ADD grows more quickly from 2018 to 2030 than from 2030 to 2040 due to increased growth in residential water use compared to commercial water use. For comparison, the Deschutes County Coordinated Population Forecast[8] projects population growth rates of 2.52 percent from 2018 through 2030 and 2.18 percent from 2030 to 2040. The lower growth in the City's demand from 2030 through 2040 is attributable to the anticipated slower growth of the City's water service area, particularly commercial water users, compared to the UGB as a whole during that period. Maximum operational demand is projected to be 83.3 cfs in 2041 and 97.4 cfs in 2050.

[8] Portland State University. Population Research Center; Chun, Nicholas; Rancik, Kevin; Haggerty, Rhey; Ollinger, Joshua; and Rynerson, Charles, "Coordinated Population Forecast for Deschutes County, its Urban Growth Boundaries (UGB), and Area Outside UGBs 2018-2068" (2018). *Oregon Population Forecast Program*. 39. Available at https://archives.pdx.edu/ds/psu/26643. (Accessed November 18, 2020.)

Exhibit 5-3. Projected Average Day, Max Day, and Peak-Hour Demand and Associated AAGRs, 2018 through 2050

Year	ADD (cfs)	ADD AAGR	MDD (cfs)	MDD AAGR	Maximum Operational Demand (cfs)
2018	20.3	N/A	43.5	N/A	50.8
2030	27.5	2.55%	58.8	2.52%	68.8
2040	32.6	1.70%	69.9	1.74%	81.8
2041	33.2	1.70%	71.2	1.74%	83.3
2050	38.7	1.70%	83.2	1.74%	97.4

Notes
ADD = average day demand
AAGR = average annual growth rate
cfs = cubic feet per second
MDD = maximum day demand

5.4 Schedule to Exercise Permits and Comparison of Projected Need to Available Sources

OAR 690-086-0170(2) and (4)

The City holds surface water rights that authorize the use of up to 36.1 cfs (23.3 mgd). As described in Section 2, the actual amount of surface water available to the City is limited by a number of factors, including a limitation of 18.2 cfs under the City's SUP from USFS for the operation of the surface water facilities. The City's WFF is a membrane treatment facility consisting of racks of filter tubes. For the purposes of planning for the firm capacity of the City's surface water supply, the City assumed that one existing filter rack would be out of service, limiting the City to a surface water capacity of 14.7 cfs (6,600 gpm). With respect to groundwater, the City has assumed that the limiting factor is the rate of appropriation authorized by the City's water rights. The City holds groundwater rights authorizing use of up to 68.2 cfs (44.1 mgd), including the full 3.84 cfs rate of Permit G-11379, for which an extension application remains pending. The City's groundwater rights and planning-level firm capacity of surface water supply of 14.7 cfs provide a planning-level reliable water supply of 82.9 cfs (53.67 mgd). Although two of the City's permits require mitigation under the Deschutes Basin Groundwater Mitigation Program, for the purposes of this analysis, the City has assumed the rate of these two permits will be fully developed and has evaluated the rate of all groundwater rights together.

Exhibit 5-4 shows the City's projected ADD, MDD, and maximum operational demand superimposed on the City's firm surface water supply and groundwater rights.

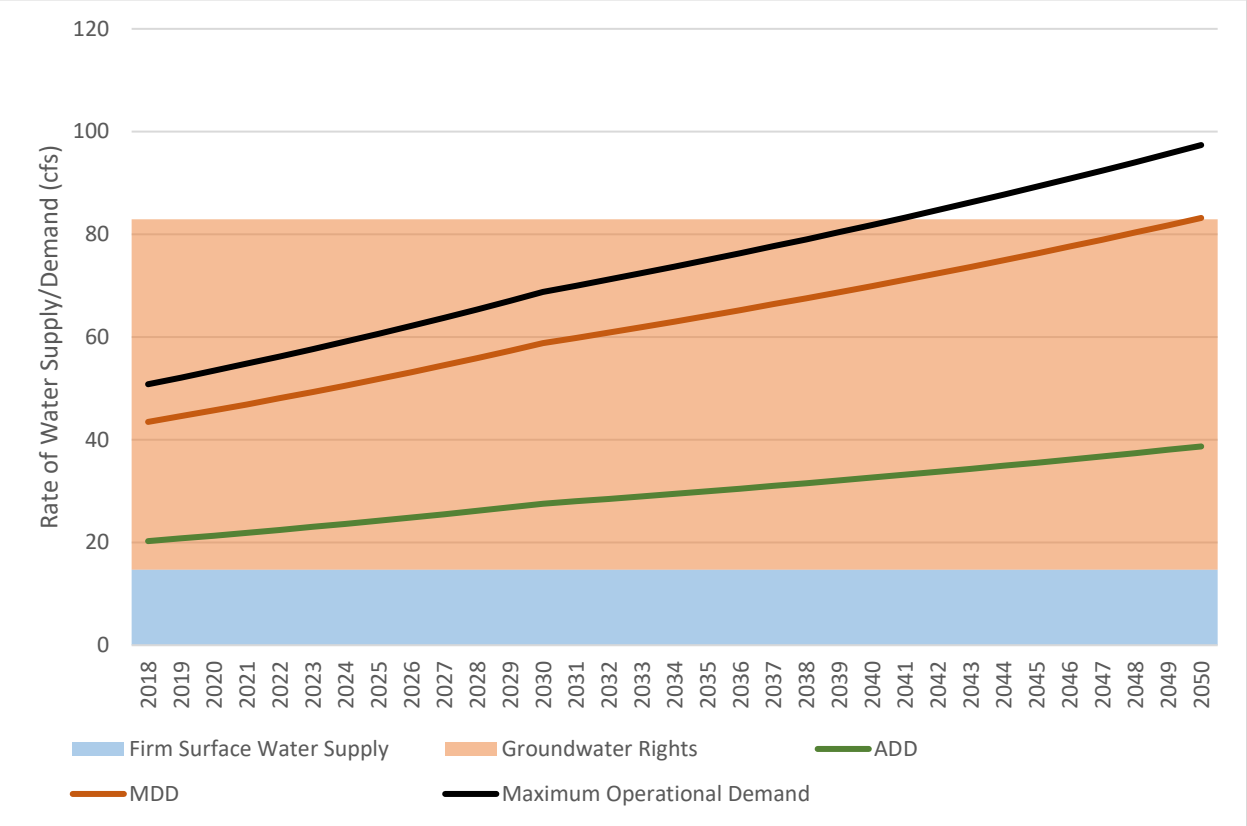
As this exhibit shows, based on the assumptions described above, the City expects to narrowly have sufficient water rights to meet projected demands through 2040. However, extending the 2030 through 2040 projected annual average growth rate of 1.74 percent for maximum operational demand one additional year through 2041, the projected maximum operational demand is 83.3 cfs, slightly exceeding the total reliable water supply. Because this WMCP likely will not be approved by OWRD until mid-2021, the City is using projected demand through 2041 for its 20-year demand projection. The reliable supply includes the full 3.84 cfs rate of Permit G-11379., including 1.49 cfs not developed prior

to 2005. Therefore, the City projects that access to water under Permit G-11379 will be required prior to 2041. However, the City's permit extension application is still pending, so the City cannot request access to the undeveloped portion of the permit in this WMCP.

Similar to Permit G-11379, the City's extension application for Permit S-49823 is still pending, so the City cannot request access to the undeveloped portion of the permit in this WMCP. However, use of water under Permit S-49823 is an important part of the City's water supply portfolio during winter and spring. Moreover, surface water treated at the City's WFF costs substantially less than water pumped from the City's groundwater wells. Development of new groundwater supplies also requires significant infrastructure investments. The City currently has the demand to utilize the remaining 2.8 cfs under Permit S-49823, and intends to complete development of the permit prior to October 1, 2032 as described in the pending extension application.

Extending the projection further, through 2050, the City's maximum operational demand is projected to be 97.4 cfs, exceeding the City's reliable supply by 14.5 cfs. Therefore, the City will likely need to apply for a new groundwater right within the next 10 years to ensure adequate time to obtain a new permit, obtain required mitigation credits, and develop the infrastructure needed to apply the water to beneficial use.

Exhibit 5-4. Projected Average Day, Maximum Day, and Maximum Operational Demand and Reliable Water Supply



5.5 Alternative Sources

OAR 690-086-0170(5) requires an analysis of alternative sources of additional water if expansion or initial diversion of water allocated under existing permits is necessary to meet the needs shown in Section 5.3. OAR 690-086-0170(8) requires an analysis of alternative sources of additional water if acquisition of new water rights will be necessary within the next 20 years to meet the projected water demands. Although the City is not seeking access to water under an extended permit, the analysis above shows that the City does require access to the full 3.84 cfs rate of Permit G-11379, including the 1.49 cfs portion subject to fish persistence conditions, to meet its projected demands through 2041.

5.5.1 Conservation

OAR 690-086-170(5)(a) & OAR 690-086-170(8)(a)

OAR 690-86-170(5)(a) requires an assessment of whether projected water needs can be satisfied through implementation of conservation measures identified under OAR 690-86-150. As described in Section 3, the implementation of the City's water conservation measures under OAR-690-86-150(4) and (5) have been effective at promoting water conservation, both by reducing water loss and reducing authorized consumption, particularly for irrigation of large landscapes. The City incorporated AMI meter data into its 20-year demand projections for the IWSMP, which form the basis of the City's projections described in Section 5.3. The City proposes to continue the same conservation measures that have already been implemented, meaning that projected demands already reflect much of the water savings from these programs. This does not preclude the City's need for access to its extended permits and potentially seeking a new groundwater right within 10 years.

Section 3.3 and **Appendix C** discuss the City's efforts to evaluate the potential water savings and cost-effectiveness of water conservation measures beyond those the City has already adopted. The potential impact of those conservation measures on projected water demands is discussed in greater detail below in Section 5.5.3.

5.5.2 Interconnections

OAR 690-086-170(5)(b) & OAR 690-086-170(8)(b)

OAR 690-86-170(5)(b) requires an assessment of whether projected water needs can be satisfied through interconnection with other municipal water supply systems and cooperative regional water management. The City does not have any usable interconnections that would allow nearby water suppliers to serve water to the City of Bend. With the exception of Avion and Roats, interconnection would be cost-prohibitive due to a variety of issues such as pressure, water quality (neither Avion nor Roats uses chlorine), and related additional water quality testing requirements. The City's request for access to the undeveloped portion of extended Permit G-11379 (1.49 cfs) is based on projected maximum operational demands. During the period that the City would benefit from access to the undeveloped portion of Permit G-11379, it is unlikely that Avion or Roats would consistently have excess capacity available to provide water via an interconnection. As a result, the City has not explored the possibility of an interconnection with Avion or Roats. An interconnection with Avion or Roats would not be expected to be cost-effective compared with the use of water under Permits G-11379 and S-49823 and does not preclude the potential need to apply for a new groundwater right within 10 years.

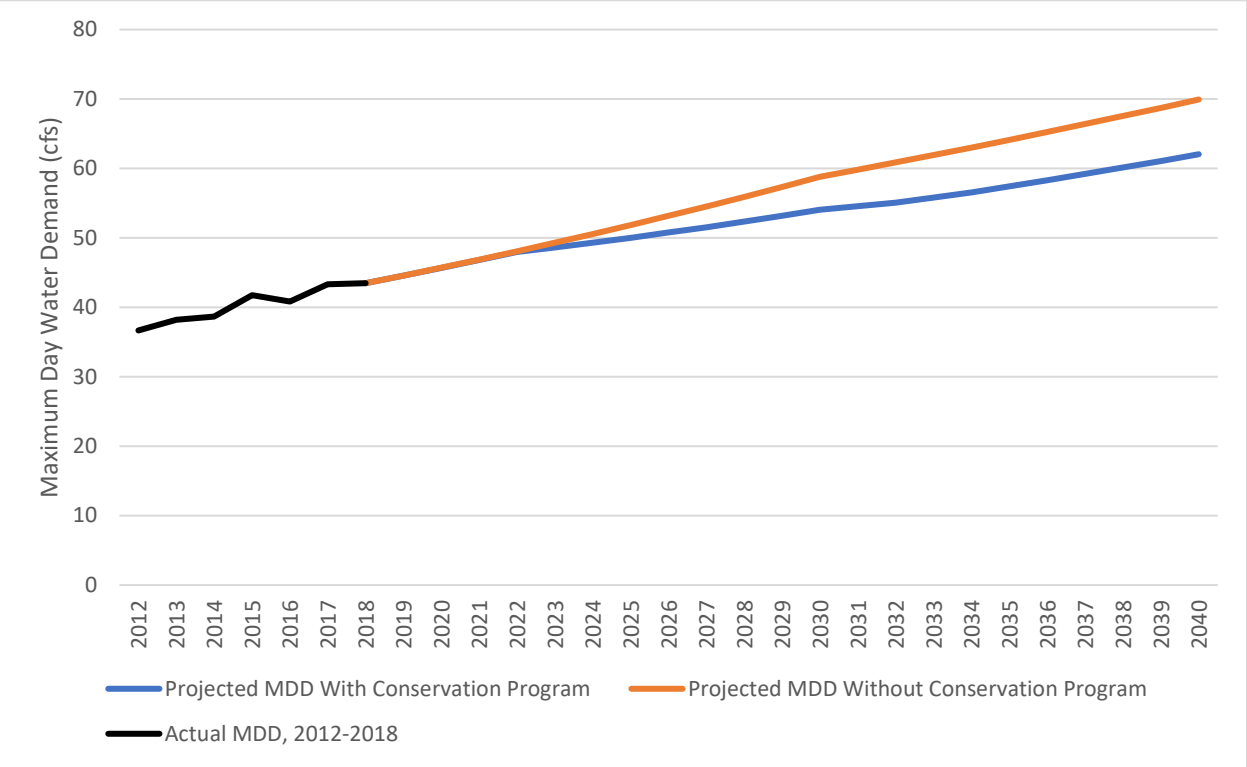
5.5.3 Other Water Conservation Measures

OAR 690-086-170(5)(c) & OAR 690-086-170(8)(c)

OAR 690-086-170(5)(c) requires an assessment of whether projected water needs can be satisfied through additional conservation measures that would provide water at a cost that is equal to or less than the cost of other identified sources. As described in Section 3 above, and in **Appendix C**, the City completed an evaluation of the potential costs and water savings from various conservation measures. The City developed a package of water conservation measures that was analyzed through the Maddaus Water Management Inc.'s DSS Model. This analysis indicates the package of water conservation measures would reduce the City's projected 2040 MDD by 5.1 mgd (7.9 cfs; 3,540 gpm). The City did not specifically evaluate the impact of water savings on maximum operational demands, but projected that water savings would be realized primarily from reductions in outdoor water use, which tends to be concentrated during the part of the day in which maximum operational demands occur. The City also evaluated water savings through 2040 only, but water savings would be expected to continue, to the extent that conservation programs prove cost-effective.

For the purposes of the IWSMP, the City assumed that future new wells would have production rates of 1,150 gpm. Therefore, the projected maximum-day water savings of 3,540 gpm would eliminate the need to construct three wells (and one above-ground reservoir) over the next 20 years at an estimated cost of $21 million. Additional savings may also be realized through reductions in operational costs (primarily the cost to pump water). The estimated cost of implementing the package of conservation measures is approximately $11 million. Therefore, the $11 million investment in the conservation program would reduce water demands at a lower cost than the cost to construct the infrastructure alone needed to meet projected MDDs through 2040 without conservation. **Exhibit 5-5** shows projected maximum-day water demands through 2040 with and without the conservation program.

Exhibit 5-5. Actual MDD, 2012-2018, and Projected MDD With and Without Implementation of Conservation Program, 2018-2040



The conservation program City staff determined as the preferred option (Program C) requires allocation of budget, creation of staff positions, and the approval of the City Council. Individual elements of the conservation program would also require specific changes to City ordinances. As shown in Exhibit 5-6, the City has assumed that the implementation of the expanded conservation program, if funded and approved by City Council, would not begin until 2023. This will allow adequate time for City staff to develop specific proposals for Council review and public input.

Until the expanded conservation program is funded and approved by Council, the City cannot assume that the projected water and financial savings can be realized. As a result, the City will continue to plan for the need to access the undeveloped portions of extended Permits S-49823 and G-11379 and the potential need to seek a new groundwater permit within the next 10 years.

5.6 Quantification of Maximum Rate and Monthly Volume

OAR 690-086-0170(6)

OAR 690-086-0170(6) requires a quantification of the maximum rate of withdrawal and maximum monthly use if expansion or initial diversion of water allocated under an existing permit is necessary to meet demands in the 20-year planning horizon. Although extensions of time for Permits S-49823 and G-11379 have not yet been approved, The City anticipates expanding its use under Permits S-49823 and G-11379 during the 20-year planning horizon.

Assuming the 2.8 cfs undeveloped portion of Permit S-49823 is used at the maximum rate for 24 hours per day over 31 days during the maximum demand month, the maximum monthly volume of use would be approximately 56.1 MG.

The City projects that by 2041, the 1.49 cfs undeveloped portion of Permit G-11379 will be required to meet maximum operational demands. Assuming this 1.49 cfs is used at the maximum rate for 24 hours per day over 31 days during the maximum demand month, the maximum monthly volume of use would be approximately 29.9 mgd.

5.7 Mitigation Actions under State and Federal Law

OAR 690-086-0170(7)

Under OAR 690-086-0170(7), for expanded or initial diversion of water under an existing permit, the water supplier is to describe mitigation actions it is taking to comply with legal requirements of the Endangered Species Act, Clean Water Act, and other applicable state or federal environmental regulations. As described above, the City's SUP (BEN1158) for the operation of the Bend Municipal Watershed facilities limits the City's diversion rate to no more than 18.2 cfs, however, the City currently is not required to take any mitigation actions under federal law.

The City must provide mitigation credits as part of the Deschutes Basin Groundwater Mitigation Program to offset the impacts to surface water from use of groundwater under Permit G-18123 and G-18124. The City has an approved incremental mitigation plan on file with OWRD and will continue to use water under these two permits in compliance with the mitigation plan.

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Appendix A

City Request for Comment and Comments Received on Draft WMCP

GSI Water Solutions, Inc.
1600 SW Western Blvd.
Suite 240
Corvallis, OR 97333

November 16, 2020

Peter Gutowsky
Planning Manager
Deschutes County Community Development
117 NW Lafayette Avenue
Bend, OR 97703

Subject: Water Management and Conservation Plan for the City of Bend

To whom it may concern:

The City of Bend Utility Department has developed a Draft Water Management and Conservation Plan. The City has prepared this plan to fulfill the requirements of Oregon Administrative Rule Chapter 690, Division 86 of the Oregon Water Resources Department (OWRD).

Under these rules, a water supplier is required to make its draft plan available for review by each affected local government and seek comments relating to consistency with the local governments' comprehensive land use plans.

Please provide comments to me within 30 days from the date of this letter. If the plan appears consistent with your Agency's Comprehensive Land Use Plan, a letter response to that effect would be appreciated. You may send your comments to me at the address on this letterhead or e-mail them to me directly at: omcmurtrey@gsiws.com

If you have any questions, please feel free to contact me at 541-257-9005. Thank you for your interest.

Sincerely,

Owen McMurtrey

Owen McMurtrey
GSI Water Solutions, Inc.

Owen McMurtrey

From: Peter Gutowsky <Peter.Gutowsky@deschutes.org>
Sent: Tuesday, November 17, 2020 1:18 PM
To: Owen McMurtrey
Cc: Adam Sussman; Suzanne de Szoeke; Katherina Barguil
Subject: RE: Water Management and Conservation Plan for the City of Bend

Owen,

Yes, Tree Farm and Miller Tree Farm are the same. Westgate is the first plat recorded in the Westside Transect Zone. The City of Bend agreed to serve this development and other lands within the zone with municipal water.

Peter Gutowsky, AICP | Planning Manager
DESCHUTES COUNTY COMMUNITY DEVELOPMENT
117 NW Lafayette Avenue | Bend, Oregon 97703
Tel: (541) 385-1709

Enhancing the lives of citizens by delivering quality services in a cost-effective manner.

From: Owen McMurtrey <OMcMurtrey@gsiws.com>
Sent: Tuesday, November 17, 2020 12:08 PM
To: Peter Gutowsky <Peter.Gutowsky@deschutes.org>
Cc: Adam Sussman <asussman@gsiws.com>; Suzanne de Szoeke <SDeSzoeke@gsiws.com>; Katherina Barguil <kbarguil@bendoregon.gov>
Subject: RE: Water Management and Conservation Plan for the City of Bend

[EXTERNAL EMAIL]

Thanks for the quick response Peter,

I had to look up the Westside Transect Zone, but I see what you mean. As those areas are outside the UGB, and there is no water supply contract in place, the City did not address them as part of their projected water demands or water service population. The current Plan does address the provision of water to what we call “The Tree Farm,” which I believe is equivalent to Miller Tree Farm, south and west of the south transect property, outside the UGB, as the City already serves water to that rural residential neighborhood. The Plan identifies this as a water supply contract in section 2.4, along with provision of water to Tetherow, but these do not factor significantly in the water demand projections. The City’s next WMCP will be due in 2030 or 2031.

Thanks,

Owen

Owen McMurtrey
Water Resources Consultant
direct: 541.257.9005 | mobile: 541.740.5619
1600 SW Western Boulevard, Suite 240, Corvallis, OR 97333
GSI Water Solutions, Inc. | www.gsiws.com

Please note: GSI is open for business, although most of us are working remotely. I'm available by phone or email, as always.

From: Peter Gutowsky [mailto:Peter.Gutowsky@deschutes.org]
Sent: Tuesday, November 17, 2020 8:21 AM
To: Owen McMurtrey <OMcMurtrey@gsiws.com>
Cc: Adam Sussman <asussman@gsiws.com>; Suzanne de Szoeke <SDeSzoeke@gsiws.com>; Katherina Barguil <kbarguil@bendoregon.gov>
Subject: RE: Water Management and Conservation Plan for the City of Bend

Owen,

Thanks for the opportunity to review the WMCP. The Deschutes County Planning Division has no comments.

Just a fyi. The next iteration of the WMCP will likely need to address two rural residential areas served by Bend municipal water: Miller Tree Farm and the Westside Transect Zone (example: Westgate).

Peter Gutowsky, AICP | Planning Manager
DESCHUTES COUNTY COMMUNITY DEVELOPMENT
117 NW Lafayette Avenue | Bend, Oregon 97703
Tel: (541) 385-1709

Enhancing the lives of citizens by delivering quality services in a cost-effective manner.

From: Owen McMurtrey <OMcMurtrey@gsiws.com>
Sent: Monday, November 16, 2020 6:19 PM
To: Peter Gutowsky <Peter.Gutowsky@deschutes.org>
Cc: Adam Sussman <asussman@gsiws.com>; Suzanne de Szoeke <SDeSzoeke@gsiws.com>; Katherina Barguil <kbarguil@bendoregon.gov>
Subject: Water Management and Conservation Plan for the City of Bend

[EXTERNAL EMAIL]

Hi Peter,

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Under these rules, a water supplier is required to make its draft plan available for review by each affected local government and seek comments relating to consistency with the local governments' comprehensive land use plans.

Please provide comments to me within 30 days from the date of this letter. If the plan appears consistent with your agency's Comprehensive Land Use Plan, a letter or email response to that effect would be appreciated. You may send your comment to me at the address on this letterhead or e-mail them to me directly at: omcmurtrey@gsiws.com

If you have any questions, please feel free to contact me at 541-257-9005 or at 541-740-5619. Thank you.

Sincerely,

Owen McMurtrey
Water Resources Consultant
direct: 541.257.9005 | mobile: 541.740.5619
1600 SW Western Boulevard, Suite 240, Corvallis, OR 97333
GSI Water Solutions, Inc. | www.gsiws.com
Please note: GSI is open for business, although most of us are working remotely. I'm available by phone or email, as always.

Appendix B

M36 Water Audit Reporting Worksheets (2014 through 2019) and Performance Indicators (2019)

AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend / Utility Department	
Reporting Year:	2014	1/2014 - 12/2014
Data Validity Score:	64	

Own Sources (Adjusted for known errors)
4,460.645

Water Imported
0.005

System Input
4,460.650

Water Exported
0.000

Water Supplied
4,460.650

Authorized Consumption
4,370.556

Billed Authorized Consumption
4,358.246

Billed Water Exported

Billed Metered Consumption (water exported is removed)
4,358.246

Billed Unmetered Consumption
0.000

Unbilled Authorized Consumption
12.310

Unbilled Metered Consumption
0.000

Unbilled Unmetered Consumption
12.310

Water Losses
90.094

Apparent Losses
43.948

Unauthorized Consumption
11.152

Customer Metering Inaccuracies
21.901

Systematic Data Handling Errors
10.896

Real Losses
46.146

Leakage on Transmission and/or Distribution Mains
Not broken down

Leakage and Overflows at Utility's Storage Tanks
Not broken down

Leakage on Service Connections
Not broken down

Revenue Water
0.000

Revenue Water
4,358.246

Non-Revenue Water (NRW)
102.404

AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend / Utility Department	
Reporting Year:	2015	1/2015 - 12/2015
Data Validity Score:	64	

Own Sources (Adjusted for known errors)
4,745.630

Water Imported
0.005

System Input
4,745.635

Water Exported
0.000

Water Supplied
4,745.635

Authorized Consumption
4,454.736

Billed Authorized Consumption
4,444.316

Billed Water Exported
Billed Metered Consumption (water exported is removed)
4,444.316

Billed Unmetered Consumption
0.000

Unbilled Authorized Consumption
10.420

Unbilled Metered Consumption
0.000

Unbilled Unmetered Consumption
10.420

Water Losses
290.899

Apparent Losses
45.308

Unauthorized Consumption
11.864

Customer Metering Inaccuracies
22.333

Systematic Data Handling Errors
11.111

Real Losses
245.591

Leakage on Transmission and/or Distribution Mains
Not broken down

Leakage and Overflows at Utility's Storage Tanks
Not broken down

Leakage on Service Connections
Not broken down

Revenue Water
0.000

Revenue Water
4,444.316

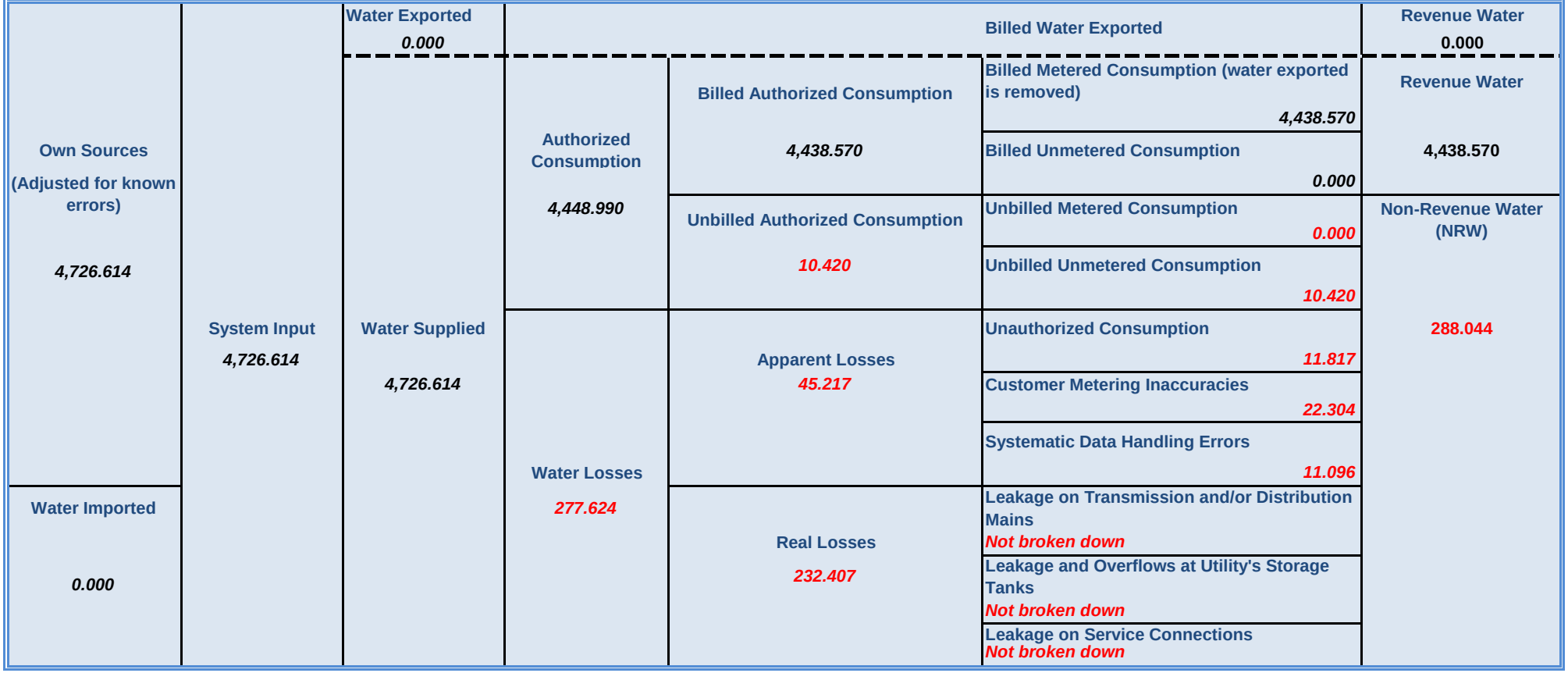
Non-Revenue Water (NRW)
301.319

AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend / Utility Department	
Reporting Year:	2016	1/2016 - 12/2016
Data Validity Score:	65	



AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend / Utility Department	
Reporting Year:	2017	1/2017 - 12/2017
Data Validity Score:	65	

Own Sources (Adjusted for known errors)
4,746.113

Water Imported
0.000

System Input
4,746.113

Water Exported
0.000

Water Supplied
4,746.113

Authorized Consumption
4,452.514

Billed Authorized Consumption
4,440.884

Billed Water Exported
Billed Metered Consumption (water exported is removed)
4,440.884

Billed Unmetered Consumption
0.000

Unbilled Authorized Consumption
11.630

Unbilled Metered Consumption
0.000

Unbilled Unmetered Consumption
11.630

Water Losses
293.599

Apparent Losses
45.283

Unauthorized Consumption
11.865

Customer Metering Inaccuracies
22.316

Systematic Data Handling Errors
11.102

Real Losses
248.316

Leakage on Transmission and/or Distribution Mains
Not broken down

Leakage and Overflows at Utility's Storage Tanks
Not broken down

Leakage on Service Connections
Not broken down

Revenue Water
0.000

Revenue Water
4,440.884

Non-Revenue Water (NRW)
305.229

AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend / Utility Department
Reporting Year:	2018 — 1/2018 - 12/2018
Data Validity Score:	65

Own Sources (Adjusted for known errors)
4,792.910

Water Imported
0.000

System Input
4,792.910

Water Exported
0.000

Water Supplied
4,792.910

Authorized Consumption
4,548.914

Billed Authorized Consumption
4,537.064

Billed Water Exported

Billed Metered Consumption (water exported is removed)
4,537.064

Billed Unmetered Consumption
0.000

Unbilled Authorized Consumption
11.850

Unbilled Metered Consumption
0.000

Unbilled Unmetered Consumption
11.850

Water Losses
243.996

Apparent Losses
46.124

Unauthorized Consumption
11.982

Customer Metering Inaccuracies
22.799

Systematic Data Handling Errors
11.343

Real Losses
197.872

Leakage on Transmission and/or Distribution Mains
Not broken down

Leakage and Overflows at Utility's Storage Tanks
Not broken down

Leakage on Service Connections
Not broken down

Revenue Water
0.000

Revenue Water
4,537.064

Non-Revenue Water (NRW)
255.846

AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend / Utility Department
Reporting Year:	2018 — 1/2018 - 12/2018
Data Validity Score:	65

Own Sources (Adjusted for known errors)
4,792.910

Water Imported
0.000

System Input
4,792.910

Water Exported
0.000

Water Supplied
4,792.910

Authorized Consumption
4,548.914

Billed Authorized Consumption
4,537.064

Billed Water Exported

Billed Metered Consumption (water exported is removed)
4,537.064

Billed Unmetered Consumption
0.000

Unbilled Authorized Consumption
11.850

Unbilled Metered Consumption
0.000

Unbilled Unmetered Consumption
11.850

Water Losses
243.996

Apparent Losses
46.124

Unauthorized Consumption
11.982

Customer Metering Inaccuracies
22.799

Systematic Data Handling Errors
11.343

Real Losses
197.872

Leakage on Transmission and/or Distribution Mains
Not broken down

Leakage and Overflows at Utility's Storage Tanks
Not broken down

Leakage on Service Connections
Not broken down

Revenue Water
0.000

Revenue Water
4,537.064

Non-Revenue Water (NRW)
255.846

AWWA Free Water Audit Software: Water Balance

WAS v5.0

American Water Works Association.

Water Audit Report for:	City of Bend Utility Department	
Reporting Year:	2019	1/2019 - 12/2019
Data Validity Score:	58	

		Water Exported *0.000*			Billed Water Exported	Revenue Water 0.000
Own Sources (Adjusted for known errors) *4,369.733*	System Input *4,369.733*	Water Supplied *4,369.733*	Authorized Consumption *4,118.832*	Billed Authorized Consumption *4,115.920*	Billed Metered Consumption (water exported is removed) *4,115.920*	Revenue Water 4,115.920
					Billed Unmetered Consumption *0.000*	
				Unbilled Authorized Consumption *2.912*	Unbilled Metered Consumption *0.000*	Non-Revenue Water (NRW) 253.813
					Unbilled Unmetered Consumption *2.912*	
			Water Losses *250.901*	Apparent Losses *41.897*	Unauthorized Consumption *10.924*	
					Customer Metering Inaccuracies *20.683*	
					Systematic Data Handling Errors *10.290*	
Water Imported *0.000*				Real Losses *209.004*	Leakage on Transmission and/or Distribution Mains *Not broken down*	
					Leakage and Overflows at Utility's Storage Tanks *Not broken down*	
					Leakage on Service Connections *Not broken down*	

AWWA Free Water Audit Software:
System Attributes and Performance Indicators

Water Audit Report for: City of Bend Utility Department
Reporting Year: 2019 | 1/2019 - 12/2019

*** YOUR WATER AUDIT DATA VALIDITY SCORE IS: 58 out of 100 ***

System Attributes:

	Apparent Losses:	41.897	MG/Yr
+	Real Losses:	209.004	MG/Yr
=	**Water Losses:**	**250.901**	MG/Yr
?	Unavoidable Annual Real Losses (UARL):	171.90	MG/Yr
	Annual cost of Apparent Losses:	$109,771	
	Annual cost of Real Losses:	$48,451	Valued at **Variable Production Cost**

Return to Reporting Worksheet to change this assumpiton

Performance Indicators:

Financial:	Non-revenue water as percent by volume of Water Supplied:	5.8%	
	Non-revenue water as percent by cost of operating system:	0.9%	Real Losses valued at Variable Production Cost
Operational Efficiency:	Apparent Losses per service connection per day:	4.00	gallons/connection/day
	Real Losses per service connection per day:	19.94	gallons/connection/day
	Real Losses per length of main per day*:	N/A	
	Real Losses per service connection per day per psi pressure:	0.29	gallons/connection/day/psi
	From Above, Real Losses = Current Annual Real Losses (CARL):	209.00	million gallons/year
?	Infrastructure Leakage Index (ILI) [CARL/UARL]:	1.22	

* This performance indicator applies for systems with a low service connection density of less than 32 service connections/mile of pipeline

Appendix C

DSS Model Report

City of Bend, Oregon

Water Conservation Program Water Savings and Cost-effectiveness Analysis

Water Management and Conservation Plan Version

December 2020

Prepared by:
GSI Water Solutions, Inc.
1600 SW Western Boulevard, Suite 240, Corvallis, OR 97333

MADDAUS WATER MANAGEMENT INC.

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Contents

Exhibits

Abbreviations and Acronyms

cfs	cubic feet per second
DSS Model	Demand Side Management Least Cost Planning Decision Support System
gpf	gallons per flush
gpm	gallons per minute
HEW	high-efficiency washer
IWSMP	Integrated Water System Master Plan
MDD	maximum day demand
MG	million gallons
mgd	million gallons per day
MGY	million gallons per year
PV	present value
WMCP	Water Conservation and Management Plan

SECTION 1: **Executive Summary**

1.1 Introduction

In an effort to find the most cost-effective approach to meeting water demands over the next 20 years, the City of Bend, Oregon (City) has been developing an Integrated Water System Master Plan (IWSMP) that incorporates analyses of the City's water supply sources, water system infrastructure, water demand projections, and water conservation potential. To determine its water conservation potential, the City conducted a water conservation program water savings and cost-effectiveness analysis. GSI Water Solutions, Inc. (GSI), partnered with Maddaus Water Management, Inc. (Maddaus), to help the City conduct the water savings and cost-effectiveness analysis utilizing Maddaus' Demand Side Management Least Cost Planning Decision Support System (DSS Model). The City evaluated 16 individual water conservation measures and three water conservation programs consisting of different combinations of water conservation measures. The objective of the analysis was to identify a cost-effective water conservation program aimed at reducing water demand in the peak summer season and to estimate water savings produced by that program. This analysis allowed the City to subsequently determine the extent to which development of water system infrastructure could be avoided over the next 20 years.

1.2 Water Savings and Cost-effectiveness Analysis Results Summary

The City analyzed three water conservation programs: Program A, consisting of outdoor water conservation measures plus one measure contributing to indoor and outdoor water conservation; Program B, consisting of only indoor water conservation measures; and Program C, consisting of a combination of indoor and outdoor water conservation measures. These programs contained measures that the City determined it would most likely implement based on initial analysis of 16 individual measures. Program C is a more diverse and extensive approach to conserving water through indoor and outdoor measures, which is also consistent with how the City has been encouraging water conservation in recent years. Program C had the greatest water savings of the three programs as well. Consequently, the City determined that Program C is its preferred program.

Program C consists of 11 water conservation measures: 6 outdoor measures, 1 indoor and outdoor measure, and 4 indoor measures. Nearly all of the measures would be new initiatives for the City, except for the outdoor water surveys and the free faucet aerators and showerheads measures.

Exhibit 1 presents Program C water conservation measures and identifies them as indoor or outdoor and current or new measures.

Exhibit 1. Program C Water Conservation Measures

Conservation Measure	Outdoor (O) or Indoor (I)	Current (C) or New (N)
Retrofit on resale or account change ordinance	I	N
High-efficiency toilet rebate	I	N
Free faucet aerators and showerheads	I	C
Indoor plumbing fixture ordinance	I	N
Landscape and irrigation ordinance	O	N
Outdoor water surveys	O	C
Weather-based irrigation controller rebate	O	N
Pressure-regulation rebate	O, I	N
Drip irrigation kits	O	N
Rotating sprinkler nozzles rebate	O	N
Pressure-regulating sprinkler bodies rebate	O	N

Program C is projected to result in a total of 7,939 million gallons (MG) in water savings from 2020 through 2040. In 2040, Program C is projected to result in 558.7 MG in outdoor water savings, concentrated during the irrigation season of April through October, and 121.6 MG in indoor water savings, spread out equally throughout the year. The estimated present value cost to the City (utility cost) of Program C from 2020 through 2040 is approximately $11 million total.

The results of the water savings and cost-effectiveness analysis are intended to do the following:

- Guide the City's decision-making about the water conservation measures to include in its water conservation program moving forward. These results are also intended to help the City develop new 5-year water conservation benchmarks for its Water Management and Conservation Plan update in 2020.
- Inform the City's water infrastructure planning process. The City is in the process of developing an IWSMP, and the results of the water savings and cost-effectiveness analysis can help the City estimate infrastructure that it could avoid building due to potential water savings.

Implications of Results on Infrastructure Planning

GSI used the 2040 Program C indoor and outdoor water savings results to calculate that Program C would result in water savings of 5.1 million gallons per day (mgd) (7.9 cubic feet per second [cfs]; 3,540 gpm) in a maximum-day demand (MDD) scenario in 2040. The methodology used to estimate the reduction in MDD is described in greater detail in Section 4.3. The projected MDD drives the need for development of new wells and reservoirs; therefore reductions in the MDD can affect the City's projected infrastructure needs.

The City is assuming that future new wells would have production rates of 1,150 gpm for its IWSMP, which means the projected MDD water savings of 5.1 mgd (equivalent to 3,540 gpm over 24 hours) would eliminate the need to construct three wells (as well as one aboveground reservoir) saving approximately $21 million over the next 20 years. In addition, operational costs, such as the cost to pump water, would also be avoided. Thus, the $11 million estimated cost of producing those water savings is far less than the $21 million that would be needed to meet the MDD in 2040 without conservation.

SECTION 2: **DSS Model Overview**

2.1.1 DSS Model Background

The City's water savings and cost-effectiveness analysis used the Maddaus' Demand Side Management Least Cost Planning Decision Support System (DSS Model).

The DSS Model:

- Prepares short- and long-range detailed water demand and conservation water savings projections to quantify the estimated impact of water conservation programs on demand over time.
  - The analysis can use either a statistical approach to forecast demands (e.g., an econometric model) or forecasted increases in population and employment to evaluate future demands.
- Is an end-use model that breaks down total water production (i.e., water demand in the service area) into specific water end-uses (e.g., toilets, faucets, irrigation) to more accurately assess the impact of water conservation programs on demand.
  - This "bottom-up" approach allows for detailed criteria to be considered when estimating future demands, such as the effects of natural fixture replacement, plumbing codes, and conservation efforts.
- Evaluates conservation measures using a benefit-cost analysis, with the economic indicators being present value of the cost of water saved and benefit-to-cost ratio.
  - The utility and the community (i.e., utility plus its customers) perspectives are included in the analysis.
- Compares the present value of water savings, present value of utility costs, and benefit-to-cost ratio of different conservation programs, which are constituted of individual conservation measures.
- Takes into account savings from passive conservation in its demand projections.
  - Passive conservation refers to water savings resulting from customer actions and activities that do not depend on direct assistance from a utility's water conservation programs. This includes water savings resulting from the following:
    1. The natural replacement of existing plumbing fixtures with water-efficient models required under current plumbing code standards
    2. The installation of water-efficient fixtures in new buildings and retrofits as required under federal and state law

The DSS Model involves three major steps to arrive at the results: data collection, a demand analysis, and a conservation analysis.

- **Data Collection**
  - Data collected include historical surface water and groundwater production (i.e., demand), historical consumption, historical population levels, census housing characteristics, as well as growth projections.

- **Demand Analysis**
  - Develops demand projections by incorporating the following:
    - Data collected as described above
    - A base-year profile for projections based on historical data and professional judgment
    - A percentage breakdown of end uses by customer categories
    - Water fixtures' average water use, useful life, and replacement rates
    - Current and future proportional use of fixtures by different water efficiencies for plumbing fixtures with codes/standards
- **Conservation Analysis**
  - Develops conservation measure and conservation program benefit-cost information, as well as demand projections with conservation, by incorporating the following:
    - Results of the demand analysis described above
    - Avoided costs (e.g., the cost of construction of new wells and associated reservoirs, assuming some costs are "sunk costs" that would be incurred regardless of water conservation)
    - Inflation rates
    - Assumptions about conservation measures, including the following:
      - Period of implementation
      - Measure life (i.e. how long the savings are expected to continue)
      - Measure costs for the utility and customer as well as administrative costs
      - End uses affected by the measure, by customer category
      - Percent end use savings per account
      - Percent of accounts targeted per year or number of accounts targeted per year

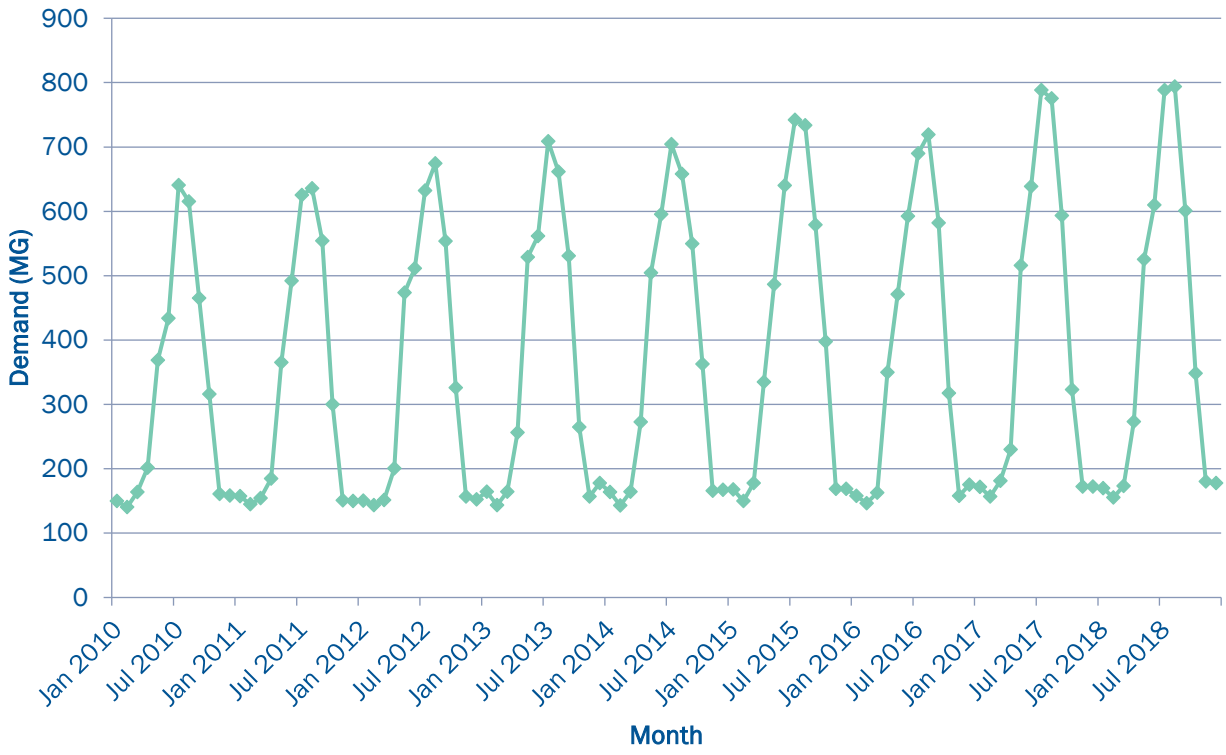
More details about the DSS Model are provided in the full Water Savings and Cost-effectiveness Report.

2.1.2 Model Inputs and Assumptions

2.1.2.1 Historical Production and Consumption

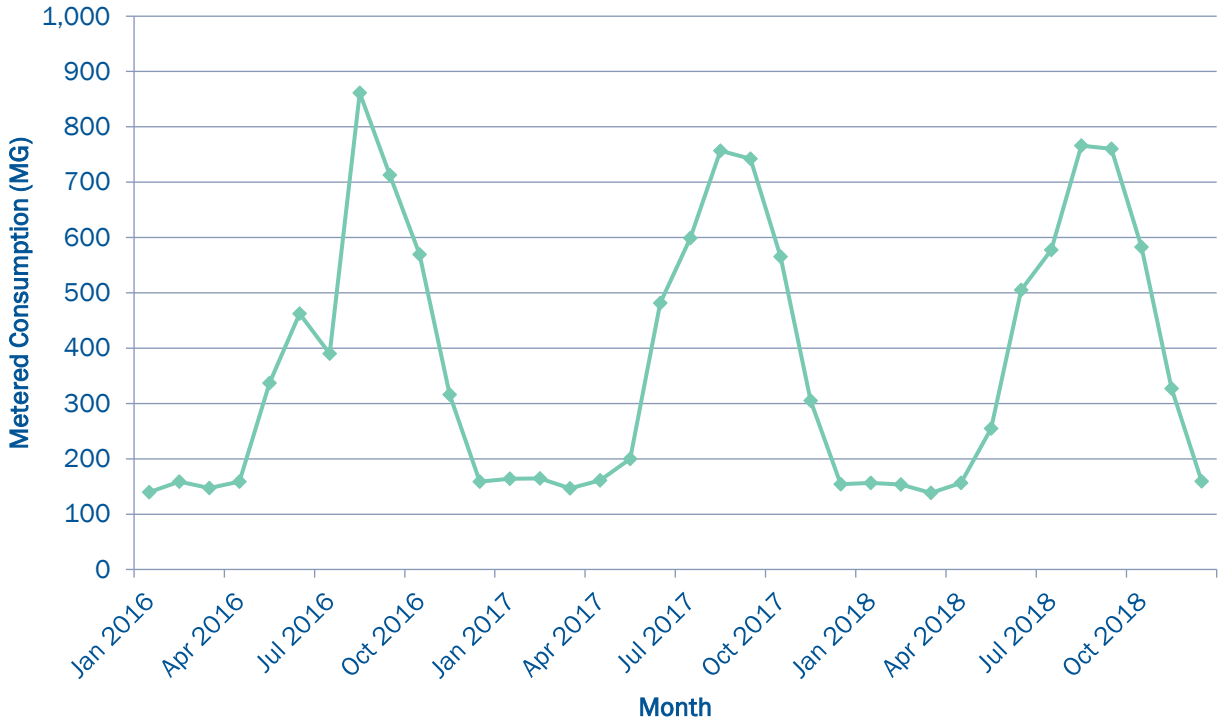
The DSS Model uses historical surface water and groundwater production data (i.e., demand) and historical metered consumption data in its demand projections. The City provided historical surface water and groundwater demand data from 2010 through 2018. **Exhibit 2** shows historical monthly demand.

Exhibit 2. Historical Total Monthly Demand, 2010–2018



Historical monthly metered consumption is presented in **Exhibit 3**. The metered consumption data used in the DSS Model spans from January 2016 through December 2018, which are the most recent years with complete data available for consumption and number of accounts. The DSS Model also included analyses of water consumption by customer category, which are described below. The City's five customer categories are single family residential, multi-family residential, commercial, irrigation, and hydrant meters.

Exhibit 3. Historical Total Monthly Metered Consumption, 2016–2018



2.1.2.3 Inputs and Assumptions for Demand Projections

A number of assumptions and inputs are used to develop the DSS Model demand projections, which are outlined in Exhibit 4. Some of the parameters refer to a "start" (i.e., base) year, meaning the first year of the projections. The start year forms the foundation of subsequent annual demand projections. The City of Bend Utility Department reviewed these assumptions and considers them reasonable.

Exhibit 4. DSS Model Input Values and Assumptions

Parameter	Model Input Values and Assumptions
Model start year for conservation analysis	2019
Water demand factor year (start year for demand projections)	Annual demand in 2018 represents the total start year demand in 2019 (4,796 MG)
Start year accounts by category	2018 accounts data
Non-revenue water in start year	5.4 percent (2018)[1]
Population projection source	Draft IWSMP (2020), developed by Murraysmith ▪ Population projection represents the service area population (approximately 75 percent of the City of Bend UGB population)
Start year customer category consumption breakdown ▪ Consumption percentage and consumption volume per account	2018 consumption data ▪ Customer categories: single family residential, multi-family residential, commercial, irrigation only, and hydrant meters
Start year customer category indoor consumption percent breakdown	Single family residential, multi-family residential, and commercial: 2018 (lowest months) Irrigation only and hydrant meters: Categorized as outdoor use only, so not included in indoor water use

Notes

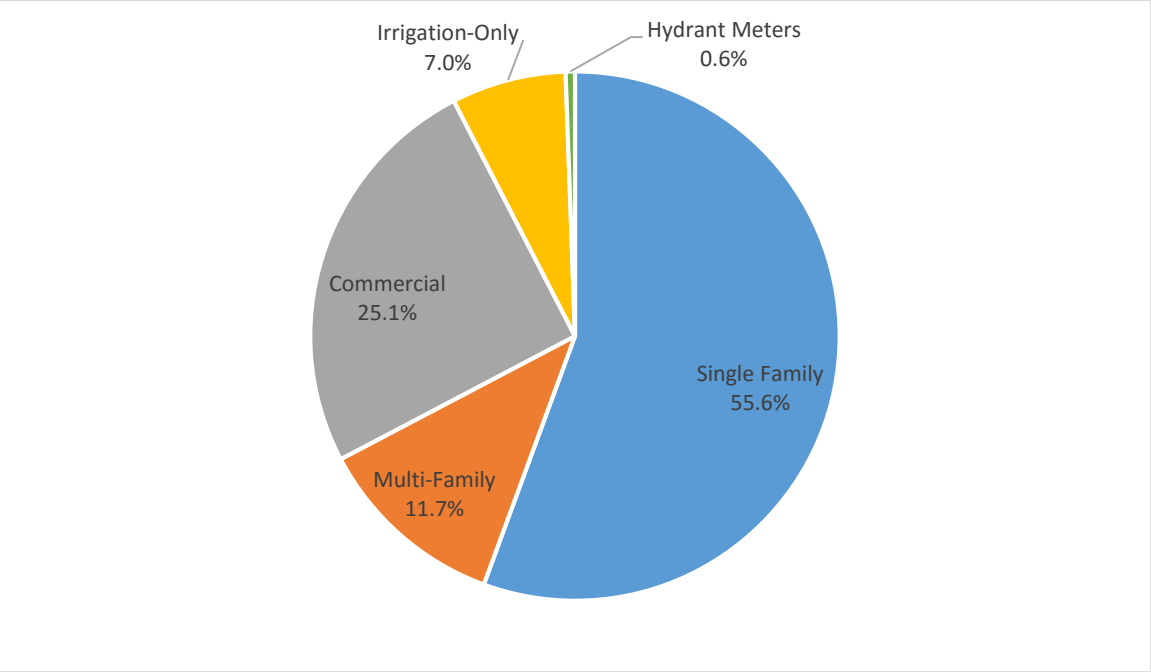
[1]The City's 2018 M36 water audit reported 5.3 percent non-revenue water and 5.1 percent water loss. The non-revenue water input to the model for 2018 was 5.4 percent. The small difference in non-revenue water is attributable to the City's surface water and groundwater production numbers that appear in the 2018 M36 water audit varying slightly from the annual sum of monthly production totals input to the model.

MG = million gallons

UGB = urban growth boundary

The start year is based on 2018 data. The percentage breakdown of metered consumption by customer category in 2018 is shown in **Exhibit 5**.

Exhibit 5. Percent Annual Consumption by Customer Category, 2018



SECTION 3: **Conservation Measures Evaluated**

3.1 Water Conservation Measures Analyzed

The City selected 16 water conservation measures for the water savings and cost-effectiveness analysis, which are described in **Exhibit 6**. The City's process to select these measures involved first reviewing a comprehensive list of water conservation measures created by Maddaus and then selecting indoor and outdoor water conservation measures for which the City wanted more information about the water savings and costs of implementation. All of the chosen measures were new measures except for the outdoor water audits and free faucet aerators and showerheads. The selection was based on institutional knowledge of the City's existing water conservation program and water management efforts, City resources, and customer water use. The City was especially interested in measures that provide a financial incentive to customers to voluntarily reduce water use, particularly in the peak season given that MDD is the primary driver for additional infrastructure needs.

The City staff were also interested in ordinances that require water fixtures have greater indoor and outdoor water use efficiency, which are considered an important component of a water conservation program in the water industry, as evidenced by feedback the City received from the Alliance for Water Efficiency. In 2017, the City's Water Conservation Program successfully achieved a Silver Rating from the Alliance for Water Efficiency for meeting the American Water Works Association (AWWA) G480 Water Conservation Program Operation and Management Standard. The Alliance for Water Efficiency explained that the City did not achieve a Gold or Platinum Rating (the highest ratings) due to the need for City building codes or ordinances that do more to promote water conservation. While the Bend Code addresses water waste, irrigation timing, and efficient use in public projects under its Engineering Standards and Specifications, it does not address water efficiency of indoor water and outdoor water fixtures and landscaping in private development.

The City chose to exclude some of the water conservation measures that it is currently implementing (e.g., AMI with WaterSmart Software; annual water audits using the AWWA M36 methodology; water conservation communications; and public outreach events, such as workshops for landscapers), because some of the excluded measures were too complex to analyze and the City requires more data regarding water savings outcomes for other measures.

Exhibit 6. Water Conservation Measures Analyzed

	Measure	Description
1	Clothes Washer Rebate - Residential	Provide a rebate for EPA ENERGY STAR-labeled washing machines to single family homes and apartment complexes that have common laundry rooms. It is assumed that the rebates would remain consistent with relevant state and federal regulations (i.e., the U.S. Department of Energy and EPA ENERGY STAR) and only offer the best available technology. Only applicable on eligible models and for replacing an existing high-water-using washer.
2	Clothes Washer Rebate - Commercial	Provide a rebate for the installation of a high-efficiency commercial washer (HEW). Rebate amounts would reflect the incremental purchase cost.
3	Retrofit on Resale or Account Change Ordinance	Require installation of WaterSense-approved fixtures in conjunction with any construction that requires a permit or in the course of resale of the property: lavatory faucets that flow at no more than 1.0 gpm (public restrooms are 0.5 gpm), kitchen faucets no more than 1.8 gpm, showerheads no more than 1.5 gpm, urinals no more than 0.125 gpf, and toilets no more than 1.28 gpf. Work with the real estate industry to require a certificate of compliance be submitted to the City that verifies that a qualified inspector has inspected the property and water-efficient fixtures were either already there or were installed before close of escrow.
4	High-efficiency Toilet Rebate	Provide customers a rebate for replacing a toilet that uses 1.6 gpf or more with an EPA WaterSense-approved ultra-high-efficiency toilet that uses 1.28 gpf or less. For single family, multi-family, and commercial customers.
5	High-efficiency Urinal Rebate	Provide a rebate to commercial customers for the installation of a high-efficiency urinal (0.125 gpf). The WaterSense standard is 0.5 gpf or less, although models flushing as low as 0.125 gpf are available and function well. Rebate amounts would reflect the incremental purchase cost and have been about $100.
6	Free Faucet Aerators and Showerheads	Provide free water-efficient showerheads (1.5 gpm) and faucet aerators (1.5 gpm for bathrooms and kitchens) to single family, multi-family, and commercial customers by mail upon customer request or as a prize for signing up for WaterSmart. (This is an existing water conservation measure; the fixtures are distributed in the indoor water conservation kits.)
7	Indoor Plumbing Fixture Ordinance	Require developers to install the following WaterSense-approved fixtures in new developments: lavatory faucets that flow at no more than 1.0 gpm (public restrooms are 0.5 gpm), kitchen faucets no more than 1.8 gpm, showerheads no more than 1.5 gpm, urinals no more than 0.125 gpf, and toilets no more than 1.28 gpf. Work with the real estate industry to require a certificate of compliance be submitted to the City that verifies that the property has been inspected and water-efficient fixtures were installed before close of escrow.
8	Turf Removal Rebate	Provide single family customers a $1-per-square-foot rebate (up to $2,000) to remove turf and replace it with low-water-use plants, mulch, or permeable hardscape. Rebates are confirmed with site visits.
9	Landscape and Irrigation Ordinance	Develop and enforce Water Efficient Landscape Design Standards. Standards specify that new development projects and renovations of existing units subject to design review be landscaped according to water-efficient best management practices including, appropriate plant selection and placement, water-efficient irrigation systems, and smart irrigation controllers. The ordinance could require certification of landscape professionals.

	Measure	Description
10	Outdoor Water Surveys	Provide free landscape water surveys to existing single family and multi-family residential customers upon request and to high-water-use single family and multi-family customers identified by the City. The City provides a customized report (a water budget generated using WaterSmart Software)[1] to the customer on how to save water. The water budget will be updated annually based on the lot square footage and weather. No devices will be given away as part of this program. (This is an existing water conservation measure; these surveys are provided under the Sprinkler Inspection Program and the Large Landscape Program.)
11	Weather-based Irrigation Controller Rebate	Provide a rebate of $100 for the purchase of a WaterSense approved weather-based irrigation controller. These controllers have on-site weather sensors or rely on a signal from a central weather station that modifies irrigation times at least weekly.
12	Pressure Regulation Rebate	Provide a $100 rebate for the installation of an in-line pressure regulator. This device is meant to regulate the incoming service pressure to the entire property affecting indoor and outdoor end uses, such as faucets, showers, clothes washers, and irrigation.
13	Drip Irrigation Kits	Offer free drip irrigation kits to single family residential customers.
14	Rotating Sprinkler Nozzles Rebates	Provide rebates to replace standard spray sprinkler nozzles with high-efficiency nozzles. Rebates will be $4 per nozzle up to a maximum purchase of 20 nozzles.
15	Soil Amendment Rebate	Provide a $70 rebate for irrigated areas to have soil amended to be more water-efficient (covers the cost of delivery but could cover soil costs if customers pick up the soil themselves).
16	Pressure-regulating Sprinkler Bodies Rebate	Rebate customers $3 per pressure-regulating sprinkler body (e.g., Rainbird PRS/Hunter PR40 or similar) to regulate pressure at the sprinkler head on individual irrigation zones.

Notes:

[1] The City of Bend partners with WaterSmart Software to provide customers with the ability to track their water use, receive notifications of potential leaks, and compare their use with other similar customers. More information is available at the City of Bend website, https://www.bendoregon.gov/government/departments/utilities/watersmart-software-2867. (Accessed November 24, 2020.)

3.2 Conservation Measure Analysis

This subsection presents the assumptions and calculations used to analyze each conservation measure described above.

Assumptions

The DSS Model conservation measure analysis involved making assumptions about the following variables for each conservation measure:

- **Targeted water user group end use**
  - End uses (e.g., indoor or outdoor water uses) of each water user group (e.g., single family residential).

- **Utility unit cost**
  - Cost of rebates, incentives, materials/technology, and contractors hired to implement measures.
- **Retail customer unit cost**
  - Cost for implementing measures that is paid by retail customers, which consists of the portion of a measure's cost not covered by a City rebate or incentive.
- **Utility administration and marketing cost**
  - Cost to the utility for administering the measure, including staff time, consultant contract administration, marketing, participant tracking, general expenses, and overhead.

The City of Bend Utility Department reviewed these assumptions and considered them reasonable. The full Water Savings and Cost-effectiveness Analysis Report provides details about each conservation measure, including comments describing assumptions about end use percent water savings per account and fixture costs. As a whole, assumptions about a water conservation measure's end use percent water savings per account, fixture costs, percentage of accounts targeted per year, and period of measure implementation are based on empirical data, field experience, online research, and/or professional judgment.

Calculations

Below are formulas the DSS Model uses to calculate measure costs:

- Annual utility cost = annual market penetration rate (i.e., percentage of accounts targeted per year) x total accounts in category x unit cost per account x (1 + administration and marketing markup percentage)
- Annual customer cost = annual number of participants x unit customer cost
- Annual community cost = annual utility cost + annual customer cost

Analyses

The full Water Savings and Cost-effectiveness Analysis report contains additional information about DSS Model analyses, as well as key references.

3.3 Comparison of Water Conservation Measures

The DSS Model calculated water savings, present value costs, and present value benefits for each conservation measure in 2040, corresponding with the 20-year planning period of the IWSMP and WMCP. Exhibit 7 presents the values used by the City in its decision-making of measures to include in the individual program analysis.

Parameters Analyzed by the DSS Model

The following are parameters included in the DSS Model and Exhibit 7:

- **Present value utility costs:** the present value of the 20-year (2020 through 2040) stream of annual costs discounted to the base year.
  - **Utility costs:** the costs that the City's water utility will incur to operate the water conservation measure/program, including administrative costs and staff time.
- **Present value community costs:** the present value of the 20-year (2020 through 2040) stream of annual costs discounted to the base year.
  - **Community costs:** utility costs plus customer costs, with customer costs being the costs customers will incur to implement a water conservation measure and maintain its effectiveness over the life of

the measure(s). Community costs were not evaluated outside of the DSS Model and values from the DSS Model were not used by the City.

- **Five years of water utility costs (2023 through 2028) ($):** the sum of the annual utility costs for the years from 2023 to 2028. The year 2023 is the first year when all measures are implemented. Note that some measures start before 2023. The measures start in the years as specified for each measure shown in the full Water Savings and Cost-effectiveness Analysis report.
- **Water savings in 2040 (MGY):** water saved in million gallons per year (MGY). The year 2040 is provided, as both the City's IWSMP and WMCP have 20-year planning periods.
- **Utility cost of water savings ($/MG):** present value of utility costs over 20 years divided by the 20-year water savings. The analysis period is 2020 through 2040. This value is compared to the City's avoided cost of water as one indicator of the cost-effectiveness of conservation efforts. It should be noted that the value somewhat undervalues the cost of savings because program costs are discounted to present value and the water benefit is not.

The following are additional parameters included in the DSS Model:

- **Present value utility benefits:** the present value of the 20-year (2020 through 2040) time stream of annual benefits discounted to the base year.
  - **Utility benefits:** the avoided future costs of producing water (including operational and avoided infrastructure costs). However, instead of using utility benefits calculated by the DSS Model, utility benefits were evaluated outside of the DSS model and included consideration of avoided infrastructure costs only, information generated by Murraysmith as part of the IWSMP.
- **Present value community benefits:** the present value of the 20-year (2020 through 2040) time stream of annual benefits discounted to the base year.
  - **Community benefits:** utility benefits plus customer benefits, with customer benefits being the savings other than from reduced water/sewer utility bills, such as energy savings resulting from reduced use of hot water. Conservation program participants will see lower water and sewer bills, but in general, there will be no net customer benefit. Community benefits were not evaluated outside of the DSS Model and values from the DSS Model were not used by the City.
- **Water utility benefit to cost ratio:** present value of utility costs divided by present value (PV) of Utility Benefits over 20 years (2020 through 2040).
- **Community benefit to cost ratio:** (PV of Utility Benefits plus PV of customer energy savings) divided by (sum of PV of Utility Costs plus PV of Customer Costs), over 20 years (2020 through 2040).

Important Points about DSS Model Conservation Measures Results

- These results do not incorporate savings associated with the plumbing code.
- The conservation measures results assume the measures are independent of each other.
  - The present value benefits are the cost of saved water per unit volume if the conservation measures were implemented on a standalone basis (without interaction or overlap from other conservation measures that may address the same end use[s]).
  - Given that the interactions between conservation measures have not been considered in the comparison, totals have not been included at the bottom of Exhibit 7 to avoid double counting water savings estimates.
  - Given that savings from measures that address the same end use(s) are not additive, the conservation program analysis later in this report does consider interactions between conservation measures.

- The DSS Model uses impact factors to avoid double counting in estimating the water savings from programs of measures.
- For example, if two measures are planned to address the same end use and both save 10 percent of the prior water use, then the net effect is not the simple sum (20 percent). Rather, it is the cumulative impact of the first measure reducing the use to 90 percent of use without the first measure in place, then reducing the use another 10 percent, resulting in the use being 81 percent of what it was originally. In this example the net savings is 19 percent, not 20 percent. Using impact factors, the model computes the reduction in the example as follows, 0.9 x 0.9 = 0.81, or 19 percent water savings.

Exhibit 7. Comparison of Water Conservation Measures

	Measure	Present Value of Water Utility Costs	5 Years of Water Utility Costs 2023-2028	Water Savings in 2040 (MG per Year)	Utility Cost of Water Savings per Unit Volume ($/MG)
1	Clothes Washer Rebate - Residential	$141,419	$15,760	0.003838	$9,796
2	Clothes Washer Rebate - Commercial	$48,276	$5,380	0.004926	$2,824
3	Retrofit on Resale or Account Change	$214,059	$115,200	0.113560	$355
4	High-efficiency Toilet Rebate	$552,985	$297,600	0.065457	$1,581
5	High-efficiency Urinal Rebate	$37,710	$12,390	0.003551	$2,179
6	Free Faucet Aerators and Showerheads	$212,330	$51,982	0.030052	$1,789
7	Indoor Plumbing Fixture Ordinance	$3,113,304	$1,633,138	0.130752	$4,522
8	Turf Removal Rebate	$1,915,590	$524,000	0.048621	$9,380
9	Landscape and Irrigation Ordinance	$4,983,654	$1,539,508	0.747737	$1,908
10	Outdoor Water Surveys	$573,351	$150,000	0.026313	$3,140
11	Weather-based Irrigation Controller Rebates	$685,325	$212,000	0.660652	$299
12	Pressure Regulation Rebate	$119,665	$64,400	0.021709	$525
13	Drip Irrigation Kits	$91,049	$49,000	0.007480	$1,169
14	Rotating Sprinkler Nozzle Rebate	$259,983	$131,812	0.053226	$508
15	Soil Amendment Rebate	$282,439	$152,000	0.110109	$520
16	Pressure-regulating Sprinkler Bodies Rebate	$265,347	$110,852	0.055414	$507

SECTION 4: **Conservation Program Evaluation**

4.1 Conservation Program Descriptions

The DSS Model analyzed three water conservation programs (Programs A, B, and C) consisting of different combinations of the 16 individual conservation measures presented in the previous section. The City chose to compare a program with outdoor water conservation measures plus one measure that conserves water indoors and outdoors (Program A), a program with only indoor water conservation measures (Program B), and a program with a combination of the City's preferred indoor and outdoor water conservation measures (Program C).

Regardless of whether the measure was an indoor measure or outdoor measure, the City decided not to include individual measures with low returns on investment. For example, the City chose not to include four measures in any of the programs: clothes washer rebates for residential customers, high efficiency urinal rebates, turf removal rebates, and soil amendment rebates.

Descriptions of each program and the measures that comprise each program are presented in **Exhibit 8**. A breakdown of whether the conservation measures selected for each conservation program are indoor ("I") or outdoor ("O") measures and are existing ("E") or new ("N") measures is presented in **Exhibit 9**.

Exhibit 8. Descriptions of Conservation Programs

Conservation Program	Program Description

Program A	▪ Outdoor water conservation measures only, except for one measure with dual indoor and outdoor benefits
	▪ Seven measures, including one existing measure (outdoor water surveys) and six new measures:
	  ▪ One giveaway of a free drip irrigation kit
	  ▪ One ordinance addressing water-efficiency of landscapes and irrigation
	  ▪ Three rebates to increase irrigation system water-efficiency
	  ▪ One pressure regulation rebate that conserves water indoors and outdoors

Program B	▪ Indoor water conservation measures only
	▪ Five measures, including one existing measure (free faucet aerators and showerheads, which are made available in the City's free indoor water conservation kits), and four new measures:
	  ▪ Two rebates to encourage replacement of inefficient commercial clothes washers and toilets (for residential and commercial customers)
	  ▪ Two ordinances focused on ensuring that new homes, existing homes for resale or having any construction that requires a permit, and homes with changing accounts have water-efficient fixtures (e.g., faucet aerators, showerheads, and toilets)

Program C	▪ A combination of outdoor and indoor water conservation measures preferred by the City
	▪ Eleven measures consisting of two existing measures and nine new measures:
	  ▪ Four indoor-only water conservation measures:
	  ▪ One giveaway of free faucet aerators and showerheads (existing measure)
	  ▪ One rebate to increase toilet water efficiency
	  ▪ Two ordinances focused on ensuring that new homes, existing homes for resale or having any construction that requires a permit, and homes with changing accounts have water-efficient fixtures (e.g., faucet aerators, showerheads, and toilets)
	  ▪ Six outdoor-only water conservation measures:
	  ▪ Outdoor water surveys (existing measure)
	  ▪ One giveaway of free drip irrigation kits
	  ▪ One ordinance addressing water-efficiency of landscapes and irrigation
	  ▪ Three rebates to increase irrigation system water efficiency
	  ▪ One pressure regulation rebate that conserves water indoors and outdoors

Exhibit 9. Conservation Measures Comprising Conservation Programs and Type of Conservation

Conservation Measure	Existing (E) or New (N)	Outdoor or Indoor	Program		
			A	B	C
Clothes washer rebates - commercial	N	Indoor		X	
Retrofit on resale or account change ordinance	N	Indoor		X	X
High-efficiency toilet rebate	N	Indoor		X	X
Free faucet aerators and showerheads	E	Indoor		X	X
Indoor plumbing fixture ordinance	N	Indoor		X	X
Landscape and irrigation ordinance	N	Outdoor	X		X
Outdoor water surveys	E	Outdoor	X		X
Weather-based irrigation controller rebate	N	Outdoor	X		X
Pressure regulation rebate	N	Indoor/ Outdoor	X		X
Free drip irrigation kits	N	Outdoor	X		X
Rotating sprinkler nozzles rebate	N	Outdoor	X		X
Pressure regulating sprinkler bodies rebate	N	Outdoor	X		X

4.2 Conservation Program Analysis

Selected results of the DSS Model analysis of the three conservation programs (Programs A, B, and C) are presented in **Exhibits 10 through 14**. More detailed results are presented in the full Water Savings and Cost-effectiveness Analysis Report.

Typical values for assessing and selecting a particular conservation program are water savings, utility and community costs, and benefit-cost ratios, which incorporate the preceding values and provide a view of the entire program. A benefit-cost ratio greater than 1.2 is ideal as it indicates the utility has some financial buffer in case the costs of the conservation program are slightly higher than anticipated. Programs A, B, and C all had benefit-cost ratios greater than 1.2. Given that water savings and cost of the programs were the outputs needed from the DSS Model to assess whether implementing a water conservation program would be cost-effective, the remainder of this section focuses on water savings and costs.

Exhibit 10. Projected Annual Water Savings (MG) by Conservation Program

Conservation Program	Projected Annual Water Savings (MG)			Projected Total Water Savings (MG)
	2023	2030	2040	(2020-2040)
Program A	46.4	325.6	559.9	6,228.5
Program B	15.3	105.1	122.3	1,729.0
Program C	61.7	430.0	680.4	7,939.5

Note MG = million gallons

Exhibit 11. Projected Annual Water Savings (MG) by Conservation Program

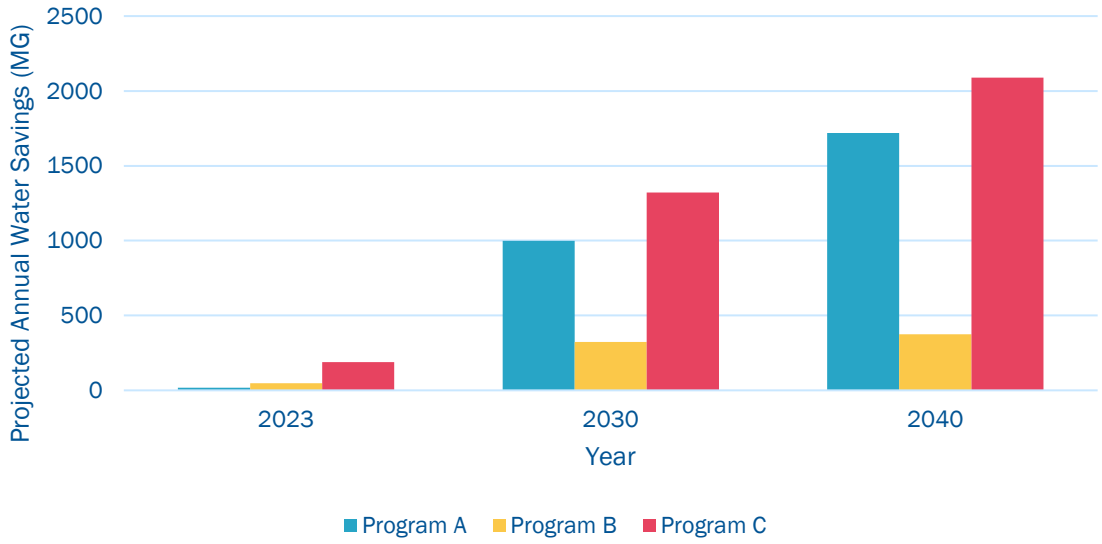


Exhibit 12. Indoor and Outdoor Water Savings (MG) by Conservation Program

Conservation Program	Year	Projected Annual Water Savings (MG)		
		Indoor	Outdoor	Total
Program A	2023	0.3	46.0	46.3
	2030	2.4	323.1	325.5
	2040	1.1	558.7	559.9
Program B	2023	15.4	0.0	15.4
	2030	105.2	0.0	105.2
	2040	122.3	0.0	122.3
Program C	2023	15.7	46.0	61.7
	2030	106.9	323.1	430.0
	2040	121.6	558.7	680.3

Note MG = million gallons

Estimated utility costs in 2023, 2030, and 2040 are presented in Exhibit 13. The costs are lower in 2040 than in 2023 and 2030, because some conservation measures end before 2040. Exhibit 14 presents the projected utility costs per year of each conservation program. Costs presented in these two exhibits are not adjusted for present value.

Exhibit 13. Projected Utility Costs and Community Costs by Conservation Program

Conservation Program	Projected Utility Costs ($)		
	2023	2030	2040
Program A	$435,538	$494,531	$339,813
Program B	$402,016	$472,335	$12,673
Program C	$837,554	$961,486	$412,486

Exhibit 14. Projected Utility Costs by Conservation Program

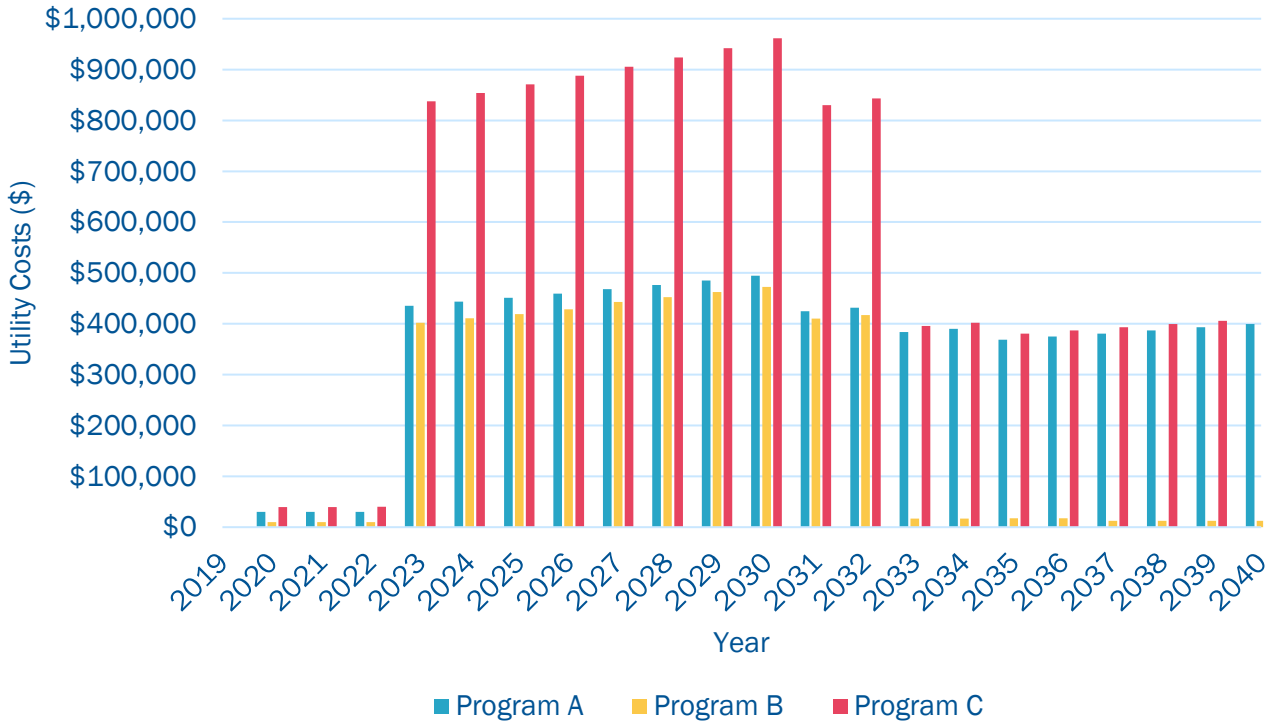


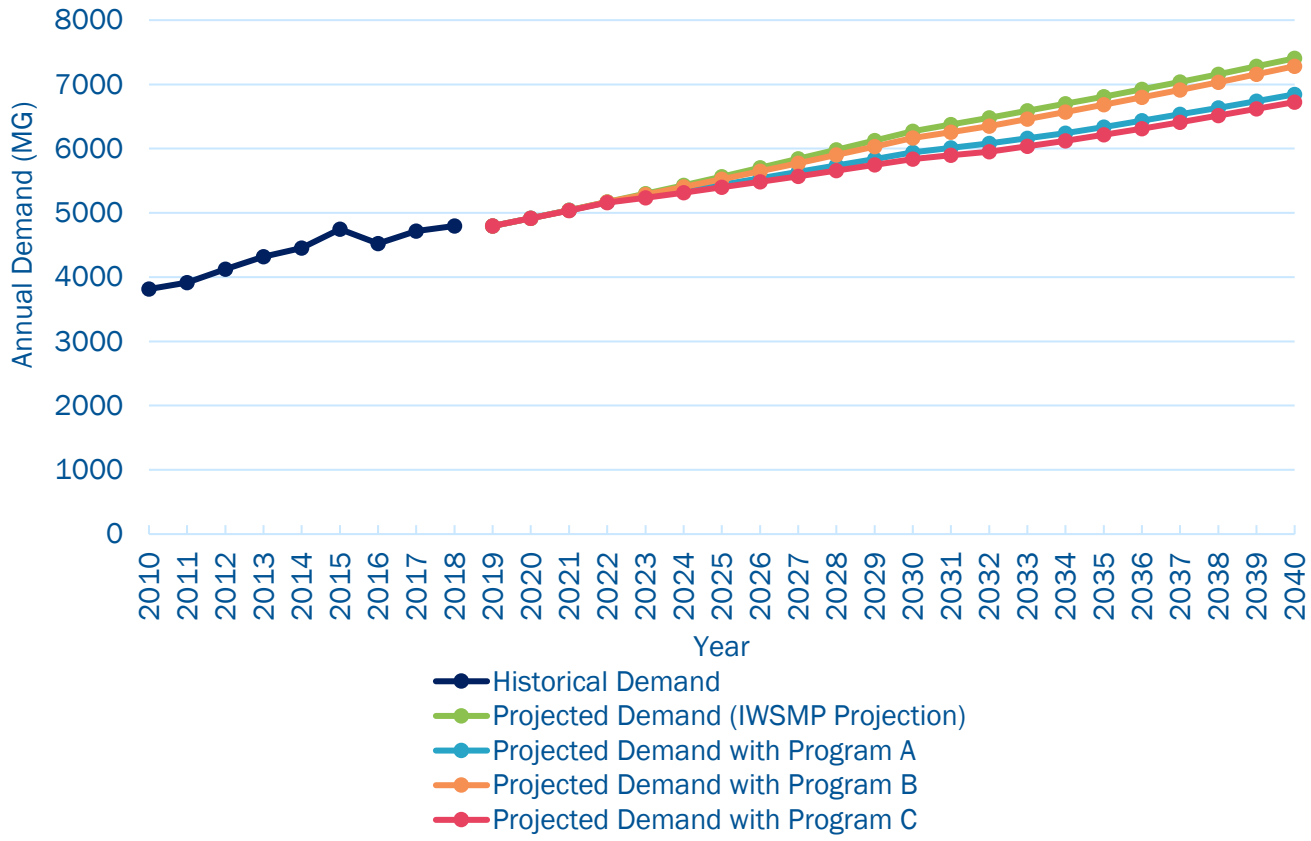
Exhibit 15 shows the present value costs for each conservation program over 20 years, considered the life of the program for the purposes of this analysis. The current value of future costs uses the real interest rate of 0.87 percent. This reflects the difference in the projected nominal interest rate and assumed rate of inflation for the City Utility's capital expenditures over the 20 year period of implementation. These results include water savings from plumbing codes and standards. Plumbing codes consist of current state and federal standards for water fixtures, such as toilets, faucet aerators, showerheads, and clothes washers.

Exhibit 15. Present Value Costs for the Water Utility by Conservation Program (With Plumbing Code)

Conservation Program	Present Value of Utility Costs
Program A	$6,978,373
Program B	$4,140,954
Program C	$11,071,052

Annual demand projections for each conservation program are presented in **Exhibit 16**. The projected annual demand developed for the IWSMP (IWSMP Projection) is 6,497 MG in 2030 and 7,702 MG in 2040. For comparison, the annual demand projection if Program C is implemented is 6,067 MG in 2030 and 7,021 MG in 2040, a reduction of 9 percent. The baseline IWSMP projection incorporates information about current water use, which has been influenced by some of the City's existing conservation programs, and should not be considered a "no conservation" scenario.

Exhibit 16. Projected Annual Demand with Conservation Programs



4.3 Program Selection and Cost-effectiveness

Program C is the City's preferred program, as it includes indoor and outdoor water conservation measures that produce substantial water savings at a reasonable cost. Program C is projected to result in a total of 7,939 MG in water savings from 2020 through 2040 and 680.3 MG in outdoor water savings in 2040. The estimated present value cost to the City (utility cost) of Program C from 2020 through 2040 is a total of $11,071,052.

The water savings and cost results of Program C were then used to (1) assess the extent to which the City could avoid building infrastructure as a result of water savings and (2) determine whether water conservation was more cost-effective than building infrastructure to meet future demands without implementing Program C.

To assess the extent to which water savings could avoid building new water system infrastructure, projected water savings under an MDD scenario must be considered. The need for development of new wells and reservoirs is driven primarily by increases in the MDD. GSI Water Solutions, Inc. (GSI), used the indoor and outdoor water savings in 2040, an output from the water savings and cost-effectiveness analysis, to calculate the reduction in the MDD in 2040 realized as a result of conservation. Existing indoor water use was estimated to be 6.0 mgd, based on demand during the months of November through March. Indoor water use is assumed to be constant throughout the year (1/365 = 0.27 percent of indoor water use occurs each day). GSI estimated outdoor water use by subtracting the indoor water use from the 2018 MDD of 28.1 mgd, resulting in outdoor water use of 22.1 mgd on the date of the MDD. GSI subtracted annual indoor demand (6 mgd × 365 = 2,190 MG) from the 2018 total annual demand of 4,796 MG to calculate total outdoor water demand (4,796 MG − 2,190 MG = 2,606 MG). Therefore, outdoor water demand on the date of MDD in 2018 is 0.85 percent of the total annual outdoor water use (22.1 MG / 2,606 MG = 0.85 percent).

GSI assumed that the reduction in indoor and outdoor water use on the date of the MDD would be proportional to the volume of water used. As a result, 0.85 percent of outdoor water conservations savings and 0.27 percent of indoor water conservation savings would occur on the date of MDD. Based on the projected annual outdoor and indoor water savings of 558.7 MG and 121.6 MG, respectively, GSI estimated that the reduction in the City's water use as a result of Program C would result in conservation savings of 5.1 mgd (7.9 cfs; 3,540 gpm) compared with the projected MDD without conservation (121.6 MG × 0.27% + 558.7 × 0.85% = 5.1 mgd on the date of MDD).

To determine whether implementing the water conservation program would be cost-effective, the cost of Program C was compared to the cost of constructing new infrastructure without Program C. For the purposes of its IWSMP, the City assumed that future new wells would have production rates of 1,150 gpm. Using that production rate, the projected MDD water savings of 5.1 mgd (equivalent to 3,540 gpm) would eliminate the need to construct three new wells, as well as one aboveground reservoir. The estimated cost of constructing three wells and one aboveground reservoir is approximately $21 million over the next 20 years. This does not include additional operational costs associated with groundwater production (e.g., cost of pumping groundwater), which would also be avoided. Consequently, the $11 million estimated cost to implement Program C is projected to be less than the $21 million cost of infrastructure anticipated to meet the projected 2040 MDD.

Results from the water savings and cost-effectiveness analysis will be incorporated into the City's IWSMP and WMCP, which are currently under development. The projected MDD water savings will inform the demand projections for both plans and related analyses. The identification of Program C with its suite of conservation measures will inform the WMCP water conservation 5-year benchmarks.