City of Sandy

Water System Master Plan

December 2022

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December 2022

RENEWS June 30, 2023

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A Groundwater Supply Evaluation for City of Sandy Water Master Plan Update, GSI Water Solutions, July 2022

B Presentation to Sandy City Council

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CHAPTER 1

Existing Water System

1.1 Introduction

The purpose of the Water System Master Plan (WSMP) is to perform an analysis of the City of Sandy's (City's) water system and:

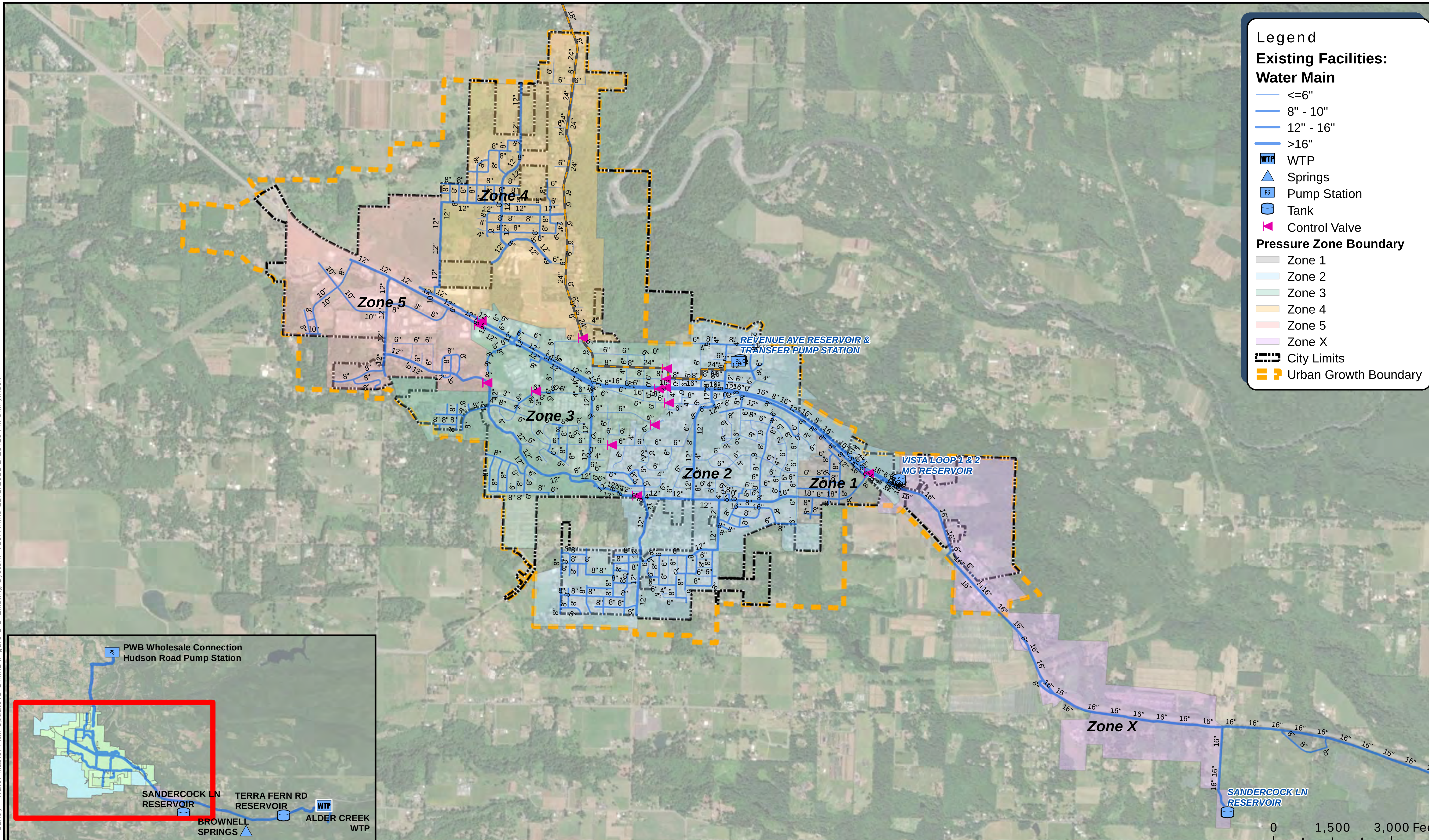
- Document the existing water system including improvements completed since the 1991 WSMP and 1999 WSMP Update.
- Develop and calibrate a new water system hydraulic model.
- Estimate future water requirements including potential water system expansion areas.
- Identify deficiencies and recommend water facility improvements that may correct system deficiencies and provide for growth.
- Recommend an updated water system capital improvement program (CIP) for the water system.
- Develop a document which will support future review of system development charges (SDCs) and water rates based on the updated CIP.
- Document the City's supply strategy and potential change to the current wholesale water supply agreement with the City of Portland.

In order to identify system deficiencies, existing water infrastructure inventoried in this section will be assessed based on the existing and future water needs summarized in **Chapter 2** and water system performance criteria described in **Chapter 3**. The results of this analysis are presented in **Chapter 4** and **Chapter 5**. **Chapter 6** provides recommendations for system improvements and a 20-year capital improvement program. The planning and analysis efforts presented in the WSMP are intended to provide the City with the information needed to inform long-term water supply and distribution infrastructure decisions.

This plan complies with water system master planning requirements established under Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 333, Division 61.

1.2 Service Area

The City is located in Clackamas County, southeast of the City of Portland. The water system provides potable water to approximately 13,000 customers within city limits and some surrounding areas through about 4,100 single-family residential, multi-family, and commercial/industrial service connections. Future growth of the water service area will encompass the current urban growth boundary (UGB). The City also sells water to three wholesale customers: Section Corner Water District (WD), Alder Creek-Barlow WD, and Skyview Acres Water Company. The City is the sole source of water for the Section Corner and Alder Creek-Barlow WDs; Skyview Acres serves part of its system through a connection to Portland Water Bureau (PWB). An overview map of the water service area can be found in **Figure 1-1**.



City of Sandy
Water System Master Plan

Figure 1 - 1
Existing System

1.3 Supply Sources

The City's supply sources and current operation are described in the following paragraphs. Future supply options, strategy, and limitations are discussed in more detail in **Chapter 5**. The locations of all supply connections are shown in **Figure 1-1**.

The City currently receives its water from three sources: Alder Creek (a tributary of the Sandy River), Brownell Springs (a tributary of Beaver Creek), and PWB, which receives its water supply from the Bull Run Watershed. The water purchased from PWB is subject to minimum purchase requirements in accordance with the Water Supply Agreement. During fall and winter, approximately two-thirds of the City's water supply is purchased from PWB (492,000 gallons), while Alder Creek and Brownell Springs supply the remaining one-third to meet the total demand of approximately 700,000-800,000 gallons. During the summer and fall, PWB continues to supply 492,000 gallons while more water is drawn from Alder Creek and Brownell Springs, fulfilling increased warm weather demands.

1.3.1 Alder Creek WTP

Since 1971 the City has held water rights on Alder Creek. In 1977, the City constructed the Alder Creek Water Treatment Plant (WTP) to treat 1.0 million gallons per day (MGD) of water from Alder Creek. In 1998, they expanded the WTP and its capacity to 2.0 MGD. Shortly thereafter, in 2001, a more efficient system replaced the old treatment unit, increasing the WTP's capacity to 2.6 MGD. While the sustainable capacity of this source is unknown as there are no stream gauges located on Alder Creek, it is believed that at peak capacity it is capable of supplying the 2.6 MGD flow rate allowed by the City's water right.

The Alder Creek raw water intake is located approximately 4,000 feet upstream of the WTP. An intake structure directs water into a 12-inch raw water main and is pumped to the plant via an 1,800 gallon per minute (gpm) duplex booster pump station (two 20 horsepower (hp) pumps with variable frequency drives (VFDs)). Based on anecdotal information from City and Veolia staff (contract operator of the WTP), the firm capacity of the raw water pump station (capacity with the largest pump out of service) is approximately 1,800 gpm.

The WTP is a Trident MicroFloc package, direct-filtration plant. The filters are dual media (sand and anthracite) and backwash is accomplished by gravity flow from the Terra Fern Road Reservoir. The WTP does not use sedimentation or coagulation; pretreatment consists only of flocculation by hydraulic mixing, with no rapid mixing.

The WTP consists of three packaged filtration units – Filters #1 and #2 each have a capacity of approximately 0.5 MGD but have not operated in more than a decade due to control panel issues and instrumentation failures. Filter #3 operates at an approximate capacity between 1.2 MGD and 1.6 MGD.

Finished water is pumped to the distribution system via pumps at the WTP, which send water to the Terra Fern Road Reservoir and Pump Station. Filters #1 and #2 have three submersible turbine pumps with an estimated capacity of 1,050 gpm. These pumps have not been operated since Filters #1 and #2 were in operation (over a decade). Filter #3 has one vertical turbine pump with an approximate capacity of 1,100 gpm (1.6 MGD). The Filter #3 pump has a spare motor, but there is no backup pump. Additionally, this pump is oversized and does not have a VFD.

The WTP site has a standby generator, though the current transfer switch is manual. There is an ongoing project that will convert this to an automatic transfer switch (ATS) and prevent City staff from having to drive to the site to transfer the power source to the generator.

1.3.2 Brownell Springs

Approximately six miles east of Sandy, a series of eight springs, known as Brownell Springs, are located on 22 acres of City-owned land on Lenhart Butte. Water from the individual springs is collected in open-bottom concrete boxes and piped to a 1,000-gallon concrete holding tank where the spring water is disinfected with sodium hypochlorite. Turbidity, disinfectant residual monitoring, and supervisory control and data acquisition (SCADA) communications equipment are housed in a nearby building with a separate room for sodium hypochlorite storage and pumping equipment.

The Springs consistently produce between 0.3 and 0.5 MGD year-round. While peak flows from the Springs occur during the early summer, by late summer, the City is typically regulated down to 90 gpm (0.13 MGD) due to impacts on senior water rights.

From the common holding tank, the chlorinated water blends with water traveling from the Terra Fern Road Reservoir and Pump Station to the Sandercock Lane Reservoir and Vista Loop Reservoirs.

There are three customers downstream of the holding tank who have grandfathered water rights to Brownell Springs water from the City. Their usage is metered, but they do not pay the City for water usage.

1.3.3 Portland Water Bureau

Since a wholesale water supply agreement was established in 2008, the City acquires 0.5 MGD to 3.0 MGD from the PWB. The City is required to pay for at least 0.5 MGD regardless of how much water is actually used, the Guaranteed Minimum Purchase amount stipulated in the current City's wholesale water supply agreement with PWB. This interconnection allows the City to supplement their Alder Creek and Brownell Springs sources, as well as providing redundancy to the system in case of emergency. The PWB receives water from the Bull Run Watershed, located approximately 3 miles northeast of the City at the base of the Cascade Mountains. Water is supplied from Bull Run Lake and Bull Run Reservoirs No. 1 and No. 2, with a combined storage capacity of approximately 17 billion gallons. Water is delivered to the City of Portland and various wholesale customers in the Portland metro area through three large-diameter conduits. The City receives water from the PWB at the Hudson Road Intertie and through a master meter that the PWB is responsible for maintaining and calibrating. The current contract with the PWB expires in 2028 and a new long-term wholesale water supply agreement is currently being developed.

The Hudson Road Intertie is located between the headworks, where chlorine is added to the Bull Run surface water source, and the Lusted Hill Facility where ammonia is added to the water (to create a more stable disinfectant residual in the water, called chloramines) and the pH of the water is adjusted for corrosion control. As discussed further in **Chapter 5**, the Hudson Road Intertie is located upstream of the future PWB water treatment plant meaning that the water supplied to the City of Sandy at the Hudson Road Intertie will be unfiltered and untreated, and PWB will discontinue chlorination of the water at the Bull Run headworks.

The Hudson Road Intertie with the PWB was established in 2014 approximately 4 miles north of the City. The City cannot convey water back to the PWB from this interconnection. Nearby, the Hudson Pump Station pumps water through approximately 27,000 feet of 18 and 24-inch diameter pipeline to the Revenue Avenue Reservoir, which is located within city limits. On the same site, the Transfer Pump Station pumps water from the reservoir into the distribution system in Zone 2 and up to the Vista Loop Reservoirs. Customers east of Langensand Road, between the Vista Loop Reservoirs and the Alder Creek WTP, cannot currently be served by the PWB source because the pump stations are not configured to pump up to these elevations.

1.3.4 Salmon River

The City holds Permit S-48451 for use of up to 25.0 cubic feet per second (cfs) (16.1 MGD) from the Salmon River, which is currently undeveloped and has an extension of time to October 1, 2069. This water right is intended to provide a long-term water supply to accommodate the City's growth. In the *Agreement for Instream Conversion* (executed October 24, 2002) associated with Portland General Electric's decommissioning of Marmot Dam, the City voluntarily agreed to reduce this permit from 25.0 cfs to 16.3 cfs (16.1 MGD to 10.5 MGD) when the flow available in the Sandy River near Brightwood, OR is 600 cfs (387.8 MGD) or less, but can still divert up to 25.0 cfs when the flow available is more than 600 cfs. No gauge is currently operating near Marmot, OR to provide a picture of the flow in the Sandy River at that location.

1.4 Distribution System

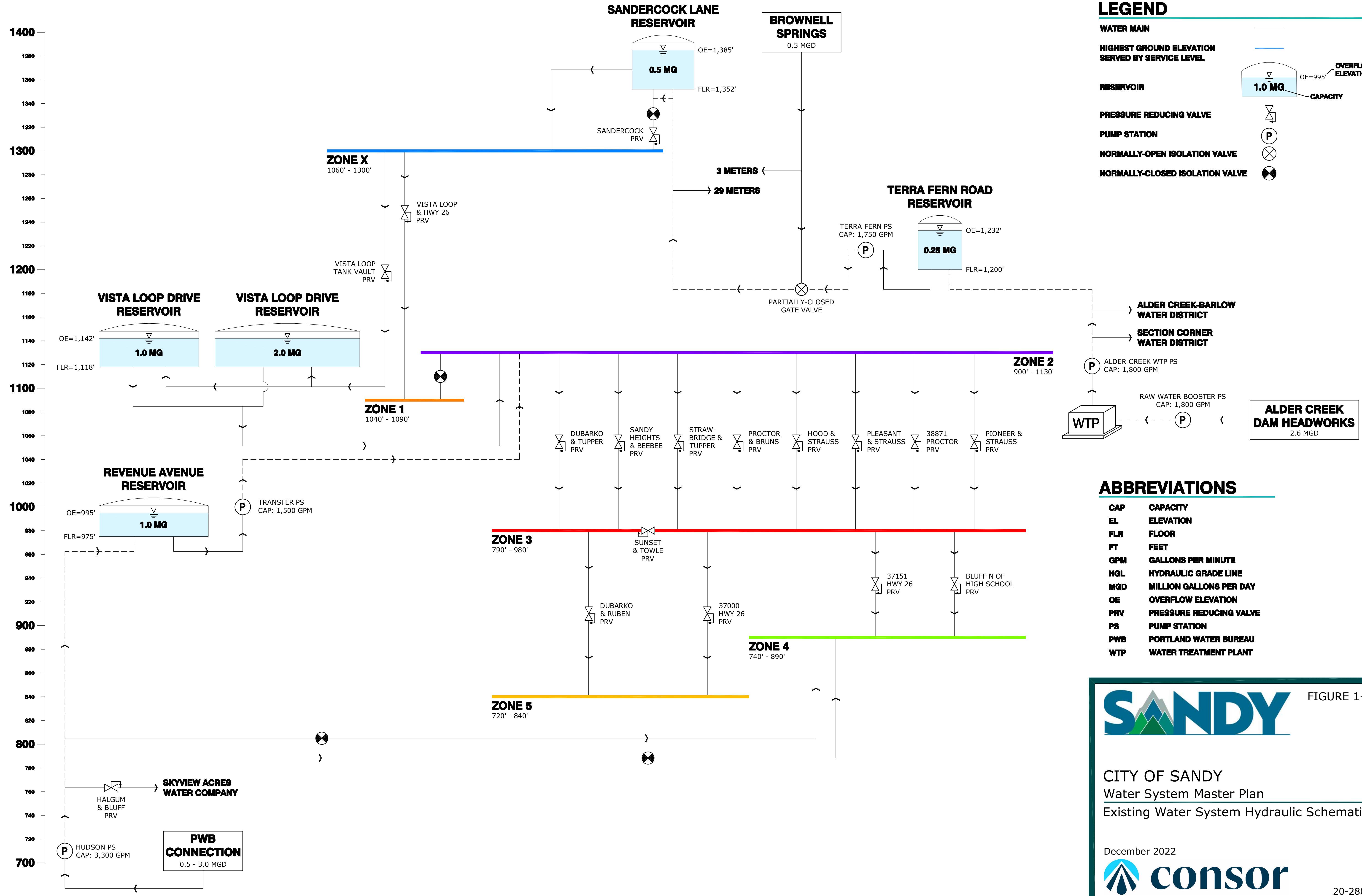
The City's existing water distribution system consists of six pressure zones, five storage reservoirs, four pump stations, and 15 pressure-reducing valve (PRV) stations throughout the City's service area. These components and the supply sources are shown in the existing water system hydraulic schematic included as **Figure 1-2**. The City's distribution system and current operational strategy are described in further detail in **Chapter 4**.

1.4.1 Pressure Zones

Pressure zones are defined by ground topography and their hydraulic grade lines (HGLs) are determined by overflow elevations of water storage reservoirs, discharge pressure at pump stations, or outlet settings of PRVs. Pressure zone boundaries are defined in order to maintain an acceptable range of service pressures to all customers and fire hydrants.

The City's water distribution system is divided into six pressure zones. They are identified simply as Zone X and Zones 1 through 5. The topography of the City's water service area generally slopes down from southeast to northwest, with Sandercock Lane Reservoir acting as the high point in the distribution system. Water from Alder Creek WTP is pumped up to the Sandercock Lane Reservoir while water from Brownell Springs flows by gravity to the reservoir. From here, water flows directly into Zone X, into Zone 1 via PRV, and into the Vista Loop Reservoirs through the Vista Loop Control Valve. From the PWB intertie, water is transmitted to the Revenue Avenue Reservoir where it is blended with Alder Creek and Brownell Springs source water to control disinfection byproduct formation. Water from the Revenue Avenue Reservoir is pumped into Zone 2 from the Transfer Pump Station. From Zone 2, water travels by gravity throughout the remaining pressure zones, passing through PRVs as necessary.

In addition to these six established and named pressure zones, the City supplies water to the three aforementioned wholesale customers, as well as 29 meters above the Sandercock Lane Reservoir, and three meters supplied by gravity between Brownell Springs and a partially-closed gate valve, located near Highway 26, that regulates the flow rate from the springs to the City's allowed water right capacity.



ABBREVIATIONS

CAP	CAPACITY
EL	ELEVATION
FLR	FLOOR
FT	FEET
GPM	GALLONS PER MINUTE
HGL	HYDRAULIC GRADE LINE
MGD	MILLION GALLONS PER DAY
OE	OVERFLOW ELEVATION
PRV	PRESSURE REDUCING VALVE
PS	PUMP STATION
PWB	PORTLAND WATER BUREAU
WTP	WATER TREATMENT PLANT

SANDY

FIGURE 1-2

CITY OF SANDY

Water System Master Plan

Existing Water System Hydraulic Schematic

December 2022

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20-2800

G:\PDX_Projects\20\2800 - Sandy - Water Master Plan Update\CAD\20-2800-OR Hydraulic Schematic.dwg FIG 1-2 12/7/2022 1:06 PM TAYLOR.SPENCER 23.0s (LMS Tech)

Figure 1-1 shows the geographical locations of the pressure zones. **Table 1-1** summarizes approximate ground elevations served, HGLs, and service pressures, as well as facilities supplying each pressure zone. The information included in **Table 1-1** is depicted visually in **Figure 1-2**.

Table 1-1 | Pressure Zone Summary

Pressure Zone	Elevation Range Served (feet)[1]	Supply Source	Pressure Control (Reservoir/Pump Station/PRV)	Controlling HGL (feet)	Approximate Pressure Range (psi)
Zone X	1,060 to 1,300	Sandercock Lane Reservoir	Sandercock Lane Reservoir	1,385	37 to 141
Zone 1	1,040 to 1,090	Sandercock Lane Reservoir	Vista Loop & Hwy 26 PRV	1,206	50 to 72
Zone 2	900 to 1,130	Vista Loop Reservoirs, Revenue Avenue Reservoir/Transfer Pump Station	Vista Loop Reservoirs	1,228	42 to 142
Zone 3	790 to 980	Zone 2	Several PRVs	1,098	51 to 133
Zone 4	740 to 890	Zone 3	37151 HWY 26 PRV, Bluff Road PRV	980	39 to 104
Zone 5	720 to 840	Zone 3	Dubarko & Ruben PRV, 37000 HWY 26 PRV	987	64 to 116

[1] Individual services with pressures above 80 psi are assumed to have individual PRVs.

1.4.2 Storage Reservoirs

The City's water system includes five active storage reservoirs with a total capacity of 4.75 million gallons (MG). Key information on these reservoirs can be found in **Table 1-2**. See **Figure 1-1** for the geographical locations of the reservoirs.

Located outside of city limits, the easternmost reservoir, Terra Fern Road Reservoir, is of welded steel construction and has a capacity of 0.25 MG. It is filled from the Alder Creek WTP finished water pumps. Water is then boosted by the adjacent Terra Fern Pump Station to the Sandercock Lane Reservoir.

Sandercock Lane Reservoir, another steel reservoir, is the highest reservoir in the City's system and is the second reservoir located outside city limits. Access to the site is unreliable as it is steep and can be subject to downed trees and hazardous driving conditions during winter months. It has a capacity of 0.5 MG and is filled by the Terra Fern Pump Station as well as water from Brownell Springs. Sandercock Lane Reservoir serves Zone X, pressure regulated Zone 1, and supplies the Vista Loop Reservoirs.

The Vista Loop Reservoirs are an older 1.0 MG capacity steel tank and a more recently constructed 2.0 MG prestressed concrete tank. The Vista Loop Reservoirs directly serve Zone 2 and provide the supply to pressure regulated Zones 3, 4, and 5 through Zone 2 distribution piping. Neither the Sandercock Lane nor Vista Loop sites have generators, ATSs, manual transfer switches (MTSs), or back-up power available onsite.

The fifth and final tank is the newest and the lowest in the system. The concrete Revenue Avenue Reservoir receives water from the Hudson Road Intertie with the PWB. Water is pumped directly to the tank from the Hudson Pump Station located more than five miles north. The Transfer Pump Station pumps water from the reservoir to Zone 2. From here, a series of PRVs supply Zones 3, 4, and 5.

Table 1-2 | Reservoir Summary

Reservoir Name	Pressure Zone	Overflow Elevation (feet)	Volume (MG)	Diameter (feet)	Height to Overflow (feet)	Material	Year Constructed
Revenue Avenue	2	995	1.0	92	20	Concrete	2014
Vista Loop	2	1,142	1.0	86	24	Steel	1975
Vista Loop	2	1,142	2.0	122	24	Concrete	2001
Terra Fern Road	N/A	1,232	0.25	32	32	Steel	1978
Sandercock Lane	X	1,385	0.5	51	33	Steel	1966

1.4.3 Pump Stations

The City's existing water system includes four distribution system pump stations and a raw water booster pump station. **Table 1-3** presents a summary of all existing pumping facilities. See **Figure 1-1** for the geographical locations of the pump stations.

The first pump station is the raw water booster pump station which was constructed in 1996 to provide additional capacity to the Alder Creek WTP from the 12-inch diameter raw water intake pipeline. The pump station consists of two 20-hp pumps with VFDs. The pump station provides the WTP with approximately 1,800 gpm (2.6 MGD). Back-up power for the raw water booster pump station is provided from the generator at the WTP.

The WTP houses four finished water pumps. Three submersible turbine pumps operate with Filters #1 and #2. Filter #3 operates with one vertical turbine pump. If all three filter trains are operating, three of the finished water pumps can convey a total of approximately 1,800 gpm (2.6 MGD). The Filter #3 pump has a design capacity of 1,100 gpm (1.6 MGD).

From the WTP, finished water is pumped to the Terra Fern Road Reservoir. The Terra Fern Road Reservoir controls the WTP operation by pressure transducer level transmitters. There is a generator onsite at the WTP, but it does not have an ATS and requires manual override. There is an ongoing project that will install an ATS at the WTP.

The Terra Fern Pump Station shares a site with the reservoir and pumps water to the Sandercock Lane Reservoir, picking up water from Brownell Springs along the way. The pump station was constructed in 1977 and houses five submersible turbine pumps for a capacity of 1,750 gpm (2.5 MGD).

Wholesale water purchased from the PWB at the Hudson Road Intertie is pumped to the City's water system by the Hudson Pump Station. From here, three pumps, two duty and one standby, can supply up to 3,300 gpm (4.8 MGD) of water through 27,000 feet of pipe to the Revenue Avenue Reservoir, located within city limits. There are also hydrated lime chemical feed facilities to adjust the pH of the supply from PWB at this pump station, though it has never been necessary to implement the chemical equipment.

The fifth and final pump station is the Transfer Pump Station, which can convey up to 2,100 gpm (3 MGD) via three pumps, two duty and one standby, into Zone 2. The Terra Fern, Hudson, and Transfer pump stations all have a generator and ATS onsite.

Table 1-3 | Pump Station Summary

Pump Station	Pumping To	Pumping From	Pump No.	Approximate Capacity (gpm)	Emergency Back-up Power	VFD or Constant Speed	Year Constructed
Raw Water Booster	Alder Creek WTP	Alder Creek Intake	2	3,600	Manual Transfer Switch / Control Switch[1]	VFD	2018 (upgraded)
Alder Creek WTP	Terra Fern Road Reservoir	Alder Creek WTP	4	1,800	Manual Transfer Switch / Control Switch[1]	Constant Speed	1977
Terra Fern	Sandercock Lane Reservoir	Terra Fern Road Reservoir	5	1,750	Automatic Transfer Switch / Control Switch	Constant Speed	1977
Hudson	Revenue Avenue Reservoir	PWB Intertie	3	3,300	Automatic Transfer Switch / Control Switch	Constant Speed	2014
Transfer	Zone 2	Revenue Avenue Reservoir	3	2,100	Automatic Transfer Switch / Control Switch	Constant Speed	2014

[1] There is an ongoing project at the WTP that will upgrade this to an automatic transfer switch.

1.4.4 Pressure-Reducing Valves

A total of 15 pressure-reducing stations, installed throughout the distribution system, divide it into pressure zones, providing customers with appropriate water pressures. Of these, 13 PRVs are used to reduce pressure from Zone 2, directly and indirectly supplying Zones 3, 4, and 5. One PRV reduces pressure from the Sandercock Lane Reservoir, supplying Zone X. One more PRV serves Zone 1 from Zone X. The pressure zones served and settings of the PRVs are shown in **Table 1-4**. The geographic location and hydraulic configuration of these PRVs are illustrated in **Figure 1-1** and **Figure 1-2**, respectively.

Table 1-4 | Pressure Reducing Valves Summary

PRV Name	Elevation (ft)	Main Valve			Bypass Valve			Pressure Zone
		Setting (psi)	Size (in)	Grade (ft)	Setting (psi)	Size (in)	Grade (ft)	
Sandercock (Tank Bypass)	1226	75	6	1399	80	2	1411	Zone X
Vista Loop and US 26	1089	55	8	1216	60	3	1228	Zone 1
Sandy Heights South of Beebee	958	53	6	1080	64	1.5	1106	Zone 3
Pleasant and Strauss	960	55	6	1087	-	-	-	Zone 3
Pioneer and Strauss	970	50	4	1086	-	-	-	Zone 3
Towle and Sunset	824	65	6	974	68	1.5	981	Zone 3
Strawbridge and Tupper	903	60	6	1042	60	1.5	1042	Zone 3
Hood and Strauss	954	55	6	1081	-	-	-	Zone 3
Dubarko and Tupper	896	70	8	1058	80	2.5	1081	Zone 3
Proctor and Bruns	960	55	8	1087	-	-	-	Zone 3
38871 Proctor	966	50	10	1082	55	3	1093	Zone 3
37151 Hwy 26	840	56	10	969	61	3	981	Zone 4
Bluff North of High School	870	50	6	986	50	2	986	Zone 4
Dubarko East of Ruben	793	60	10	932	65	3	943	Zone 5
37000 SE Hwy 26	832	57	10	964	65	4	982	Zone 5

1.4.5 Distribution Piping

The City's water transmission and distribution system contains approximately 67 miles of piping and is composed of various pipe materials ranging in size from 2 to 24 inches in diameter. The majority of the piping is 6, 8, 12, and 16 inches in diameter. Most of the pipes are ductile iron (75 percent) or cast iron (CI) (16 percent), in addition to other materials, including steel, polyvinyl chloride (PVC), and asbestos cement. The City has exclusively been installing ductile iron since 1979. **Table 1-5** presents an inventory of existing pipes by diameter.

Table 1-5 | Distribution System Pipe Summary

Diameter (inches)	Length (feet)	Percentage of All Pipe
2	1,616	0.5%
4	9,657	2.7%
6	88,126	24.9%
8	110,865	31.3%
10	4,810	1.4%
12	61,146	17.3%
16	47,787	13.5%
18	16,067	4.5%
24	14,124	4.0%
TOTAL	**354,197**	**100%**

CHAPTER 2

Water Requirements

This chapter characterizes current water demands and summarizes future growth scenarios, population projections, and projected future water demands for the City's water service area. Water demand forecasts presented in this chapter are used with performance criteria presented in **Chapter 3** to evaluate the existing water system's capacity to serve current customers and future growth. Demand forecasts are developed from historical water consumption and production records, regional planning data, current land use designations, and previous City water planning efforts.

2.1 Water Service Area

2.1.1 Existing Service Area

The existing City water service area includes approximately 80 percent of the land within the city limits. The City also provides service to three wholesale customers outside of the City's service area: Section Corner WD, Alder Creek-Barlow WD, and Skyview Acres Water Company. The service area is shown in **Figure 1-1**.

2.1.2 Future Service Area

Based on existing development types in the area, some re-development and densification is expected within the existing water service area, particularly in the central portion of the city. The City expects growth and expansion within its UGB, which is expected to be mostly low density residential. Subdivisions in the east are actively being developed and will affect Zone X in particular. The proposed future service area is illustrated in **Figure 1-1**.

2.2 Planning Period

The planning period for this WSMP is 20 years, through the year 2043, which meets the requirements for WSMPs outlined in the OAR 333-061. Water supply capacity is evaluated through 2050, to accommodate long-range supply development planning.

2.3 Water Demand Description

Water demand refers to all potable water required by the system including residential, commercial, industrial, city, and public uses. Water demands are described using three water use metrics: average daily demand (ADD), maximum (peak) day demand (MDD), and peak hour demand (PHD). Each of these metrics is stated in MGD.

- ADD is the total annual water volume used system-wide divided by 365 days per year.
- MDD is the largest 24-hour water volume for a given year. MDD typically occurs each year between July 1st and September 30th.
- PHD is estimated as the largest hour of demand on the peak water use day.

Water demand can be calculated using either water consumption or water production data. Water consumption data is taken from the City's Advanced Metering Infrastructure (AMI) data and includes all revenue metered uses. This data can be analyzed by geographical location and customer type, which is useful for quantifying typical water use for different pressure zones and land uses. However, consumption data does not capture any water loss or unmetered uses, making it less useful in determining system-wide peak demands.

Water production is calculated as the sum of water supplied from the Alder Creek WTP, Brownell Springs, and the PWB connection. This includes unaccounted-for water such as loss through minor leaks and unmetered, non-revenue uses such as hydrant flushing. Total water production is recorded daily, making it useful for analyzing seasonal water demand trends, supply, and storage capacity.

2.4 Historical Water Demand

For the purposes of this WSMP, daily water production data is used to calculate system-wide historical water demand in order to account for all water uses including those which are not metered by the City and to develop peaking factors. Customer consumption and water service location data are used to distribute water demands throughout the hydraulic model, to estimate demands by pressure zone, and to quantify average water use by customer type for future demand projections described later in this chapter.

2.4.1 System-Wide Water Production

System-wide historical water production is presented in **Table 2-1**. The historical ratio of MDD:ADD, or peaking factor, is used to estimate future MDD from ADD. In addition, to understand the effect of outdoor water usage during the summer, Peak Season Demand (PSD) is calculated as the ADD between July 1st and September 30th.

Table 2-1 | Historical System-Wide Water Demand

Year	ADD (MGD)	PSD (MGD)	MDD (MGD)	MDD:ADD Peaking Factor
2016	1.15	1.49	2.36	2.1
2017	1.16	1.54	2.33	2.0
2018	1.22	1.67	2.87	2.3
2019	1.09	1.42	2.49	2.3
2020	1.24	1.59	2.47	2.0
2021	1.38	1.81	2.57	1.9
Average	**1.21**	**1.59**	**2.51**	**2.1**

[1] Based on City staff observations, actual demands may be less due to routine historical overflow of Revenue Avenue Reservoir when Hudson Pump Station supplied the City system from the PWB that has since ceased occurring. Consor was unable to identify a clear quantification of the overflow volume. It is recommended that the City investigate the impact of the recurring overflow event on demand forecast at the end of the year 2022.

2.4.2 Water Consumption by Pressure Zone

As described in **Chapter 1**, water systems are divided into pressure zones to provide adequate service pressure to customers at different elevations. Each pressure zone is served by specific facilities such as reservoirs, pump stations, or PRVs, which supply water to customers within an acceptable range of service pressures. To assess the adequacy of these facilities, it is necessary to estimate demand in each pressure zone. System-wide water consumption from 2020 was distributed uniformly within the City's pressure zones and with respect to the number of meters in each pressure zone. The percentage of water consumption by pressure zone is summarized in **Table 2-2**. The maximum day peaking factor was applied to these demands to determine MDD.

Table 2-2 | 2020 Water Consumption by Pressure Zone

Pressure Zone	Percent of Demand
Zone X	5.0%
Zone 1	2.7%
Zone 2	46.5%
Zone 3	25.3%
Zone 4	13.4%
Zone 5	7.1%

2.4.3 Water Consumption by Customer Type

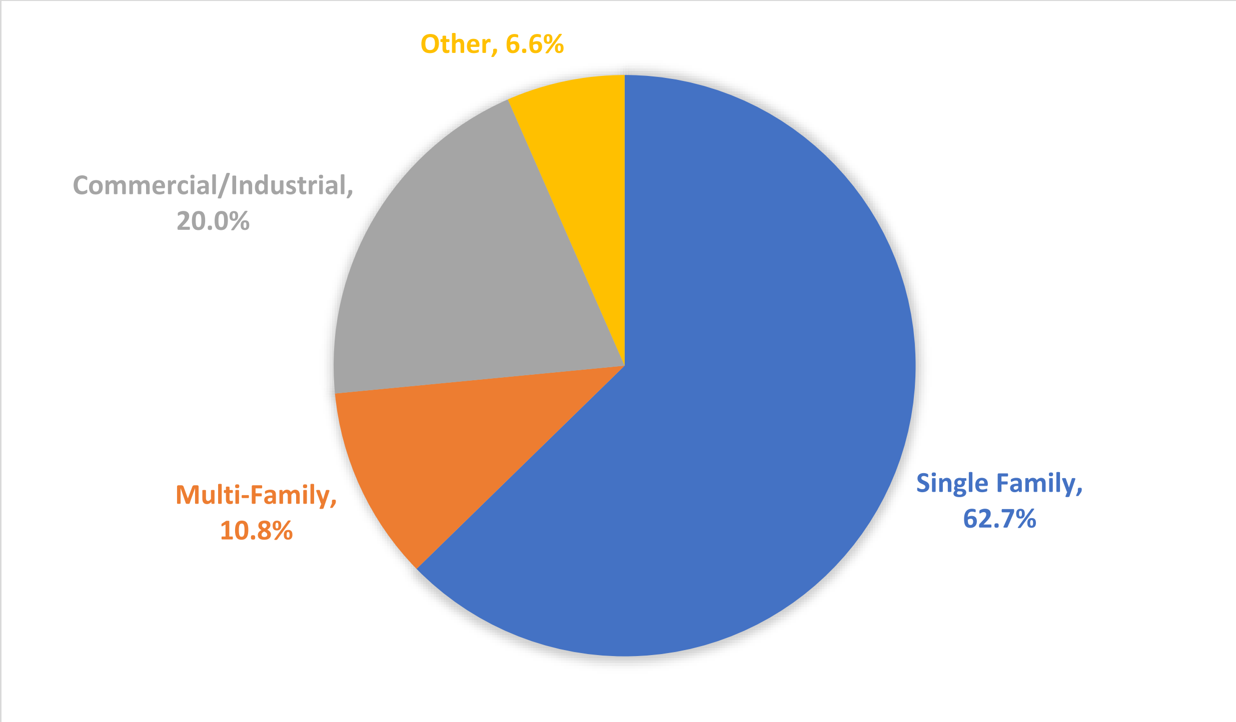
City AMI data provided historical average daily water consumption by customer type including single-family residential, multi-family residential, residential outside of city limits, commercial, industrial, and other (wholesale and public use). Historical use by customer type is presented in **Table 2-3**. The percentage of total 2020 average daily water consumption for each major customer type is presented in **Figure 2-1**.

Residential customer use makes up the majority of demand in the City. This category is assumed to be predominantly comprised of single-family homes, duplexes, and triplexes. Multi-family residential and industrial/commercial customer use also contribute significantly to overall demand. Combined (Other) wholesale, outside city limits residential, public, and City use constitutes approximately 6.6 percent of the total customer use.

Table 2-3 | Historical Water Consumption by Customer Type

Year	Water Consumption by Customer Type (MGD)				
	Single-family	Multi-family	Commercial/Industrial	Other (Wholesale, Outside City Limits Res. Public, etc.)	Total
2017	0.62	0.10	0.22	0.06	1.00
2018	0.62	0.10	0.23	0.06	1.02
2019	0.56	0.09	0.22	0.05	0.92
2020	0.61	0.10	0.19	0.07	0.98

Figure 2-1 | 2020 Water Consumption by Customer Type



2.4.4 Equivalent Dwelling Units (EDUs)

Sandy's public water system serves a significant number of single-family residential customers as well as multifamily housing developments and commercial customers. Single-family residential water services generally have a consistent daily and seasonal pattern of water use or demand. Water demands for multifamily residential, commercial, and industrial users may vary significantly from service to service depending on the number of multifamily units per service or the type of commercial enterprise. When projecting future water demands based on population change, the water needs of non-residential and multi-family residential customers are represented by comparing their water use volume to the average single-family residential unit. The number of single-family residential units that could be served by the water demand of these other types of customers is referred to as the number of "equivalent dwelling units" (EDUs). EDUs differ from actual metered service connections in that they relate all water services to an equivalent number of representative single-family residential services based on typical annual consumption.

In order to establish the average consumption per EDU, the total number of single-family residential service connections is compared to the total consumption by single-family residential customers. Residential ADD divided by the number of base size meters is the average demand per EDU (ADD/EDU in gpd/EDU). Average consumption per EDU (ADD/EDU) is anticipated to remain constant through time and based on the calculations using 2017 to 2020 water consumption records, assumed to be 182 gpd/EDU.

2.5 Future Water Demand Forecast

Future water demands were projected based on historical data, population forecasts, and growth trends. Projections take into account anticipated growth in new development areas and estimated water loss. Specific criteria used to forecast future water demands are listed below.

Actual demands may be less than projected. At one time, Hudson Pump Station supplied the City system from the PWB. During this time, City staff observed routine overflow of Revenue Avenue Reservoir. This overflow has since ceased occurring. Consor was unable to identify a clear quantification of the overflow volume. It is recommended that the City investigate the impact of the recurring overflow event on demand forecast at the end of the year 2022.

2.5.1 Residential Water Demand

Population projections were the basis for estimated residential water demand. The Coordinated Population Forecast for Clackamas County published by the Portland State University (PSU) Population Research Center (PRC, June 2020) includes US census population data from 2010 and estimated populations and growth rates for 2020 through 2070 for the City. Historical and projected populations are summarized in **Table 2-4**. The population projections do not include areas served by the Alder Creek Barlow WD, Section Corner WD, or Skyview Acres Water Company.

Table 2-4 | Historical and Projected Populations

Year	Population	Source
2010	9,980	U.S. Census
2022	12,991	PSU-PRC Population Estimate
2023	13,415	Projected using 2.1% AAGR (PSU PRC)
2025	13,985	Projected using 2.1% AAGR (PSU PRC)
2030	15,516	Projected using 2.1% AAGR (PSU PRC)
2035	17,215	Projected using 2.1% AAGR (PSU PRC)
2040	19,100	Projected using 2.1% AAGR (PSU PRC)
2043	20,329	Projected using 2.1% AAGR (PSU PRC)
2045	21,192	Projected using 2.1% AAGR (PSU PRC)
2050	22,942	Projected using 1.6% AAGR (PSU PRC)

Using the 2020 city-wide population estimate and residential water consumption data provided by the City for 2017 through 2020, the average use per capita per day was calculated. Note that this is for single- and multi-family consumption combined. The average per capita use was 65 gallons per capita per day (gpcd) between 2017 and 2020. The same value of 65 gpcd is used to estimate future residential water demand.

2.5.2 Non-Residential Water Demand

Commercial, industrial, wholesale, outside city limit residential, public, and City water use projections are based on consumption data from 2017 through 2020. Average 2020 consumption data for Commercial/Industrial and Other were used as basis of demands for 2023. Commercial and industrial demands are expected to increase proportional to residential demand as described in **Section 2.5.1**. Other (wholesale, outside city limit residential, and public and City water) usage is expected to remain constant through the planning period.

2.5.3 Non-Revenue Water Demand

Non-revenue water is the amount of water produced that is not billed to a customer. This generally includes water losses in the distribution system, unauthorized use, and authorized unbilled use such as hydrant flushing for water quality. This water must be accounted for in demand projections to ensure proper infrastructure sizing. Non-revenue water is estimated as the difference between billed consumption and production.

Non-revenue water is projected using historical data, based on the difference between billed consumption and production data from 2017 through 2020. Average annual non-revenue demand was estimated at 15 percent of system production volume. This is on the high end of typical system-wide non-revenue water. It is expected that the City could decrease water loss as they continue to update and repair water system infrastructure. Additionally, water loss will be reduced in newly constructed water system infrastructure. For these reasons, non-revenue water demand is not expected to increase over the planning period proportional to growth. A constant, average non-revenue water demand was applied to the demand projections in **Table 2-5**. The demand is based on 15 percent of 2020 annual production (equivalent to 0.184 MGD).

2.5.4 Water Demand Projections

Table 2-5 presents future demand projections by customer type, as well as total ADD and MDD through 2050. A peaking factor of 2.3 (maximum peaking factor from 2017-2020 historical data, **Table 2-1**) was used to estimate MDD from ADD projections.

Table 2-5 | Future Water Demand Projections by Customer Type (MGD)

	Single-family Residential	Multi-family Residential	Commercial/ Industrial	Other (Wholesale, Outside City Limits Res., Public, etc.)	Total ADD	MDD
2023	0.74	0.12	0.22	0.07	1.33	2.59
2025	0.77	0.13	0.21	0.07	1.38	2.69
2030	0.86	0.14	0.24	0.07	1.50	2.95
2035	0.95	0.16	0.26	0.07	1.64	3.23
2040	1.06	0.18	0.29	0.07	1.79	3.55
2043	1.13	0.19	0.31	0.07	1.88	3.75
2045	1.17	0.20	0.33	0.07	1.95	3.90
2050	1.27	0.21	0.36	0.07	2.10	4.21

1 Accounts for 0.184 MGD constant, average non-revenue water demand through projections. Historical data shows average system non-revenue water demand as 15 percent of production volume. 2020 production volume used to estimate 0.184 MGD average non-revenue demand.

2 Based on City staff observations, actual demands may be less due to routine historical overflow of Revenue Avenue Reservoir when Hudson Pump Station supplied the City system from the PWB that has since ceased occurring. Consor was unable to identify a clear quantification of the overflow volume. It is recommended that the City investigate the impact of the recurring overflow event on demand forecast at the end of the year 2022.

2.6 Future Water Demand by Pressure Zone

Due to the limited available water consumption data, projected future water demand by pressure zone cannot be accurately forecast without a reliable spatial allocation of current water usage. As presented in **Chapter 5**, future water demands by pressure zone will be estimated using an estimate of developable land by land use type (residential – single-family or multi-family, commercial/industrial, and other uses). While the Oregon House Bill 2001 Middle Housing implementation rules could result in increased residential housing density in some areas, the increase is anticipated to be minimal. The City should review housing density increases on a case-by-case basis during the plan development process. If a situation arises where increased housing density would be limited by available fire flow in the area, the City may require additional sprinkling requirements on structures to meet fire codes and allow for development. This methodology will provide a rough forecast by pressure zone to support capacity analyses and future water system facility sizing.

It is recommended that the City work with their AMI provider to extract detailed records of annual usage by customer, to support future refinement of hydraulic model demand distribution and pressure zone demand allocation.

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CHAPTER 3

Planning and Analysis Criteria

3.1 Introduction

This chapter documents the performance criteria used for analyses of the City's water supply and distribution system presented in **Chapter 4** and **Chapter 5**. Criteria are established for evaluating water supply, distribution system piping, service pressures, storage and pumping capacity, and fire flow availability. These criteria are used in conjunction with the water demand forecasts presented in **Chapter 2** to complete the water system analysis.

3.2 Performance Criteria

The water distribution system should be capable of operating within certain performance limits under varying customer demand and operational conditions. The recommendations of this plan are based on the performance criteria developed in this chapter and summarized in **Table 3-1** at the end of this chapter. These criteria have been developed through a review of City design standards, State of Oregon requirements, American Water Works Association (AWWA) acceptable practice guidelines, the *Ten States Standards*, the *State of Washington Water System Design Manual*, and practices of other water providers in the region.

3.2.1 Supply

Supply adequacy is measured based on firm capacity. For a treatment plant, this is the total plant capacity with the largest single treatment train out of service. For wholesale supply, it is based on the wholesale supply agreement and the firm capacity of the City facilities transmitting supply to the water system. For a pump station, such as the Hudson Road Intertie, this is the capacity with the largest pump out of service.

The City's total firm supply capacity must equal, or exceed, the MDD of the water system.

3.2.2 Service Pressure

Water distribution systems must provide water to customers within a limited pressure range, generally 40 to 80 pounds per square inch (psi). To do this, systems are divided into pressure zones which provide water to customers within a band of ground elevations. Pressure zones are typically served by one or more reservoirs with the same overflow elevation. The ground elevation band is limited by the pressure available from the HGL within each level. The HGL in each pressure zone is set by the water level in the reservoirs or settings of PRVs serving the level. Areas of the system can also be hydraulically connected to another pressure zone by a PRV or pump station.

The City's acceptable service pressure range under normal operating conditions, or ADD, is 40 to 80 psi. However, due to ground elevations in some pressure zones, some customers receive service pressures outside this range. Where mainline pressures exceed 80 psi, services are equipped with individual PRVs to maintain their static pressures at no more than 80 psi in compliance with the Oregon Plumbing Specialty Code. During a fire flow event or emergency, the minimum service pressure is 20 psi as required by Oregon Health Authority, Drinking Water Program (OHA) regulations.

3.2.2.1 Distribution System Evaluation

The distribution system is evaluated for adequacy under two key demand scenarios: MDD plus fire flow and PHD. The distribution system should provide the required fire flow to a given location under MDD conditions while maintaining a minimum residual service pressure of 20 psi at any customer meter in the system as required by OHA regulations.

3.2.2.2 Main Size

Typically, new water mains should be no smaller than 8 inches in diameter. However, 8-inch mains may cause water quality concerns in areas with small, non-emergency demands and minimal looping. Pipe may be 6 inches in diameter if it is directly connected to an 8-inch or larger loop and as long as no hydrants are connected to the 6-inch diameter pipe. For areas with commercial or industrial use or fire flows exceeding 1,000 gpm, a minimum of 12-inch diameter pipe is recommended.

3.2.3 Storage Capacity

Water storage reservoirs should provide capacity for four purposes: operational storage, equalization storage, fire storage, and standby or emergency storage. A brief discussion of each storage element is provided below. Adequate storage capacity must be provided for each set of hydraulically connected pressure zones. Storage volume for closed pressure zones served through PRVs or by constant pressure pumping is provided by the upstream pressure zone supplying the PRV or pump station. The City does not currently have any constant pressure pumped pressure zones but has four PRV-fed constant pressure zones.

3.2.3.1 Operational Storage

Operational storage is the storage in reservoirs between the on and off set points for the supply sources under normal operating conditions. It is calculated by actual reservoir geometries; a typical variation in reservoir level is 3 to 5 feet. An operational range of 5 feet is recommended.

3.2.3.2 Equalization Storage

Equalization storage is the volume of water dedicated to supplying demand fluctuations throughout the day. Per the *Washington Water System Design Manual,* water systems must provide equalization storage when source pumping capacity cannot meet the PHD. It is recommended that the City plan for equalization storage equal to approximately 25 percent of MDD. This is consistent with the practices of similar water utilities in the region.

3.2.3.3 Fire Storage

Water stored for fire suppression is typically provided to meet the single most severe fire flow demand within each pressure zone. Fire services in the City's water service area are provided by Sandy Fire District No. 72, which uses the Oregon Fire Code (OFC) as a standard for addressing general requirements by building construction and development type.

Required fire flows vary depending on the type of development and building construction. Zoning is used as an analog for development type when evaluating required fire flows for planning within the City's water service area as discussed in **Section 3.2.5**. According to the 2019 OFC, the largest required fire flow for buildings in areas with adequate and reliable water systems, like the City, is 3,000 gpm for a recommended duration of 3 hours. The recommended fire storage volume is determined by multiplying the fire flow rate by the duration of that flow.

3.2.3.4 Emergency Storage

Emergency storage is provided to supply water during emergencies such as pipeline failures, equipment failures, power outages, or natural disasters. The amount of emergency storage provided can be highly variable depending upon an assessment of risk and the desired degree of system reliability. An emergency storage volume of twice the ADD is recommended and is consistent with practices of other utilities in the region.

3.2.4 Pump Stations

Pumping capacity requirements vary depending on the water demand, volume of available storage, and the number of pumping facilities serving a particular pressure zone.

3.2.4.1 Pumping to Storage

When pumping to storage reservoirs, a firm pumping capacity equal to the pressure zone's MDD is recommended. Firm pumping capacity is defined as a pump station's pumping capacity with the largest pump out of service.

3.2.4.2 Backup Power

It is recommended that pump stations supplying gravity storage reservoirs include, at a minimum, MTSs and connections for a portable back-up generator. The emergency storage volume in each reservoir will provide short term water service reliability in case of a power outage at the pump station. On-site back-up generators with ATSs are recommended for pump stations critical to the operation of the system.

3.2.5 Required Fire Flow

The water distribution system provides water for domestic use and fire suppression. The amount of water required for fire suppression purposes at a specific location is associated with the local building size and construction type. Zoning and land use are used as analogs for building size when evaluating required fire flows for planning within the City's water service area.

Fire flow requirements are typically much greater in magnitude than the MDD in any local area. Therefore, fire flow must be considered when sizing pipes to ensure adequate hydraulic capacity is available for these potentially large demands. Sandy Fire District No. 72 has generally adopted the 2019 OFC as its own standard.

3.2.5.1 Single-Family and Two-Family Dwellings

The 2019 OFC guidelines specify a minimum fire flow of 1,000 gpm for single-family and two-family dwellings with square footage 3,600 square feet or less. For residential structures larger than 3,600 square feet, the minimum fire flow requirement is 1,500 gpm. The actual fire flow requirement is based on building construction and size and can be found in Table B105.1(2) in Appendix B of the OFC.

For the purposes of this WSMP, distribution piping fire flow capacity will be tested in the water system hydraulic model with a minimum requirement of 1,500 gpm to accommodate the range of potential future residential development in the City. Where deficiencies are identified in the existing system based on this

1,500 gpm requirement, existing homes that are less than 3,600 square feet will be evaluated at a 1,000 gpm fire flow to confirm if a potential deficiency exists for current customers.

3.2.5.2 Other Dwelling Types

For buildings that are not single- and two-family residential dwellings, the fire flow requirement is based on building type and size and can be found in Table B105.1(2) in Appendix B of the OFC. The fire flow rate and duration requirements are reduced if a building has an automatic sprinkler system. Section B106.1 of the OFC sets the maximum fire flow requirement at 3,000 gpm. This applies to any new, altered, moved, enlarged, or repaired building. Buildings that require more than 3,000 gpm need approval from the fire code official.

Table 3-1 | Performance Criteria Summary

Water System Component	Evaluation Criterion	Value	Design Standard/Guideline
Water Supply	Primary Source Capacities	Firm Capacity >= MDD[3]	Ten States Standards, Washington Water System Design Manual
Service Pressure	Normal Range, during ADD[1]	40-80 psi	AWWA M32
	Maximum (without PRV)	80 psi	AWWA M32, Oregon Plumbing Specialty Code Section 608.2
	Minimum, PHD[2]	30 psi	Consor Recommended
	Minimum, during fire flow	20 psi	AWWA M32, OAR 333-061
Distribution Mains	Maximum Pipe Velocity	Not to exceed 12 fps	Consor Recommended
	Minimum Pipe Diameter	8-inch unless specific criteria is met	City Standard
Storage	Operational Storage	Tank level set points	Consor Recommended and Washington Water System Design Manual
	Equalization Storage	25% of MDD[3]	
	Fire Storage	Required fire flow x flow duration	
	Emergency Storage	2 x ADD	
Pump Stations	Firm Capacity Pump to Storage	MDD	Consor recommended
	Backup Power	Automatic transfer switch and on-site generator	
Required Fire Flow and Duration	Single- or Two-Family Residential <=3,600 square feet	1,000 gpm for 2 hours	2019 Oregon Fire Code
	Residential >3,600 square feet and other Buildings	Use OFC criteria for building size and type up to a maximum of 3,000 gpm for 3 hours	
	Commercial and Industrial	Use OFC criteria for building size and type up to a maximum of 3,000 gpm for 3 hours	

1 ADD: Average daily demand, defined as the average volume of water delivered to the system or service area during a 24-hour period.

2 PHD: Peak hour demand, defined as the maximum volume of water delivered to the system or service area during any single hour of the MDD.

3 MDD: Maximum day demand, defined as the maximum volume of water delivered to the system or service area during any single day.

CHAPTER 4

Distribution System Analysis

4.1 Introduction

This chapter provides an evaluation of the City's water service distribution system, including storage reservoirs, pump stations, control valves, and distribution system piping. As discussed in **Chapter 1**, the City's distribution system consists of six pressure zones, five storage reservoirs, four pump stations, and 15 PRV stations. System facilities are analyzed for adequacy in both existing (2023) and near-term (2030) conditions within the 20-year planning horizon (2043), as well as build-out (2050) conditions beyond the planning period. These analyses inform the City's recommended CIP, presented in **Chapter 6**.

This section documents the distribution system analysis according to the performance criteria outlined in **Chapter 3** and water demand forecasts summarized in **Chapter 2**. The analysis assesses overall system performance including service pressures, pipeline velocities, storage and pumping capacities, and emergency fire flow availability. An analysis of the City's existing water supply system is presented in **Chapter 4**.

4.2 Pressure Zone Analysis

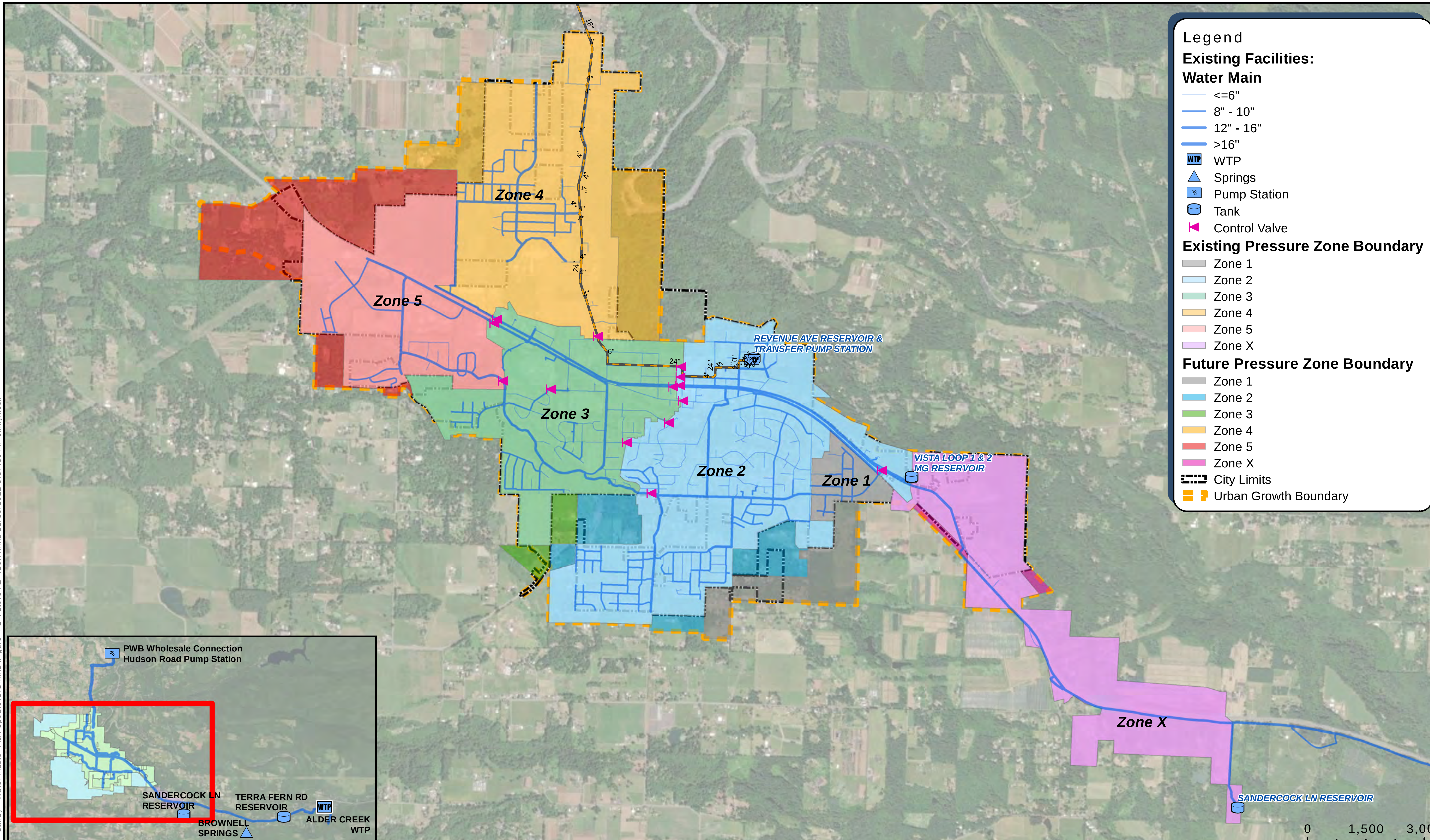
4.2.1 Existing Pressure Zones

As presented in **Chapter 1**, the City's current water service area includes all properties within city limits and some surrounding areas, including three wholesale customers. The City's distribution system is divided into six pressure zones. In addition to customers within zone boundaries, the City provides water to the three wholesale customers, 29 meters above Zone X and the Sandercock Lane Reservoir, and three meters supplied by gravity from Brownell Springs. Zones 1, 3, 4, and 5 are currently served by 14 PRVs. The Sandercock Lane and Vista Loop Reservoirs serve Zones X and 2, respectively.

4.2.2 Pressure Zone Findings

Under existing PHD conditions, the City's six pressures zones provide adequate minimum services pressures of at least 30 psi throughout the system. The maximum acceptable pressure at a water main within the system is 80 psi. Where water main pressure exceeds 80 psi, PRVs are required on individual service connections.

As discussed in **Chapter 2**, future development and densification is expected within the City's UGB. New customers are anticipated to be served primarily by expansion of the existing six pressure zones. Future pressure zone boundaries are illustrated in **Figure 4-1**. Boundaries were developed based on contour and tax lot data.



consor SANDY

City of Sandy
Water System Master Plan

Figure 4 - 1
Future Pressure Zone Boundary

December 2022

20-2800

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4.3 Storage Capacity Analysis

4.3.1 Existing Storage Facilities

This section details the City's existing and future storage capacity needs. Storage projects are identified to accommodate long-term demand projections and improve overall resiliency, reliability, and operational efficiency. As discussed in **Chapter 3**, required storage capacity is calculated as a sum of operational, equalization, fire, and emergency storage. **Table 4-1** summarizes current and projected storage capacity analyses performed for each of the City's pressure zones.

For these analyses, the existing reservoir storage volumes were summed and associated with pressure zones accordingly. The Terra Fern Road and Sandercock Lane Reservoirs provide storage to Zone X, which supplies Zone 1 via a PRV. The two Vista Loop Reservoirs and the Revenue Avenue Reservoir supply Zone 2. Zone 3 is served from Zone 2 by a system of eight PRVs. Zone 3 then serves Zones 4 and 5 via two PRVs per zone. In summary, the Terra Fern Road and Sandercock Lane Reservoirs are associated with Zones X and 1, while the Vista Loop and Revenue Avenue Reservoirs are associated with Zones 2, 3, 4, and 5.

The existing Sandercock Lane Reservoir and the Vista Loop Reservoirs serve customers in Zone X and Zone 2, respectively, by gravity. The City's remaining pressure zones are supplied by PRVs. There must be adequate storage volume to meet customer demands in the zones served directly from reservoirs, as well as smaller zones served through PRVs from the higher level zones with reservoirs.

Table 4-1 | Storage Capacity Analysis

Scenario	Pressure Zone	Required Storage Volume (MG)					Existing Storage Available (MG)	Storage Deficit (MG)
		Operational	Equalization	Fire Flow	Emergency	Total		
2023	Zone X	0.05	0.03	0.54	0.13	0.76	0.75	0.69
	Zone 1	0.05	0.02	0.54	0.07	0.68		
	Zone 2	0.23	0.30	0.54	1.24	2.30	4	2.12
	Zone 3	0.23	0.16	0.54	0.67	1.60		
	Zone 4	0.23	0.09	0.54	0.36	1.21		
	Zone 5	0.23	0.05	0.54	0.19	1.00		
	System	**1.01**	**0.65**	**3.24**	**2.66**	**7.56**	**4.75**	**2.81**
2030	Zone X	0.05	0.04	0.54	0.15	0.78	0.75	0.77
	Zone 1	0.05	0.03	0.54	0.12	0.75		
	Zone 2	0.23	0.31	0.54	1.29	2.37	4	2.46
	Zone 3	0.23	0.17	0.54	0.70	1.64		
	Zone 4	0.23	0.11	0.54	0.44	1.31		
	Zone 5	0.23	0.08	0.54	0.30	1.14		
	System	**1.01**	**0.74**	**3.24**	**3.00**	**7.99**	**4.75**	**3.24**
2043	Zone X	0.05	0.05	0.54	0.18	0.82	0.75	0.96
	Zone 1	0.05	0.06	0.54	0.23	0.89		
	Zone 2	0.23	0.34	0.54	1.40	2.51	4	3.24
	Zone 3	0.23	0.19	0.54	0.76	1.71		
	Zone 4	0.23	0.16	0.54	0.62	1.55		
	Zone 5	0.23	0.14	0.54	0.56	1.47		

Scenario	Pressure Zone	Required Storage Volume (MG)					Existing Storage Available (MG)	Storage Deficit (MG)
		Operational	Equalization	Fire Flow	Emergency	Total		
	System	**1.01**	**0.94**	**3.24**	**3.76**	**8.95**	**4.75**	**4.20**
2050	Zone X	0.05	0.05	0.54	0.20	0.85	0.75	1.07
	Zone 1	0.05	0.08	0.54	0.30	0.97		
	Zone 2	0.23	0.36	0.54	1.47	2.59	4	3.69
	Zone 3	0.23	0.20	0.54	0.79	1.76		
	Zone 4	0.23	0.19	0.54	0.73	1.68		
	Zone 5	0.23	0.18	0.54	0.70	1.65		
	System	**1.01**	**1.05**	**3.24**	**4.20**	**9.50**	**4.75**	**4.75**

4.3.2 Storage Capacity Findings

As shown in **Table 4-1**, the existing water distribution system is lacking in storage for the current 2023 scenario by approximately 2.81 MG, system wide. By the build-out scenario in 2050, the system has a storage deficit of about 4.75 MG.

The City identified three City-owned tax lots that could serve as potential reservoir sites: 24E13BD00101 (Site 2), 24E14DA00700 (Site 1A), and 24E14DB07300 (Site 1B). A summary of these sites and their potential uses is provided in **Table 4-2**.

Site 1A is located at a ground elevation of approximately 850 feet. On Site 1A, the City could construct a buried tank to serve Zone 5 at its current HGL. They also have the option of constructing a tank that would raise the HGL of Zone 5. For the purposes of this WSMP, a reservoir with a floor elevation of 802 feet and a volume of 1.7 MG was modeled at this site to serve Zone 5 at its current HGL. A reservoir at this site would require approximately 1,200 feet of supply piping and 2,000 feet of outlet piping.

With a ground elevation of approximately 900 feet, Site 1B is too high to serve Zone 5 and too low to serve Zone 3. This site could be utilized to provide storage for Zone 4. This would require approximately 3,000 feet of transmission main. Use of this site would be limited by its small size.

Site 2 is the largest by area and has the widest range of ground elevations. One potential use for this site is to construct an elevated storage tank to supply Zone 3. The site could also be used to supply storage to Zone 4 by raising the zone's HGL, which would allow it to be tied directly into the PWB transmission main. For this WSMP, a reservoir was modeled on this site to supply Zone 4, with a floor elevation of 882 feet and a volume of 1.7 MG. This reservoir would require about 300 feet of supply piping and 3,200 feet of transmission main.

In addition to the undeveloped potential reservoir sites, the Sandercock Lane site could be utilized to increase available storage for Zones X and 1 and provide gravity supply to lower elevation pressure zones. An additional reservoir could be constructed on the site or the existing reservoir removed and replaced with a larger one.

Table 4-2 | Potential Reservoir Sites

Tax Lot ID (Address)	Site Name	Ground Elevation Range (feet)	Potential Uses for Site
24E13BD00101 (17255 Smith Ave)	Site 2	890 to 970	➢ Construct an elevated reservoir to provide storage for Zone 3 ➢ Raise the HGL of Zone 4 by providing storage from this site; Zone 4 could then be directly tied in to the PWB transmission main ➢ Construct a ground-level reservoir and pump station to supply the system where needed
24E14DA00700 (Sunset St and University Ave)	Site 1A	840 to 860	➢ Construct a buried reservoir to serve Zone 5 ➢ Raise the HGL of Zone 5 by providing storage from this site ➢ Construct a ground-level reservoir and pump station to supply the system where needed
24E14DB07300 (37615 Sandy heights St)	Site 1B	895 to 905	➢ Construct a reservoir to serve Zone 4

4.4 Pumping Capacity Analysis

4.4.1 Existing Pumping Facilities

As described in **Section 1.4.3**, the existing distribution system includes four pump stations. The Alder Creek WTP, Terra Fern, and Hudson Pump Stations pump directly to the Terra Fern Road, Sandercock Lane, and Revenue Avenue Reservoirs, respectively. Aside from a handful of customers served above Zone X from the Terra Fern pump station discharge piping, the Revenue Transfer pump station is the only one that pumps directly into the distribution system piping.

Pressure zones with the benefit of gravity storage are also referred to as open zones. All six of the City's pressure zones are open. Operational and fire storage supplied by open zone reservoirs make it unnecessary to plan for fire flow or peak hour capacity from pump stations or other supplies, assuming adequate storage is available. Open zone pump stations must have sufficient firm capacity to meet the MDD for all customers in the zone.

4.4.2 Pumping Capacity Findings

The pumping capacity analysis was completed for the entire system, rather than by pressure zone, and accounted the capacities of the Terra Fern and Transfer Pump Stations. **Table 4-3** summarizes the analysis of the City's existing and future pumping requirements. The existing pump stations provide adequate capacity to supply existing and future demands.

Table 4-3 | Pumping Capacity Analysis

Scenario	Existing Total Capacity (MGD)	Required Capacity, MDD (MGD)	Pumping Deficit (MGD)
2023	4.68	2.59	-2.09
2030	4.68	2.95	-1.73
2043	4.68	3.75	-0.93
2050	4.68	4.21	-0.47

Though the system's existing pumping capacity is sufficient to meet existing and future demands, adequate fire flow is not being provided for the system above the Sandercock Lane Reservoir. In order to meet MDD plus fire flow demands, it is recommended that upgrades be completed at the Terra Fern Pump Station. A 1,000 gpm fire flow pump should be added to supply current and future demands.

In addition to upgrades at the Terra Fern Pump Station, a pump station should be constructed at the Vista Loop site to provide redundancy to the system. Currently, if the Alder Creek WTP supply is unavailable, Brownell Springs may not supply sufficient capacity to customers above Zone 2 that the Transfer pump station cannot serve. A Vista Loop Pump Station would be able to supply Zones X and 1 as well as customers above Sandercock Lane Reservoir in case of an emergency. The Vista Loop Pump Station should be sized to provide 400 gpm, which will meet Zone X plus Zone 1 demands. It should provide 310 feet of head so that it can pump up to Sandercock Lane Reservoir, which is the highest point in the system.

4.5 Distribution System Analysis

4.5.1 Hydraulic Model

A hydraulic model was developed using the City's GIS data. This included utilizing shapefiles provided by the City. **Table 4-4** presents the shapefiles used to create the hydraulic model.

Table 4-4 | City GIS Data

File Name	Model Element	Notes
Water_Mainlines(1).shx	Pipes	Determined pipe length, diameter, material, and pressure zone from shapefile
PRV_Valves(1).shx	Valves	Determined PRV location and size from shapefile

In addition to the model build, the meter shapefile and tax lot shapefile were utilized to allocate demands to the system. The Demand Allocation used the 2020 consumption data to allocate the demand based on meter type and meter size. **Table 4-5** presents the demand allocation by meter type and meter size.

Table 4-5 | Demand Allocation

Land Use	Meter Size	Number of Meters	Total Demand (gpm)	Demand per Meter (gpm)
Single Family	¾ and 1-inch	3,623	435.37	0.12
Single Family	2-inch	4	2.17	0.54
Multi Family	¾, 1, 1½, 2, and 4-inch	47	72.85	1.55
Commercial/Industrial	¾, 1, 1½, and 2-inch	253	136.76	0.54

[1] Meter data was obtained from December 2020 billing data provided by the City.

Once the demand was spatially allocated per the known meter locations, it could be scaled to simulate ADD, MDD, and PHD. **Table 4-6** presents the demands within the system scaled to meet the required simulation conditions.

Table 4-6 | Demand Scenarios

Scenario	System-Wide Water Demand (MGD)		
	ADD	MDD	PHD
Existing (2023)	1.33	2.59	4.26
Near-Term (2030)	1.50	2.95	4.83
Build-Out (2050)	2.10	4.21	6.85

4.5.2 Model Calibration

4.5.2.1 Fire Flow Testing

Consor provided the City with the proposed locations for hydrant testing to be conducted for the purpose of hydraulic model verification and calibration. Some of the test locations provided static pressure to verify the HGL of specific areas of the system. At the majority of locations, fire hydrants were operated to stress the system to calibrate the model. The data obtained when the system is stressed can be used to determine required changes to the boundary conditions and pipe roughness factors within the hydraulic model. The City provided fire flow test results conducted over the course of three days. **Table 4-7** presents an overview of the fire flow test locations and purpose of the test. **Figure 4-2**, **Figure 4-3**, and **Figure 4-4** provide maps of the fire flow test locations.

Table 4-7 | Fire Flow Test Location Overview

Date of Test	Test #	Pressure Zone	Approximate Test Location	Time of Test
01/20/2022	1	X	Mt Hood Hwy & SE Wagoneer Loop	10:25
	2	X	Mt Hood Hwy & SE Rainbow Hill Rd	10:35
	3	X	SE Vista Loop Dr & SE 412th Ave	10:51
	4	1	Antler Ave & Dubarko Dr	11:00
	5a	2	Langensand Rd & McCormick Dr	11:31
	6a	2	Pacific Ave & Dubarko Dr	13:55
	7a	2	Cork Ave & Cascadia Dr	14:13
	8a	2	Revenue Ave & Idleman St	15:00
	9	3	Sandy Heights St & Nettie Connett Dr	15:31
	10a	3	37695 HWY 26	15:52
	14	5	36535 Industrial Way	16:10
	15	5	Skogan Rd & Aubin St	16:26
01/24/2022	11	4	Coralburst St & Jewelberry Ave	14:05
	12	4	Jefferson Ave & Olson St	14:21
	13	5	Kelso Rd & Shalimar Dr	14:38
	16	PWB	SE Bluff Rd & SE Hauglum Rd	15:06
	17	PWB	SE Bluff Rd & SE Hudson Rd	15:23
	18	PWB	39175 SE Hudson Rd	15:32
01/25/2022	5b	2	Langensand Rd & McCormick Dr	14:13
	6b	2	Pacific Ave & Dubarko Dr	15:02
	7b	2	Cork Ave & Cascadia Dr	15:37
	8b	2	Revenue Ave & Idleman St	16:10
	10b	3	37695 HWY 26	16:37

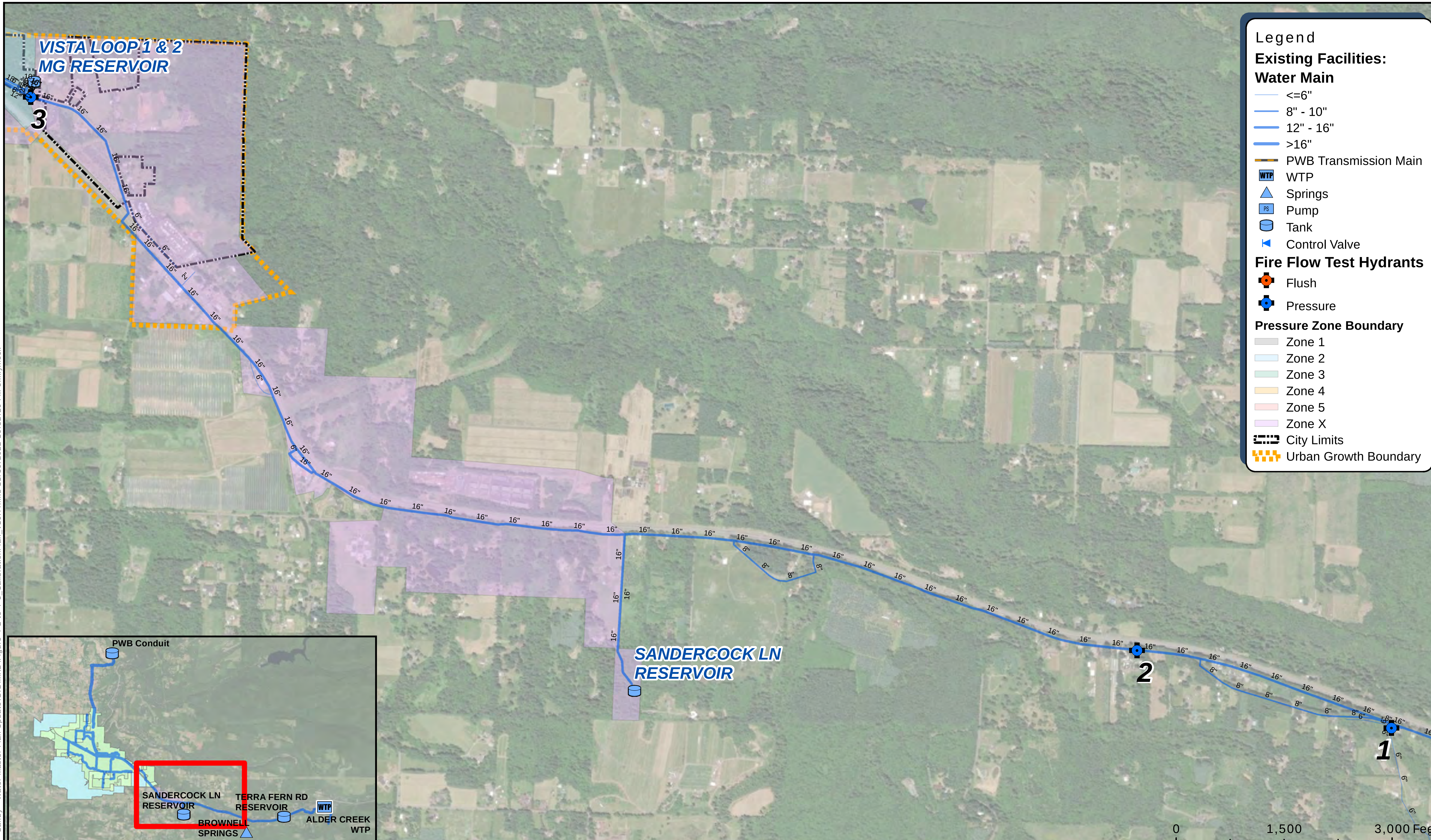

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Figure 4-2
Field Fire Pressure and Flow
Test Locations 1-3

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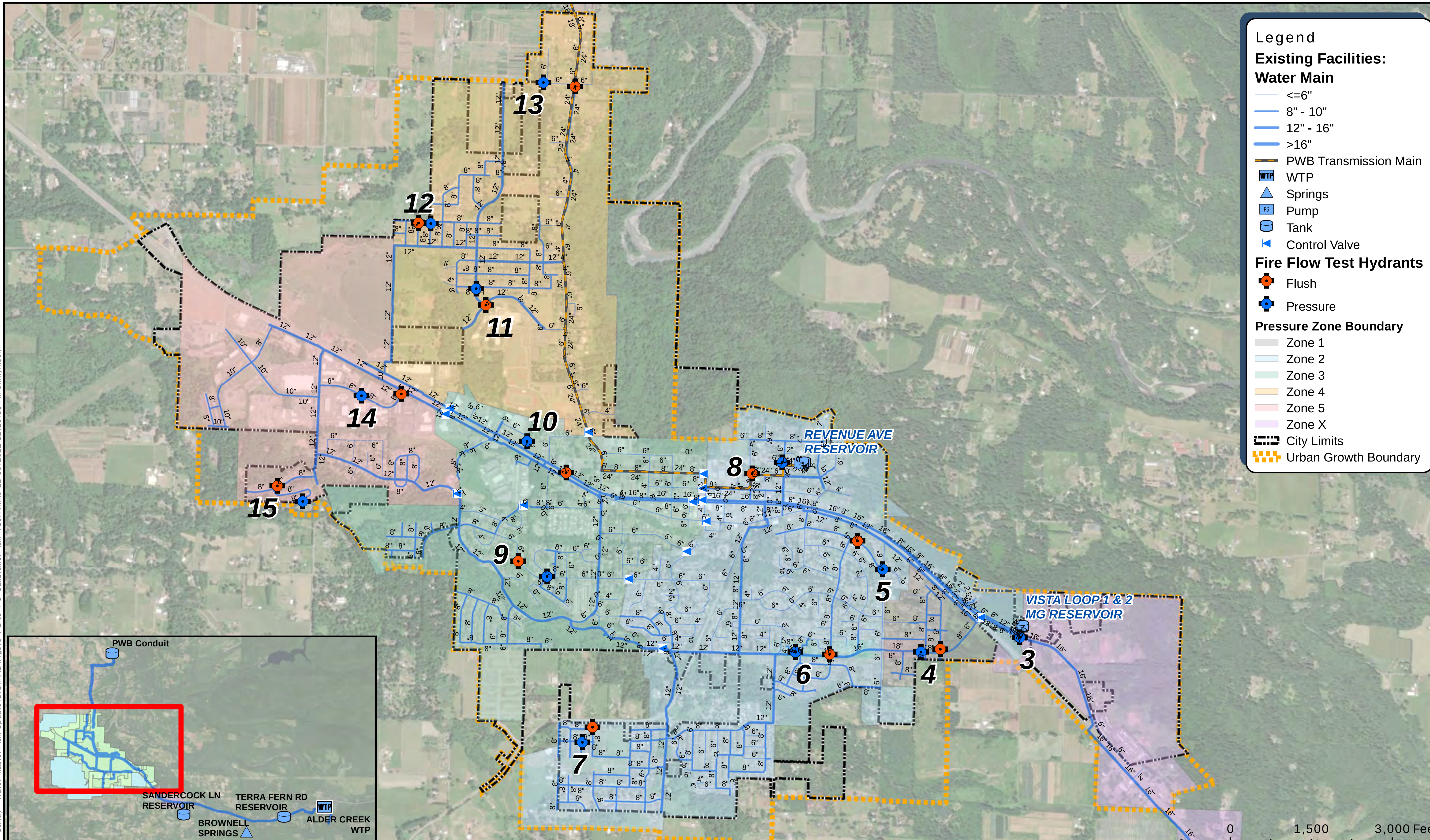

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Figure 4-3
Field Fire Pressure and Flow Test Locations 3-15

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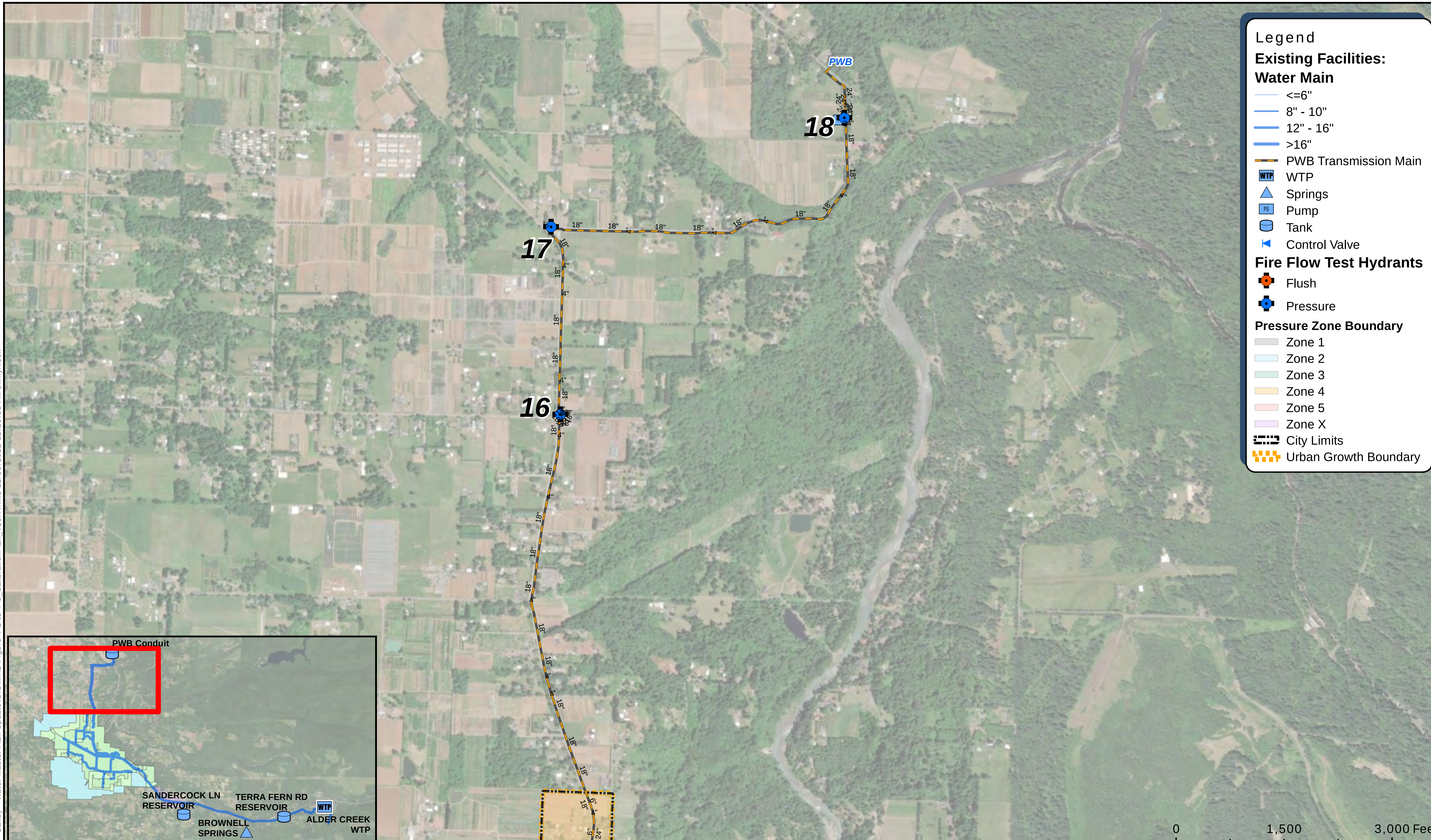

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Figure 4-4
Field Fire Pressure and Flow Test Locations 16-18

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4.5.2.2 Calibration Results

In addition to providing the results of the hydrant tests, the City provided the boundary conditions of water system facilities at the time of each test. The boundary conditions were used to calculate the demand observed during each test. The boundary conditions were also input into the model for each hydrant test to accurately simulate the conditions of the test. **Table 4-8** presents the boundary conditions for each hydrant test.

Table 4-8 | Fire Flow Test Boundary Conditions

Date of Test	Test #	Reservoir Water Level (feet)			
		Terra Fern Road	Sandercock Lane	Vista Loop	Revenue Avenue
01/20/2022	1	8.8	19.6	19.9	12.49
	2	8.8	19.7	20	12.07
	3	8.7	19.7	20.1	11.64
	4	8.6	19.7	20.3	11.2
	5a	8.6	19.6	20.5	10.34
	6a	14	20.1	21.5	6.56
	7a	17.5	20.1	21.7	5.91
	8a	22.7	20.4	22	4.5
	9	26.1	20.5	21.8	4.5
	10a	29.4	20.6	21.7	4.5
	14	29.4	20.6	21.6	4.5
	15	30.1	20.6	21.5	4.5
01/24/2022	11	28.4	27.7	21.6	5.58
	12	28.4	27.8	21.7	5.04
	13	28.3	27.9	21.8	4.61
	16	28.2	29.9	22	3.85
	17	28.2	27.9	21.9	3.85
	18	28.2	28	21.8	3.85
01/25/2022	5b	29.3	27.8	21.7	5.37
	6b	29.2	28	21.6	3.85
	7b	29.1	28.2	21.4	3.85
	8b	29	28.2	21.1	3.85
	10b	29	28.2	21.1	3.85

A fire flow calibration scenario was set up within the model and each of the hydrant test locations was simulated. **Table 4-9** provides the field flow data compared to the flow data input into the model. **Table 4-10** provides a comparison of the static pressures and pressure drops observed at each hydrant test.

Table 4-9 | Fire Flow Test Flow Comparison

Date of Test	Test #	Flow Hydrant			Notes
		Flow (gpm)	Model Flow (gpm)	Difference (gpm)	
1/20/2022	1	---	---	---	
	2	---	---	---	
	3	---	---	---	
	4	740	740.68	0.68	Difference due to demand on Node
	5a	812.5	813.3	0.8	Difference due to demand on Node
	6a	700	701.02	1.02	Difference due to demand on Node
	7a	650	650.8	0.8	Difference due to demand on Node
	8a	937.5	937.5	0	
	9	962	962.34	0.34	Difference due to demand on Node
	10a	914	916.28	2.28	Difference due to demand on Node
	14	760	762.36	2.36	Difference due to demand on Node
	15	990	990.46	0.46	Difference due to demand on Node
1/24/2022	11	760	760	0	
	12	974	974.71	0.71	Difference due to demand on Node
	13	500	500	0	City indicated "Low Flow" for this hydrant test
	16	---	---	---	
	17	---	---	---	
	18	---	---	---	
1/25/2022	5b	1940	1940.77	0.77	Difference due to demand on Node
		740	740.66	0.66	Difference due to demand on Node
	6b	1680	1680.99	0.99	Difference due to demand on Node
		675	675.44	0.44	Difference due to demand on Node
	7b	1880	1880.77	0.77	Difference due to demand on Node
	8b	2380	2380	0	
	10b	2380	2382.21	2.21	Difference due to demand on Node

Table 4-10 | Fire Flow Test Pressure Comparison

Date of Test	Test #	Pressure Hydrant					
		Static Pressure (psi)	Model Static Pressure (psi)	Difference (psi)	Pressure Drop (psi)	Model Pressure Drop (psi)	Difference (psi)
1/20/2022	1	110	110.52	0.52	---	---	---
	2	52	53.81	1.81	---	---	---
	3	105	104.27	-0.73	---	---	---
	4	60	60.65	0.65	3	5.83	2.83
	5a	57	57.37	0.37	0	1.52	1.52
	6a	62	62.73	0.73	0	1.78	1.78
	7a	85	83.39	-1.61	5	7.12	2.12
	8a	88	89.01	1.01	2	1.39	-0.61

Date of Test	Test #	Pressure Hydrant					
		Static Pressure (psi)	Model Static Pressure (psi)	Difference (psi)	Pressure Drop (psi)	Model Pressure Drop (psi)	Difference (psi)
	9	93	88.48	-4.52	7	4.13	-2.87
	10a	88	90.83	2.83	4	1.2	-2.8
	14	77	75.58	-1.42	17	9.77	-7.23
	15	70	71.13	1.13	22	17.15	-4.85
1/24/2022	11	67	67.11	0.11	13	7.65	-5.35
	12	80	84.44	4.44	11	8.94	-2.06
	13	59	53.95	-5.05	39	41.35	2.35
	16	73	78.53	5.53	---	---	---
	17	93	97.56	4.56	---	---	---
	18	29	24.69	-4.31	---	---	---
1/25/2022	5b	56	57.9	1.9	8	11.37	3.37
	6b	59	61.96	2.96	5	12.58	7.58
	7b	81	82.45	1.45	22	40.27	18.27
	8b	83	84.59	1.59	7	6.64	-0.36
	10b	87	90.83	3.83	3	4.17	1.17

4.5.2.2.1 Test 1

The purpose of this test was to confirm the HGL at a location in Zone X downstream of Brownell Springs. In order to satisfy the HGL of this test, the HGL of Brownell Springs was adjusted to 1545 feet.

4.5.2.2.2 Test 2

The purpose of this test was to confirm the HGL at a location in Zone X upstream of Sandercock Lane Reservoir. In order to satisfy the HGL of this test, additional losses were required in the pipeline upstream of the reservoir. It was determined that the pipeline into the reservoir was incorrect. Based on field investigations, the diameter of the pipeline into Sandercock Lane Reservoir was reduced to 8 inches. Even with this change, the losses observed in the field did not match the losses in the model. It was determined that C-factor adjustments and/or adding minor losses in the model would not provide the required losses in the pipeline to simulate the additional losses observed in the field. Therefore, a pressure sustaining valve was added to the model to set the appropriate HGL in the area upstream of Sandercock Lane Reservoir.

4.5.2.2.3 Test 3

The purpose of this test was to confirm the HGL at a location in Zone X upstream of Vista Loop Reservoir. In order to satisfy the HGL of this test, additional losses were required in the pipeline upstream of Vista Loop Reservoir. The losses observed in the field did not match the losses in the model. It was determined that C-factor adjustments and/or adding minor losses in the model would not provide the required losses in the pipeline to simulate the additional losses observed in the field. Therefore, a pressure sustaining valve was added to the model to set the appropriate HGL in the area upstream of Vista Loop Reservoir.

4.5.2.2.4 Test 4

The purpose of this test was to stress the system in Zone 1. Based on the observed static pressure and pressure drops, the following changes were made to the model.

- Vista Loop & Highway 26 PRV
  - Lowered the 3-inch PRV setpoint from 60 psi to 53 psi
  - Lowered the 8-inch PRV setpoint from 55 psi to 48 psi

4.5.2.2.5 Tests 5 – 8

The purpose of these tests was to stress the system in Zone 2. Tests 5 through 8 had to be retested due to insufficient pressure drops observed in the field. Based on the observed static pressure and pressure drops, the following changes were made to the model.

- Raised the concrete Vista Loop Reservoir floor elevation from 1,114 feet to 1,136 feet
- Raised the steel Vista Loop Reservoir floor elevation from 1,118 feet to 1,136 feet
- Adjusted elevation of pressure fire hydrants 5, 6, and 7 to match Digital Terrain Model

Even with these changes, there were still locations where the model could not simulate field conditions. Test 6B observed a higher pressure drop in the model than what was observed in the field at the second observation hydrant. As the pressure drop in the model was higher than what was observed in the field, the C-factor adjustment required would smooth the pipe (i.e. increase the C-factor) and would make the other tests and observation hydrants out of range. In addition, the C-factor for specific pipe types would be outside of acceptable ranges (i.e. too high). In addition to test 6, the two observation hydrants for test 7B observed a higher pressure drop in the model than what was observed in the field. This area is fed by a single pipeline. The only plausible explanation for the pressure drop observed in the field is a second feed to this area (i.e. there is a unknown pipeline supplying water to this area that completes a loop). Further field investigations would be required to rectify this error.

4.5.2.2.6 Tests 9 – 10

The purpose of these tests was to stress the system in Zone 3. Test 10 had to be retested due to insufficient pressure drops observed in the field. Based on the observed static pressure and pressure drops, the following changes were made to the model.

- Dubarko & Tupper PRV
  - Raised the 2.5-inch PRV setpoint from 80 psi to 81 psi
  - Lowered the 8-inch PRV setpoint from 80 psi to 76 psi
- Sandy Heights & Beebee PRV
  - Lowered the 1.5-inch PRV setpoint from 57 psi to 55 psi
  - Lowered the 6-inch PRV setpoint from 57 psi to 50 psi
- Strawbridge & Tupper PRV
  - Kept 1.5-inch PRV setpoint at 80 psi
  - Lowered the 6-inch PRV setpoint from 85 psi to 83 psi

- 38871 Proctor PRV
    - Lowered the 3-inch PRV setpoint from 55 psi to 53 psi
    - Lowered the 10-inch PRV setpoint from 55 psi to 50 psi
- Adjusted elevation of pressure fire hydrant to match Digital Terrain Model

4.5.2.2.7 Tests 11 – 13

The purpose of these tests was to stress the system in Zone 4. Based on the observed static pressure and pressure drops, the following changes were made to the model.

- 37151 HWY 26 PRV
    - Lowered the 4-inch PRV setpoint from 65 psi to 58 psi
    - Lowered the 10-inch PRV setpoint from 58 psi to 55 psi
- Bluff, north of high school, PRV
    - Lowered the 2-inch PRV setpoint from 55 psi to 43 psi
    - Lowered the 6-inch PRV setpoint from 55 psi to 37 psi
- Adjusted elevation of pressure fire hydrant to match Digital Terrain Model

Test 11 had more pressure drop observed in the field than what was simulated in the model. However, further C-factor adjustments would adversely affect other hydrant tests. Therefore, the C-factors were not adjusted further to increase losses at this test. Test 13 had a static pressure that was different from the field, but further PRV Setpoint adjustments were not completed as Test 12 static pressure would then be out of range.

4.5.2.2.8 Tests 14 – 15

The purpose of these tests was to stress the system in Zone 5. Based on the observed static pressure and pressure drops, the following changes were made to the model.

- Dubarko & Ruben PRV
    - Raised the 3-inch PRV setpoint from 65 psi to 75 psi
    - Raised the 10-inch PRV setpoint from 65 psi to 70 psi
- 37000 HWY 26 PRV
    - Kept 3-inch PRV setpoint at 61 psi
    - Raised the 10-inch PRV setpoint from 61 psi to 65 psi

Tests 14 and 15 had less pressure drop observed in the field than what was simulated in the model. However, further C-factor adjustments would adversely affect other hydrant tests. Therefore, the C-factors were not adjusted further to increase losses at these tests.

4.5.2.2.9 Tests 16 – 18

The purpose of these test was to confirm the HGL along the PWB upstream of Revenue Avenue Reservoir. Tests 16 and 17 had static pressures that were approximately 5 psi too high while Test 18 had a static pressure that was approximately 5 psi too low. No model changes were made due to these tests.

4.5.3 Distribution System Analysis

The distribution system was analyzed using the demands shown in **Table 4-6** above. **Table 4-11** presents the scenarios created and boundary conditions.

Table 4-11 | Distribution System Scenarios

Scenario	Demand (MGD)	Facilities	Notes
Existing ADD	1.33	Existing system	Placeholder scenario
Existing MDD	2.59	Existing system	Placeholder scenario
Existing MDD+FF	2.59	Existing system	Analyzed available fire flow
Existing PHD	4.26	Existing system	Analyzed pressure and velocity
Near-term ADD	1.5	Existing system with CIP improvements	Placeholder scenario
Near-term MDD	2.95	Existing system with CIP improvements	Placeholder scenario
Near-term MDD+FF	2.95	Existing system with CIP improvements	Analyzed available fire flow in 2030
Near-term PHD	4.83	Existing system with CIP improvements	Analyzed pressure and velocity in 2030
Buildout ADD	2.1	Existing system with CIP improvements	Placeholder scenario
Buildout MDD	4.21	Existing system with CIP improvements	Placeholder scenario
Buildout MDD+FF	4.21	Existing system with CIP improvements	Analyzed available fire flow in 2050
Buildout PHD	6.85	Existing system with CIP improvements	Analyzed pressure and velocity in 2050

Figure 4-5 through **Figure 4-10** present the results of distribution system analysis.

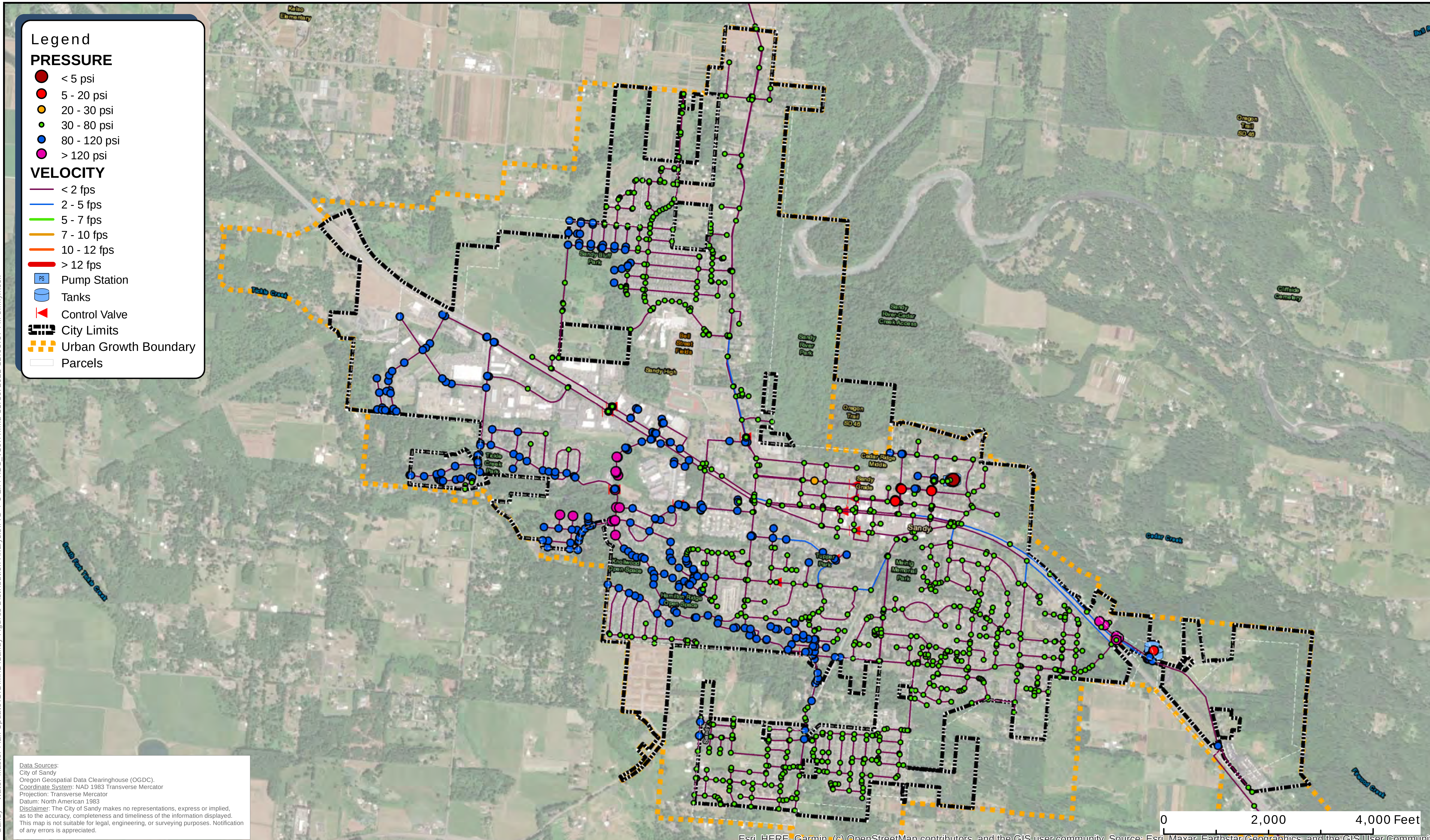

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Figure 4-5
Existing PHD
Pressure and Velocity

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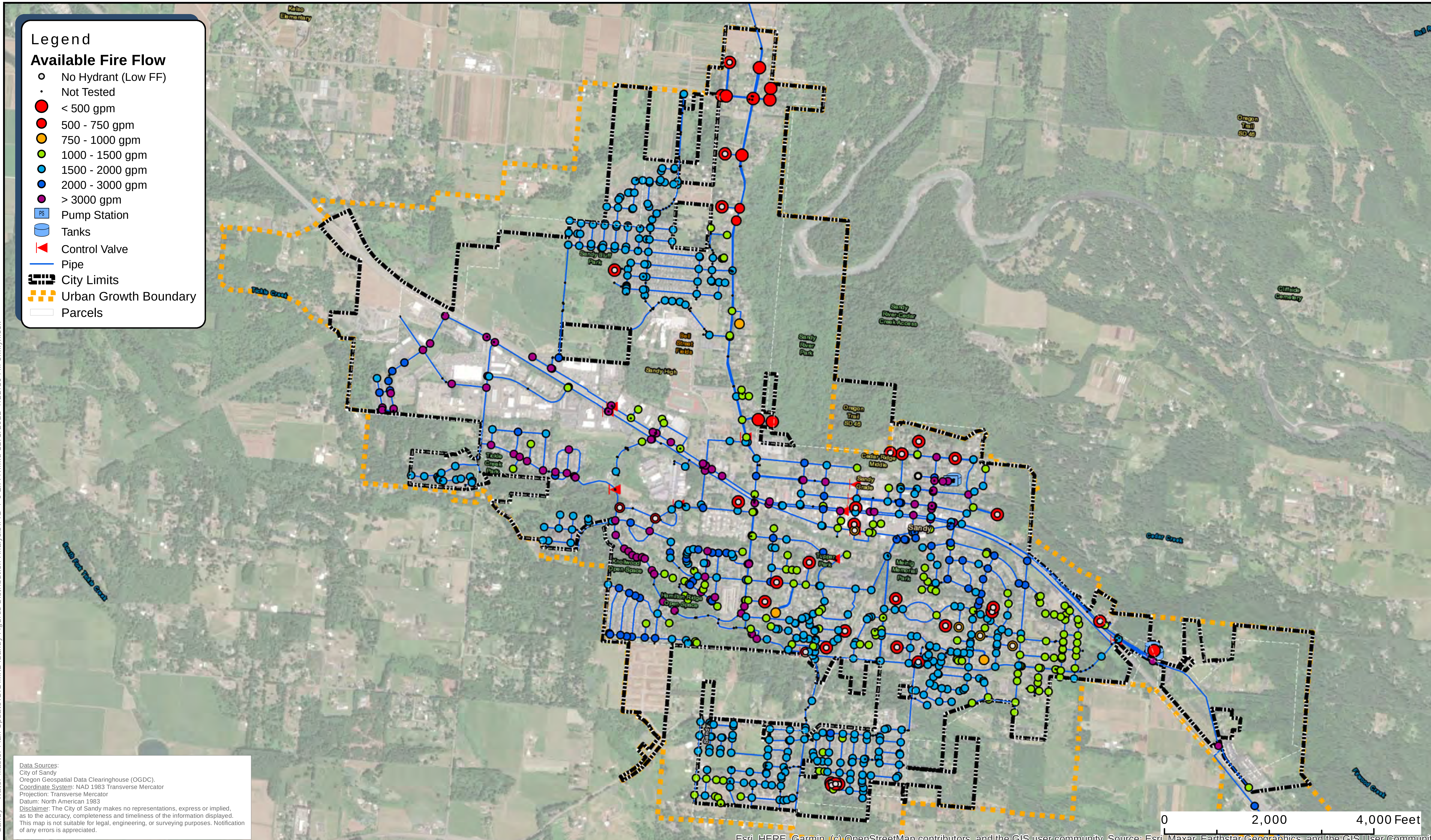

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Figure 4-6
Existing MDD
Available Fire Flow

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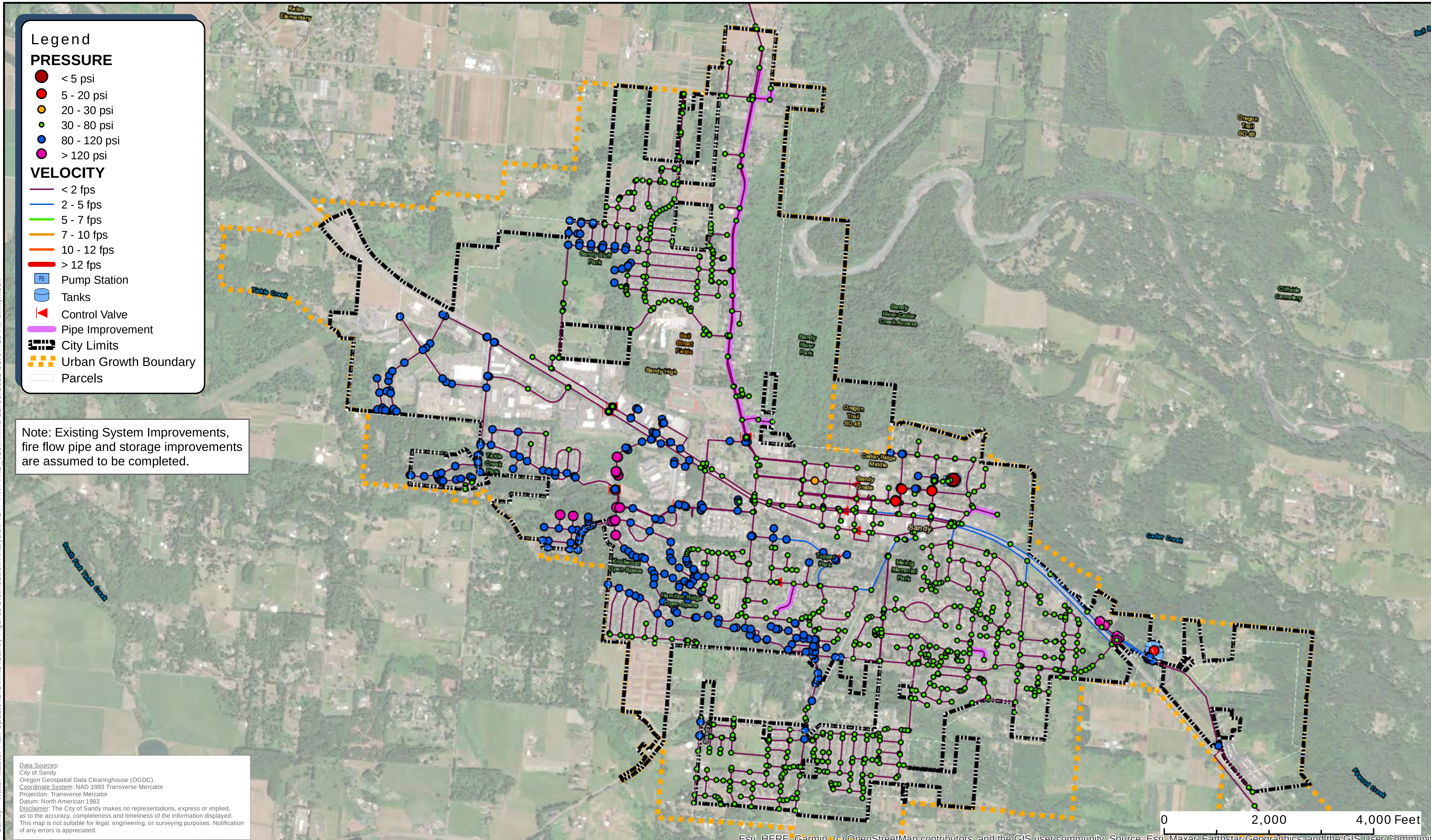

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Figure 4-7
Near-Term PHD w/ Prop Improv
Pressure and Velocity

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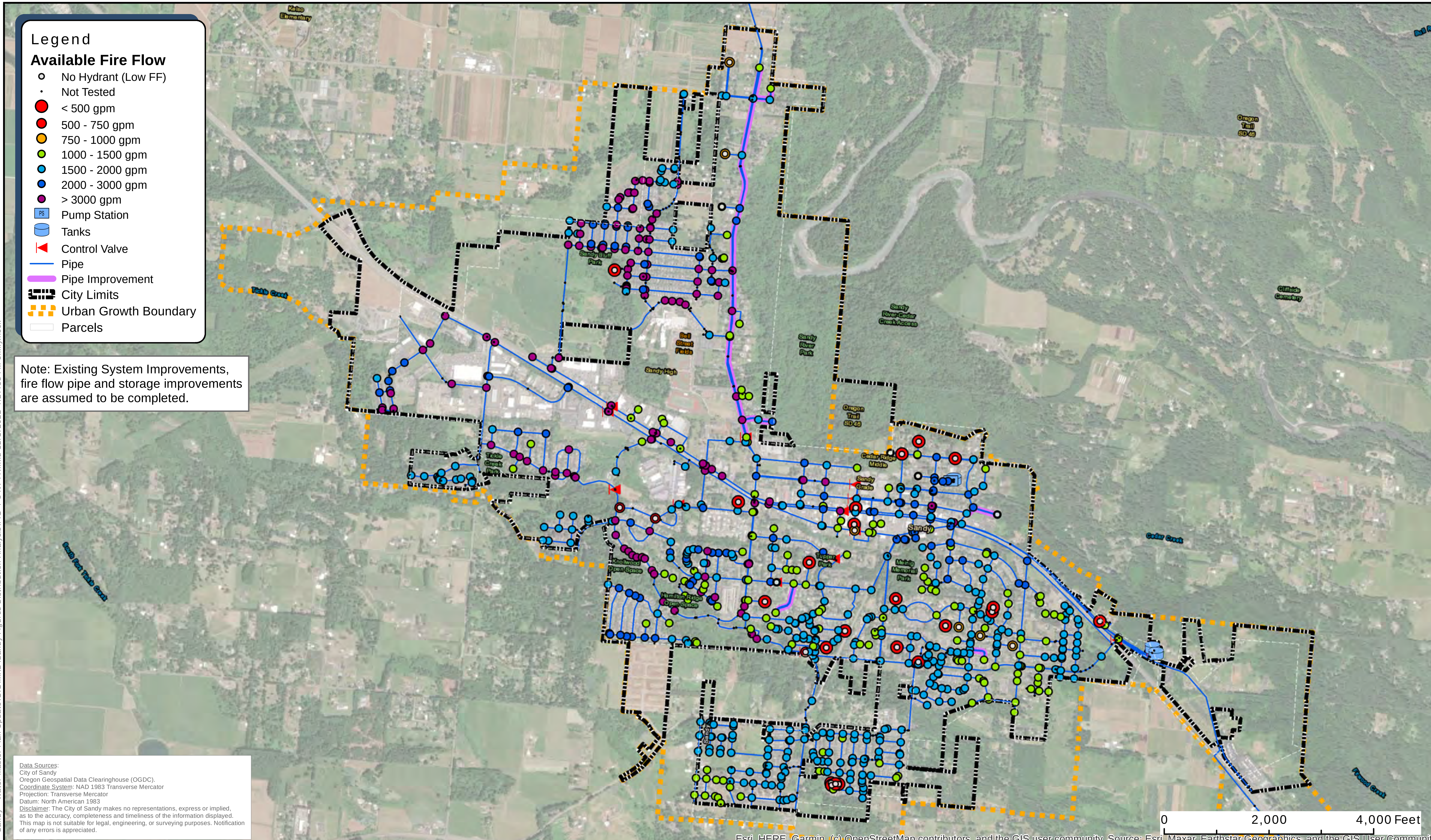

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City of Sandy
Water Master Plan Update

Figure 4-8
Near-Term MDD w/ Prop Improv
Available Fire Flow

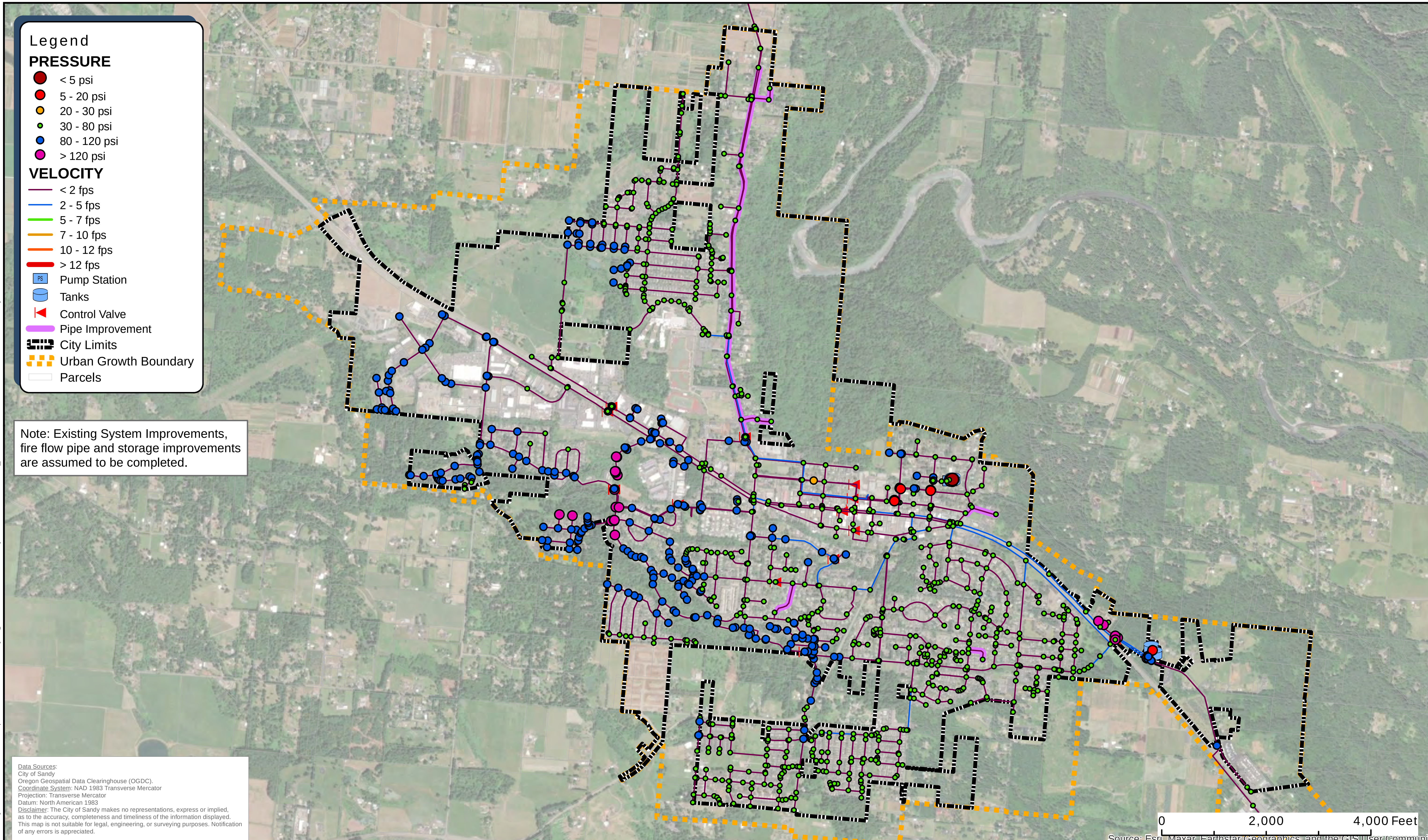

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Figure 4-9
Buildout PHD w/ Prop Improv
Pressure and Velocity

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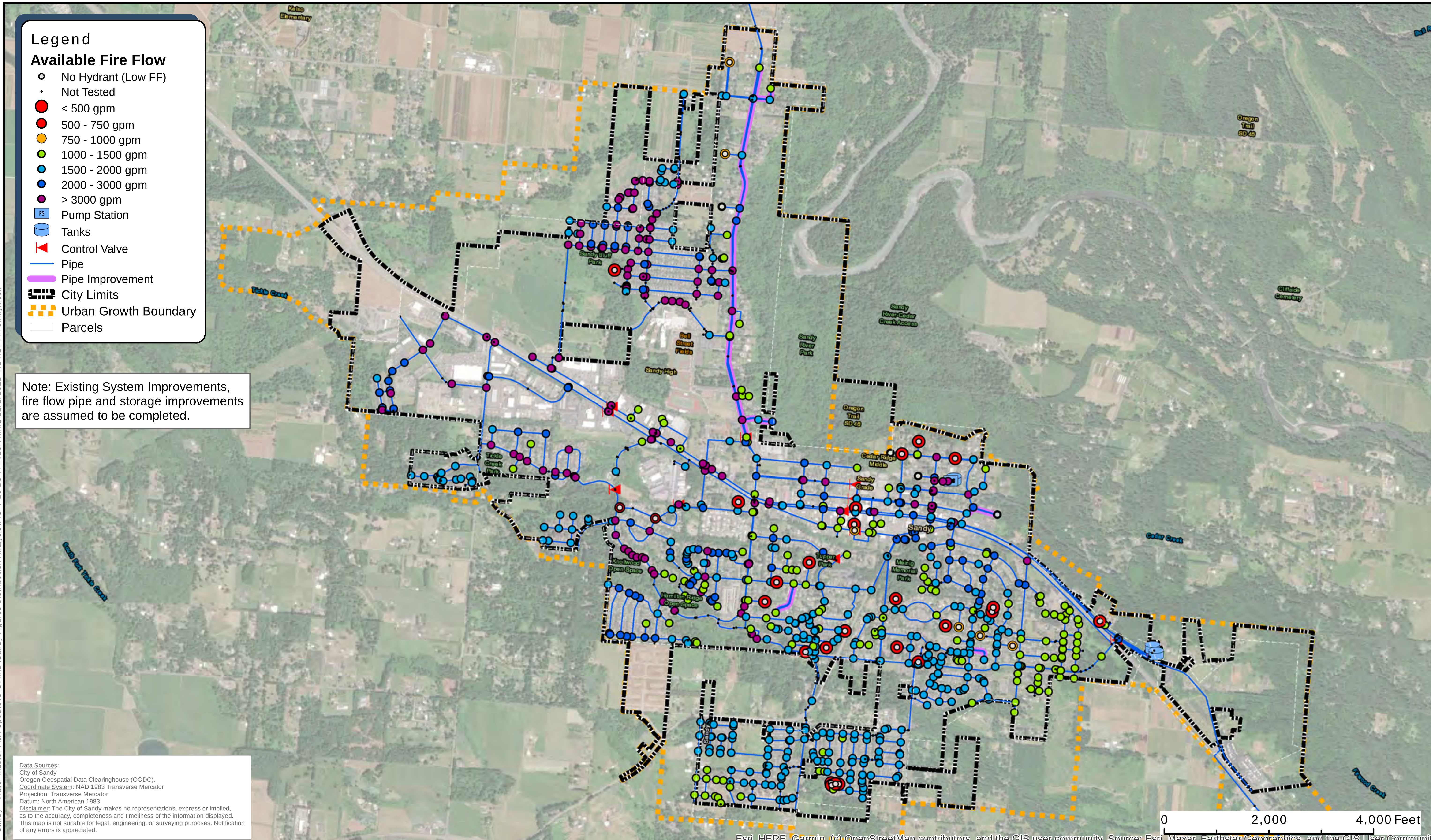

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Water Master Plan Update

Figure 4-10
Buildout MDD w/ Prop Improv
Available Fire Flow

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4.5.3.1 Peak Hour Demand

The PHD was analyzed for Existing, Near-Term, and Buildout Scenarios. Based on the analysis, there were no service connections that were below 30 psi for each of these scenarios. The Near-Term and Buildout scenarios were retested using floating storage at the sites identified by the City. With appropriate pipeline transmission from the floating storage sites, the service connections all maintained higher than 30 psi. There are some locations of low pressures observed in each of these scenarios, which occur on the PWB Transmission pipeline and near existing storage facilities. No improvements are recommended at this time to maintain 30 psi under peak hour conditions for each of the scenarios tested.

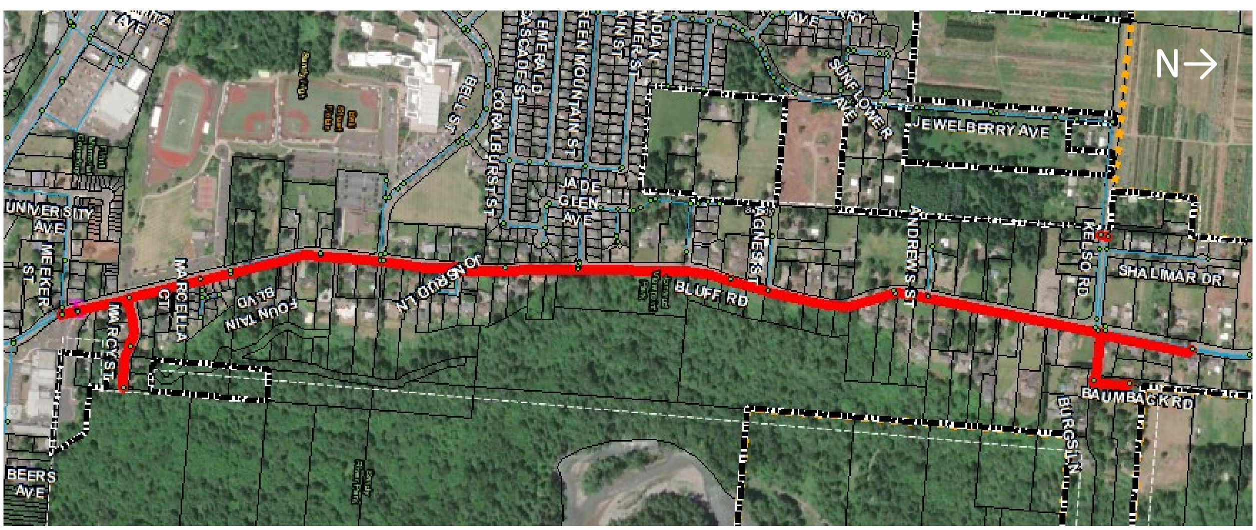
4.5.3.2 Fire Flow Availability

The available fire flow was analyzed for Existing, Near-Term, and Buildout Scenarios. The analysis focused on Demand Nodes, to simulate the conditions observed at service connections. Based on the analysis, there were multiple locations that failed Fire Flow under Existing Conditions. These locations also failed under Near-Term and Buildout Conditions. Each of the failed locations were reviewed to determine if a hydrant was nearby. Where hydrants were not in the vicinity of the failed node, no improvements are recommended. Improvements were identified to provide adequate fire flow to locations where a hydrant was near the failure.

4.5.3.2.1 Bluff Road Fire Flow Improvements

This project consists of improving the pipelines on Bluff Road, Burgs Lane, Kelso Road, and SE Baumback Avenue. There is also a hydrant in the GIS on Marcy Street, which is being reviewed by the City to determine if improvements are required to serve. For cost estimating purposes, it is assumed that Fire Flow service is required on Marcy Street. **Figure 4-11** shows the location of the Bluff Road Improvements.

Figure 4-11 | Bluff Road Improvements



Based on comments from the City, it was determined that there is already a 12-inch diameter pipeline in Kelso Road. It is recommended that the hydrant in Kelso Road be connected to this 12-inch diameter line in lieu of a new pipeline. This pipeline is connected to the PWB Pipeline in Bluff Road with a normally closed isolating valve. The services and hydrant on Kelso Road and the pipeline on Shalimar Drive can be connected directly to the 12-inch diameter pipeline, which will also back feed the 6-inch diameter Zone 4 pipeline in Bluff Road. **Figure 4-12** shows the recommended connection on Kelso Road.

Figure 4-12 | Kelso Road Improvements

4.5.3.2.2 Hood Street Fire Flow Improvements

This project consists of improving the pipelines on SE Ten Eyck Road and Hood Street to meet fire flow requirements. A new 8-inch pipeline is needed to provide the required fire flow to the hydrant on Hood Street. See **Figure 4-13** for the location of the Hood Street Improvements.

Figure 4-13 | Hood Street Improvements

4.5.3.2.3 Mitchell Court Fire Flow Improvements

This project consists of improving the pipelines on Mitchell Court to meet fire flow requirements. A new 8-inch pipeline is needed to provide the required fire flow to the hydrant on Mitchell Court. **Figure 4-14** shows the location of the Mitchell Court Improvements.

Figure 4-14 | Mitchell Court Improvements

4.5.3.2.4 Seaman Avenue Fire Flow Improvements

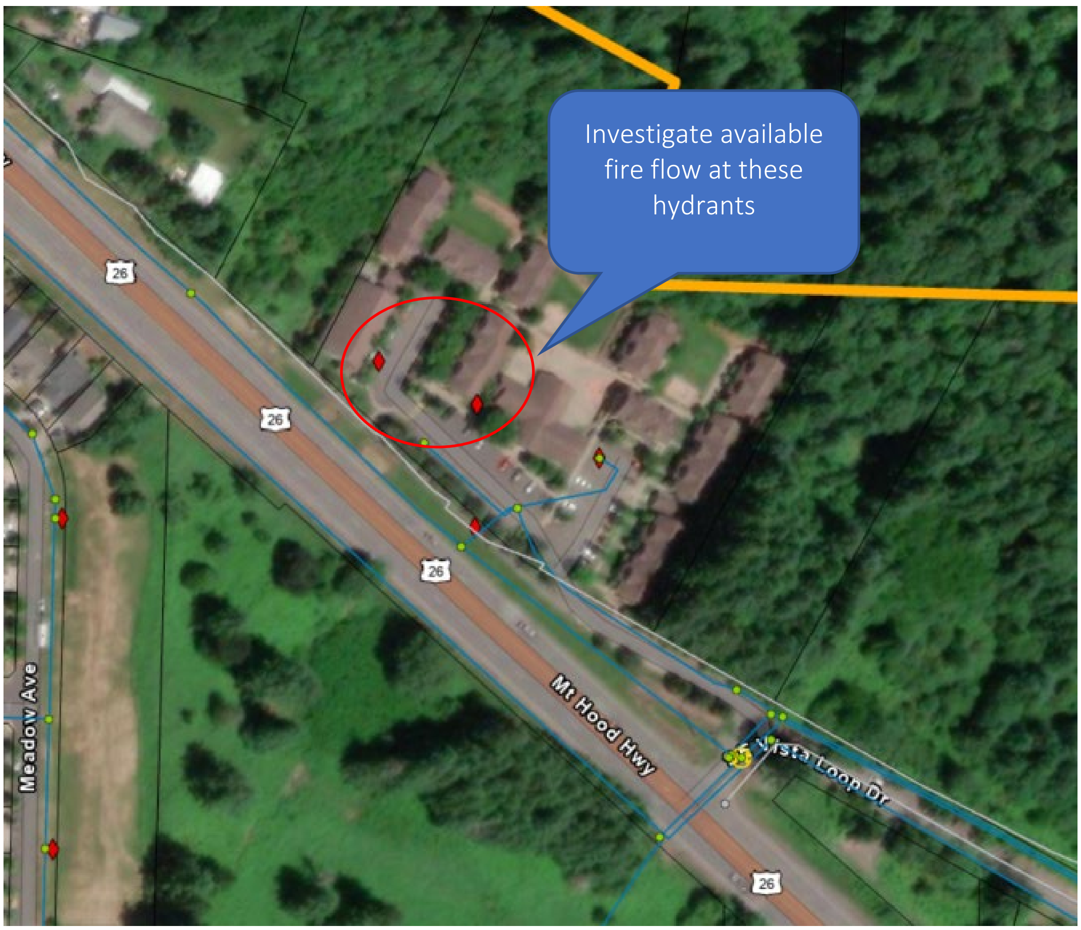
This project consists of improving the pipelines on Seaman Avenue to meet fire flow requirements. A new 12-inch pipeline is needed to provide the required fire flow to the hydrant on Hood Street. Alternatively, a new 8-inch pipeline may be installed in the walkway between Seaman Avenue and Miller Road. It is unknown if it is possible to install a pipeline at this location without a site investigation. See **Figure 4-15** for the location of the Seaman Avenue Improvements.

Figure 4-15 | Seaman Avenue Improvements

4.5.3.2.5 Area North of Mt Hood Highway near Vista Loop Drive

This area north of Mt. Hood Highway near Vista Loop Drive has multiple hydrants and pipelines from both Zone X and Zone 2. It is unknown how these hydrants are connected to these pipelines. If the hydrants are connected to the Zone X pipeline, then the hydrants would not meet fire flow requirements. The 6-inch and 4-inch Zone X pipelines would need to be upsized to 12 inches. It is suggested that flow testing be conducted in this area to determine the available fire flow at these hydrants. See **Figure 4-16** for the location of the hydrants in question.

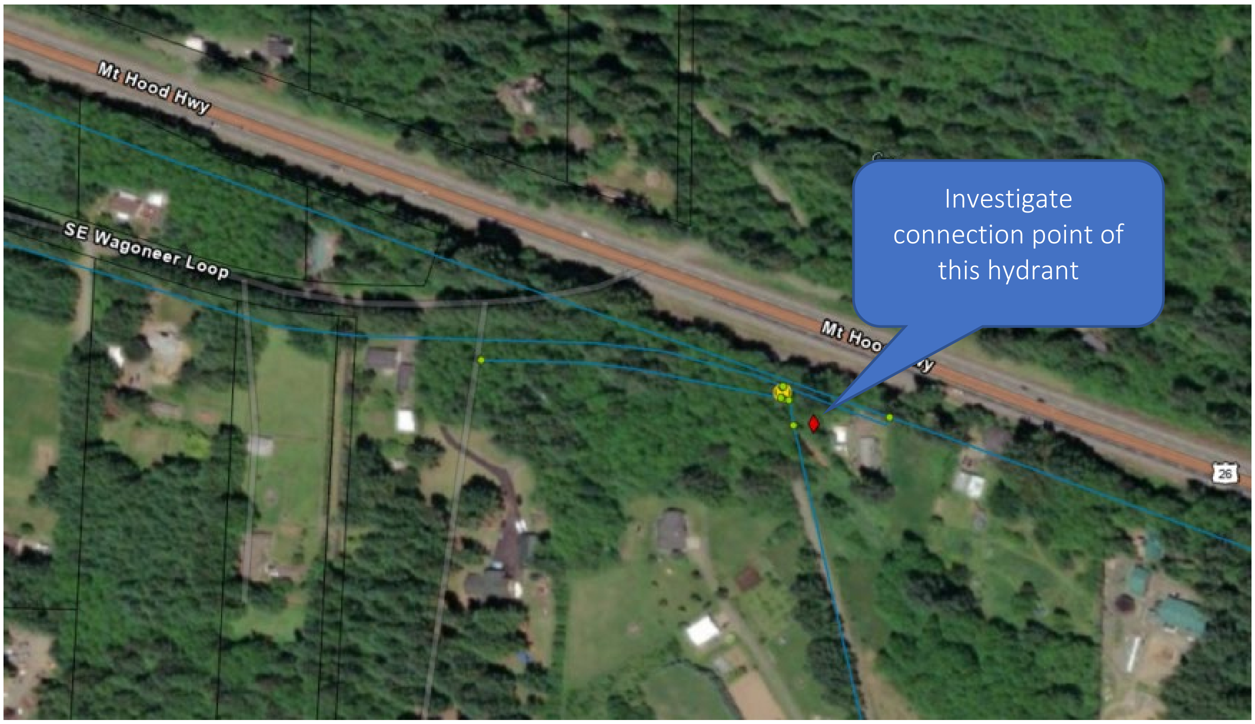
Figure 4-16 | Area North of Mt Hood Highway near Vista Loop Drive



4.5.3.2.6 Area South of Mt Hood Highway on Wagoneer Loop

The area south of Mt Hood Highway on Wagoneer Loop has a hydrant where the connection is unknown. If the hydrant is connected to the pipeline to the west (which connects to Brownell Springs Source), it should be reconnected to the 16-inch pipeline located to the north (parallel to Mt Hood Highway). A site investigation should be conducted to determine where the hydrant connects to the distribution system. See **Figure 4-17** for the location of the hydrant in question.

Figure 4-17 | Area South of Mt Hood Highway on Wagoneer Loop



4.6 Summary

The current boundaries of the City's six pressure zones allow the system to provide water during peak hour conditions to customers within the acceptable range of 30 psi and 80 psi, with the use of individual PRVs as needed. Adjustments of these boundaries are recommended to accommodate future growth within city limits and the UGB.

The storage capacity analysis concluded that the City currently has a storage deficit of 2.81 MG, which will increase to 4.75 MG at buildout conditions in 2050. It is recommended that the City construct an additional 5.0 MG of storage to overcome this deficiency.

The City's current pumping capacity was determined to be sufficient to meet current and future demands. Though the construction of an additional pump station is recommended, it is not necessary to meet pumping capacity requirements.

Four areas within the existing distribution system exhibit pressures below 20 psi under MDD plus fire flow conditions. Piping improvements are recommended to mitigate these deficiencies. Two additional areas require further investigation to determine if deficiencies exist.

- Bluff Road Improvements – New pipelines on Bluff Road, Burgs Lane, Kelso Road, Marcy Street, and SE Baumback Avenue
    - Kelso Road – Connect hydrant to the existing 12-inch pipeline in Kelso Road
    - Marcy Road – Determine if the hydrant in Marcy Road is required to provide fire flow
- Hood Street Improvements – New 8-inch pipelines on SE Ten Eyck Road and Hood Street
- Mitchell Court Improvements – New 8-inch pipeline on Mitchell Court
- Seaman Avenue Improvements – New 12-inch pipeline on Seaman Avenue
    - Alternative – New 8-inch pipeline in the walkway between Seaman Avenue and Miller Road
- Area north of Mt Hood Highway near Vista Loop Drive – Conduct fire flow test for the hydrants in this area
- Area south of Mt Hood Highway on Wagoneer Loop – Investigate the connection of the hydrant to the distribution system

CHAPTER 5

Water Supply Analysis

5.1 Introduction

This chapter presents an assessment of the City's current water supply system, a summary of existing water rights and analysis of future supply development needs. Due to the age and condition of the City's surface water and springs supply source, and the PWB's planned modifications to the Bull Run surface water supply, the City needs to make major supply improvement decisions to meet projected future water demands presented in **Chapter 2**.

5.2 Supply Source Evaluation

5.2.1 Water Rights

The City holds water rights associated with three water supply sources: three certificated water rights for Brownell Springs, a certificated water right for Alder Creek, and an undeveloped permit for the Salmon River. **Table 5-1** summarizes these water rights.

Table 5-1 | City of Sandy Municipal Water Rights

Source	Permit	Certificate	Priority Date	Authorized Rate (MGD)	Authorized Date of Completion	Notes
Brownell Springs	S-6597	5427	7/11/1924	0.13	--	Limited to 0.13 MGD during summer season
	S-21879	26132	11/10/1952	0.45	--	
	S-35394	91156	7/23/1970	1.19	--	
Alder Creek		93884	11/11/1971	2.6	--	
Salmon River		--	4/28/1983	16.1	10/1/2069	Limited to ~10.5 MGD during summer season

A further detailed discussion of the City's water rights is included in **Appendix A**, *Groundwater Supply Evaluation for City of Sandy Water Master Plan Update (GSI Water Solutions, July 2022).*

5.2.2 Source of Supply – Capacity and Condition

5.2.2.1 Brownell Springs

The City's Brownell Springs source provides a reliable 0.3 MGD of supply year-round, but is limited by interference with senior water rights, resulting in frequent notification by the Water master to reduce flows to 0.13 MGD during the summer. As a result, the reliable peak season capacity of the springs source is 0.13 MGD.

Brownell Springs remains a low-cost, low-maintenance gravity source of supply feeding the system with the only treatment required being the addition of sodium hypochlorite (chlorine) to serve as residual disinfectant in the distribution system.

The primary deficiencies at the Brownell Springs site involve access and maintenance of equipment in a remote location. Improved vehicular access to the site and control of vegetation for operator access to the spring boxes and reservoir are the highest priority improvements.

5.2.2.2 Alder Creek

The City's Alder Creek source was the primary source of supply to the City until approximately 2014 when the City began purchasing wholesale water supply from the PWB due to anticipated capacity limits to meet peak summer demands. The existing constructed infrastructure provides a total supply capacity of 2.6 MGD, but the condition of several components of the supply and treatment system reduces the current operational capacity of the Alder Creek source to approximately 1.4 MGD. In addition, both scenarios lack redundancy to provide firm capacity as all available filter trains are needed to provide the capacities stated. For the purposes of this analysis, an existing capacity of 1.4 MGD is assumed, with the understanding that incremental operation and deferred maintenance improvements to existing facilities could increase this capacity back to 2.6 MGD, with further improvements to increase the reliability and redundancy of this source phased over time. A list of the major deficiencies limiting the reliable capacity is presented below.

5.2.2.2.1 Raw Water Intake and Pump Station

City staff have observed that the intake structure, which is almost entirely unchanged from the original construction, is experiencing many of the access and age-related issues that are typical of this type of stream intake, including:

- Access is challenging during high flow and wet weather season.
- Both the screen frame and screens are showing signs of deterioration.
- Diversion dam wooden beams are failing.
- Aging control valve operators
- The raw water intake pipeline has reached its expected life and should be rehabilitated or replaced.
- The seismic stability of the raw water intake pipeline should be evaluated.
- The raw water booster pump station should be rehabilitated or replaced.
- The site of the stream intake is silted in with deposits and debris.

In addition, there is no stream gauge on Alder Creek to track seasonal and annual variation in creek flows. Stream gauge data would be beneficial in validating the reliable supply from Alder Creek, as the anticipated reliable capacity from the Alder Creek source is currently based on anecdotal information from operation of the Alder Creek WTP at full capacity over 15 years ago. A record of seasonal low flow rates over a longer period of time will also help inform the reliability of this supply under future conditions due to the impacts of climate change.

The Raw Water Pump Station, which is required to deliver the full water right capacity of 2.6 MGD to the Alder Creek WTP, lacks firm capacity to supply 2.6 MGD, as both of the pumps must operate to convey the full capacity. In addition, the pump station electrical and mechanical equipment is reaching the end of its service life. The site also needs to be redesigned to allow easier service of pumps.

5.2.2.2.2 Alder Creek WTP

The Alder Creek WTP has fallen into disrepair over the past 15 years, as the City has focused on the investments necessary to transmit the wholesale water supply from the PWB to the City. As a result, the WTP is currently operating at a reduced capacity with only one train in operation and without prudent redundant equipment. Redundancy to the water system is currently provided by the PWB connection. However, use of this connection for redundancy must include facilities to treat for cryptosporidium after September 30, 2027. In order to return the WTP to an operational capacity of 2.6 MGD, a number of deficiencies must be addressed. The initial list of upgrades to address existing deficiencies includes:

- Replace programmable logic controller to allow for operation of Filter #1 and #2. Once Filters #1 and #2 are operational, further upgrades, including replacement of control valving may be required.

- Repair Filter #3 pneumatic control valves. Currently, operation of the filter valving requires manual control by an on-site operator.

- Full filter media replacement and package treatment unit assessment for all three packaged filter units. The condition of the structure of the packaged water treatment units is unknown and requires a thorough investigation with the filter media removed. Once Filters #1 and #2 are operational and high priority improvements have addressed Filter #3 to allow for automatic operation, the City should proceed with a thorough assessment of the condition of each filter unit to determine if repair or replacement is the best course of action.

- Upgrade the chemical feed systems to include:
  - Automated control
  - Replacement of containment systems
  - Re-configuration of storage and feed pumps to fully utilize stored chemical volumes

- Upgrade standby power systems to include an ATS

- Evaluation and replacement of SCADA communication system to allow for reliable remote monitoring and operation of the Alder Creek WTP

- General site improvements to maintain access and minimize the risk of power and communications disruption, including clearing trees along the access roadway and evaluating the resiliency of the power feed to the site

The findings of the investigation of the filter units may result in a determination that rehabilitation and upgrade of the existing facilities is not cost effective. If this is the case, the City should complete the minimum improvement required to maintain effective operation at 2.6 MGD and begin planning for full replacement of the Alder Creek WTP.

5.2.2.2.3 PWB Wholesale Supply

In 2008, the City signed a 20-year wholesale supply agreement with the PWB. Over the next several years, the City completed major infrastructure improvement projects to transmit this wholesale supply to the City distribution system. These improvements included 4 major components.

- *Hudson Road Intertie and Pump Station:* The intertie at Hudson Road provides a metered connection to the PWB's water supply conduits which deliver chlorinated water from the Bull Run Watershed to terminal reservoirs at Powell Butte and Kelly Butte. The City's Pump Station boosts water from the intertie into a dedicated transmission main that extends from Hudson Road to the Revenue Avenue Reservoir.

- *Transmission Main:* An 18/24-inch diameter transmission main transmits the boosted supply from the Hudson Road Intertie to the Revenue Avenue Reservoir.

- *Revenue Avenue Reservoir:* The 1.0 MG reservoir is the terminal reservoir for the City's PWB wholesale supply and is where supply from PWB and the Alder Creek WTP is blended before being transmitted to customers in the distribution system to minimize the aesthetic impact of highly chlorinated PWB water.

- *Transfer Pump Station:* The Transfer Pump Station boosts the blended supply from the Revenue Avenue Reservoir into Pressure Zone 2 and the Vista Loop Reservoirs.

- *Service Area:* PWB supply cannot be transmitted to Zones 1 and X (above the Vista Loop Reservoirs).

The PWB is currently in the process of completing a major improvement to the Bull Run water supply, as required by the OHA-DWS. In order to comply with the Long-Term 2 Enhanced Surface Water Treatment Rule, the PWB must begin filtration of the Bull Run supply by September 30, 2027, as documented in a Bilateral Compliance Agreement.

The result of these improvements is that the City's Hudson Road Intertie will be located on a connection to the PWB conduits that is transmitting raw water (un-filtered and un-disinfected) to the new PWB filtration plant, currently under construction. The City also has a bilateral compliance agreement with the OHA-DWS, requiring the City to address this deficiency by either relocating the point of wholesale supply to the PWB filtration plant or treating the wholesale water supply before transmitting it to the City's distribution system.

The existing wholesale water supply contract expires in 2028. The City is currently negotiating a new wholesale water supply contract with PWB. The terms of this agreement and the anticipated cost of wholesale water supply should be considered as the City prioritizes investment in existing and future water supply sources.

The wholesale supply connection provides for a current capacity of approximately 3.1 MGD, limited by the firm capacity of the Hudson Road Pump Station. The intertie facilities and transmission main are sized to provide approximately 10 MGD of wholesale supply in the future.

5.2.2.2.4 Salmon River

The City has not completed detailed investigations of the feasibility of developing the Salmon River as a water supply source. Several potential alternatives exist, including development of a surface water intake at the currently identified point of diversion near to Highway 26 at Brightwood, transfer of the water right to a new diversion location downstream on the Sandy River, or potential transfer of the right to a groundwater use to support local development of groundwater. The memorandum in **Appendix A**, *Groundwater Supply Evaluation for City of Sandy Water Master Plan Update (GSI Water Solutions, July 2022)* includes a more detailed discussion of these options.

While the Salmon River water right presents an opportunity for long-term water supply development to meet the City's needs, the actions required to develop this source cannot be feasibly completed prior to the City's deadlines outlined in the Bilateral Compliance Agreement. Therefore, it is recommended that the City further investigate this alternative water supply source as a long-term alternative to wholesale water supply from the PWB beyond the 20-year planning horizon. Investigations should include a detailed assessment of water diversion locations, water rights and environmental permitting constraints, treatment approaches, and transmission alignments.

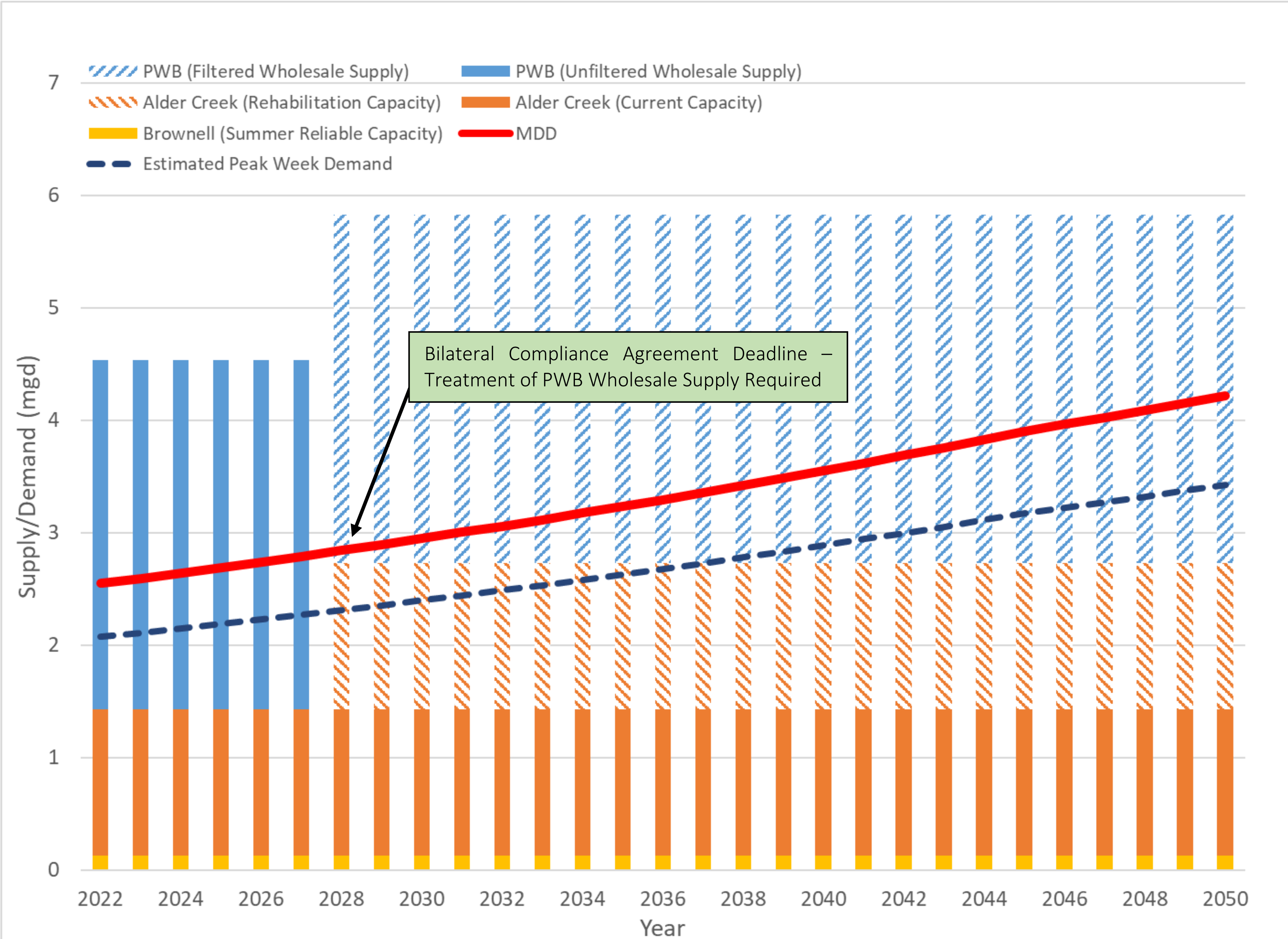
5.3 Water Supply Needs

As described in **Chapter 3**, it is recommended that the City maintain a firm supply capacity that equals or exceeds the City's MDD. While the City currently has adequate supply capacity to meet existing demands, there are three conditions that threaten the City's ability to meet its water supply requirements.

- Future development within the City's UGB is expected to increase the MDD of the City's water system customers from 2.6 MGD to 4.2 MGD by 2050.
- Reliable operation of the Alder Creek supply at 2.6 MGD. Currently, the WTP is limited to approximately 1.3 MGD and has nearly no redundancy.
- Major infrastructure improvements are required to continue accessing the PWB wholesale supply.

Figure 5-1 illustrates a comparison of existing supply capacities with the projected City water demands. This chart illustrates the three conditions listed above. As this comparison shows, it is critical that the City advance a water supply strategy that addresses the near-term water supply needs triggered by the changes to the PWB wholesale supply by 2028 and further develop a long-term water supply strategy that balances wholesale water supply with continued development of City-owned water supply sources and provides system redundancy.

Figure 5-1 | Water Supply and Water Demand Comparison



5.4 Water Supply Strategy

5.4.1 Initial Decision Regarding PWB Wholesale Supply (Spring 2021)

The City began developing a water supply strategy in 2021 to respond to the requirements of the Bilateral Compliance Agreement. An initial investigation was conducted to inform City policy makers of the terms of the Bilateral Compliance Agreement and to provide information to allow them to decide if the City would construct the infrastructure necessary to purchase treated wholesale water supply from PWB or purchase raw water and construct a separate facility to treat the unfiltered wholesale supply from the existing Hudson Road Intertie. This limited analysis was prepared to meet the PWB's identified deadline of July 2021. While the analysis demonstrated that the long-term total cost (capital investment, wholesale water purchase and operations and maintenance (O&M)) was expected to be similar, based on the information provided, the City Council directed staff to proceed with planning for the purchase of raw water supply from PWB and development of a new WTP for the City's supply.

5.4.2 Updated Analysis, Findings and Recommendations

In the Spring of 2022, as the WSMP progressed and further information became available, City staff re-evaluated the decision to purchase unfiltered wholesale supply from PWB. The decision to re-evaluate was driven by a number of factors, including:

- Dramatic increases in the cost of public infrastructure construction
- Refined understanding of the alternatives available to deliver filtered wholesale supply from PWB
- Assessment of the development schedule for a City-owned WTP for the PWB unfiltered supply
- Updated analysis of life-cycle costs, considering capital investments required for the Alder Creek source and the significant benefit of maximizing use of City-owned sources

Based on this refined analysis, City Council was presented with the new findings on June 6, 2022, and as a result, directed City staff to plan for and implement connection to the new PWB WTP for treated water purchase from PWB. In order to achieve this objective, the City must construct a new pump station at or near to the PWB WTP and a pipeline from the PWB WTP to the existing Hudson Road Intertie transmission main.

A summary of the analysis and presentation to the City Council is included in **Appendix B**.

5.4.3 Next Steps

In order to meet the requirements of the Bilateral Compliance Agreement and maintain adequate and reliable water supply, the City should proceed with the following immediate action items.

1. *Confirm that PWB wholesale supply of unfiltered water will remain uninterrupted through September 30, 2027.* As shown in **Figure 5-1**, the City is at risk of being unable to meet MDD in the summer of 2027 without the full developed capacity of the Alder Creek source and wholesale supply from PWB. The City should obtain written confirmation from PWB that unfiltered supply will remain available through the summer of 2027.
2. *Coordinate with PWB to secure property on the PWB WTP site for a new Booster Pump Station and Transmission Main alignment (and necessary easements) extending south to Bluff Road.* In

preliminary discussions, PWB has indicated that siting of the new booster pump station on the PWB WTP site is feasible, and further indicated that access easements being obtained to the south of the PWB's property to SE Bluff Road could accommodate the City's new wholesale supply transmission main. The City should confirm the current status of these opportunities and take steps necessary to formalize this arrangement. If either becomes infeasible, then the City will need to identify both a booster pump station property and transmission main alignment and begin securing the necessary property and easements.

3. *Continue participation in regional wholesale contract negotiations before September 30, 2027.* With the expiration of the current PWB wholesale water supply contracts in the upcoming years (the City's contract expires in 2028), current efforts are underway to negotiate a new wholesale contract and rate structure. The City's wholesale water supply situation is unique and requires active participation in the negotiations to protect the City's interest in this process and ensure a fair and equitable wholesale contract for the City.

4. *Complete near-term improvements to address Alder Creek supply deficiencies before September 30, 2027.* As described earlier in this chapter, much of the Alder Creek supply facilities are approaching the end of their useful life, have fallen into disrepair, or lack sufficient redundancy to provide reliable supply. It is recommended that the City begin a program of addressing the identified deficiencies and further assessment to ultimately achieve a reliable 2.6 MGD supply from Alder Creek. The initial actions include:

    a. Control Panel upgrades to return Filters #1 and #2 to operation

    b. Filter #3 maintenance (once Filters #1 and #2 are back on-line)

    c. Upgrade of standby power systems with an automatic transfer switch

    These improvements restore the WTP to an operational capacity of 2.6 MGD

    d. Detailed assessment of the condition of all structural, mechanical, and electrical systems at the Alder Creek WTP

    e. Cost-benefit analysis of rehabilitation versus replacement of the Alder Creek WTP

    f. Development of an Alder Creek Source Improvement Plan

5. *Design and construction of the PWB filtered wholesale supply connection before September 30, 2027.*

6. *Long-term water supply study.* Investigation of the feasibility and cost of developing the Salmon River water supply source as a long-term alternative, or supplement, to the City's existing supply sources should be completed. Development of the Salmon River as a source of supply for the City will take several years to advance from evaluation of feasibility through permitting, design, and ultimately construction. As the new PWB wholesale contract is completed and the City develops a better understanding of the investments required in the Alder Creek source, the potential benefit of adding the Salmon River to the City's water supply portfolio can be better defined.

7. *Implement Long-Term Supply Study Recommendations.*

CHAPTER 6

Capital Improvement Program

This chapter presents recommended improvements for the City's water system based on the analysis and findings presented in Chapter 4 and Chapter 5 and projects identified in the City's current water CIP projects list. These improvements include supply, storage reservoir, water main, and seismic resilience projects. The CIP presented in Table 6-3 summarizes recommended improvements and provides an approximate timeframe for each project. Appendix C contains planning level cost estimate details for each project. Proposed improvements are illustrated in Figure 6-1.

6.1 Project Cost Estimates

An estimated project cost has been developed for each recommended improvement consistent with previously identified projects from the City's current CIP and current preliminary design work, as applicable. Cost estimates represent opinions of cost only, acknowledging that final costs of individual projects will vary depending on actual labor and material costs, market conditions for construction, regulatory factors, final project scope, project schedule, and other factors.

6.2 Timeframes

A summary of all improvement projects and estimated project costs is presented in Table 6-3. This CIP table provides for project sequencing by showing prioritized projects for the 5-year, 6 to 10-year, and 11 to 20-year timeframes defined as follows.

- 5-year timeframe - recommended completion through 2027
- 6 to 10-year timeframe - recommended completion between 2028 and 2032
- 11 to 20-year timeframe - recommended completion beyond 2032

6.3 Storage Reservoirs

As presented in Table 4-1, the City currently has a deficit in storage capacity serving the water system. The existing Sandercock Lane site can accommodate construction of an additional reservoir or replacement with a larger storage facility to add 1.0 MG of storage above Zone X. As discussed in further detail in Section 4.3.2, three City-owned sites were identified that could serve as potential reservoir sites. It is recommended that the City construct at least two reservoirs to add 4.0 MG of storage to the system, for a total of 5.0 MG, as identified in Project No. R.1. Further investigation is required before design and construction of these reservoirs can occur. A Storage Siting Study is presented as Project No. R.2. These reservoirs will all require altitude control valves, additional supply and transmission main piping, and it is recommended that they be of prestressed concrete tank construction.

In addition to constructing new storage, the City should conduct a Reservoir Seismic and Condition Assessment of their existing reservoirs, which is included in this CIP as Project No. R.3. It is recommended the Seismic and Condition Assessment be completed before any new reservoir projects as it could inform system storage improvement plans. For example, if the assessment indicated a tank needed major refurbishment, building a new, larger tank could be an alternative to refurbishing the existing tank.

6.4 Pump Stations

As noted in **Table 4-3**, the City has adequate distribution system pumping capacity through the build-out scenario (2050) and no additional capacity is required. However, as discussed in detail in **Section 4.4.2**, it is recommended that the City complete upgrades to the Terra Fern Pump Station so that fire flow demands are met above the Sandercock Lane Reservoir, which is included as Project No. PS.1.

It is also recommended that the City construct a pump station at the Vista Loop site that can supply Zones X and 1 with PWB wholesale supply in the event that Alder Creek WTP and Brownell Springs sources are unable to supply sufficient flows. The Vista Loop Pump Station is included in this CIP as Project No. PS.2.

6.5 Distribution Mains

As presented in **Chapter 4**, hydraulic modeling of the City's water distribution system revealed few areas of low pressure. There were no service connections below 30 psi for the existing, near-term, and buildout scenarios. Modeled low pressures were located along the PWB transmission mains and near existing storage facilities. No improvements are recommended to raise low pressures.

Multiple areas failed fire flow conditions under existing conditions. Proposed distribution piping projects are presented as Project Nos. D.1, D.2, D.3, and D.4. These pipeline improvement projects will take place near Bluff Road, Hood Street, Mitchell Court, and Seaman Avenue to provide fire hydrants with sufficient fire flows.

6.6 Supply

As described in **Chapter 5**, the City is currently in the process of coordinating regional wholesale contract and source changes with the PWB as well as evaluating and updating the Alder Creek WTP before September 2027. In order to maintain an adequate and reliable water supply, the City should proceed with the steps detailed in **Section 5.4.3** and summarized below. The short-term improvements (first four bullets below) should be completed before September 30, 2027, the date the PWB is guaranteeing unfiltered wholesale water through.

- Coordinate with the PWB and participate in regional wholesale contract negotiations.
- Complete near-term Alder Creek WTP improvements to restore the WTP to an operational capacity of 2.6 MGD.
- Complete a detailed assessment of the Alder Creek WTP and its associated infrastructure, evaluate alternatives, and develop an Alder Creek Source Implementation Plan.
- Design and construct the PWB Filtered Wholesale Supply Connection.
- Refurbish or replace the raw water intake infrastructure.
- Complete a Long-Term Water Supply Study.

These improvements are included in **Table 6-3**. Implementation of recommendations from the Long-Term Supply Study should be evaluated in the study and included in an updated CIP as recommended. It is expected that some or many of the recommendations may extend beyond the planning period of the WSMP.

6.7 Other Projects

6.7.1 Water System Master Plan Update

It is recommended that the City continue to update this WSMP every ten years. An updated WSMP is required by the State of Oregon for a 20-year planning period. The Alder Creek WTP detailed assessment and/or the Long-Term Water Supply Study could prompt an update to the WSMP and CIP depending on the findings and recommendations. As the City grows or more information is collected, it is prudent for the City to continue to regularly evaluate capital investment, prioritize needs for the water system, and document this long-term water service strategy in the WSMP.

6.7.2 Water Management and Conservation Plan

The City was required to submit a WMCP by April 2016, with an update required in 10 years. The next update of the WMCP is due to the state of Oregon Water Resources Department in November 2025, and it is anticipated that a future update within this WSMP's 20-year planning horizon will be required in 2024.

6.7.3 SCADA Upgrades

The water utility SCADA system equipment is out of date and reaching the end of its useful life. Furthermore, the communication systems consist of numerous aging and unreliable leased lines that are prone to failure. It is recommended that the City proceed with a SCADA Master Plan to identify the most effective approach to upgrade and replace aging equipment.

While the full scope and cost of a SCADA system upgrade will be defined by the SCADA Master Plan, a preliminary budget placeholder has been included in the CIP as Project M.5. This preliminary budget estimate should be refined and incorporated into the City's capital planning following completion of the SCADA Master Plan.

6.7.4 Water Meter Replacement

The City completed a water service meter replacement and AMI project between 2019 and 2021. Water meters typically have a service life of 15-20 years, at which point the meter accuracy may decrease and the battery operated meter registers that transmit data to the City's AMI system begin to fail. It is recommended that the City include a budget in the CIP for a meter replacement program. Based on the year of installation of most current meters in the system, the meter replacement program should be completed in the 11-to-20-year timeframe. The City has approximately 3,000 service meters, so it is assumed that the replacement program will be conducted over 5 years.

6.7.5 Replacement and Operations and Maintenance

A systematic, planned replacement program will provide the following benefits.

- Reduced impacts to customers and the environment from unplanned pipe failures
- Reduced repair and replacement costs by performing the work proactively rather than on an emergency basis
- Reduced water loss that results from main breaks and leaks

- Reduction in claims for property damage and loss of revenues from commercial and industrial customers

It is recommended that the City aim to implement an aggressive pipe replacement program to avoid having to replace a disproportionate amount of pipe in the future as the pipes age. For this reason, it is recommended that the City aim to replace 4,750 linear feet (LF) of pipe per year. This is a replacement rate of about one percent of pipe per year. Pipe replacement projects should be coordinated with other City programs such as the Pavement Management Program and other utility projects to save on cost and prevent redundant work and obstruction of roadways. Water mains were assumed to need replacement after 75 years. Total costs for the full time period were uniformly divided into annual costs for the respective timeframes. These costs represent a significant investment in the water system, and substantially more than the City's current annual water main replacement budget. However, continued investment in renewal and replacement of the water system is essential to ensuring reliable system operation and minimizing expensive emergency repairs associated with failing pipeline infrastructure.

The existing system contains 4-inch diameter mains as well as asbestos concrete (AC) and CI mains. The small pipes can cause flow restrictions, reducing system capacity. Replacement of AC and CI material pipes are recommended for health and safety and reducing risk of breaks or failures. There is approx. 64,000 LF of 4-inch diameter, AC, or CI mains in the existing system. These pipes are recommended to be the highest priority in the City's Replacement Program. At the recommended replacement length described above (4,750 LF), it would take approximately 13.5 years to replace all of these mains.

Annual maintenance for pipes, tanks, pump stations, valves, and other facilities is not considered in the CIP list. It is assumed these maintenance items are addressed in the operations budget.

6.8 Cost Estimating Assumptions

All cost estimates for CIP projects presented in this WSMP are planning level costs approximately equivalent to Association for the Advancement of Cost Engineering Class 5 estimates. Cost estimates of this type are classified as order-of-magnitude cost estimates, which assume a 0 to 2 percent level of project definition to reflect the significant number of unknowns in project scope and conditions. Correspondingly, Class 5 cost estimates have a wide accuracy range to reflect these uncertainties at the master planning stage; actual costs may vary from these by minus 50 percent to plus 100 percent:

- Low End Accuracy Range: -20 to -50 percent (i.e. the low end of the accuracy range for a $1 million cost estimate is $0.5 to $0.8 million).

- High End Accuracy Range: +30- to +100 percent (i.e. the high end of the accuracy range for a $1 million cost estimate is $1.3 to $2.0 million).

All costs are in 2022 dollars, and the Engineering News-Record's Seattle, WA Construction Cost Index for November 2022 was 15202.68. The estimates are subject to change as the project designs mature. The cost of labor, materials, and equipment may also vary in the future.

6.8.1 Pipeline Unit Cost Assumptions

Table 6-1 presents general assumptions for unit costs of different-sized pipelines that may be used in a CIP project.

Table 6-1 | Pipeline Unit Costs

Pipe Diameter (Inches)	Pipeline Cost, Arterial Road, Including Cost Factors ($/Linear Foot)
8	$509
10	$598
12	$686
18	$931

Pipeline costs are for ductile iron pipe and include general markups for earthwork and construction, erosion and traffic control, fittings and valves, mobilization, contingencies, contractor overhead, engineering design, and legal/admin coordination. Pipeline construction costs do not include property acquisition costs or easement or right-of-way costs. Roadway resurfacing unit costs assume open trench construction with trench patches and do not include full street resurfacing. Where open trench construction may not be possible, individual project cost estimates were modified, as needed, to reflect costs for boring or other construction methods.

6.8.2 Direct Construction Cost Development

Direct construction costs were developed using historical project data, vendor quotes, and general market trends. Direct construction cost estimates focused on major facilities and equipment and include allowances for additional civil, mechanical, electrical, and instrumentation requirements.

6.8.3 Cost Factors

To estimate total project costs for inclusion in the CIP, cost factors were added to the direct construction cost estimates. **Table 6-2** summarizes the cost factors and provides an example of how they were applied to determine a CIP project's cost.

Table 6-2 | Cost Factors

Cost Element	Cost Factor	Cost
Direct Construction Cost		$1.00M
Bonds and Insurance	2%	$0.02M
Mobilization	10%	$0.10M
Construction Cost		$1.12M
Project Contingency	30%	$0.33M
Total Construction Cost		$1.45M
Oregon Corporate Activity Tax	1%	$0.02M
Engineering Allowance	20%	$0.29M
Permitting, Inspections, and Administration	5%	$0.07M
Construction Contract Administration	10%	$0.14M
Total CIP Project Cost		**$1.97M**

6.9 CIP Funding

The City may fund the water system CIP from a variety of sources including governmental grant and loan programs, publicly issued debt, and cash resources and revenue. The City's cash resources and revenue available for water system capital projects include water rate funding, cash reserves, and SDCs.

Generated through development and system growth, SDCs are typically used by utilities to support capital funding needs. The charge is intended to recover a fair share of the costs of existing and planned facilities that provide capacity to serve new growth. Projects intended to serve only new growth would have 100 percent of the cost allocated to growth. Other projects that are intended to improve reliability and efficiency or address asset renewal are assumed to benefit existing and new customers. For these projects, the percent allocated to growth is the percentage of future demand projected to be generated from new customers. The percentage of project costs allocated to growth are shown in **Table 6-3** as the Preliminary SDC Eligibility.

Subsequent to the final review and approval of this WSMP, the City will conduct a financial analysis to review the current water rates and SDC methodology to support the recommended CIP described in this section.

6.10 CIP Summary

The CIP is summarized in **Table 6-3** and **Figure 6-1** on the following pages.

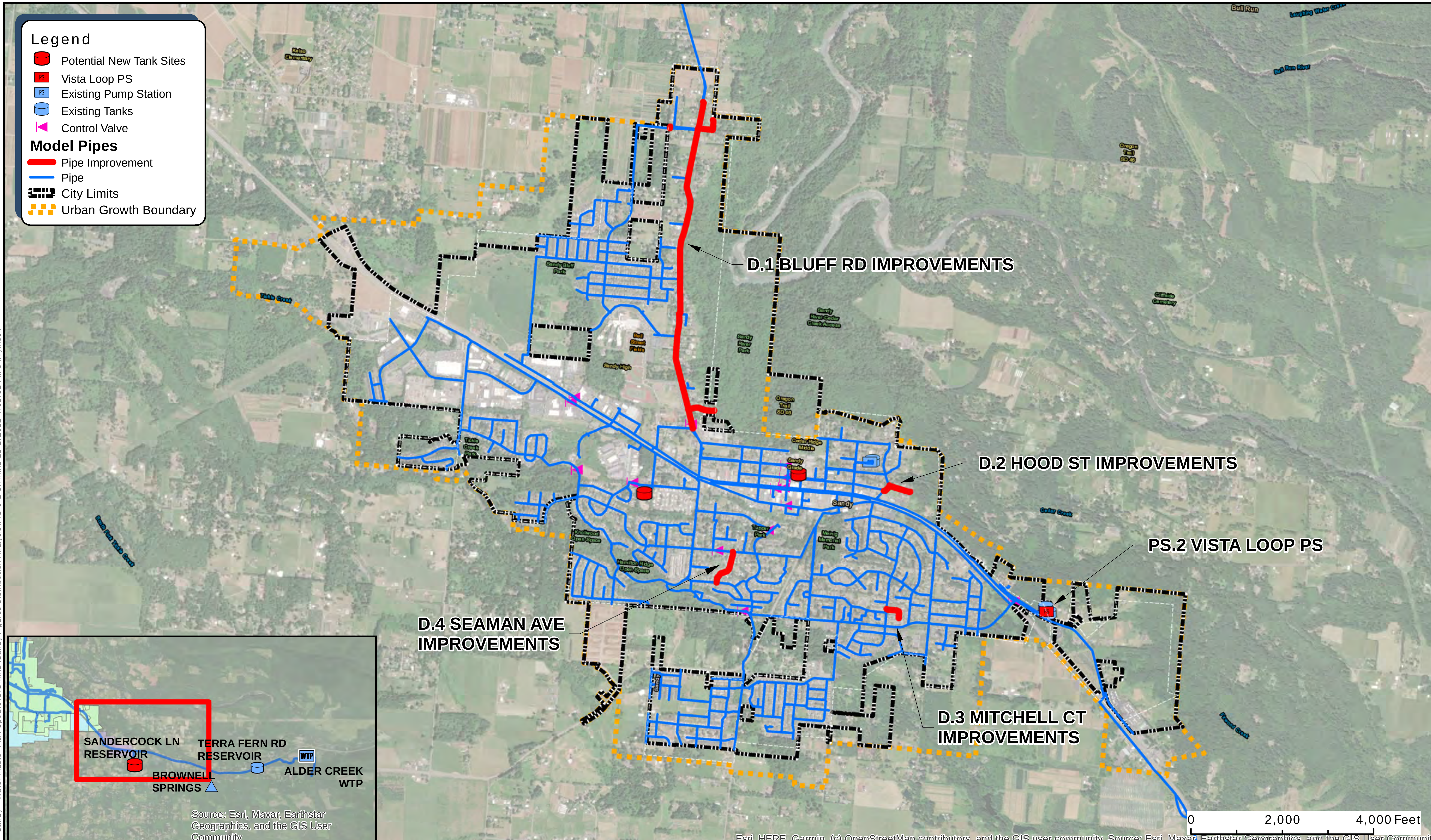
Table 6-3 | Capital Improvement Program

Project No.	Project Description	CIP Schedule and Project Cost Summary (2022 Dollars)				Preliminary SDC Eligibility
		1-5 Years (2023-2027)	6-10 Years (2028-2032)	11-20 Years (2033-2042)	TOTAL	
R.1	5.0 MG Additional Storage		$17,290,000	$17,290,000	$34,580,000	49%
R.2	Storage Siting Study	$180,000			$180,000	49%
R.3	Reservoir Seismic and Condition Assessment		$375,000		$375,000	49%
	Storage Subtotal	**$180,000**	**$17,665,000**	**$17,290,000**	**$35,135,000**	
PS.1	Terra Fern Pump Station Upgrades	$780,000			$780,000	45%
PS.2	Vista Loop Pump Station	$1,420,000			$1,420,000	45%
	Pump Station Subtotal	**$2,200,000**	**$-**	**$-**	**$2,200,000**	
D.1	Bluff Rd Fire Flow Improvements		$5,580,000		$5,580,000	45%
D.2	Hood St Fire Flow Improvements		$540,000		$540,000	45%
D.3	Mitchell Ct Fire Flow Improvements		$260,000		$260,000	45%
D.4	Seaman Ave Fire Flow Improvements		$550,000		$550,000	45%
	Distribution Subtotal	**$-**	**$6,930,000**	**$-**	**$6,930,000**	
S.1	Near-Term Alder Creek WTP Improvements	$1,050,000			$1,050,000	0%
S.2	Short-Term Alder Creek WTP Assessment	$240,000			$240,000	45%
S.3	Alder Creek WTP Improvements	$42,080,000			$42,080,000	45%
S.4	PWB Filtered Water Supply Connection	$39,416,000			$39,416,000	45%
S.5	Long-Term Supply Study		$240,000		$240,000	45%
	Supply Subtotal	**$82,786,000**	**$240,000**	**$-**	**$83,026,000**	
M.1	Water System Master Plan Update		$220,000		$220,000	45%
M.2	Water Management and Conservation Plan	$110,000			$110,000	45%
M.3	Annual Replacement Budget	$-	$6,000,000	$24,000,000	$30,000,000	45%
M.4	Water Service Meter Replacement			$7,920,000	$7,920,000	0%
M.5	SCADA Master Plan	$150,000			$150,000	45%
M.6	SCADA Upgrades (Preliminary Budget Placeholder)		$760,000		$760,000	45%
	Other Subtotal	***$260,000***	***$6,980,000***	***$31,920,000***	***$39,160,000***	
	CIP Total	**$85,426,000**	**$31,815,000**	**$49,210,000**	**$166,451,000**	

1 All costs in 2022 dollars and include all soft costs including bonds and insurance, mobilization, contingency, engineering, permitting and admin, and construction contract admin

2 Engineering News-Record's Seattle, WA Construction Cost Index for November 2022 was 15202.68 (for all costs)

3 Percentage based on MDD (or governing demand) from 2023 compared to MDD (governing demand) in 2043



City of Sandy
Water Master Plan Update

Figure 6-1
Capital Improvement Plan

December 2022

20-2800

APPENDIX A

GROUNDWATER SUPPLY

EVALUATION FOR CITY OF SANDY

WATER MASTER PLAN UPDATE,

GSI WATER SOLUTIONS, JULY 2022

TECHNICAL MEMORANDUM-FINAL

Groundwater Supply Evaluation for City of Sandy Water Master Plan Update

To: Brian Ginter, PE, - Murraysmith

Jeff Fuchs, PE - Murraysmith

From: Owen McMurtrey, GSI Water Solutions, Inc.

Andrew Wentworth, RG - GSI Water Solutions, Inc.

Walt Burt, RG - GSI Water Solutions, Inc.

Ronan Igloria, PE – GSI Water Solutions, Inc.

Date: July 7, 2022

1. Introduction and Summary of Findings

At the request of Murraysmith and the City of Sandy (City), GSI Water Solutions, Inc. (GSI) developed the following summary of information pertinent to whether and how the City could meet its water demands using water supplied under its own water rights. This memorandum discusses the limitations of the City's water rights for Brownell Springs, Alder Creek, and the Salmon River, as well as the hydrogeology of the area around the City and its suitability for development as a water supply source.

The City's most senior water right for Brownell Springs, combined with an estimated maximum reliable supply from Alder Creek of 3.7 cubic feet per second (cfs) or 2.4 million gallons per day (mgd), provide a reliable supply of 2.72 mgd (4.2 cfs).[1] The City's undeveloped water use permit from the Salmon River, with permitted use of 16.2 mgd (25.0 cfs), has limitations on the maximum rate of diversion allowed, and development of a point of diversion (POD) anywhere on the Salmon River or Sandy River faces significant regulatory obstacles. The key limitations and challenges to the Salmon River permit include:

- With POD upstream of Boulder Creek confluence (river mile [RM] 0.8):
  - No water may be diverted from August 16 through October 31
  - No water may be diverted from November 1 through February 29 when target flows are not met upstream of Boulder Creek confluence.
- With POD downstream of Boulder Creek confluence (RM 0.8):
  - The City must provide the Oregon Water Resources Department (OWRD) with an executed agreement between the City and Oregon Department of Fish and Wildlife (ODFW) setting out specific fish passage requirements.

[1] This reliable supply estimate may be high and operations data from the City's water treatment plant (WTP) indicate there are periods when streamflows may not support the City's entire 4.0 cfs water right. This is discussed further in Section 2.2 of this tech memo.

With a POD upstream of Boulder Creek, aquifer storage and recovery (ASR) could provide an option to meet the peak summer demands; however, the restrictions on diversion from November through February makes the Salmon River an unreliable source of supply for ASR injection during winter. Furthermore, available data suggests that the aquifer characteristics in the vicinity of the City are not conducive for ASR. As a result, the most feasible pathway for the development of the City's Salmon River surface water permit as a reliable, year-round source of supply is through a surface water to groundwater transfer to a hydraulically connected well on the Sandy River downstream of the confluence with the Salmon River. Approval of the permit amendment needed to transfer the surface water diversion to groundwater would be contingent on demonstrating that the withdrawals do not impact Cedar Creek.

Based on a review of the hydrogeologic conditions in areas near the City where an infiltration gallery or collector well could be constructed, the composition of the aquifer appears to be too thin and not laterally extensive enough for a 5 mgd facility. However, a 1 mgd facility may be feasible under favorable circumstances.

2. Water Rights Review

The City holds three water right certificates for municipal use authorizing diversions from Brownell Springs. Certificate 5427 authorizes the use of up to 0.13 mgd (0.2 cfs), Certificate 26132 authorizes the use of up to 0.7 cfs (0.45 mgd), and Certificate 91156 authorizes the use of up to0.19 mgd (0.3 cfs). In addition, the City holds Certificate 93884 for the use of up to 2.59 mgd (4.0 cfs) from Alder Creek and Permit S-48451 for the use of up to 16.16 mgd (25.0 cfs) from the Salmon River. Table 1 summarizes these water rights.

Table 1. City of Sandy Municipal Water Rights

Source	Application	Permit	Certificate	Priority Date	Type of Beneficial Use	Authorized Rate (cfs/mgd)	Authorized Date for Completion
Brownell Springs (tributary of Beaver Creek)	S-9669	S-6597	5427	7/11/1924	Municipal	0.2/0.13	N/A
	S-27810	S-21879	26132	11/10/1952	Municipal	0.7/0.45	N/A
	S-47254	S-35394	91156	7/23/1970	Municipal	0.3/0.19	N/A
Alder Creek (tributary of Sandy River)	S-48840	S-36601	93884	11/11/1971	Municipal	4.0/2.59	N/A
Salmon River	S-65051	S-48451	N/A	4/28/1983	Municipal	25.0/16.16	10/1/2069

Note

cfs = cubic feet per second

mgd = million gallons per day

N/A = not applicable

Historically, the City has used a combination of its sources from Brownell Springs and Alder Creek to meet demands. As presented in the City's 2015 water management and conservation plan, the City has relied on the springs to meet approximately one-third of demand and Alder Creek to meet approximately two-thirds of demand.

2.1 Brownell Springs

The City holds three water right certificates authorizing a total of 1.2 cfs from Brownell Springs. The priority date of Certificate 5427 (0.2 cfs) pre-dates all other water rights within the Beavercreek and Cedar Creek system. The City's other two certificates, Certificates 26132 and 91156, are junior in priority to the ODFW's 25.0 cfs water right for fish propagation (i.e., a hatchery); ODWF's water right has a priority date of 1949. In at least one instance, occurring in 2015, these two certificates held by the City were regulated off in favor of ODFW's water right. The City's records indicate that Brownell Springs reliably produces approximately 0.77 cfs, but due to the potential for regulation in favor of ODFW's senior fish hatchery water right on Cedar Creek, the City only has 0.2 cfs of reliable supply from Brownell Springs.

2.2 Alder Creek

The City's Alder Creek water right certificate has a priority date of November 11, 1971. The City's water rights on Alder Creek are senior to instream water rights on Alder Creek and the Sandy River. There is no history of regulation by priority on Alder Creek. There are no long-term streamflow records available for Alder Creek, but as part of the City's water supply investigation for the Alder Creek Basin, the City measured fairly consistent streamflows of approximately 5.1 cfs on Alder Creek approximately 0.5 miles above the Mt. Hood Loop Highway in August and September of 1971 and 1973. According to the City's WTP operators, however, there are periods when streamflows may not support the City's entire 4.0 cfs water right. The water use records available through OWRD's water use reporting database show that the City's average daily diversion during peak demand months of July and August does not exceed approximately 2.0 cfs. Murraysmith has assumed Alder Creek produces a reliable supply of 2.4 mgd (3.7 cfs) in the Water Master Plan. For purposes of this memo, Alder Creek is assumed to provide a reliable supply of 3.7 cfs. The City could further evaluate the reliable supply available from the Alder Creek source during periods of low flow.

2.3 Salmon River

The City holds Permit S-48451 for use of up to 16.2 mgd (25.0 cfs) from the Salmon River, which is currently undeveloped and has an extension of time to October 1, 2069. In the *Agreement for Instream Conversion* executed October 24, 2002 as part of the *Settlement Agreement Concerning the Removal of the Bull Run Hydroelectric Project (FERC Project No. 447)* (Settlement Agreement), the City voluntarily agreed to reduce the maximum rate of diversion under Permit S-48451 from 25.0 cfs to 16.3 cfs when the flow available in the Sandy River near Marmot, Oregon is 600 cfs or less, but can still divert up to 25.0 cfs when the flow available is more than 600 cfs. Based on data from a stream gage on the Sandy River near Marmot (U.S. Geological Survey Gage 14137000), a flow of 600 cfs is typically not exceeded from July through October, and for longer periods of time during years with low snowpack (e.g., 2015, 2018), when flows drop below 600 cfs prior to the beginning of June.

2.3.1 Fish Persistence Conditions Imposed by Extension Final Order

In addition to the restriction imposed by the Settlement Agreement, the order approving the City's extension of time for Permit S-48451 (extension order) imposes several conditions on the City's use of water under the permit, depending on where water is diverted. The City's currently authorized POD from the Salmon River is located at approximately RM 7.5. For diversion from the Salmon River at a location **upstream** from the confluence with Boulder Creek (RM 0.8), the extension order includes the following conditions:

1. Prior to using water under the permit, the City must install a means of measuring streamflow at a location between the confluence with Cheeney Creek (RM 7) and the mouth of the Salmon River. The City must receive OWRD's written concurrence with the location of measurement.
2. Prior to using water under the permit, the City must provide OWRD with an executed agreement between the City and ODFW, setting out specific fish passage requirements that ensure adequate upstream and downstream passage for fish.

3. No water may be diverted from August 16 to October 31.
4. From November 1 through February 29, the target flow for maintaining the persistence of listed fish species in the Salmon River is 129 cfs, or the average flow for the previous October, whichever is less. When the target flow is not met, no water can be diverted.

Given the restriction on any diversion of water from August 16 to October 31 for a diversion located above the confluence with Boulder Creek, the City would need to provide water from an alternate source from August 16 through October 31. The City's late August demands are likely similar to the maximum day demand. Alder Creek and Brownell Springs are not expected to be capable of meeting the City's projected maximum day demand. Figure 1 shows the City's projected demands compared to reliable supply under the City's Brownell Springs and Alder Creek water rights.

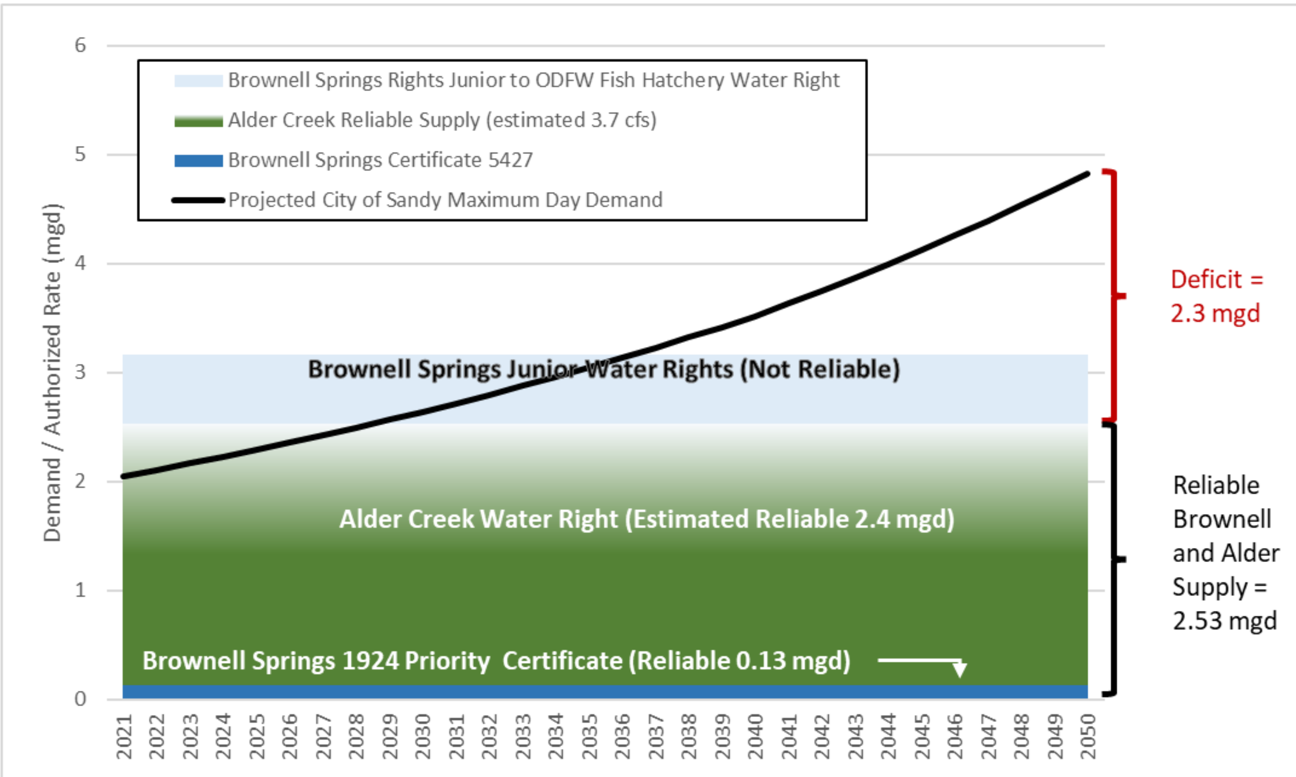


Figure 1. City of Sandy Projected Demand and Reliable Water Supply from Alder Creek and Brownell Springs

For diversion of water from a location **downstream** from the confluence with Boulder Creek at approximately RM 0.8, including a diversion from the Sandy River, the only condition included in the extension order, apart from repetition of conditions of the Settlement Agreement, is that prior to using water under the permit, the City must provide OWRD with an executed agreement between the City and ODFW setting out specific fish passage requirements that ensure adequate upstream and downstream passage for fish.

2.3.2 Surface Water to Groundwater Modification

The requirement for an agreement with ODFW regarding fish passage requirements, and the potential for additional federal conditions on any surface water diversion structure pose significant regulatory challenges to the development of a surface water diversion anywhere on the Salmon River or Sandy River. However, it may be possible for the City to minimize state and federal permitting associated with a new POD by amending Permit S-48451 to change the surface water POD on the Salmon River to a hydraulically connected groundwater point of appropriation (POA) downstream on the Sandy River.

The City previously evaluated the potential to develop a groundwater source with a capacity of at least 5 mgd that meets OWRD requirements for transferring surface water rights to a hydraulically connected groundwater source (GSI, 2007). GSI's review and update of this evaluation is discussed in Section 4.

While there are no administrative rules governing permit amendments, OWRD reviews permit amendments using the same criteria as it does for water right transfers. OWRD would require the City's permit amendment application include a report prepared by a licensed geologist demonstrating that the use of the groundwater at the new POA downstream near the Sandy River would meet the following criteria:

1. The change would not result in injury or enlargement[2].
2. The new POD appropriates groundwater from an aquifer that is hydraulically connected to the authorized surface source.
3. The proposed change in POD will affect the surface water source similarly to the authorized POD specified in the water use subject to transfer.

OWRD considers "similarly" to mean that the use of groundwater at the new POA will affect the surface water source specified in the permit and would result in stream depletion of at least 50 percent of the rate of appropriation within 10 days of continuous pumping.

Although the surface water source identified in the City's permit is the Salmon River, recent OWRD practice indicates that OWRD likely would not preclude a surface water to groundwater change to a downstream surface water body.

One potential obstacle to completing a surface water to groundwater permit amendment to a well hydraulically connected to the Sandy River is the proximity of Cedar Creek to the Sandy River in areas most suitable for development of a hydraulically connected groundwater POD. Near Sandy, Cedar Creek flows parallel to the Sandy River at a distance of 0.75 to 0.25 miles from the Sandy River. It is theoretically possible, although unlikely, that a well hydraulically connected to the Sandy River could also influence flows in Cedar Creek. Depending on the pumping rate, recharge from the Sandy River would probably limit the extent of the cone of depression. Regardless, if OWRD determines that a well hydraulically connected to the Sandy River also influence flows in Cedar Creek, then OWRD may find that such a change would not meet the criteria that use of the well impact surface water "similarly." Furthermore, any impact to Cedar Creek flows would likely result in a finding that the change would cause injury. ODFW holds a surface water right for the use of water from Cedar Creek for its fish hatchery at a location near the confluence with the Sandy River. This water right has previously been the basis for regulation of one the City's junior Brownell Springs water rights in 2015, so any impact to Cedar Creek flows identified through modelling of the proposed hydraulically connected well would have the potential to result in OWRD finding injury.

Therefore, although a surface water to groundwater permit amendment to a well hydraulically connected to the Sandy River appears to present the most feasible opportunity of navigating the conditions imposed by the Settlement Agreement and the final order approving the City's extension of time for Permit S-48451, some uncertainty remains as to the possibility of receiving approval of the permit amendment.

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[2] OWRD considers "injury" to mean a proposed water right action would result in another, existing water right not receiving previously available water to which it is legally entitled. OWRD considers "enlargement" to mean expansion of a water right and includes using a greater rate or duty of water per acre than currently allowed; increasing the acreage irrigated; failing to keep the original place of use from receiving water from the same source; or diverting more water at the new point of diversion or appropriation than is legally available to that right at the original point of diversion or appropriation.

It should be noted that the City has the option to include only a portion of its Salmon River permit in a downstream surface water to groundwater permit amendment. For example, the City's projected groundwater supply need of 2.53 mgd (3.91 cfs), described in section 3, could be included in a surface water to groundwater modification to a downstream hydraulically connected well, while the remaining permitted rate remains associated with the currently authorized point of diversion on the Salmon River.

Furthermore, if the downstream surface water to groundwater permit amendment is approved, but for some reason, the City does not want to complete development of a hydraulically connected well, the City can return the rate moved to a downstream hydraulically connected well to the original point of diversion within five years of the approval of the permit amendment to move the point of diversion to a hydraulically connected well.

3. Groundwater Supply Needs

The City's current water master planning effort projects demand through 2050. The water demand projection is predicated on assumption of steady, continual growth of Sandy over the next 30 years. Table 2 provides a summary of the results of the projection in the draft Water Master Plan at the time this tech memo was prepared.

Table 2. City of Sandy Projected Demands through 2050 (in million gallons per day)[3]

Year	Single-Family Residential	Multi-Family Residential	Commercial/ Industrial	Other (Wholesale, Backwater, Bulk)	Total ADD[1]	EDUs	MDD
2021	0.65	0.11	0.21	0.05	1.20	6,613	2.05
2030	0.77	0.13	0.35	0.06	1.55	8,535	2.64
2040	0.89	0.15	0.64	0.07	2.07	11,362	3.52
2050	0.99	0.16	1.17	0.08	2.84	15,618	4.83

Notes

[1] Includes 18% water loss

ADD = average-day demand

EDU = Equivalent dwelling unit

MDD = maximum day demand

As described above, the City's maximum reliable supply under its senior Brownell Springs water right and Alder Creek is 2.53 mgd. This is lower than the City's projected maximum day demand of 4.83 mgd and average day demand of 2.84 mgd by 2050. If the City maintains its Brownell Springs and Alder Creek sources of supply, in order to meet the City's maximum day demand using its own existing water rights, the City would need to develop a reliable supply of at least 2.3 mgd from a hydraulically connected well on the Sandy River downstream of the confluence with the Salmon River.

4. Future Groundwater Supply Alternatives

In 2007, GSI, under contract with Curran-McLeod, completed the *City of Sandy Groundwater/Riverbed Filtration Hydrogeologic Evaluation* (GSI, 2007). The objective of this evaluation was to determine if a groundwater source with a capacity of at least 5 mgd could be developed on the Sandy River that meets OWRD requirements for transferring surface water rights to a hydraulically connected groundwater source.

[3] Data in this table is from Draft City of Sandy Water Master Plan (2022) being prepared by Murraysmith at the time this tech memo was prepared.

The information presented below is based on a review of those findings to confirm if other/newer data warrant updates or refinements to those findings and recommendations.

Figure 2 is a map of the City's authorized surface water POD and areas evaluated as part of the 2007 hydrogeologic evaluation.

4.1 Aquifer Storage and Recovery Feasibility near the City of Sandy

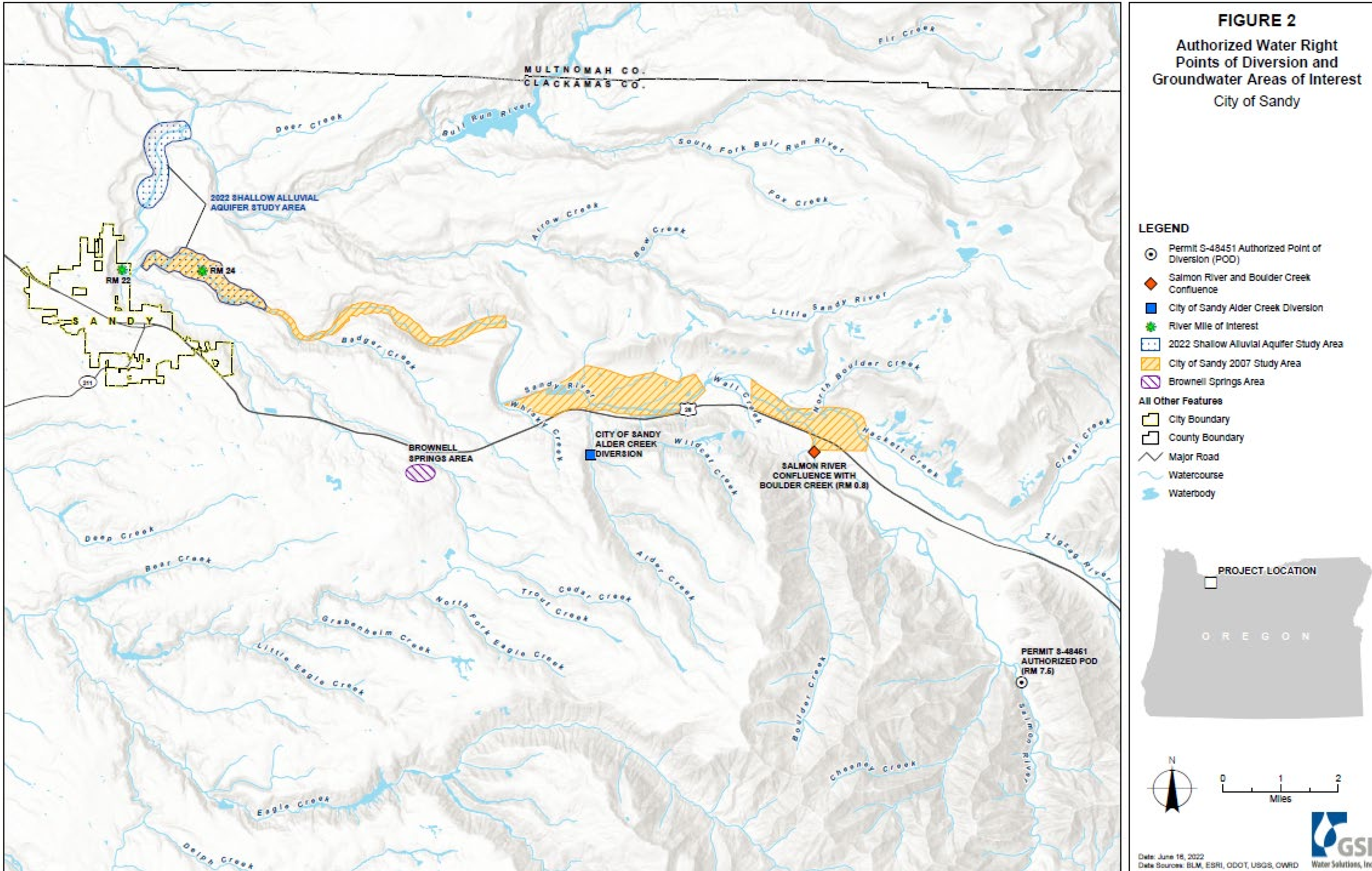
An ASR project would allow the City to inject water into the aquifer during the winter months for recovery during the high demand summer period. A successful ASR system requires an aquifer with several characteristics, including the ability to accept/yield water at a sufficient rate, sufficient storage volume, confined conditions that will not lose stored water to surface water bodies, and an acceptable depth from the surface (i.e., not so deep as to render drilling and operation of the well prohibitively expensive).

GSI evaluated the feasibility of ASR development for the following water-bearing formations in the vicinity of Sandy:

- **Columbia River Basalt Group (CRBG) —** The CRBG unit consists of a series of basalt sheetflows characterized by thin, often permeable, interflow zones separated by thick, low permeability flow interiors. Interflow zones include the top of one flow, the base of an overlying flow, and intervening sediments. Well yields are moderate to high, with most high-capacity wells open to multiple interflow zones. In the Sandy area, the CRBG is assumed to underlie the younger sedimentary units, but the depth to the top of the CRBG is uncertain, and likely greater than 1,000 feet below ground surface. A productive ASR well would likely need to extend at least several hundred feet into the basalt. Costs associated with drilling and operation of a high-capacity ASR well in the CRBG would be very high, and the presence and nature of suitable aquifer storage targets in the CRBG is not known in this area.
- **Rhododendron Formation —** The Rhododendron Formation consists of debris-flow breccias and andesite lava flows, with generally poor water-bearing characteristics (Swanson et al., 1993). Yields range from 10 to 60 gallons per minute (gpm), often with considerable drawdown (specific capacity 0.04 to 3 gpm per foot).[4]
- **Troutdale Formation —** The Troutdale Formation is an important aquifer for water supply in the area and consists of volcanic and quartzite-bearing conglomerate and vitric sandstone. The greater well yields in the Troutdale Formation near the City are 40 to 50 gpm, much less than the City's needs. The Troutdale Formation near Sandy is mostly unconfined and in hydraulic connection with surface water bodies. Both the unconfined condition and hydraulic connection with surface water are associated with considerable risk of losing stored water.
- **Boring Lava —** The Boring Lava consists of localized accumulations of basaltic lavas, vent plugs, and volcanic debris. The potential to encounter favorable conditions in the Boring Laval for an ASR system that can meet the City's needs is low because of the limited extent and locally variable nature of the unit.

The feasibility of developing ASR in the shallower water-bearing units is mostly limited by aquifer characteristics, whereas the development potential of a deeper aquifer is more affected by uncertainty regarding the presence of a suitable storage aquifer, and the drilling and construction depth that would be required to construct a high-capacity ASR well.

[4] This information was obtained from the following reference well logs for the Rhododendron Formation near Sandy: CLAC 6699, CLAC 18898, CLAC 18519, CLAC 6688, and CLAC 51283/52951.



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In addition, restrictions on diversion of water from an upstream POD during November through February may make the Salmon River an unreliable source of supply for ASR injection during winter. GSI reviewed Salmon River flow data from 1925 through 1952. While water was typically available from November through February, during dry years from the 1925 through 1952 period of record, data indicate that water would have been available for less than 90 days in 3 out of 25 years in the period of record. There is no Salmon River flow data available for the winter of 1976 to 1977, but Sandy River flow data from 1976 to 1977 suggest the possibility that no water would have been available from November through February in that year. The City would need to have sufficient excess water supply available from Alder Creek and Brownell Springs to provide water for ASR injection.

4.2 Shallow Alluvial Aquifer near the City of Sandy

GSI evaluated the favorability of groundwater development from the shallow alluvial aquifer on the south side of the Sandy River between RM 22 and RM 24 (GSI, 2007) and between RM 19 and RM 22. Both reaches of the Sandy River are downstream from the confluence with Boulder Creek and would likely meet the criteria for a downstream transfer of the Salmon River water right. Although the composition of the aquifer indicates potential for high-yielding shallow groundwater production, the shallow alluvial aquifer appears not to be laterally extensive, and the limited saturated thickness may constrain yield potential from either riverbank filtration (RBF) or a vertical well. According to nearby wells logs (CLAC 6688, CLAC 6723, CLAC 18462, CLAC 1327, CLAC 74908, and CLAC 11163) the saturated thickness of the aquifer is approximately 20 to 25 feet. Two well logs from geotechnical borings (CLAC 51394 and CLAC 51395) located near where Lusted Road meets Dodge Park (approximately RM 19) reported gravels and cobbles to a depth of 35 feet. However, the majority of logs between RM 19 and RM 22 reported depths of coarse alluvial deposits between 11 and 27 feet. GSI affirms the findings from the 2007 study that it is unlikely that an infiltration gallery or collector well system constructed in the shallow alluvial aquifer near the City could produce the desired 5 mgd.

A vertical well that is hydraulically connected to the Sandy River may be able to produce yields in excess of 100 gpm, but there are considerable uncertainties that might limit actual yields, including seasonal water level fluctuations and the depth of the productive zone(s). For example, if only the uppermost layer of the aquifer is in connection with the river, it might be highly productive during the wet season, but lose some or all hydraulic connection during periods of low water levels in the river. Similarly, pumping from the well might cause the water level to drawdown below the top of a shallow screen interval and cause water to cascade into the well. Cascading water should be avoided because it increases the risks of corrosion and biofouling. A horizontal gallery or lateral well may be capable of higher rates. Similar settings with suitable hydrogeologic characteristics may yield more than 1 mgd to a horizontal facility under the right conditions. Completion of a test well would be the best recommended approach to estimate actual sustainable production rates from the shallow alluvial aquifer.

In summary, the current review confirms that the saturated thickness of the shallow alluvial aquifer in this area is likely insufficient to provide a 5 mgd groundwater supply source, but may be capable of yielding 1 mgd to a horizontal well at a site under favorable circumstances.

5. Additional Data Needs

A comprehensive field characterization program would be necessary should the City decide to investigate the feasibility of developing a lower capacity source (i.e., 1 mgd) in the alluvial aquifer through a surface to groundwater transfer. The objectives of the field characterization program include:

1. Determine potential yield of a groundwater source under low stage/flow (summer) conditions on the river

2. Evaluate the feasibility of a surface to groundwater transfer based on hydraulic connection with the river during the summer season, assessing the likelihood of interference with streamflow in Cedar Creek.

The characterization program should include the following elements to develop a sufficient confidence in the capacity of a given location to before investing in infrastructure to develop the source:

1. Identify a site(s) adjacent to the flood plain and with space within 100 feet of the river. The City may consider identifying more than one site to explore in the event that characteristics at the first site are unsuitable and/or the City should desire to develop an additional increment of supply.
2. Complete a field exploration and monitoring program including the following activities:
    - Generate an accurate topographic map of the site using either survey or LiDAR data, depending on availability
    - Conduct a geophysical survey to map the extent and thickness of shallow deposits
    - Drill 2–4 small boreholes using sonic drilling technique to identify geologic materials and assess initial suitability
    - Construct a test well and two piezometers to serve as observation wells
    - Perform a constant-rate aquifer test during the low flow season in the Sandy River, and monitor water level responses and field water quality parameters.
    - Collect samples for water quality analysis and conduct microscopic particulate analysis (MPA) during the constant-rate aquifer test
    - Monitor water levels in the test well and observation wells over periods of high- and low-stages in the Sandy River
3. Evaluate source capacity and stream depletion from testing and monitoring data, water quality data and analytical modeling.
4. Develop preliminary design of horizontal well or infiltration gallery.

We estimate that planning level costs for this assessment <u>per site</u> are approximately $225,000. Including a 25 percent contingency, the total per site assessment cost would be $281,000.

6. References

GSI. 2007. *City of Sandy Groundwater/Riverbed Filtration Hydrogeologic Evaluation*. Draft report prepared for Curran-McLeod, Inc. and City of Sandy. May 2007.

GSI. 2015. City of Sandy Water Management and Conservation Plan.

PGE. 2002. Settlement Agreement Concerning the Removal of the Bull Run Hydroelectric Project (FERC Project No. 447

Swanson, R.D., McFarland, W.D., Gonthier, J.B., and Wilkinson, J.M. 1993. A description of hydrogeologic units in the Portland Basin, Oregon and Washington: U.S. Geological Survey Water-Resources Investigations Report 90–4196, 56 p., 10 sheets, scale 1:100,000.

APPENDIX B

PRESENTATION TO

SANDY CITY COUNCIL

Bull Run Water Supply Decision Re-Evaluation

June 6, 2022

Presented by:

Jennifer Coker
Public Works Director

Murraysmith

SANDY

murraysmith

Presentation Overview

- Background, Drivers
- Existing Water Supply Sources
- Water Demand
- Changes to Portland Supply
- Water Supply Alternatives
- Schedule
- Recommendation & Next Steps
- Q&A

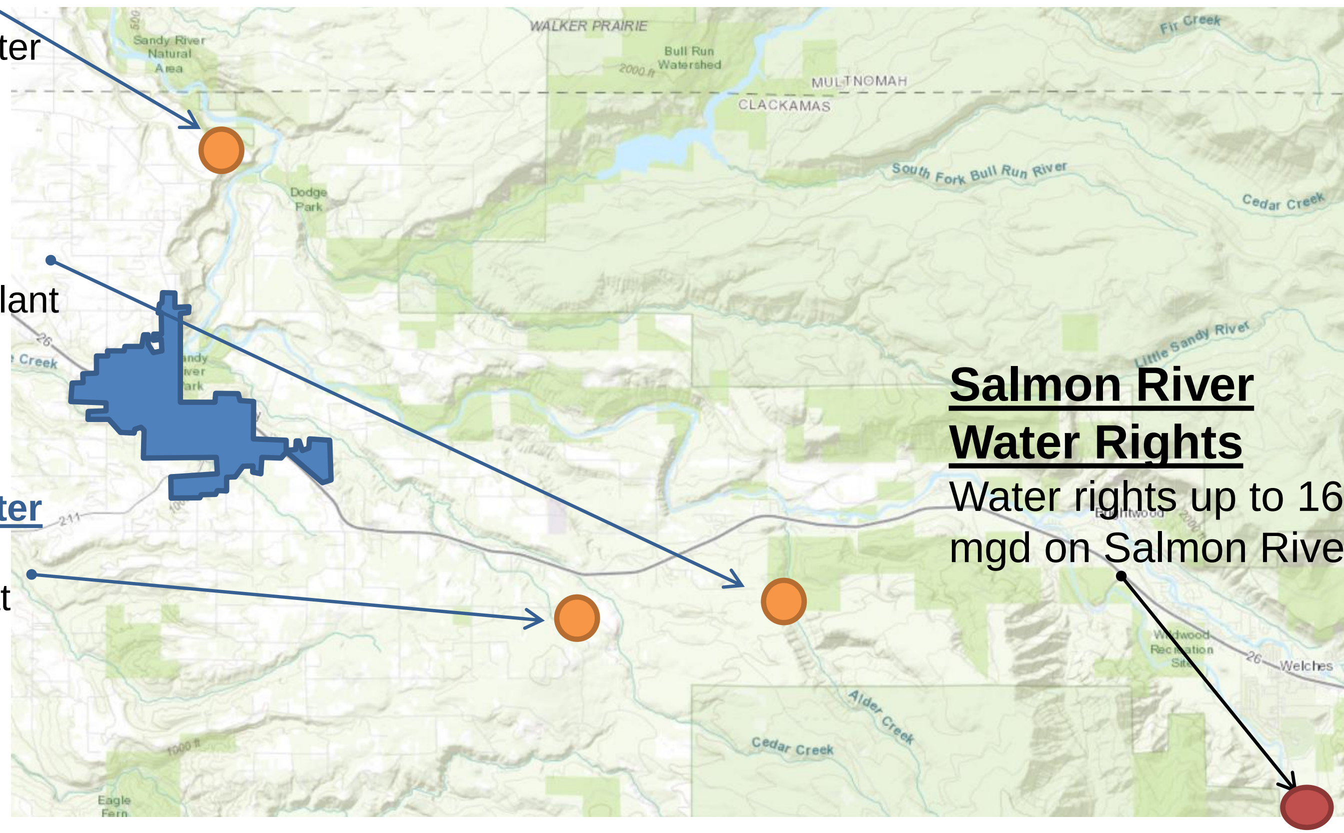
Existing Water Supply

Today, water is supplied from three sources

Portland Wholesale Supply
Purchase unfiltered treated water from Portland : 3 (mgd)

Alder Creek Surface Water Source
City owned Water Treatment Plant on Alder Creek: 0.9 mgd

Brownell Springs Groundwater Source
City owned groundwater well at Brownell Springs: 0.12 mgd



Salmon River Water Rights
Water rights up to 16 mgd on Salmon River

Groundwater

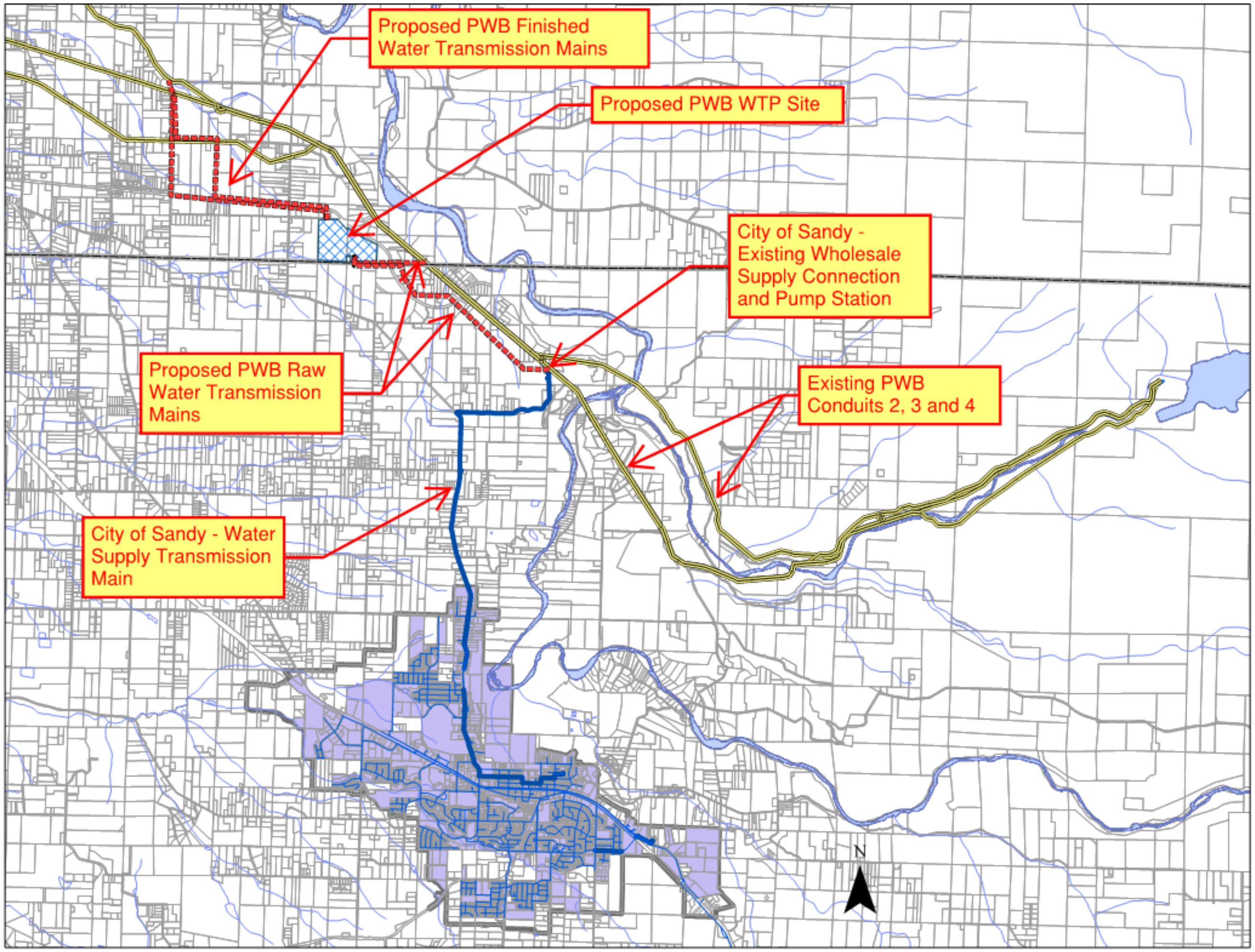
- **Water Rights Review**
  - Brownell Springs & Alder Creek @ 2.7 MGD water right priority
  - Undeveloped Salmon River Permit – 16.2 MGD– significant regulatory hurdles.
    - Surface water to groundwater transfer of permit to a well on the Sandy River downstream of Salmon River confluence may be feasible.
    - Uncertain outcome, cannot happen by 2027
- **Groundwater Review**
  - Unlikely a wellfield could produce 5 MGD

Changes to Portland Supply

- **Portland is building a new filtration plant to meet Surface Water Treatment Rules**
- **Must be in service by fall 2027**
- **Treated water will not be available to Sandy when plant goes in service without constructing improvements**
- **Sandy can buy untreated water from Portland and build a treatment plant**

or

- **Sandy can buy filtered water from Portland and build a new pipeline from Portland's WTP to existing connection at Lusted Road and Hudson Road**



Sandy Water Supply History

2008 20-year Water Supply Agreement w/ PWB

2011 Sandy constructs infrastructure to connect to PWB

2018 Sandy Agreement w/OHA treat Bull Run Water for Cryptosporidum by **September 2027**

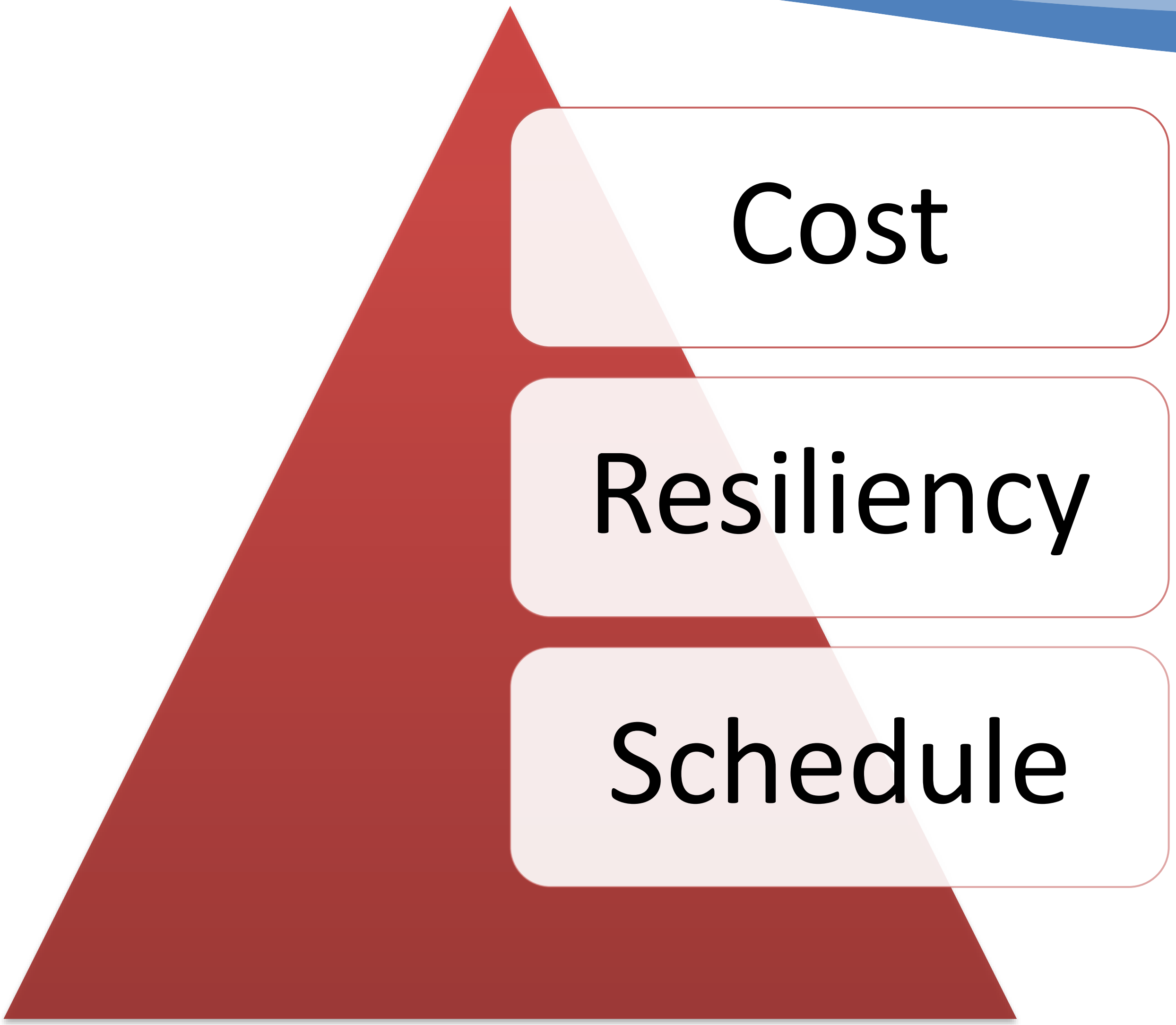
June 2021 Sandy chooses water treatment plant & purchase unfiltered water from PWB

May 2022 Revisit Decision based on updated costs

Compliance Status with OHA

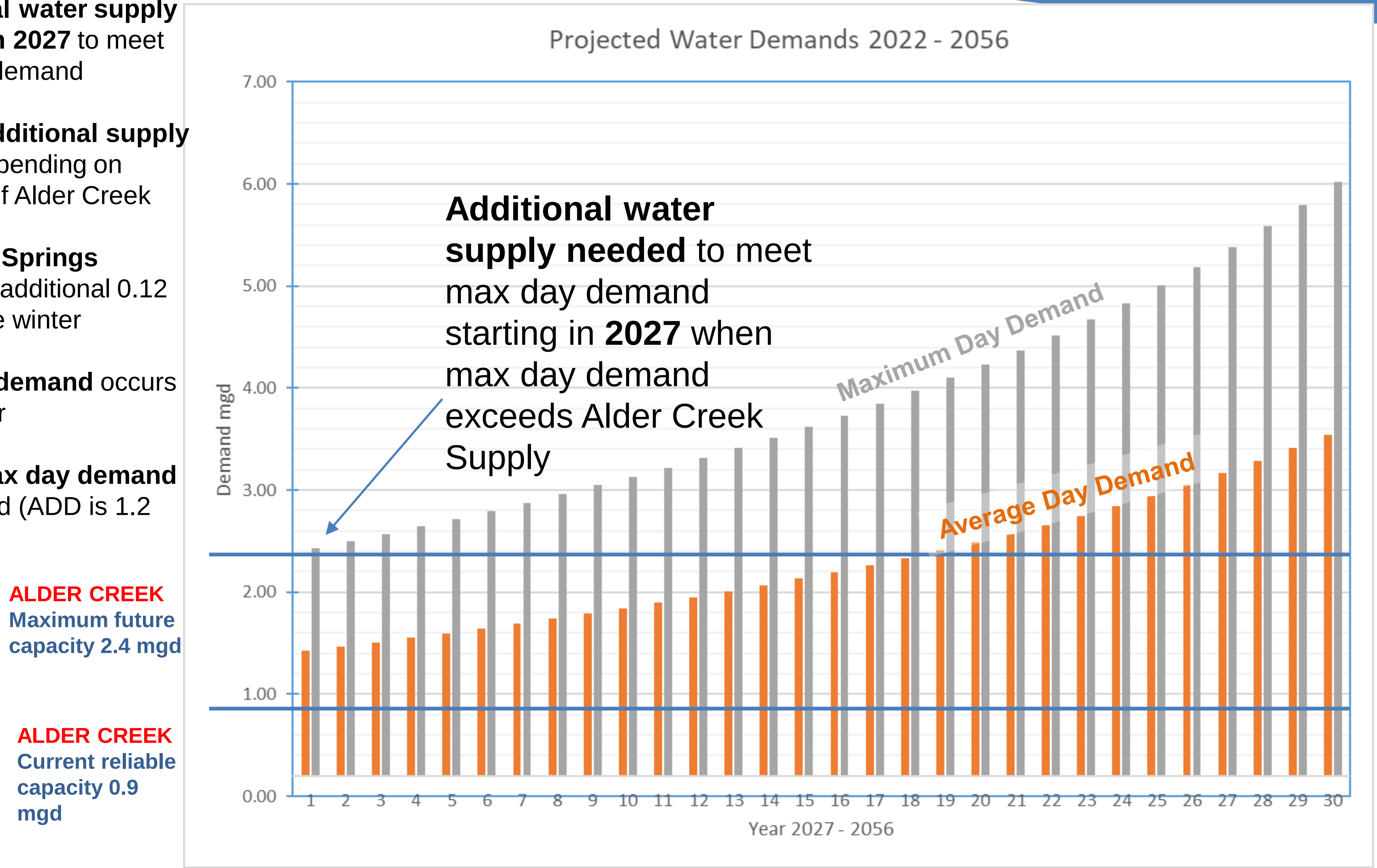
Bilateral Compliance Agreement	Date Issued	Due Date	Closed Date
Submit Master Plan	Sept 2018	December 2020	**OVERDUE**
Begin Construction	Sept 2018	July 31, 2024	
Correct Water Quality Deficiencies	Sept 2018	September 30, 2027	

Decision Drivers

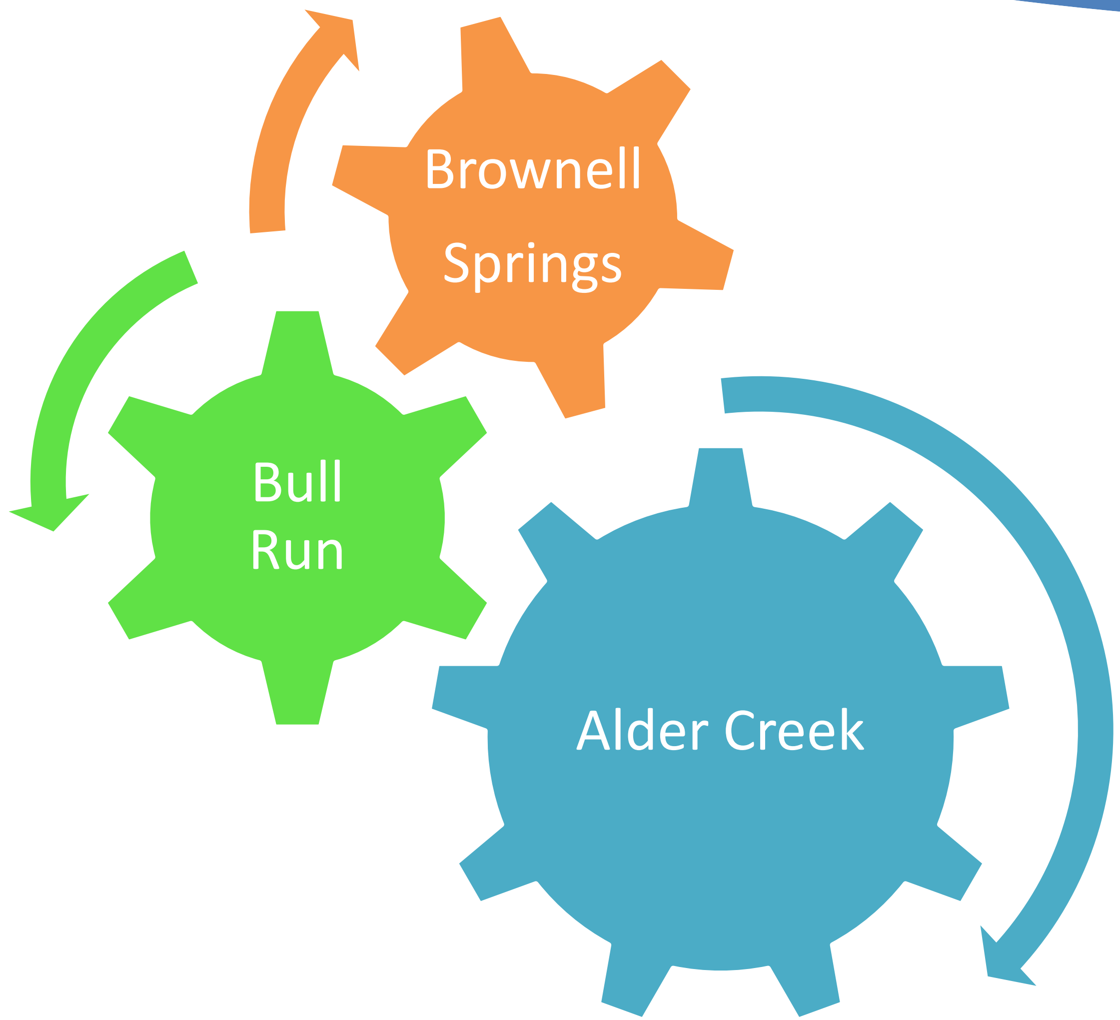


Water Demand

- **Additional water supply needed in 2027** to meet max day demand
- **Size of additional supply varies** depending on capacity of Alder Creek
- **Brownell Springs provides** additional 0.12 mgd in the winter
- **Max day demand** occurs in summer
- **Today max day demand** is 2.1 mgd (ADD is 1.2 mgd)



Water Supply Alternatives Screening



Water Supply Alternatives Screening

<u>Upgrade existing supply at Alder Creek,</u>

- Maintain existing capacity of 0.9 mgd with minor maintenance
- Improve supply to 1.4 mgd with major maintenance
- Maximize supply to 2.4 mgd with upgrades

PLUS:

A) Purchase raw water & build second treatment plant;

or

B) Purchase filtered water and build Pipeline

Pipeline Alignment for Finished Water

Potential PWB Backfeed Pipeline

Would need to be oversized to feed Sandy

Bluff Rd. Pipeline

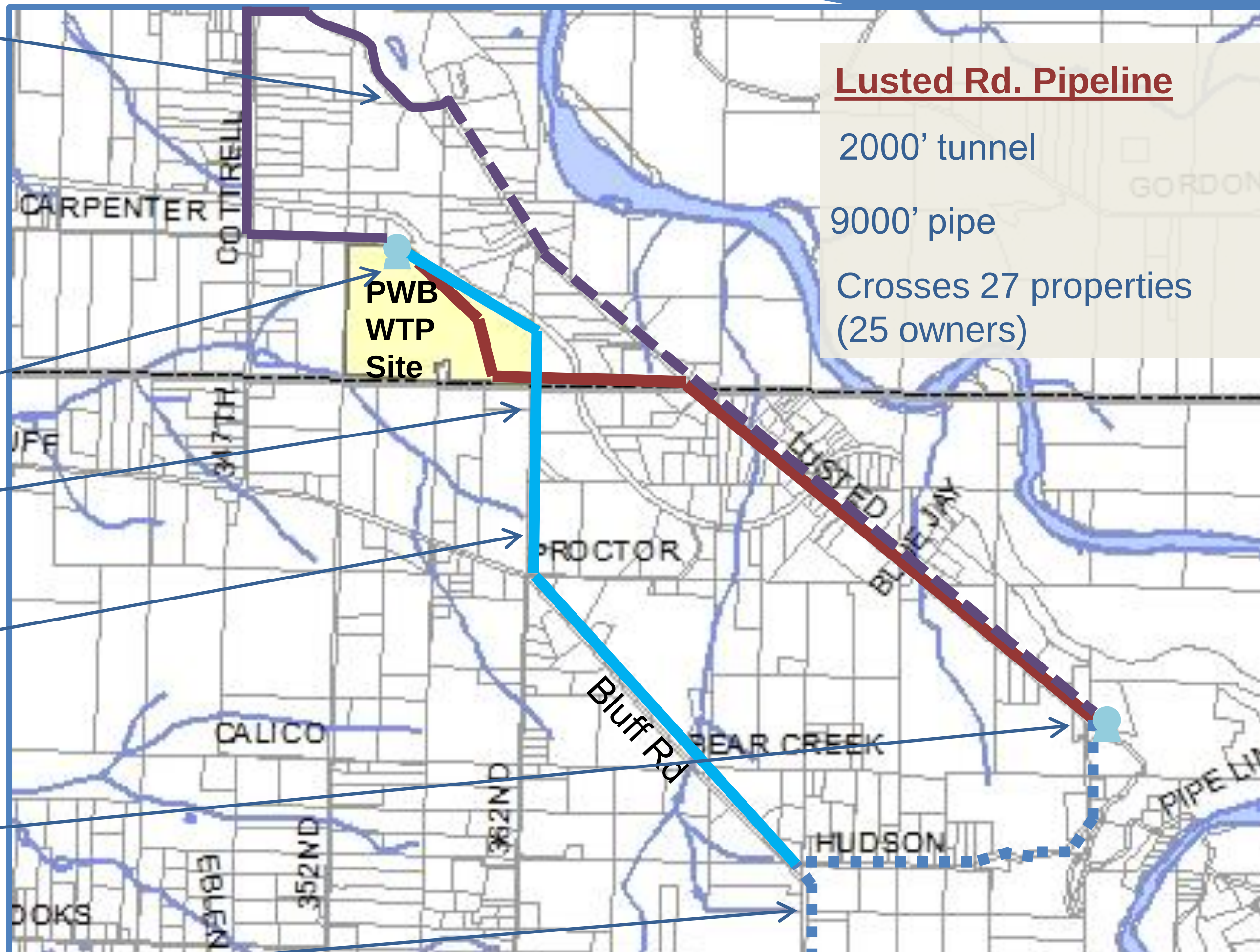
New low-head pump station – 5 mgd

PWB obtaining easement

New pipeline 11,500 FT – 24” dia.

Exist. Connection and pumpstation

Exist. Sandy supply pipeline



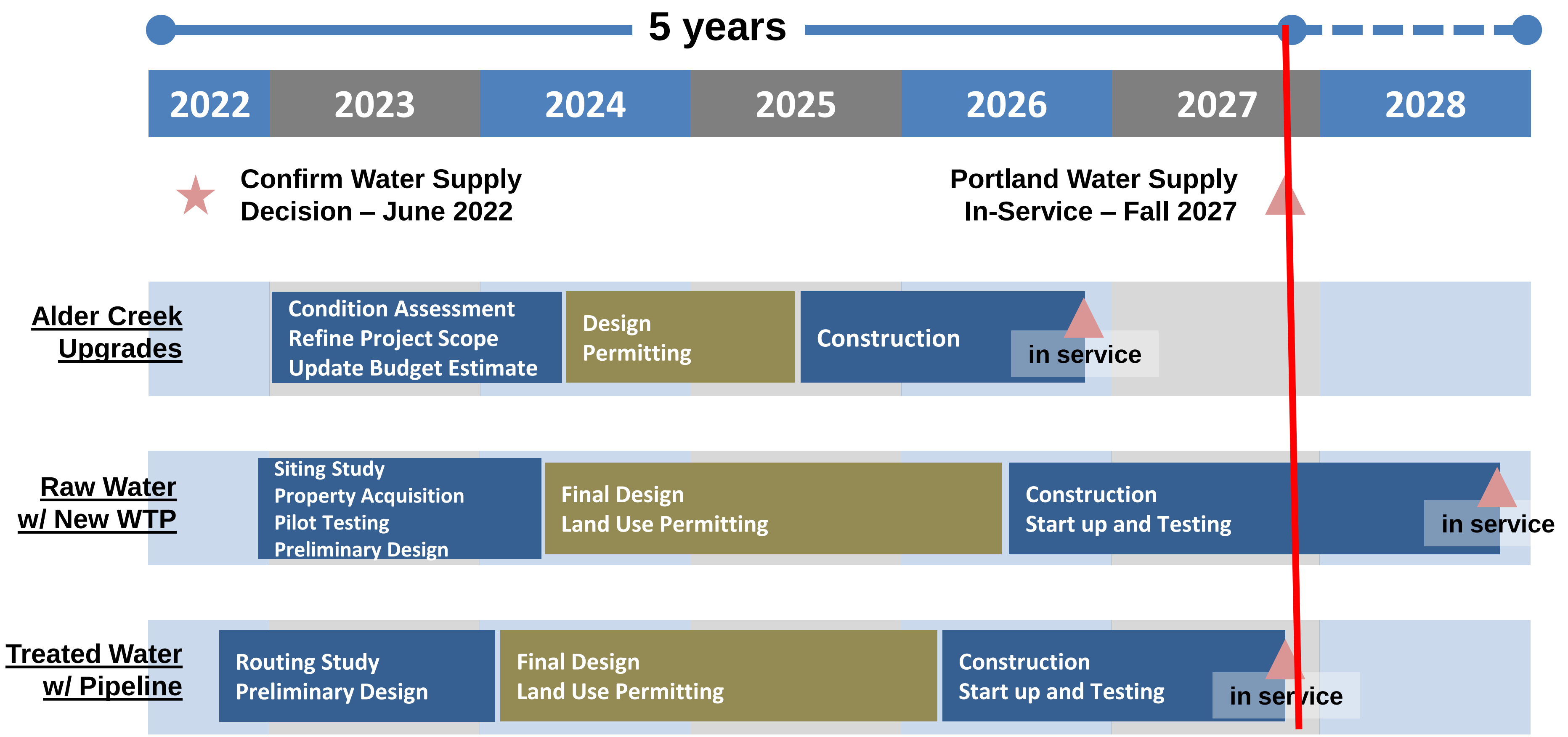
Supply Alternatives Filtered vs. Unfiltered Water Purchase

CRITERIA	PURCHASE FILTERED WATER FROM PDX BUILD BLUFF ROAD PIPELINE			PURCHASE RAW WATER FROM PDX BUILD WATER TREATMENT PLANT		
Water Supply Cost (30-yr cost in 2026 $)	LifeCycle Cost: Total Investment:	**$85.6M** **$47.2M**	**+**	LifeCycle Cost: Total Investment:	**$143.4M** **$ 58.4M**	**-**
Cost of Portland Water (in 2026 $)	30-yr Cost:	**$10.7M**	**-**	30-yr Cost:	**$ 6.1M**	**+**
Implementation Risk	* Entire pipeline must be built - can't be phased * Requires Carpenter Ln Easement * All construction is outside the City * Without pipeline, City can't meet summer demand in 2027		**-**	* WTP can be built in phases * Requires one (1) 3-to-5-acre property near existing pipeline * Land use permitting provides some uncertainty		**+**

Supply Alternatives including Alder Creek Upgrades

CRITERIA	PURCHASE FILTERED WATER FROM PDX BUILD BLUFF ROAD PIPELINE		PURCHASE RAW WATER FROM PDX BUILD WATER TREATMENT PLANT	
Water Filtration	* Water Treatment Plant (WTP) built by Portland * WTP cost shared by wholesale purchasers & Portland rate payers	+	* City builds and owns new WTP * WTP paid for by City Rate Payers	-
Operational Complexity	* Minimal O&M cost for pipeline * Need To evaluate disinfection approach * City operates only upgraded Alder Creek WTP and new pumpstation * PWB responsible for compliance	+	* City operates two water treatment plants * Higher O&M cost * City responsible for compliance	-
Resilience / Reliability	Portland groundwater supply provides redundancy	+	Portland groundwater supply **not** available for raw water option	-

Water Supply Program Schedule



Recommendation

- Upgrade Alder Creek & Install Bluff Road Water Transmission Pipe, **purchase filtered water**
- Capital Cost **$47.2 Million**
- 30-year Lifecycle cost **$85.6 Million**
- Lowest Capital and Lifecycle Costs, Faster Schedule, and Resiliency/Groundwater access

Next Steps

- **Council Formalize** purchase decision
- **Refine condition assessment** to maximize Alder Creek WTP and determine water system CIP
- **Complete Master Plan**
- **Evaluate land use and permitting** associated with building a pipeline
- **Develop funding** approach for program
- **Hire** program manager/design team

Questions

Portland Supply Alternatives

We also considered new pipeline in Lusted Road.

- Included a 2,000 ft tunnel and 200’ deep bore shaft – high risk
- Required property acquisition from 25 property owners along Lusted Road – high risk
- Cost was higher than Bluff Road option

Screening: Raw Water Alternatives

Raw Water Alternatives	Initial Investment (2026 Dollars)	Lifecycle Cost (30 years)	Water Purchase	O & M
(R1) New Plant +	$43,947,000	**$176,607,000**	$37,756,000	$27,300,000
Alder minor	$ 1,033,000			
TOTAL	**$44,900,000**			
(R2) New Plant +	$43,947,000	**$161,668,000**	$17,835,000	$36,270,000
Alder major maintenance	$ 4,164,000			
TOTAL	**$48,100,000**			
(R3) New Plant +	$43,947,000	**$143,356,000**	$6,057,000	$32,240,000
Upgrade Alder Creek	$ 14,407,000			
TOTAL	**$58,400,000**			

Build a new WTP and perform minor maintenance at Alder Creek. Alder Creek Contributes today's amount 0.9 MGD

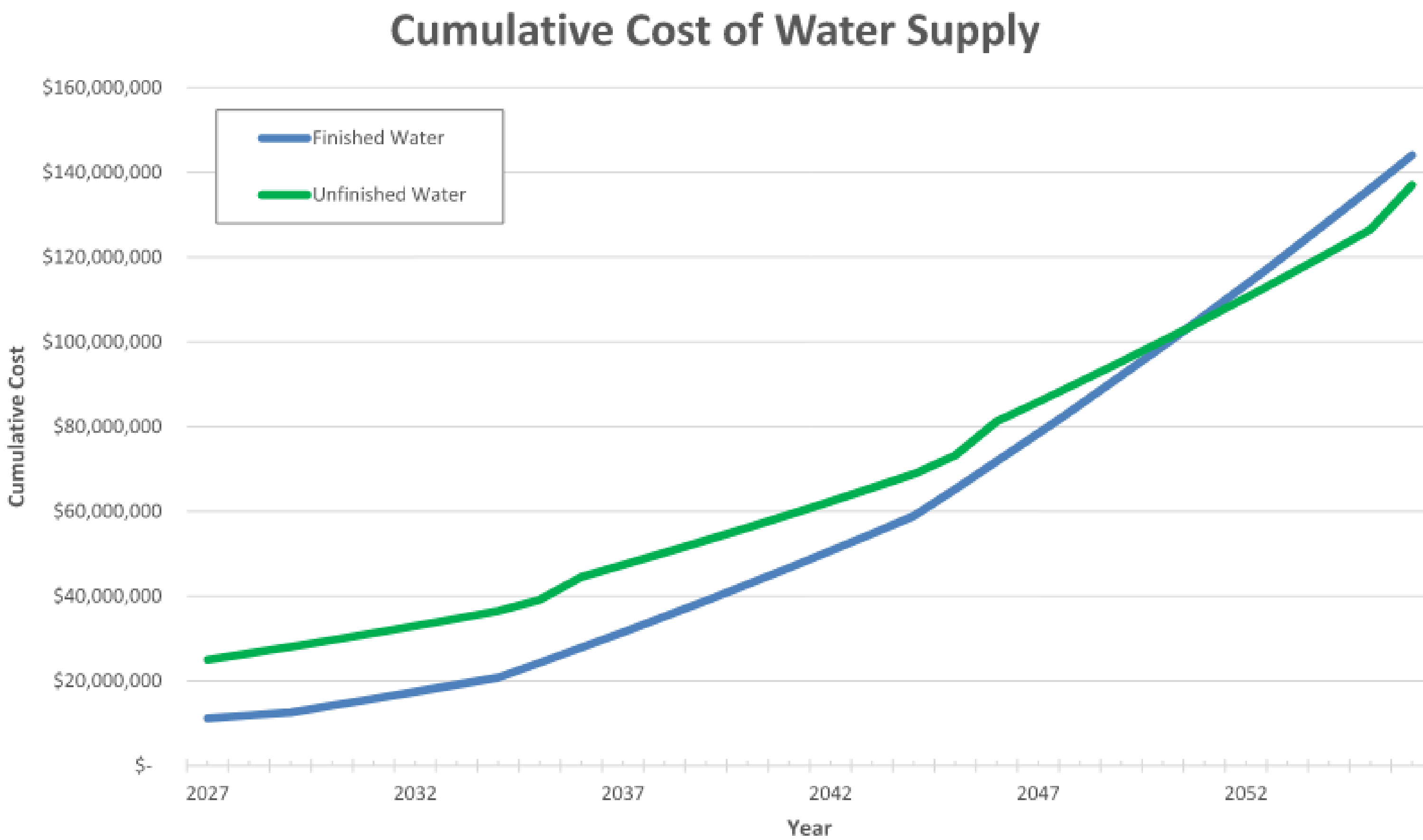
Major maintenance at Alder Creek includes new filters, control repair/upgrades. Alder Creek contributes 1.4 MGD.

Partial replacement of Alder Creek includes new filters, new control, new process piping and upgraded pump station. Alder Creek contributes 2.4 MGD

Screening: Filtered Water Alternatives

Filtered Water Alternative	Initial Investment (2026 $)	Lifecycle Cost (30 years)	Water Purchase	O & M
(FB1) New Bluff Rd Pipe Alder Creek minor maintenance **TOTAL**	$32,784,000 $1,033,000 **$33,817,000**	**$177,700,000** *11,500 LF of 24" pipe including 5 mgd pump station. Alder Creek produces current rate for 10 years*	$75,061,000	$4,977,000
(FB2) New Bluff Rd Pipe Alder Creek major maintenance **TOTAL**	$32,784,000 $4,164,000 **$36,948,000**	**$119,289,000** *11,500 LF of 24" pipe including 5 mgd pump station. Increase Alder Creek production to 1.4 MGD*	$31,146,000	$14,208,000
(FB3) New Bluff Rd Pipe Upgrade Alder Creek **TOTAL**	$32,784,000 $14,407,000 **$47,190,000**	**$85,618,000** *11,500 LF of 24" pipe including 5 mgd pump station. Increase Alder Creek production to 2.4 MGD*	$10,682,000	$10,177,000

Previous Analysis



Future Water Supply Alternatives

Evaluating Alder Creek Alternatives

All options assume Alder Creek improvements are completed before 2027

Note: Maximum capacity from Alder Creek requires additional source to meet max day demand

Alternative	Capacity	Cost	Benefits/Risk
Minor Maintenance	0.9 mgd	$ 1M	• Requires most water from Portland • Alder Creek has approx. 10-year life expectancy without significant upgrades • Does not Maximize Alder Creek supply
Major Maintenance	1.4 mgd	$ 4.2M	• Reduces water needed from Portland • Restores reliable long-term water supply • Does not Maximize Alder Creek supply
Partial Replacement	2.4 mgd	$ 14.4M	• Maximizes Supply from Alder Creek • Requires least water from Portland • Restores reliable long-term water supply

APPENDIX C
CIP COST ESTIMATES

Table 6-3
Sandy Capital Improvement Plan Summary

Project No.	Project Description	CIP Schedule and Project Cost Summary (2022 Dollars) 1-5 Years (2023-2027)	6-10 Years (2028-2032)	11-20 Years (2033-2042)	TOTAL	Preliminary SDC Eligibility
R.1	5.0 MG Additional Storage		$ 17,290,000	$ 17,290,000	$ 34,580,000	49%
R.2	Storage Siting Study	$ 180,000			$ 180,000	49%
R.3	Reservoir Seismic and Condition Assessment		$ 375,000		$ 375,000	49%
	Storage Subtotal	$ 180,000	$ 17,665,000	$ 17,290,000	$ 35,135,000	
PS.1	Terra Fern Pump Station Upgrades	$ 780,000			$ 780,000	45%
PS.2	Vista Loop Pump Station	$ 1,420,000			$ 1,420,000	45%
	Pump Station Subtotal	$ 2,200,000	$ -	$ -	$ 2,200,000	
D.1	Bluff Rd Fire Flow Improvements		$ 5,580,000		$ 5,580,000	45%
D.2	Hood St Fire Flow Improvements		$ 540,000		$ 540,000	45%
D.3	Mitchell Ct Fire Flow Improvements		$ 260,000		$ 260,000	45%
D.4	Seaman Ave Fire Flow Improvements		$ 550,000		$ 550,000	45%
	Distribution Subtotal	*$ -*	*$ 6,930,000*	*$ -*	*$ 6,930,000*	
S.1	Near-Term Alder Creek WTP Improvements	$ 1,050,000			$ 1,050,000	0%
S.2	Short-Term Alder Creek WTP Assessment	$ 240,000			$ 240,000	45%
S.3	Alder Creek WTP Improvements	$ 42,080,000			$ 42,080,000	45%
S.4	PWB Filtered Water Supply Connection	$ 39,416,000			$ 39,416,000	45%
S.5	Long-Term Supply Study		$ 240,000		$ 240,000	45%
	Supply Subtotal	$ 82,786,000	$ 240,000	$ -	$ 83,026,000	
M.1	Water System Master Plan Update		$ 220,000		$ 220,000	45%
M.2	Water Management and Conservation Plan	$ 110,000			$ 110,000	45%
M.3	Annual Replacement Budget	$ -	$ 6,000,000	$ 24,000,000	$ 30,000,000	45%
M.4	Water Service Meter Replacement			$ 7,920,000	$ 7,920,000	0%
M.5	SCADA Master Plan	$ 150,000			$ 150,000	45%
M.6	SCADA Upgrades (Preliminary Budget Placeholder)		$ 760,000		$ 760,000	45%
	Other Subtotal	$ 260,000	$ 6,980,000	$ 31,920,000	$ 39,160,000	
	CIP Total	$ 85,426,000	$ 31,815,000	$ 49,210,000	$ 166,451,000	

Probable Cost of Construction
CIP R.1

Project: 5.0 MG Additional Storage

Location To be assessed

Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	2.0 MG Reservoir	1	LS	$4,000,000	$4,000,000
A2	2.0 MG reservoir	1	LS	$4,000,000	$4,000,000
A3	1.0 MG Reservoirs	1	LS	$3,000,000	$3,000,000
A4	12-inch transmission piping	15,900	LF	$370	$5,890,000
A5	Control Valve Vault	3	EA	$100,000	$300,000
				SubTotal:	**$17,190,000**
Special					
C1	Property Acquisition	2	AC	$660,000	$1,320,000
				SubTotal:	**$1,320,000**

Material & Labor Total:		**$18,510,000**
Bonds and Insurance	2%	$370,200
Mobilization:	10%	$1,851,000
Subtotal		**$20,740,000**
Oregon Corporate Activity Tax	1.0%	$207,400
Subtotal:		**$20,950,000**
Contingency:	30%	$6,290,000
Engineering	20%	$4,190,000
Permitting and Admin	5%	$1,050,000
Construction Contract Administration	10%	$2,100,000
Total Estimated Project Cost:		***$34,580,000***
Cost Range	***-30%***	***$24,206,000***
	50%	***$51,870,000***

Probable Cost of Construction
CIP R.2

Project: Storage Siting Study
Location n/a
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Storage Siting Study	1	LS	$150,000	$150,000
			SubTotal:		**$150,000**
	Contingency:	20%			$30,000
Total Estimated Project Cost:					***$180,000***
Cost Range		***-30%***			***$126,000***
		50%			***$270,000***

Probable Cost of Construction
CIP R.3

Project: Reservoir Seismic and Condition Assessment
Location Reservoir Locations
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Reservoir Seismic and Condition Assessment	1	LS	$375,000	$375,000
			SubTotal:		**$375,000**

Total Estimated Project Cost:		***$375,000***
Cost Range	***-30%***	***$262,500***
	50%	***$562,500***

Probable Cost of Construction
CIP PS.1

Project: Terra Fern Pump Station Upgrades
Location Terra Fern Road
Date: December 1, 2022

For the purposes of future updating, all cost estimates are in November 2022 dollars

ENR, CCI - Seattle, WA: 15,202.68

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Fire Flow Pump	1	LS	$400,000	$400,000
			SubTotal:		**$400,000**

Material & Labor Total:		**$400,000**
Bonds and Insurance	2%	$8,000
Mobilization:	10%	$40,000
Subtotal		**$450,000**
Oregon Corporate Activity Tax	1.0%	$4,500
Subtotal:		**$460,000**
Contingency:	30%	$140,000
Engineering	20%	$100,000
Permitting and Admin	5%	$30,000
Construction Contract Administration	10%	$50,000

Total Estimated Project Cost:		***$780,000***
Cost Range	***-30%***	***$546,000***
	50%	***$1,170,000***

Probable Cost of Construction
CIP PS.2

Project: Vista Loop Pump Station
Location Vista Loop
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Pump Station	1	LS	$750,000	$750,000
			SubTotal:		**$750,000**

Material & Labor Total:		**$750,000**
Bonds and Insurance	2%	$15,000
Mobilization:	10%	$75,000
Subtotal		**$840,000**
Oregon Corporate Activity Tax	1.0%	$8,400
Subtotal:		**$850,000**
Contingency:	30%	$260,000
Engineering	20%	$170,000
Permitting and Admin	5%	$50,000
Construction Contract Administration	10%	$90,000
Total Estimated Project Cost:		***$1,420,000***
Cost Range	***-30%***	***$994,000***
	50%	***$2,130,000***

Probable Cost of Construction
CIP D.1

Project: Bluff Rd Fire Flow Improvements
Location Bluff Rd, Burgs Ln, Kelso Rd, SE Baumback Ave, Marcy St
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	8-inch diameter	1800	LF	$270	$490,000
A2	12-inch diameter	6700	LF	$370	$2,480,000
				SubTotal:	**$2,970,000**

Material & Labor Total:		**$2,970,000**
Bonds and Insurance	2%	$59,400
Mobilization:	10%	$297,000
Subtotal		**$3,330,000**
Oregon Corporate Activity Tax	1.0%	$33,300
Subtotal:		**$3,370,000**
Contingency:	30%	$1,020,000
Engineering	20%	$680,000
Permitting and Admin	5%	$170,000
Construction Contract Administration	10%	$340,000

Total Estimated Project Cost:		***$5,580,000***
Cost Range	***-30%***	***$3,906,000***
	50%	***$8,370,000***

Probable Cost of Construction
CIP D.2

Project: Hood St Fire Flow Improvements
Location Hood St and SE Ten Eyck Rd
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	12-inch diameter	680	LF	$370	$260,000
			SubTotal:		**$260,000**

Material & Labor Total:		**$260,000**
Bonds and Insurance	2%	$5,200
Mobilization:	10%	$26,000
Subtotal		**$300,000**
Oregon Corporate Activity Tax	1.0%	$3,000
Subtotal:		**$310,000**
Contingency:	30%	$100,000
Engineering	20%	$70,000
Permitting and Admin	5%	$20,000
Construction Contract Administration	10%	$40,000

Total Estimated Project Cost:		***$540,000***
Cost Range	***-30%***	***$378,000***
	50%	***$810,000***

Probable Cost of Construction
CIP D.3

Project: Mitchell Ct Fire Flow Improvements
Location Mitchell Court
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	8-inch diameter	430	LF	$270	$120,000
			SubTotal:		**$120,000**

Material & Labor Total:		**$120,000**
Bonds and Insurance	2%	$2,400
Mobilization:	10%	$12,000
Subtotal		**$140,000**
Oregon Corporate Activity Tax	1.0%	$1,400
Subtotal:		**$150,000**
Contingency:	30%	$50,000
Engineering	20%	$30,000
Permitting and Admin	5%	$10,000
Construction Contract Administration	10%	$20,000
Total Estimated Project Cost:		***$260,000***
Cost Range	***-30%***	***$182,000***
	50%	***$390,000***

consor

Probable Cost of Construction
CIP D.4

Project: Seaman Ave Fire Flow Improvements
Location Seaman Ave
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	12-inch diameter	720	LF	$370	$270,000
			SubTotal:		**$270,000**

Material & Labor Total:		**$270,000**
Bonds and Insurance	2%	$5,400
Mobilization:	10%	$27,000
Subtotal		**$310,000**
Oregon Corporate Activity Tax	1.0%	$3,100
Subtotal:		**$320,000**
Contingency:	30%	$100,000
Engineering	20%	$70,000
Permitting and Admin	5%	$20,000
Construction Contract Administration	10%	$40,000
Total Estimated Project Cost:		***$550,000***
Cost Range	***-30%***	***$385,000***
	50%	***$825,000***

Probable Cost of Construction
CIP S.1

Project: Near-Term Alder Creek WTP Improvements
Location Alder Creek WTP
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Minor Maintenance at Alder Creek WTP	1	LS	$550,000	$550,000
			SubTotal:		**$550,000**

Material & Labor Total:		**$550,000**
Bonds and Insurance	2%	$11,000
Mobilization:	10%	$55,000
Subtotal		**$620,000**
Contingency:	30%	$190,000
Engineering	20%	$130,000
Permitting and Admin	5%	$40,000
Construction Contract Administration	10%	$70,000
Total Estimated Project Cost:		***$1,050,000***
Cost Range	***-30%***	***$735,000***
	50%	***$1,575,000***

Probable Cost of Construction
CIP S.2

Project: Short-Term Alder Creek WTP Assessment
Location Alder Creek WTP
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Detailed WTP Assessment (includes structure, mechanical, and electrical assessments; cost benefit analysis; improvement plan	1	LS	$200,000	$200,000
				SubTotal:	**$200,000**
	Contingency:	20%			$40,000
Total Estimated Project Cost:					***$240,000***
Cost Range		***-30%***			***$168,000***
		50%			***$360,000***

Probable Cost of Construction
CIP S.3

Project: Alder Creek WTP Improvements
Location Alder Creek WTP
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Full Replacement of Alder Creek WTP and Associated Infrastructure (2.6 MGD Capacity)	1	LS	$22,530,000	$22,530,000
			SubTotal:		**$22,530,000**
	Material & Labor Total:				**$22,530,000**
	Bonds and Insurance	2%			$450,600
	Mobilization:	10%			$2,253,000
Subtotal					**$25,240,000**
	Oregon Corporate Activity Tax	1.0%			$252,400
	Subtotal:				**$25,500,000**
	Contingency:	30%			$7,650,000
	Engineering	20%			$5,100,000
	Permitting and Admin	5%			$1,280,000
	Construction Contract Administration	10%			$2,550,000
Total Estimated Project Cost:					***$42,080,000***
Cost Range		***-30%***			***$29,456,000***
		50%			***$63,120,000***

Probable Cost of Construction
CIP S.4

Project: PWB Filtered Water Supply Connection
Location Hudson PS
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	5 MG Pump Station	1	LS	$12,005,000	$12,005,000
A2	24-inch diameter transmission line	11,500	LF	$738	$8,490,000
				SubTotal:	**$20,495,000**

Material & Labor Total:		**$20,495,000**
Bonds and Insurance	2%	$409,900
Mobilization:	10%	$2,049,500
Subtotal		**$22,955,000**
Oregon Corporate Activity Tax	1.0%	$229,550
Subtotal:		**$23,185,000**
Contingency:	35%	$8,115,000
Engineering	20%	$4,637,000
Permitting and Admin	5%	$1,160,000
Construction Contract Administration	10%	$2,319,000
Total Estimated Project Cost:		***$39,416,000***
Cost Range	***-30%***	***$27,591,200***
	50%	***$59,124,000***

Probable Cost of Construction
CIP S.5

Project: Long-Term Supply Study
Location n/a
Date: December 1, 2022

For the purposes of future updating, all cost estimates are in November 2022 dollars

ENR, CCI - Seattle, WA: 15,202.68

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Long-Term Water Supply Study	1	LS	$200,000	$200,000
			SubTotal:		**$200,000**
	Contingency:	20%			$40,000
Total Estimated Project Cost:					***$240,000***
Cost Range		***-30%***			***$168,000***
		50%			***$360,000***

Probable Cost of Construction
CIP M.1

Project: Water System Master Plan Update
Location n/a
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Water System Master Plan Update	1	LS	$200,000	$200,000
		SubTotal:			**$200,000**
	Contingency:	10%			$20,000
Total Estimated Project Cost:					***$220,000***
Cost Range		***-30%***			***$154,000***
		50%			***$330,000***

consor

Probable Cost of Construction
CIP M.2

Project: Water Management and Conservation Plan
Location n/a
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Water Conservation Management Plan	1	LS	$100,000	$100,000
			SubTotal:		**$100,000**
	Contingency:	10%			$10,000
Total Estimated Project Cost:					***$110,000***
Cost Range		***-30%***			***$77,000***
		50%			***$165,000***

Probable Cost of Construction
CIP M.3

Project: Annual Replacement Budget
Location Distribution System
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	8-inch diameter (average)	4740	LF	$270	$1,280,000
			SubTotal:		**$1,280,000**

Material & Labor Total:		**$1,280,000**
Bonds and Insurance	2%	$25,600
Mobilization:	10%	$128,000
Subtotal		**$1,440,000**
Oregon Corporate Activity Tax	1.0%	$14,400
Subtotal:		**$1,454,400**
Contingency:	30%	$437,000
Engineering	20%	$291,000
Permitting and Admin	5%	$73,000
Construction Contract Administration	10%	$146,000

Total Estimated Project Cost:		***$2,400,000***
Cost Range	*-30%*	***$1,680,000***
	50%	***$3,600,000***

Probable Cost of Construction
CIP M.4

Project: Water Service Meter Replacement
Location n/a
Date: December 1, 2022

For the purposes of future updating, all cost estimates are in November 2022 dollars

ENR, CCI - Seattle, WA: 15,202.68

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	Water Service Meter Replacement	3000	EA	$2,400	$7,200,000
				SubTotal:	**$7,200,000**
	Contingency:	10%			$720,000
Total Estimated Project Cost:					***$7,920,000***
Cost Range		***-30%***			***$5,544,000***
		50%			***$11,880,000***

Probable Cost of Construction
CIP M.5

Project: SCADA Master Plan
Location n/a
Date: December 1, 2022

For the purposes of future updating, all cost estimates are in November 2022 dollars

ENR, CCI - Seattle, WA: 15,202.68

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	SCADA Master Plan	1	LS	$125,000	$125,000
			SubTotal:		**$125,000**
	Contingency:	10%			$20,000
Total Estimated Project Cost:					***$150,000***
Cost Range		***-30%***			***$105,000***
		50%			***$225,000***

Probable Cost of Construction
CIP M.6

Project: SCADA Upgrades (Preliminary Budget Placeholder)
Location n/a
Date: December 1, 2022

ENR, CCI - Seattle, WA: 15,202.68

For the purposes of future updating, all cost estimates are in November 2022 dollars

Item No.	Item	Quantity		Unit Costs	Total Cost
Facilities					
A1	SCADA Upgrades (Preliminary Budget Placeholder)	1	LS	$450,000	$450,000
		SubTotal:			**$450,000**
	Contingency:	30%			$140,000
	Engineering	20%			$90,000
	Permitting and Admin	5%			$30,000
	Construction Contract Administration	10%			$50,000
Total Estimated Project Cost:					***$760,000***
Cost Range		***-30%***			***$532,000***
		50%			***$1,140,000***