2020 Water System Master Plan Update

Prepared for:

OAK LODGE
WATER SERVICES

Prepared Under the Responsible Charge of:

Scott Duren, PE

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WSC
WATER SYSTEMS CONSULTING, INC.

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Kevin Williams, President

Paul Gornick, Secretary/Vice President

Mark Knudson, Treasurer

Susan Keil, Director

Ginny Van Loo, Director

Sarah Jo Chaplen, General Manager

Jason Rice, District Engineer

Todd Knapp, Field Superintendent

Markus Mead, Development Review

Brad Lyon, Water Field Supervisor

Gary Floyd, Asset Resources Specialist

Rob Moody, Financial Consultant

The Oak Lodge Water Services District 2020 Water System Master Plan was prepared by Water Systems Consulting, Inc. The primary authors are listed below.

WSC
WATER SYSTEMS CONSULTING, INC.

Scott Duren, P.E.

Kirsten Plonka

Samantha Schreiner

Spencer Waterman

Adam Donald, P.E.

Heather Freed

Water Systems Consulting, Inc. received assistance in the preparation of the Oak Lodge Water Services District 2020 Water System Master Plan from the following subconsultants:

Barney & Worth

Nicki Pozos, P.E.

FCS Group

Doug Gabbard

John Ghilarducci

Wyatt Zimbelman

McMillen Jacobs Associates

Wolfe Lang, P.E., G.E.

Jeremy Fissel, P.E.

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Glossary of Terms

AACE	Association for the Advancement of Cost Engineering
AC	Asbestos Cement
ADA	American's with Disabilities Act
ADD	Average Day Demand
AF	Acre-Feet
AFY	Acre-Feet per Year
AL	Action level
ALA	American Lifelines Alliance
AWIA	America's Water Infrastructure Act
AWWA	American Water Works Association
BPS	Booster Pump Station
C-factor	Hazen Williams pipe roughness coefficient
CCI	Construction Cost Index
CCR	Consumer Confidence Report
CI	Cast iron
CIP	Capital Improvement Program
CMLC	Cement Mortar Lined & Coated Steel
CMMS	Computerized Maintenance Management Software
CRW	Clackamas River Water
CSZ	Cascadia Subduction Zone
DBP	Disinfectant Byproduct
DBPR	Disinfectant Byproduct Rule
DI	Ductile iron
DOGAMI	Department of Geology and Mineral Industries
DWS	Drinking Water Services
E. coli	Escherichia coli
ENR	Engineering News Record
EPA	Environmental Protection Agency
EPS	Extended Period Simulation
ERP	Emergency Response Plan
EUL	Estimated Useful Life
°F	Fahrenheit

FF	Fire Flow
fps	feet per second
ft	Feet
FY	Fiscal Year
GIS	Geographic Information Systems
GPCD	gallons per capita per day
gpm	gallons per minute
HAA5	Haloacetic acids
HDPE	High-density polyethylene
HGL	Hydraulic Grade Line
HP	Horsepower
IGA	Intergovernmental Agreement
in	inch
LCR	Lead and Copper Rule
MCE	Meter capacity equivalent
MCL	Maximum Contaminant Limit
MCLG	Maximum Contaminant Level Goal
MCMJ	McMillen Jacobs Associates
MDD	Maximum Day Demand
MG	Million Gallons
mg/L	milligrams per liter
MGD	Million Gallons per Day
MRDL	Maximum residual disinfectant level
MSL	Mean Sea Level
NCCWC	North Clackamas County Water Commission
NRW	Non-revenue water
NTU	Nephelometric Turbidity Units
OAR	Oregon Administrative Rule
OHA	Oregon Health Authority
OLWSD	Oak Lodge Water Services District
ORS	Oregon Revised Statutes
OSSPAC	Oregon Seismic Safety Policy Advisory Commission
PE	Polyethylene
PGA	Peak ground acceleration
PGV	Peak ground velocity
PGD	Peak ground deformation
PHD	Peak Hour Demand
PLC	Programmable logic controller
PNR	Public Notification Rule

ppb	parts per billion
ppm	parts per million
PRV	Pressure Reducing Valve
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
RRA	Risk and Resiliency Assessment
RTCR	Revised Total Coliform Rule
RUL	Remaining Useful Life
SCADA	Supervisory Control and Data Acquisition
SDC	System Development Charge
SFWB	South Fork Water Board
STL	Steel
SWA	Sunrise Water Authority
TAZ	Transportation analysis zone
TCR	Total Coliform Rule
TT	Treatment Technique
TTHM	Total trihalomethanes
UCMR	Unregulated Contaminant Monitoring Rule
U.S.	United States
VFD	Variable Frequency Drive
WMCP	Water Management and Conservation Plan
WSMP	Water System Master Plan
WSC	Water Systems Consulting
WTP	Water Treatment Plant

CHAPTER 1

Executive Summary

Oak Lodge Water Services District (OLWSD or District) owns and operates a potable water system that serves approximately 28,000 residents and commercial customers in unincorporated western Clackamas County. This Water System Master Plan (WSMP) updates the previous plan developed in 2008 and assesses the ability of the system to meet the needs of current and future customers. The WSMP identifies a prioritized list of improvements to address fire flow deficiencies, repair or replace aging infrastructure, and mitigate the risk of a seismic event. To assist in long-term planning and budgeting for improvement projects, a capital improvement program (CIP) has been developed.

1.1 System Description

The District service area is comprised mostly of the Oak Grove and Jennings Lodge County Planning Organizations (CPOs) and is located entirely within Metro's Urban Growth Boundary for the Portland regional area. Water supply is provided by the North Clackamas County Water Commission (NCCWC), a partnership between OLWSD, Sunrise Water Authority (Sunrise), and the City of Gladstone. Although the District turned over its water rights on the Clackamas River to the NCCWC, the Amended and Restated Intergovernmental Agreement (IGA) for the NCCWC states that OLWSD shall be allocated up to 42 percent of the NCCWC Water Treatment Plant (WTP) capacity. The NCCWC also maintains interconnections with Clackamas River Water (CRW) and the South Fork Water Board (SFWB). All District supply is conveyed through a 24-inch diameter supply pipeline that terminates at the Valley View Reservoirs. Prior to formation of the NCCWC, District water was supplied from the CRW Pump Station located at the CRW WTP. The District still owns the CRW Pump Station but currently leases operation to Sunrise. The District also maintains three

IN THIS SECTION

System Description

Evaluation Criteria

Demand, Supply and Storage

Hydraulic Analysis

Asset Rehabilitation and Replacement

Seismic Analysis

Water Quality

Capital Improvement Program

interconnections apiece with CRW and Gladstone, but due to the difference in hydraulic elevations of the systems, water is only available for export out from the District's distribution system.

The OLWSD distribution system is comprised of three pressure zones; lower, upper, and high-level. The lower zone is fed by gravity flow from the Valley View Reservoirs, twin 5.0 million gallon (MG) prestressed concrete cylinder tanks. The upper zone is fed by gravity flow from the View Acres Reservoirs, twin 2.8 MG welded steel tanks. The Valley View Booster Pump Station (BPS) conveys water from Valley View to the View Acres Reservoirs, and the View Acres BPS feeds the high-level zone. Three pressure reducing valves (PRVs) separate the upper and lower zone. A supervisory control and data acquisition (SCADA) system allows operations to monitor and control the pump stations and reservoirs. Overall there are approximately 105 miles of distribution and transmission piping in the system, with the majority in the 6- and 8-inch diameter sizes.

1.2 Evaluation Criteria

Water system criteria were developed for evaluating the performance of the OLWSD system using a variety of sources including Oregon Drinking Water Rules, District Standards and preferences, Clackamas County Fire Code and engineering judgement. A level of service workshop was conducted with District staff to discuss and confirm desired level of service during both normal operating conditions and in a theoretical emergency scenario. Criteria were organized into three categories; distribution system, storage volume, and booster pump stations. Actual system performance data and hydraulic modelling results were compared to the criteria to identify system deficiencies and recommend improvements.

1.3 Demand, Supply, and Storage

Based on historical billings for water meter readings between 2013 and 2017, the District's current consumption is 2,705 acre-feet per year (AFY). Production over the same period was measured at magnetic flow meters at the Valley View facility that monitor the volume of water entering the distribution system and indicates that 21 percent of water entering the distribution system is non-revenue water (NRW). This NRW percentage was a dramatic increase from the 8.9 percent NRW calculated in the previous 2008 WSMP. As this WSMP update was being prepared, the District has conducted a detailed water audit and is developing a multi-faceted strategy to optimize the amount of NRW in the system.

A spatial allocation of demands using District GIS data was scaled to expected population growth rates provided by Metro Transportation Analysis Zone (TAZ) data to determine the impacts of forecasted future demands on the existing water distribution system. Population within the OLWSD service area is anticipated to grow by approximately 6 percent above the 2017 estimate by the year 2037. The current and projected future demands for the District are provided in Table 1-1.

Table 1-1. Current and Future Projected Demands

Demand Condition	2017 Demand (MGD)	2037 Demand (MGD)
Average Day Demand (ADD)	3.07	3.25
Maximum Day Demand (MDD)	5.52	5.84
Peak Hour Demand (PHD)	9.32	9.87
MGD = million gallons per day		

Between 2014 and 2018, the average maximum daily production rate from the NCCWC WTP was 18.3 million gallons per day (MGD). Based on the District's allocation of NCCWC WTP production as described in the Amended and Restated IGA, the maximum supply available to the District has averaged 7.7 MGD, well above the projected 2037 maximum day demand (MDD) of 5.84 MGD.

Using the spatially distributed demands, each of the BPS was evaluated to determine if sufficient capacity exists to meet demands and fire flow requirements (for the high-level zone only). Both the Valley View and View Acres BPS were found to have excess firm capacity, the capacity with the largest pump out of service, beyond the projected future demands.

Existing storage was evaluated by calculating the necessary operational, fire flow, and emergency storage volumes for each of the zones served by each pair of reservoirs. Both the Valley View and View Acres tanks have excess storage in 2037, and the total existing storage volume of 15.60 MG exceeds the projected total required storage of 9.78 MG.

1.4 Hydraulic Analysis

The District's updated Geographic Information System (GIS) database of the water distribution system was used to construct a hydraulic model using InfoWater, Innovyze's® GIS-based hydraulic modeling software. District staff provided a review of the hydraulic model and several recently constructed improvements were incorporated. Five hydrant flow tests were conducted throughout the distribution system and were used to calibrate pipe friction factors based on pipe materials and age.

A system capacity analysis was conducted using the model and consisted of both a pressure and a fire flow analysis. No deficiencies were found for maintaining a minimum service pressure of 35 pounds per square inch (psi) under 2037 peak hour demands. Fire flow scenarios were created and run to evaluate the available fire flow at each fire hydrant while maintaining a residual pressure in the zone of 20 psi during both current and 2037 MDD. Fire flow improvement projects were identified to address individual hydrants with predicted flows less than the required minimum fire flow for the class of land-use served. A total of 37 fire flow projects, resulting in the upgrade of approximately 12 miles of distribution pipes, were identified. Each project was ranked based on operations and engineering staff input, estimated age of pipe, customer zoning classification, and number of fire flow deficient hydrants improved.

1.5 Asset Rehabilitation and Replacement

The District understands the importance of proactively rehabilitating and replacing aging assets to maintain a safe and reliable water system for its customers. Assets are divided into two categories; buried pipelines which are difficult to inspect for condition, and non-buried assets that can be visually inspected as needed to assess condition deterioration.

Pipeline rehabilitation and replacement needs were developed system-wide using pipe material and installation data within the GIS database. The District does not have detailed installation records prior to 1965 and assumes that pipes with no installation date were installed prior to 1965 and are most likely to be constructed of cast iron pipe. Available and assumed data on pipe age and material were compared against estimated useful lifetimes of various pipe materials to develop an estimate of remaining useful life (RUL) for each pipe. A recommended pipe rehabilitation and replacement rate of approximately one mile per year, or roughly $1.4M in capital replacement costs, is recommended. Expected useful life of water distribution pipes are anticipated to range between 60 to 110 years depending on material type, size, and installation methods. The recommended replacement rate of one mile per year represents one percent of the total system pipeline length and would result in a full replacement of the distribution system in 100 years. District operations staff also identified six pipeline replacement projects based on history of repairs and potential risk.

The District identified several rehabilitation and replacement projects anticipated over the next 20 years for addressing aging non-buried assets. An additional ten projects were identified that address condition deficiencies at the storage tanks, BPSs, PRVs, SCADA system, large customer meter vaults, and fire hydrants.

1.6 Seismic Analysis

Since the last WSMP Update for the District in 2008, new federal and state requirements have been adopted that require analysis of seismic risk. The Oregon Health Authority (OHA) updated the Oregon Administrative Rules (OARs) to require that WSMPs include a seismic risk assessment and mitigation plan for water systems located in high seismic risk areas, which includes the District service area. The risk assessment must identify critical facilities, evaluate the likelihood and consequences of seismic failure, and provide a mitigation plan that addresses deficiencies within the next 50 years for any capital improvements or additional studies. The seismic assessment will also help in compliance with the America's Water Infrastructure Act (AWIA) which requires Risk and Resiliency Assessments (RRAs) for both natural hazards and malevolent acts as well as preparation of an Emergency Response Plan (ERP).

The District's system was divided into primary backbone pipelines that provide water for fire suppression at the Valley View and View Acres facilities, and secondary backbone pipelines that serve potential community distribution centers, in accordance with the Oregon Resiliency Plan. Seismic hazard mapping was conducted by McMillen Jacobs Associates (MCMJ) to estimate the peak ground velocity (PGV) and peak ground deformation (PGD) within the District service resulting from a Cascadia Subduction Zone (CSZ) seismic event. A pipe fragility analysis was conducted to estimate the repair rates for each pipeline based on assumed pipe materials and estimated PGD. Pipes were then categorized in terms of the priority for seismic retrofits.

Recommendations were provided for both updates to the District Design Standards and for capital improvements. District Design Standards should be updated to require fully-restrained ductile iron pipe for all backbone pipelines, with the use of seismic joints evaluated for backbone pipelines in areas anticipated to experience over one foot of PGD. Non-backbone pipe in areas with PGD greater than 1 foot shall also be replaced with fully restrained ductile iron pipe. Recommended improvements included establishing emergency interties with CRW and the City of Milwaukie and extending the backbone system to the intertie locations, a seismic study of the existing 24-inch water supply pipeline, and replacement of all medium- and low-priority pipe over the next 50 years. Portions of the seismically fragile pipe overlap with pipes identified for either fire flow or condition-based improvements and will be replaced as part of the CIP.

1.7 Water Quality

Drinking water regulations established by the United States (U.S.) Environmental Protection Agency (EPA) and enforced in Oregon by OHA were reviewed to determine both the compliance levels and required sampling frequency. The District regularly complies with all necessary sampling and reporting. Sampling results, including the dates of each sampling event, are available to the public on the OHA website. OLWSD sampling results indicate compliance with all water quality regulations.

1.8 Capital Improvement Program

Projects identified to address level of service deficiencies, condition-based rehabilitation and replacement projects, and seismic risk mitigations are scheduled as part of a recommended CIP. Cost estimates were developed for individual projects in conformance with the Class 4 Conceptual Report Classification of Opinion of Probable Construction Costs as developed by the Association for the Advancement of Cost Engineering (AACE International). Opinions of probable construction costs for all eligible capacity increasing costs were used to calculate a recommendation for an updated system development charge (SDC). Projects were scheduled and prioritized based on District input, anticipated end of useful life, coordination with Clackamas County road projects, and other prioritization criteria. A summary of the recommend capital improvement projects, including the opinion of probable construction costs, is provided in Table 1-2.

To implement the CIP, the District will need to spend approximately $1.5M on average each year to fund capital improvement projects. In the fiscal year (FY) 2021 budget, the District adopted a capital improvement budget of $1.2M with a 0.55 percent increase to water rates. With a remaining balance of nearly $4M in the water capital improvement fund, it appears that the District may need to raise rates to generate enough revenue to meet the recommendations contained within this document over the next 20 years. The District will consider various rate and financing options to fund the recommended capital improvement program. Several grant programs exist to help water agencies with seismic resiliency projects and should be explored by the District. Based on an analysis by the FCS Group, the maximum defensible SDC per ¾-inch meter equivalent is $10,608.

Table 1-2. Capital Improvement Program Summary

Project ID	Description	Pipe Length (feet)	Diameter (Inches)	Project Total (2020 Dollars)
Engineering/Planning Studies (E)				***$900,000***
E-1	AWIA Risk and Resilience Assessment and Updates (every 5 years)	-	-	$300,000
E-2	Water System Master Plan Update (every 5 years)	-	-	$600,000
Fire Flow Improvement (F) Projects				***$20,464,000***
F-1	28th Avenue, Lakewood Drive, Kellogg Lake Apartments	4,015	8 & 12	$1,156,000
F-2	River Road	6,805	8 & 12	$3,297,000
F-3	Vista Sunrise Court	400	8	$122,000
F-4	Jennings, Colina Vista, Clayson Avenues, Emerald Drive, Colony Circle	4,415	8	$1,514,000
F-5	Alderway Avenue	1,070	8	$338,000
F-6	View Acres Road	2,130	8	$553,000
F7-F37	Increase pipeline diameters to meet fire flow criteria	42,475	8 & 12	$13,484,000
Condition (C) Projects				***$6,715,000***
C-1	Aldercrest Road	3,025	8	$925,000
C-2	Ranstad and Cinderella Courts	300	6	$79,000
C-3	Marcia Court	475	6	$128,000
C-4	Lisa Lane	760	6	$225,000
C-5	Oatfield Road	15,995	8	$3,278,000
C-6	Round Oaks Court	345	4	$58,000
C-7	Seal Coat Concrete Dome on Valley View Reservoirs	-	-	$70,000
C-8	Recoat Exterior of View Acres Tanks	-	-	$400,000
C-9	Replace Equipment and Refurbish Valley View Pump Station	-	-	$380,000
C-10	Replace Equipment and Refurbish View Acres Pump Station	-	-	$250,000
C-11	Upgrade SCADA System	-	-	$32,000
C-12	Radio Telemetry Activation Study	-	-	$24,000
C-13	Rebuild Pressure Reducing Valves (every 5 years)	-	-	$100,000
C-14	Large Meter Testing and Replacement	-	-	$337,000
C-15	Vault Meter Bypass Installations	-	-	$110,000
C-16	Replace All 4 ¼-inch Fire Hydrants	-	-	$319,000
Resiliency (R) Projects				***$3,250,000***
R-1	Intertie Pump Station with Clackamas River Water	-	-	$1,250,000
R-2	Intertie Pump Station with City of Milwaukie	-	-	$1,800,000
R-3	Seismic Study of 24-inch supply pipeline	-	-	$200,000
			CIP Total	**$31,329,000**

Notes: Project costs rounded up to nearest $1,000 and based on ENR 20-City Average CCI of 11392 for January 2020.

CHAPTER 2

Introduction

Oak Lodge Water Services District (OLWSD or District) provides water services to the Oak Grove and Jennings Lodge areas of unincorporated Clackamas County, as well as small areas within adjacent agency service areas. This Water System Master Plan (WSMP) Update guides planned capital project expenditures and asset management for its water system in an efficient and cost-effective manner.

2.1 Purpose

IN THIS SECTION

Purpose

Authorization

The following report is provided as an update to the OLWSD WSMP. The WSMP was last updated in 2008 and 2000, when the water system was managed by the Oak Lodge Water District. On January 1, 2017, OLWD and the Oak Lodge Sanitary District combined into one single agency to more efficiently and cost-effectively deliver water, sanitary sewer, and surface water utility services to its respective service areas.

The purpose of the 2020 WSMP Update is to refresh the previous plan for the District's capital project expenditures and asset management to meet anticipated capacity, water quality, and emergency supply goals in a financially sustainable manner. To achieve the stated purpose, the 2020 WSMP Update has been developed with the following goals:

- Satisfy the Oregon Health Authority (OHA) Drinking Water Services (DWS) water master plan requirements as outlined in Oregon Administrative Rule (OAR) 333-61-060,
- Define level of service goals for the water system,
- Determine population and demand projections through 2037,
- Develop an accurate hydraulic model of the distribution system,

- Identify existing and future system capacity deficiencies through 2037,
- Evaluate level of service and identify deficiencies,
- Identify a long-term renewal strategy for the aging assets within the water system,
- Conduct a seismic risk assessment on the existing water system,
- Prepare a seismic mitigation plan to be completed over the next 50 years,
- Develop a Capital Improvement Program (CIP) for pipelines, pump stations, and reservoirs through 2040,
- Identify financing strategy options for the District to fund the CIP through 2040.

2.2 Authorization

OLWSD has contracted Water Systems Consulting, Inc. (WSC) to complete the update to the Water System Master Plan, as described in the Engineering Services Agreement with OLWSD for the 2018 Water Master Plan, executed on March 23, 2018. WSC has partnered with Barney and Worth to assist in defining level of service goals, McMillen Jacobs to assist in preparing a seismic risk assessment and mitigation plan, and the FCS Group to assist in conducting a system development charge (SDC) analysis.

CHAPTER 3

Existing System

The OLWSD water system is comprised of 105 miles of distribution pipeline, three booster pump stations, and four storage reservoirs. The system contains three pressure zones, and water is supplied to the District through a 24-inch supply pipeline that connects to the North Clackamas County Water Commission transmission mains and water treatment plant.

3.1 Water System Area

The OLWSD provides water to approximately 28,000 residents and commercial customers in unincorporated western Clackamas County (Oregon Metro, 2018). The District service area covers more than 6.4 square miles, comprising the communities of Oak Grove and Jennings Lodge, and small portions of the City of Milwaukie, the City of Gladstone, and Clackamas River Water. The service area is located entirely within Metro's Urban Growth Boundary for the Portland regional area. OLWSD is bordered by the City of Milwaukie to the north, Clackamas River Water service area to the east, the City of Gladstone to the south, and the Willamette River to the west. The District service area and boundary are shown in Figure 3-1.

3.2 Existing Supply and Distribution Interconnections

Each of the normal and emergency supplies and interconnections are described in the sections below. The District has an agreement with partner agencies within the North Clackamas County Water Commission (NCCWC) for receiving normal and emergency supply. The District also has several agreements to supply water to neighboring agencies. Several interconnections provide the District with the ability to wheel water through its transmission and distribution infrastructure to more efficiently supply higher elevation customers in neighboring service areas.

IN THIS SECTION

Water System Area
Existing Supply & Distribution Interconnections
Pressure Zones
Storage
Booster Pump Stations
Distribution & Transmission Mains
Pressure Reducing Valve Stations
Supervisory Control and Data Acquisition

Figure 3-1. OLWSD Service Area Boundary and Location Map

3.2.1 Water Supply

The OLWSD distribution system is primarily supplied by the NCCWC Water Treatment Plant (WTP). The District also periodically receives water from both Clackamas River Water (CRW) and the South Fork Water Board (SFWB), both of which operate WTPs on the Clackamas River, due to interconnections and agreements that rely on shared infrastructure. Each of the potential sources for water supply are described in detail below. An overview of the shared water supply infrastructure is provided in Figure 3-2.

3.2.1.1 North Clackamas County Water Commission

The NCCWC is a partnership of three water agencies; OLWSD, Sunrise Water Authority (Sunrise), and the City of Gladstone. Through the NCCWC partnership, the three agencies share ownership of the Allen F. Herr Water Treatment Facility (NCCWC WTP) which treats water from the Clackamas River. The facility began production in August 1999 with a 10 million gallon per day (MGD) capacity slow sand filtration plant. In July 2005, low pressure submerged membranes were added to increase peak hour design capacity by 10 MGD to a total of 20 MGD. The actual capacity of the NCCWC WTP varies based on operational conditions. As described in the Amended and Restated Intergovernmental Agreement for the NCCWC, the allocation of water treatment plant capacity is at any time: 42% to Oak Lodge, 48% to Sunrise, and 10% to City of Gladstone. The District and the City of Gladstone receive all of their normal supply from NCCWC, while Sunrise supplements their supply with other sources. As a condition for joining the NCCWC, the District turned over its water rights to Clackamas River surface supply to the NCCWC. The District no longer holds any water rights of its own and therefore has access to surface water supply through the water rights held by the NCCWC.

3.2.1.2 Clackamas River Water

CRW is a domestic water supply district that serves customers in Clackamas County. In addition to providing retail water service within its boundaries, CRW provides wholesale water to Sunrise, as well as the City of Milwaukie. The CRW treatment plant utilizes conventional coagulation, flocculation, and filtration to treat water from the Clackamas River.

The District received its primary water supply from CRW from 1966 until 1999 when the NCCWC WTP began production. The District still owns a water pump station at the CRW WTP that is connected to the NCCWC transmission main, which connects to the existing 24-inch diameter water transmission main from the NCCWC to the Valley View Reservoirs. Currently OLWSD leases the pump station to Sunrise. Sunrise has an intergovernmental agreement to purchase a minimum of 122 million cubic feet each calendar year (approximately 2.5 MGD) from CRW and uses the pump station to convey water to its distribution system at the Mather Road pump station (PS). Because the water from the CRW WTP is conveyed through a portion of the District's 24-inch diameter water transmission main, treated water from the CRW WTP could enter OLWSD's distribution system and thus CRW continues to be listed as a permanent water source under the State of Oregon's Drinking Water Program.

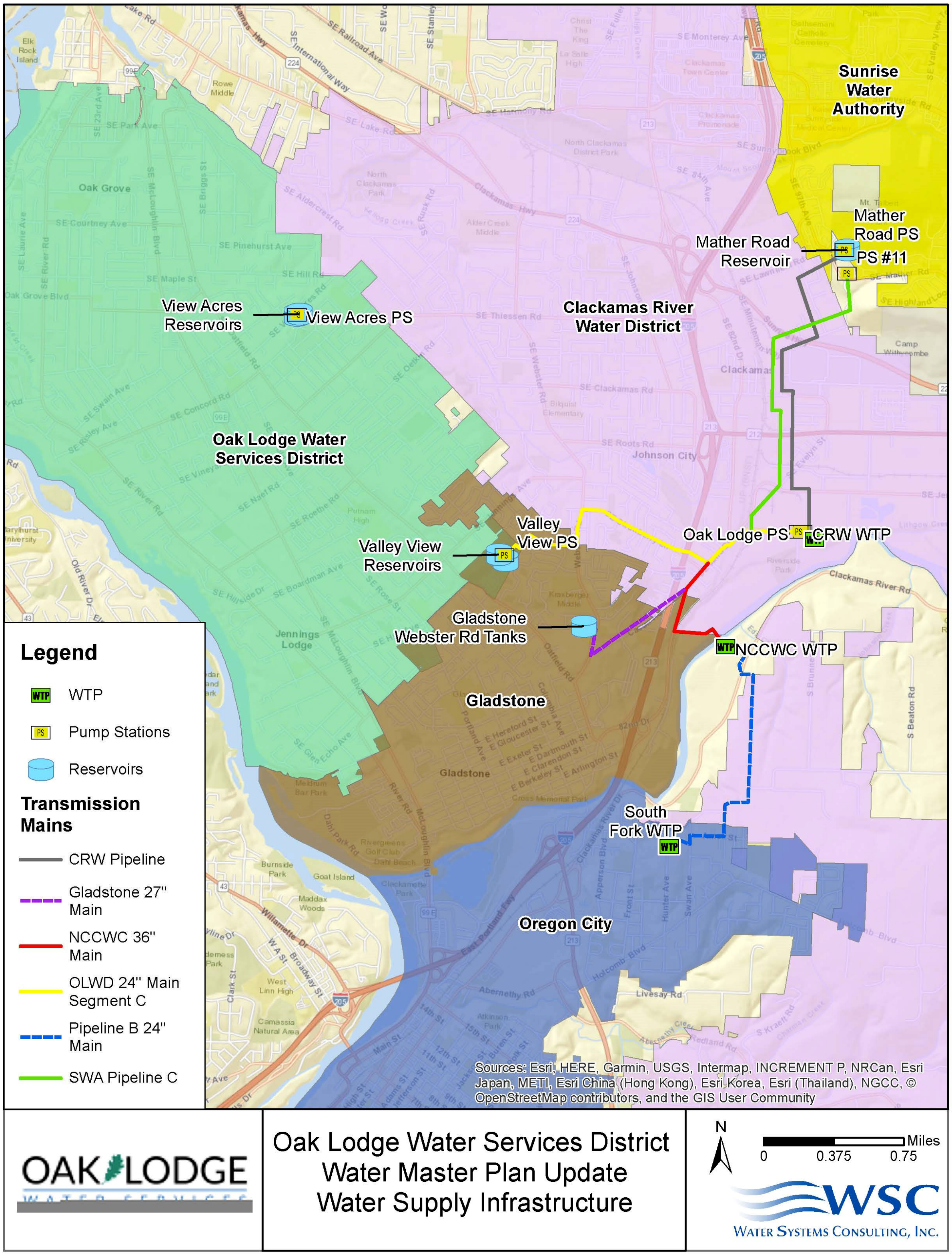

Figure 3-2. Water Supply Infrastructure

CRW is able to supply water to OLWSD during an emergency utilizing the existing OLWSD pump station. The capacity of the pump station is 10 MGD, but the ability to purchase that much water is dependent on CRW's supply availability at the time.

CRW also has an agreement with the NCCWC to provide service to customers that are connected directly to the 24-inch diameter water supply pipeline that delivers treated water to the Valley View Reservoirs.

3.2.1.3 South Fork Water Board

SFWB is a wholesale water provider to the cities of Oregon City and West Linn and to the CRW service area. The SFWB WTP is connected to the NCCWC WTP by a 24-inch pipeline designated Pipeline B, which was constructed in 2002. The SFWB WTP utilizes conventional flocculation, sedimentation, and filtration processes for treating water from the Clackamas River.

SFWB and NCCWC have a wholesale water agreement allowing NCCWC to purchase up to 12 MGD from SFWB during the wet weather months between October to April, when there is surplus capacity. During the remainder of the year, NCCWC may purchase SFWB surplus as available. SFWB may also purchase water from NCCWC. Water from the SFWB will enter the NCCWC transmission pipeline during periodic flushing of Pipeline B to prevent water age issues, and during any NCCWC plant shutdown for maintenance. SWA also regularly purchases supply from SFWB which is transferred through the shared NCCWC and District transmission lines.

3.2.2 Distribution Interconnections

The District maintains several distribution system interconnections that allow water to be transferred to neighboring service areas. The OLWSD distribution interconnections provide treated water to higher elevation areas within adjacent service areas that cannot be supplied as efficiently from within their own service area. CRW and the City of Gladstone purchase water from the District through several distribution interconnections to serve higher elevation customers. Due to the difference in hydraulic gradients, all distribution interconnections are only available to export water out of the District's distribution system. Pump stations, either temporary or permanent, would be necessary to use these interconnections to provide an emergency supply to the District from the CRW or Gladstone distribution systems. A map of the District's distribution system and locations of one-way interconnections is provided as Figure 3-3.

Clackamas River Water: The District maintains three separate interconnections with CRW along the eastern boundary of the service area to provide supply to CRW customers located above 190 feet in elevation. The three connections (at Valley View Road and Jennings Street, Hill Road and Thiessen Street, and Minerva Lane and Oetkin Street) provide service to approximately 237 CRW customers. Approximately 17 of these customers are physically located within the District's service area and could be switched over to the District. Additionally, there are approximately 78 District customers that are located within CRW service area and could be switched to CRW although they would continue to receive water from the District. Water delivery to customers within the CRW service area is tracked through individual customer billing meters and not through a master meter at the interconnection.

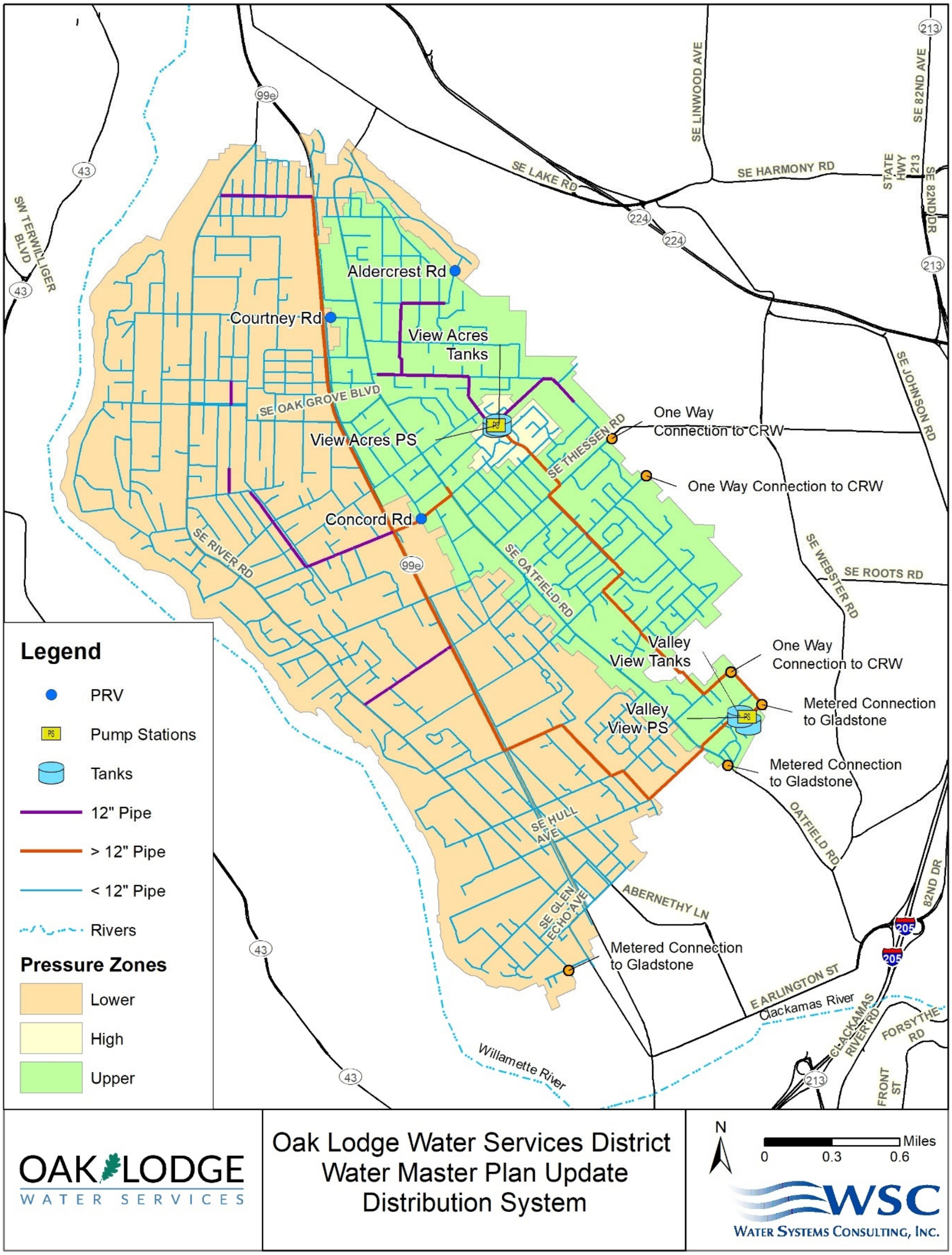

Figure 3-3. Oak Lodge Water Distribution System

City of Gladstone*:* The District has three unidirectional interties that can be used to sell water to the City of Gladstone. Although Gladstone has a dedicated 27-inch diameter supply pipeline that connects the Webster Road Reservoir to the NCCWC's 36-inch diameter supply transmission line, there is no direct connection to the District's 24-inch diameter supply transmission line. The District occasionally provides peak and emergency supply to the City through the interconnections in the distribution system to supply the higher elevations portion of the City's system. Due to the hydraulic grade line, the City cannot provide water to the District unless portable pumps are used. The three interconnections include a 10-inch connection at the Valley View pump station site, a 6-inch connection at Caldwell Street and Oatfield Road, and a 6-inch connection at Rinearson Road.

Sunrise Water Authority*:* There are no direct connections between the Sunrise and District distribution systems downstream of the master meters (located at Valley View Reservoirs) that record supply entering the District's distribution system. However, Sunrise does utilize a connection to the District's Valley View Reservoirs and transmission system to better serve portions of their distribution system.

3.3 Pressure Zones

The District water service area is comprised of three pressure zones, each of which is described below:

Lower Zone: The Lower Zone is the largest pressure zone in the distribution system and makes up most of the western portion of the service area. The Lower Zone is fed by gravity flow from the Valley View Reservoirs. A 24-inch magnetic flow meter measures the flow that enters the Lower Zone and serves as one of the two "master meters" that are used to record the water supply to the District. The lower zone can also be fed by three pressure reducing valve stations (PRVs) that are connected to the Upper Zone.

Upper Zone: The Upper Zone makes up most of the eastern portion of the service area and is fed by the Valley View Pump Station which pumps out of the Valley View Reservoirs. The Valley View Pump Station conveys treated water through a 16-inch diameter transmission main to the View Acres Reservoirs, which then feed the Upper Zone via gravity. A 16-inch diameter magnetic flow meter measures the discharge to the Upper Zone and serves as one of the two "master meters" that are used to record water supply to the District.

High-level Zone: The High-level Zone is the smallest pressure zone and is a closed-loop system fed by the View Acres pump station. This zone does not have gravity storage supply and is surrounded by the Upper Zone.

A hydraulic profile of the distribution system, including each of the reservoirs, pump stations, and PRVs is provided in Figure 3-4. The geographic delineations of each of the three pressure zones, pump stations, storage reservoirs, and PRVs are provided in Figure 3-5.

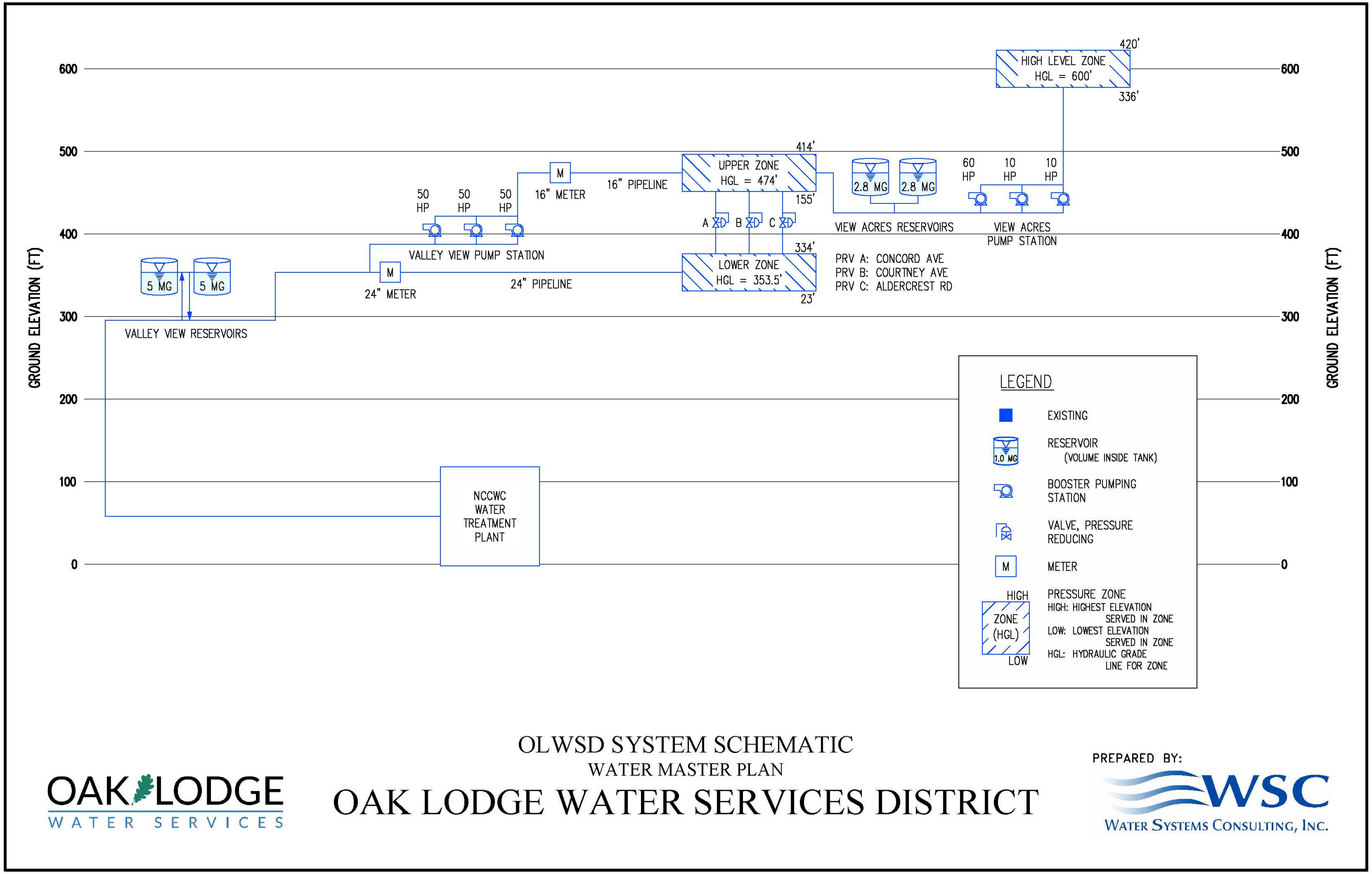

Figure 3-4. Oak Lodge System Schematic

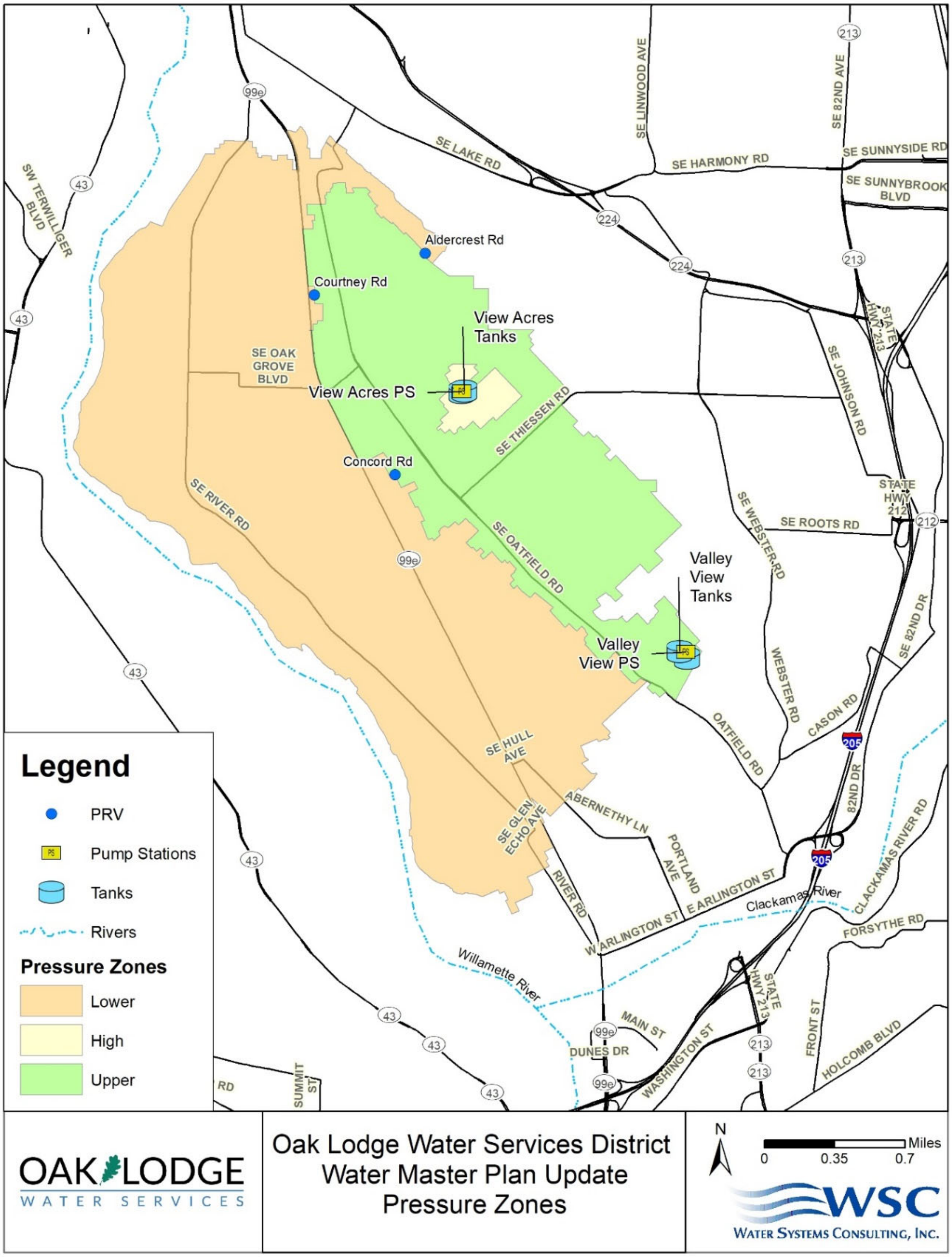

Figure 3-5. Oak Lodge System Pressure Zones

3.4 Storage

The District distribution system has four storage reservoirs at two sites that provide operational, emergency, and fire flow storage for the distribution system. The total storage capacity is 15.6 million gallons (MG). Each of the two reservoir locations include two identical reservoirs that provide gravity storage for each of the respective zones and are adjacent to pump stations that supply the higher elevation zones. Table 3-1 summarizes the storage reservoir characteristics based on the best available data including the 2008 WMP.

In April 2012, a Seismic Vulnerability Report was completed to assess the structural and mechanical integrity of the District's four reservoirs. Based on the findings and recommendations of the report, the View Acres Reservoirs underwent a seismic retrofit in 2013 as well as an upgrade to various site and mechanical components. Improvements were made to the Valley View Reservoirs in 2017 which included upgrades to the reservoirs exterior and interior access, mechanical fittings and valves, drainage and improvements to the valve vault (RH2, 2012). Both View Acres Reservoirs are circular steel tanks and have cathodic protection, while the Valley View Reservoirs are circular prestressed concrete.

Each reservoir is visually inspected every six to eight months. Due to the redundant tanks at each reservoir site, the District is able to drain one tank at a time to allow for detailed inspections and recoating of the tank interior approximately every ten years.

Table 3-1. Storage Summary

Reservoir Name	Zone Served by Gravity	Zone Served by Pump Station	Type	Year Built	Ground Elevation (feet)	Overflow Elevation (feet)	Diameter (feet)	Height (feet)	Capacity (MG)
View Acres 1	Upper	High-level	Circular Steel	1965	400	474	80.5	74	2.8
View Acres 2	Upper	High-level	Circular Steel	1989	400	474	80.5	74	2.8
Valley View 1	Lower	View Acres Reservoirs	Circular Prestressed Concrete	1966	320	353.5	161	33.5	5.0
Valley View 2	Lower	View Acres Reservoirs	Circular Prestressed Concrete	1989	320	353.5	161	33.5	5.0

MG = million gallons

3.5 Booster Pump Stations

The District distribution system contains two booster pump stations (BPS). The Valley View BPS pumps water from the Lower Zone to the View Acres Reservoirs in the Upper Zone. The View Acres BPS supplies water from the View Acres Reservoirs to the High-level Zone around the reservoirs. The High-level Zone does not contain storage and relies solely on the View Acres BPS for adequate supply and pressure. The View Acres BPS includes a fire pump for emergency supply since reservoir storage is not available in the High-level Zone.

Both booster pump stations have been upgraded and are equipped with emergency generators with sufficient capacities to operate the pumps, including the fire pump at View Acres BPS. Each BPS is inspected one to two times every month and maintenance is performed as needed.

The Valley View BPS operates based on the View Acres reservoir levels. The View Acres BPS operates on pressure settings for the High-level zone. The settings are used to maintain adequate supply and pressure in the system. Table 3-2 provides a summary of the booster station information, pump specifications, and respective associated infrastructure. Table 3-2 also includes the finished water pump station at the NCCWC WTP, which is owned and operated by the NCCWC, due to its impact on operation of the OLWSD system. The CRW WTP pump station is included because it is owned by OLWSD, although it is leased and operated by Sunrise.

Table 3-2. Booster Pump Station Summary

Booster Pump Station	Number & Type of Pumps	Design Capacity[1] (gpm)	Design Total Dynamic Head[1] (feet)	Motor Size (HP)	Firm Capacity	Year Built or Latest Rehab.	Zone Pumping From/To	Associated Infrastructure
Valley View	3 Vertical Turbine Pumps	1,100	155 ft	3 x 50	2,200 gpm	Built in 1966. Rehabilitated in 2008 including replacement of pumps	Lower Zone/ Upper Zone	Valley View Reservoirs
View Acres	2 VFD Pumps 1 Fire Pump	200 gpm 1,650 gpm	110 ft 100 ft	2 x 10 (VFD) 1 x 60	200 gpm	Built in 1965 Rehabilitated in 2005 including replacement of pumps	Upper Zone/ High-level Zone	View Acres Reservoirs
NCCWC Finished Water[2]	5 Pumps			3 x 500 1 x 200 1 x 400	20 MGD	Built in 1998	NCCWC WTP/ Lower Zone	Valley View Reservoirs
CRW Pump Station[3]	3 Pumps	3,100 gpm 5,200 gpm 6,600 gpm		2 x 100 1 x 150	5,200 gpm	Rehabilitated in 1985	CRW WTP/ Valley View Reservoirs (SWA)	Valley View Reservoirs

gpm = gallons per minute; HP = horsepower; VFD = variable frequency drive; MGD = million gallons per day

[1] Design capacity and total dynamic head vary based on pump configuration that is being utilized. Some stations do not provide operational variability.

[2] NCCWC finished water pumps are owned and operated by NCCWC and provide water to the OLWSD distribution system via the 24-inch transmission main.

[3] CRW Pump Station is owned by OLWSD but leased and operated by Sunrise. This pump station pumps water from the CRW WTP to the Sunrise distribution system. The Sunrise distribution system includes usage of some of OLWSDs transmission system, including the Valley View Reservoirs for operational storage.

3.6 Distribution and Transmission Mains

The District distribution system consists of about 105 miles of distribution and transmission mains. Transmission mains are generally mains that are 12-inches or greater and transport larger amounts of flow through the system, while distribution mains are pipes 8-inches or less in diameter that deliver flow to service connections. The District's geographic information system (GIS) database is updated by the District on an on-going basis and includes information on pipe material, diameter, and installation year, although this information is not complete for the entire distribution system. The system is predominately located within public rights-of-way, giving OLWSD access for repairs and maintenance. The District has been in the process of upgrading all 2-inch diameter lines in the system to 6-inch or greater and there are few 2-inch lines remaining. The District has also been in the process of upsizing 4-inch hydrant laterals. Blow offs were added to all dead-end mains in 2008.

The distribution system is maintained with an annual unidirectional flushing program, alternating zones each year. Leak detection is performed annually on portions of the distribution system.

A summary of lengths of water main diameters in the District's system is presented in Table 3-3. Additional information on pipeline materials and age is provided in Chapter 7.

Table 3-3. Distribution System Main Diameter Summary

Diameter	Total[1] (miles)
2"	1.1
3"	0.1
4"	5.2
6"	67.5
8"	17.6
10"	1.0
12"	3.6
16"	4.2
18"	0.1
24"	4.4
Total (miles)	104.8

[1] Data is based on the District geographic information system data as of October 2018

3.7 Pressure Reducing Valve Stations

The District has three PRV stations that connect the Upper Zone to the Lower Zone. PRVs are used to regulate system pressures and to augment the lower level system in a fire flow demand event. PRV stations are tested and rebuilt every five years. PRV settings are currently maintained by a District contractor and provided in Table 3-4.

Table 3-4. Pressure Reducing Valve Station Summary

Service Level	PRV Location	Size (inches)	Downstream Setting[1] (psi)
Upper to Lower Zone	SE Fernridge & Willamette (Aldercrest PRV)	8	55
	SE Concord Ave	6	50
	SE Courtney Ave	6	50

PRV = pressure reducing valve; psi = pounds per square inch

[1] Downstream pressure settings provided by District contractor.

3.8 Supervisory Control and Data Acquisition

The OLWSD system is monitored and controlled by a central SCADA system. The SCADA system allows OLWSD to monitor and control its reservoirs, pump stations, and supply meters. NCCWC is able to monitor the OLWSD system to regulate the NCCWC WTP production. Further discussion of the condition and status of the existing SCADA system is provided in Chapter 7. The SCADA system for the District's water facilities was installed prior to the District merger and is not integrated with the wastewater collection and treatment plant SCADA system.

CHAPTER 4

Evaluation Criteria

This section summarizes the desired performance criteria for the water distribution system that was used to analyze the system and identify recommended improvements. Performance criteria were developed from Oregon Drinking Water Rules, District Standards, Clackamas County Fire Code, the District's preferences and engineering judgement. A Level of Service workshop was conducted with OLWSD staff to discuss desired goals and criteria under normal and emergency operational scenarios. The evaluation criteria are organized into three categories; distribution, storage, and booster pump stations. The specific criteria included in each category are described in the following sections.

4.1 Distribution System

Pipeline capacity within the distribution system is typically evaluated based on system pressures during various demand scenarios. Most commonly, the adequacy of distribution piping sizes will be determined during fire flow scenarios, which vary for different types of construction. The pressure criteria that will be used to evaluate the distribution pipeline, which were the same criteria used in the 2008 WSMP, are summarized in Table 4-1.

IN THIS SECTION

Distribution Criteria

Storage Criteria

Booster Pump Station Criteria

Table 4-1. Water System Planning and Evaluation Criteria: Distribution

Purpose	Regulation or Reference	Engineering and Planning Criteria	
System Pressure	District Preference	35 psi minimum at Peak Hour Demand	
	Oregon Health Authority	20 psi minimum residual at MDD plus FF	
Fire Flows	Oregon Fire Code (Appendix B) and Clackamas Fire District #1	Residential[1]	1,500 gpm for 2 hours
		Commercial, Mixed-Use, Offices, Schools	3,500 gpm for 3 hours
		Industrial	5,000 gpm for 4 hours
		The distribution system analysis assumes only one fire will occur within the system at a time.	
New Distribution Mains	District Preference	All new water mains must be 8-inch or greater[2]	

MDD = maximum day demand; FF = fire flow; gpm = gallons per minutes; psi = pounds per square inch

[1] For single-family residential areas that are at the end of a dead-end main with a single hydrant, the fire flow criteria was evaluated at 1,000 gpm for 1 hour.

[2] Unless otherwise approved by District Engineer for special cases including dead-end mains beyond the hydrant where no expansion is anticipated.

4.2 Storage Facilities

A distribution system's storage facilities provide operational, fire flow and emergency storage. This section describes the criteria used to evaluate the District's storage facilities. Evaluation criteria for water storage within the OLWSD distribution system are provided in Table 4-2.

4.2.1 Operational Storage

Operational storage is the volume of water needed to equalize the daily supply and demand. Operational storage is used to meet diurnal peaks that occur in excess of the maximum day demands (MDD) and allows pumps to cycle off during the day and fill reservoirs during the night. Operational storage should be sized appropriately to allow adequate turnover that limits water age and maintains disinfectant residuals.

4.2.2 Fire Storage

Fire storage is the volume in the reservoir used in a fire event. The required fire storage is determined by multiplying the required maximum fire flow (FF) rate in gallons per minute for the service area by the required duration. It is assumed that only one fire will occur in a pressure zone at a time. The fire flow rates and duration requirements are set by the Clackamas Fire District #1 in accordance with Oregon Fire Code Appendix B.

4.2.3 Emergency Storage

Emergency storage is water that is available for use by water system customers in the event of a long-term disruption of water supply. Emergency scenarios may include pipeline failures, equipment failures, power outages, pumping system failures, water treatment plant failures, raw water contamination, or natural disasters. The quantity of emergency storage is determined based on the required water system dependability, risk acceptance, and water quality in storage reservoirs. Oversized reservoirs can potentially have a negative impact on stored water quality.

Table 4-2. Water System Planning and Evaluation Criteria: Storage

Purpose	Regulation or Reference	Engineering and Planning Criteria
Operational Storage[1]	District's Preference	0.25 x MDD of the area served by each reservoir
Fire Flow Storage	Oregon Fire Code (Appendix B) and Clackamas Fire District #1	Sufficient storage is required to provide the fire flows for each zone listed in Table 3-1
Emergency Storage[2]	District's Preference	2 x ADD of the area served by each reservoir
MDD = maximum day demand; ADD = average day demand		

[1] Operational Storage does not consider storage requirements in the Valley View Reservoirs to meet the operational requirements of the District's shared transmission system.

[2] Emergency Storage is in addition to fire flow storage to provide water in case of a pipeline failure, equipment failure, source contamination, power outage, or natural disaster.

4.3 Booster Pump Stations

Boosted zones with storage reservoirs capable of supplying fire flow and peak hour demands, must include booster station facilities with firm capacity to supply maximum day demand. For zones without gravity storage, booster stations should have a firm capacity to supply maximum day demand plus fire flow or peak hour demands, whichever is greater. Firm capacity is defined as the booster pump station capacity with the largest pump turned off. Dedicated emergency supply pumps, such as the View Acres fire pump are included in evaluating sufficient capacity. Evaluation criteria for pump stations within the District's distribution system are provided in Table 4-3.

Table 4-3. Water System Planning and Evaluation Criteria: Booster Pumps

Purpose	Regulation or Reference	Engineering and Planning Criteria
Capacity for Zone with Storage	Accepted Engineering Practices	Firm capacity must supply MDD to service zone Firm capacity of lower elevation pressure zone pumps must also deliver the MDD of all higher elevation pressure zones they supply.
Capacity for Zone without Storage	Accepted Engineering Practices	Firm capacity, including dedicated fire pumps, must supply MDD plus FF or PHD, whichever is greater, to service zone.
Emergency Power	Recommended Standards for Water Works[1] and District's Preference	Emergency power must be sufficient to meet system ADD or fire flow demands, whichever is greater.
MDD = maximum day demand; FF = fire flow; PHD = peak hour demand; ADD = average day demand		

[1] Recommended Standards for Water Works (Ten State Standards). Water Supply Committee of the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. Albany: Health Research, Inc., 2007.

CHAPTER 5

Demand, Supply and Storage Analysis

To evaluate the sufficiency of the District's water supply and existing system storage over the planning period, the historic and current demand must be determined and used as the basis for projections of future demand. This section provides a description of both current demands and future projections and uses the calculated demands to analyze the District's existing supply and storage capacity to determine if any current of future deficiencies exist.

5.1 Definitions

For the purposes of this WSMP, the following defined terms are used:

- **Consumption:** The amount of billed metered water consumed by customers. OLWSD provided annual deliveries data by customer for 2013-2017.
- **Production:** The amount of water produced from OLWSD's supply sources and put into the distribution system based on metered flows entering the District's distribution system. OLWSD provided monthly production data from 2014-2017 by supply source and daily production data from 2013-2017.
- **Non-revenue Water (NRW):** The amount of water losses making up the difference between production and consumption.
- **Demand:** The amount of water distributed through the water system calculated based on consumption and production. Demand takes into account NRW.

IN THIS SECTION

Historic & Projected Demands

Demand Peaking Factors

System Supply Analysis

BPS Capacity Analysis

System Storage Requirements

Supply and Storage Recommendations

5.2 Historic and Projected Water Demands

To evaluate the District's water distribution system, the location and quantities of water demands must be known and modeled. Water consumption records only include billed metered water consumption and do not include any NRW. NRW can also be referred to as water loss, either physically from leaking pipes, pipe flushing, overflows at facilities, or as apparent losses resulting from meter inaccuracies. To account for consumption and NRW, water demand is calculated based on water consumption and water production data. The production of all water was divided by the consumption to create a scaling factor. The scaling factor was then applied to consumption data to normalize the water consumption records to better model the total demand distributed through the District's water system.

Historical consumption, production, NRW, population and per capita demand in gallons per capita per day (GPCD) were analyzed to determine baseline and projected demands as shown in Table 5-1 and Figure 5-1. A baseline demand is representative of recent historic demand patterns that could be used to base future demand projections on. Baseline demand NRW was assumed to equal the average percentage from 2015-2017 and the baseline GPCD was assumed to equal the average from 2014-2017. Projected population was estimated using data within GIS software based on Oregon Metro Transportation Analysis Zone (TAZ) data. The District provided additional input on planned developments within the service area, but the resulting population increases were lower than those created from the Oregon Metro projections, so the TAZ data was used for projecting future demands. The projected population was applied to the baseline GPCD to yield estimated demands from 2022-2037. The Oregon Metro TAZ data predicts slow growth in the system over the next 20 years, thus projected water demands are also not expected to increase significantly through 2037.

Table 5-1. Historical and Projected Water Use

Year	Production (AFY)	Total Billed Consumption (AFY)	NRW (%)	Population	GPCD
2014	3,210	2,677	17%	27,401	105
2015	3,498	2,836	19%	27,505	114
2016	3,530	2,661	25%	27,610	114
2017	3,424	2,764	19%	27,715	110
Baseline Demand	3,435	2,705	21%	27,715	111
2022	3,501	2,757	21%	28,246	111
2027	3,568	2,810	21%	28,787	111
2032	3,602	2,837	21%	29,065	111
2037	3,637	2,864	21%	29,345	111
AFY = acre-feet per year; GPCD = gallons per capita per day					

Several limitations to the demand projections merit further discussion. Although a constant GPCD is used and is based on the best and most recently available data, the future GPCD will likely vary over time due to conservation programs, climate change, reductions in NRW, and modifications to land use. Future updates to the demand forecast should also update the GPCD with the best available data. As with future variations in GPCD, the effects on population growth and densification due to House Bill 2001 (HB2001) are also difficult to predict for the District. The effects of HB2001, which allows multi-family and auxiliary housing within areas currently zoned for single-family residential housing, are not yet clear and observed trends in development should be used to inform updated population projections within future WSMP updates.

The average NRW from 2015-2017 was 21 percent, a dramatic increase from the average of 8.9 percent calculated in the 2008 WSMP. Oregon Water Resources Department sets a goal for municipal water suppliers to keep NRW below ten percent. Operations has not observed or recorded substantial leaking pipes across the system during routine maintenance work, and the NRW percentage is alarming. Although the following sections of this chapter demonstrate that existing storage and pumping facilities provide adequate capacity to accommodate the increased NRW, the District understands the need to reduce the amount of NRW as soon as possible.

District staff are actively working to troubleshoot and diagnose a variety of possible causes for the high rate of NRW. District operations staff are checking pipelines and valves for potential leaks. Control valves at interconnections with adjacent agencies are being checked for proper functioning. The District is reviewing the billing process to ensure accurate billing records, which were used to calculate NRW. In 2019, the District replaced all residential meters which reduced meter inaccuracy, another potential source of NRW. Finally, the District is tracking and logging all maintenance activities and water loss events to account for water loss, so that the sources of NRW can be better understood. As sources of NRW are identified and mitigated, the percentage of NRW should be recalculated as data becomes available and used to reduce the projected future water demands across the District.

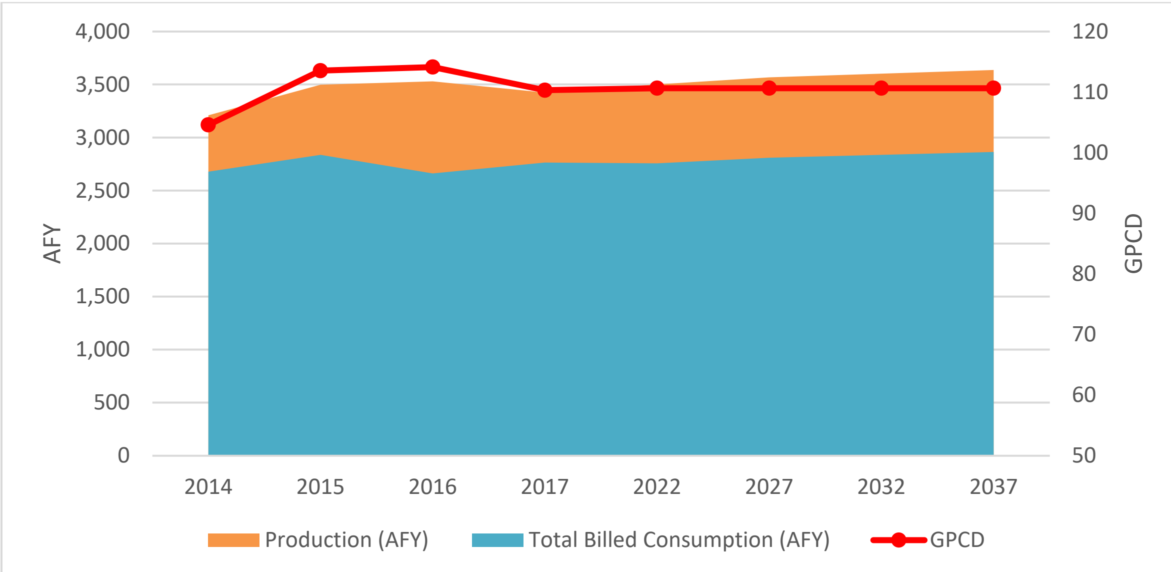

Figure 5-1. Historical and Projected Water Use

Spatially allocated demands were established based on District GIS data including historical annual water customer consumption and production records. The GIS data provided locations of small and large meters which were linked with customer billing records using account numbers, and addresses in some cases, to spatially allocate customers' water use. The spatial distribution of existing demands was then scaled to expected population growth rates. Projected demands in five-year increments from 2022-2037 were assigned to each existing customer location based on each customer's percentage of total water demand in 2017. An example of spatially allocated customer demand sized by water demand volume is shown in Figure 5-2 below.

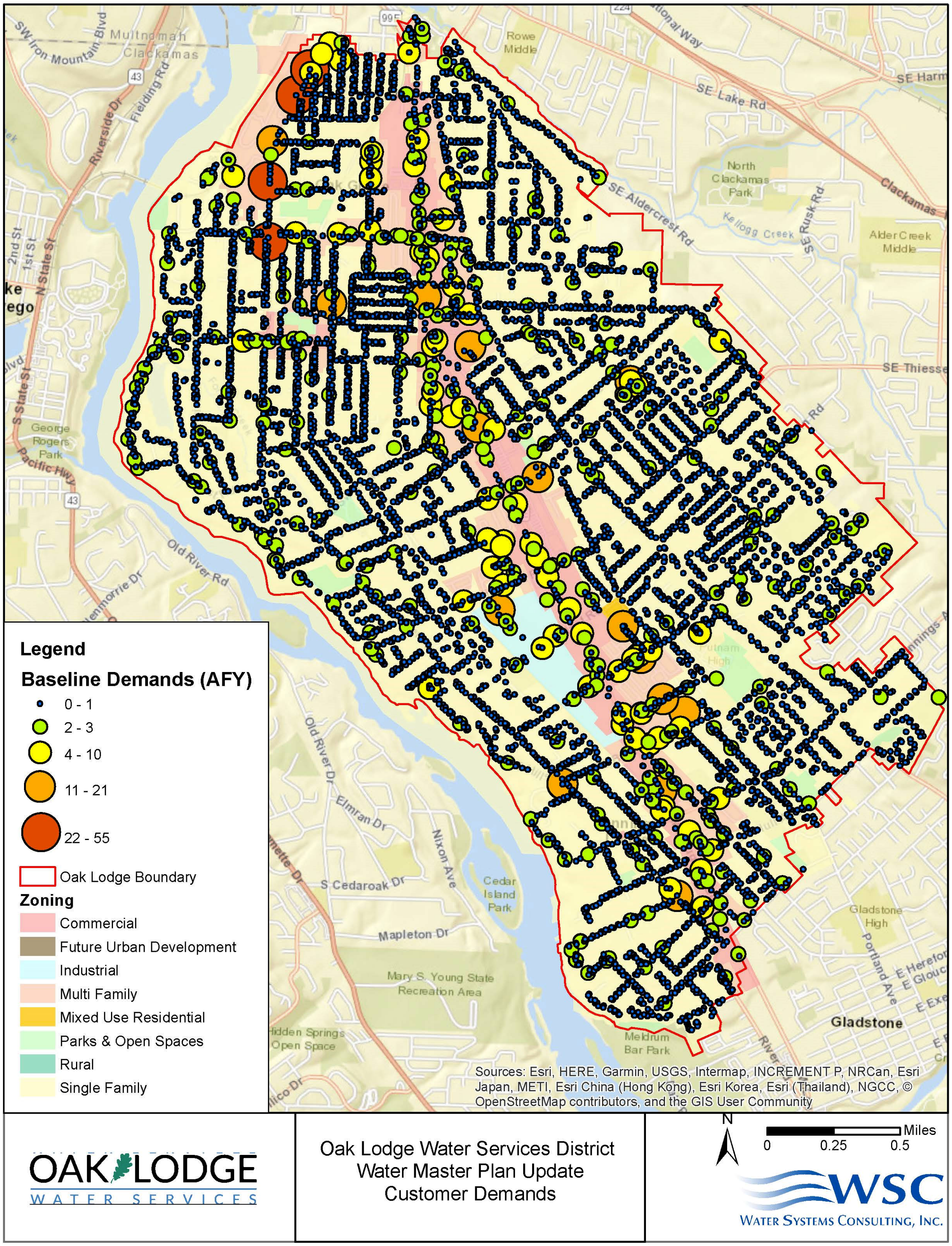

Figure 5-2. Spatially Allocated Demands

5.3 Peaking Factors

Monthly production data from 2014-2017 provided by the District was used to develop average monthly peaking factors, included in Table 5-2. Figure 5-3 depicts the monthly production from 2014 through 2017, with peak production occurring between July and August and significantly lower demands from November through April.

Table 5-2. Monthly Peaking Factors Developed from 2014-2017 Production Data

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
0.84	0.81	0.79	0.81	0.92	1.21	1.49	1.50	1.15	0.87	0.80	0.81

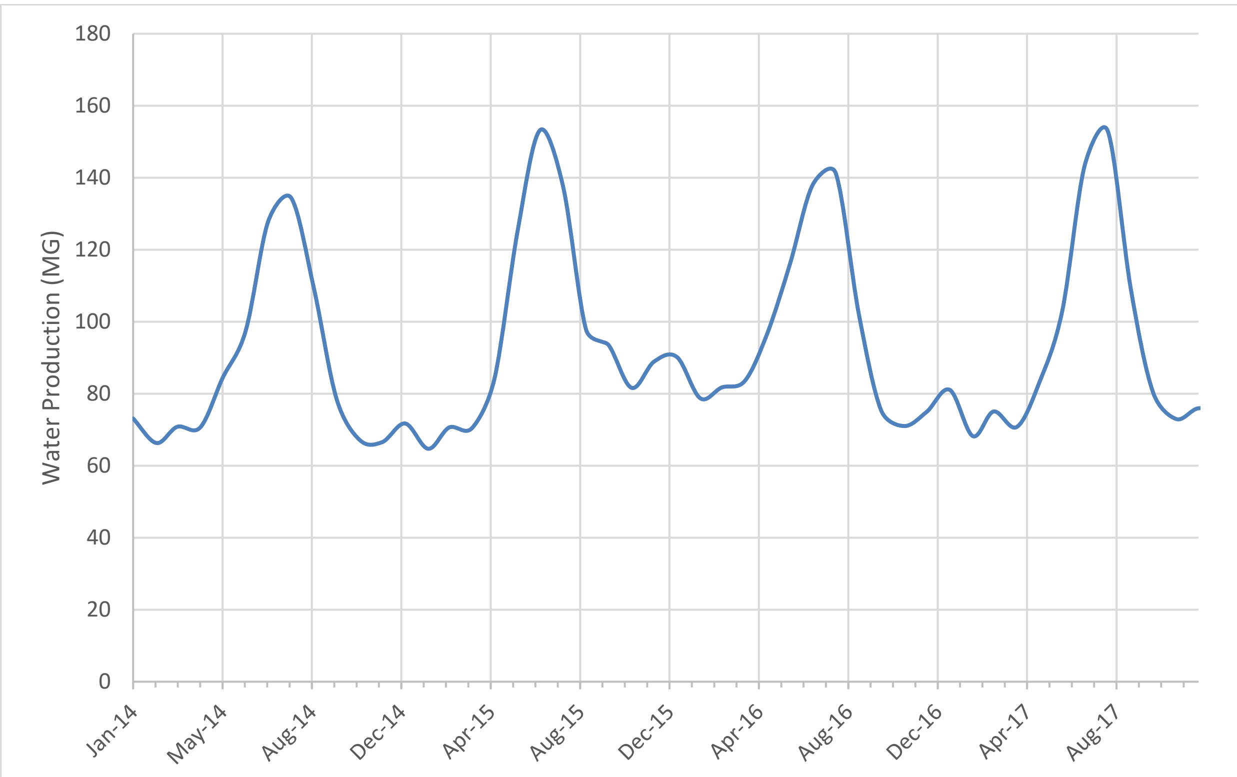

Figure 5-3. Historic Montly Water Production

Historic daily production data was also reviewed to develop daily and hourly peaking factors. The peaking factors were calculated using the 2014-2017 average daily production and peak productions. The MDD peaking factor was calculated using the maximum day production recorded from 2014-2017. Peak hour production was recorded during summer 2018 and used to develop a peak hour demand (PHD) peaking factor. Table 5-3 includes the historical average and peak productions used to develop the MDD and PHD peaking factors. Table 5-4 includes current and future demand values for each five-year planning period.

Table 5-3. Daily and Hourly Peaking Factors

Demand Condition	Demand[1] (MGD)	Calculated Peaking Factor[2]
Maximum Day Demand (MDD)	5.36	1.8 x ADD
Peak Hour Demand (PHD)	9.32	3.04 x ADD
MGD = million gallons per day; MDD = maximum day demand; ADD = average day demand; PHD = peak hour demand		

[1] Peak daily production from 2014-2017 was used for MDD and peak hourly production recorded during summer 2018 was used for PHD.

[2] The 2014-2017 Average Day Demand = 3.01 MGD was used to calculate both peaking factors.

Table 5-4. Baseline and Future Demand

Demand Condition	2017 Demand (MGD)	2022 Demand (MGD)	2027 Demand (MGD)	2032 Demand (MGD)	2037 Demand (MGD)
Average Day Demand (ADD)	3.07	3.13	3.19	3.22	3.25
Maximum Day Demand (MDD)	5.52	5.63	5.73	5.79	5.84
Peak Hour Demand (PHD)	9.32	9.50	9.68	9.78	9.87
MGD = million gallons per day; MDD = maximum day demand; ADD = average day demand; PHD = peak hour demand					

5.4 Supply Analysis

5.4.1 Water Supply

The District water supply is provided from the NCCWC WTP. The NCCWC WTP supplies water from the Clackamas River to the District, Sunrise, and the City of Gladstone through a shared transmission main. The NCCWC WTP is rated to produce up to 20 MGD and operates based on system demands. The actual production of the NCCWC WTP varies based on operational conditions. As described in the Amended and Restated Intergovernmental Agreement (IGA) for the NCCWC, the District is currently allocated 42 percent of the water treatment plant capacity at any time. Although the treatment plant has a design production capacity of 20 MGD, the actual available capacity may be limited by operational constraints including river turbidity and flow, water temperature, intake conditions, cleaning cycles and other factors. The IGA states that the NCCWC will develop a supply strategy to meet the 5-year projections of future demands, both in terms of annual volume and maximum day demand for the NCCWC members. The supply strategy shall optimize the most cost-effective use of the treatment plant and provide the overall least cost of water to each member from all available sources, including conservation and management of unaccounted water loss. If for any reason the availability of water at the river intake or overall production capacity of the treatment plant is curtailed or diminished at any time, the maximum available supply from the NCCWC WTP would be up to 42 percent of the available production capacity. The NCCWC has the authority to purchase or obtain water from any other sources to meet the immediate needs of the members. The District can also receive emergency water from SFWB and CRW through the shared transmission main. A more detailed description of the District's existing water supply is included in Chapter 3.

5.4.2 System Supply Capacity Analysis

Accepted engineering practices require that the water system supply must be able to meet the MDD. The sole source of supply for the District is the Clackamas River. Historically, this supply source has been able to meet District demands and appears to be an adequate supply source for normal operations. Table 5-5 compares the District's supply allocation from the NCCWC WTP between 2014 and 2018 to the current and future system MDD. It is assumed for this analysis that the District is allocated 42 percent of the historical maximum daily production from NCCWC WTP. Based on this assumption, the existing supply allocation from the NCCWC WTP will be sufficient to meet current demands and future demands through year 2037.

Table 5-5. System Supply Analysis

Demand Condition	Historically Available Supply from the NCCWC WTP[1] (MGD)	System MDD (MGD)
Current Demands	7.7	5.5
2037 Demands	7.7	5.8

MGD = million gallons per day; MDD = maximum day demand; NCCWC WTP = North Clackamas County Water Commission

[1] The 2014-2018 maximum daily production from the NCCWC WTP is 18.3 MGD. The maximum supply available to the District is assumed to be 42% of NCCWC WTP capacity.

It should be noted however, that the IGA also dictates that in the event of a curtailment order from Oregon Water Resources Department or an emergency that impacted the capacity of the treatment plant, the maximum allowable capacity to each NCCWC member shall be reduced on a pro rata basis (equal percentages). This supply analysis does not consider emergency supply situations when water may not be available through the shared transmission main or from the Clackamas River. Interconnections through nearby water purveyors will improve supply redundancy and reduce system risks. Emergency supply connections are further described in Chapter 7.

5.5 Booster Pump Station Capacity Analysis

Adequate BPS capacity is additionally important in maintaining reliable supply. The supply analysis above focuses on system-wide supply, but BPS capacity is important to effectively distribute water to the Upper and High Level zones. Based on accepted engineering practices, the Valley View BPS firm capacity must be able to meet the Upper Zone MDD and High-level Zone MDD. The View Acres BPS firm capacity must be able to supply the High-Level Zone MDD plus fire flow or PHD, whichever is larger, since the High-Level Zone does not contain gravity storage. Firm capacity is defined as the BPS capacity with the largest pump out of service. Dedicated emergency supply pumps, such as the View Acres fire pump are included in evaluating sufficient capacity. Table 5-6 and Table 5-7 evaluate the BPS supply capacity under current and future demands, respectively.

Table 5-6. Pump Station Capacity Analysis under Current Demands

Pump Station	Zone Served	Zone ADD (gpm)	Zone MDD (gpm)	Zone FF (gpm)	Zone PHD (gpm)	Required pump Capacity (gpm)	BPS Total Capacity (gpm)	BPS Firm Capacity (gpm)	Excess BPS Capacity (gpm)
Valley View	Upper	596	1,154	---	---	1,154	3,300	2,200	1,046
View Acres	High Level	45	82	1,500	137.8	1,582	2,050	1,850	268
gpm = gallons per minute; MDD = maximum day demand; ADD = average day demand; PHD = peak hour demand; FF = fire flow; BPS = booster pump station									

Table 5-7. Pump Station Capacity Analysis under 2037 Demands

Pump Station	Zone Served	Zone ADD (gpm)	Zone MDD (gpm)	Zone FF (gpm)	Zone PHD (gpm)	Required pump Capacity (gpm)	BPS Total Capacity (gpm)	BPS Firm Capacity (gpm)	Excess BPS Capacity (gpm)
Valley View	Upper	631	1,222	---	---	1,222	3,300	2,200	978
View Acres	High Level	48	86	1,500	145.9	1,586	2,050	1,850	264
gpm = gallons per minute; MDD = maximum day demand; ADD = average day demand; PHD = peak hour demand; FF = fire flow; BPS = booster pump station									

Based on the current and projected demands, the District’s booster pump stations are equipped with adequately sized pumps and will have sufficient capacity through year 2037.

Additionally, emergency power for each BPS shall be sufficient to meet system ADD or fire flows for zones without gravity storage. Both the Valley View BPS and View Acres BPS are equipped with backup generators for emergency power. The Valley View BPS generator is sufficient to provide power to supply current and projected future ADD for the Upper Zone and the backup generator for the View Acres BPS is sufficient to provide power to supply the fire flow requirements of the High Level zone. Based on system demands, the existing emergency power is adequately sized through year 2037.

5.6 Storage Analysis

Supply sources do not need to be sized for peak hour demands (operational storage), to provide water for firefighting (fire flow storage), and to meet demands during an emergency such as disruption of a major supply source (emergency storage) if sufficient storage volumes are provided. The storage criteria are described in Chapter 4 and include specific criterion for each of these three types of storage.

5.6.1 Operational Storage

Operational storage is the volume of water needed to equalize the daily supply and demand. Without operational storage, water supply facilities would need to be sized to meet the instantaneous peak demands throughout the day. Historically the District has sized operational storage requirements based on 25% of the MDD of the area served by each storage reservoir for one day. The operational storage criterion is considered adequate and is used in this WSMP to evaluate storage requirements. Table 5-8 includes the operational storage requirements to meet current and future demands.

Table 5-8. Operational Storage Requirements

Zone	Current Demands			2037 Demands		
	ADD (gpm)	MDD (gpm)	Operational Storage (gallons)	ADD (gpm)	MDD (gpm)	Operational Storage (gallons)
Lower	1,534	2,761	993,857	1,624	2,923	1,052,327
Upper	550	991	356,650	583	1,049	377,632
High Level	45	82	29,365	48	86	31,092
Total	2,129	3,833	1,379,871	2,225	4,058	1,461,051

gpm = gallons per minute; MDD = maximum day demand; ADD = average day demand

5.6.2 Fire Storage

The fire flow requirements are set by Clackamas County Fire District # 1 and the Oregon Fire Code. When assessing the fire flow in the distribution system the supply sources are assumed to be off, and the storage reservoirs are required to hold the volume of water required for firefighting. The fire storage requirements are based on the largest fire flow requirements for the development within the service area and assume that only one fire will occur at a time within the system. The Upper and High Level zones share storage in the View Acre Reservoirs, and since only one fire is assumed to occur at a time, the fire storage is combined for these two zones, using the largest fire flow requirement of the two zones. Table 5-9 lists the fire storage requirement for the system.

Table 5-9. Fire Storage Requirements

Zone	Flow (gpm)	Time (hour)	Fire Flow Volume (gallons)
Lower	5,000	4	1,200,000
Upper/ High Level	3,500	3	630,000

gpm = gallons per minute

5.6.3 Emergency Storage

According to the American Water Works Association (AWWA) Manual M19 Emergency Planning for Water Utilities, emergency storage is water that is available for use by water system customers in the event of a longer-term disruption of water supply. "Emergency storage provides water during events such as pipeline failures, equipment failures, power outages, pumping system failures, water treatment plant failures, raw water contamination, or natural disasters" (American Water Works Association, 2001). The quantity of emergency storage is determined by the agency and based on the required water system dependability, risk acceptance, and water quality in storage reservoirs. Oversized reservoirs can potentially have a negative impact on stored water quality because of increased difficultly in maintaining the chlorine residual and a higher risk of exceeding disinfection byproduct limits. The District has historically used twice the ADD for 24 hours as the emergency storage requirement, and the same criteria is used in this WSMP to evaluate emergency storage in the District's system. Table 5-10 includes the emergency storage requirements by zone under current and future demands.

Table 5-10. Emergency Storage Requirements

Zone	Current Demands		2037 Demands	
	ADD (gpm)	Emergency Storage (gallons)	ADD (gpm)	Emergency Storage (gallons)
Lower	1,534	4,417,141	1,624	4,677,009
Upper	550	1,585,111	583	1,678,365
High Level	45	130,510	48	138,188
Total	**2,129**	**6,132,762**	**2,255**	**6,493,562**

gpm = gallons per minute

5.6.4 Total Storage Requirements

The total required storage is the sum of the operational, fire flow, and emergency storage. Table 5-11 and Table 5-12 summarize the storage requirements for the Valley View and View Acres Reservoirs under current and future demands, respectively. The Valley View Reservoirs include the storage requirement for the Lower Zone and the View Acres Reservoirs include the storage requirements for the Upper and High-Level Zones.

Based on the storage criteria and the projected water demands, the District is expected to have sufficient storage volume now and through the next 20 years. In 2037, the system is expected to have an excess storage volume of 5.82 MG. As all tanks can be completely emptied using the adjacent pump stations, there does not appear to be any effectively unusable or "dead storage" volume in the tanks. Although excess capacity is available, the District strives to operate the tanks as close to the full volume as possible to avoid dropping pressure in the distribution system below the minimum level in areas at higher elevation.

Table 5-11. Total Storage Requirements under Current Demands

Reservoirs	Operational Storage (MG)	Fire Storage (MG)	Emergency Storage (MG)	Total Required Storage (MG)	Total Existing Storage (MG)	Excess Storage (MG)
Valley View	0.99	1.20	4.42	6.61	10	3.39
View Acres	0.39	0.63	1.72	2.73	5.6	2.87
Total	1.38	1.83	6.13	9.34	15.60	6.26
MG = million gallons						

**Note: The View Acres Reservoirs contain storage for the Upper and High-Level Zones*

Table 5-12. Total Storage Requirements under 2037 Demands

Reservoirs	Operational Storage (MG)	Fire Storage (MG)	Emergency Storage (MG)	Total Required Storage (MG)	Total Existing Storage (MG)	Excess Storage (MG)
Valley View	1.05	1.20	4.68	6.93	10	3.07
View Acres	0.41	0.63	1.82	2.86	5.6	2.74
Total	1.46	1.83	6.49	9.78	15.60	5.82
MG = million gallons						

**Note: The View Acres Reservoirs contain storage for the Upper and High-Level Zones*

5.7 Supply and Storage Recommendations

The District's current supply sources are sufficient to meet current and future projected demands. The District's normal and emergency supplies are all from the Clackamas River and conveyed through the shared transmission main. It is recommended to evaluate additional emergency intertie options to improve the District's resiliency in response to an outage of the current supply source. Alternative emergency supply sources are discussed in greater detail in Chapter 7.

The District's Valley View BPS and View Acres BPS were both found to have more than sufficient capacity now and through year 2037. The existing storage volume in the water system is also more than sufficient and will have a projected surplus storage volume of 5.82 MG in 2037.

Chapter 6

Hydraulic Analysis

The objective of the hydraulic model is to create a calibrated, representative model of the District's distribution system to simulate and predict the performance under a variety of demand and operational scenarios. The hydraulic model is also used for evaluating alternative configurations to address performance deficiencies in support of capital improvement recommendations.

6.1 Model Development

The District maintains an updated GIS database of the water distribution system, which allowed the model structure to be digitized within InfoWater, Innovyze's® GIS-based hydraulic modeling software. Major facilities such as tanks, pump stations, and valves were also manually added to the model. The modeling software was used to check the connectivity of the piping network, and pipe segments were added to build a fully functioning model. District staff provided a review of the model and identified several recently constructed improvements that had not yet been included within the GIS database, and these modifications were incorporated into the model pipe network. Spatially allocated demands were applied based on the historical and projected demands developed in Chapter 5 and applied to existing customer meter locations.

IN THIS SECTION

Model Development

System Capacity Analysis

Recommended Capacity Projects

The model was then calibrated based on five hydrant tests throughout the distribution system. During calibration the pipe friction-factors were adjusted based on pipe material and age to better reflect the hydrant testing results. Detailed information on the model development and calibration is included in Appendix A, Hydraulic Model Development Technical Memorandum.

6.2 System Capacity Analysis

This section analyzes the District's water distribution system pressure and available fire flow. Evaluation criteria are described in Chapter 4. Areas that do not meet the pipeline evaluation criteria are identified and recommendations to improve the system are included in Section 6.3.

6.2.1 Pressure Analysis

An important part of a water distribution system is the pressure supplied to consumers. Pressures should be adequate to supply services, but not too high to cause damage to appliances or pipelines. The District's water distribution system was evaluated based on maintaining a minimum pressure of 35 psi under PHD conditions.

The system pressure was evaluated under PHD for current (2017) and future (2037) demand scenarios. Because the demands over the next 20 years are not expected to increase significantly, the pressure across the distribution system is also not expected to change significantly in that timeframe. Pressure in the system is dependent on the water level in the storage tanks and pump station operations. To best characterize system pressures, the model used the same typical operating status for facilities under both current and future demand scenarios. Table 6-1 includes the operational assumptions that reflect typical daily operational settings provided by the District's SCADA System.

Table 6-1. Operational Assumptions for Pressure Analysis

Facility	Operational Condition
Valley View BPS	No Pumps Operating
View Acres BPS	1 Pump Operating
Tank Volume	All Tanks 75% Full

Significant demand changes are not expected within the planning period, which is reflected when comparing the results of the current (2017) demand scenario to the future (2037) demand scenario. The location of pressure deficiencies under PHD was identical for both scenarios. The greatest variation in modeled pressure between the two scenarios was approximately 5-10 psi at any location which is not significant. Because the results were largely the same, only the deficiencies associated with the future (2037) PHD scenario are provided, as this is the more conservative analysis.

Figure 6-1 includes a map of the pressures experienced across the water distribution system under future PHD demands. There are no pressure deficiencies below the minimum pressure requirement of 35 psi at service connections within the District's service area. There are locations just downstream of the tanks and pump stations that show pressures below 35 psi, however low pressures at these locations are typical for these facilities and do not impact customers' service connections.

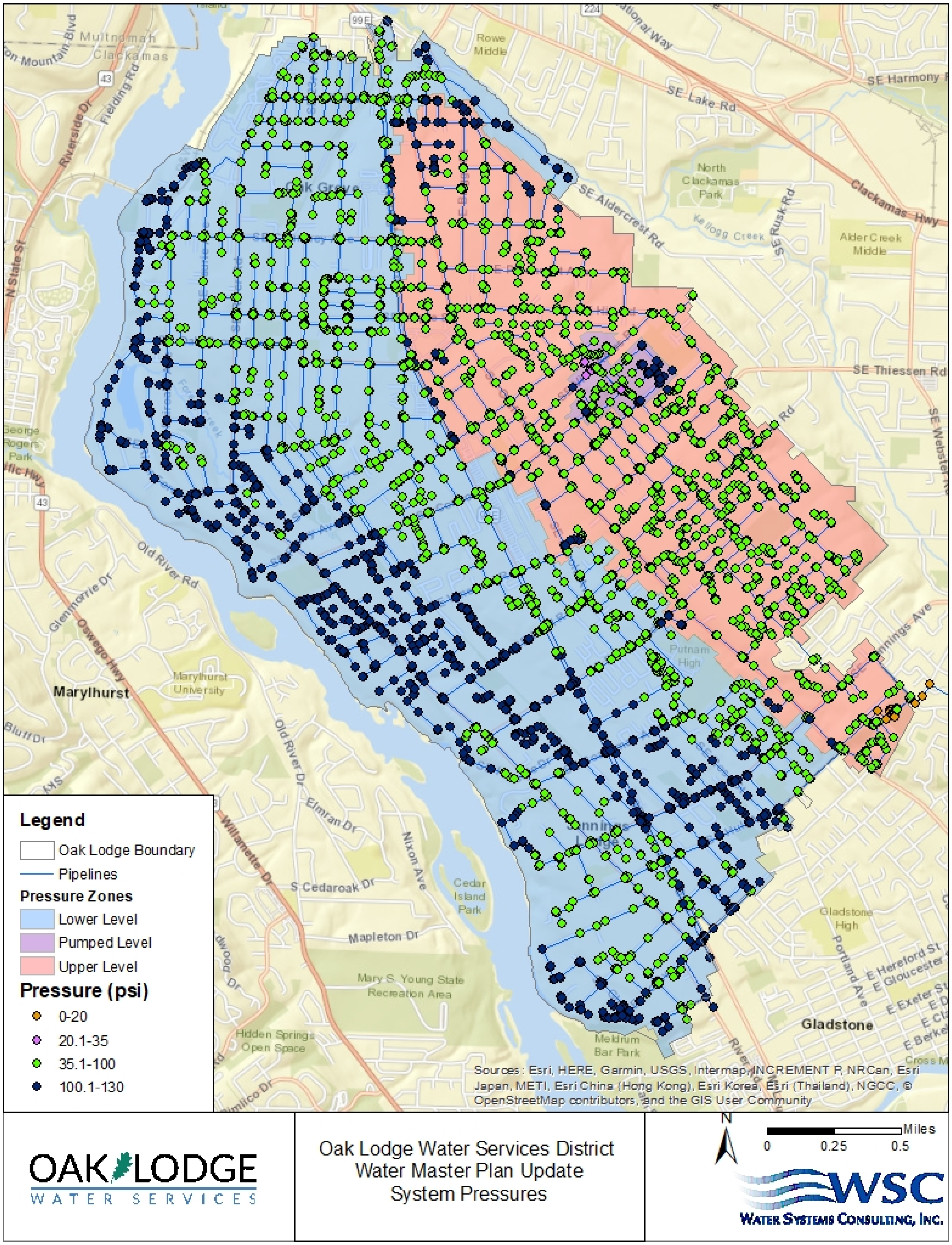

Figure 6-1. System Pressure Analysis

6.2.2 Fire Flow Analysis

Water distribution systems must provide adequate protection during a fire. The District's fire flow requirements at each hydrant location are based on the zoning category of the parcels served by the hydrant. A fire flow of 5,000 gpm is required for industrial zones, 3,500 gpm for commercial zones, mixed-use and schools, 1,500 gpm of flow in residential zones, and 1,000 gpm of flow in single-family residential zones with houses less than 3,600 square feet. Most of OLWSD is zoned as residential with some commercial, mixed use, and industrial zones.

The current available fire flow in the system was modeled using the calibrated hydraulic model. A fire flow scenario was created and run to evaluate the available fire flow at each fire hydrant while maintaining a residual pressure in the zone of 20 psi. For a conservative fire flow analysis, MDD was assumed, the reservoirs were set to 75 percent full, and all the pumps were turned off except for the View Acres fire pump.

The available fire flow was modeled under current (2017) MDD and future (2037) MDD and assumes no significant changes in land use. Since demands are not expected to increase significantly, the available fire flow under current demands is similar to the expected fire flow under future demands. Fire flow improvement projects were modeled under 2037 MDD to recommend pipe sizing that will accommodate future fire flow within the planning horizon. Any future changes in land use that increase densification are not anticipated to require additional upsizing unless an area were to move from residential to commercial or industrial land use. The fire flow requirement is based on the type of land use served and is several orders of magnitude greater than the demand created by additional users, so any upsizing to address fire flow requirements should also be sufficient to accommodate future growth beyond 2037. Figure 6-2 displays the available fire flow throughout the distribution system under the conservative settings and the required fire flow based on zoning.

Figure 6-3 shows the system fire hydrants and indicates the hydrants that cannot provide the required fire flow for their zoning. The available fire flow is highly dependent on pipeline size and available looping in the distribution system. Thus, many of the hydrant deficiencies occur on small-diameter dead-end pipelines.

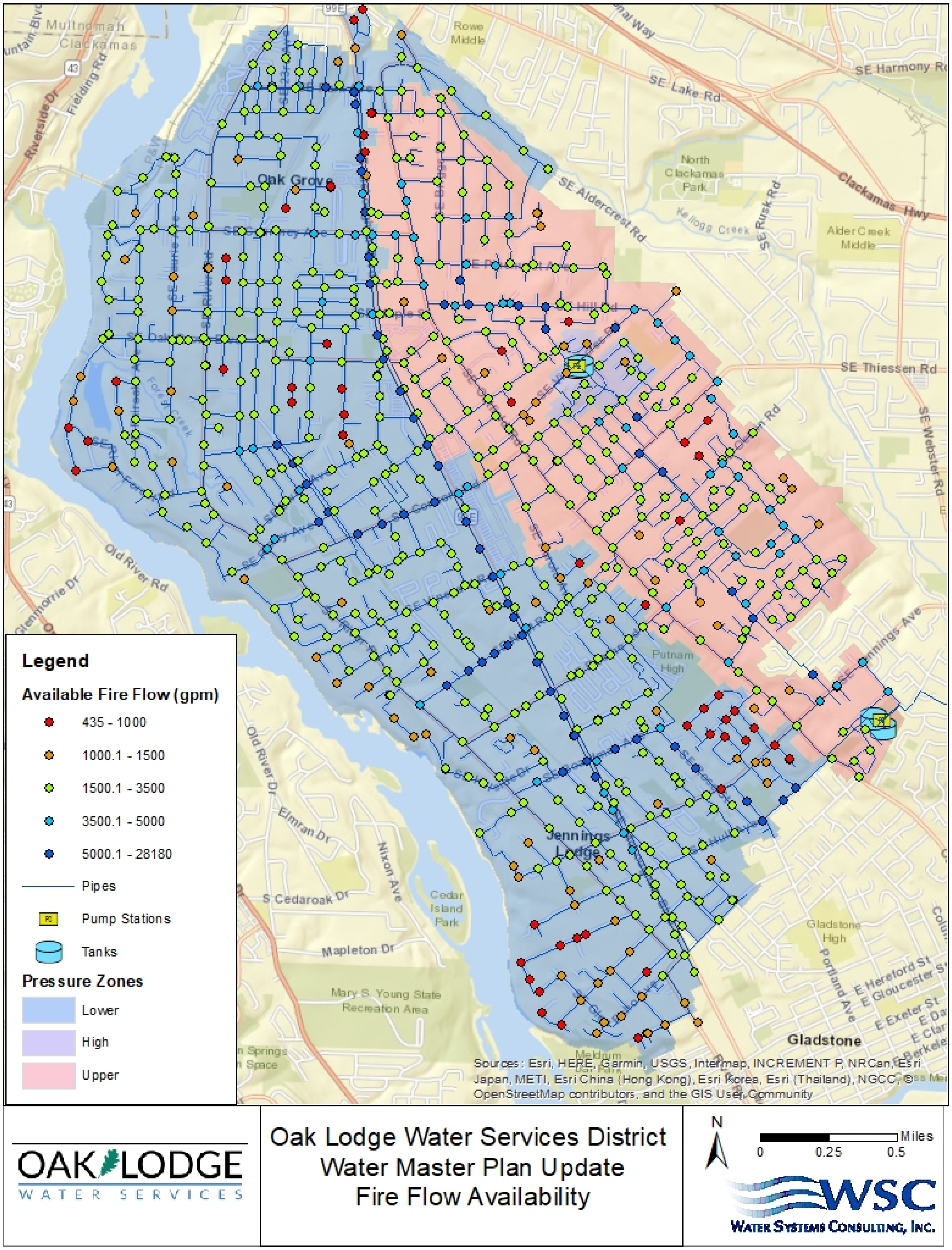

Figure 6-2. Available Fire Flow Under Future Maximum Day Demand

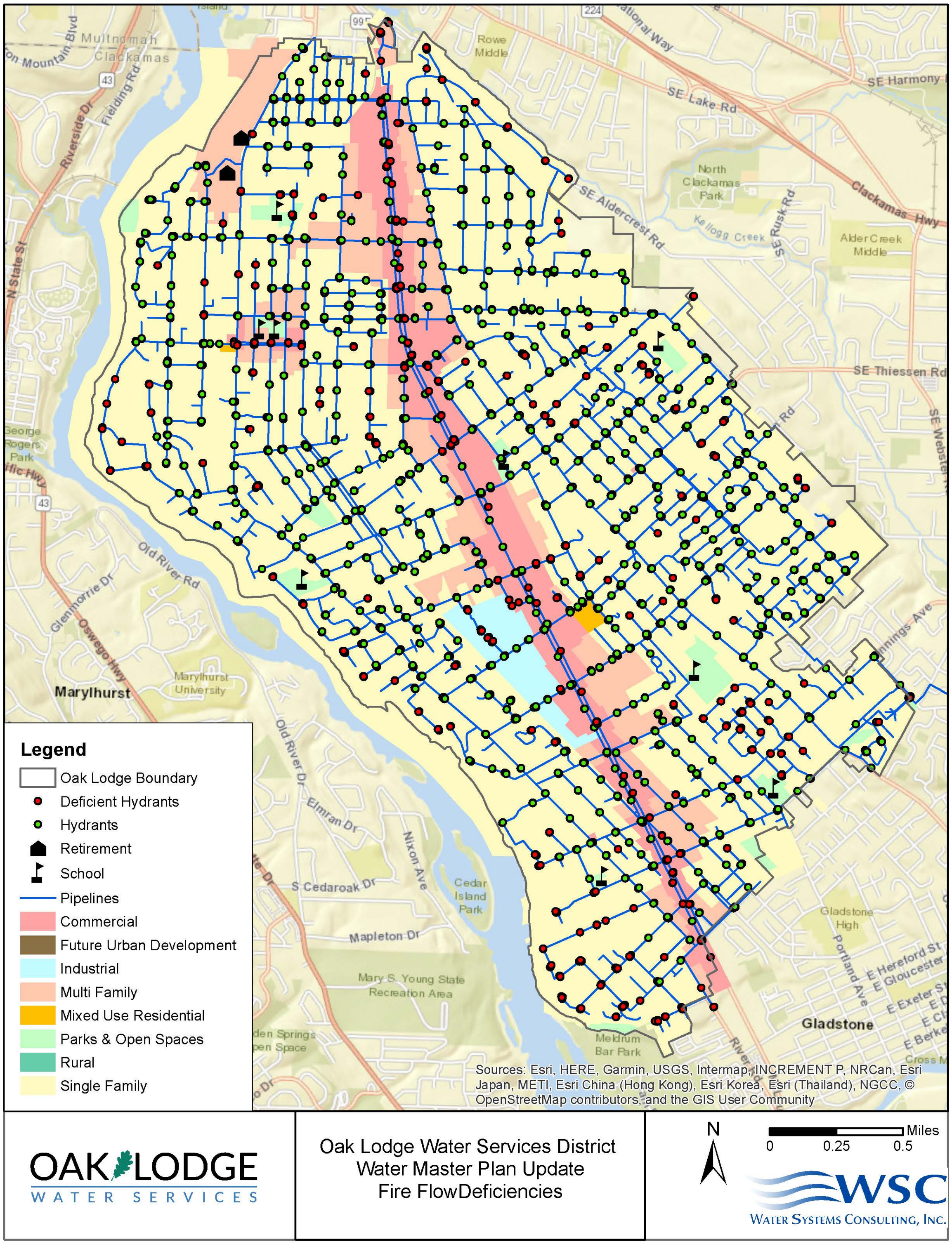

Figure 6-3. Fire Flow Deficiencies Under Future MDD

6.3 Recommended Capacity Projects

Projects to improve fire flow were developed by upsizing pipelines that restrict fire flow and adding new pipelines to create additional looping in the system where possible, and then rerunning the model to see if the modifications addressed the performance deficiency. Projects were iterated until the fire flow requirement was met with the minimum amount of upsizing or new pipe construction. For example, a deficient hydrant would not require an upsizing of pipe if there is a nearby hydrant that could also be used to meet the required fire flow. Upsizing of dead-end mains in residential zones was only recommended if the hydrant at the end of the main could not supply 1,000 gpm.

The resulting projects were then reviewed with District staff and modified further to incorporate staff preferences and opportunities to address condition deficiencies. Most of the recommended projects include upsizing aging 4-inch and 6-inch cast iron mains on dead-end mains that restrict fire flow. Overall, WSC recommends upgrading about 12.1 miles of small diameter pipelines with 8-inch or 12-inch diameter pipe to improve fire flow through the OLWSD distribution system.

Table 6-2 lists the recommended fire flow improvement projects in order of priority. The projects have been ranked based on operations and engineering staff input, installation of existing pipe, number of hydrant deficiencies corrected by the project, and the customer zoning. Prioritization and timing of projects was also coordinated with the Clackamas County Department of Transportation planned paving projects to allow pipes to be installed prior to, or in coordination with road paving projects to reduce restoration costs. Figure 6-4 includes a map of the recommended fire flow projects in the system and corresponds to the project list.

Table 6-2. Fire Flow Projects

Project Number	Project Type	Zone	Location	Existing Size and Material	Total New Pipe Length	Recommended Size and Material	Recommended Project (Segments)
F-1	Pipeline	Lower	SE 28th Avenue, SE Lakewood Drive, Kellogg Lake Apartments	6"	4,015 feet	8" and 12" DI	Replace 60 feet of 8" pipe and 270 feet of 6" pipe with 12" DI pipe along SE 28th Avenue north of SE Park Avenue. Replace 1,255 feet of 6" pipe with 8" DI pipe along SE McLoughlin Boulevard and SE Lakewood Drive. Replace 800 feet of 6" pipe with 8" DI pipe along SE Lark Street and SE Whitcomb Drive from SE Lakewood Drive to Kellogg Lake Apartments Road. Install 975 feet of 8" DI pipe to connect loop from SE Oatfield Road through Kellogg Lake Apartments to existing main on SE Whitcomb Drive. Replace 655 feet of 6" pipe with 8" DI pipe along SE Oatfield Road to Aldercrest Road.
F-2	Pipeline	Lower	SE River Road	4", 6", and 8"	6,805 feet	8" and 12" DI	Replace 5,105 feet of 6" pipe with 12" DI pipe along SE River Road from Park Avenue to Oak Grove Boulevard. Replace 1,035 feet of 8" pipe with 12" DI pipe along SE Torbank Road from SE River Road to Oak Grove Elementary. Replace 665 feet of 4" pipe with 8" DI pipe along SE Maple Street between Laurie Avenue and River Road.
F-3	Pipeline	Upper	SE Vista Sunrise Court	6"	400 feet	8" DI	Replace 400 feet of 6" pipe with 8" DI pipe along SE Vista Sunrise Court north of SE Oetkin Road.
F-4	Pipeline	Lower	Jennings Avenue, Emerald Drive, Colina Vista Avenue, Clayson Avenue, Colony Circle	6"	4,415 feet	8" DI	Replace 1,010 feet of 6" pipe with 8" DI pipe along SE Jennings Avenue between SE Portland Avenue and SE Colina Vista Avenue and connect the new 8" pipe to the existing 24" DI pipe at corner of SE Portland Avenue and SE Jennings Avenue. Replace 1,055 feet of 6" pipe with 8" DI pipe along SE Emerald Drive between SE Jennings Avenue and SE Clayson Avenue. Replace 735 feet of 6" pipe with 8" DI pipe along SE Clayson Avenue between SE Emerald Drive and SE Colony Circle. Replace 600 feet of 6" pipe with 8" DI pipe along SE Colony Circle between SE Clayson Avenue and the existing hydrant. Replace 1,015 feet of 6" pipe with 8" DI pipe along SE Colina Vista Avenue between SE Clayson Avenue and SE Jennings Avenue.
F-5	Pipeline	Upper	Alderway Avenue	4"	1,070 feet	8" DI	Replace 1,070 feet of 4" pipe with 8" DI pipe along Alderway Avenue between Wallace Road and Hillwood Avenue.
F-6	Pipeline	Upper and High-level	View Acres Road	6"	2,130 feet	8" DI	Replace 1,675 feet of 6" pipe with 8" DI pipe along SE View Acres Road between View Acres tanks and SE Oatfield Road. Replace 455 feet of 6" pipe with 8" DI pipe along SE View Acres Road from the View Acres Pump Station to SE Danica Court.
F-7	Pipeline	Lower	Old Orchard Court, SE Meldrum Avenue	4" and 6"	1,850 feet	8" DI	Replace 540 feet of 4" pipe with 8" DI pipe along Old Orchard Court southwest of SE Glen Echo Avenue. Replace 710 feet of 6" pipe with 8" DI pipe along SE Meldrum Avenue between SE Glen Echo Avenue and SE Cottonwood Street. Replace 600 feet of 6" pipe with 8" DI pipe along SE Glen Echo Avenue between SE Old Orchard Court and SE Meldrum Avenue.
F-8	Pipeline	Lower	SE Hull Avenue	6"	3,565 feet	8" and 12" DI	Replace 2,645 feet of 6" pipe with 8" DI pipe along SE Hull Avenue between northbound SE McLoughlin Boulevard and SE Water Edge Way. Replace 920 feet of 6" pipe with 12" DI pipe along SE Wilmot Street between SE Hull Avenue and SE Jennings Avenue.
F-9	Pipeline	Upper	McLoughlin Boulevard	4" and 6"	5,455 feet	8" DI	Replace 2,675 feet of 6" pipe with 8" DI pipe along SE McLoughlin Boulevard between SE Maple Street and SE Risley Avenue. Replace 1,005 feet of 6" pipe with 8" DI pipe along SE Maple Street from SE McLoughlin Boulevard and SE Oatfield Road. Replace 500 feet of 6" pipe with 8" DI pipe along SE Oak Grove Boulevard from SE McLoughlin Boulevard and SE Oatfield Road. Replace 1,275 feet of 4" and 6" pipe with 8" DI pipe along SE Risley Avenue from SE McLoughlin Boulevard and SE Oatfield
F-10	Pipeline	Lower	McLoughlin Boulevard	6" CI and Unknown	4,810 feet	8" DI	Replace 2,730 feet of 6" with 8" DI pipe along northbound SE McLoughlin Boulevard from SE Boardman Avenue to south of SE Hull Avenue. End replacement at existing 8" DI pipe section between Hull Avenue and Meldrum Avenue. Replace 1,120 feet of 6" pipe with 8" DI pipe along SE McLoughlin Boulevard starting at end of existing 8" DI pipe between SE Hull Avenue and SE Meldrum Avenue and ending at SE Glen Echo Avenue. Replace 75 feet of 6" pipe with 8" DI pipe along SE Boardman Avenue between SE McLoughlin Boulevard and SE Addie Street connecting new 8" pipe along McLoughlin Boulevard to existing 24" pipe along Boardman Avenue. Replace 85 feet of 6" pipe with 8" DI pipe along SE Hull Avenue crossing SE McLoughlin Boulevard. Replace 305 feet of 6" pipe with 8" DI pipe along southbound SE McLoughlin Boulevard north of SE Hull Avenue. Replace 105 feet of 6" pipe with 8" DI pipe along SE Glen Echo Avenue crossing McLoughlin Boulevard. Replace 390 feet of 6" pipe with 8" DI pipe along SE McLoughlin Boulevard south of SE Glen Echo Avenue to end of main.

Project Number	Project Type	Zone	Location	Existing Size and Material	Total New Pipe Length	Recommended Size and Material	Recommended Project (Segments)
F-11	Pipeline	Lower	River Road	6”	780 feet	8” DI	Replace 780 feet of 6” pipe with 8” DI pipe along SE River Road between SE Risley Avenue and SE Tarbell Avenue.
F-12	Pipeline	Lower and Upper	Harold Avenue, Derry Lane, and Gordon Street	6”	1,210 feet	8” DI	Replace 435 feet of 6” pipe with 8” DI pipe along Harold Avenue between Naef Road and Derry Lane. Replace 500 feet of 6” pipe with 8” DI pipe along Derry Lane between Harold Avenue and Rayna Court. Replace 275 feet of 6” pipe with 8” DI pipe along SE Gordon Street between SE Whipple Avenue and SE Naef Road.
F-13	Pipeline	Lower	McLoughlin Boulevard	6”	170 feet	8” DI	Install 90 feet of 8” DI pipe along SE Courtney Avenue connecting the parallel 16” and 8” mains along McLoughlin Avenue. Connect existing Hydrant 5-8 located along northbound McLoughlin Boulevard to the 16” main along southbound Mcloughlin Boulevard by abandoning the existing hydrant lateral and installing 80 feet of new 8” DI hydrant lateral across McLoughlin Boulevard.
F-14	Pipeline	Lower	McLoughlin Boulevard	6”	450 feet	6” and 8” DI	Connect four existing hydrants (Hydrant 6-11, Hydrant 6-10, Hydrant 6-8, and Hydrant 6-7) located along northbound McLoughlin Boulevard between SE Vineyard Road and SE Ina Avenue to the 24” main along southbound Mcloughlin Boulevard by abandoning the existing hydrant laterals and installing a total of 360 feet (90 feet per hydrant lateral) of new 6” DI hydrant lateral across McLoughlin Boulevard. Install 90 feet of 8” pipe across McLoughlin Boulevard connecting the existing 6” pipe along northbound McLoughlin Boulevard to the existing 24” pipe along McLoughlin Boulevard at the corner of SE Ina Avenue.
F-15	Pipeline	Lower	McLoughlin Boulevard, Glen Echo Avenue, River Road	6”	1570 feet	8” DI	Replace 520 feet of 6” pipe with 8” DI pipe along SE Glen Echo Avenue between SE McLoughlin Boulevard and SE River Road. Replace 160 feet of 6” pipe with 8” DI pipe along SE River Road between SE Glen Echo Avenue and SE Britton Avenue. Replace 890 feet of 6” pipe with 8” DI pipe along SE River Road between SE Glen Echo Avenue and SE Rinearson Road.
F-16	Pipeline	Lower	Vineyard Road, Vineyard Lane, commercial parking lot, Kens Court	6”	2,830 feet	8” and 12” DI	Replace 395 feet of 6” pipe with 12” DI pipe along SE Vineyard Road between McLoughlin Boulevard and SE Vineyard Lane. Replace 585 feet of 6” pipe with 8” DI pipe along Vineyard Lane south of Vineyard Road. Replace 285 feet of 6” pipe with 8” DI along the parking lot road behind Protech Autoworks building from McLoughlin Boulevard to the existing hydrant. Replace 1,565 feet of 6” pipe with 12” DI pipe along Kens Court and the industrial parking lot between SE Vineyard Road and SE Naef Road.
F-17	Pipeline	Lower and Upper	Austin Street and Sandra Avenue and Roethe Road	6”	1,450 feet	8” DI	Replace 550 feet of 6” with 8” DI pipe along SE Austin Street northwest of SE Roethe Road. Replace 350 feet of 6” pipe with 8” DI pipe along SE Sandra Avenue northeast of SE Gordon Street. Replace 550 feet of 6” pipe with 8” DI pipe along SE Roethe Road between SE Oatfield Road and SE Gordon Street (up to pressure zone isolation valve).
F-18	Pipeline	Lower	SE Roethe Road	6”	850 feet	8” DI	Replace 850 feet of 6” pipe with 8” DI pipe along SE Roethe Road between SE McLoughlin Boulevard and SE Blanton Street.
F-19	Hydrant Laterals	Lower	River Road, Oak Grove Boulevard	6”	110 feet	6” and 8” DI	Connect existing Hydrant 3-91, located at SE Oak Grove Boulevard and SE Arista Drive, to the 8” pipeline across Oak Grove Boulevard by installing 60 feet of new 6” hydrant lateral across the street. Replace 50 feet of 6” hydrant lateral with 8” DI pipe for Hydrant 1-32, located at Oak Grove Boulevard and SE River Road, and connect to the existing 8” main.
F-20	Pipeline	Lower	SE Maple Street	6”	300 feet	8” DI	Replace 300 feet of 6” pipe with 8” DI pipe along SE Maple Street from SE Lee Avenue to SE Arista Drive.
F-21	Pipeline	Lower	Vineyard Road	6”	350 feet	8” DI	Replace 350 feet of 6” pipe with 8” DI pipe along SE Vineyard Road between McLoughlin Boulevard and SE Sun Avenue.
F-22	Pipeline	Lower	SE River Drive	6”	980 feet	8” DI	Replace 980 feet of 6” pipe with 8” DI pipe along SE River Drive between SE River Road and SE River Cress Lane.
F-23	Pipeline	Lower	Poplar Place	4” and 6”	2,695 feet	8” DI	Replace 325 feet of 4” pipe with 8” DI along SE Poplar Place east of SE Linden Lane. Replace 935 feet of 6” pipe with 8” DI pipe along Marian Street south of Oak Grove Boulevard. Replace 1,435 feet of 6” pipe with 8” DI pipe along Woodland Way south of Oak Grove Boulevard.
F-24	Pipeline	Lower	River Forest Road, River Forest Drive, River Forest Court (loop)	4” and 6”	3,035 feet	8” and 12” DI	Replace 3,035 feet of 4” and 6” pipe with 8” and 12” DI pipe looping along River Forest Road, River Forest Drive and River Forest Court.

Project Number	Project Type	Zone	Location	Existing Size and Material	Total New Pipe Length	Recommended Size and Material	Recommended Project (Segments)
F-25	Pipeline	Upper	Cottonwood Court	6”	965 feet	8” DI	Replace 965 feet of 6” pipe with 8” DI pipe along SE Cottonwood Court from SE Hill Road
F-26	Pipeline	Lower	Cedar Avenue	6”	1140 feet	8” DI	Replace 1,140 feet of 6” pipe with 8” DI pipe along SE Cedar Avenue north of SE Maple Street.
F-27	Pipeline	Lower	Thornton Drive	4”	1,000 feet	8” DI	Replace 1,000 feet of 4” pipe with 8” DI pipe along Thornton Drive between Fairbanks Avenue and the existing 6” pipe along Thornton Drive.
F-28	Pipeline	Upper	SE Diamond Lane	4”	310 feet	8” DI	Replace 310 feet of 4” pipe with 8” DI pipe along SE Diamond Lane south from SE Risley Avenue.
F-29	Pipeline	Upper	SE Sierra Vista Drive	6”	1,500 feet	8” DI	Replace 1,500 feet of 6” pipe with 8” DI pipe along SE Sierra Vista Drive from SE Thiessen Road to SE Mt Royale Court.
F-30	Pipeline	Lower	SE Britton Avenue	4” and 6”	440 feet	8” DI	Replace 440 feet of 4” and 6” pipe with 8” DI pipe along SE Britton Avenue between SE Kay Street and SE River Road.
F-31	Pipeline	Upper	Raintree Court	6”	540 feet	8” DI	Replace 540 feet of 6” pipe with 8” DI pipe along SE Raintree Court from SE Hager Lane.
F-32	Pipeline	Lower	Walta Vista Drive	6”	535 feet	8” DI	Replace 535 feet of 6” pipe with 8” DI pipe along SE Walta Vista Drive southwest of SE River Road.
F-33	Pipeline	Lower	SE Torbank Road and SE Lindenbrook Court	6”	1,190 feet	8” DI	Replace 320 feet of 6” pipe with 8” DI pipe along SE Torbank Road east of SE Linden Lane. Replace 870 feet of 6” pipe with 8” DI pipe along SE Lindenbrook Court west of SE Linden Lane.
F-34	Pipeline	Lower	McLoughlin Boulevard	6”	110 feet	8” DI	Replace 110 feet of the remaining 6” pipe segment along McLoughlin Boulevard south of SE Concord Road with 8” DI pipe.
F-35	Pipeline	Upper	SE Evergreen Street	4”	240 feet	8” DI	Replace 240 feet of 4” pipe with 8” DI pipe along SE Evergreen Street between SE Oatfield Road to SE 29th Avenue.
F-36	Pipeline	Lower	SE McLoughlin Blvd	NA	80 feet	8” DI	Connect the existing 6” main located along northbound McLaughlin Boulevard to the 16” main along southbound Mcloughlin Boulevard by installing 80 feet of new 8” DI pipe across McLoughlin Boulevard.
F-37	Pipeline	Upper	SE McLoughlin Blvd and Holly Ave	6”	1,965 feet	8” DI	Replace 735 feet of 6” pipe with 8” DI pipe along Holly Avenue from SE Oatfield Road to McLoughlin Boulevard. Replace 1,230 feet of 6” pipe with 8” DI pipe along McLoughlin Boulevard from Holly Avenue to end of main.

DI = ductile iron; SE = southeast; Blvd = Boulevard; Ave = Avenue; NA = not available; CI = cast iron

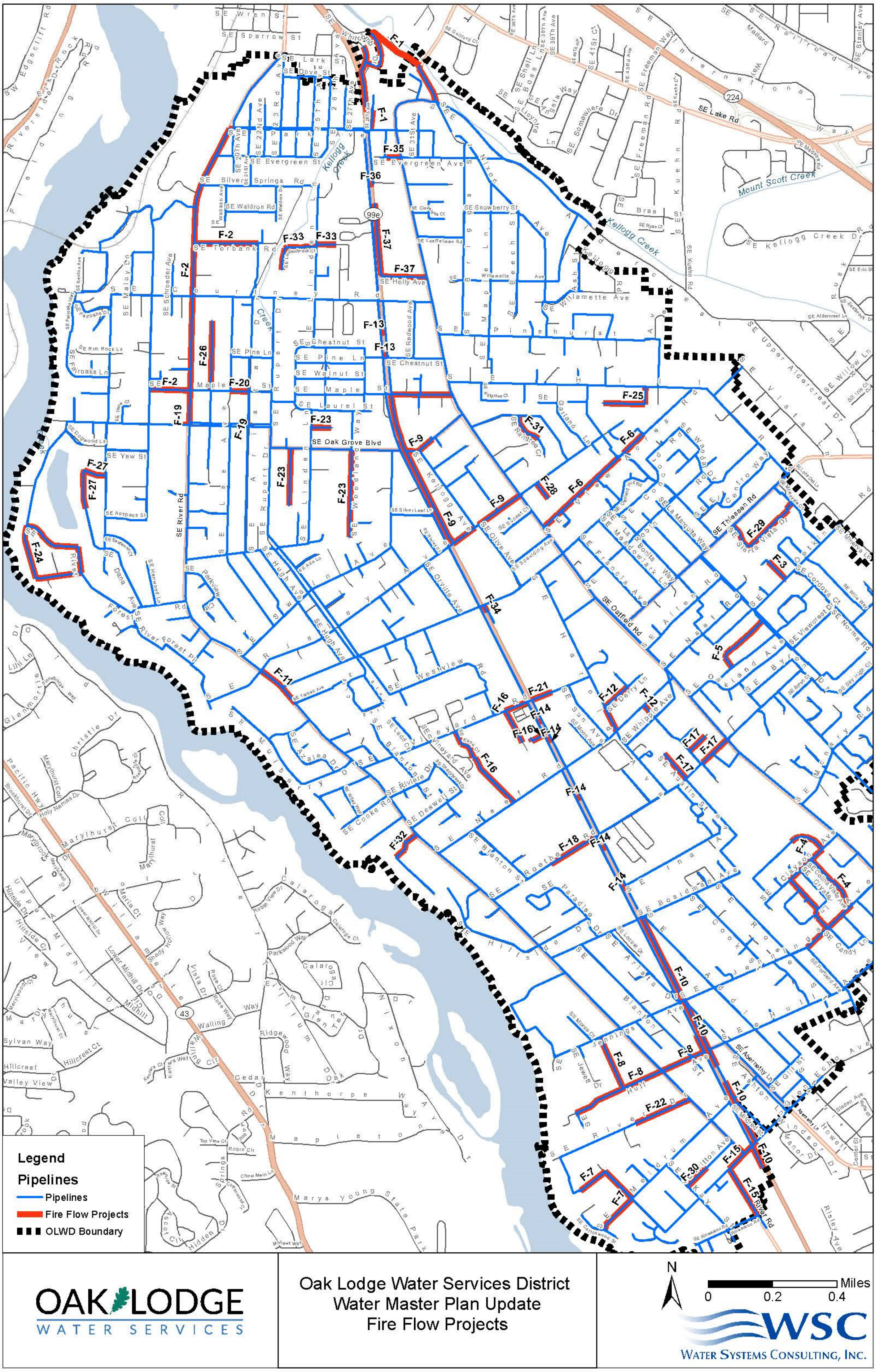

Figure 6-4. Fire Flow Projects

CHAPTER 7

Asset Rehabilitation and Replacement

The purpose of this chapter is to identify the District's asset rehabilitation and replacement needs within the 20-year CIP. OLWSD has the challenge of proactively maintaining a safe and reliable water distribution system while rehabilitating and replacing aging assets in a cost-effective manner.

IN THIS SECTION

Pipeline Replacement

Non-Buried Assets

7.1 Pipeline Replacement

Most of the distribution system is underground and not able to be visually inspected. Water purveyors must manage these assets based on regular leak detection surveys, review of installation and maintenance records, and proactive replacement of aging infrastructure based on industry standard expected useful life.

7.1.1 Available Pipeline Data

The District's current GIS database is missing a significant amount of pipe material and installation year data, which is necessary to estimate when pipelines should be replaced. The District did not maintain records prior to 1965. Although the material and installation years are not recorded in the GIS database for these pipes, the District assumes that pipes missing this information were installed prior to 1965 and were cast iron material. The District does not have pipe material recorded in the District's database for about 77 percent of the system's pipes. Assuming pipes with unknown material are cast iron, about 80 percent of the distribution system is comprised of cast iron pipe and 19 percent is ductile iron pipe. The percentage of each type of pipe material that currently comprises the District distribution system is provided in Figure 7-1.

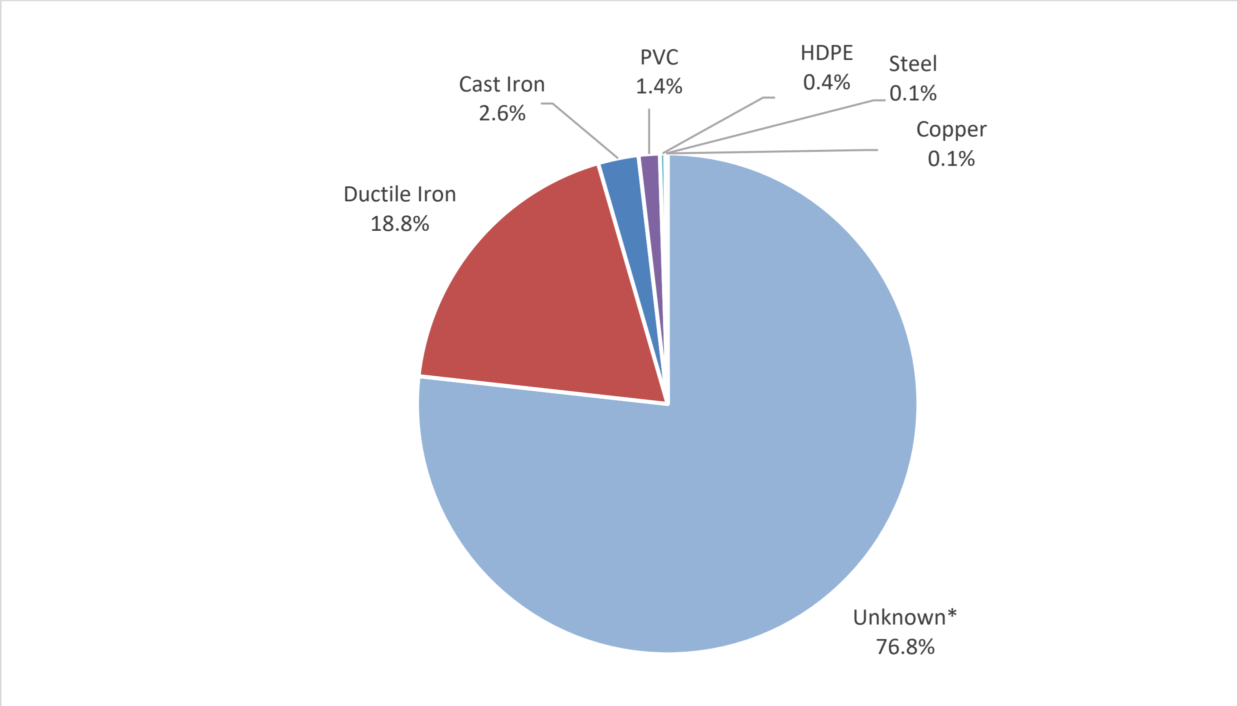

Figure 7-1. Percentage of Pipeline Materials within the Distribution System

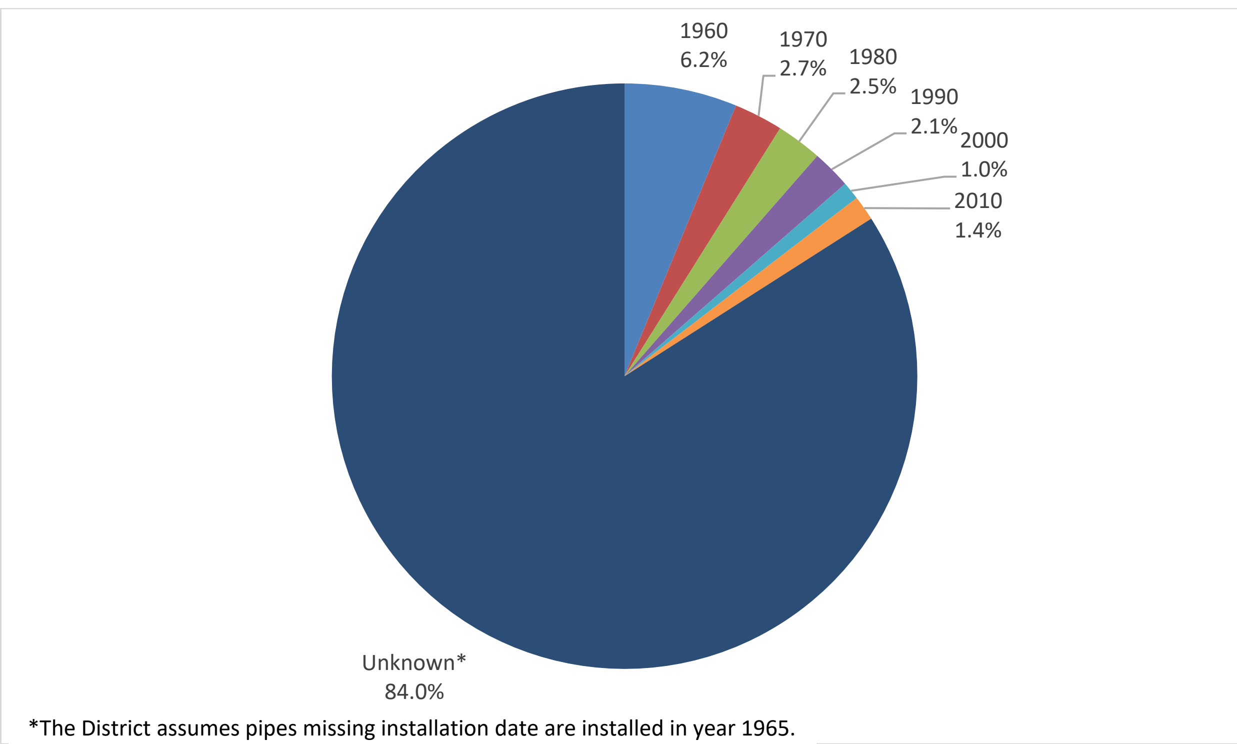

Figure 7-2. Percentage of Pipeline Installed Each Decade within the Distribution System

The District has identified the need to improve their asset management database system. Historically, the District has stored asset information for the water system in a georeferenced database in GIS. Currently the District is undergoing the process to implement a Computerized Maintenance Management System (CMMS). The CMMS system will allow the District to better store, track and mange asset data related to the water system.

Figure 7-2 shows the number of miles of pipe installed each decade. For pipes missing installation dates, the District assumes installation was prior to 1965. Using this assumption, about 90% of the District's pipes were installed prior to 1969.

7.1.2 Remaining Useful Life Evaluation

Pipeline condition data, leak detection results, or histories of repairs are not available for evaluating the current condition of the District's water distribution system. Although this data is not available, the District's underground assets can be evaluated based on remaining useful life (RUL). The RUL of an asset is the amount of time that asset is expected to be functional without major failures. While the actual service life of a pipeline will vary, the RULs are commonly accepted as estimates for long term planning and a starting point to identify pipelines that need replacement. The RUL is not intended to suggest that the District will experience an immediate simultaneous failure of these pipes once the RUL reaches zero, but rather that they will have an increased likelihood of breakage or leakage. The likelihood of failure will increase as a pipe continues to remain in place beyond its RUL. Actual failure patterns can be variable and depend on construction quality, manufacturer, pressure, water quality, soil type and condition, proximity to other utilities and many other attributes.

Using available information documenting pipeline material and the year of installation, the RUL can be estimated by subtracting the age of the pipe from the typical industry standard expected useful life for the given pipe material. Other underground assets, including valves, services, and hydrant laterals are assumed to have a similar RUL as the water main that serves them, as they were likely installed at the same time. The RUL can be used to determine the year in which each pipeline and its associated services, valves, and hydrants should be replaced.

For this analysis, industry accepted pipeline service lifetimes, shown in Table 7-1, were used to estimate the decade each pipe is expected to fail. This analysis is focused on identifying a system-wide strategy for quantifying and funding pipeline replacements. Detailed condition assessments and/or leak detection survey results are not available to identify and prioritize individual pipes for replacement. Prioritization of pipeline replacements should be reviewed and adjusted annually based on updated condition and leak testing data, coordination with planned road improvement projects, and new developments. The timing of individual pipe replacement projects may also require adjustment to align with annual District financial budgeting processes, short- and long-term rate strategies, and financing opportunities.

Table 7-1. Pipeline Estimated Useful Life Based on Material

Pipe Material	Estimated Useful Lifetime (years)[1]
Cast Iron	75
Ductile Iron	100
PVC	100
Steel	90
Copper	90
HDPE	110
PVC = polyvinyl chloride; HDPE = high-density polyethylene	

[1] Estimated useful life is adapted from Deb, Arun, Herz, Raimund, et al; "Quantifying Future Rehabilitation and Replacement Needs of Water Mains"; WRF 1998

Interviews with District operations staff were also used to identify and prioritize condition-based replacement projects. Operators leveraged their knowledge of the frequency of past pipeline breaks and repairs to identify pipeline segments that may be at the end of their useful life. Operators also helped prioritize condition-based replacements by identifying segments with high consequence of failure.

7.1.3 Pipeline Renewal Strategy

The District should plan to replace pipe in a proactive manner to avoid pipeline failures and costly emergency repairs. In the absence of condition data, the anticipated need for renewal each year is estimated based on the total length of pipe reaching the end of its remaining useful life within that year.

To account for the uncertainty associated with the number of pipes that are missing data for the year of installation, a normal distribution was applied to distribute the installation years for these pipes across the 20-year period from 1945 to 1965. Otherwise, 84 percent of all pipe with unknown installation year would be estimated to fail simultaneously in 2040. Figure 7-3 shows cumulative miles of pipeline reaching expected end of useful life, both with and without the normal distribution applied.

Figure 7-3 also shows a straight-line rate of replacement of one percent of the system per year, representing a full replacement of the entire distribution system over the next 100 years. A constant one percent rate of renewal requires replacing about one mile of pipeline per year at an estimated cost of $1.4 million in 2018 dollars. The figure shows that the one mile per year rate of replacement falls largely under the curve of when pipelines are expected to reach the end of service life. Because the actual installation dates and materials are unknown for the majority of the system, there is not sufficient data to justify accelerating the pipeline replacement rate at this time to keep up with the RUL curve. Given the potential that there may be a significant amount of distribution piping that is at or beyond its RUL, WSC recommends a minimum replacement rate of one mile per year across the system.

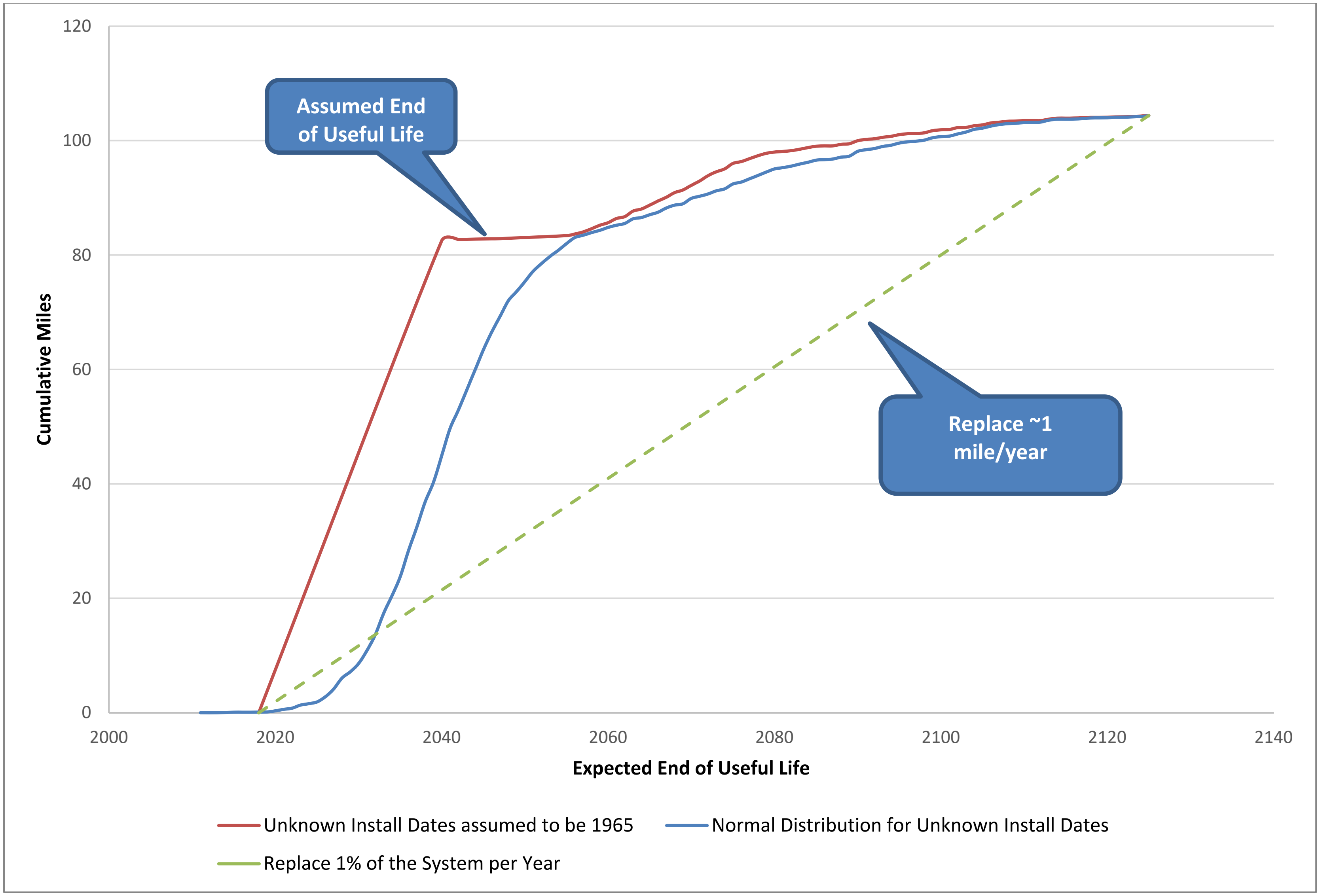

Figure 7-3. Cumulative Pipeline Reaching End of Expected Useful Life and Renewal Strategy

The District should continue to monitor pipeline condition, leaks and repairs on a regular basis as an indicator of assets reaching the end of useful life and proactively identify and replace individual pipeline assets. As installation and material data continue to be captured, the accuracy of the RUL curve can be improved and budgeting for pipeline replacement projects can be refined. Additional field studies, such as leak detection surveys and coupon analysis, would provide data necessary to adjustment the RUL to reflect field conditions.

The RUL analysis includes all of the District's pipes, including those identified for capacity projects as described in Chapter 6. The total footage of capacity-based projects recommended for the 20-year CIP is approximately 12 miles. Addressing the recommended capacity projects along with the operator-identified condition projects over the 20-year CIP will roughly match the recommended minimum renewal rate of one mile per year. The capacity upgrade projects were also prioritized to replace older pipelines over newer pipelines. Operator identified projects are provided in the following section.

7.1.4 Pipeline Rehabilitation & Replacement Projects

The District operations staff identified and prioritized six pipeline projects based on age and condition to be upgraded in the CIP, presented in Table 7-2. The condition-based projects total about four miles of pipeline. The locations for each of the operator identified condition replacement projects within the District are shown in Figure 7-4.

Table 7-2. Pipeline Condition Projects

Project	Location	Existing Size and Material	Total New Pipe Length	Recommended Size and Material
C-1	Aldercrest Road (Oatfield to Kellogg Rd)	6" and 8"	3,025 feet	8" DI
C-2	Lisa Lane (North of Swain Ave)	2"	300 feet	6" DI
C-3	Marcia Court (North of Glen Echo Ave)	4" CI	475 feet	6" DI
C-4	Ranstad and Cinderella Courts	4" CI	760 feet	6" DI
C-5	Oatfield (Jennings to Park Ave)	6" and 8"	15,995 feet	8" DI
C-6	Round Oaks Court (East of Harold Ave)	3" PVC	345 feet	4" DI
DI = ductile iron; CI = cast iron; PVC = polyvinyl chloride; Rd = road; Ave = avenue				

7.2 Non-Buried Assets

Many of the District's major facilities are above ground and able to be visually inspected and proactively maintained, such as tanks and pump stations. The District's above ground assets and recent upgrades are described in Chapter 3. There are also assets within the distribution system that are located above ground or within underground vaults that can also be inspected and proactively maintained, such as large commercial meters, pressure reducing valves, and fire hydrants. The District Operations team has identified significant rehabilitation and replacement projects that are anticipated over the next 20-years for these non-buried assets as described in the following sections.

7.2.1 Storage Tanks

The Valley View and View Acres storage reservoirs are both anticipated to require coating repairs to extend the remaining useful life of these assets. Coating repairs are anticipated to require specialty contractors with the necessary equipment to prepare surfaces and apply new coatings to meet the necessary performance requirements and to achieve the desired longevity for the coating.

The Valley View tanks are prestressed concrete tanks and require a seal coat on the domed roofs of the two tanks to protect small surface cracks in the concrete from further deterioration. Timing of a seal coat will depend on continued monitoring of the tank roof condition through periodic inspections. Application of a seal coat is anticipated to be necessary within the next 5 to 10 years unless observed crack propagation indicates a more immediate need.

View Acres Tanks are steel and require periodic recoating to protect against corrosion on both the interior and exterior of the tanks. The two tanks were coated in 2002 and again in 2013. Periodic tank inspections are conducted to monitor the condition of the interior and exterior coating. Touch up coating can be applied to local areas of coating failure as needed but based on the frequency of past coating applications and industry standard coating recommendations the tanks should be completely recoated every 10 to 15 years. Tank coatings can be achieved with an application of a new top-coat or can require a full stripping of existing coating down to bare metal followed by the application of primer and subsequent coating layers to provide the desired protection. Interior coatings can often last longer than exterior coatings and may not require replacement as frequently. Previous coatings for the tanks have been successfully applied as a new top-coat over existing coating. Based on discussions with operations staff, the interiors of the View Acres tanks were inspected during the installation of seismic retrofit measures in 2013 with touch-up coating applied where necessary. For planning purposes, the District should assume that a full external top-coating will be required for both tanks between 2023 and 2028. Completing the coating for one tank at a time would allow the District to continuously provide the required storage for the upper and high pressure zones if draining the tank is determined to be necessary to obtain the adhesion performance required for the exterior coatings.

7.2.2 Booster Pump Stations

The Valley View and View Acres pump stations were last upgraded in 2017 and 2005 respectively. The pump stations are anticipated to require pump and motor replacements every 20 years. The pipe galleries are also anticipated to require a new coating every 20 years, including removing the old coating by sand blasting to bare steel. Based on the timing of the previous upgrades, the View Acres pump station is scheduled for pump and motor replacements as well as pipe gallery maintenance in 2025. The Valley View pump station would not require pump and motor replacements or pipe gallery recoating until approximately 2037, although periodic inspections may indicate a modification to the timing of proposed upgrades.

7.2.3 Pressure Reducing Valves

The District has three PRVs that regulate pressure throughout the system. The District has indicated that each of the PRVs should be rebuilt every five years. Typically this work is performed by an outside contractor and includes a tear-down of each valve to inspect the diaphragm, seats, and other parts subject to wear, and the replacement of any components that have outlived their useful service life. In addition to rebuilding the valve, the PRV vault should also be assessed to determine if additional improvements to address drainage, safe access and egress, and ventilation.

7.2.4 SCADA System

The technological advancement of SCADA and communications components requires periodic upgrades to take advantage of instrumentation and automation that can improve operational efficiency and response to emergencies. In 2013 the District upgraded all communications from radio to cellular modems, and in 2019 the District replaced the programmable logic controllers (PLCs) at the two booster pump stations. The District has indicated that SCADA and PLC upgrades are desirable every 10 to 12 years. In addition to upgrading the SCADA system, the District has identified a benefit to reactivating radio telemetry communications to serve as a backup communications system to the cellular modems. Radio telemetry units would be necessary at four District facilities including Valley View, View Acres, the central operations shop, and the NCCWC WTP. To allow integration of any new SCADA system upgrades and the backup radio telemetry system, both upgrades are recommended to occur in the same year and would between 2023 and 2025. An evaluation of the benefits of standardizing the SCADA system with the wastewater and stormwater systems should also be considered by the District prior to the next round of replacements.

7.2.5 Large Billing Meters

All commercial, industrial, and multi-family billing meters on services of 3-inch diameter or greater are located within vaults that may also include backflow prevention devices that protect the water within the District system from contamination that could originate within the premise plumbing on private property. The revenue generated from these meters can be substantial and testing is recommended on a 3-year frequency. The large meters should also be replaced once the tested accuracy drops below acceptable standards. Meter technology continues to improve and meters should be replaced as they become technologically obsolete, which can be estimated to occur between 10 to 20 years after initial purchase. District billing records currently indicate 82 meters for services ranging from 3-inch to 10-inch diameter. For planning purposes, a representative sample of meters should be tested every 3-years and older meters or those that cannot meet the desired accuracy should be replaced.

7.2.6 Fire Hydrants

The District's current potable water system standards require each fire hydrant to use a 5 ¼-inch valve. Older hydrants exist throughout the distribution system that have a 4 ½-inch valve. Over the next 20-years the District plans to replace all 4 ½-inch hydrants to meet the current standard. Replacements are likely to occur in conjunction with condition based replacements as described in the previous section and with fire flow projects described in the previous chapter. There will still be a remaining number of hydrants outside of the scope of the condition and fire flow projects that will also need to be replaced within the next 20 years.

7.2.7 Non-Buried Asset Rehabilitation & Replacement Projects

The District operations staff identified and prioritized ten projects on non-buried assets at major facility installations and throughout the distribution system. The project timeless are based on age of assets or timing of the most recent upgrades and are and presented in Table 7-3.

Table 7-3. Non-Buried Asset Condition Projects

Project	Facility	Recommended Improvement
C-7	Valley View Reservoirs	Seal coat concrete dome roof of each reservoir within 5-10 years
C-8	View Acres Reservoirs	Recoat interior and exterior of steel tank between 2023 and 2028
C-9	View Acres Pump Station	Replace pumps and motors and recoat pipes by 2037
C-10	Valley View Pump Station	Replace pumps and motors and recoat pipes by 2025
C-11	SCADA	Upgrade SCADA system between 2023 and 2025
C-12	SCADA	Radio telemetry activation study in conjunction with SCADA upgrades
C-13	PRVs	Rebuild PRVs every 5 years
C-14	Large Meters	Meter testing and replacements every 3 years
C-15	Large Meters	Vault meter bypass installation within 5-10 years
C-16	Hydrants	Replace all 4 ¼” hydrants by 2040

SCADA = supervisory control and data acquisition; PRV = pressure reducing valve

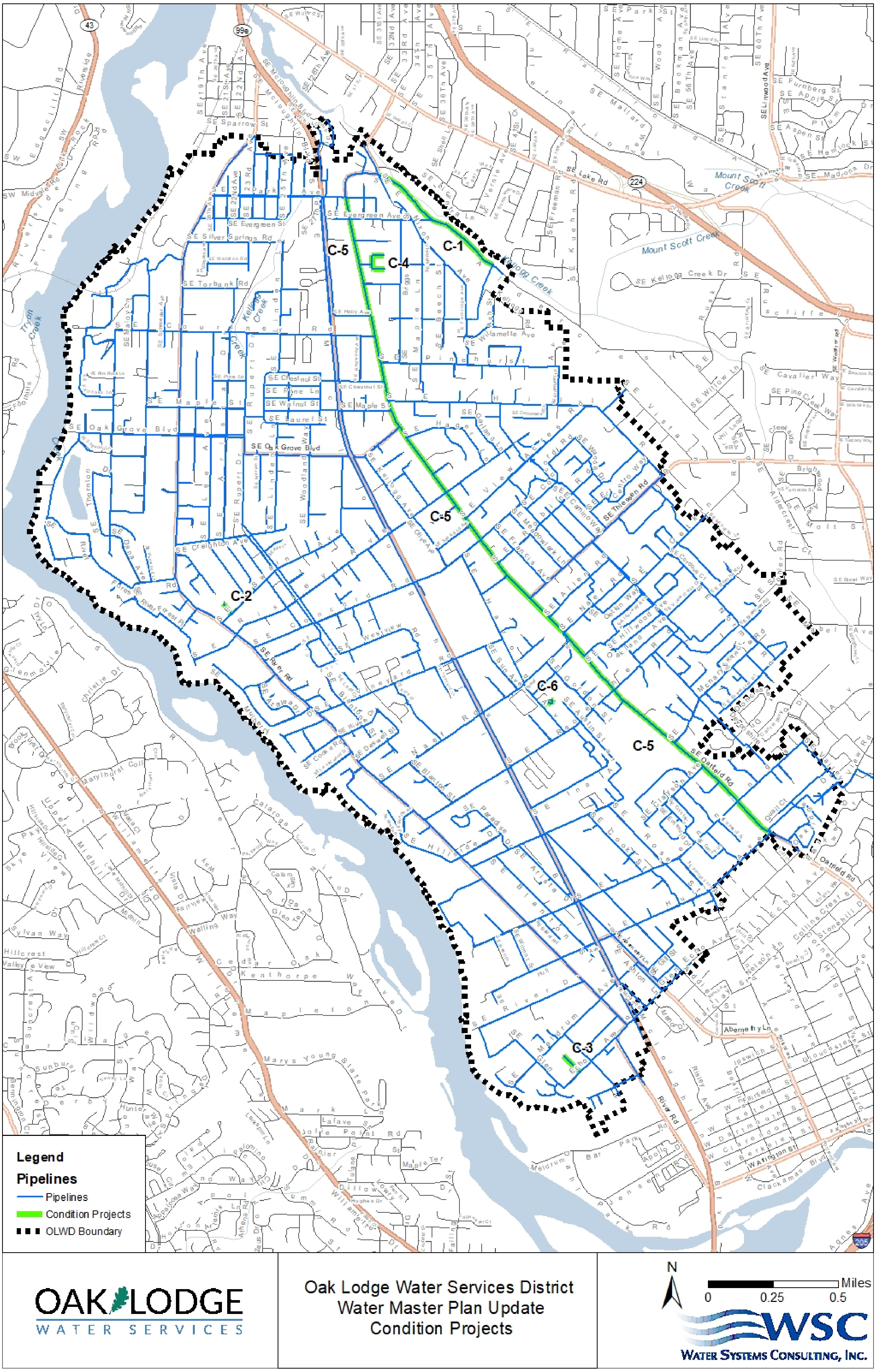

Figure 7-4. Pipeline Rehabilitation and Replacement Projects

CHAPTER 8

Seismic Analysis

In 2018 the Oregon Health Authority updated the requirements for WSMPs to include a seismic analysis with mitigation over the next 50 years. The requirement aligns with recommendations provided in the 2013 Oregon Resiliency Plan which addresses the state's vulnerability to a subduction zone seismic event. This section provides the results of a seismic hazard mapping and fragility analysis along with recommendations to mitigate the risk and improve the resiliency of the District water distribution system following an earthquake.

8.1 Background

In the 1980s, well after a majority of the OLWSD distribution system was installed, the Cascadia subduction zone (CSZ) was recognized as an active fault that poses a major geological hazard to Oregon (OSSPAC, 2013). Recent studies of the CSZ indicate a potential to generate a large earthquake with a magnitude ranging from 8.0 to 9.2. Analysis of the historical recurrence intervals estimates the probability of a high magnitude earthquake originating in the CSZ is approximately 16 to 22 percent over the next 50 years. In the decades since the discovery of the risk associated with the CSZ, Oregon building code has been updated to account for seismic forces in structures and in 2013 the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) developed the Oregon Resilience Plan. The plan provides recommendations for improving the resilience of communities to a CSZ seismic event, including prioritizing the phased restoration of water services.

IN THIS SECTION

Background

Resiliency Planning Requirements

Identification of Critical Facilities

Seismic Hazard Mapping

Pipe Fragility Analysis

Recommended Design Standards

Recommended Improvements

In response to the risk presented by a CSZ seismic event, the District has performed seismic retrofits on the critical water storage facilities at Valley View and View Acres. In 2013 the foundations and anchorage of the View Acres Reservoirs were improved and seismic valves were installed to retain water in the tanks following a CSZ magnitude seismic event. In 2017 mechanical piping improvements were made at the Valley View Reservoirs to add flexibility at tank connections and a seismic valve was installed to retain stored water in the tank immediately following a seismic event.

8.2 Resiliency Planning Requirements

Since the last Water Master Plan Update for the District in 2008, new federal and state requirements have been adopted that require analysis of seismic risk. A brief description of each requirement is provided in the subsequent sections.

8.2.1 Oregon Health Authority

In January 2018, the Oregon Health Authority updated Chapter 333 Division 61 of the OARs which covers Public Water Systems. The update included a new requirement in OAR 333-061-0060.5.J for water system master plans to include a seismic risk assessment and mitigation plan for water systems located in high seismic risk areas, including Oak Lodge. The risk assessment must identify critical facilities, evaluate the likelihood and consequences of seismic failure, and provide a mitigation plan that addresses deficiencies within the next 50 years for any capital improvements or additional studies.

8.2.2 America's Water Infrastructure Act

On October 23, 2018, America's Water Infrastructure Act (AWIA) was passed, tasking the United States Environmental Protection Agency (EPA) with enforcing community water systems serving more than 3,300 people to conduct Risk and Resiliency Assessments and to develop an Emergency Response Plan.

The AWIA Risk and Resiliency Assessments are meant to help the District characterize critical assets and the threats from both natural hazards and malevolent acts. Outcomes from the assessments can then be used to develop appropriate emergency response procedures and planning as part of the District's Emergency Response Plan. The District's compliance deadline for completing the AWIA Risk and Resilience Assessment is June 30, 2021. Preparation of the assessment and planning documents will commence following the completion of this Water Master Plan Update and findings from the seismic analysis will be incorporated.

8.3 Identification of Critical Facilities

As described in the Oregon Resilience Plan, a phased approach to providing water following a seismic event requires having a hardened "backbone" to the water system. The backbone system consists of key supply, treatment, transmission and distribution elements that would help meet community needs, including fire suppression, health and emergency response, and community drinking water distribution points, while damage to the larger, non-backbone system is being addressed. (Oregon Seismic Safety Policy Advisory Commission, 2013)

In accordance with the Oregon Resiliency Plan, the District's water facilities have been separated into three distinct categories representing a descending level of priority for returning the water system to service following a CSZ seismic event:

- **Primary Backbone**. Includes essential components of the water supply and transmission system, including the transmission main from the NCCWC and the Valley View and View Acres pump stations and reservoirs. These facilities will also provide water for fire suppression at key supply points.
- **Secondary Backbone**. Includes distribution pipes which supply potential community distribution centers. For the District, these facilities are assumed to include fire stations and schools, which may serve as emergency shelters.
- **Non-backbone**. The remainder of the distribution system will be necessary to provide potable water to individual residences and businesses and provide fire suppression using existing fire hydrants.

For the District's water distribution system, the primary and secondary backbone systems, as shown in Figure 8-1, consist of pipelines with nominal diameter greater than or equal to 12-inches. The backbone also includes the pipelines necessary to serve critical facilities located within the District's service area, such as public schools and Clackamas Fire District Stations. Although additional facilities are considered critical, such as hospitals, Sheriff's Office Stations, or other public safety facilities (e.g. emergency operations centers), there are none currently identified within the District's service area that would indicate additional backbone pipeline locations.

Water treatment and supply facilities should also be considered part of the Primary Backbone system. The District does not own the shared transmission mains that water from the NCCWC, CRW and SFWB WTPs so these facilities are not considered within the scope of this WSMP. OLWSD will need to work with the partners in the Clackamas River Water Providers group to develop appropriate mitigation measures for these shared facilities. Similarly, any new emergency interconnections within the District's distribution system will require the expansion of the backbone piping system to connect to these intertie locations.

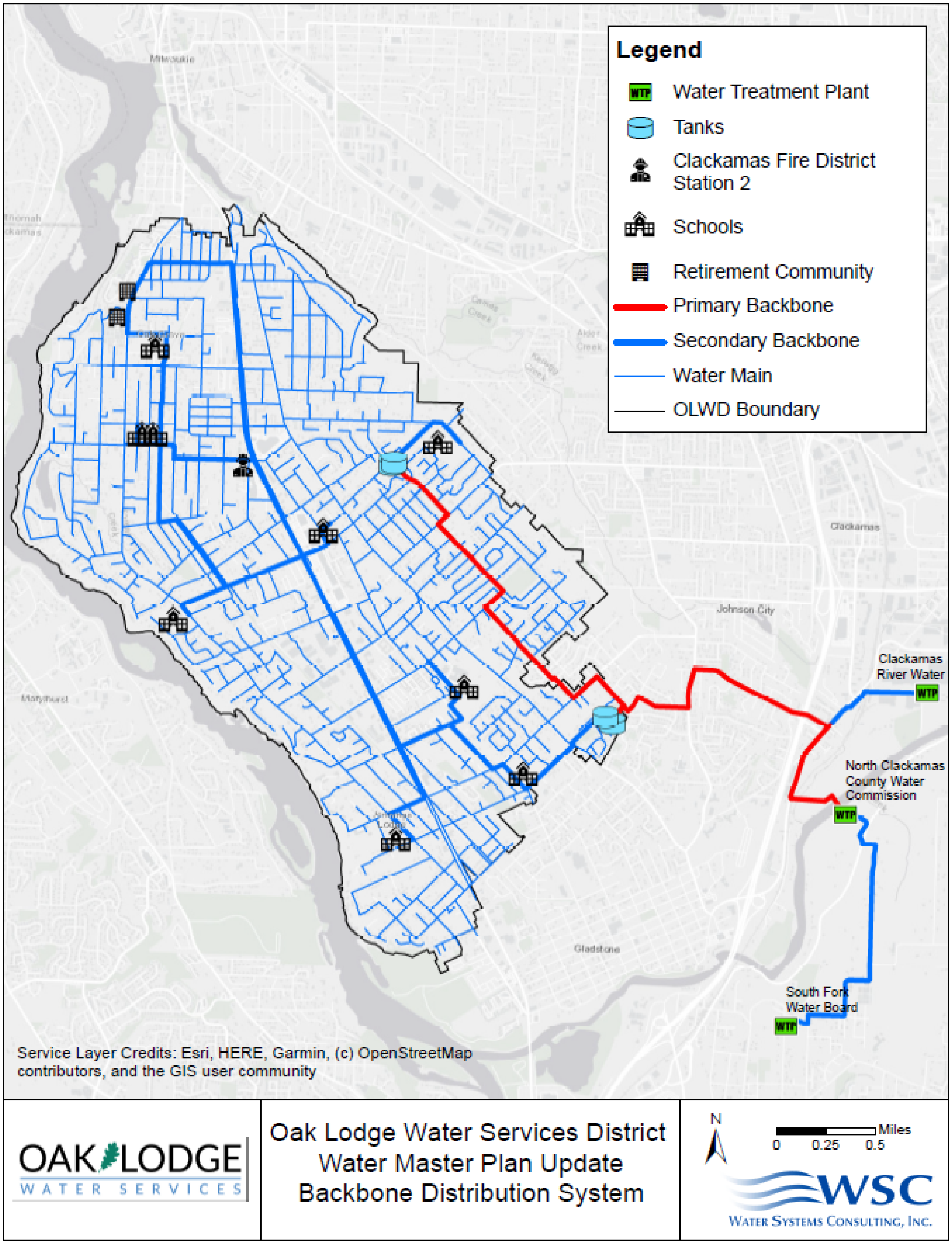

Figure 8-1. OLWSD Water System Backbone Pipelines

8.4 Seismic Hazard Mapping

Subsurface conditions influence the nature of both shallow and surface level responses associated with a seismic event and these conditions are not consistent across the District. To better understand the potential risk of damage to the water system, a seismic hazard map is helpful to compare the expected seismic responses based on existing subsurface conditions with the locations of critical water facilities.

McMillan Jacobs Associates (MCMJ) prepared a geotechnical seismic hazards evaluation for the District's service area by reviewing Oregon's Department of Geology and Mineral Industries (DOGAMI) seismic hazard maps for a magnitude 9.0 CSZ earthquake, reviewing available geological and geotechnical information, and performing site reconnaissance to confirm key assumptions and verify published maps. Based on the field data and site reconnaissance, MCMJ refined the DOGAMI seismic hazard maps to provide best estimates for strong ground shaking, liquefaction-induced settlement, lateral spreading permanent ground deformation, and seismic landslide instability within the District's service area. An overview of these seismic hazard parameters is provided below:

- Peak Ground Velocity (PGV) – the ground shaking near the surface, which is amplified by thick soil units, and varies based on the subsurface materials. It serves as a measure for the amount of ground shaking a buried pipeline experiences. For the District's service area, the PGV ranged from 7 to 16 inches per second.
- Peak Ground Acceleration (PGA) – the measure for ground shaking used for above ground components. A PGA of 0.20 g was used to represent the effects of a magnitude 9.0 CSZ seismic event within the District's service area.
- Liquefaction-Induced Settlement – settlement within saturated, granular soils caused by rapid shearing from an earthquake that results in the soil losing its shear strength and becoming a viscous fluid mass. Much of the District's service area is located within non-liquefiable soils but there are sections where liquefaction is expected to be as high as 4 inches.
- Lateral Spreading – the lateral movement of liquefied soils that occurs when the ground acceleration from a seismic event causes liquified soil to move laterally and break the non-liquefied soil crust into blocks, that then move downslope. During a magnitude 9.0 CSZ event, the southwestern third of the District's service area is expected to experience lateral spreading, with permanent ground deformation of up to 2 feet.
- Seismic Landslide Instability – landslides that occur on slopes when an earthquake adds additional loading to the slope.

The results of the MCMJ study, including seismic hazard mapping, is provided in a Technical Memorandum included as Appendix B. The areas of elevated hazards associated with peak ground velocity, liquefaction-induced settlement, lateral spreading, and seismic induced landslides in relation to the Primary and Secondary backbone systems are provided in Figure 8-2 through Figure 8-5.

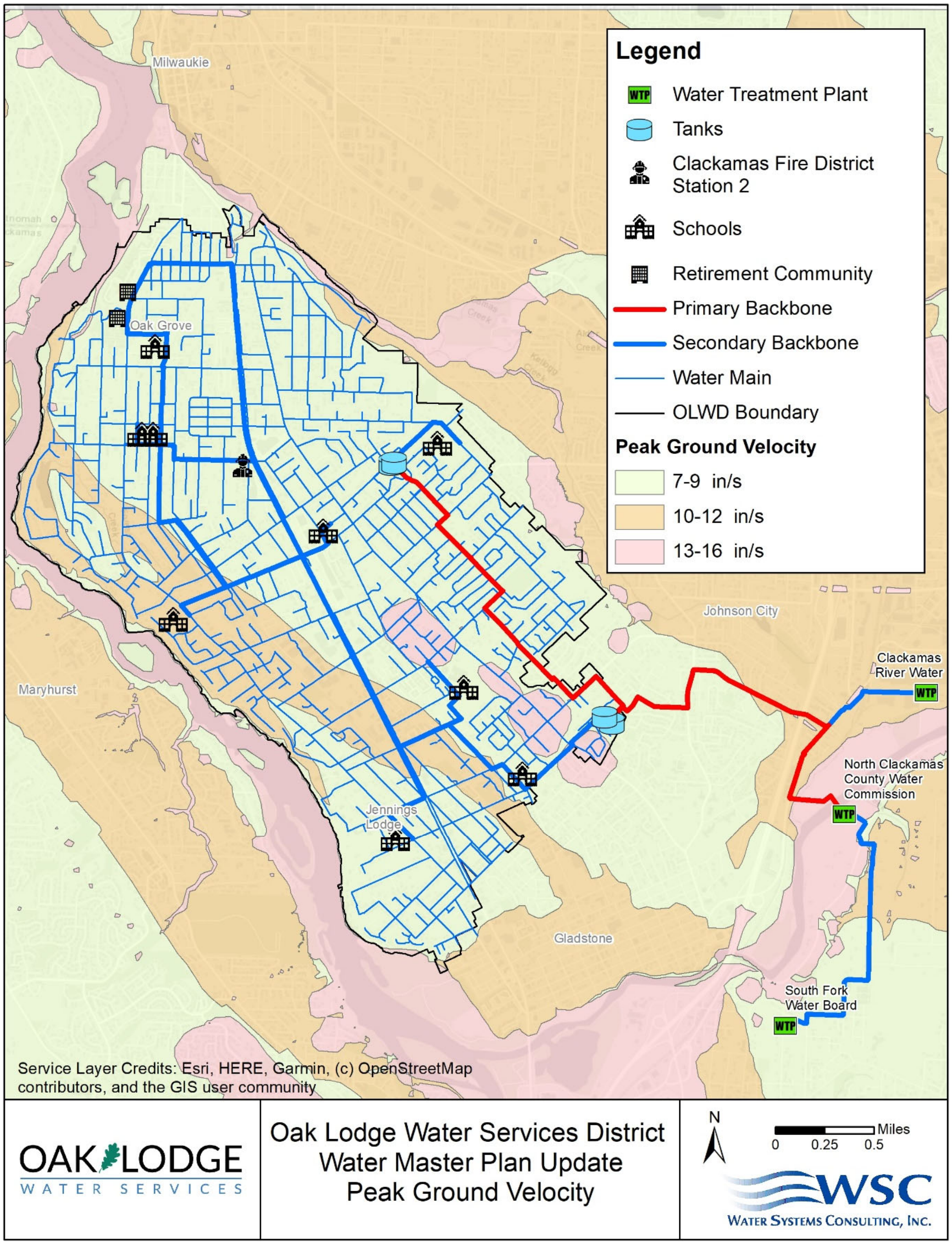

Figure 8-2. District Mapping of Peak Ground Velocity

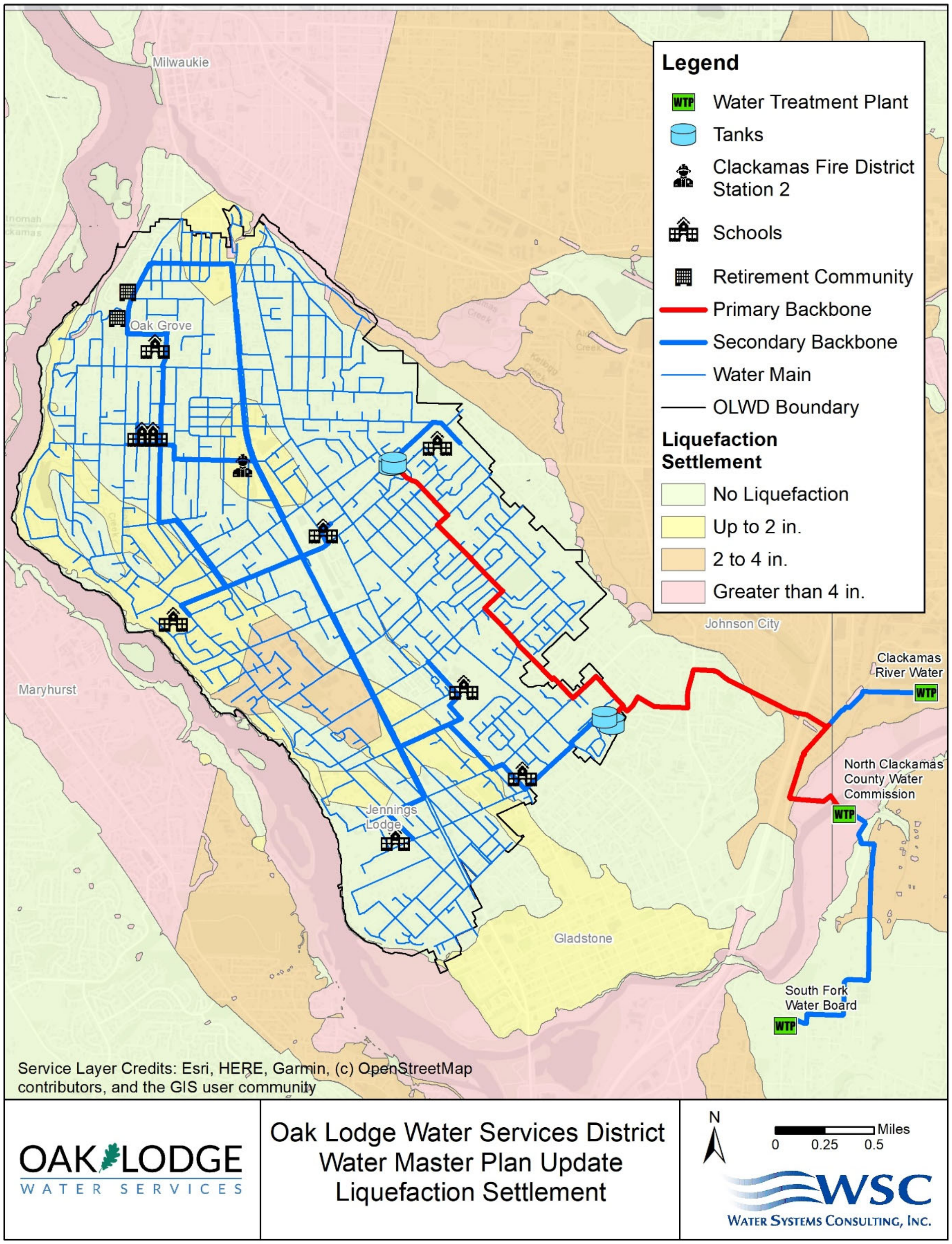

Figure 8-3. District Mapping of Seismically Induced Liquefaction Settlement

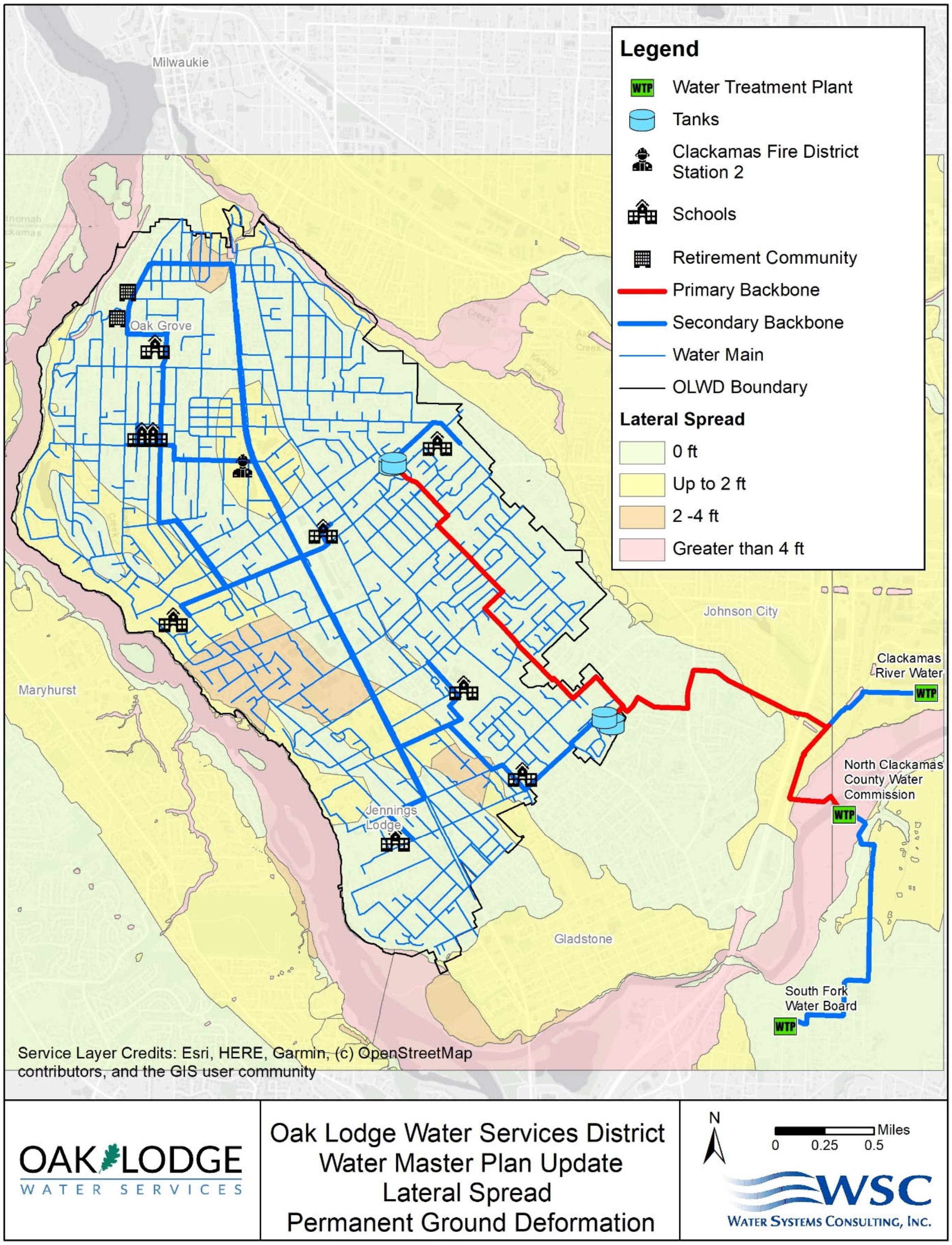

Figure 8-4. District Mapping of Lateral Spreading Peak Ground Deformation

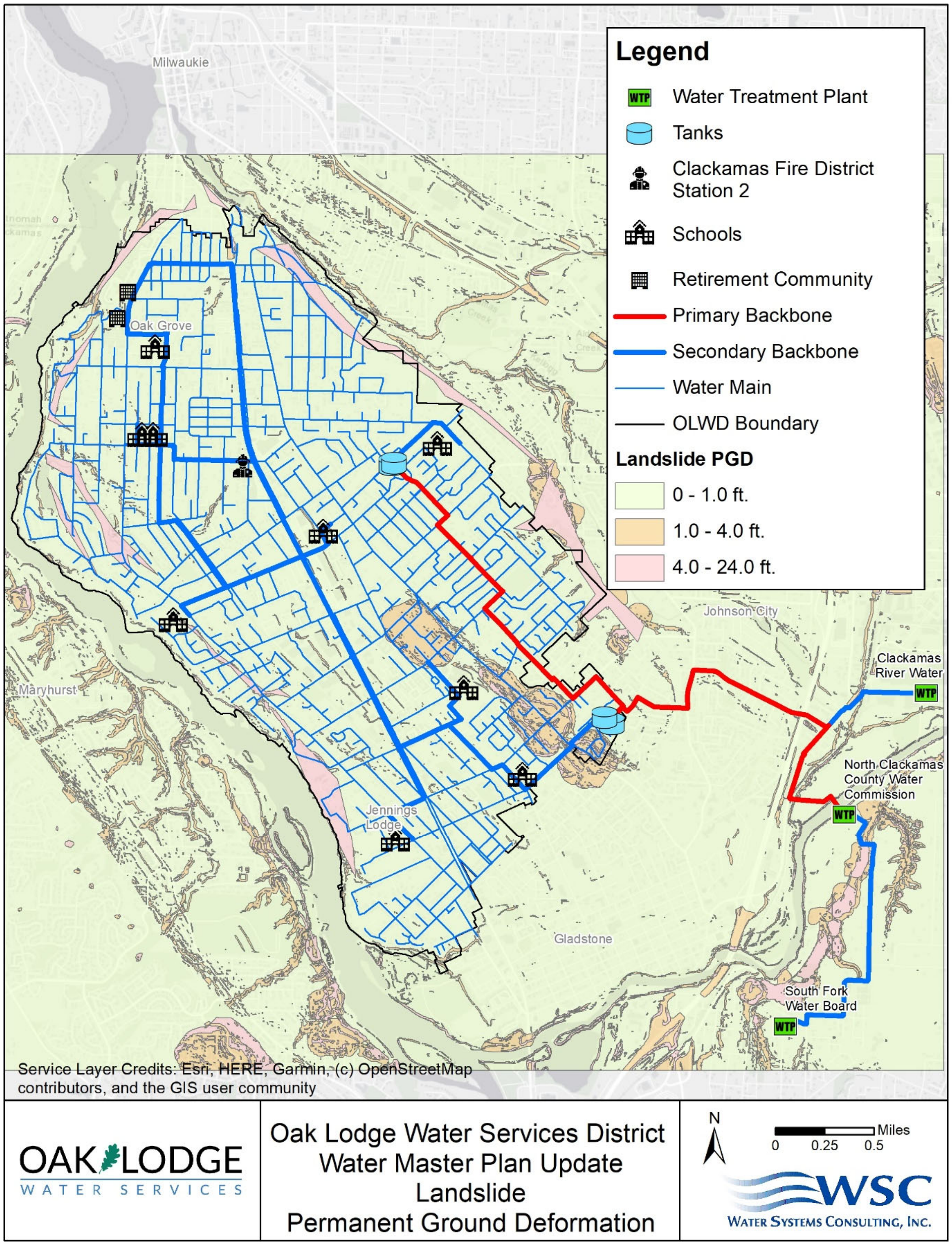

Figure 8-5. District Mapping of Seismic Landslide Peak Ground Deformation

8.5 Pipe Fragility Analysis

In 2012 the District performed a seismic vulnerability assessment of the reservoirs at the View Acres and Valley View facilities that resulted in seismic retrofits in 2013 and 2017, respectively. A review of the seismic vulnerability assessment does not indicate that a seismic assessment of the pump stations was performed. Since the District's storage facilities have been recently addressed and an assessment of the pumping station structures is not available, the piping system will be the focus of seismic analysis.

The guidelines and methodology provided in the American Lifelines Alliance's (ALA) *Seismic Fragility Formulations for Water Systems,* in combination with the seismic hazards evaluation, was used to evaluate the District's water distribution system. The ALA developed empirical algorithms to predict the repair rate (repairs per 1,000 feet of pipe) based on data collected from major past seismic events, including, but not limited to, the 1994 Northridge Earthquake, 1989 Loma Prieta Earthquake, and the 1971 San Fernando Earthquake. The key data used to predict repair rates include the following data:

- **Pipeline material**. Findings from past earthquakes have indicated that ductile pipe materials such as ductile iron, steel, and plastic exhibit less breaks compared to rigid and brittle materials such as cast iron. Each pipe material correlates to a fragility curve modification factor, K_1 and K_2, that represents the ability of the pipe and joints to withstand ground movement and deformation.
- **PGV.** The magnitude of the ground velocity, as measured in inches per second (in/s), exhibits a linear relationship with the amount of pipe breaks.
- **Permanent ground deformation (PGD)**. The ground deformation measured in inches, whether caused by liquefaction induced settlement, a seismically induced landslide, or lateral spreading, exhibits a power, or exponential, relationship with the amount of pipe breaks.

Some assumptions are required to select K factors for the pipeline material. The ranges of observed fragility curve modifications by pipe type are provided in Table 8-1 below along with the values assumed for the District's distribution system.

Table 8-1. Fragility Curve Modification Factors by Pipe Type

Pipe Material	K_1 Typical Range	K_1 Assumed Value	K_2 Typical Range	K_2 Assumed Value	Supporting assumptions
Cast Iron	0.7-1.4	0.8	0.7-1.0	0.8	Assume rubber gasket joints
Ductile Iron	0.5	0.5	0.5	0.5	Assume rubber gasket joints
Steel	0.15-1.3	0.7	0.15-0.7	0.7	Assume rubber gasket joints
Copper	NA	0.3	NA	0.15	Equivalent to welded steel
PVC	0.5	0.5	0.8	0.8	Assume rubber gasket joints
HDPE	NA	0.3	NA	0.15	Equivalent to welded steel

Equation 1: $\boldsymbol{RR = K_1 * 0.00187 * PGV}$ **Equation 2:** $RR = K_2 * 1.06 * PGD^{0.319}$

NA = not available RR = rate of repairs per 1,000 feet of pipe K_1 = fragility curve modification factor for ground shaking
K_2 = fragility curve modification factor for permanent ground deformation PGV = peak ground velocity in inches per second
PGD = peak ground deformation in inches
Values for typical range of K_1 and K_2 take from American Lifelines Alliance Seismic Fragility Formulations for Water Systems

Using the seismic hazard mapping and the ALA fragility calculations, estimated repair rates per 1,000 feet of pipe were calculated for the primary, secondary, and non-backbone pipelines within the District's water system. A graphic representation of the repair rates for the backbone system and the water distribution system as a whole are shown in Figure 8-6 and Figure 8-7, respectively.

Based on the analysis, the District's primary backbone system shows vulnerability to breakages during a CSZ seismic event within the District owned 24-inch water supply pipeline and within the NCCWC combined pipeline near the WTP. A break in the 24-inch water supply pipeline carries a particularly high risk to the District as there is currently no other infrastructure that can be used to supply emergency demand.

Sections of the secondary backbone system also predict breakage rates that exceed 1.0 breaks per 1,000 feet and thus are likely to require repairs immediately following an earthquake. Assuming that these breaks can be isolated, the District's looped system may still allow water service to schools and fire stations to provide emergency access, so retrofitting the secondary backbone to withstand a seismic event has a lower priority than the primary system.

Smaller pipes in the distribution system are predicted to break at a frequency of 2.0 breaks per 1,000 feet or greater in the areas of the lower pressure zone near the Willamette, and within areas of higher risk to ground deformation due to liquefaction induced settlement, lateral spreading, or landslides. Although retrofitting these pipes to improve the performance following an earthquake is desired, the priority for implementing these repairs should be considered lower than that of the primary and secondary backbone pipelines. A summary of the anticipated linear footage of pipe requiring repairs as well as the estimated replacement costs is provided in Table 8-2.

Table 8-2. Prioritization for Addressing Pipe Fragility within District system

Priority Level	Criteria	Total Length (feet)	Pipe Diameter (inches)	Total Replacement Cost
High	Primary Backbone pipelines with 0.5 or greater repairs per 1,000 feet	7,246	24 to 36	$3.4M
Medium	Secondary backbone pipeline with 1.0 or greater repairs per 1,000 feet	14,184	6 to 24	$4.8M
Low	Secondary backbone pipeline with greater than 0.5 but less than 1.0 repairs per 1,000 feet	23,033	6 to 24	$5.3M
Low	Non-backbone pipelines with 1.0 or greater repairs per 1,000 feet	124,575	6 to 8	$20.8M

The replacement costs provided in the table reflect recommendations for seismically resilient pipe standards discussed in the following section.

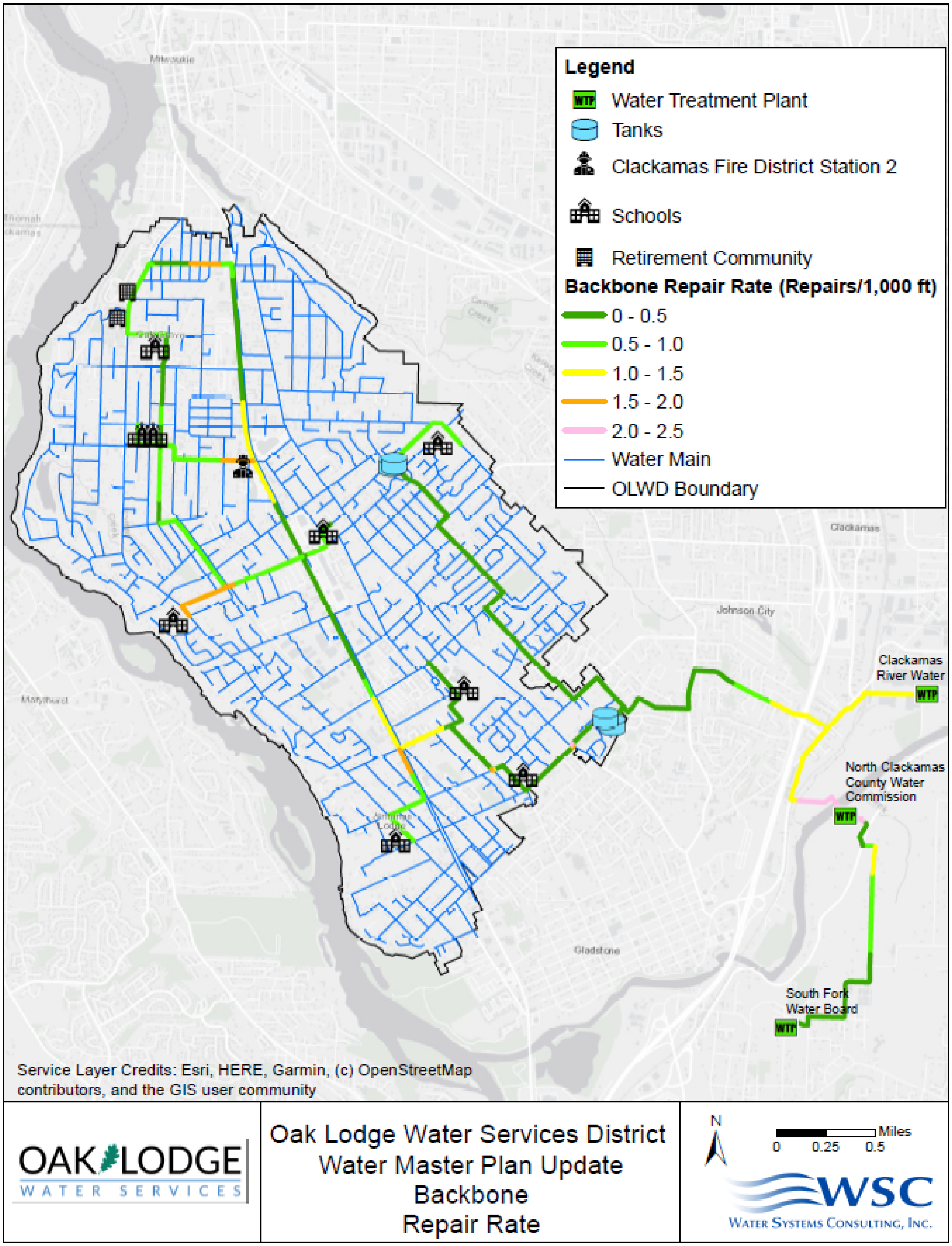

Figure 8-6. OLWSD Backbone Distribution System Repair Rates

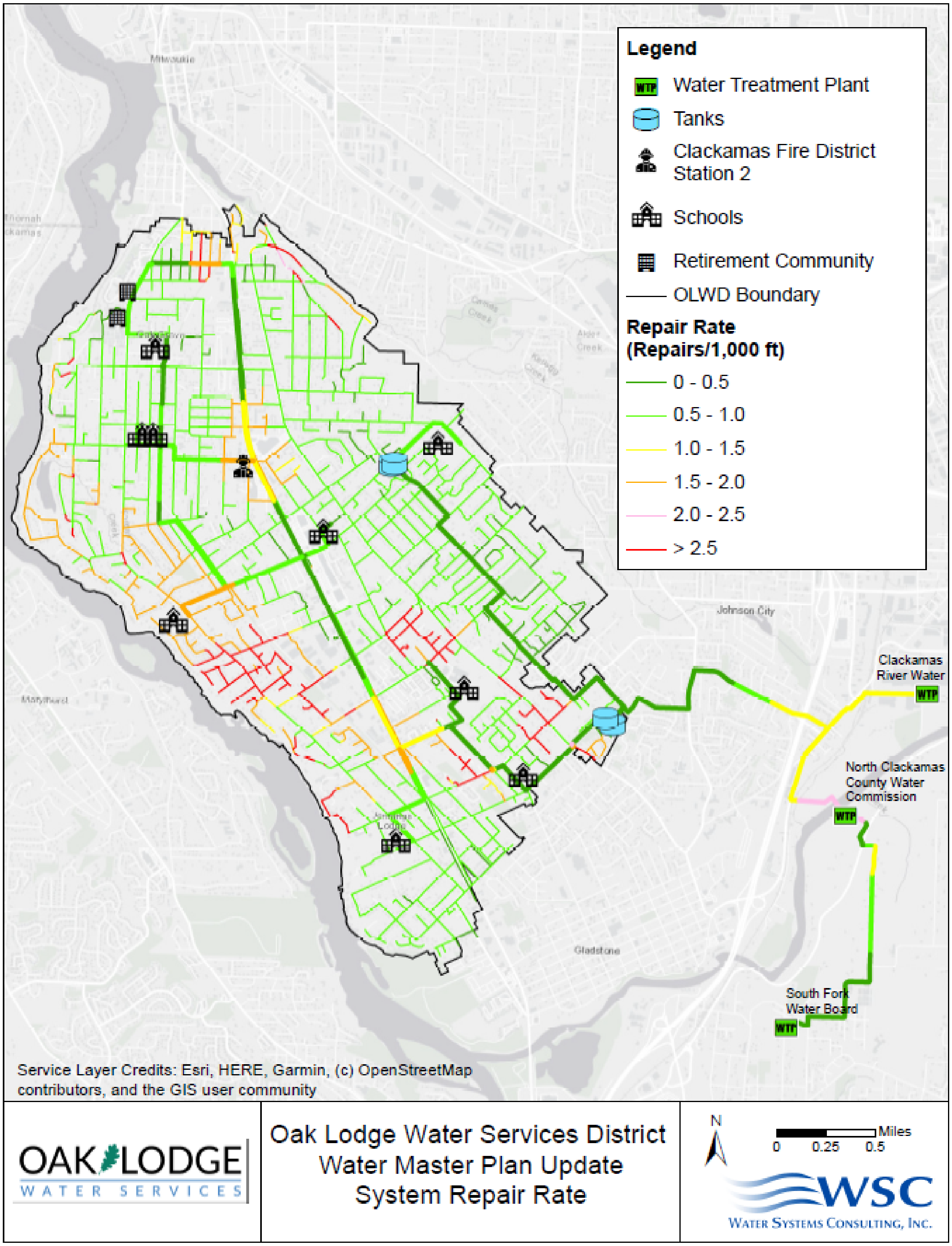

Figure 8-7. OLWSD Water Distribution System Repair Rates

8.6 Recommended Design Standards

The District's 2019 Design and Construction Standards require all new water distribution piping to be ductile iron cement mortar-lined pipe with push-on or mechanical joints. All bell and spigot joints must be restrained using Field LOK (or equivalent) gaskets. Pipelines and fittings should be encased with 8 mil polyethylene tubing meeting manufacturer and AWWA standards in areas with corrosive conditions. All fittings must be restrained by joint restraint glands and thrust blocks or "rodding" are not permitted. The District's standards allow alternative pipeline materials to be used in locations where there is an active cathodic protection system protecting other systems near the pipe.

The District does not currently have any seismic design standards for water pipelines. Seismically resistant pipeline design varies on a site by site basis due to the important role subsurface conditions play within the design of these systems. As such, there is no industry standard seismic pipeline design document at this time. District Design Standards should be updated to require fully restrained ductile iron pipe and appropriate pipe connections to accommodate anticipated PGD for all backbone pipelines. HDPE pipe with fused joints and steel pipe with double welded joints are suitable alternatives for seismic design and may be recommended on a case-by-case basis by the design engineer.

Seismically resilient pipe material must be sufficiently ductile to accommodate deformations without failing and must use joints that are sufficiently restrained such that slight deformation of the pipe will occur before the joint fails. In areas where PGD is anticipated to be relatively minor, ductile iron pipe with restrained joints should allow some deformation in response to ground movement without pulling joints apart or breaking pipes. In areas where significant PGD is anticipated, ductile iron pipe with seismic joints that allow rotation, deflection of up to 15 degrees, and expansion/contraction of up 1 percent of pipe segment length may be necessary to accommodate the ground movement without the pipe or joint failing. A description of recommended pipe replacement materials for both backbone and non-backbone pipe is provided in Table 8-3.

Table 8-3. Recommended Design Standards for Pipe Replacement

Pipe Type	Corresponding Seismic Hazard Zones	Replacement Pipe Material
Backbone	Lateral spreading with PGD up to 2 feet or greater Seismic landslide with PGD 1 foot or greater	Ductile Iron Pipe w/ Seismic Joints
Backbone	No lateral spreading risk Seismic landslide with PGD less than 1 foot	Restrained Ductile Iron Pipe
Non-backbone	Lateral spreading with PGD up to 2 feet or greater Seismic landslide with PGD 1 foot or greater	Restrained Ductile Iron Pipe
Non-backbone	No lateral spreading risk Seismic landslide with PGD less than 1 foot	Current Design Standards

PGD = peak ground deformation

Although some of the backbone pipe was not included within the high, medium, or low priority groupings provided in Table 8-2, the recommended design standards would still require that all backbone pipe is replaced with restrained ductile iron pipe as it reaches the end of its useful life.

8.7 Recommended Improvements

Based on the results of the pipeline fragility analysis, recommendations are provided for installation of new emergency interties, a seismic study of the 24-inch diameter supply line, and replacement of selected segments of the backbone and non-backbone pipelines.

8.7.1 Emergency Interties

With a single source of supply through the 24-inch pipeline from the NCCWC, the District is vulnerable to an outage caused by an unplanned pipe break. Portions of the pipeline closer to the Clackamas River are expected to have an increased risk of breakage due to lateral spreading and liquefaction induced settlement. As shown in Figure 8-6, the NCCWC WTP is also located in an area of elevated seismic risk, as are the interconnecting pipelines that allow the NCCWC to purchase emergency supply from CRW or the SFWB. Furthermore, all of these water sources rely on the Clackamas River as the primary source of supply.

To increase the ability to reliably deliver water under potential adverse conditions such as curtailment due to drought conditions, toxic algae blooms, seismic events, or other natural hazards, the District conducted a study to determine the feasibility and preferred alternatives for construction of new emergency interties to neighboring water agencies. After a thorough review, two emergency intertie connections were identified that could each deliver the emergency level of service demand of 2.7 MGD:

- **Clackamas River Water Intertie at the Intersection of Strawberry Lane and Webster Road**. The 24-inch diameter water supply pipeline is located immediately adjacent to a 12-inch diameter CRW transmission main. A booster pump station could be used to pump water from the CRW system into the Valley View tanks at an estimated cost of $1,248,000.
- **City of Milwaukie Intertie at River Road and Lark Street**. An existing 10-inch diameter main in the Milwaukie system is located adjacent to existing 8-inch diameter District main along River Road. A booster pump station could be used to pump water from Milwaukie’s lower zone to the District’s lower zone to fill the Valley View tanks. Upsizing of 2,000 feet of pipe along River Road to 12-inch diameter would be required at an estimated cost of $1,789,000.

A full description of all alternatives that were considered and ranked is provided in Appendix C. Based on hydraulic modeling of the alternatives, a similarly sized 35 horsepower pump would be sufficient at each location. A single trailer-mounted portable pump station could be used to provide flexibility to use either intertie in an emergency. The estimated combined cost for a portable pump station is approximately $3M which is similar in cost to constructing two separate emergency pump stations. A preliminary design is recommended to refine the locations, costs, agreements, and permits required for construction of the proposed emergency interties.

Due to the current vulnerability without any redundant supply options in an emergency, the construction of an emergency intertie is recommended as a high priority improvement. Conversations with both CRW and the City of Milwaukie have indicated there is mutual interest, although the City of Milwaukie indicated that they may not be able to complete the necessary modeling to confirm pipe sizing until the next biennial budget cycle in 2023. Thus, proceeding with an intertie with CRW is recommended first, to be followed with an intertie with Milwaukie.

8.7.2 Seismic Study of 24-inch Supply Pipeline

The District's 24-inch supply line was constructed in the late 1960s. Record drawings indicate the pipe is class 175 ductile iron, but there is no indication of the joints used. Replacement of the pipeline will be technically challenging and costly, as the alignment is located within easements through private property, crosses underneath I-205, and would require temporary bypassing of supply flows to the District.

A seismic vulnerability study is recommended for the pipeline to better determine the anticipated magnitude of PGD at locations along the alignment where landslides or lateral spreading are anticipated for comparison against the ability of the aged pipe materials and joints to respond to the ground movement. The scope of such a study should include in-situ condition assessment of the pipeline, including carrier and casing pipe at the I-205 crossing, documentation of pipe material condition and joint type, site-specific geotechnical data along the alignment, and specific recommendations for improvements. The cost of such a study is estimated to be $200,000. The study is recommended as a high priority for the District and should be performed as soon as possible. The study should also include a structural seismic assessment of the Valley View and View Acres pump stations. The pump stations are also considered part of the primary backbone system and it is not clear if these facilities have undergone a seismic assessment.

8.7.3 Replacement of Medium Priority Pipelines

As described in Table 8-2, approximately 14,200 linear feet of the secondary backbone piping will need to be updated to meet the proposed seismically resilient design standards at an estimated cost of $4.4M. In accordance with the Oregon Resiliency Plan, the priority for restraining the secondary backbone piping is considered to be secondary in priority to the primary backbone piping. Much of the secondary piping identified for restraining overlaps with projects identified to address fire flow or condition deficiencies within previous chapters. Thus, it is recommended that only those pipes that also present fire flow or condition deficiencies are included within the 20-year CIP. To avoid excessive burden to customers, restraining of medium priority pipelines should occur as pipes reach the end of their useful life or are identified for capacity deficiencies.

8.7.4 Replacement of Non-Backbone Pipelines

Replacement of backbone pipelines that are predicted to experience greater than 0.5 but less than 1 repair per 1,000 feet of pipe, and those non-backbone pipelines that are predicted to experience greater than 1 repair per 1,000 feet, should be improved over the next 50 years as defined in OAR 333-061 but are considered to be the lowest priority. There is approximately 150,000 feet of pipe in this category that represents a total replacement cost estimated at $26.1M. Some of the pipe identified for replacement overlaps with projects previously identified to alleviate fire flow capacity or condition deficiencies and is recommended for replacement in the 20-year CIP.

The remaining low-priority pipe should be prioritized for replacement between 2040 and 2070 to mitigate the seismic risk throughout the distribution system. The average rate of spending of $870,000 per year would be less than the recommended replacement rate of $1.4M (or 1 mile of pipe) per year recommended for addressing condition deficiencies. Assuming that sufficient funding will be provided to achieve the minimum replacement rate over the 20-year CIP, there would be enough capital budget each year to prioritize the medium and low priority seismic pipe replacements over the next 50 years. Thus, specific identification of seismic mitigation projects for medium and low-priority pipelines are not included within the CIP.

CHAPTER 9

Water Quality

The purpose of this chapter is to review the District's water quality compliance with current drinking water regulations provided by OAR 333-061 and the U.S. EPA. The regulatory review includes a brief description of current and proposed water quality regulations that apply to the OLWSD water system, a description of water quality monitoring and sampling practices, and a summary of the water quality results and compliance.

9.1 Regulatory Review

Drinking water regulations are established by the U.S. EPA to protect drinking water quality. State health departments typically assume the role of primacy agency and are responsible for enforcing drinking water regulations at the state level. Any drinking water regulations that are promulgated by the state are required to be at least as strict as the U.S. EPA regulation and in some cases may be more stringent than the U.S. EPA regulation. In Oregon, the OHA Drinking Water Program is the responsible agency for drinking water regulations. The regulations are detailed in OAR 333-061. This review includes OHA Drinking Water Program rules that are relevant to the District's distribution system.

IN THIS SECTION

Regulatory Review

Regulatory Schedule

Water Quality Compliance

9.1.1 Current Regulations

The rules described in this section address distribution system water quality and are the responsibility of the District. The description under each rule only includes aspects of the rule that are relevant to the District.

9.1.1.1 Stage 1 and Stage 2 Disinfectants and Disinfection Byproducts Rule (DBPR)

The Stage 1 DBPR established maximum contaminant level goals (MCLGs) and maximum contaminant levels (MCLs) for total trihalomethanes (TTHMs) and haloacetic acids (HAA5s). The MCL for TTHM is 0.080 milligrams per liter (mg/L) and HAA5 is 0.060 mg/L. The maximum residual disinfectant limit (MRDL) was set to 4.0 mg/L as an annual average.

The Stage 2 DBPR requires monitoring sites to reflect areas of the system that exhibit highest disinfection byproduct (DBP) concentrations and at least one quarterly monitoring period that reflects peak monthly DBP concentrations. Stage 2 DBPR also requires that each MCL be met by a running average at each of the monitoring locations rather than a system total average for all locations. The District collects samples from four (4) compliance locations within the distribution system.

9.1.1.2 Lead and Copper Rule (LCR) – Promulgated in 1991

The LCR requires systems to monitor drinking water for lead and copper at customer taps every 6 months. The sample size is based on the size of the water system. If lead concentrations exceed an action level (AL) of 15 parts per billion (ppb) or copper concentrations exceed an AL of 1.3 parts per million (ppm) in more than 10 percent of the customer taps sampled, additional actions are required that may include water quality parameter monitoring, corrosion control, source water monitoring or treatment, public notification and education, and lead service line replacement programs. Water systems may qualify for reduced monitoring schedules if the water system meets the appropriate criteria.

The LCR has undergone various revisions since inception with the most recent being in 2007. The following revisions were made:

1. An additional requirement that prevents water systems that exceed the action limit to be able to remain on a reduced monitoring schedule.
2. Water systems must provide advanced notification and gain approval of the primacy agency before changing treatment or source water that could impact corrosion.
3. Notification of water monitoring results at customer taps must be provided to those customers.

Adjustments were made to the lead service line replacement requirements.

9.1.1.3 Revised Total Coliform Rule (RTCR) – Promulgated in 2013

The Total Coliform Rule (TCR) was established in 1989 and required that total coliform samples be collected at sites representative of water quality throughout the distribution system. The total number of samples required was based on the population served. A monthly MCL violation is triggered if greater than five percent of monthly samples are positive for total coliforms. Directly following violations, the state and the public must be informed of the violation and a repeat sample must occur.

The RTCR, promulgated in 2013, established an MCL for Escherichia coli (E. coli) as a reliable indicator of fecal contamination. The E. coli MCL is exceeded if the sample tests positive and is confirmed by a repeat positive sample. The MCL also qualifies as exceeded if the repeat sample is not taken or when a sample tests positive for total coliform and is confirmed with a second sample of Escherichia coli (E. coli). The RTCR also sets a total coliform treatment technique (TT) requirement that triggers differing levels of assessment following an MCL violation. Requirements for monitoring locations and schedules are established according to the specific water system.

9.1.1.4 Unregulated Contaminant Monitoring Rule 4 (UCMR4) – Promulgated in 2016

The fourth UCMR requires monitoring for 30 unregulated chemical contaminants between 2018 and 2020. This monitoring data is used by the USEPA to inform future regulatory actions. Water systems are required to monitor for cyanotoxins, metals, pesticides, alcohols, semivolatile chemicals, indicators, and three brominated haloacetic acid groups. The District monitors the haloacetic acid groups for the UCMR4 at the entry point to the distribution system and at the same four monitoring locations identified for compliance with the Stage 2 DBPR in the distribution system. Samples at the surface water intake to the NCCWC WTP are collected by the NCCWC.

9.1.1.5 Public Notification Rule (PNR) – Promulgated in 2000

The PNR requires the public water system to notify their customers when the water system violates USEPA regulations, State regulations or monitoring requirements. The PNR establishes notification levels based on violations.

9.1.1.6 Consumer Confidence Report (CCR) – Promulgated in 1996

The CCR rule requires that public water systems with more than 500 customers prepare an annual CCR to inform customers about water quality data. The report is required to contain a specific list of information.

9.1.2 Future Regulations

The rules described in this section are only those relevant to distribution systems that will likely impact the District and are pending review by U.S. EPA.

9.1.2.1 Lead and Copper Long Term Revisions

The U.S. EPA has discussed and is working to establish long-term revisions that will replace the short-term revisions made to the LCR in 2007. Revision items include lead service line replacements, sample site selection, tap sampling, corrosion control, and public education about copper.

9.1.2.2 Use of Lead-Free Materials for Drinking Water

The USEPA is currently reviewing a proposed regulation for the use of lead free pipes, fittings, fixtures, solder, and flux for drinking water systems. The regulation would modify the definition for lead free plumbing and prohibit a lead level above 25 percent.

9.2 Regulatory Schedule

The District complies with the regulatory schedules in

Table 9-1 to meet all regulatory rule requirements. The District is currently on a reduced monitoring schedule for the LCR.

Table 9-1. Regulatory Schedules

Regulation	Regulatory Schedule
Stage 2 Disinfectant and Disinfection Byproduct Rule	The District is required to test four (4) samples for TTHM and HAA5 on a quarterly schedule during the months of October, January, April, and July.
Lead and Copper Rule	The District is required to take 30 samples every three (3) years between June 1 and September 30. Customer notice of sample results is required. The last sample occurred in 2017.
Revised Total Coliform Rule	The District is required to take 30 routine samples on a monthly schedule.
Public Notification	The District is required to notify customers of any violations or issues with drinking water.
Consumer Confidence Reports	The District is required to provide an annual report to inform users of the water quality in the District.

TTHM = total trihalomethanes; HAA5 = haloacetic acids

9.3 Water Quality Compliance

The District is responsible for water quality sampling at the entry point to the distribution system and within the distribution system. This includes conducting water quality tests for coliform bacteria, DBPs, lead, copper and unregulated contaminants. The District also maintains one online sampling station at the View Acres Pump Station which monitors chlorine residual. This monitoring station is connected to the District's SCADA system. NCCWC performs water quality testing at the surface water intake and water treatment plant. All water quality sampling results are publicly available on the OHA website at https://yourwater.oregon.gov.

9.3.1 Disinfection Byproducts

The District is required to collect four samples per quarter to determine compliance with the Stage 2 DBPR. District average total TTHM and HAA5 levels have been well below their respective MCLs in 2018.

9.3.2 Lead and Copper Rule

The District monitors lead and copper on a reduced schedule. The District collects 30 samples every three years between June 1 and September 30. The NCCWC WTP installed a corrosion control unit in 2005 that raises pH to prevent metal leaching from plumbing fixtures. The last monitoring cycle occurred in 2017 and lead and copper samples were well below action levels at all the monitoring locations. Results were provided to customers.

9.3.3 Total Coliform Rule

The District collects 30 total coliform samples each month in compliance with the TCR. The District has never exceeded the maximum monthly five percent positive samples allowed under the TCR. In 2018 the District did not detect any positive samples.

9.3.4 Consumer Confidence Report

The most recent (2018) CCR is provided in Appendix D. In addition to water quality data within the District's distribution system, the CCR includes raw and treated water quality data for the NCCWC WTP, which is provided by NCCWC.

CHAPTER 10

Capital Improvement Program

The previous chapters have identified improvement projects that address level of service deficiencies, rehabilitation and replacement of aging infrastructure, and mitigation of seismic risk. The purpose of this chapter is to recommend a water system CIP to be completed over the next 20 years that includes a schedule for implementation. Options to be explored for funding and financing the recommended improvements over the planning period, including an analysis of system development charges, are also included.

10.1 Methodology

The following sections describe the basis and assumptions used to develop cost estimates for recommended projects, a brief summary of the calculations used to identify SDC eligible costs, and the criteria used to prioritize individual projects within the CIP.

IN THIS SECTION

Methodology
Recommended CIP
Capital Improvement Projects
Funding and Financing
Summary

10.1.1 Cost Estimating Basis and Assumptions

Engineering opinions of probable construction costs (estimates) have been developed for each of the projects identified in previous chapters. The design concepts and associated costs presented in this CIP are conceptual in nature due to the limited design information that is available at this stage of project planning. For pipeline replacement projects, District GIS data was used to estimate quantities for pipeline length, depth, fittings, valves, hydrants, services, and pavement restoration. The scope of work for non-pipeline projects and studies were approximated based on equipment and/or facility size and comparison with similar replacement projects. As each project progresses into design and construction, the associated costs may vary as project-specific requirements are identified.

All estimates provided in this chapter were prepared in conformance with the Class 4 Conceptual Report Classification of Opinion of Probable Construction Costs as developed by the Association for the Advancement of Cost Engineering (AACE International). The purpose of a Class 4 Estimate is to provide a conceptual level of effort that is expected to range in accuracy from -30 percent to +50 percent. A Class 4 Estimate also includes an appropriate level of contingency so that it can be used in future planning and feasibility studies. These cost estimates are based on unit costs developed using a combination of data from RS Means CostWorks® and recent bids, experience with similar projects, and foreseeable regulatory requirements. Costs are tied to an Engineering News Record (ENR) Construction Cost Index (CCI) of 11392. The ENR CCI can be used to adjust projected future costs based on monthly updates to the CCI.

For budgeting purposes, the construction cost estimates were adjusted to account for contingency to capture unknown aspects of the work at the planning stage and for the "soft costs" required to plan, design, and manage each project through construction. Adjustments to each project estimate were made using the following markups:

- A 10 percent markup of the itemized construction sub-total was added to account for unknown items not included in the opinion of cost
- A 20 percent markup of the itemized construction sub-total was added to account for construction contingency
- A 15 percent markup of the total construction cost including unknown items and contingency was added to account for design phase services including project administration, planning, alternatives analysis, engineering design, surveying, permitting, etc.
- A 10 percent markup of the total construction cost including unknown items and contingency was added to account for construction phase support services, including administration, inspection, materials testing, office engineering, construction administration, etc.

Detailed cost estimates are included in Appendix E.

10.1.2 System Development Charges

Oregon Revised Statutes (ORS) 223.297 to 223.314 authorize the District to establish SDCs to recover a fair share of the cost of existing and planned facilities that provide capacity to serve future growth. The SDC is a one-time fee on new development that is paid prior to connection to the water system.

To calculate an SDC for the District's water system, improvement, administrative, and reimbursement costs can be considered. Improvement costs include those portions of future costs that will provide increased capacity that could serve new connections. Reimbursement costs include the eligible costs for existing facilities associated with the unused capacity that could benefit new connections. Administrative costs include salary and benefits for Oak Lodge staff or consulting fees associated with tracking, managing, and reporting on the SDC funds to meet regulatory requirements. The eligible costs are divided by the number of meter capacity equivalents (MCE) of anticipated growth in the District through 2037. One MCE equals the capacity of a 5/8-inch by 3/4-inch water meter. A detailed description of the SDC methodology can be found in a Memorandum prepared by FCS Group and included as Appendix F. The most current version of the memorandum included with this Draft WSMP calculates a recommended SDC using only the incremental cost for increasing the capacity of the system, but current analysis is underway to modify the calculation to include administrative and reimbursement costs in addition to the improvement costs.

10.1.3 Project Scheduling and Prioritization

In addition to developing a cost estimate for each project and determining the SDC eligible costs, the timing of each project was considered. Timing was determined using one of four possible criteria:

- **District Determined Frequency**. Where applicable, the District has provided a desired frequency for upgrades, replacements, or updates and the timing of projects was set accordingly.
- **End of Useful Life**. Refurbishment or replacement of assets is timed to occur as close as possible to the anticipated end of useful service life based on the typical expected life of an asset or type of refurbishment (i.e. external coating, internal lining, etc.) and the date of original installation or last refurbishment.
- **Coordination with Clackamas County Road Projects.** The District requested the Clackamas County 10-year paving plan to determine if any water system improvements are located within roads that are planned for future pavement. The County imposes a 5-year moratorium on trenching or excavation within newly constructed roads, and water main replacement projects were prioritized to occur ahead of any planned paving. Only one road improvement project was identified that corresponds with water system improvements, and that is the County's Oatfield Road project which includes American's with Disabilities Act (ADA) compliance improvements along with road paving. The ADA improvements are anticipated to occur in fiscal year 2025 (FY25), with paving planned for FY27 and FY28.
- **Prioritization Criteria**. Those projects that do not fit the first two categories, were prioritized based on risk, as determined by the consequence and the likelihood of failure. Consequence of failure was determined by the magnitude of customers whose service would be disrupted with a higher priority given to those customers (i.e. schools, care facilities) that provide a critical community function. Likelihood of failure was determined by the age of the facility, seismic risk, and input from operations and maintenance staff on the current condition.

10.2 Recommended Capital Improvement Program

Using the scheduling, prioritization and cost estimating methodology described in the previous sections, a plan was developed to determine the annual capital spending required to address deficiencies within the water system over the next 20 years. Project timing was adjusted to keep the annual capital costs as consistent as possible to allow the District to execute projects with the current level of staff. A detailed description of the initial 10 years through fiscal year 2030 is provided, with the remainder of the capital spending summed for future allocation in fiscal years 2031 through 2040. Assignment of projects to individual fiscal years beyond 2030 was not performed. Future changes in prioritization and identification of additional projects is expected to modify timing and will be reflected in future master plan updates. The recommended CIP plan is provided in Table 10-1.

A total of approximately $30M in capital improvements were identified for the water system. Costs are tied to an ENR CCI of 11392 associated with the 20-City Average for January of 2020. The ENR CCI can be used to adjust projected future costs based on monthly updates to the CCI. Annual budgeting should use the most recently published CCI to adjust costs for future years.

In current dollars, the average annual capital spending should be approximately $1.5M per year. Annual spending was kept as consistent as possible to allow the District to fund projects through reserves in the drinking water capital fund, incremental rate increases, and SDC’s whenever possible. The recommended year for implementing each improvement was established using the methodology described in Section 10.1.3 above. Projects with estimates exceeding $1.5M were separated into multiple phases across two or more fiscal years to keep the annual average capital spending as close as possible to $1.5M. Projects with probable construction costs exceeding $800,000 were assumed to require design costs that would be incurred in the fiscal year preceding the project construction. All projects scheduled for FY31 through FY40 were not assigned to individual years as the prioritization and coordination with paving projects is likely to change over the next ten years. The average spending between 2031 and 2040 is also approximately $1.5M in current dollars.

10.3 Capital Improvement Projects

The following sections provide a brief description of each of the prioritized CIP projects including engineering and planning studies, fire flow improvements, resiliency, and condition driven projects. All CIP projects are also identified on a system map provided as a plate in Appendix G.

Table 10-1. Capital Improvement Program Implementation

Recommended 20-Year CIP For Oak Lodge Water Services District Water System																
Project ID	Project Category	Description	Pipe Length, feet	Diameter, Inches/ Capacity	Project Total (2020 Dollars)	CIP Value in Current 2020 Dollars										
						FY21 1	FY22 2	FY23 3	FY24 4	FY25 5	FY26 6	FY27 7	FY28 8	FY29 9	FY30 10	FY31-40 11-20
Engineering/Planning Studies (E)					***$900,000***	***$100,000***	***$0***	***$0***	***$0***	***$0***	***$200,000***	***$0***	***$0***	***$0***	***$0***	***$600,000***
E-1	Planning Study	AWIA Risk and Resilience Assessment and Updates (every 5 yr)	-	-	$300,000	$100,000					$50,000					$150,000
E-2	Planning Study	Water System Master Plan Update (every 5 yr)	-	-	$600,000						$150,000					$450,000
Fire Flow Improvement (F) Projects					***$20,464,000***	***$0***	***$115,600***	***$1,040,400***	***$0***	***$0***	***$0***	***$329,700***	***$1,483,650***	***$1,483,650***	***$1,636,000***	***$14,375,000***
F-1	Fire Flow	28th Avenue, Lakewood Drive, Kellogg Lake Apartments	4,015	8 & 12	$1,156,000		$115,600	$1,040,400								
F-2	Fire Flow	River Road	6,805	8 & 12	$3,297,000							$329,700	$1,483,650	$1,483,650		
F-3	Fire Flow	Vista Sunrise Court	400	8	$122,000										$122,000	
F-4	Fire Flow	Jennings, Colina Vista, Clayson Avenues, Emerald Drive, Colony Circle	4,415	8	$1,514,000										$1,514,000	
F-5	Fire Flow	Alderway Avenue	1,070	8	$338,000											$338,000
F-6	Fire Flow	View Acres Road	2,130	8	$553,000											$553,000
F7 - F37	Fire Flow	Increase pipeline diameters to meet fire flow criteria	42,475	8 & 12	$13,484,000											$13,484,000
Condition (C) Projects					***$6,715,000***	***$92,500***	***$832,500***	***$50,550***	***$534,800***	***$1,552,400***	***$1,353,950***	***$1,149,400***	***$200,000***	***$250,550***	***$25,000***	***$673,350***
C-1	Pipeline	Aldercrest Road	3,025	8	$925,000	$92,500	$832,500									
C-2	Pipeline	Ranstad and Cinderella Courts	300	6	$79,000				$79,000							
C-3	Pipeline	Marcia Court	475	6	$128,000				$128,000							
C-4	Pipeline	Lisa Lane	760	6	$225,000					$225,000						
C-5	Pipeline	Oatfield Road	15,995	8	$3,278,000				$327,800	$983,400	$983,400	$983,400				
C-6	Pipeline	Round Oaks Court	345	4	$58,000											$58,000
C-7	Non-buried Asset	Seal Coat Concrete Dome on Valley View Reservoirs	-	-	$70,000						$70,000					
C-8	Non-buried Asset	Recoat Exterior of View Acres Tanks	-	-	$400,000								$200,000	$200,000		
C-9	Non-buried Asset	Replace Equipment and Refurbish Valley View Pump Station	-	-	$380,000											$380,000
C-10	Non-buried Asset	Replace Equipment and Refurbish View Acres Pump Station	-	-	$250,000						$250,000					
C-11	Non-buried Asset	Upgrade SCADA System	-	-	$32,000							$32,000				
C-12	Non-buried Asset	Radio Telemetry Activation Study	-	-	$24,000							$24,000				
C-13	Non-buried Asset	Rebuild Pressure Reducing Valves (every 5 years)	-	-	$100,000					$25,000					$25,000	$50,000
C-14	Non-buried Asset	Large Meter Testing and Replacement	-	-	$337,000			$50,550			$50,550			$50,550		$185,350
C-15	Non-buried Asset	Vault Meter Bypass Installations	-	-	$110,000							$110,000				
C-16	Non-buried Asset	Replace All 4 ¼-inch Fire Hydrants	-	-	$319,000					$319,000						
Resiliency (R) Projects					***$3,250,000***	***$1,450,000***	***$180,000***	***$810,000***	***$810,000***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***	***$0***
R-1	Emergency Supply	Intertie Pump Station with Clackamas River Water	-	-	$1,250,000	$1,250,000										
R-2	Emergency Supply	Intertie Pump Station with City of Milwaukie	-	-	$1,800,000		$180,000	$810,000	$810,000							
R-3	Seismic Resiliency	Seismic Study of 24-inch supply pipeline	-	-	$200,000	$200,000										
				CIP Total	**$31,329,000**	**$1,642,500**	**$1,128,100**	**$1,900,950**	**$1,344,800**	**$1,552,400**	**$1,553,950**	**$1,479,100**	**$1,683,650**	**$1,734,200**	**$1,661,000**	**$15,648,350**

Notes: Project costs rounded up to nearest $1,000. All costs are based on an Engineering News and Review 20-City Average Construction Cost Index of 11392 for January of 2020.

10.3.1 Engineering and Planning Studies

State and federal rules and regulations require periodic engineering and planning studies for water systems. These studies have been included within the CIP and include the following projects:

- **E-1 America's Water Infrastructure Act (AWIA) Risk and Resilience Assessment and Updates**. In 2018 the AWIA was signed into law and requires the District to conduct a risk and resilience assessment (RRA) and a subsequent development of an emergency response plan (ERP) prior to June 30, 2021. The law also mandates that the that the RRA and ERP are updated every 5 years.
- **E-2 Water System Master Plan (WSMP) Update.** Planning capital improvements beyond 5 years can be a challenge for water utilities, and a targeted update to the master plan on a 5-year cycle can dramatically improve the utility of the WSMP.

Although a Water Management and Conservation Plan (WMCP) is also required for nearly all municipal water suppliers and must be periodically updated, the District's requirement is met through the WMCP prepared by the NCCWC.

10.3.2 Fire Flow Improvements

A total of 37 fire flow capacity improvement projects were identified and described in Chapter 5 of this WSMP. Table 5-2 provides a description of the extents of each project, including the existing and recommended pipe size and materials. Locations of each project are provided on the CIP map included in Appendix G. The projects were numbered based on prioritization criteria, with the first four projects (F-1 through F-4) scheduled for implementation between FY21 and FY30. The next highest priority projects, F-5 Alderway Avenue and F-6 View Acres Road, are also included as separate CIP projects in Table 10-1. Both projects could be implemented earlier than FY30 if annual capital budget capacity becomes available if other projects are delayed or suspended.

10.3.3 Rehabilitation and Replacement Projects

A total of 16 condition driven improvement projects were identified and described in Chapter 6 of this WSMP. Projects were divided into two categories; pipelines and non-buried assets. The first six projects (C-1 through C-6) are pipeline replacements identified by the District based on current condition and history of repairs. The remaining projects (C-7 through C-16) represent various repairs, refurbishments, or replacements to pumps, motors, meters, pressure reducing valves, hydrants, coatings, and communications infrastructure.

In addition to the specific projects identified by District operations and maintenance staff, a minimum pipeline replacement rate of approximately one mile per year was identified in Chapter 7 to provide a full system replacement over the next 100 years. The approximate spending rate required to achieve this pipeline replacement rate is $1.4M per year in current dollars. After removing all costs for engineering studies and non-buried assets, the proposed pipeline replacement costs over the next 20 years approximately equals $1.4M per year so no additional condition based projects were identified within the CIP.

10.3.4 Seismic Resiliency Improvements

A detailed analysis of the seismic vulnerability of the District's water system is provided in Chapter 8 of this WSMP. Three recommended improvements were identified for high priority implementation and include the following projects:

- **R-1 Intertie Pump Station with Clackamas River Water.** To provide a redundant supply that could be used during an outage of the 24-inch water supply pipeline to the District, an intertie with Clackamas River Water is recommended. A pumping station will be necessary to overcome the difference in pressure between the two systems.
- **R-2 Intertie Pump Station with City of Milwaukie.** To provide access to an alternative supply source than the Clackamas River, and to provide additional redundant supply that could be used during an outage of the 24-inch water supply pipeline to the District, an intertie with the City of Milwaukie is recommended. A pumping station will be necessary to overcome the difference in pressure between the two systems. The City of Milwaukie has indicated a preference to defer the design and construction of this intertie until the next biennial budget cycle in FY23.
- **R-3 Seismic Study of 24-inch Supply Pipeline.** To improve the reliability of the District's 24-inch water supply pipeline, a seismic study is recommended to assess the current condition and the potential site-specific ground deformations anticipated along the alignment based on geotechnical explorations. Identification of any excessive seismic risk and appropriate mitigation measures is a high priority for improving the overall system resilience.

As described in Chapter 8, additional medium- and low-priority improvements are recommended over the next 50 years for both backbone and non-backbone pipelines. A summary of the total estimated pipeline replacement costs for mitigation of medium and low-priority seismic risks comes to approximately $26.1M. Many of the fire flow and condition improvements for distribution pipelines identified in the CIP will also address replacement of pipelines with medium and low-priority seismic risk. These pipes are recommended to be replaced per the seismic standards recommended in Chapter 8. At the recommended replacement rate of one mile of pipe per year identified in Chapter 7, and assuming medium- and low-priority seismic risk pipelines are prioritized for replacement, the recommendations for mitigating seismic risk can be accomplished well within the 50-year target established in the Oregon Resiliency Plan.

10.4 Funding and Financing

The District has several options to fund the CIP including user fees, short- and long-term borrowing, grants from outside agencies, and SDCs. The following sections will describe the potential for funding the recommended capital improvements through user fees and SDCs, borrowings, or grants from outside agencies.

10.4.1 Rates and SDCs

The District maintains a specific Drinking Water Capital Fund that is used to fund capital improvement projects for the drinking water system. The Drinking Water Capital Fund receives transfers from the Drinking Water Fund, which is primarily funded through water sales. Over the past three years, SDCs have contributed between 6 to 9 percent of revenue. A summary of the Drinking Water Capital Fund activity since the formation of the OLWSD is provided in Table 10-2.

Table 10-2. Drinking Water Capital Fund from 2019 to 2021

Item	FY19 (Actual)	FY20 (Estimate)	FY21 (Budget)
Beginning Fund Balance	$0	$3,236,048	$3,942,090
Transfer from Drinking Water Fund	$2,700,000	$1,675,000	$500,000
Interest Revenue or Borrowing Proceeds	$1,394,267	$85,000	$50,000
Total Resources Available	$4,094,267	$4,996,048	$4,492,090
Capital Improvement Projects	$133,715	$777,000	$1,480,000
Other Capital Spending	$724,504	$276,958	$35,000
Total Capital Outlay	$858,220	$1,053,958	$1,515,000
Remaining Balance	$3,236,048	$3,942,090	$2,977,090

In May of 2020, the District budget committee approved a budget for FY21 to be adopted by the District Board at the May 19, 2020 meeting. The adopted budget includes $1.2M for capital improvement projects as part of the Drinking Water Capital Fund and incorporated a 0.55 percent increase to water rates. If the projected capital improvement budget is fully spent, the fund will still retain a reserve of approximately $3M.

Based on the past transfers from the Drinking Water Fund and historical rate increases it appears that an annual average capital spending rate of $1.5M per year can be funded initially through rate increases that keep up with inflation, but it is likely that substantial rate increases will be required in future years to fund the recommended capital plan. The District financial budgeting tool could be used to estimate the potential impacts on rate increases under various spending scenarios to confirm that a more drastic increase in rates is not required.

FCS Group analyzed the SDC eligible and calculated their opinion of the District's maximum defensible SDC for the water utility to be $10,608 per MCE, where one MCE is a 5/8" x ¾" meter. The maximum defensible SDC includes a reimbursement fee for available capacity within the existing District supply, storage, and BPS facilities, an improvement fee for planned capacity-increasing projects included in the CIP of this WSMP, and administrative costs to the District for developing the SDC methodology and providing annual accounting of SDC expenditures. A full description of the SDC calculation based on improvement costs is provided in Appendix F.

10.4.2 Long-term Borrowing

Several options for long-term borrowing are available to the District to finance the CIP, including the issuance of revenue-backed bonds and obtaining through various state and federally administered low-interest loan programs specifically for water utilities. Debt financing of capital improvements through issuance of revenue bonds is common practice, but typically will incur a higher interest rate than may be available through state and federal low-interest financing programs. The District does not currently have any outstanding debt for water system capital improvements. If expediting the implementation of the CIP is desired, the District could use revenue bonds, and/or low-interest state and federal loan programs to finance water system improvements.

There are several state and federal programs that offer low-interest financing that may be available to the District. Applicants and/or projects meeting certain criteria may also qualify for principal forgiveness or grant funding. Several potential programs are listed below and could be considered for funding specific capital improvements:

- **Safe Drinking Water Revolving Loan Fund.** The Safe Drinking Water Revolving Loan Fund is managed through the OHA drinking water program with loans managed by the Oregon Infrastructure Finance Authority. Loans can be used for system improvements, including design and planning costs, up to $6,000,000 per project.
- **Water and Wastewater Financing and Special Project Works Fund Programs**. These programs, both managed by the Oregon Infrastructure Finance Authority, offer low-interest loans for up to $10,000,000 per project through a combination of direct and/or bond funded loans.
- **Oregon Water Resources Water Project Grants and Loans**. The Water Project Grants and Loans provide funding for implementation ready projects that help meet Oregon's instream and out-of-stream water supply needs and could be applied to the proposed emergency intertie projects.
- **Federal Emergency Management Agency Pre-Disaster Mitigation Loans**. Projects for mitigating seismic risk can be eligible for this program but must be consistent with the goals and objectives identified within the County's Natural Hazard Mitigation Plan.
- **Water Infrastructure Finance and Innovation Act Program**. Offers low-interest supplemental loans for regionally and nationally significant projects with construction value of $20,000,000 or more, likely requiring the District to bundle projects into a single application package to achieve eligibility.

At the time of preparation of this WSMP update, the District is planning to develop a comprehensive funding and financing plan for the water, wastewater, and stormwater utilities and will consider all available options for funding each respective utilities CIP.

10.5 Summary

The recommended CIP identifies approximately $30M in projects, with roughly half of the work to be completed within the next 10 years. An implementation schedule that provides for an average capital improvement budget of $1.5M per year appears feasible and may be accomplished with moderate rate increases similar to those implemented by the District over previous years. Risk of insufficient fire flows, unplanned failure due to poor condition, or outages following a major seismic event are the primary drivers of individual projects and do not include specific timelines, however if there is a desire to accelerate the improvement schedules, bond or government low-interest financing can be pursued.

CHAPTER 11

References

1. **Oregon Metro.** *Regional Transportation Plan- Population, Employment, Households, and 2040 Design Type by Transportation Analysis Zone (TAZ).* 2018.

2. **RH2.** *Oak Lodge Water District Seismic Vulnerability Report.* 2012.

3. **American Water Works Association.** *AWWA Manual M19, Fourth Edition. Emergency Planning for Water Utilities.* 2001.

4. **Oregon Seismic Safety Policy Advisory Commission.** *The Oregon Resilience Plan.* Salem : s.n., 2013.

Appendix A. Hydraulic Model Development TM

Date: [Publish Date]

To: Jason Rice
District Engineer
14611 SE River Road
Oak Grove, Oregon 97267

Phone: (503) 353-4202

Prepared by: Samantha Schreiner

Reviewed by: Kirsten Plonka, Scott Duren

Project: Oak Lodge Water Services District Water Master Plan Update

SUBJECT: **DRAFT HYDRAULIC MODEL DEVELOPMENT TM**

Oak Lodge Water Services District (OLWSD) has appointed Water Systems Consulting, Inc. (WSC) with the task of updating their Water Master Plan (WMP). Part of updating the WMP includes building and calibrating a new hydraulic model in Innovyze's InfoWater® hydraulic modeling software based on OLWSD's current system mapping. A calibrated hydraulic model is a valuable tool that OLWSD can use to evaluate the distribution system, determine system deficiencies, and predict the system response due to operational changes.

This technical memorandum (TM) describes how the model was built and calibrated, including assumptions made for unknown data. This TM will be included as an appendix to the final WMP update. WSC requests that the District review the draft provided in this TM and provide comments within 2 weeks. The District's review comments will be incorporated into revised final draft TM.

For reference, a list of terms is provided below:

ADD	Average Day Demand
AWWA	American Water Works Association
GIS	Geographical Information Systems
gpm	Gallons per Minute
HDPE	High Density Polyethylene
MDD	Maximum Day Demand
MG	Million Gallons
MGD	Million Gallons per Day
NRW	Non-Revenue Water
OLWSD	Oak Lodge Water Services District
PHD	Peak Hour Demand
PRV	Pressure Reducing Valve
PVC	Polyvinyl Chloride
SCADA	Supervisory Control and Data Acquisition
TAZ	Transportation Analysis Zone

1 BACKGROUND

An updated and calibrated model is an important tool for evaluating the water system. Having a model that accurately represents the water system helps make the tool more robust. The District maintains a Geographic Information System (GIS) database as the most up to date record of the water system assets. Consistency between the GIS database is important for the District's ability to track assets, maintain an accurate model as changes to the system occur, and to support decision making. The District is in the process of expanding use of their asset management software system. Part of this process includes a plan to establish asset ID numbering that is consistent between the asset management software, GIS database, and the model.

2 MODEL STRUCTURE AND CONNECTIVITY

The first steps in model development are to build the model structure, confirm the pipe and facility connectivity, and populate basic facility physical information. The model structure was built using OLWSD's Geographic Information System (GIS) database that contains a map of the distribution system's assets and information on the system's water mains, laterals, reservoirs, pump stations, hydrants, valves, meters, pipe fittings, and other assets. There is a significant amount of information contained in the GIS database, such as billing account information, addresses, and location coordinates, that is not required in the hydraulic model and was excluded to decrease the model complexity and keep model run times low. The GIS data was carefully reviewed for pertinent information that would affect the system hydraulics and was prepared for transfer to the hydraulic model. Some GIS data, such as zone, valve type, and descriptions, are useful for reference and were imported to the model when available.

The GIS Gateway Tool in Innovyze's InfoWater® software was used to easily transfer GIS data and attributes into the hydraulic model. InfoWater's GIS Gateway Tool transfers GIS shapefiles into InfoWater model features. The District continuously maintains the GIS database as the most accurate representation of the distribution system. To allow for as much consistency as possible between the GIS dataset and the InfoWater model dataset, changes to pipes and junctions were avoided where possible. The InfoWater GIS Gateway Tool allows GIS Data Fields to be mapped to the Model Network Data Fields. This allowed information in the GIS data fields to be preserved in the model. Table 1 lists the water distribution system facilities and assets transferred into the hydraulic model from the GIS database as well as the relevant properties transferred for each asset.

Table 1. Attributes transferred into the Model from OLWSD's Geodatabase

InfoWater Facility	GIS Shapefile Data Source	Attributes Transferred from GIS database	Notes
Pipes	Water Mains	FID	The GIS database contained an ID number labeled FID for each pipe that was used to populate the unique ObjectID field in the model.
		Pipe Diameter	The GIS database contained diameter in inches for all pipes.
		Pipe Length	The pipe length was 0 inches for 2 of the pipes. Pipe length calculation is discussed below.
		Pipe Material	The material was listed for 25% of the transferred water mains as cast iron, ductile iron, HDPE, steel, or PVC. The District assumes the remaining 75% of pipes are cast iron material.
		Year Installed	The year installed was listed for 16% of the transferred water mains as years ranging from 1965 to 2018. The District assumes the additional 84% were installed before 1965.
		Zone	The pressure zone was not listed for 431 feet of pipe length. The majority of pipe zones were included as either Lower, Upper or Pumped. The Pumped Zone is also referred to as the High-Level Zone.
	Hydrant Laterals	FID	The GIS database contained an ID number labeled FID for each hydrant line that was preserved as the Description. The ObjectID field in the model was populated by the GIS Gateway Tool with a unique ID to avoid conflict with the Water Main ObjectIDs.
		Pipe Diameter	The diameter was listed as 6 inches for 1% of the hydrant laterals. The remaining 99% were blank. It was assumed that the remaining laterals have a diameter of 6 inches and assigned a diameter of 5.99 inches to distinguish it as an assumed diameter.
		Pipe Length	The pipe segment length was listed for 8 of the hydrant laterals. The remaining were blank. Pipe length calculation is discussed below.
		Pipe Material	The material was listed as Ductile for 1% of the hydrant laterals. The remaining 99% were blank.
		Year Installed	Date installed was listed as 2014 or 2015 for 5 of the hydrant laterals. The remaining were blank.
Junctions	Hydrants	HYD-ID	The GIS database contained a unique Hydrant ID labeled HYD-ID for each hydrant that was transferred to the description to differentiate hydrants from junctions transferred from other GIS shapefiles.
		Year Installed	The year installed was not listed for 10% of the hydrants. The remaining 90% were listed as years ranging from 1946 to 2014.
		Zone	The pressure zone was listed for all hydrants.

	Hydrant Valves	Valve Type	Valve type was listed for all hydrant valves and preserved as the Description.
	Valves	Valve Type	Valve type was listed for all valves and preserved as the Description.
		Zone	The zone was listed for all valves as either Lower, Upper, or Pumped/Pressure. Pumped and pressure both refer to the High-Level Zone. Zone was listed as "Hi_Lo" to indicate isolation valves between zones.
	Blow Off Valves	FID	The GIS database contained an ID number labeled FID for each blow off valve that was preserved as the Description.
	Fittings	Blockname	The GIS database contained a field labeled Blockname that indicates the type of fitting. This field was transferred to the description.
		Zone	The zone was listed for fittings as either Lower, Upper, or Pumped. Pumped refers to the High-Level Zone. Zone was listed as "Hi/Lo" to indicate fittings near isolation valves between zones. Less than 1% of fittings did not have a zone listed.

Assumptions were made for elements with unknown GIS attribute data when necessary. 7,050 feet of hydrant lateral pipe were transferred into the model with a diameter of zero inches. Because OLWSD's standard hydrant lateral diameter is 6 inches, these pipes were all assigned a diameter of 5.99 inches. Hydraulically, the pipe still operates similar enough to a 6 inch pipe in the model, but is different from all other pipe diameters to indicate it is an assumed diameter. As more detailed information is available, these pipe diameters can easily be updated.

When importing pipes, scaled lengths are automatically calculated based on the geographic location data. The scaled lengths are sometimes different than the length value imported from the GIS dataset and in these cases the scaled length was used because it is based on the pipe location. There were three locations of pipes with a scaled length of zero feet. These pipes were found to be duplicate pipes and were made inactive.

Once the GIS Gateway Tool was executed and the structure built, the system's connectivity needed to be confirmed. Some of the junctions and pipes created from the GIS Gateway Tool were not necessary for the function of the model. To maintain consistency with the District's GIS Database, these unnecessary elements were made inactive rather than deleting them from the model. A field "Exist_Mod" was created as an indicator used to query all active elements by assigning 1 to active elements and 0 to inactive elements.

The InfoWater Fill Pipe Connectivity Tool assigns a "to" and "from" nodes to the ends of each pipe based on graphic overlap of pipes and junctions. The Fill Pipe Connectivity Tool was applied to the entire model with a pipe tolerance of 0.001 foot. A small tolerance was used to avoid errors in connecting pipes and nodes where multiple nodes may fall within the searching distance.

InfoWater Connectivity tools can use queries such as "nodes in close proximity", "orphaned nodes", "crossing pipes", and more to review the connectivity and troubleshoot problems. After review of the distribution system's connectivity using the Network Navigator tools, orphan nodes not connected to nearby pipes were located. These orphan nodes not required for connectivity were made inactive.

The InfoWater Domain Manager was used to select Disconnected Nodes to identify remaining nodes disconnected from the system, that are not orphaned nodes. These areas, along with a few other manually identified areas, were adjusted by adding small pipes to connect two nodes or by making overlapping nodes or pipes inactive. In some cases where a node is in close proximity to a pipe but not connected, the pipe was manually split at the node location and the nearby node was merged to the split pipe as shown in Figure 1. When pipes were added or modified for connectivity, an indicator "EDIT_WSC" was used to differentiate changes made to the pipe network in the model. A number 1 indicates that WSC modified or added a pipe.

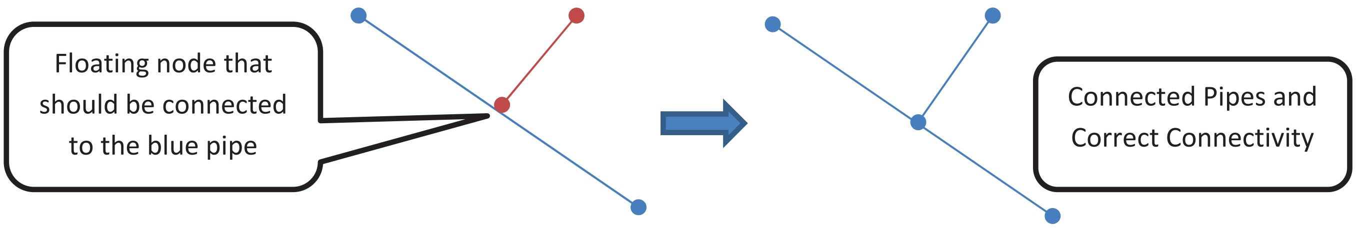

Figure 1. Joining pipes in the model to fix connectivity issues

Tanks, pumps, and pressure reducing valves (PRVs) were manually added to the model with necessary piping for connectivity. Additionally, isolation valves were closed at zone boundaries where necessary. The model was then manually reviewed a last time for other connectivity issues, focusing at zone boundaries and tank and pump station connections.

The last step in building the model structure is populating basic physical and operating information for the model and facilities. This information includes elevation data at the junctions and facilities, tank operating elevations, pump operating points or pump curves, and PRV settings. OLWSD's 2008 Water Master Plan was the basis of much of the information in the water model, along with record drawings, supervisory control and data acquisition (SCADA) information, pressure reducing valve calibration and setting information from vendors, and workshop input from the District.

Table 2 lists the sources used to populate facilities.

Table 2. Sources of Manually added Physical and Operating Data

Hydraulic Model Elements	Source
Pipe Connectivity	GIS Database, Pipeline As-Builts, and input from OLWSD
Elevation	10 foot elevation contours provided by OLWSD
Pump Dimensions and Definitions	Pump curves provided by OLWSD, Pump Station Upgrade As-Builts, 2008 Water Master Plan
Tank Elevations and Dimensions	2008 Water Master Plan, Reservoir Upgrade As-Builts
Tank Operating Levels	SCADA provided by OLWSD
PRV Location and Direction	2008 Water Master Plan
PRV Settings and Dimensions	Settings provided by GC Systems
Zone Boundary	GIS Database

3 SYSTEM DEMANDS

To evaluate OLWSD's water distribution system, the location and quantities of water demands must be known and modeled. Spatially allocated demands were established based on historical annual water customer consumption and production data from District. Future demands were projected in 5-year increments from 2022-2037 using the current consumption per capita and expected population forecasts by the Oregon Metro Transportation Analysis Zone (TAZ) data.

The GIS attributes and demand data provided for small and large meters were linked using account numbers, and addresses in some cases, to spatially allocate customers' water use. The spatial distribution of existing demands scaled to expected population growth rates is assumed to be sufficient for modeling purposes because the District is at buildout. Therefore, projected demands from for each 5-year period from 2022-2037 were assigned to each existing customer location based on each customer's percentage of total water demand in 2017. To address the gap between the production rates and demand, the assigned customer demands were increased to account for non-revenue water (NRW) to normalize the total consumption distributed across the system.

A spatially allocated demand shapefile was loaded into the model with the InfoWater Demand Allocation Manager. The Demand Allocation Manager assigns each customer meter demand to the nearest pipe. The tool automatically identifies the closest pipe to each meter and distributes the meter's demand to the junctions at either end of the pipe.

The maximum daily demands (MDD) were determined by evaluating historic daily production data. The average maximum production days from 2014-2017 were compared to the average daily production data in 2014-2017 to determine the peaking factors. The historical maximum production data included some anomalous high values that were confirmed by the District to be maintenance activities and were removed from the demand analysis. OLWSD does not store historical hourly production data, so the highest peak production was recorded during summer 2018 and used to calculate a peaking factor that could be used to develop future peak hourly demand (PHD).

Table 3 summarizes the modeled demands and peaking factors.

Table 3. Summary of Modeled Demands

System Demand	Current (MGD)	Current (gpm)	Future[1] (MGD)	Future[1] (gpm)	Peaking Factor
Average Daily Demand (ADD)	3.07	2129	3.25	2255	N/A
Maximum Daily Demand (MDD)	5.52	3834	5.84	4058	1.80 x ADD
Peak Hourly Demand (PHD)	9.32	6474	9.87	6854	3.04 x ADD

[1]Future demand is evaluated at the 20-year planning period in year 2037.

For more information on demand spatial allocation and demand projections, see Chapter 4 Demand, Supply, and Storage.

4 MODEL CALIBRATION

After the model was developed and demands allocated, the model needed to be calibrated for accuracy. WSC and OLWSD Staff worked together to select five (5) fire hydrant flow test locations throughout the water distribution system. The testing locations were selected based on pressure zone, pipe size, material, and number of available hydrants in the area. The OLWSD water distribution system is comprised of three pressure zones: the Lower Zone, Upper Zone, and High Level pumped Zone. The five testing locations were in the Lower and Upper Zones because the data from the small pumped zone would not have yielded useful data for model calibration. In this zone the pumps will maintain constant pressure when a hydrant is opened preventing an accurate pressure drop reading.

On May 7, 2018, WSC and OLWSD staff performed the five selected hydrant flow tests, shown in Figure 2. The fire hydrant flow tests were performed by using at least two hydrants. One hydrant, known as the flow hydrant (FH), is open and the flowrate is measured with a pitot gage, and the pressure drop from a nearby hydrant, known as the residual hydrant (RH), is measured with a pressure gage. The pressure taken when the hydrant is closed is known as the static pressure, and the pressure taken when the hydrant is open is the residual pressure. In addition to the static and residual pressure at the flow and residual hydrant, three data loggers (DL) were also placed on nearby hydrants to monitor pressures during the fire hydrant flow test and provide additional data points. The static and residual pressures recorded at all hydrants were used to calibrate the model. The fire hydrant flow testing results compared to the calibrated model results are provided in Table 6.

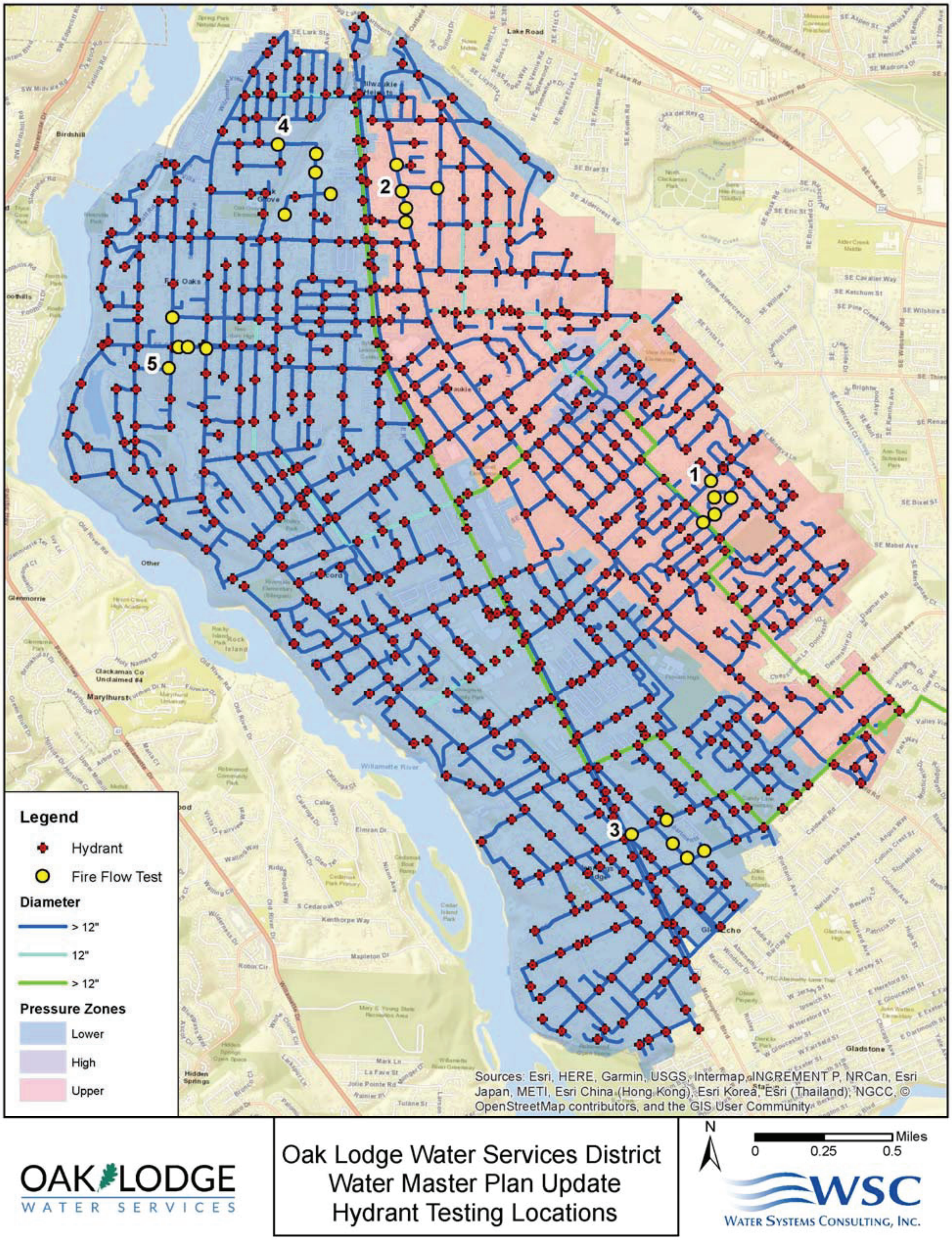

Figure 2. Location of Hydrant Flow Tests

To accurately calibrate the model with the hydrant flow testing data, the system conditions during testing are also required. These conditions, usually referred to as boundary conditions, include tank levels, pump status, and PRV settings. Average day demands were loaded into the model, which is typical of a May weekday. The critical steady state boundary conditions for each hydrant flow test are shown in Table 4. PRV settings were provided by GC systems and were constant during all hydrant flow tests.

Table 4. Model Calibration Boundary Conditions

Hydrant Flow Test	Facility	Boundary Condition
1	Valley View Tank Levels View Acres Tank Levels Valley View Pump Station	27.2 feet 61.8 feet All Pumps Off
2	Valley View Tank Levels View Acres Tank Levels Valley View Pump Station	27.2 feet 61.4 feet All Pumps Off
3	Valley View Tank Levels View Acres Tank Levels Valley View Pump Station	27.0 feet 61.7 feet Pump turned On
4	Valley View Tank Levels View Acres Tank Levels Valley View Pump Station	27.2 feet 60.8 feet Pump turned On
5	Valley View Tank Levels View Acres Tank Levels Valley View Pump Station	27.2 feet 60.8 feet Pump turned On

Ten new scenarios were developed in the model, one static and one dynamic scenario for each fire flow test. Each scenario was loaded with the allocated ADD and the boundary conditions recorded for each test. The flowing and residual hydrants were identified in the model, and the flowrate measured during the test was applied to the flowing hydrant in the model. The model was run under both static and dynamic conditions, and the modeled pressures were compared to the observed field data. Once results were tabulated, the model was adjusted to reflect observed pressures, including:

- The pipe C-factors were adjusted broadly throughout the system to account for variations in head loss based on location in the system. C-factors are determined by pipe material and age. The District does not have records for all pipes installed prior to 1965. These pipes are assumed by the District to be cast iron but the exact age is unknown. The C-factor ranges used are listed in Table 5 are within the accepted range for the material and age of the pipes.
- In the area around Test 3, C-factors were lowered from 85 to 70-75 to account for head loss in the model.
- In the area around Tests 4 and 5, C-factors were lowered from 85 to 60-70 to account for head loss in the model.

Table 5. Adjusted C-Factors

Material	C-Factor
Ductile Iron	100-130
PVC	130
Cast Iron	60-85
All hydrant laterals (PVC, Copper, and unknown material)	130

Over time the inside of pipes become rougher, either from sand or grit in the system wearing down the pipes or metal corrosion. Roughened pipes are generally in worse condition than smooth pipes, and can lead to increased head loss in the distribution and lower the available fire flow. Rough pipes are characterized with a lower C-factor. Pipe materials known to have a significant increase in pipe roughness over time are cast iron, steel, and galvanized iron pipes. The OLWSD distribution system was originally built with a significant amount of cast iron pipes.

Following each adjustment to the C-factors, a batch of model runs was completed again and the adjustments to C-factors continued as an iterative process until the difference between modeled and observed pressures was less than or equal to ±10 pounds per square inch (psi). Table 6 includes the observed and modeled results.

Table 6. May 2018 Hydrant Flow Testing Results Compared to Modeled Pressures

					Observed Pressures			Modeled Pressures			Difference between Observed and Modeled Pressures (Goal is within ±10 psi)		
Test	Location	Fire Flow ID	Hydrant Model ID	Measured Flow (gpm)	Static Pressure (psi)	Residual Pressure (psi)	Pressure Drop (psi)	Static Pressure (psi)	Residual Pressure (psi)	Pressure Drop (psi)	Δ Static Pressure (psi)	Δ Residual Pressure (psi)	Δ of the Pressure Drop (psi)
1	Hillwood Circle	FH 1	8-92	1400				50.9	36.3	14.7			
		RH 1	8-91		58	53	5	52.2	46.9	5.3	5.8	6.1	-0.3
		DL 1-1	8-93		48	46	3	50.0	48.7	1.4	-2.0	-3.2	1.2
		DL 1-2	8-71		54	48	6	53.2	51.8	1.4	0.9	-3.4	4.2
		DL 2-3	8-90		59	53	6	58.3	53.8	4.5	0.7	-0.6	1.3
2	Oatfield Road	FH 2	7-9	1875				101.7	79.2	22.5			
		RH 2	7-10		108	86	22	105.4	85.7	19.7	2.6	0.3	2.3
		DL 2-1	5-22		101	76	25	100.4	81.0	19.4	0.6	-5.2	5.8
		DL 2-2	7-30		94	81	13	95.9	78.6	17.3	-1.8	2.4	-4.3
		DL 2-3	7-15		111	95	16	110.7	91.9	18.9	0.3	3.5	-3.3
3	Addie Street	FH 3	6-100	1675				112.6	60.5	52.1			
		RH 3	6-99		108	90	18	108.7	87.3	21.4	-0.7	2.7	-3.4
		DL 3-1	6-98		114	102	12	116.0	102.3	13.7	-2.0	-0.3	-1.7
		DL 3-2	6-83		114	97	17	113.9	102.1	11.7	0.1	-4.8	5.0
		DL 3-3	6-82		108	94	14	108.7	99.3	9.4	-0.7	-5.3	4.6
4	Linden Lane	FH 4	3-60	1600				85.9	44.6	41.3			
		RH 4	3-146		78	40	38	78.0	44.6	33.4	0.0	-4.6	4.6
		DL 4-1	3-61		80	53	27	81.5	56.7	24.9	-1.5	-3.7	2.1
		DL 4-2	3-47		73	49	24	76.1	58.3	17.8	-3.1	-9.0	5.9
		DL 4-3	3-63		66	40	26	66.6	41.0	25.6	-0.6	-1.0	0.4
5	Oak Grove Boulevard	FH 5	1-33	1700				86.6	63.0	23.6			
		RH 5	1-31		80	66	14	81.7	61.7	20.0	-1.7	4.3	-6.0
		DL 5-1	1-34		92	66	26	95.4	75.8	19.6	-3.4	-9.8	6.4
		DL 5-2	1-19		81	56	25	82.4	65.1	17.4	-1.4	-8.8	7.4
		DL 5-3	3-5		71	52	19	74.1	59.9	14.1	-3.1	-7.6	4.6

FH= flow hydrant; RH= residual hydrant; DL= data logger hydrant

Figure 3 includes a graphical representation between the modeled and observed pressures at the flowing hydrant as well as the residual hydrant and other data logger locations.

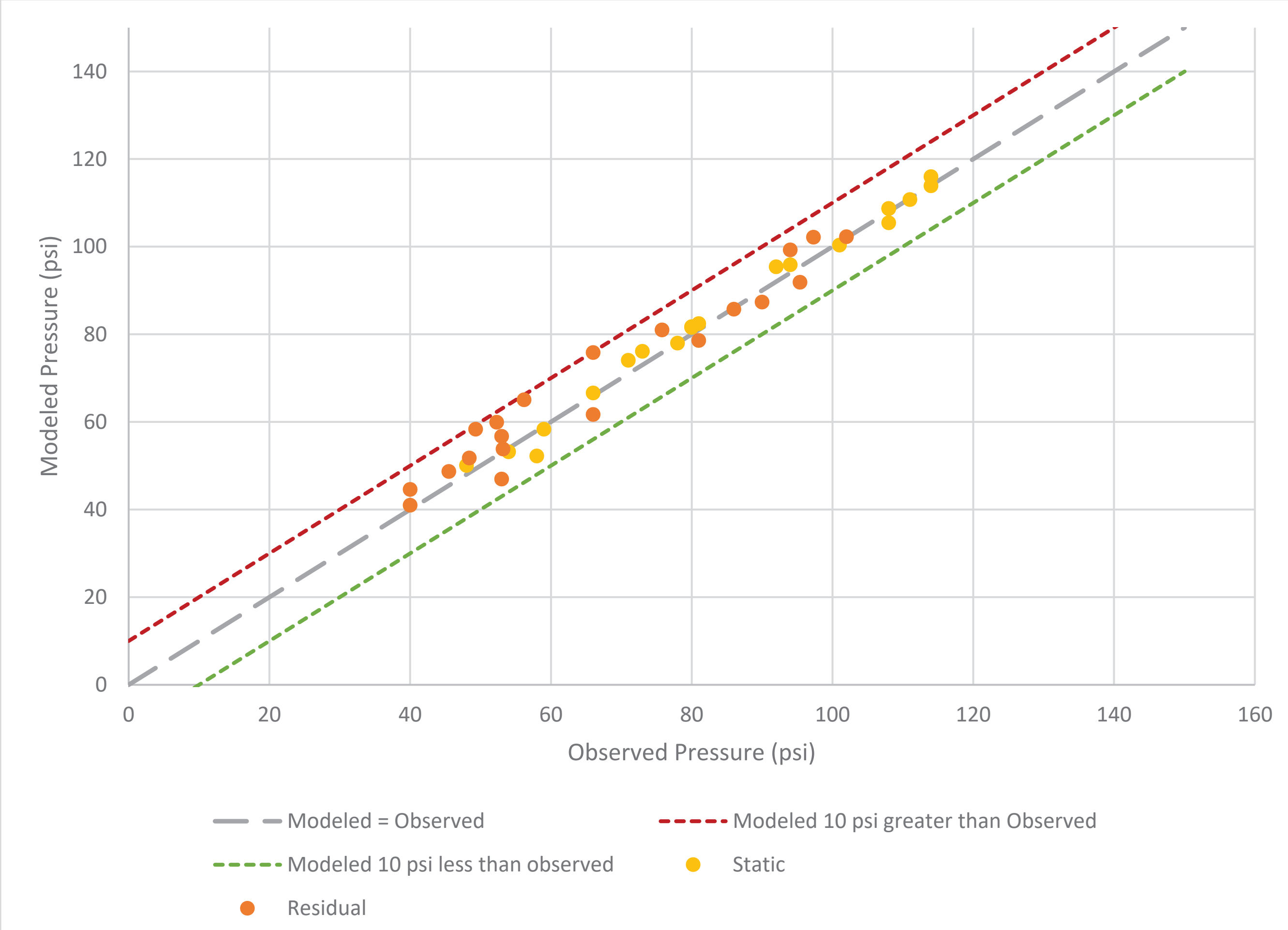

Figure 3. Linear Regression Relationship between Observed and Modeled Pressures for both Static and Residual Pressure Data from Fire Flow Test Simulations

As mentioned, a well-calibrated hydraulic model will have a maximum difference between modeled and observed pressures of ±10 psi (indicated on the graph as the green and red lines). All modeled pressures were within this range when compared to observed pressures, and the majority were within less than 4 psi difference.

Based on the calibration results, the model developed by WSC can be used effectively for evaluating steady state simulations within the OLWSD water system under for the intended purposed of updating the Water Master Plan.

Appendix B. Geotechnical Seismic Hazards Evaluation TM

Technical Memorandum

To:	Scott Duren, Water Systems Consulting	Project:	Oak Lodge Water Service District – 2018 Master Plan Update, Task #1.3
From:	Wolfe Lang, PE, GE	cc:	
Prepared by:	Jeremy Fissel, PE	Job No.:	5815.0
Date:	June 08, 2020		
Subject:	Geotechnical Seismic Hazards Evaluation		

1.0 Introduction

Oak Lodge Water Service District (OLWSD) is conducting an update to its Water Master Plan and this seismic resiliency study is part of the update. OLWSD has contracted Water Systems Consulting (WSC) to provide professional engineering services for the Water Master Plan update. McMillen Jacobs Associates has been retained by WSC to provide geotechnical engineering services.

This memorandum presents the results of our evaluation. The following tasks were completed in accordance with the scope of work for Task 1.3 – Identification of Seismic Geohazards for the 2018 Water Master Plan Update Subconsultant Agreement:

1. Review of available geological and geotechnical information;
2. Review of The Department of Geology and Mineral Industries (DOGAMI) seismic hazard maps for a magnitude 9.0 Cascadia Subduction Zone (CSZ) event in the OLWSD's service area;
3. Site reconnaissance to address key geological and geotechnical assumptions and to verify published maps with our analyses and field observations, as well as examine areas that are potentially prone to failures from lateral spreading and seismic landslide hazards;
4. Develop estimates of strong ground shaking, liquefaction-induced settlement, lateral spreading permanent ground displacement, seismic landslide slope instability, and develop maps illustrating these hazards in relation to the OLWSD service area; and
5. Develop this memorandum summarizing the results of our evaluations and including updated hazard maps.

In the following sections, we present the results of the data review, seismic hazards evaluation, and a summary of geotechnical hazards at the facilities and along the backbone system.

2.0 Data Review

We reviewed previous geotechnical reports and subsurface data for various projects in the area conducted between the years of 2004 and 2017. A list of reviewed documents is provided below:

- Report of Geotechnical Services, Task 1, Landslide Investigation and Reconnaissance, Oak Lodge Water Main Alignment, Gladstone, Oregon, July 9, 2004, GeoDesign, Inc.**
- Report of Geotechnical Services, Task 1, Storm Sewer Video Analysis, Oak Lodge Water Main Alignment, Gladstone, Oregon, January 19, 2005, GeoDesign, Inc.
- Report of Geotechnical Services, Strain Gauge Installation, Oak Lodge Water Main Alignment, Gladstone, Oregon, April 27, 2005, GeoDesign, Inc.
- Report of Geotechnical Services, Strain Gauge and Inclinometer Monitoring, Oak Lodge Water Main Alignment, Gladstone, Oregon, January 10, 2006, GeoDesign, Inc.**
- Report of Geotechnical Services, Inclinometer Monitoring, Oak Lodge Water Main Alignment, Clackamas County, Oregon, January 15, 2007, GeoDesign, Inc.
- Report of Geotechnical Services, Inclinometer and Groundwater Monitoring, Oak Lodge Water Main Alignment, Clackamas County, Oregon, June 2, 2008, GeoDesign, Inc.
- Report of Geotechnical Services, Inclinometer and Groundwater Monitoring, Oak Lodge Water Main Alignment, Clackamas County, Oregon, May 11, 2009, GeoDesign, Inc.
- Report of Geotechnical Services, Inclinometer and Groundwater Monitoring, Oak Lodge Water Main Alignment, Clackamas County, Oregon, May 2, 2012, GeoDesign, Inc.
- Seismic Vulnerability Report – Valley View and View Acres Reservoir Seismic Improvements, Oak Lodge Water District, April 2012, RH2 Engineering, Inc.
- Construction Drawings, View Acres Reservoirs Seismic Retrofit, Oak Lodge Water District, Clackamas County, Oregon, May 7, 2013, RH2 Engineering, Inc.
- Construction Drawings, Valley View Reservoir Improvements, Oak Lodge Water District, Clackamas County, Oregon, Winter 2016/2017, RH2 Engineering, Inc.
- Preliminary Geotechnical Report, Boardman Wetland Complex, Oak Lodge Sanitary District, Clackamas County, Oregon, November 9, 2016, Shannon and Wilson, Inc.*
- Report of Geotechnical Engineering Services, Northpoint – Willamette View, Southeast River Road, Portland, Oregon, December 29, 2017, GeoDesign, Inc.*
- Subsurface Exploration and Preliminary Geotechnical Engineering Report, Proposed Lot Partition, 5212 and 5314 Southeast Jennings Avenue, Portland, Oregon, November 19, 2007, Chinook GeoServices, Inc.
- Preliminary Geotechnical Engineering Report for Private Roadway Grading, Portland, Oregon, June 3, 2009, Chinook GeoServices, Inc.
- Geotechnical Investigation, Sarah Estate Subdivision, Portland, Oregon, January 22, 2010, Rapid Soil Solutions, LLC.*
- Engineering Geologic Hazard Report for Proposed Residence, 17264 SE Oatfield Road, Milwaukie, Oregon, August 18, 2006, Hydro-GeoEngineering, Inc.
- Geotechnical Site Assessment for Proposed New Garage/Loft Building, Clackamas County, Oregon, March 2, 2010, Strata Design, LLC.
- Geotechnical Report, Ken’s Court Commercial Development, Clackamas County, Oregon, March 9, 2005, West Coast Geotech, Inc.*
- Report of Geotechnical Engineering Services, Proposed Pacific Northwest Storage Facility, 3260 SE Oak Grove Blvd., Portland, Oregon, January 27, 2017, Geotech Solutions, Inc.*
- Geotechnical Engineering Services, Proposed Walgreens Site, Oak Grove, Milwaukie, Oregon, August 16, 2012, Geotech Solutions, Inc.*
- Geotechnical Engineering Report, Jennings Lodge Estates, 18121 SE River Road, Clackamas County, Oregon, June 17, 2015, GeoPacific Engineering, Inc. **

- Geotechnical Engineering Report, Jennings Lodge Estates, 18121 SE River Road, Clackamas County, Oregon, January 21, 2016, GeoPacific Engineering, Inc.**
- Geotechnical Review, Stormwater Outfall – Energy Dissipation System, Jennings Lodge Estates, 18121 SE River Road, Clackamas County, Oregon, September 14, 2016.

Collectively, the provided documents include limited subsurface information, such as deep soil borings. A single asterisk (*) after the citation indicates soil borings and Penetration Testing (SPT) were included up to a depth of 20 feet below ground surface (bgs). A double asterisk (**) after the citation indicates those documents that include soil borings and SPT sampling to a depth of 50 feet bgs or greater.

In addition to the above documents, we reviewed our internal soil borings and SPT sampling for previously completed projects located within the OLWSD's service area. We also reviewed maps and publications by Oregon's Department of Geology and Mineral Industries (DOGAMI), the United States Geological Survey (USGS), and various publicly available well logs provided by the Oregon Water Resources Department.

Subsurface information included with the provided documents listed above and that of other previously completed explorations is discussed in greater detail below by general locations within the OLWSD.

2.1 View Acres Reservoirs

The Seismic Vulnerability Report for the Valley View and View Acres Reservoirs by RH2 Engineering RH2) dated April 2012 refers to a geotechnical engineering report by Shannon & Wilson dated May 2, 1988. The report by RH2 cites that this Shannon & Wilson geotechnical report was used for the construction of one of the two reservoirs at the View Acres site in 1989. This geotechnical investigation report for the construction of this reservoir was not provided. In addition, RH2 cited that the ringwall foundation of the 1989 reservoir was too small to distribute the bearing loads to the soil. RH2 recommended structurally expanding the existing ringwall foundation of the 1989 reservoir by a 10-foot diameter. The provided as-built drawings for the project show that the diameter of the existing ringwall foundation was expanded by 9 feet.

2.2 Valley View Reservoirs

The Landslide Investigation Report by Geodesign (July 2004) included a 105-foot deep soil boring, B-1, with SPT sampling and rock coring, located approximately 400 feet west of the intersection of SE Oatfield Road and SE Oakridge Drive. A slope inclinometer was installed in this boring. The inclinometer extends the full distance of B-1. It is noted that one page was missing from the B-1 boring log in the provided report; this missing page should include subsurface information from depths from 40 to 80 feet bgs.

A slope stability analysis was performed for the site as part of GeoDesign's investigation. However, the analyses appear to be only under static conditions.

GeoDesign's January 10, 2006 Strain Gauge and Inclinometer Monitoring Report cites that a second soil boring, B-2, was drilled uphill and to the east of SE Oatfield Road on July 29, 2005. A slope inclinometer was also installed at B-2 and extends to a depth of 40 feet bgs. B-2 is located within the "homeowners park". The boring log, included in their January 10, 2006 report, cites B-2 was drilled to a depth of 130-feet bgs. Subsurface soils in B-2 are cited to be 7 feet of gravel at the surface, overlying 115 feet of stiff to very stiff silty clay, and terminating in a soft to medium hard basalt at 130 feet.

The information provided for this site indicates that inclinometer readings were periodically taken up to May 2012. GeoDesign reports that their inclinometer readings between January 2006 through May 2012 result in ales than 0.02-inch cumulative movement in B-1 and less than 0.1-inch cumulative movement in B-2. GeoDesign concludes that this movement is minor and that shallow soil creep may be occurring in B-1.

Periodic piezometer readings by GeoDesign report general flat trends increasing toward the month of April, from March 2004 through May 2012. At B-1, a groundwater elevation between 200 and 210 feet (MSL) is reported. At B-2, water level elevations are reported to be between about 230 to 235 feet (MSL). A 2.5-foot of groundwater elevation was gained between from October 2011 to April 2012.

GeoDesign monitored strain gauges installed on portions of the existing water main. The locations of those areas of strain gauge installation are identified as along SE Hull Avenue and within "the Oak Ridge homeowner's park." Depth of the water main at these locations are cited to be between 5 and 8 feet below the surface. GeoDesign concluded that changes reflected in the periodic readings of the installed gauges are primarily due to temperature changes on the water, which can be attributed to the seasonal temperature fluctuation of the Clackamas River, the source for the water service area.

GeoDesign performed a Storm Sewer Video Analysis for the Oak Lodge Water Main Alignment project, which is summarized in their report dated January 19, 2005. This report includes additional background information for the Valley View site and associated infrastructure. GeoDesign reports a 12-inch diameter concrete storm sewer line was installed adjacent to the water main in 1965, one year after the installation of the subject water main. The two utilities are located within the same trench for a 300-foot long section of their alignment from SE Oatfield Road, extending upslope along SE Oakridge Road to the northeast. GeoDesign cites that severe cracking of the concrete sewer pipe was not observed, but several minor cracks and fissures are present in the alignment of the storm sewer pipe scoped. Increases in water depths were also observed within the vicinity of the alignment where it enters "the homeowner's park." GeoDesign concludes that there has been no large-scale movement of the water main and storm sewer since installation in 1964 and 1965, respectively. However, they also consider the video survey to be an inconclusive indicator with respect to small to moderate movement or distresses within the two utilities.

GeoDesign provided several options for mitigating the effects of continued subsurface soil movement at the Valley View site. These options included installation of horizontal drains, installation of flexible couplings, realigning problematic sections of the waterline alignment, and replacing or de-stressing over-stressed portion of the pipeline.

2.3 Jennings Lodge - Boardman Wetland Complex

The November 9, 2016 Preliminary Geotechnical Report for Boardman Wetland Complex by Shannon & Wilson includes advancing SPT soil borings to depths of 20 and 21 feet bgs, as well as various test pit explorations. The location of B-1 is northeast of the intersection of SE Boardman Avenue and SE McLoughlin Boulevard. B-2 is located near the southcentral region of the wetland that extends from SE Boardman to SE Jennings. The soils boring logs report a layer of loose or soft fine-grained flood deposits or marsh deposits overlying medium dense coarse-grained flood deposits. Shannon & Wilson estimates groundwater elevations to range from 6 inches above to 12 inches below the existing ground surface.

Similar surficial conditions were documented in the Geotechnical Investigation Report by Rapid Soil Solutions dated January 22, 2010 for a property at SE Jennings Avenue and SE Cook Street. Site photos in the report show that surficial water is ponding at the site. In addition, three drilled borings up to 18 feet deep with SPT sampling were performed for this investigation and laboratory testing resulted in wet conditions. The soils described are very soft clay from the surface to 12 feet, followed by a 3-foot thick stratum of medium stiff sandy silt, and hard gravel as the final stratum encountered.

2.4 Jennings Lodge - SE River Road and SE Faith Avenue

The January 21, 2016 and June 17, 2015 Geotechnical Engineering Reports by GeoPacific for Jennings Lodge Estates was prepared for the proposed residential development of a region of the OLWSD located at the referenced intersection between the Boardman Wetland Complex and the Willamette River. This engineering report includes one drilled soil boring to a depth of 50 feet bgs. The subsurface soil strata are described as a surficial layer of silt to 15 feet bgs, followed by medium dense transitioning to dense sands and gravel. A groundwater depth is not reported for this project. However, mud rotary methods were used to advance the soil boring. GeoPacific cites that the USGS reports the depth to groundwater at the site to be approximately 57 feet bgs.

A quantitative slope stability analysis is included with this report. This analysis was performed along a 170-foot long cross section that includes the subsurface information from the 50-foot soil boring. The cross section extends downslope to the west to SE Willamette Drive. The analyses were performed assuming for the proposed residential structures would be set back a minimum of 15 feet from the top of the native soil slopes. The stable analyses resulted in a Factor of Safety of 1.59 and 1.15 for static and seismic conditions, respectively.

2.5 SE McLoughlin Boulevard and SE Vineyard Road

The March 9, 2005 Geotechnical Report by West Coast Geotech, Inc (WCG) is for the construction of new commercial/industrial buildings located southeast of the intersection of SE Vineyard Road and SE Vineyard Ave. This report includes eleven SPT soil borings logs ranging from 11 to 30 feet in depth. Boring logs indicate that the site is underlain by fill soils comprised of soft silts and clays followed by loose to medium dense mixtures of sand and silt. Groundwater is reported to be 6 to 12 feet bgs and groundwater seepage is reported in each boring. WCG cites that historic fill was placed in a region of the area evaluated in order to fill a swale. Fill placement had begun at the site around 1975, based WCG's review of historic imagery.

2.6 SE McLoughlin Boulevard and SE Oak Grove Boulevard

Two reports provided by Geotech Solutions, Inc. dated August 6, 2012 and January 27, 2017, are for two separate properties located near the intersection of SE McLoughlin Boulevard and SE Oak Grove Boulevard. SPT soil borings up to 25 feet were used to develop geotechnical design recommendations for the construction of two commercial properties near the referenced intersection. Up to 6 feet of fine-grained fill is reported and overlays a native gravel stratum. The borings terminate in a stratum of medium stiff to stiff silt with varying amounts of sand. Perched groundwater is encountered in these investigations at a depth of approximately 10 feet bgs.

2.7 SE River Road and SE Park Avenue

GeoDesign's December 29, 2017 Report of Geotechnical Engineering Services includes three SPT soil borings. The locations of these borings are along the northwest limits of the OLWSD. These borings range in depth from 18 to 20 feet below ground surface. Medium hard basalt is encountered at 5 and 10 feet below the surface in the borings. Generally, the basalt stratum is overlain by gravelly soils. A piezometer is installed in B-2 and extends to a depth of 19 feet bgs. Piezometer readings are not included with this report. Additional reports of groundwater monitoring of this piezometer are not provided. GeoDesign estimates that groundwater is likely present along to the surface of the basalt stratum.

2.8 SE McLoughlin Boulevard from SE Lark Avenue to SE Park Avenue

McMillen Jacobs Associates was previously provided (by others) a Geotechnical Data Report for a previously completed project within the north portion of the OLWSD. Primarily, the information in this Data Report includes drilled soils borings along SE McLoughlin Boulevard, between SE Lark Street and SE Park Avenue. Subsurface strata differ significantly in this region. Generally, the north portion of the OLWSD along SE McLoughlin Boulevard includes fine and coarse-grained Missoula Flood Deposits, underlain by basalt bedrock. The fine-grained soils were medium stiff to stiff apparent consistency, while coarse-grained soils were medium dense to dense. Standard Penetration Test sampler refusal was generally encountered within the basalt bedrock stratum.

2.9 SE River Road and SE Hull Avenue

McMillen Jacobs Associates was previously provided (by others) two subsurface soil borings performed along the east banks of the Willamette River. The two borings are located along SE Hull Avenue in Milwaukie, OR and are advanced to a depth of 161 and 260 feet bgs. The soils are reported to be generally loose to medium dense silty sand to a depth of 15 feet which overlays dense gravels and very stiff fine-grained soils. Basalt bedrock is encountered at 120 feet bgs in one of these two borings.

3.0 Site Reconnaissance

On May 18 and June 17, 2018, Wolfe Lang, PE, GE, and Jeremy Fissel, PE, respectively, performed geotechnical reconnaissance of the following sites within the OLWSD service area:

- Two 5 million-gallon reservoirs and associated pumps along SE Valley View Road;
- Two 2.8 million-gallon reservoirs and associated pumps along SE View Acres Road;
- The Water Main which traverses primarily along SE McLoughlin Boulevard;

- Oak Lodge Pump Station located southeast of the intersection of SE Mangan Drive and SE Water Avenue in Gladstone, OR; and,
- North Clackamas County Water Commission Water Treatment Plant located at 14275 Clackamas River Drive, Oregon City, OR.

During the reconnaissance, we noted site conditions, surface or exposed soil conditions, site topography, proximity to bodies of water, and features (i.e. culverts, retaining walls, etc.).

The two locations of the reservoirs are within the general OLWSD service area. Each of these sites are within a residentially developed community. The reservoirs are generally located at the top of a gentle to moderately sloping hillside. Slopes are approximately 5:1 to 3:1 with occasional isolated areas up to 1:1 (H:V).

The North Clackamas County Water Treatment Plant and Oak Lodge Pump Station are located outside the general service area near the flood plains of the Clackamas River. The pump station and water treatment plant include in-ground, open-air water treatment vessels (clarifiers, aerators, filtration vessels, etc.). Generally, the existing structures are located on nearly level terrain, however adjacent very steep slopes are present. The water treatment plant facility includes a concrete retaining wall about 10 feet in height next to the access road and existing in-ground vessels. That retaining wall decreases in height as it traverses to the north. It is noted that at the time of our visits the Oak Lodge Pump Station and the North Clackamas County Water Commission Treatment Plant were closed, surrounded by chain link fencing; our visual reconnaissance of these two facilities was limited to the immediate surrounding areas.

Our evaluation results from our site observations and review of available data for these facilities are further discussed in Section 6.

4.0 Geology

4.1 Geologic Setting

The Portland basin is a structural depression created by complex folding and faulting of the basement rocks, a sequence of middle Miocene age, about 17 to 6 Ma (“Mega annum” or million years ago), lava flows of the Columbia River Basalt Group (CRBG). An extensive sedimentary fill has then accumulated in the basin and overlies the CRBG basement (Trimble, 1963; Tolan and Beeson, 1984). The Tertiary sedimentary units include up to 1,300 feet of the Sandy River Mudstone, which directly overlies the CRBG, and 100 to 350 feet of sandstone and conglomerate of the Troutdale Formation, which overlies the Sandy River Mudstone (Pratt et al., 2001).

Unconsolidated sediments at the top of the basin fill sequence consist primarily of catastrophic flood sediment deposited near the end of the last ice age, between 15,300 and 12,800 radiocarbon years ago (Mullineaux et. al., 1978; Waitt, 1987; Allen et al., 2009). Forty or more catastrophic floods occurred at intervals of several decades on the Columbia River system. The flood waters swept across the Portland basin and deposited tremendous loads of sediment. Boulders, cobbles, and gravels were deposited near the mouth of the Columbia River Gorge and along the main channel of the Columbia River, while great cobble and gravel bars stretched westward across the Portland basin, grading to thick blankets of micaceous sand. Within the Portland basin, the flood deposits mantle the Troutdale Formation at elevations below about 350 feet above mean sea level. The flood deposits generally consist of unconsolidated gravel topped by fine sand and silt and range from a few feet to more than 200 feet thick.

During the late Pliocene epoch, fluvial conglomerate, volcaniclastic sandstone, siltstone and debris flow deposits, originating in the Cascade Range, were deposited in a broad fan in the Boring Hills area at the southern margin of the Portland Basin (Tolan and Beeson, 1984). These deposits, the Springwater Formation, interfingered with the late Troutdale Formation sediments. Deposition of the Springwater Formation continued into the Pleistocene (Madin, 1994).

During the middle to late Pleistocene (after about 2 Ma), Boring Lava was erupted from several local vents in the Portland basin and in the Boring Hills south of Gresham, intruding the Sandy River Mudstone, Troutdale Formation, and Springwater Formation sediments (Trimble, 1963; Madin, 1994). The lava flows were relatively thin and apparently of small volume, because they do not appear to have flowed far from their source. Both the Springwater Formation and the Boring Lavas are very deeply weathered and decomposed.

During the Holocene epoch (the last 10,000 years), minor alluvial deposits have accumulated along the several creeks and streams that drain the area. These young alluvial sediments are largely reworked from older materials in the Boring Hills and from the catastrophic flood deposits on the basin floor. Other active geologic processes include soil creep and land sliding.

4.2 Seismic Setting

The Pacific Northwest is located near an active tectonic plate boundary. Off the coast, the Juan de Fuca oceanic plate is subducting beneath the North American crustal plate. This tectonic regime has resulted in seismicity in the Pacific Northwest occurring from three primary sources:

- Shallow crustal faults within the North American plate;
- CSZ intraplate faults within the subducting Juan de Fuca plate; and,
- CSZ megathrust events generated along the boundary between the subducting Juan de Fuca plate and the overriding North American plate.

Among these three sources, CSZ megathrust events are considered as having the most hazard potential due to the anticipated magnitude and duration of associated ground shaking. Recent studies indicate that the CSZ can potentially generate large earthquakes, with magnitudes ranging from 8.0 to 9.2 depending on rupture length. The recurrence intervals for CSZ events are estimated at approximately 500 years for the mega-magnitude full rupture events (magnitude 9.0 to 9.2) and 200 to 300 years for the large-magnitude partial rupture events (magnitude 8.0 to 8.5). Additionally, current research indicates a probability of future occurrence because the region is “past due” based on historic and prehistoric recurrence intervals documented in ocean sediments. For example, over the next 50 years, the CSZ earthquake has an estimated probability of occurrence off the Oregon Coast on the order of 16 to 22 percent (Goldfinger et. al., 2016).

In 2013, the State of Oregon developed the Oregon Resilience Plan (ORP, 2013) to prepare for a magnitude 9.0 CSZ event. We understand that this earthquake scenario is selected as the seismic source in the OLWSD service area seismic hazards study.

Locally, the service is mapped to include 2 Class A faults – the Oatfield and Portland Hills faults. Class A faults have geologic evidence that demonstrate the existence of Quaternary origin. Class A faults can be exposed for mapping or inferred from liquefaction or other permanent ground deformation features.

The Oatfield Fault bisects the service area. The Oatfield Fault is about 29 km (18 mi) in length located on the western flank of the West Hills. The strike of the Oatfield Fault is paralleled by the Portland Hills Fault at the east and the trend of the West Hills. The Oatfield Fault was observed offsetting Boring Lava in Portland's light rail tunnel, but no offset of Quaternary units was observed (Walsh et al., 2011). The USGS Fault database (USGS, 2006) lists the age of the Oatfield Fault up to 1.6 million years old. (Personius, 2002).

The service area is bordered to the east by the Portland Hills Fault. The Portland Hills Fault is a Class A fault and about 49 km (30 mi) in length and marks the western boundary of the Portland basin. There are surface features on the east face of the West Hills that suggest the presence of this fault, and a trench excavation has exposed disturbed Missoula Flood sediments, but no offset. The disturbed sediments might suggest liquefaction during a prehistoric earthquake. However, the limited historical earthquake records do not place any known earthquake on the Portland Hills Fault. Many small magnitude historic earthquakes have been recorded and located near the Portland Hills Fault suggesting that there are active structures nearby; "the presence of small earthquakes, more often than not, delineates areas where larger earthquakes are likely to occur" (Wong et al., 2001). The USGS Fault database (USGS, 2006) lists the age of last activity on this fault as less than 15 thousand years ago (Personius and Haller, 2017). The Oatfield Fault might be structurally connected to the Portland Hills Fault (Wong, et al., 2001).

The USGS maps the Portland Hills Fault to extend about 300 feet from the North Clackamas County Water Commission Water Treatment Plant. The Oatfield Fault is mapped to cross SE McLoughlin Boulevard, the alignment of the existing water main, at approximately SE Oak Grove Boulevard.

5.0 Subsurface Conditions

Minimal deep subsurface information was provided to McMillen Jacobs Associates. Three deep soil borings (greater than 50 feet bgs) were provided and located within the service area. Geologic maps, publications, and subsurface information previously provided to McMillen Jacobs Associates by others were used to further identify the subsurface conditions at the site. Based on this information, the subsurface within the project area is predominantly the following geologic units:

- Alluvial Deposits: Generally consist of soft fine grained material near existing surface water locations and low lying areas. This material is highly variable in its susceptibility to seismic liquefaction and lateral spreading hazards. DOGAMI mapping shows these soils along the banks of the Willamette River and Kellogg Creek at the north portion of the service area as well as along the banks of the Clackamas River at the North Clackamas County Water Treatment Plant and Oak Lodge Pump Station.

- Missoula Flood Deposits: Fine-grained deposits generally consist of very soft to stiff silt with varying concentrations of clay and sand. When saturated, the fine-grained material is generally prone to seismic liquefaction and lateral spreading hazards. Coarse-grained flood deposits generally consist of medium dense to very dense sand and gravel with varying concentrations of silt. The coarse-grained deposits are generally seismically stable and not susceptible to liquefaction and lateral spreading permanent ground deformations. These deposits are shown to be scattered throughout most of the west portion of the service area.
- Troutdale Formation: Generally, consists of very dense silty or clayey sand and gravel mixtures. This material is seismically stable and not susceptible to liquefaction and lateral spreading permanent ground deformations. This formation is shown in the southeast vicinity of the service area near the Valley View Pump and Reservoirs.
- Basalt: Although only encountered in a few explorations provided, this bedrock stratum was in varying states of weathering. This material is seismically stable and not susceptible to liquefaction, lateral spreading, or permanent ground deformations. This material is mapped sparsely at locations in the northwest quadrant of the service area and predominantly along the northeast quadrant of the service area.

DOGAMI shows similar geology in their mapping of the service area (Bauer et. al., 2018). Figure 1 shows the distribution of the geologic units across the general service area per DOGAMI.

6.0 Geotechnical Seismic Hazards

Seismic hazards including very strong ground shaking, liquefaction potential, lateral spreading, and seismic-induced landslide were analyzed. These hazards have the potential to damage facilities (i.e., pipelines, reservoirs, pump stations, treatment plants) through either permanent ground deformation (PGD) or intense shaking. Our analysis of these seismic hazards is based on information provided from existing geotechnical explorations, DOGAMI hazard maps, and our knowledge of the geotechnical conditions of the area. In our seismic analyses, we assumed a magnitude 9.0 earthquake and a peak ground acceleration (PGA) of 0.20 g to represent the effects of a M9 CSZ seismic event in the project area.

6.1 Present Landslides Identified within or adjacent to the OLWSD Service Area

DOGAMI's Statewide Landslide Information Database for Oregon (SLIDO) (Burns and Watzig, 2014) shows that the OLWSD service area includes several landslides. Figure 2 shows the locations of these landslides. These mapped landslide features are predominantly in the southeastern limits of the service area. The slides are reported to be deep-seated with a failure depth up to 45 feet. There are two slide masses downslope from the two existing reservoirs along SE Valley View Road. These slides are cited to have occurred within the last 150 years. GeoDesign (GeoDesign, July 2004) previously performed a landslide investigation and reconnaissance for a portion of the OLWSD waterline alignment fed by these two reservoirs. A summary of the information provided to us regarding GeoDesign's investigation is included in Section 2.0.

SLIDO also maps a series of pre-historic (greater than 150 years old) landslides and debris flows located just outside the northeastern limits of the service area. These mapped landslides and debris flows are located on steep slopes that trend downward to Kellogg Creek. Figure 2 shows the locations of these slides and flows. It is noted that Figure 2 displays landslide deposits and debris flows or fans as a single unit and does not differentiate between the two slide mass types.

A series of deep-seated, prehistoric landslides as well as a historic debris slide are shown along the east and south banks of the Clackamas River next to the North Clackamas County Water Treatment Plant. Additionally, a localized slide is shown along Clackamas River Drive, just east of the entrance to the water treatment facility. Finally, a deep-seated, historic landslide (less than 150 years old) is shown adjacent to the southeast corner of the Oak Lodge Pump Station.

Finally, SLIDO also shows the presence of small localized slides along the east banks of the Willamette River within the OLWSD.

6.2 Ground Shaking

6.2.1 Seismic Ground Shaking Parameters for CSZ Earthquake

To assess the hazard potential of ground shaking in the project area, we reviewed the peak ground velocity (PGV) map published by DOGAMI in their Open File Report for Earthquake Regional Impact Analysis for Clackamas, Multnomah, and Washington Counties, Oregon in the event of a M9 CSZ earthquake (Bauer et. al., 2018).

The estimated ground shaking intensity (PGV) depends on the subsurface materials. The ground shaking near the surface will be amplified by thick soil units. Generally, the average PGV is estimated to range between 7 and 16 inches per second. The PGV map is shown in Figure 3.

6.2.2 Seismic Ground Shaking Parameters for Maximum Considered Earthquake

DOGAMI cites a peak ground acceleration of 0.15 to 0.20 g for the general service area in Plate 4 of its Earthquake Regional Impact Analysis for Clackamas, Multnomah, and Washington Counties, Oregon (Bauer et. al., 2018).

Since detailed, deep subsurface information was provided for most of the OLWSD's above-ground structures, we assessed the code-based seismic ground motion parameters for the structural evaluations of the two reservoirs and associated pump located at Valley View Road. The seismic ground motion parameters were developed based on the current building code (2015 NEHRP) requirements for Site Class D (stiff soil). The seismic parameters are provided in Table 1. These parameters are for the maximum considered earthquake (MCE) with a 2,475-year recurrence interval.

Table 1. 2015 NEHRP Seismic Ground Acceleration Parameters for a 2,475-Year MCE for Structures at SE Valley View Road

Seismic Parameter	Site Class D
MCE Peak Bedrock Acceleration (PBA)	0.39 g
MCE Bedrock Spectral Acceleration, 0.2 second period (S_s)	0.87 g
MCE Bedrock Spectral Acceleration, 1.0 second period (S_1)	0.39 g
Site Coefficient (F_{PGA})	1.20
Short-Period Site Factor, F_a	1.15
Long-Period Site Factor, F_v	1.91
Soil MCE Peak Ground Acceleration (MCE PGA_M)	0.47 g
Soil MCE Spectral Acceleration, 0.2 second period (S_{MS})	1.04 g
Soil MCE Spectral Acceleration, 1.0 second period (S_{M1})	0.74 g

It is noted that the above parameters are based on deep subsurface information, B-1 and B-2, which were part of the 2004 Landslide Investigation and subsequent reporting by GeoDesign. The design parameters in Table 1 should not be used for other structures within OLWSD unless additional deep subsurface information confirms these values.

6.3 Liquefaction

Liquefaction is a phenomenon affecting saturated, granular soils in which cyclic, rapid shearing from an earthquake results in a drastic loss of shear strength and a transformation from a granular solid mass to a viscous, heavy fluid mass. The results of soil liquefaction include loss of shear strength, loss of soil materials through sand boils, flotation of buried chambers/pipes, and post liquefaction settlement.

To evaluate the hazard potential of soil liquefaction in the service area, we reviewed liquefaction hazard maps published by DOGAMI for the Portland Metro Area in the event of a M9 CSZ earthquake (Bauer, et. al., 2018). Where geotechnical data was available or provided, we conducted site specific analyses based on the subsurface conditions using SPT-based liquefaction susceptibility and settlement assessment procedures (Boulanger and Idriss, 2014; Idriss and Boulanger, 2008). Based on our calculated post-liquefaction settlement results using the provided subsurface information discussed in Section 2.0, we slightly revised DOGAMI's liquefaction probability map and developed a liquefaction induced settlement map included in Figure 4.

In general, we mostly concur with DOGAMI's mapping for the risks of liquefaction settlement. We considered most of the northeast section of the service area (northeast of McLoughlin Boulevard) to be non-liquefiable. We consider the region of the Valley View pump and reservoirs to be non-liquefiable based on the extensive geotechnical work performed at the site and the significant depth to groundwater shown by the USGS (Snyder, 2008). Finally, we concur with DOGAMI's mapping of the southwest quadrant of the service district to be non-liquefiable based on our review of deep explorations for previously completed projects performed by others.

However, some of the provided subsurface information indicates that there is a potential for a dynamic settlement due to liquefiable soils along SE McLoughlin Boulevard at SE Oak Grove Boulevard and SE Park Avenue. In addition, we revised a region of DOGAMI's mapping for a generally low risk area near south of SE McLoughlin Boulevard between SE Concord Road and SE Roethe Road based on provided geotechnical information. Shallow groundwater was reported and is generally confirmed by the USGS mapping of groundwater (Snyder, 2008). DOGAMI estimated settlement to be up to 2 inches while we estimated the settlement due to liquefiable soils to be around 4 inches based on the available subsurface information.

Outside the general service area, alluvial deposits along the Clackamas River are susceptible to liquefaction, which can impact the Oak Lodge Pump Station and the North Clackamas County Water Treatment Plant. No subsurface information was provided for either of these facilities. DOGAMI estimates a moderate to high risk of liquefaction at the North Clackamas County Water Commission Water Treatment Plant and a moderate risk for the Oak Lodge Pump Station. A subsurface investigation should be performed at each site to better evaluate the seismic hazards at these locations.

To refine or revise our opinions regarding the locations of potentially liquefiable soils, additional subsurface information will need to be provided or additional explorations should be performed.

6.4 Lateral Spreading

Liquefaction can result in progressive deformation of the ground known as lateral spreading. The lateral movement of liquefied soil breaks the non-liquefied soil crust into blocks that progressively move downslope or toward a free face in response to the earthquake generated ground accelerations. Seismic movement incrementally pushes these blocks downslope as seismic accelerations overcome the strength of the liquefied soil column. The potential for and magnitude of lateral spreading depends on the liquefaction potential of the soil, the magnitude and duration of earthquake ground accelerations, the site topography, and the post-liquefaction strength of the soil.

To assess the hazard potential of lateral spreading in the project area, we reviewed a lateral spreading hazard map published by DOGAMI for the Portland Metro Area in the event of a M9 CSZ earthquake (Bauer et. al., 2018). The primary zones of lateral spreading hazard areas are at a region within the southwestern one-third of the service area. Similarly, shallow groundwater is also mapped in this region. DOGAMI reports that permanent ground deformation will be up to 2 feet in the southwest portion of the immediate service area, while most of the service area is showing negligible lateral spread.

To verify and refine the DOGAMI mapping, we used pseudo-static slope stability analyses for areas with gentle slope with no free face and used lateral displacement index (LDI) method (Zhang et. al., 2004) for areas with free face (gentle slope and flat ground). The pseudo-static slope stability analyses were completed using the computer software SLIDE by RocScience (version 7.0) to calculate the minimal slope degree at which lateral spreading may occur. In our analyses we used an average residual shear strength of 250 psf for the liquified soil, under a block-type failure. The residual shear strength was estimated for Missoula Flood Deposits and Alluvial soils assuming soft or loose consistency. A pseudo-static coefficient of 0.1g was applied, which is one-half of DOGAMI's estimated Peak Ground Acceleration for a simulated Cascadia Subduction Zone Magnitude 9.0 earthquake, (Bauer et. al., 2018). When back-calculating to seismically stable conditions (a stability factor of safety slightly less than less than 1.10), the results of the analyses indicate that lateral spreading may occur for slopes steeper than 12 percent (7 degrees) and located within areas susceptible to liquefaction.

Where geotechnical data was available, we conducted site specific analyses for LDI based on the subsurface conditions and SPT N-values shown in previous geotechnical explorations listed in Section 2. The available subsurface information for these analyses include the community of Jennings Lodge (located between SE River Road and Oatfield Road, and SE Roethe Avenue and SE Hull Avenue), the Valley View site, several locations along SE McLoughlin Boulevard, and a few scattered locations within the general service area.

A portion of the Jennings Lodge community is reported to be a wetland in Shannon & Wilson's Preliminary Geotechnical Report dated November 9, 2016. Similar surficial conditions were documented in the Geotechnical Investigation Report by Rapid Soil Solutions dated January 22, 2010 for a nearby property. Based on the limited subsurface information provided to us our site-specific analyses of LDI results in expected PGD within this region to be on the order of 2 to 3 feet.

In addition, we considered risks of lateral displacement due to liquefaction at two isolated regions located along SE McLoughlin Boulevard. These regions are in areas where we consider settlement due to liquefaction to be more of a risk than DOGAMI's mapping (also discussed in Section 6.3). Based on the provided subsurface information as well as internal subsurface information for previously completed projects, we estimate the lateral spreading displacement to be up to 4 feet in isolated regions within the northeast portion of the service area near SE McLoughlin and SE Park Avenue. We estimate that up to 2 feet of lateral displacement due to potentially liquefiable soils could occur in the vicinity of the intersection of SE McLoughlin and SE Oak Grove Boulevards.

DOGAMI mapping shows the North Clackamas County Water Treatment Plant and the Oak Lodge Pump Station to include risks of lateral spreading. The water treatment plant is shown to be in a "very high" risk zone, with PGD between 39 and 173 inches. The Oak Lodge Pump Station is shown to be of a "moderate" risk, with 4 to 12 inches of lateral spread. Without subsurface information for these two facilities, we generally concur with the risk levels denoted by DOGAMI. An investigation should be performed at these sites to further evaluate the risks of potentially liquefiable subsurface conditions.

Based on DOGAMI mapping and provided subsurface information, we identified those areas where we consider risks present for lateral displacement due to liquefiable soils. See Figure 5.

6.5 Seismic Landslides

Earthquake induced landslides can occur on slopes due to the inertial force from an earthquake adding load to a slope. The ground movement due to landslides can be extremely large and damaging to pipelines and other structures.

To assess the hazard potential of seismic landslides in the project area, we reviewed several publicly available documents from DOGAMI: the landslide deformation map for the Portland Metro Area in the event of a M9 CSZ earthquake (Bauer et. al., 2018), the Statewide Landslide Information Database for Oregon (SLIDO), and the topography of the project area in conjunction with visual assessment of slopes during our site visit.

We also evaluated the stability of the area using SLIDE software by RocScience Version 7.0 to quantitatively evaluate the degree of the slope where a soil mass would become unstable. We assumed subsurface soil parameters based on the geotechnical information provided to us. In our analyses we used a 5-foot thick crustal layer with a unit weight of 125 pounds per cubic foot (pcf), no cohesion, and an internal angle of friction of 30 degrees, overlying a 125 pcf stratum of soil with an internal angle of friction of 30 degrees, and 50 psf of cohesion. The final stratum in our analyses included soil parameters of 130 pcf, cohesion of 50 psf, and an internal angle of friction of 32 degrees. We back-calculated the minimal slope angle of the soil strata that would become unstable with circular failures under a seismic condition using a peak ground acceleration of 0.1 g. We concluded that inclinations of 22 degrees and great (40 percent and greater) would become unstable (an analysis resulting with a stability factor of safety slightly less than 1.10) for a depth of 1-foot over a lateral distance of 300 feet.

The service area is generally located on relatively flat to gently sloping ground. There are, however, many isolated regions that include moderate to steeply sloping terrain. One is located near the southeastern extent of the service area downslope from the two existing reservoirs along SE Valley View Road. The site slopes are overall about 5:1 to 2:1 (Horizontal:Vertical), but there are isolated slopes up to approximately 1:1 present along the northeast side of SE Oatfield Road. These steeper slopes are generally down to the southwest and located within previously discussed landslide masses.

The two reservoirs along SE Valley View Road sit above the mapped slide scarps to the northeast. DOGAMI's SLIDO shows a series of four landslides which cross SE Oatfield Road in this area near the southeast limits of the service area (Burns and Watzig, 2014). The GeoDesign 2004 Landslide Investigation Report reports the presence of smaller secondary landslides within the slide masses along SE Oatfield Road.

GeoDesign's monitoring of the two slope inclinometers between January 2004 and May 2012, showed nearly negligible soil movement and concluded shallow soil creep movement was present at the site. The greatest cumulative displacement, about 0.02 inches, is shown in the piezometer installed along SE Oatfield Road. The depth of this maximum movement is shown to be approximately 4 to 6 feet below the top of the inclinometer. Although that monitoring was observed during seismically dormant periods and showed nearly negligible movement, we have concern about potential soil instabilities within the mapped landslide at the Valley View site. We consider these risks moderate. Because potential soil movement could damage the existing water system, which in turn could introduce subsurface water into the region, we recommend that OLWSD continue to have the previously installed inclinometers and piezometers periodically monitored. Introduction of subsurface water into the existing landslide mass could create and/or expedite instabilities. Routine inspections should be performed on the subsurface pipe system to identify potential leaks or breaks to limit the amount of subsurface water introduced into the surrounding soils. Excessive lateral deformation of the inclinometer or excessive rise in groundwater levels should be evaluated to determine if mitigation efforts will be necessary.

Similar slopes are present at the View Acres site. However, known landslides documented by DOGAMI are not shown in this area. Generally, the existing reservoirs site on top of a gentle hill that slopes downward in each direction. The steepest slopes, up to approximately 1:1 (H:V), are located about 120 feet northeast of the tanks. The underlying geology in this steeply sloping region is shown to include Columbia River Basalt (see Figure 1). The RH2 April 2012 Seismic Vulnerability Report for Valley View and View Acres refers to a geotechnical engineering report by Shannon & Wilson dated May 2, 1988. This report has not been provided to us for review. However, considering the general stable geologic formation within the vicinity of the area (Columbia River Basalt Group) and the overall gentle terrain, the risks of potential instabilities due to a CSZ seismic event at the View Acres site are expected to be low. We recommend additional review of the geotechnical information to verify this expectation.

The northeast border of the service area also contains sloping terrain, generally down to Kellogg Creek located to the northeast. Similarly, steep slopes are present along the service areas west border along the Willamette River. Generally, these slopes are on the order of 20 to 45 percent, but also include isolated regions that are nearly vertical. Finally, the north portion of the western extent of the service area, along the banks of the Willamette River, contain regions of near vertical slopes that extend nearly 2,500 lateral feet. SLIDO shows that there are small, localized landslides along this portion adjacent to the banks of the Willamette River (Burns and Watzig, 2014). Larger pre-historic landslide and debris flows are mapped near the northeast border of the general service area. We consider the risk of seismically induced landslides along Kellogg Creek and the southwest border of the service area adjacent to the Willamette River to be moderate to high. In our opinion the higher risk regions are located on or adjacent to steep slopes, such as those properties and areas near the perimeter of the service area. If needed, a detailed subsurface investigation and stability analyses should be performed to further evaluate these areas.

The Oak Lodge Pump Station and North Clackamas County Water Treatment Plan, each located outside the general service area along the Clackamas River, are situated adjacent to steeply sloping terrain. As discussed in Section 6.1, DOGAMI's SLIDO maps pre-historic, historic, as well as recent localized landslides and debris fans near each of these facilities.

We consider North Clackamas County Water Treatment Plant to have a high risk associated with ground instabilities during a Cascadia event. In addition to potential structural damages associated with soil movement, potential landslide debris could encroach the existing in-ground vessels of this water treatment plant. To provide a detailed stability analysis of the area, a subsurface investigation will need to be performed.

We consider the Oak Lodge Pump Station to have moderate to high risks for potential soil instabilities due to a Cascadia event. The primary areas of concern are those structures located near steep slopes, such as the open-air aeration, clarification, or filtration vessels located on the river flood plains. Upslope instable soils could migrate to these vessels. There are steeper slopes adjacent to the property to the east that are at higher risk for potential instabilities. A subsurface investigation will need to be performed or provided so that detailed stability analyses can be performed.

Figure 6 shows the regions of the OLWSD where we consider the various levels of risks of landslides occurring under design-level seismic events. Generally, we consider those areas at risk to be located on sloping terrain greater than 22 degrees and within mapped landslide masses per DOGAMI (Burns and Watzig, 2014). In Figure 6, we incorporate DOGAMI's report for the Portland Metro Area (Bauer et. al., 2018) to include lateral displacement amounts in three increments: 0 to 1; 1 to 4; and 4 to 24 feet.

7.0 Seismic Hazard Assessment and Recommendations for Critical Facilities

As discussed in Section 6, we have concerns regarding the sites of the reservoirs, the water treatment plant, and the pump station. These location have various risk levels for potential seismic hazards. Table 2 summarizes the results of the site visits, document review, as well as our opinions regarding the seismic hazards and geotechnical concerns at these locations. Our recommendations for future studies are also included in Table 2.

MCMILLEN JACOBS ASSOCIATES

Yuxin "Wolfe" Lang, P.E., G.E.
Principal Engineer

Jeremy Fissel, P.E.
Project Engineer

Table 2. Preliminary Seismic Hazard Assessment Summary for Critical Facilities

Structure Name	Available or Nearby Geotechnical Information	Mapped Seismic Hazards and Levels	Anticipated Subsurface Conditions and Site Topography	Preliminary Geotechnical Seismic Concerns & Issues	Recommendations/Notes
Two Reservoirs and Pump Station along SE View Acres Road	A site-specific study for these reservoirs have already been performed by RH2 in 2012. RH2's conclusions were based on a 1988 Geotechnical Investigation Report by Shannon & Wilson. This report was **not** provided for our review. Seismic upgrades of the two reservoirs were performed in 2013.	Liquefaction and landslide hazards are anticipated to be low at this site.	Located at the top of a moderately sloping hill with isolated steep slopes. The hillside slope ranges from about 3:1 and includes slopes up to 1:1 (H:V). Geology is mapped as Columbia River Basalt Group.	Isolated steep slopes along hillside. Lack of subsurface information.	Obtain and perform a detailed review of the May 2, 1988 Shannon & Wilson Geotechnical Engineering Report which was used during the design and construction of the 1989 reservoir and the recent RH2 seismic retrofit design.
Two Reservoirs and Pump Station along SE Valley View Road	Landslide Investigation performed by GeoDesign in 2004. Two soil borings, B-1 and B-2, were drilled to 105 and 130 feet, respectively. Very stiff silt and clay to a depth of 57 and 124 feet, underlain by basalt. Slope inclinometers were installed in each borehole installed – B-1 to 100 feet, B-2 to 40 feet. Inclinometer readings provided between 2004 and 2012 show no significant movement but possible soil creep. Piezometer readings do not indicate large fluctuations in groundwater levels.	Site sits above the headscarp of a mapped historic landslide. Surrounding area includes moderate landslide hazards due to steep slopes and nearby existing slide mass. Liquefaction hazards are not anticipated at this site.	Located on level ground at the top of a hill, behind the headscarp of a landslide. Slide mass slopes up to about 1:1 (H:V) degrees and crosses SE Oatfield Road. Geology is mapped as Troutdale Formation.	Isolated steep slopes located adjacent to existing structures. Located in a region of a known landslide about 300 feet downslope of the facility. Adjacent ground movement within the slide mass observed during that last 20 years along SE Oatfield Road and surrounding neighborhood. Repairs to a few single-family homes were needed (as cited by GeoDesign in 2004). Lack of global subsubsurface information.	Continue monitoring slope inclinometers and piezometers previously installed by GeoDesign. Should ground movement be observed through continued monitoring, follow recommendations provided in GeoDesign's 2004 report. Potential ground movement may negatively impact surrounding private properties. Should excessive ground movement be observed during the continued inclinometer monitoring, a global stability investigation and analysis of the slide area may need to be performed. Develop a pipeline inspection program to quickly identify potential subsurface leaks or breakages.
North Clackamas County Water Commission Water Treatment Plant	No geotechnical data available.	High liquefaction susceptibility rating. Liquefaction settlement estimated to be greater than 4 inches. Liquefaction lateral spread displacement estimated to be greater than 4 feet. Historic landslide and debris slide mapped adjacent to facility. High landslide hazard area upslope from site based on existing site slopes. Location mapped along the Portland Hills Fault.	The site is located within the flood plains of the Clackamas River. There is an approximately 180-foot tall very steep slope directly to the east of Clackamas River Drive. Site is about 200 feet east of the Clackamas River. The geologic map indicates the site is near the border of present day alluvial deposits and continental sedimentary rocks.	Very steep slope adjacent to site. Historic landslides and debris slides located near property. Lack of subsurface information.	Perform subsurface investigation, site-specific stability, and liquefaction analyses.
Oak Lodge Pump Station	No geotechnical data available.	Moderate liquefaction susceptibility rating. Liquefaction settlement estimated to be 2 to 4 inches. Liquefaction lateral spread estimated to be up to 2 feet. Moderate to high landslide hazard based on existing site slopes. Historic landslide located at the east corner of property.	The site is located within the flood plains of the Clackamas River. There is approximately 30 to 40 feet of vertical relief between the pump facility and the lower nearby flood plains. The Clackamas River is located about 700 feet south of the main facility and about 400 feet south of the existing in-ground, open-air water treatment vessels that are situated on a lower terrace adjacent to steep slopes. The geologic map indicates subsurface soils are present day alluvial deposits.	Very steep slopes located adjacent to site. Historic landslides located adjacent to property. Lack of subsurface information.	Perform subsurface investigation, site-specific stability, and liquefaction analyses.

8.0 References

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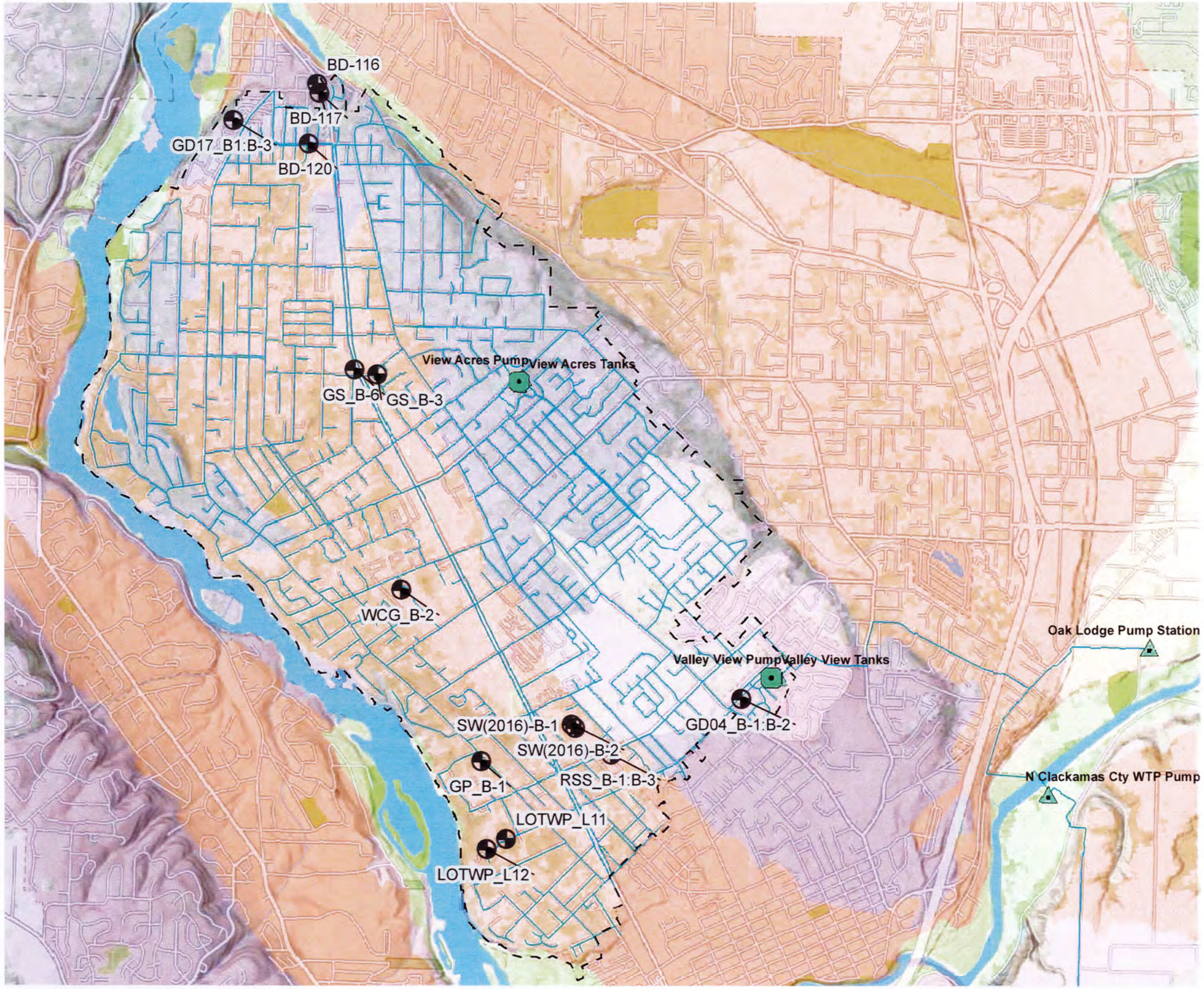
Figures



LEGEND

- Analyzed Borings
- Oak Lodge District Boundary
- Tanks
- Pumps
- Water Main

GEOLOGY

- Alluvial Deposits
- Columbia River Basalt Group
- Landslide Deposits
- Missoula Flood Deposits
- Portland Basin Volcanoes
- Terrace Deposits
- Troutdale Formation

NOTES:

1. ESTIMATES SHOWN ARE BASED ON HAZARD DATA FROM DOGAMI OPEN-FILE REPORT O-18-02 AND DATA FROM EXISTING BORINGS. AREAS OUTSIDE OF EXISTING BORING LOCATIONS HAVE NOT BEEN VERIFIED.
2. DATA SOURCE: DOGAMI O-18-02, SLIDO 3-4, OGDC-6
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3. THIS MAP IS INTENDED ONLY FOR THE OLWSD SERVICE AREA. OUTSIDE OF THE SERVICE AREA, THE DOGAMI MAPPING WAS NOT REVIEWED AND SHOWN FOR INFORMATION ONLY.

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Coordinate System: NAD 1983 HARN Oregon Statewide Lambert Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN

McMILLEN JACOBS ASSOCIATES

OAK LODGE WATER SERVICE DISTRICT

SEISMIC HAZARDS EVALULATION

TECHNICAL MEMORANDUM
SEISMIC HAZARDS
GEOLOGIC MAP

FIG. 1

June 2018

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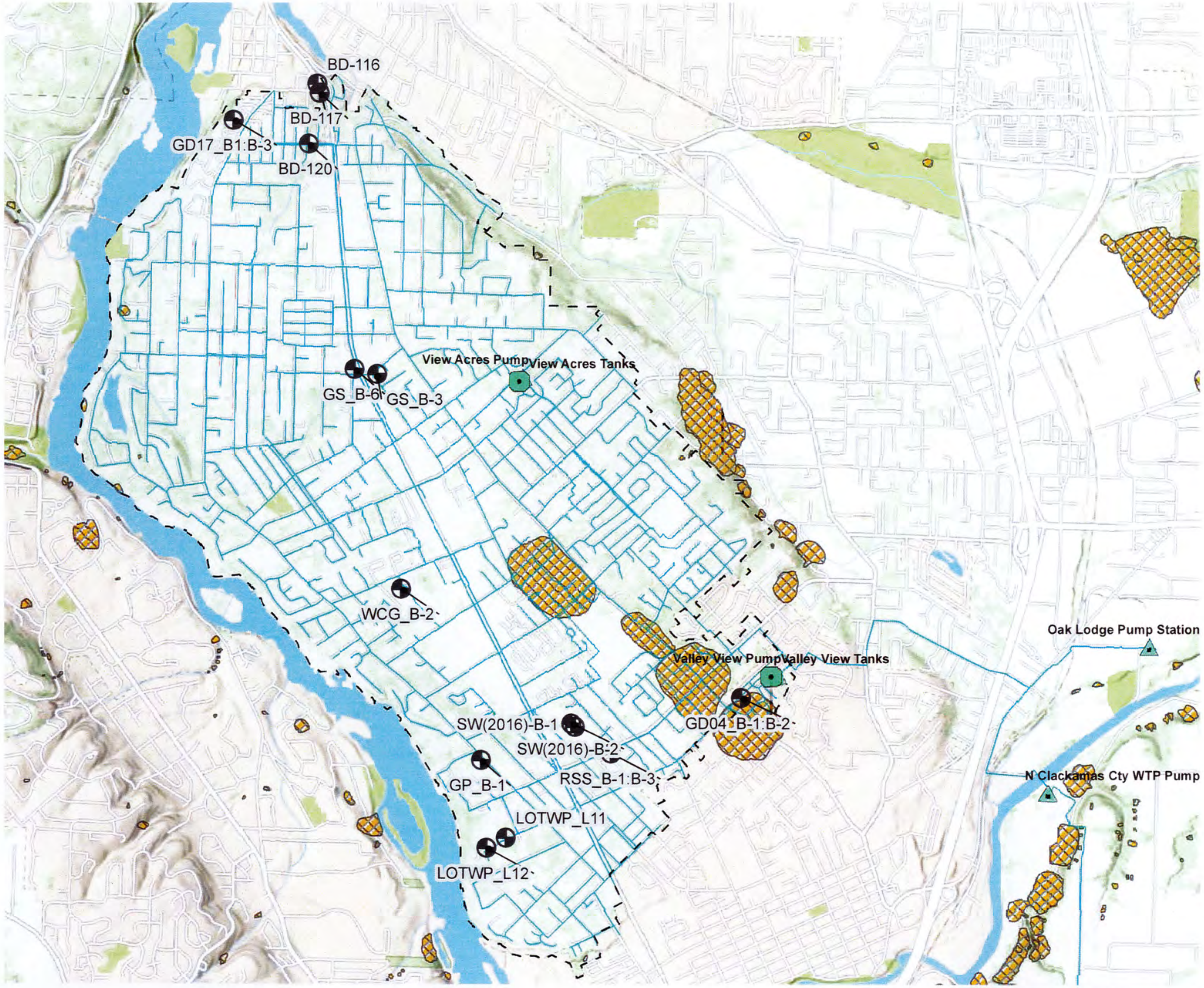

LEGEND

- Analyzed Borings
- Oak Lodge District Boundary
- Tanks
- Pumps
- Water Main
- Landslide Deposits

NOTES:

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McMILLEN JACOBS ASSOCIATES

OAK LODGE WATER SERVICE DISTRICT

SEISMIC HAZARDS EVALULATION

TECHNICAL MEMORANDUM
SEISMIC HAZARDS
LANDSLIDE DEPOSITS

FIG. 2

June 2018

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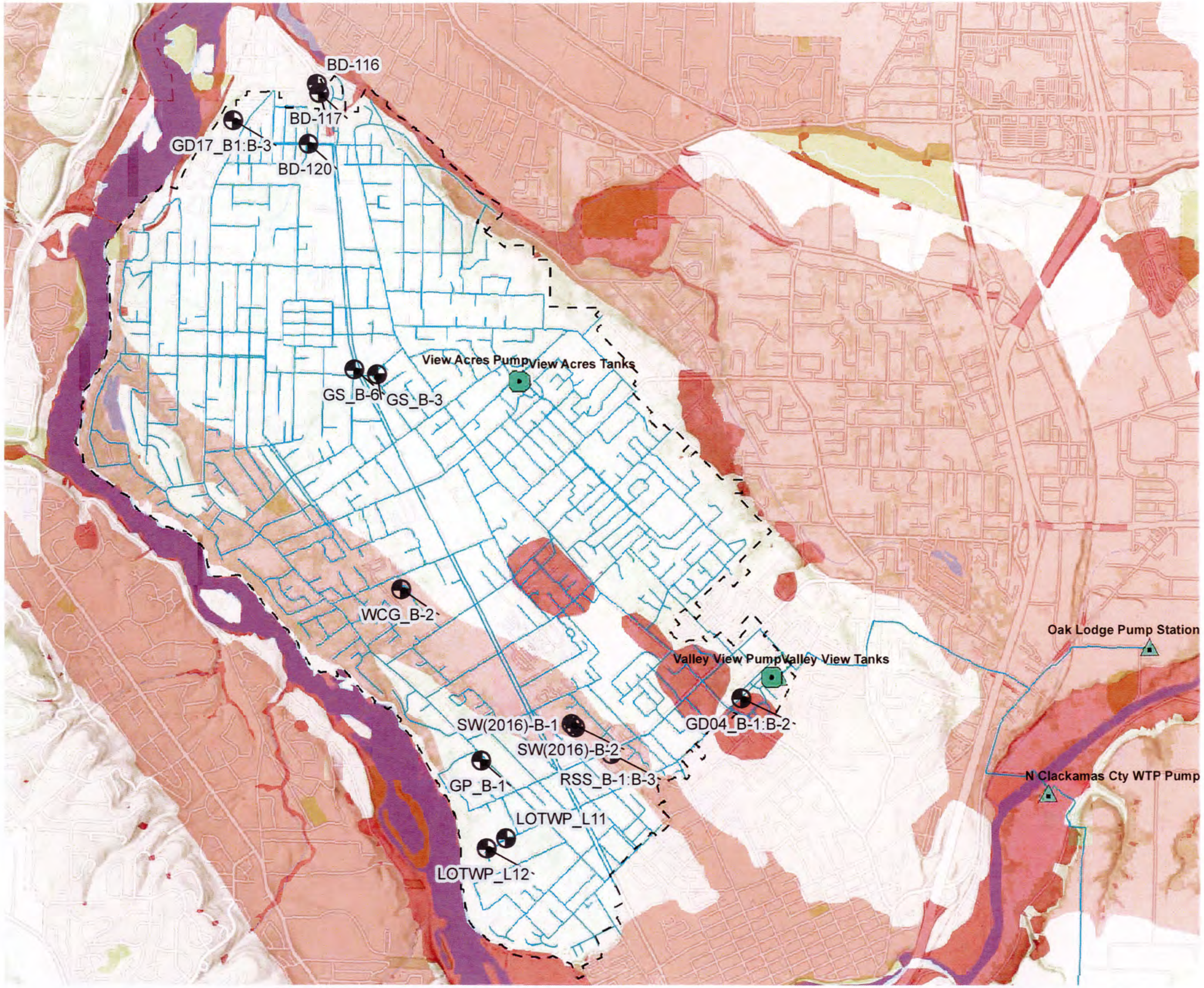

LEGEND

- Analyzed Borings
- Oak Lodge District Boundary
- Tanks
- Pumps
- Water Main

PEAK GROUND VELOCITY

- 7 - 9 in/s
- 10 -12 in/s
- 13 -16 in/s

NOTES:

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N

Coordinate System: NAD 1983 HARN Oregon Statewide Lambert Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN

McMILLEN JACOBS ASSOCIATES

OAK LODGE WATER SERVICE DISTRICT	FIG. 3
SEISMIC HAZARDS EVALULATION	
TECHNICAL MEMORANDUM SEISMIC HAZARDS PEAK GROUND VELOCITY	June 2018

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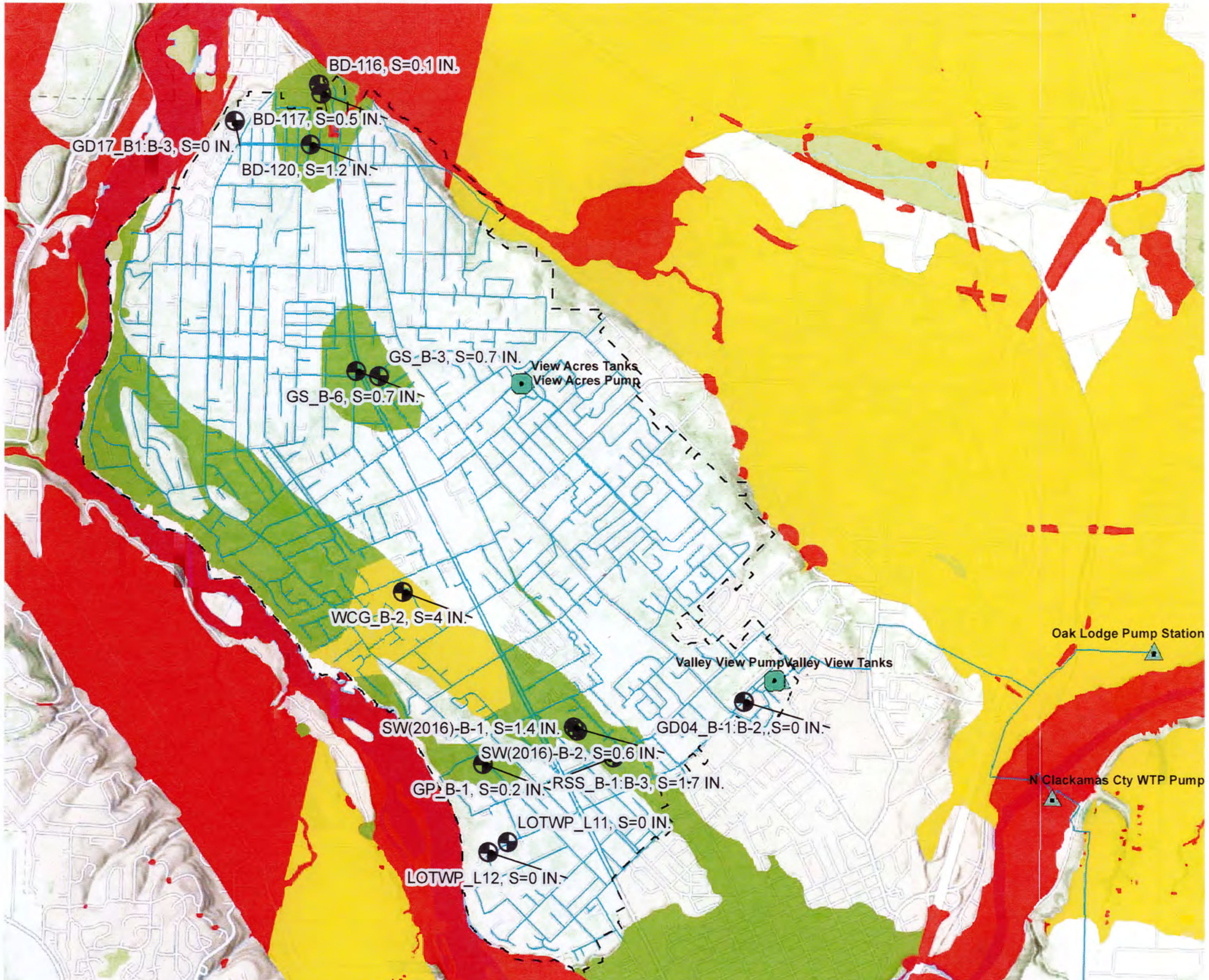

LEGEND

- Analyzed Borings
- Oak Lodge District Boundary
- Tanks
- Pumps
- Water Main

LIQUEFACTION SETTLEMENT, S

- Up to 2 in.
- 2 to 4 in.
- Greater than 4 in.

NOTES:

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Projection: Lambert Conformal Conic
Datum: North American 1983 HARN

McMILLEN JACOBS ASSOCIATES

OAK LODGE WATER SERVICE DISTRICT

SEISMIC HAZARDS EVALULATION

TECHNICAL MEMORANDUM
SEISMIC HAZARDS
LIQUEFACTION-INDUCED SETTLEMENT

FIG. 4

June 2018

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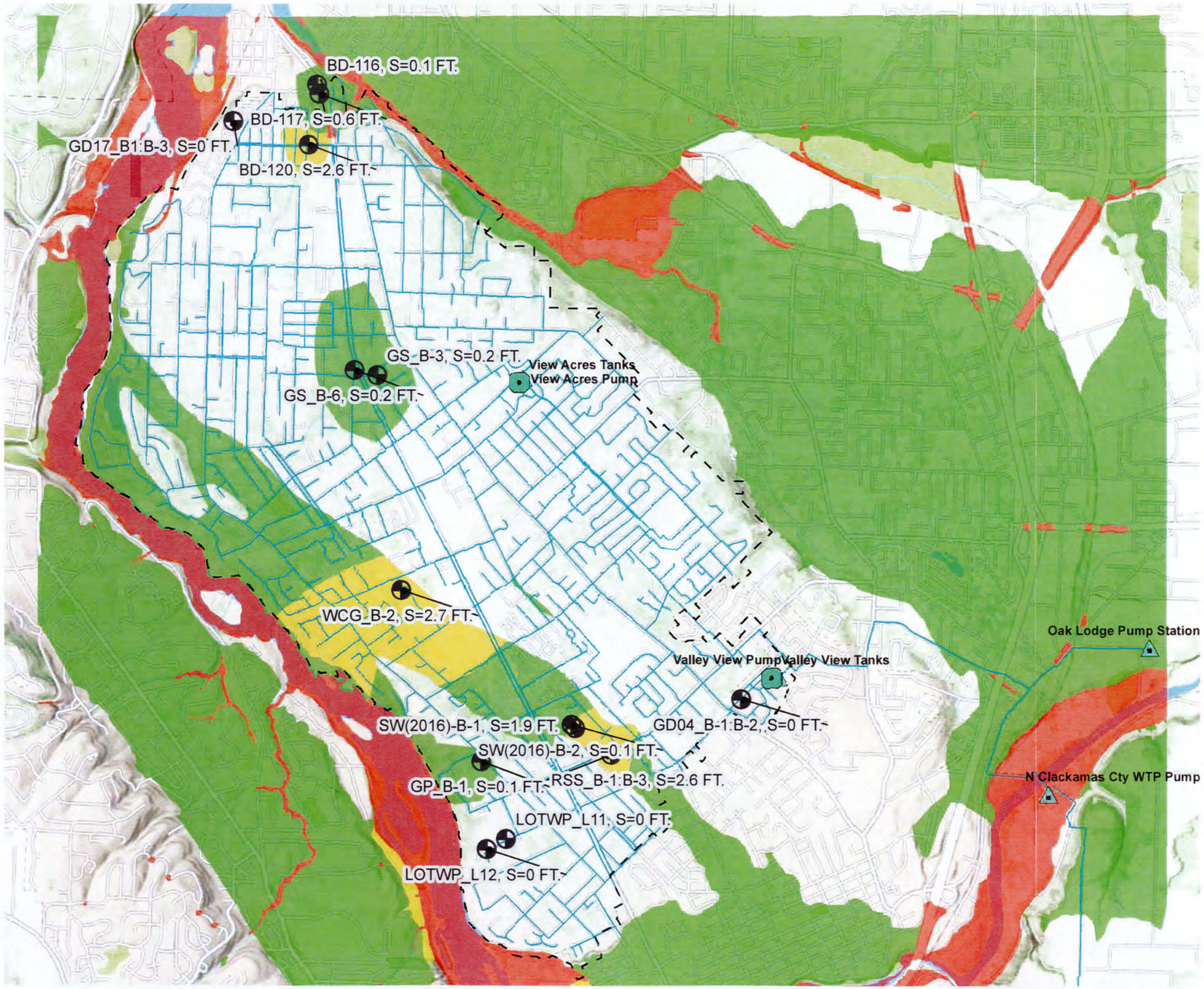

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Coordinate System: NAD 1983 HARN Oregon Statewide Lambert Feet Intl
Projection: Lambert Conformal Conic
Datum: North American 1983 HARN

LEGEND

- Analyzed Borings
- Oak Lodge District Boundary
- Tanks
- Pumps
- Water Main

LATERAL SPREADING, D

- Up to 2 feet
- 2 - 4 feet
- Greater than 4 feet

NOTES:

1. ESTIMATES SHOWN ARE BASED ON HAZARD DATA FROM DOGAMI OPEN-FILE REPORT O-18-02 AND DATA FROM EXISTING BORINGS. AREAS OUTSIDE OF EXISTING BORING LOCATIONS HAVE NOT BEEN VERIFIED.
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McMILLEN JACOBS ASSOCIATES

OAK LODGE WATER SERVICE DISTRICT	FIG. 5
SEISMIC HAZARDS EVALULATION	
TECHNICAL MEMORANDUM SEISMIC HAZARDS LIQUEFACTION LATERAL SPREADING	June 2018

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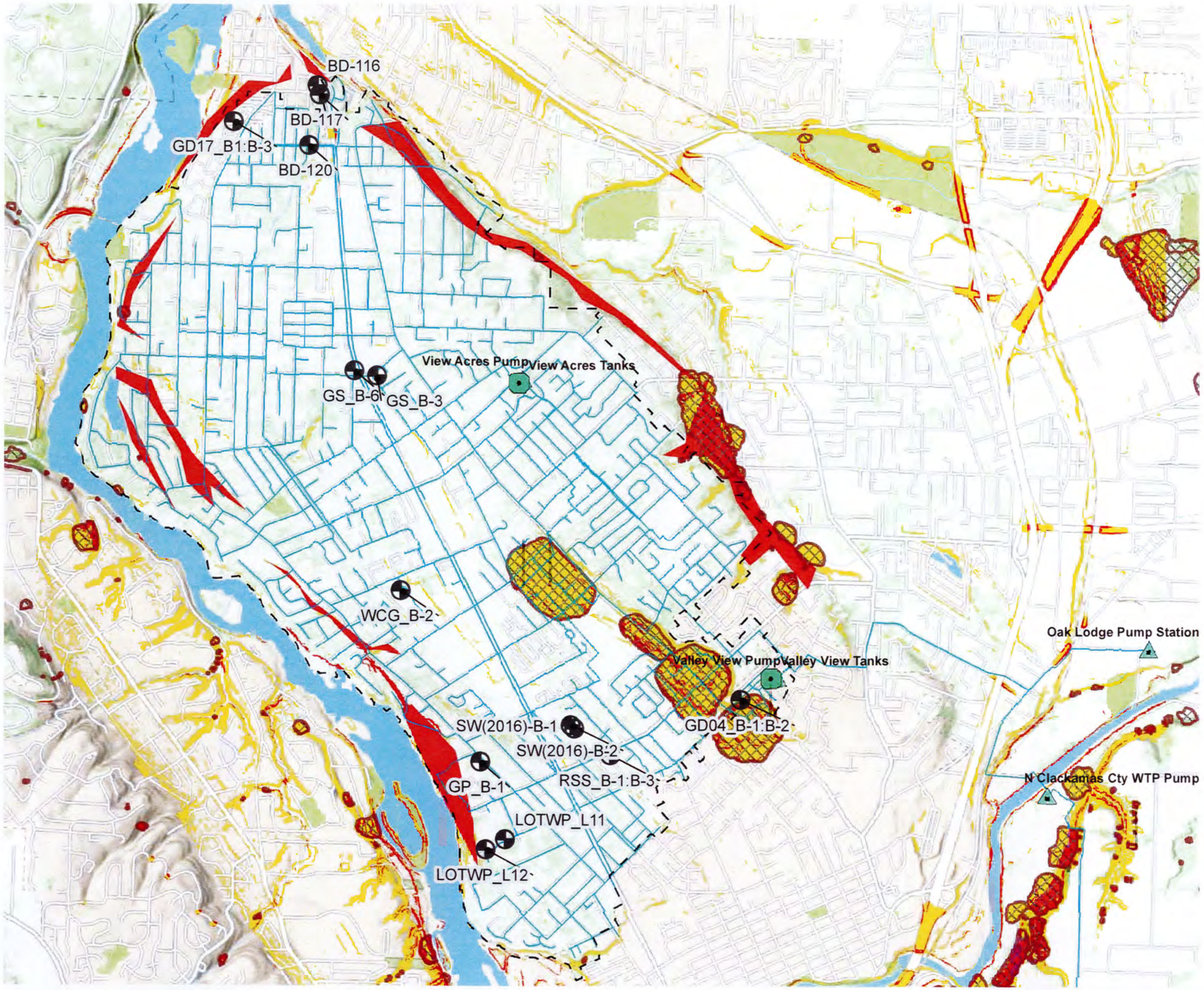

LEGEND

- Analyzed Borings
- Oak Lodge District Boundary
- Tanks
- Pumps
- Water Main
- Landslide Deposits

SEISMIC LANDSLIDE DISPLACEMENT

- Up to 1 ft.
- 1 to 4 ft.
- Greater than 4 ft.

NOTES:

1. ESTIMATES SHOWN ARE BASED ON HAZARD DATA FROM DOGAMI OPEN-FILE REPORT O-18-02 AND DATA FROM EXISTING BORINGS. AREAS OUTSIDE OF EXISTING BORING LOCATIONS HAVE NOT BEEN VERIFIED.
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Projection: Lambert Conformal Conic
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McMILLEN JACOBS ASSOCIATES

OAK LODGE WATER SERVICE DISTRICT

SEISMIC HAZARDS EVALULATION

TECHNICAL MEMORANDUM
SEISMIC HAZARDS
SEISMIC LANDSLIDE

FIG. 6

June 2018

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Appendix C. Emergency Supply Study TM

Date: 6/8/2020

To: Jason Rice
District Engineer
14611 SE River Road
Oak Grove, Oregon 97267

Phone: (503) 353-4202

Prepared by: Scott Duren

Reviewed by: Kirsten Plonka

Project: Oak Lodge Water Services District Water System Master Plan Update

SUBJECT: **EMERGENCY SUPPLY STUDY TECHNICAL MEMORANDUM**

Oak Lodge Water Services District (District) has appointed Water Systems Consulting, Inc. (WSC) with the task of updating their Water System Master Plan (WSMP). During the process of evaluating the District's water supply sources, WSC identified a major vulnerability for the District's emergency supplies. As part of the WSMP effort, the District would like to include a Capital Improvement Plan (CIP) project and budget for a project to improve the District's emergency supply options. WSC completed an emergency supply study to evaluate alternatives for emergency supplies for the District.

This technical memorandum (TM) describes the District's criteria for evaluating emergency supply alternatives, the initial screening of eight supply alternatives, and the final alternative evaluation and recommendation. This TM will be included as an appendix to the final WSMP update. WSC requests that the District review the draft provided in this TM and provide comments within 2 weeks. The District's review comments will be incorporated into revised final draft TM.

For reference, a list of terms is provided below:

ADD	Average Day Demand	NCCWC	North Clackamas County Water Commission
ASR	Aquifer storage and recovery	NRW	Non-Revenue Water
AWWA	American Water Works Association	O&M	Operations and maintenance
CRW	Clackamas River Water	OLWSD	Oak Lodge Water Services District
GIS	Geographical Information Systems	PHD	Peak Hour Demand
gpm	Gallons per Minute	PRV	Pressure Reducing Valve
HDPE	High Density Polyethylene	PVC	Polyvinyl Chloride
IGA	Intergovernmental agreement	PWB	Portland Water Bureau
LOTWP	Lake Oswego-Tigard Water Partnership	SCADA	Supervisory Control and Data Acquisition
MDD	Maximum Day Demand	SFWB	South Fork Water Board
MG	Million Gallons	TAZ	Transportation Analysis Zone
MGD	Million Gallons per Day	TVWD	Tualatin Valley Water district

1 WATER SUPPLY VULNERABILITIES

In 2018, the Oregon Water Resources Department issued new requirements for Water System Master Plans to identify improvements necessary for a seismically resilient water system within 50 years. A review of the District's water system found that water supply is entirely dependent upon a single 24-inch water supply pipeline and a single water source, the Clackamas River.

The single 24-inch diameter supply main that feeds the Valley View Reservoirs supplies treated water from the North Clackamas County Water Commission (NCCWC) water treatment plant which has a raw water intake on the Clackamas River. While the District has several interties with the adjacent City of Gladstone and Clackamas River Water (CRW) service areas, these existing interties only allow the District to export water delivery. The District's service pressure is significantly higher than the adjacent Gladstone and CRW service pressures, and there are no permanent pumps at the interties that could overcome the difference in hydraulic grade to supply water to the District. The NCCWC can obtain emergency water from other sources such as CRW and the South Fork Water Supply Board (SFWB), but conveyance of any emergency supply to the District requires the 24-inch diameter pipeline. The District has determined that a secondary means of supplying water is necessary to prevent supply outages if the 24-inch diameter pipeline is out of service.

The District also depends solely on the Clackamas River as a water source. Although the NCCWC maintains interties with CRW and SFWB, both water systems also use the Clackamas River as their source of supply. If any event caused the Clackamas River to be temporarily limited or unavailable as a supply source, the District does not have direct access to an alternative supply. The District has determined that gaining access to alternative water supply sources is key to improving resilience and reliability of water deliveries in the future.

Three potential scenarios were identified that could impact the ability of the District to supply water to customers:

- Supply Pipeline Outage. Damage to the pipeline could occur from a seismic event or adjacent underground construction, and the 50-year old District-owned pipe may require an outage for future maintenance or replacement.
- Clackamas River Contamination. Spills of hazardous materials into the river from tanker trucks, accidents on adjacent roads, or cyanotoxins from algal blooms could limit the water availability due to treatment limitations.
- Clackamas River Curtailment. During the late summer and early fall, withdrawals from the river could be curtailed provide minimum flows for fishery health and limit water availability.

New interties, or combinations of intertie options, are desired to provide the District with the ability to continue water delivery to customers under any of the above scenarios. The District has investigated several possible interties with neighboring water agencies that could reduce the risk associated with any of these events.

2 PREVIOUS EMERGENCY INTERTIES AND SUPPLY STUDIES

The need to access alternative water supply sources to the Clackamas River is not new for the District. Several past studies have evaluated different concepts, both regionally with other Clackamas River Providers, and for the District alone. Returning previously existing interties to service and modifying current interties are also options that were identified. A brief description of each concept is provided below:

- **City of Milwaukie Intertie**. Although the District has never had an intertie with the City of Milwaukie, an abandoned intertie with the Portland Water Bureau (PWB) included an alignment through the City and connected with the District at SE Aldercrest Road. An emergency pump station located within the Milwaukie service area was available to pump water from PWB into the District's system. The pump station is no longer operable but the building still exists and the intertie piping is believed to be intact. In discussions with District staff, temporary piping and pumping could allow some water to be transferred from the City of Milwaukie directly into the District's system but no formal agreement or infrastructure exists for emergency supply.
- **Clackamas River Water.** As mentioned above, the District currently maintains three interties with CRW distribution system, however due to pressure differential between the service zones, these can only be used to supply CRW with water from the District. A fourth interconnection is the District owned pump station at the CRW water treatment plant that is currently used by Sunrise, which can transfer water through the 24-inch supply pipeline to Valley View. In discussions with District staff, temporary piping and pumping could allow some water to be transferred directly between CRW and the District's distribution system but no formal agreement exists.
- **City of Portland Water Bureau Intertie**. The intertie with the City of Milwaukie, mentioned above, included a steel transmission pipeline along Linwood Road that connected to the PWB distribution system near the intersection of SE Flavel and SE Harney Drives. The majority of the pipeline was abandoned in place, but a portion was removed during construction of Highway 224.
- **City of Portland Water Bureau Regional Intertie**. Additional studies for a regional interconnection between PWB and Sunrise Water Authority were conducted by the Clackamas River Water Providers. The study investigated several options for construction of a transmission pipeline to convey water from PWB Bull Run Conduits to storage tanks at either the SE 92nd Ave and Otty Road or the SE 97th and Mather Road facilities owned and operated by Sunrise Water Authority. From these locations water could be conveyed to the District through the existing 24-inch diameter supply pipeline.
- **City of Gladstone**. Similar to CRW, the District currently maintains three interties with Gladstone, but due to pressure differential they can only be used to supply water to Gladstone from the District. In discussions with District staff, temporary piping and pumping could allow some water to be transferred into the District's system but no formal agreement exists.
- **Oak Lodge Groundwater Well**. In 2010 the District commissioned a Groundwater Feasibility Report to investigate the potential for a groundwater supply well. The study concluded that a capacity of up to 1 million gallons per day could be possible from a single well, and a minimum of two wells would be necessary at an estimated cost of $1.92M per well (in 2010 dollars) to meet District demands. The study did not include any test drilling or pumping and recommended further exploratory drilling to confirm assumptions related to yield and interference from other wells. The District does not currently maintain any groundwater rights, but the study indicated there were no obvious impediments to obtaining a groundwater right.
- **Sunrise Water Authority Aquifer Storage and Recover Wells.** The Sunrise Water Authority plans to further develop the capacity of an aquifer storage and recovery (ASR) system that could be used to store surplus water during wet years and augment water supply during periods of drought. Water from the ASR system cannot be feasibly routed to the District during normal operating conditions but could be used to offset Sunrise's water supply from the NCCWC to deliver a higher percentage of the NCCWC WTP's capacity to the District and Gladstone. This solution would require the use of the 24-inch diameter District supply pipeline.

- **Willamette River Intake**. A study commissioned by the Clackamas River Water Providers included an option to construct a new surface water intake on the Willamette River south of the confluence with the Clackamas River. The intake would include a 500-600 hp raw water pump station, a 12,500 foot long 30- to 36-inch diameter pipeline and would terminate at the South Fork WTP intake. Water could then be conveyed to the District through existing intertie pipelines between the SFWB and the NCCWC and then via the 24-inch water supply line.
- **Lake Oswego-Tigard Water Partnership**. A study commissioned by the North Clackamas County Water Commission (NCCWC) investigated the feasibility of repurposing the abandoned raw water supply pipeline to the Lake Oswego-Tigard Water Partnership (LOTWP) for supply of emergency potable water to Gladstone. Additional piping would be required to connect the existing pipeline to an abandoned 24-inch Gladstone Ranney Collector supply line and to Gladstone's Webster Tanks. An intertie pump station would be required to supply water to the District directly or emergency water could be routed through the NCCWC system and the 24-inch water supply pipeline to Valley View.

3 INITIAL SCREENING CRITERIA

To screen the list of potential emergency intertie options, the District established level of service requirements for an emergency intertie and criteria for use in ranking options.

3.1 Level of Service

During an emergency event that would require the use of an intertie, the District anticipates the ability to reduce demands through public outreach and water use restrictions such as discouraging outdoor irrigation. A minimum level of service during an emergency would provide sufficient supply to meet the average winter demands across the system. To account for projected future demands over the 20-year planning horizon, a minimum supply of 2.7 MGD would allow customers to receive continuous water service with some conservation requirements. The emergency supply must also meet the District's level of service for pressure above 40 psi at all service connections and provide fire flow with a residual pressure of 20 psi.

3.2 Initial Screening Criteria

The District developed criteria to screen potential emergency supply options as described below.

Table 3-1**Error! Reference source not found.** describes each screening category and the factors used to designate a ranking score. Each criterion results in a ranking score on a scale of 1 (lowest score) to 3 (highest score) that are summed for the purpose of ranking the alternatives. The alternatives with the highest sum of criteria scoring are preferable and will be further analyzed. A brief description of each criterion is provided below:

- **Water Sources** – The alternative's ability to provide a source of water that is not a Clackamas River source is an important ranking criterion. Alternatives that can provide access to a non-Clackamas River source, either by wheeling water from a third-party intertie or via direct connection, were given higher scores to account for the additional resilience in diversifying the District's access to water supply sources.
- **Partner Agencies** – The number of partner agencies that are required to supply the District with a non-Clackamas River water source will add complexity to an emergency situation and may impact the District's ability to access water. For example, an intertie with CRW would provide access to water from the Bull Run watershed through an interconnection with PWB, but this requires CRW to introduce non-Clackamas River water into their distribution system which may cause water quality concerns for their customers. Higher scores were awarded for alternatives that require less partner agencies.
- **Cost Estimates** – The anticipated cost of an intertie is an important factor for ranking alternatives. Preliminary cost estimates for initial capital costs were developed for each alternative or estimates from previous studies were used when available. Cost estimates prepared for this analysis conform to Class 5 Planning Level Classification of Opinions of Probable Construction Costs as developed by the Association for the Advancement of Cost Engineering. A Class 5 Estimate is typically used for concept screening purposes and has an expected accuracy ranging from -50% to +100%. Higher scores were awarded for alternatives with relatively lower estimated capital costs.
- **Operations and Maintenance (O&M)** – The anticipated O&M required is important to consider, as complex infrastructure will incur annual costs for maintaining equipment, functionality testing, and training of operations staff. For example, an intertie requiring a permanent pumping station and a long emergency pipeline will add to the annual O&M requirements for District staff compared to an intertie that only requires a few valves and a flow meter. Interties that will require reconfiguring existing District flow patterns, reservoir settings, and pump station operations are also considered to have a higher O&M burden than an intertie that mimics the existing supply and does not require specialized emergency controls or valve closures. It should be noted that additional ongoing charges that might be required by partner agencies for connecting to their system have not been determined and are not included in this study. Higher scores were given to alternatives that require less O&M.
- **Uncertainty/Risks** – Some intertie alternatives are less defined than others, and the rankings need to account for uncertainty and the risk of potential feasibility issues and hidden risk costs. For example, an alternative that depends on the unknown condition of currently abandoned pipelines or which requires the District to obtain new water rights would be ranked lower than those projects that are better defined. Alternatives that require a long pipeline alignment will have additional uncertainty related to potential water way or environmental wetland crossings, freeway crossings, or construction limitations due to land use or zoning that could increase construction costs.

Each of the criteria is presented in Table 3-1 below along with the specific parameters used to assign the individual ranking scores associated with the criteria.

Table 3-1. Initial Screening Criteria Descriptions and Scoring

Screening Criteria	Description	1	2	3
Water Sources	Ability to provide a non-Clackamas River water source	No access to non-Clackamas River Sources	Connection to a Clackamas user that can wheel non-Clackamas River water	Direct Connection to Non-Clackamas River Source
Partner Agencies	Number of partner agencies required to supply non-Clackamas River water	3+	2	0-1
Cost Estimates	Preliminary capital cost estimates	>$10M	$5M-$10M	<$5M
O&M	Modifications to current operations and increased asset maintenance	Major operational modifications And/or 2+ mechanical facilities	Minor operational modifications And/or 1 pump and over 1 mile of pipeline	No operational modifications And/or 1 pump and less than 1 mile of pipeline
Uncertainty /Risks	Potential to impact costs or project feasibility	Alignment poorly defined and >0.5 miles, water rights required, use of abandoned pipe in uncertain condition, capacity uncertainty	Alignments well defined but >0.5 miles, no new water right, all new infrastructure, minor capacity uncertainty	Alignments well defined and <0.5 miles, no new water rights, all new infrastructure, capacity can be defined

4 INITIAL ALTERNATIVE SCREENING

An overview of the alternatives that were investigated, a description of the criteria scoring for each alternative, and a summary and recommendation for more detailed analysis are provided in this section. Alternative screening was conducted in an interactive workshop with District staff to gain consensus on the recommendations for further evaluation.

4.1 Overview

To conduct an initial screening of each of the alternative emergency intertie options described in Section 2 of this TM, a conceptual description of each alternative was developed. In cases where previous studies had developed detailed descriptions of the potential emergency intertie, only the cost estimates were modified to reflect escalation and inflation to current pricing using the Engineering News Report's Construction Cost Index. Other alternatives unique to the District were developed to a conceptual level for the purpose of comparison. All the concepts were reviewed with District staff during an interactive workshop to confirm the feasibility and potential benefits or concerns with each alternative.

4.2 Alternative Screening

The following sections provide a brief description of each alternative emergency intertie and the justification behind the scoring provided for each of the screening criteria described in Section 3. As described in Section 3, the higher the score, the more preferred each alternative is for providing emergency supply to the District.

4.2.1 City of Milwaukie

The City of Milwaukie's distribution system borders the north end of the District's service area. Milwaukie receives its water supply from groundwater wells and has emergency intertie connections with CRW and PWB. A pump and upsized pipelines will be required to distribute the supply to the District's customers. Five distinct connection locations were identified and considered. Scoring for each criterion is provided below along with a brief description to explain each score.

- ***Water Sources: 3.*** The City's primary water source is groundwater which provides direct access to a non-Clackamas River source. The City also can access water from PWB (an additional non-Clackamas River source) and CRW through emergency interties.
- ***Partner Agencies: 3.*** Coordination with a single partner agency, Milwaukie, is required to obtain non-Clackamas River supply from the City's groundwater wells.
- ***Cost: 3.*** Estimated costs were developed between $1.6M and $2.5M depending on the location of the intertie. Costs include a pumping station to boost pressure from the City's operating pressure to match the District's lower pressure zone and to fill the Valley View reservoirs. Each location also requires upsizing of existing District pipelines to convey flow to Valley View.
- ***O&M: 2.*** Infrastructure maintenance includes a pump station and upsizing existing pipelines but does not add new pipelines. Upsizing existing pipelines is not considered to increase the amount of maintenance for any intertie alternative. An intertie with Milwaukie requires reversing flow through the system to pump into the north end and reach the Valley View tanks. This operational modification may increase pressures in the north end of the system and impact water quality in the distribution system.
- ***Uncertainty/Risks: 3.*** The project appears to be feasible, does not rely on abandoned infrastructure, and does not require any new water rights. The City has indicated a mutual desire for an emergency intertie.
- **Total Score: 14**

4.2.2 Clackamas River Water

The District's service area is bordered by the CRW service area to the east. To supply water from CRW to the District along the eastern service boundary, a pump station will be required to overcome the difference in service pressures. Four distinct connection locations were identified and considered. Scoring for each criterion is provided below along with a brief description to explain each score.

- ***Water Sources: 2.*** The primary water source is from the Clackamas River. Access to Bull Run watershed source water and groundwater is possible through CRW's existing 18-inch diameter intertie connection to PWB at SE 99th Avenue and Foster Road. PWB water cannot be directly accessed and must be wheeled through the CRW distribution system.
- ***Partner Agencies: 2.*** Two partner agencies, CRW and PWB, are required for the District to obtain access to a non-Clackamas River supply.
- ***Cost: 3.*** An estimated cost of $1.3M was developed for a connection between an existing 12-inch CRW water main and the District's 24-inch diameter supply line at the intersection of Strawberry Lane and Webster Road (location CRW D). The infrastructure includes a pump station and valve insertion on the District's 24-inch supply line.
- ***O&M: 3.*** Although maintenance will be required for the pump station, no modifications are needed within the District system as emergency supply would be provided to Valley View similar to normal conditions.
- ***Uncertainty/Risks: 3.*** The project appears to be feasible, does not rely on abandoned infrastructure, and does not require any new water rights. CRW has indicated an emergency intertie appears to be feasible

for supplying water from the CRW water treatment plant, but the capacity to wheel PWB water through the CRW system is unknown at this time.

- **Total Score: 13**

4.2.3 Portland Water Bureau

The PWB receives surface water supply from the Bull Run watershed and groundwater from the Columbia Shore Wellfield. A direct connection to PWB would provide the District with access to two non-Clackamas River water sources. District staff indicated that a 16-inch diameter steel pipeline along Linnwood Ave provided a connection to a PWB transmission main located along Harney and Clatsop Roads. The 16-inch diameter intertie pipe was abandoned, and sections were removed to provide for construction of Highway 224. Due to the unknown condition of the existing pipeline, a new direct connection is assumed to require 3.4 miles of pipeline to deliver water to the District at Aldercrest Road, where a pump station and pipe alignment underneath Kellogg Creek previously existed. Upsizing of existing District 8-inch diameter pipe on Aldercrest to 12-inch diameter pipe would be required.

- ***Water Sources: 3.*** PWB's primary water source is from the Bull Run watershed. Their secondary water source is groundwater from the Columbia Shore Wellfield.
- ***Partner Agencies: 3.*** With a direct connection to PWB, only one partner agency is anticipated.
- ***Cost: 2.*** An estimated cost of $8.4M would be required to construct a new pump station, 3.4 miles of new pipeline, and 1 mile of upsized pipeline within the District's system.
- ***O&M: 2.*** The pipeline will require periodic maintenance and flushing. The connection location will require reversing flow within the District from the north end of the system to fill the Valley View tanks, which has the potential to impact customer pressures in the north end of the District and could impact water quality due to reversing flow from the current operating conditions.
- ***Uncertainty/Risks: 2.*** The pipeline alignment may change based on easement acquisition, creek crossings, and highway crossings and presents the potential for unforeseen cost increases.
- **Total Score: 12**

4.2.4 City of Gladstone

The City of Gladstone borders the south end of the District's service area. The District has three existing interconnections that supply water from the District to Gladstone. A pump station would be required to supply water to the District from Gladstone's system.

- ***Water Sources: 1.*** The primary water source for Gladstone is the NCCWC which is the same source water and treatment plant that provides District water. Secondary sources for Gladstone are from the SFWB or CRW through the NCCWC. This alternative does not provide access to a non-Clackamas River water source.
- ***Partner Agencies: 1.*** Non-Clackamas River water could be obtained from PWB through interconnections with CRW and the NCCWC and then Gladstone but would require three partner agencies.
- ***Cost: 3.*** An estimated project cost of $0.5M would be required for adding a pump station at the largest diameter intertie located at Valley View.
- ***O&M: 3.*** No operational modifications are expected because the intertie location is close to the Valley View Tanks so regular operations can occur. Maintenance would be required for the pump station.
- ***Uncertainty/Risks: 3.*** The project appears to be feasible, does not rely on abandoned infrastructure, and does not require any new water rights. The emergency intertie with Gladstone already exists.
- **Total Score: 11**

4.2.5 Oak Lodge Groundwater

In 2010, the District evaluated the feasibility of drilling groundwater wells within the District service boundary to provide emergency supply. The Groundwater Feasibility Report was used to provide background information about groundwater within the District's service boundary. The report provided two locations for wells, one at the Valley View facility and one near Candy Lane Elementary School. The report was based on limited well information in the vicinity and there is uncertainty regarding the actual production of the wells. The District does not currently have groundwater rights and would need to apply for them.

- ***Water Sources: 3.*** The well would supply groundwater directly to the District.
- ***Partner Agencies: 3.*** No partners required.
- ***Cost: 2.*** Based on cost estimates provided for a single well in the previous report, an estimate of $5M was developed for two well sites. The cost estimate included exploratory well drilling, well equipping, standby power generator, chlorination system, and a treatment system should treatment be necessary.
- ***O&M: 1.*** The groundwater wells will require two additional mechanical facilities along with chlorination and controls, and possibly treatment equipment.
- ***Uncertainty/Risks: 1.*** Construction of new wells has a relatively higher uncertainty compared to other alternatives. The actual well yield and water quality is uncertain. Additional exploratory drilling and geochemical analysis is necessary to confirm the stratigraphy and thickness of the aquifer. Additional field studies and modeling to determine drawdown impacts on or by other users will also be required. A new well will also require the District to obtain a groundwater right, which presents uncertainty in permitting, zoning, and land use requirements.
- **Total Score: 10**

4.2.6 Sunrise Water Authority ASR Wells

Sunrise Water Authority owns a permit to maintain and operate up to five aquifer storage and recovery (ASR) wells. Currently, one of the five wells is installed and operational. Expanding the ASR system could reduce demand on the Clackamas River during low flow events. This alternative would offset the demand on NCCWC water by Sunrise Water Authority to allow the District to receive a greater percentage allocation.

- ***Water Sources: 1.*** The ASR wells would not provide groundwater directly to the District and would be used to offset Sunrise Water Authority's allocation of NCCWC supply. This alternative does not provide access to a non-Clackamas River water source.
- ***Partner Agencies: 1.*** Non-Clackamas River water could be obtained from PWB through interconnections with CRW and the NCCWC and would require three partner agencies.
- ***Cost: 2.*** Sunrise Water Authority has indicated a cost of $3.4M is required to fully develop the ASR water right.
- ***O&M: 3.*** No new pump stations or pipelines would be required for District maintenance and flow would enter the system through the existing 24-inch diameter supply pipeline as in normal conditions.
- ***Uncertainty/Risks: 1.*** There is a great degree of uncertainty as the capacity of individual ASR wells depends on the underlying geology which can be unpredictable. The individual yield and storage capacity of individual wells can vary, and capacity cannot be established until a bore hole is completed and pump testing can be conducted.
- **Total Score: 8**

4.2.7 Willamette River Intake

The Clackamas River Water Providers evaluated developing a new raw water intake on the Willamette River as an additional water source for the region's water suppliers. The intake and pump station would be constructed upstream of the confluence with the Clackamas River, over 2 miles of 30-inch diameter pipeline would be required to connect to the existing SFWB intake, and a new surface water right would be required.

- ***Water Sources: 3.*** The alternative would provide access to Willamette River water.
- ***Partner Agencies: 2.*** At least two partner agencies would be required, SFWB and the NCCWC.
- ***Cost: 1.*** An estimated cost of $32M-$39M was developed by escalating the estimate provided in the 2015 Alternate Water Supply Study prepared by Clackamas River Water Providers.
- ***O&M: 1.*** The intake, pump station, and pipeline will require substantial maintenance.
- ***Uncertainty/Risks: 1.*** The ability to obtain water rights is unclear and hidden costs may be present in alignment selection, intake siting, and permitting.
- **Total Score: 8**

4.2.8 Lake Oswego-Tigard Water Partnership

The Lake Oswego-Tigard Water Partnership (LOTWP) owns an abandoned raw water 27-inch main that crosses under the Willamette River. The LOTWP supplies water from the Clackamas River but is also connected to City of Portland and with the Joint Water Commission through the City of Beaverton. The NCCWC provided funding to install the necessary fittings for a future connection to the treated water from the LOTWP. With some improvements the abandoned pipeline under the Willamette River could deliver treated water to the City of Gladstone or wheel water from City of Portland from an existing intertie with the city of Tigard (Providers, 2015). Water could be delivered to Gladstone's Webster Road Reservoir by connecting to an abandoned 24-inch Ranney collector supply line within the City of Gladstone and modifying piping at existing pressure reducing valves (PRVs) and at the reservoir site. A pump station at the Webster Reservoir or at the interconnection with the District system would be required to convey flow from the lower pressure Gladstone system into the Valley View tanks. The abandoned pipelines have not been used for potable water and would likely need to be flushed before water could be conveyed to the District and it is unclear if the lines could be adequately disinfected or if the water quality would require issuance of boil water notifications within the District. The condition of the existing abandoned pipeline is not known however a study indicated the pipe should be sufficiently rated to convey flow based on initial thickness, past operating conditions, and estimated condition.

- ***Water Sources: 1.*** LOTWP primarily receives water from the Clackamas River, but does have the ability to provide Bull Run watershed source water through an intertie with PWB. The PWB connection is in the northwest end of the Tigard water system however, and the ability to wheel PWB water to the District is likely to be limited.
- ***Partner Agencies: 1.*** Access to non-Clackamas River source water would require at least three partner agencies.
- ***Cost: 2.*** A project cost estimate of $1.1M was developed assuming investigations into the existing pipe condition, new piping connections, modifications to the Gladstone Hereford PRVs and reservoir piping, and booster pump station.
- ***O&M: 2.*** The abandoned pipelines will require periodic flushing and the pump station will require maintenance. The pipeline will also require periodic inspection to verify condition and is over one mile in length.

- ***Uncertainty/Risks: 1.*** The pipeline is approximately 50 years old and current condition is unknown. The pipeline is not likely to be seismically retrofitted and may fail in a seismic event. Hidden costs may arise to provide OHA required pipeline separation and cross-connection prevention and to provide modifications to the Webster Storage Tank and Hereford PRV piping.
- **Total Score: 7**

4.3 Screening Evaluation Summary

Based on the results of the initial screening, the top three alternatives appear to be construction of new interties with Milwaukie, CRW, or PWB. A summary of the scoring for all of the alternatives including the anticipated benefits and limitations of each are provided in Table 4-1 below.

Table 4-1. Initial Screening Criteria Descriptions and Scoring

Alternatives	Rating	Water Source(s)	Partner Agencies	Estimated Capital Costs	Operational Modifications	Uncertainty/ Risks	Summary
Milwaukie	**14**	3	3	3	2	3	Provides direct access to groundwater source with minimal infrastructure improvements.
CRW	**13**	2	2	3	3	3	Minimal operational changes and infrastructure improvements.
PWB	**12**	3	3	2	2	2	Provides direct access to non-Clackamas River water supply but high costs.
Gladstone	**11**	1	1	3	3	3	Minimal infrastructure improvements but provides no new source
OLWSD Wells	**10**	3	3	2	1	1	Direct access to groundwater supply but high level of uncertainty
Sunrise	**8**	1	1	2	3	1	Minimal infrastructure improvements but provides no new source
Willamette River intake	**8**	3	2	1	1	1	Provides access to non-Clackamas River water supply but high costs.
LOTWP	**7**	1	1	2	2	1	Provides access to non-NCCWC water supply but high uncertainty.

5 ALTERNATIVES ANALYSIS

This section provides a more detailed analysis and cost estimates for each of the top three alternatives identified during the screening evaluation.

5.1 Overview of Top 3 Alternatives

The initial screening identified CRW, Milwaukie and PWB as the top three potential intertie partners. Each of these alternatives have multiple connection options. Figure 5-1 shows each of the intertie locations that were considered during the initial screening and subsequent alternatives analysis.

The top three alternatives were discussed with each of the partner agencies to confirm supply availability and impacts on their distribution systems. WSC evaluated multiple locations for the interties by modeling the additional supply in the District's distribution system. Four intertie locations for a connection with Milwaukie, four locations for CRW, and one location for PWB were evaluated based on cost, proximity to larger diameter pipelines in the respective partner agency system, and design feasibility considerations, including land availability, constructability, creek and highway crossings, and security measures.

5.2 CRW Alternative

Four intertie locations (CRW A, B, C, and D) were identified for the CRW alternative. The District and CRW have three existing intertie locations that are used to serve small areas of customers (CRW A, B, and C). The existing interties are connected to 8-inch diameter mains that would require upsizing to convey the desired emergency flow. A fourth location (CRW D) was considered due to the proximity of the District's 24-inch diameter supply pipeline and a 12-inch diameter CRW main. CRW D would require a new intertie along the District's 24-inch main that uses a 35 horsepower pump station to fill the Valley View Tanks from the CRW transmission main. An intertie at this location would allow CRW to supply the District without any major modifications to the two systems. There does not appear to be any vacant lots along the alignment, however the pump station could be located within Heddie Notz Park. North Clackamas Parks and Recreation District owns the park and further discussion would be required to determine if an intergovernmental agreement or easement could be obtained to allow placing a pump station within the park. Other locations may be available through purchase of an easement or a portion of existing private property, or through construction of a below-grade prefabricated booster pump station within the right-of-way. A proposed layout is provided in Figure 5-2.

To allow the pump station to convey water from CRW into the Valley View tanks, an isolation valve will be required on the 24-inch diameter water supply pipeline that could be closed when the emergency supply is required. Because this alternative requires conveyance through a portion of the existing supply pipeline, a seismic study is recommended and included within the costs for the project. The study could potentially be paired with a larger study of the entire 24-inch diameter supply pipeline recommended as a result of the seismic risk analysis in the WSMP. The pipeline alignment is located in close proximity to mapped areas of landslide risk located south of the Valley View facility A study to confirm the anticipated ground deformations directly under and over the pipe can confirm that the existing pipe material and joints are anticipated to remain operational following a major earthquake. An itemized cost estimate for the intertie, including land acquisition, studies, and engineering fees is provided in Table 5-1.

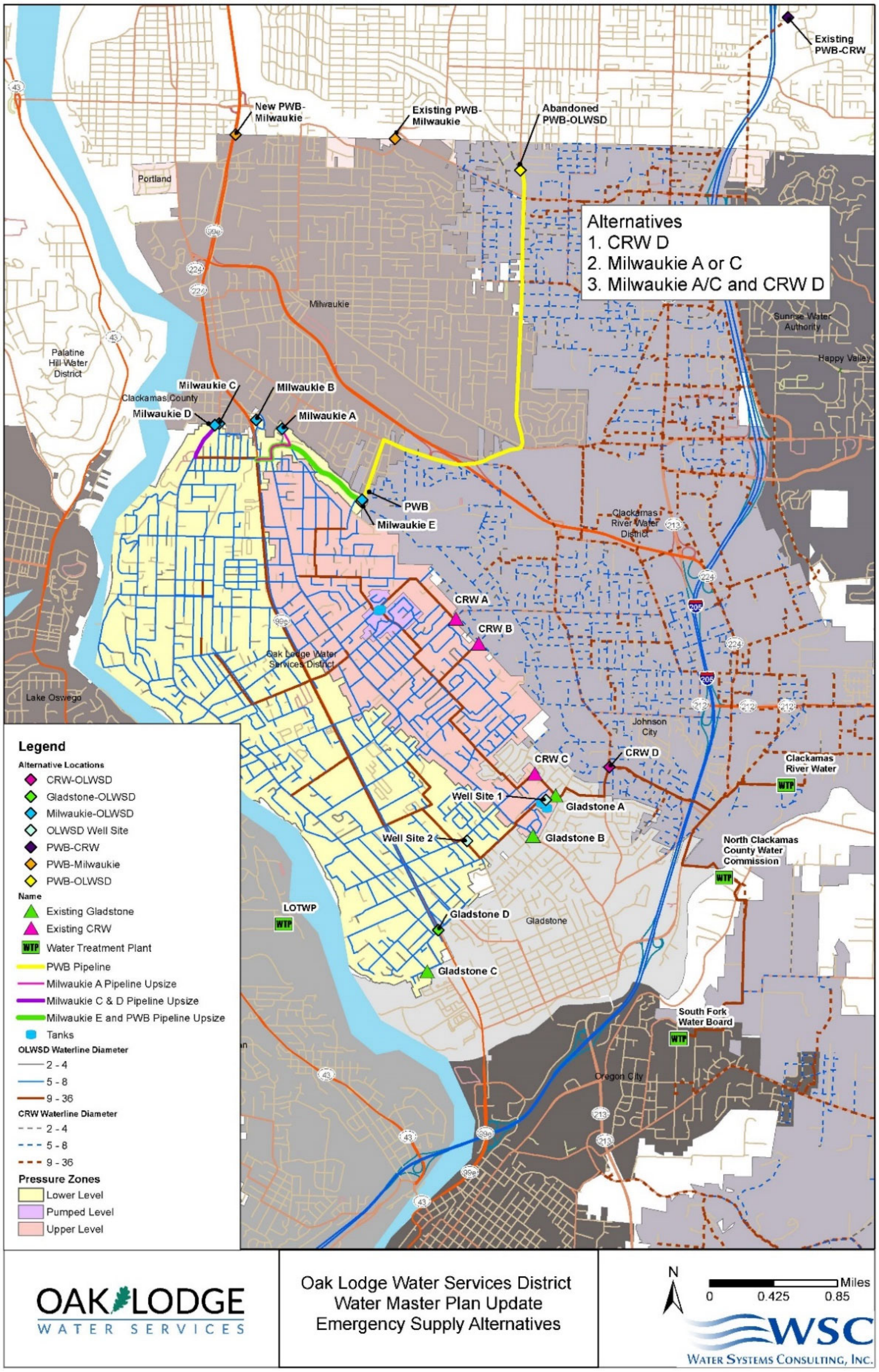


Figure 5-1. Potential Emergency Intertie Locations and Pipelines

The District engaged CRW and provided the concept for the intertie to initiate discussions of a potential emergency connection. CRW indicated that both pumping and treatment capacity are sufficient under current maximum day demand to provide the desired 2.7 MGD to the District, but by 2038 there will not be sufficient pumping and treatment capacity to deliver this much flow based on assumed growth within CRW's service area. The available pumping capacity in 2038 appears to be closer to 2.4 MGD. CRW expressed interest in further discussions to confirm capacity commitments, metering requirements, and other provisions that could be included into an intergovernmental agreement (IGA) for emergency water supply between the two providers. WSC recommends that CRW and the District discuss establishing an IGA.

Table 5-1. Itemized Cost Estimate for Emergency Intertie with CRW

Item	Unit Cost	Unit	Qty	Cost
Prefabricated Pump Station - 35 hp	$ 500,000	EA	1	$ 500,000
Isolation Valve - 24"	$ 100,000	EA	1	$ 100,000
Construction Subtotal				**$ 600,000**
Construction Contingency	20%			$ 120,000
Unaccounted for Items	10%			$ 60,000
Mobilization	3%			$ 18,000
Insurance and Bonds	1%			$ 6,000
SWPPP	1%			$ 6,000
Subtotal				**$ 810,000**
Land Acquisition	$ 25	/sqft	2000	$ 50,000
Seismic Study	$ 100,000		1	$ 100,000
Subtotal				$ **960,000**
Design/CM/Administration	30%			$ 288,000
Total				**$ 1,248,000**

Figure 5-2. Proposed Concept for Emergency Intertie with CRW

5.3 Milwaukie Alternative

Five locations (Milwaukie A, B, C, D, and E) were identified for a potential intertie connection with the City of Milwaukie. Each location was evaluated in terms of estimated cost, feasibility, land availability, and design considerations. Locations A and C were found to have the lowest capital and life-cycle costs; however, location A has limited land availability and is located along a tight curve on Oatfield Road that presents a significant safety risk. Thus, location C was chosen as the preferred Milwaukie intertie due to its proximity to a larger 10-inch diameter main on the City side and the potential for viable options for siting a relatively small booster pump station within the right-of-way or through acquisition of an easement through partial purchase of vacant private property. Location C will require the District to upsize their existing 8-inch diameter piping along River Road to 12-inch diameter to convey emergency water into the larger diameter transmission system to fill the Valley View reservoirs. A proposed conceptual location for the intertie, including the extents of upsizing required within the District system, is provided in Figure 5-3. An itemized cost estimate is provided in Table 5-2.

The District engaged the City of Milwaukie in November 2019 to discuss the potential intertie location and to gauge the interest in forming an IGA for emergency supply. The City is also interested in an intertie that could supply NCCWC water in an emergency and is willing in concept to share some of the construction costs. The City of Milwaukie agrees that the proposed location is preferable, however recent efforts are underway to update the City's water hydraulic model as part of a Water System Master Plan update. Initial review of the City's 2010 Water System Master Plan appears to indicate there is adequate supply to provide the desired 2.7 MGD based on combined well capacity and City-wide storage. The City would like to confirm that the location is preferred and that the desired emergency demand capacity can be provided once an updated and calibrated hydraulic model is available. Milwaukie indicated that with their current biennial budget cycle already finalized, they would like to continue to explore an intertie within the next 2 to 5 years.

Table 5-2. Itemized Cost Estimate for Emergency Intertie with Milwaukie

Item	Unit Cost	Unit	Qty	Cost
Prefabricated Pump Station - 35 hp	$ 500,000	EA	1	$ 500,000
OLWSD Pipe Upsize (non-CIP) - 12" pipe	$ 240	/LF	2,010	$ 482,400
Construction Subtotal				**$ 982,400**
Construction Contingency	20%			$ 196,480
Unaccounted for Items	10%			$ 98,240
Mobilization	3%			$ 29,472
Insurance and Bonds	1%			$ 9,824
SWPPP	1%			$ 9,824
Subtotal				$ **1,326,240**
Land Acquisition	$ 25	/sqft	2,000	$ 50,000
Subtotal				$ **1,376,240**
Engineering, Design, CM Services	30%			$ 412,872
TOTAL				**$ 1,789,112**

Figure 5-3. Proposed Concept for Emergency Intertie with the City of Milwaukie

5.4 Portland Water Bureau

The analysis of an emergency intertie with PWB was limited to a single alternative that matches the general description of a previously existing connection that was abandoned. Although the previous 16-inch diameter steel pipe is still in existence, the condition and ability to reuse the pipeline is unknown. A portion of the old pipeline was removed during the construction of Highway 224. The proposed emergency intertie would include a 12-inch diameter pipeline along Linnwood Road to connect to an existing PWB transmission main in Harvey and Clatsop Roads. The interconnecting pipeline would cross under Kellogg Creek near an abandoned pump station within the City of Milwaukie at the intersection of Where Else Lane and Bowman Street. The connection to the District's system would be located along Aldercrest Road. A new 35 horsepower pump station will be needed to boost the pressure before entering the District's Lower Zone. Trenchless pipeline construction is anticipated to be required for the crossing of Highway 224 and for Kellogg Creek. Upsizing of the existing 6-inch and 8-inch diameter water main on Aldercrest to a 12-inch diameter pipeline will be required to convey water to Valley View. A conceptual description of the intertie locations, including the required piping alignment, is provided in Figure 5-4. An itemized cost estimate is provided in Table 5-3.

PWB indicated that there is sufficient capacity within their system to provide the desired 2.7 MGD during maximum day demand conditions. Due to the significantly higher capital cost for the PWB intertie alternative as compared to Milwaukie and CRW, further discussions with the PWB were not pursued by the District.

Table 5-3. Itemized Cost Estimate for Emergency Intertie with the Portland Water Bureau

Item	Unit Cost	Unit	Qty	Cost
Prefabricated Pump Station - 35 hp	$ 500,000	EA	1	$ 500,000
New Pipe - 10" pipe	$ 200	/LF	18000	$ 3,600,000
OLWSD Pipe Upsize (non-CIP) - 12" pipe	$ 240	/LF	2200	$ 528,000
OLWSD Pipe Upsize (CIP) - 8" pipe to 12" pipe	$ 40	/LF	3290	$ 131,600
Construction Subtotal				**$ 4,759,600**
Construction Contingency	20%			$ 951,920
Unaccounted for Items	10%			$ 475,960
Mobilization	3%			$ 142,788
Insurance and Bonds	1%			$ 47,596
SWPPP	1%			$ 47,596
Subtotal				**$ 6,425,460**
Land Acquisition	$ 25	/sq ft	0	$ -
Subtotal				**$ 6,425,460**
Engineering Services	30%			$ 1,927,638
TOTAL				**$ 8,353,098**

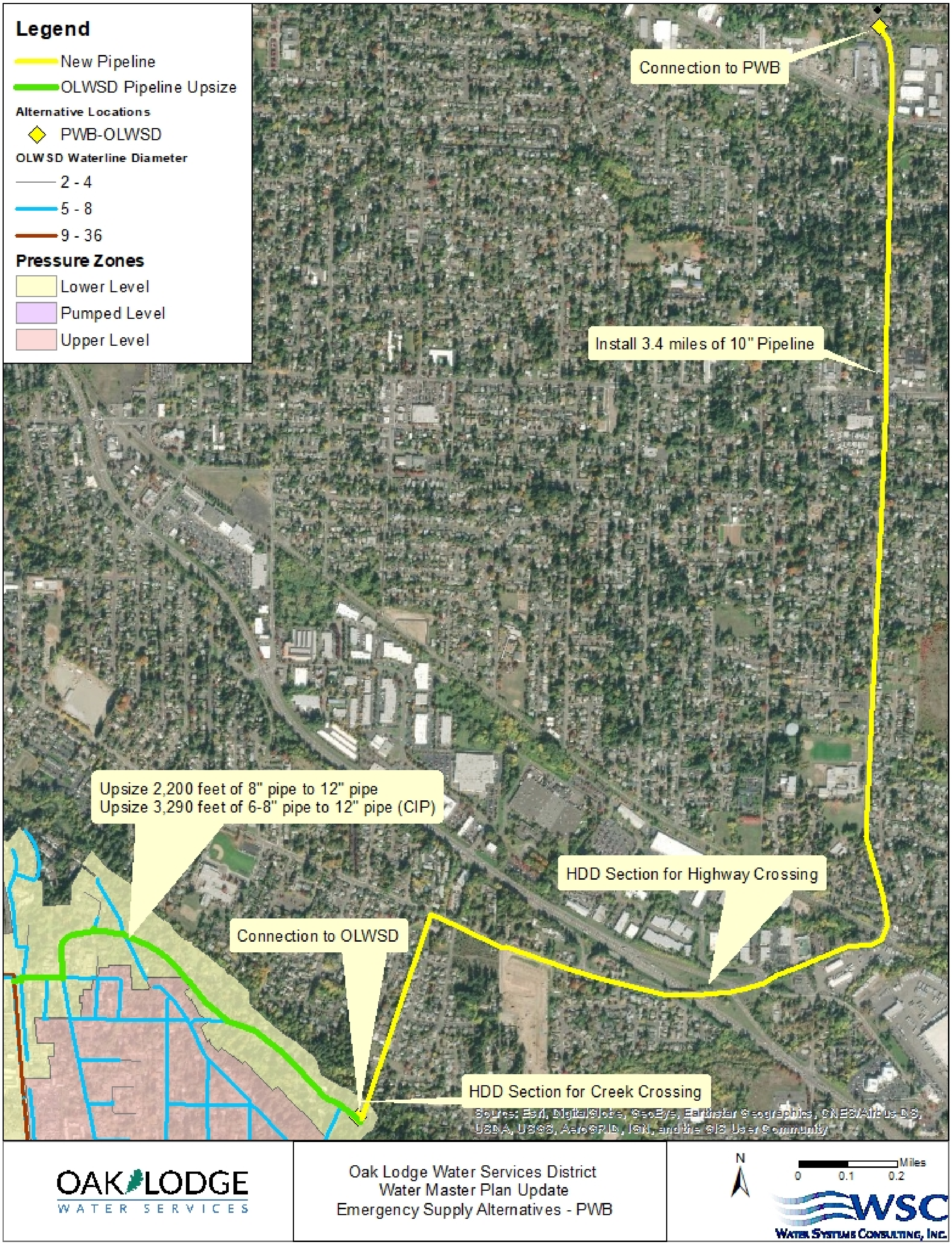


Figure 5-4. Proposed Concept for Emergency Intertie with the Portland Water Bureau

5.5 Portable Pump Station Hybrid Option

The top two alternatives, CRW and Milwaukie, may be combined into a hybrid alternative using a portable pump station. The CRW and Milwaukie alternatives require nearly identical pump sizes which lends the possibility of a single trailer mounted pumping station that could be mobilized to either of the locations in an emergency. Although a portable pump station is anticipated to be slightly more expensive than a prepackaged booster pump station due the customized design and fabrication required, there are the following significant savings:

- No building is required at either site
- Only one set of pumps is required for purchase and to maintain
- Diesel driven pumps can be used to eliminate permanent power supply or standby generator
- Property acquisition can be minimized if not eliminated

To allow rapid mobilization during an emergency, site improvements would include hard piping for pump suction and discharge, valve modifications to existing buried pipelines, and sufficient space and surfacing to allow the trailer mounted station to be placed into position. A single pump and connective piping can likely be transported on a large trailer with dimensions of approximately 8 feet in width and 25 to 30 feet in length. The exact spatial requirements will be influenced by the piping configurations at each of the potential sites and could require 40 to 50 feet in length and 20 to 30 feet in width at a minimum. Additional space may be required to account for maneuvering trailers into position, piping assembly, and flow metering. Installation could likely be completed in 1 day, excluding any extensive cleaning, disinfection, or testing requirements.

The District would need to consider where a unit could be stored securely and protected from excessive exposure, and annual training and trial installations are recommended to keep operations staff familiar with the installation and to test equipment functionality. Additional capital improvements could be performed at the Valley View facility to create a permanent testing and training installation site with similar configuration to field locations. It may also be possible to configure the testing location so that the portable pump station could also serve as a backup to the Valley View Booster Pump Station.

An example of a portable pump station designed for emergency deployment by the Tualatin Valley Water District (TVWD) is provided in Figure 5-4. The TVWD portable station includes two 5 MGD capacity pumps, each mounted on a separate 8-foot wide by 30-foot long trailer. Each trailer is also equipped to store and convey the connection fittings required for a hard-piped suction and discharge manifold to connect to the distribution system. The photo provided below is taken at a testing facility constructed by the District at a reservoir site that allows the installation to be setup and tested once a year for several days to check functionality and to train operators in installation procedures.

Figure 5-5. Example of Portable Trailer-Mounted Pump Station from TVWD

A hybrid estimate was developed to compare the cost of constructing two permanent emergency intertie pump stations as compared to a single trailer-mounted portable pump station that could be deployed at either location. Given the level of accuracy expected for a conceptual level design, the estimated costs for a portable pump station is effectively equal to the construction of a permanent station for each of the Milwaukie and CRW interties. An itemized estimate of the cost of the hybrid alternative is provided in Table 5-4.

Table 5-4. Itemized Cost Estimate for Portable Emergency Intertie Pump Station at CRW and Milwaukie

Item	Unit Cost	Unit	Qty	Cost
Trailer Mounted Pump Station - 35 hp	$ 600,000	EA	1	$ 600,000
Plumb Sites for Trailer Mounted Station	$ 150,000	EA	2	$ 300,000
Plumb Test Site at Valley View	$ 100,000	EA	1	$ 100,000
OLWSD Pipe Upsize (non-CIP) - 12" pipe	$ 240	/LF	2010	$ 482,400
Isolation Valve – 24-inch Supply Pipe	$ 100,000	EA	1	$ 100,000
Construction Subtotal				**$ 1,582,400**
Construction Contingency	20%			$ 316,480
Unaccounted for Items	10%			$ 158,240
Mobilization	3%			$ 47,472
Insurance and Bonds	1%			$ 15,824
SWPPP	1%			$ 15,824
Subtotal				**$ 2,136,240**
Land Acquisition	$ 25	/sq ft	2000	$ 50,000
Seismic Study	$ 100,000	EA	1	$ 100,000
Subtotal				**$ 2,286,240**
Engineering Services	30%			$ 685,872
TOTAL				**$ 2,972,112**

6 RECOMMENDATIONS AND NEXT STEPS

Based on the screening evaluation and analysis of alternatives for emergency interties that could provide water service to the District, connections with both Milwaukie and CRW appear to be preferred and would give the District multiple options in an emergency. The cost of constructing both interties would be approximately $3.0M. A portable trailer-mounted pump station that could provide emergency supply from either CRW or the City of Milwaukie also appears to be a viable alternative and would cost approximately $3.0M. The true costs of each alternative could vary based on siting, permitting, and other factors that are not known at this time.

WSC recommends proceeding with a preliminary design for both permanent intertie pump stations at each location and a portable pump station that could be deployed to either intertie location to determine more accurate cost estimates for each alternative. The preliminary design would include the following activities:

- Confirmation of available capacity from Milwaukie, CRW, and PWB wheeled through the CRW system
- Development of term sheets with each agency partner to determine costs for water supply during emergencies, standby charges (if any), and any cost sharing for operations and maintenance or capital costs for construction and installation
- Identification of feasible sites and the necessary property acquisition required for pump stations and connection points
- Identification of any permitting requirements
- Seismic design criteria and plans for mitigating risks in existing infrastructure required to convey emergency water to the District

WSC recommends that work commence as soon as possible to commence preliminary design of the alternatives so that a preferred project can be recommended. Upon approval of the preferred project, detailed design should commence so that construction bid documents can be developed for the construction of the much needed emergency interties.

Another step that should be considered is to evaluate and apply for grant funding that could be used to finance the project. Programs such as the Federal Emergency Management Agency Pre-Disaster Mitigation Fund provide funding for projects that improve the resilience of water systems and communities in the aftermath of a seismic event.

Appendix D. Annual Water Quality Report (2018)

Annual Water Quality Report

Water Testing Performed in 2018

Presented By

OAK LODGE
WATER SERVICES

PWS ID#: 4101512

Our Mission Continues

Oak Lodge Water Services is pleased to present our annual water quality report covering all testing performed between January 1 and December 31, 2018. Over the years, Oak Lodge has dedicated ourselves to producing drinking water that meets all state and federal standards. We continually strive to adopt new methods for delivering the best-quality drinking water to you. As new challenges to drinking water safety emerge, we remain vigilant in meeting the goals of source water protection, water conservation, community outreach and education, while continuing to serve the needs of all our water users.

Please remember that we are always available should you ever have any questions or concerns about your water. For more information about this report, or for any questions relating to your drinking water, please call Marty Guenther, Pollution Prevention Specialist, at (503) 753-9689.

Source Water Assessment

A Source Water Assessment Plan (SWAP) is now available at our office. This plan is an assessment of the delineated area around our listed sources through which contaminants, if present, could migrate and reach our source water. It also includes an inventory of potential sources of contamination within the delineated area, and a determination of the water supply's susceptibility to contamination by the identified potential sources.

According to the Source Water Assessment Plan, potential contaminants to our water system were identified and ranked by risks, which range from low to high depending on the category. If you would like to review the Source Water Assessment Plan, please feel free to contact our office during regular office hours.

> "We remain vigilant in delivering the best-quality drinking water"

Important Health Information

Some people may be more vulnerable to contaminants in drinking water than the general population. Immunocompromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants may be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. The U.S. EPA/CDC (Centers for Disease Control and Prevention) guidelines on appropriate means to lessen the risk of infection by Cryptosporidium and other microbial contaminants are available from the Safe Drinking Water Hotline at (800) 426-4791 or http://water.epa.gov/drink/hotline.

Substances That Could Be in Water

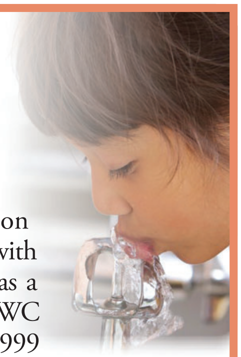
To ensure that tap water is safe to drink, the U.S. EPA prescribes regulations limiting the amount of certain contaminants in water provided by public water systems. U.S. Food and Drug Administration regulations establish limits for contaminants in bottled water, which must provide the same protection for public health. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of these contaminants does not necessarily indicate that the water poses a health risk.

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals, in some cases, radioactive material, and substances resulting from the presence of animals or from human activity. Substances that may be present in source water include: Microbial Contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, or wildlife; Inorganic Contaminants, such as salts and metals, which can be naturally occurring or may result from urban storm-water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming; Pesticides and Herbicides, which may come from a variety of sources such as agriculture, urban storm-water runoff, and residential uses; Organic Chemical Contaminants, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production and may also come from gas stations, urban storm-water runoff, and septic systems; Radioactive Contaminants, which can be naturally occurring or may be the result of oil and gas production and mining activities.

For more information about contaminants and potential health effects, call the U.S. EPA's Safe Drinking Water Hotline at (800) 426-4791.

Community Participation

You are invited to participate in our public forum and voice your concerns about your drinking water. The Board of Directors holds regular public meetings on the third Tuesday of each month, beginning at 6 p.m. at the Oak Lodge Water Services office, 14496 SE River Road, Oak Grove. Interested members of the public are encouraged to attend. Please call (503) 654-7765 or visit our website, www.oaklodgewaterservices.org, for further information.



How is My Water Treated and Purified?

Oak Lodge Water Services customers receive their water from the North Clackamas County Water Commission (NCCWC). The South Fork Water Board, with its conventional water treatment, also serves as a backup supply to the NCCWC. The NCCWC began using slow sand filtration in August 1999 and added membrane filtration processes in 2005.

The slow sand filtration process operates as follows: Untreated water is pumped onto four half-acre beds. As the water is passed down through the filter media, the top six inches of sand at the surface provide an area where pathogenic organisms are trapped or ingested by nonpathogenic organisms. This treatment zone is known as the zoogleal mass that filters out particles and helps break down organic matter. Chlorine is added to the filtered water as a follow-up treatment measure to disinfect any pathogenic organisms that may have passed through the filter media. An adequate amount of chlorine is added to provide a detectable residual throughout the distribution system.

Membrane filtration processes operate as follows: Raw water flows from the river into a cell where the filters are submerged. Each filter cell has 288 membrane modules, and each module has 9,500 individual hollow fibers. The flow is drawn through the walls of the membrane fibers by vacuum to the inside of the fiber by a pump. After the membranes have filtered a predetermined flow, the water goes through a backwash procedure for cleaning. The backwash procedure is a process where water and air is used to scour the particles that have accumulated on the fibers. This water is then chlorinated and combined, at most times, with the water from the slow sand filters.

The water from South Fork Water Board is treated in the following conventional fashion: Water is pumped to a basin where alum and polymer are added to the raw water as coagulants. The water then enters hydraulic flocculators and goes to a sedimentation basin where the floc settles. The supernatant water is collected in weirs and sent to rapid filters. The filtered water is then chlorinated and provided to the NCCWC on an as-needed basis.

Information on the Internet

The U.S. EPA (https://goo.gl/TFAMKc) and the Centers for Disease Control and Prevention (www.cdc.gov) websites provide a substantial amount of information on many issues relating to water resources, water conservation, and public health. Also, the Oregon Health Authority has a website (https://goo.gl/EQPb3C) that provides complete and current information on water issues in Oregon, including valuable information about our watershed.

Where Does My Water Come From?

Oak Lodge Water Services withdraws water from the Clackamas River. The Clackamas River is an extremely high-quality raw water source. The Clackamas River watershed covers almost 1,000 square miles, mostly located in Clackamas County, Oregon. Timothy Lake and Ollalie Lake make up the headwaters of the Clackamas River, and many tributary streams contribute to the flow of the river. Drinking water for Oak Lodge Water Services is produced by three treatment techniques: slow sand filtration, conventional filtration, and membrane filtration. The Allen F. Herr Water Treatment Facility began production in August 1999. Oak Lodge Water Services, Sunrise Water Authority, and the City of Gladstone --- known as the North Clackamas County Water Commission (NCCWC) --- jointly own the slow sand and membrane filtration systems. Water is occasionally received from the South Fork Water Board's conventional treatment plant facility. The South Fork Water Board's treatment facility was constructed in 1958 and started providing water to Oak Lodge customers in 2002. The South Fork Water Board's plant is used primarily as a backup supply.

The Commission added membrane filtration in 2005. Membrane filtration is a state-of-the-art treatment technique that filters water through a series of small tubes with openings one micron in size. This ultra-filtered water allows for a continuous supply of water, even when the turbidity of raw water rises in the winter months.

Approximately 100 miles of water mains make up the distribution system that carries water to Oak Lodge customers. The district has four reservoirs with a combined storage of 15.6 million gallons.

Testing for *Cryptosporidium*

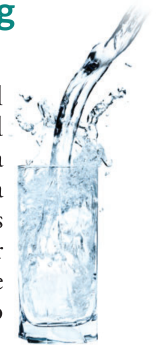
Cryptosporidium is a microbial parasite found in surface water throughout the U.S. Although filtration removes *Cryptosporidium*, the most commonly used filtration methods cannot guarantee 100 percent removal. Monitoring of source water and/or finished water indicates the presence of these organisms. Current test methods do not allow us to determine if the organisms are dead or if they are capable of causing disease. Symptoms of infection include nausea, diarrhea, and abdominal cramps. Most healthy individuals can overcome the disease within a few weeks. However, immunocompromised people are at greater risk of developing life-threatening illness. We encourage immunocompromised individuals to consult their doctor regarding appropriate precautions to take to avoid infection. *Cryptosporidium* must be ingested to cause disease, and it may be spread through means other than drinking water.

Lead in Home Plumbing

If present, elevated levels of lead can cause serious health problems, especially for pregnant women and young children. Lead in drinking water is primarily from materials and components associated with service lines and home plumbing. We are responsible for providing high-quality drinking water, but we cannot control the variety of materials used in plumbing components. When your water has been sitting for several hours, you can minimize the potential for lead exposure by flushing your tap for 30 seconds to 2 minutes before using water for drinking or cooking. If you are concerned about lead in your water, you may wish to have your water tested. Information on lead in drinking water, testing methods, and steps you can take to minimize exposure is available from the Safe Drinking Water Hotline at (800) 426-4791 or at www.epa.gov/safewater/lead.

How Long Can I Store Drinking Water?

The disinfectant in drinking water will eventually dissipate, even in a closed container. If that container housed bacteria prior to filling up with the tap water, the bacteria may continue to grow once the disinfectant has dissipated. Some experts believe that water could be stored up to six months before needing to be replaced. Refrigeration will help slow the bacterial growth.



What's a Cross-connection?

Cross-connections that contaminate drinking water distribution lines are a major concern. A cross-connection is formed at any point where a drinking water line connects to equipment (boilers), systems containing chemicals (air conditioning systems, fire sprinkler systems, irrigation systems), or water sources of questionable quality. Cross-connection contamination can occur when the pressure in the equipment or system is greater than the pressure inside the drinking water line (back-pressure). Contamination can also occur when the pressure in the drinking water line drops due to fairly routine occurrences (main breaks, heavy water demand), causing contaminants to be sucked out from the equipment and into the drinking water line (back-siphonage).

Outside water taps and garden hoses tend to be the most common sources of cross-connection contamination at home. The garden hose creates a hazard when submerged in a swimming pool or when attached to a chemical sprayer for weed killing. Garden hoses that are left lying on the ground may be contaminated by fertilizers, cesspools, or garden chemicals. Improperly installed valves in your toilet could also be a source of cross-connection contamination.

Community water supplies are continuously jeopardized by cross-connections unless appropriate valves, known as backflow prevention devices, are installed and maintained. We have surveyed industrial, commercial, and institutional facilities in the service area to make sure that potential cross-connections are identified and eliminated or protected by a backflow preventer. We also inspect and test backflow preventers to make sure that they provide maximum protection.

For more information on backflow prevention contact the Safe Drinking Water Hotline at (800) 426-4791.

Test Results

The water we deliver must meet specific health standards, so our water is monitored for many different kinds of substances on a very strict sampling schedule. Here, we only show those substances that were detected in our water between January 1 and December 31, 2018 (a complete list of all our analytical results is available upon request). Remember that detecting a substance does not mean the water is unsafe to drink; our goal is to keep all detects below their respective maximum allowed levels.

The State recommends monitoring for certain substances less than once per year because the concentrations of these substances do not change frequently. In these cases, the most recent sample data are included, along with the year in which the sample was taken.

REGULATED SUBSTANCES

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	MCL [MRDL]	MCLG [MRDLG]	AMOUNT DETECTED	RANGE LOW-HIGH	VIOLATION	TYPICAL SOURCE
Barium (ppm)	2018	2	2	0.002	0.002-0.002 -	No	Discharge of drilling wastes; Discharge from metal refineries; Erosion of natural deposits
Chlorine (ppm)	2018	[4]	[4]	1.11	0.21–1.11	No	Water additive used to control microbes
Fecal coliform and *E. coli* (# positive samples)	2018	A routine sample and a repeat sample are total coliform positive, and one is also fecal coliform or *E. coli* positive	0	0	NA	No	Human and animal fecal waste
Haloacetic Acids [HAAs] (ppb)	2018	60	NA	44	12–44	No	By-product of drinking water disinfection
Nitrate [as Nitrogen] (ppm)	2018	10	10	0.190	0.190-0.190 -	No	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits
TTHMs [Total Trihalomethanes] (ppb)	2018	80	NA	50	19–50	No	By-product of drinking water disinfection
Total Coliform Bacteria (Positive samples)	2018	TT	NA	0	NA	No	Naturally present in the environment

Tap Water Samples Collected for Copper and Lead Analyses from Sample Sites throughout the Community

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	AL	MCLG	AMOUNT DETECTED (90TH %ILE)	SITES ABOVE AL/TOTAL SITES	VIOLATION	TYPICAL SOURCE
Copper (ppm)	2017	1.3	1.3	0.006	0/60	No	Corrosion of household plumbing systems; Erosion of natural deposits
Lead (ppb)	2017	15	0	None Detected	0/60	No	Lead services lines; Corrosion of household plumbing systems, including fittings and fixtures; Erosion of natural deposits

SECONDARY SUBSTANCES

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	SMCL	MCLG	AMOUNT DETECTED	RANGE LOW-HIGH	VIOLATION	TYPICAL SOURCE
Chloride (ppm)	2018	250	NA	2.4	2.4–2.4	No	Runoff/leaching from natural deposits

UNREGULATED SUBSTANCES

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	AMOUNT DETECTED	RANGE LOW-HIGH	TYPICAL SOURCE
Sodium (ppm)	2018	6.0	6.0–6.0	Naturally occurring

Definitions

90th %ile: The levels reported for lead and copper represent the 90th percentile of the total number of sites tested. The 90th percentile is equal to or greater than 90% of our lead and copper detections.

AL (Action Level): The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

MCL (Maximum Contaminant Level): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

MCLG (Maximum Contaminant Level Goal): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

MRDL (Maximum Residual Disinfectant Level): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

MRDLG (Maximum Residual Disinfectant Level Goal): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

NA: Not applicable.

ppb (parts per billion): One part substance per billion parts water (or micrograms per liter).

ppm (parts per million): One part substance per million parts water (or milligrams per liter).

SMCL (Secondary Maximum Contaminant Level): These standards are developed to protect aesthetic qualities of drinking water and are not health based.

TT (Treatment Technique): A required process intended to reduce the level of a contaminant in drinking water.

Appendix E. Capital Improvement Project Cost Estimates

Client: Oak Lodge Water District
Project: 2020 Water Master Plan Update
Prepared By: SRS and HEF
Reviewed By: SBD and KLP
Date 5/20/2020

Opinion of Probable Construction Cost

Mobilization
SWPPP (per LF)
Traffic Control (per Day)
Subtotal
Construction Contingency
Construction Total
Project Development
Project Cost

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

C- 1

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1400	S.Y.	$9.74	$13,636
Hauling Pavement	194	L.C.Y.	$6.62	$1,284
Pavement Repair	189	Ton	$250.00	$47,250
Shoring	24200	SF Wall	$0.76	$18,392
Excavation-Trench	971	B.C.Y.	$8.10	$7,865
Pipe Bedding (sand import)	439	L.C.Y.	$34.67	$15,220
Bedding Compaction	439	E.C.Y.	$3.90	$1,712
Native Backfill & Compaction	532	E.C.Y.	$4.32	$2,298
Water Compaction	532	E.C.Y.	$2.55	$1,357
Hauling Excavation	1165	B.C.Y.	$5.31	$6,186
8" Ductile Iron Piping	3025	L.F.	$96.13	$290,793
8" Gate Valve	4	Ea.	$1,300.00	$5,200
8" Tee	1	Ea.	$1,481.77	$1,482
8" 90 Bend	1	Ea.	$872.69	$873
Air Release Valve	3	Ea.	$6,000.00	$18,000
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	3025	L.F.	$1.50	$4,538
Saddle & Tap for Service	48	Ea.	$1,700.00	$81,600

Segment Label	Laterals	Diam in	Depth ft
Aldercrest	48	8	4.0

Mobilization	6%	$32,681
SWPPP (per LF)	$2	$6,050
Traffic Control (per Day)	$500	$6,000
Subtotal		$616,651
Construction Contingency	20%	$123,330
Construction Total		**$739,982**
Project Development	25%	$184,995
Project Cost		**$924,977**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

C- 2

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	133	S.Y.	$9.74	$1,295
Hauling Pavement	18	L.C.Y.	$6.62	$119
Pavement Repair	19	Ton	$250.00	$4,750
Shoring	2400	SF Wall	$0.76	$1,824
Excavation-Trench	89	B.C.Y.	$8.10	$721
Pipe Bedding (sand import)	37	L.C.Y.	$34.67	$1,283
Bedding Compaction	37	E.C.Y.	$3.90	$144
Native Backfill & Compaction	52	E.C.Y.	$4.32	$225
Water Compaction	52	E.C.Y.	$2.55	$133
Hauling Excavation	107	B.C.Y.	$5.31	$568
6" Gate Valve	1	Ea.	$3,384.95	$3,385
6" Ductile Iron Piping	300	L.F.	$88.02	$26,406
Pipeline Testing and Disinfection	300	L.F.	$1.50	$450
Saddle & Tap for Service	3	Ea.	$1,700.00	$5,100

Segment Label	Laterals	Diam in	Depth ft
Lisa Lane	3	6	4.0

Mobilization	6%	$2,784
SWPPP (per LF)	$2	$600
Traffic Control (per Day)	$500	$500
Subtotal		$52,607
Construction Contingency	20%	$10,521
Construction Total		**$63,129**
Project Development	25%	$15,782
Project Cost		**$78,911**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

C- 3

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	211	S.Y.	$9.74	$2,055
Hauling Pavement	29	L.C.Y.	$6.62	$192
Pavement Repair	30	Ton	$250.00	$7,500
Shoring	3800	SF Wall	$0.76	$2,888
Excavation-Trench	141	B.C.Y.	$8.10	$1,142
Pipe Bedding (sand import)	59	L.C.Y.	$34.67	$2,046
Bedding Compaction	59	E.C.Y.	$3.90	$230
Native Backfill & Compaction	82	E.C.Y.	$4.32	$354
Water Compaction	82	E.C.Y.	$2.55	$209
Hauling Excavation	169	B.C.Y.	$5.31	$897
6" Gate Valve	1	Ea.	$3,384.95	$3,385
6" Ductile Iron Piping	475	L.F.	$88.02	$41,810
Pipeline Testing and Disinfection	475	L.F.	$1.50	$713
Saddle & Tap for Service	7	Ea.	$1,700.00	$11,900

Segment Label	Laterals	Diam in	Depth ft
Marcia Court	7	6	4.0

Mobilization	6%	$4,519
SWPPP (per LF)	$2	$950
Traffic Control (per Day)	$500	$500
Subtotal		$85,056
Construction Contingency	20%	$17,011
Construction Total		**$102,067**
Project Development	25%	$25,517
Project Cost		**$127,584**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

C- 4

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	338	S.Y.	$9.74	$3,292
Hauling Pavement	47	L.C.Y.	$6.62	$311
Pavement Repair	48	Ton	$250.00	$12,000
Shoring	6080	SF Wall	$0.76	$4,621
Excavation-Trench	225	B.C.Y.	$8.10	$1,823
Pipe Bedding (sand import)	95	L.C.Y.	$34.67	$3,294
Bedding Compaction	95	E.C.Y.	$3.90	$371
Native Backfill & Compaction	130	E.C.Y.	$4.32	$562
Water Compaction	130	E.C.Y.	$2.55	$332
Hauling Excavation	270	B.C.Y.	$5.31	$1,434
6" Gate Valve	2	Ea.	$3,384.95	$6,770
6" Ductile Iron Piping	760	L.F.	$88.02	$66,895
6" 90 Bend	1	Ea.	$523.40	$523
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	760	L.F.	$1.50	$1,140
Saddle & Tap for Service	12	Ea.	$1,700.00	$20,400

Segment Label	Laterals	Diam in	Depth ft
Ranstad Court	12	6	4.0

Mobilization	6%	$7,966
SWPPP (per LF)	$2	$1,520
Traffic Control (per Day)	$500	$500
Subtotal		$149,390
Construction Contingency	20%	$29,878
Construction Total		**$179,268**
Project Development	25%	$44,817
Project Cost		**$224,085**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District
Project: 2020 Water Master Plan Update
Prepared By: SRS and HEF
Reviewed By: SBD and KLP
Date 5/20/2020

C- 5

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	7405	S.Y.	$9.74	$72,125
Hauling Pavement	1029	L.C.Y.	$6.62	$6,812
Pavement Repair	1000	Ton	$250.00	$250,000
Shoring	127960	SF Wall	$0.76	$97,250
Excavation-Trench	5135	B.C.Y.	$8.10	$41,594
Pipe Bedding (sand import)	2319	L.C.Y.	$34.67	$80,400
Bedding Compaction	2319	E.C.Y.	$3.90	$9,044
Native Backfill & Compaction	2816	E.C.Y.	$4.32	$12,165
Water Compaction	2816	E.C.Y.	$2.55	$7,181
Hauling Excavation	6162	B.C.Y.	$5.31	$32,720
8" Ductile Iron Piping	15995	L.F.	$96.13	$1,537,599
8" Gate Valve	57	Ea.	$1,300.00	$74,100
Air Release Valve	8	Ea.	$6,000.00	$48,000
Fire Hydrant Assembly (Furnish and Install)	26	Ea.	$8,500.00	$221,000
Removal of Existing Fire Hydrant	26	Ea.	$500.00	$13,000
Pipeline Testing and Disinfection	15995	L.F.	$1.50	$23,993
Saddle & Tap for Service	279	Ea.	$1,700.00	$474,300

Segment Label	Laterals	Diam in	Depth ft
Oatfield_2	265	8	4.0
Oatfield_3		8	4.0
Oatfield_4	14	8	4.0

Mobilization	6%	$180,077
SWPPP (per LF)	$2	$31,990
Traffic Control (per Day)	$500	$16,500

Subtotal		$2,184,806
Construction Contingency	20%	$436,961
Construction Total		**$2,621,767**
Project Development	25%	$655,442
Project Cost		**$3,277,209**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

C- 6

Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	147	S.Y.	$9.74	$1,432
Hauling Pavement	20	L.C.Y.	$6.62	$132
Pavement Repair	22	Ton	$250.00	$5,500
Shoring	2760	SF Wall	$0.76	$2,098
Excavation-Trench	94	B.C.Y.	$8.10	$761
Pipe Bedding (sand import)	36	L.C.Y.	$34.67	$1,248
Bedding Compaction	36	E.C.Y.	$3.90	$140
Native Backfill & Compaction	58	E.C.Y.	$4.32	$251
Water Compaction	58	E.C.Y.	$2.55	$148
Hauling Excavation	113	B.C.Y.	$5.31	$600
4" PVC Pressure Pipe AWWA C900	345	L.F.	$10.54	$3,636
4" Gate Valve	1	Ea.	$2,865.20	$2,865
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	345	L.F.	$1.50	$518
Saddle & Tap for Service	3	Ea.	$1,700.00	$5,100

Segment Label	Laterals	Diam in	Depth ft
Round Oaks Court	3	4	4.0

Mobilization	6%	$2,006
SWPPP (per LF)	$2	$690
Traffic Control (per Day)	$500	$500
Subtotal		$38,296
Construction Contingency	20%	$7,659
Construction Total		**$45,956**
Project Development	25%	$11,489
Project Cost		**$57,445**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1870	S.Y.	$9.74	$18,214
Hauling Pavement	260	L.C.Y.	$6.62	$1,721
Pavement Repair	252	Ton	$250.00	$63,000
Shoring	32120	SF Wall	$0.76	$24,411
Excavation-Trench	1305	B.C.Y.	$8.10	$10,571
Pipe Bedding (sand import)	596	L.C.Y.	$34.67	$20,663
Bedding Compaction	596	E.C.Y.	$3.90	$2,324
Native Backfill & Compaction	709	E.C.Y.	$4.32	$3,063
Water Compaction	709	E.C.Y.	$2.55	$1,808
Hauling Excavation	1566	B.C.Y.	$5.31	$8,315
12" Ductile Iron Piping	330	L.F.	$150.62	$49,705
8" Ductile Iron Piping	3685	L.F.	$96.13	$354,239
8" Gate Valve	3	Ea.	$1,300.00	$3,900
12" Gate Valve	4	Ea.	$1,800.00	$7,200
12" Tee	2	Ea.	$3,042.18	$6,084
8" 90 Bend	2	Ea.	$872.69	$1,745
12" 90 Bend	1	Ea.	$1,567.84	$1,568
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	5	Ea.	$8,500.00	$42,500
Removal of Existing Fire Hydrant	5	Ea.	$500.00	$2,500
Pipeline Testing and Disinfection	4015	L.F.	$1.50	$6,023
Saddle & Tap for Service	26	Ea.	$1,700.00	$44,200

Segment Label	Laterals	Diam in	Depth ft
Lakewood Drive	5	8	4.0
Lark St and Whitcomb Dr	10	8	4.0
Kellog Lake Apartments	0	8	4.0
Oatfield	8	8	4.0
28th Ave	3	12	4.0

Mobilization	6%	$40,785
SWPPP (per LF)	$2	$8,030
Traffic Control (per Day)	$500	$8,000

Subtotal		$770,557
Construction Contingency	20%	$154,111
Construction Total		**$924,669**
Project Development	25%	$231,167
Project Cost		**$1,155,836**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	3378	S.Y.	$9.74	$32,902
Hauling Pavement	469	L.C.Y.	$6.62	$3,105
Pavement Repair	426	Ton	$250.00	$106,500
Shoring	54440	SF Wall	$0.76	$41,374
Excavation-Trench	2487	B.C.Y.	$8.10	$20,145
Pipe Bedding (sand import)	1246	L.C.Y.	$34.67	$43,199
Bedding Compaction	1246	E.C.Y.	$3.90	$4,859
Native Backfill & Compaction	1241	E.C.Y.	$4.32	$5,361
Water Compaction	1241	E.C.Y.	$2.55	$3,165
Hauling Excavation	2985	B.C.Y.	$5.31	$15,850
12" Ductile Iron Piping	6140	L.F.	$150.62	$924,807
8" Ductile Iron Piping	665	L.F.	$96.13	$63,926
8" Gate Valve	2	Ea.	$1,300.00	$2,600
12" Gate Valve	15	Ea.	$1,800.00	$27,000
12" Tee	4	Ea.	$3,042.18	$12,169
12" 90 Bend	2	Ea.	$1,567.84	$3,136
Fire Hydrant Assembly (Furnish and Install)	64	Ea.	$8,500.00	$544,000
Removal of Existing Fire Hydrant	64	Ea.	$500.00	$32,000
Pipeline Testing and Disinfection	6805	L.F.	$1.50	$10,208
12" Cross	2	Ea.	$3,279.94	$6,560
Saddle & Tap for Service	34	Ea.	$1,700.00	$57,800

Mobilization	6%	$117,640
SWPPP (per LF)	$2	$13,610
Traffic Control (per Day)	$500	$7,500

Segment Label	Laterals	Diam in	Depth ft
Torbank Road	15	12	4.0
SE Maple St	5	8	4.0
SE River Road (north-north)	14	12	4.0

Subtotal		$2,197,448
Construction Contingency	20%	$439,490
Construction Total		**$2,636,938**
Project Development	25%	$659,234
Project Cost		**$3,296,172**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	185	S.Y.	$9.74	$1,802
Hauling Pavement	26	L.C.Y.	$6.62	$172
Pavement Repair	25	Ton	$250.00	$6,250
Shoring	3200	SF Wall	$0.76	$2,432
Excavation-Trench	128	B.C.Y.	$8.10	$1,037
Pipe Bedding (sand import)	58	L.C.Y.	$34.67	$2,011
Bedding Compaction	58	E.C.Y.	$3.90	$226
Native Backfill & Compaction	70	E.C.Y.	$4.32	$302
Water Compaction	70	E.C.Y.	$2.55	$179
Hauling Excavation	154	B.C.Y.	$5.31	$818
8" Ductile Iron Piping	400	L.F.	$96.13	$38,452
8" Gate Valve	1	Ea.	$1,300.00	$1,300
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	400	L.F.	$1.50	$600
Saddle & Tap for Service	4	Ea.	$1,700.00	$6,800

Segment Label	Laterals	Diam in	Depth ft
SE Vista Sunrise Ct	4	8	4.0

Mobilization	6%	$4,283
SWPPP (per LF)	$2	$800
Traffic Control (per Day)	$500	$1,000
Subtotal		$81,032
Construction Contingency	20%	$16,206
Construction Total		**$97,239**
Project Development	25%	$24,310
Project Cost		**$121,549**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District
Project: 2020 Water Master Plan Update
Prepared By: SRS and HEF
Reviewed By: SBD and KLP
Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	2044	S.Y.	$9.74	$19,909
Hauling Pavement	284	L.C.Y.	$6.62	$1,880
Pavement Repair	277	Ton	$250.00	$69,250
Shoring	35320	SF Wall	$0.76	$26,843
Excavation-Trench	1418	B.C.Y.	$8.10	$11,486
Pipe Bedding (sand import)	640	L.C.Y.	$34.67	$22,189
Bedding Compaction	640	E.C.Y.	$3.90	$2,496
Native Backfill & Compaction	778	E.C.Y.	$4.32	$3,361
Water Compaction	778	E.C.Y.	$2.55	$1,984
Hauling Excavation	1702	B.C.Y.	$5.31	$9,038
8" Ductile Iron Piping	4415	L.F.	$96.13	$424,414
8" Gate Valve	21	Ea.	$1,300.00	$27,300
8" Tee	13	Ea.	$1,481.77	$19,263
Air Release Valve	10	Ea.	$6,000.00	$60,000
Fire Hydrant Assembly (Furnish and Install)	4	Ea.	$8,500.00	$34,000
Removal of Existing Fire Hydrant	4	Ea.	$500.00	$2,000
Pipeline Testing and Disinfection	4415	L.F.	$1.50	$6,623
Saddle & Tap for Service	82	Ea.	$1,700.00	$139,400

Segment Label	Laterals	Diam in	Depth ft
SE Colina Vista Ave	25	8	4.0
SE Emerald Dr	20	8	4.0
SE Colony Cir	15	8	4.0
SE Clayson Ave	4	8	4.0
SE Jennings	18	8	4.0

Mobilization	6%	$52,886
SWPPP (per LF)	$2	$8,830
Traffic Control (per Day)	$500	$21,500

Subtotal		$1,008,722
Construction Contingency	20%	$201,744
Construction Total		**$1,210,467**
Project Development	25%	$302,617
Project Cost		**$1,513,083**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	495	S.Y.	$9.74	$4,821
Hauling Pavement	69	L.C.Y.	$6.62	$457
Pavement Repair	67	Ton	$250.00	$16,750
Shoring	8560	SF Wall	$0.76	$6,506
Excavation-Trench	343	B.C.Y.	$8.10	$2,778
Pipe Bedding (sand import)	155	L.C.Y.	$34.67	$5,374
Bedding Compaction	155	E.C.Y.	$3.90	$605
Native Backfill & Compaction	188	E.C.Y.	$4.32	$812
Water Compaction	188	E.C.Y.	$2.55	$479
Hauling Excavation	412	B.C.Y.	$5.31	$2,188
8" Ductile Iron Piping	1070	L.F.	$96.13	$102,859
8" Gate Valve	3	Ea.	$1,300.00	$3,900
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	1070	L.F.	$1.50	$1,605
Saddle & Tap for Service	20	Ea.	$1,700.00	$34,000

Segment Label	Laterals	Diam in	Depth ft
Alderway Drive	20	8	4.0

Mobilization	6%	$11,888
SWPPP (per LF)	$2	$2,140
Traffic Control (per Day)	$500	$3,000
Subtotal		$225,068
Construction Contingency	20%	$45,014
Construction Total		**$270,082**
Project Development	25%	$67,521
Project Cost		**$337,603**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	986	S.Y.	$9.74	$9,604
Hauling Pavement	137	L.C.Y.	$6.62	$907
Pavement Repair	134	Ton	$250.00	$33,500
Shoring	17040	SF Wall	$0.76	$12,950
Excavation-Trench	684	B.C.Y.	$8.10	$5,540
Pipe Bedding (sand import)	309	L.C.Y.	$34.67	$10,713
Bedding Compaction	309	E.C.Y.	$3.90	$1,205
Native Backfill & Compaction	375	E.C.Y.	$4.32	$1,620
Water Compaction	375	E.C.Y.	$2.55	$956
Hauling Excavation	821	B.C.Y.	$5.31	$4,360
8" Ductile Iron Piping	2130	L.F.	$96.13	$204,757
8" Gate Valve	9	Ea.	$1,300.00	$11,700
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	2130	L.F.	$1.50	$3,195
Saddle & Tap for Service	42	Ea.	$1,700.00	$71,400

Segment Label	Laterals	Diam in	Depth ft
SE View Acres	38	8	4.0
View Acres	4	8	4.0

Mobilization	6%	$23,964
SWPPP (per LF)	$2	$4,260
Traffic Control (per Day)	$500	$3,500
Subtotal		$368,172
Construction Contingency	20%	$73,634
Construction Total		**$441,806**
Project Development	25%	$110,451
Project Cost		**$552,257**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	857	S.Y.	$9.74	$8,347
Hauling Pavement	120	L.C.Y.	$6.62	$794
Pavement Repair	117	Ton	$250.00	$29,250
Shoring	14800	SF Wall	$0.76	$11,248
Excavation-Trench	594	B.C.Y.	$8.10	$4,811
Pipe Bedding (sand import)	268	L.C.Y.	$34.67	$9,292
Bedding Compaction	268	E.C.Y.	$3.90	$1,045
Native Backfill & Compaction	326	E.C.Y.	$4.32	$1,408
Water Compaction	326	E.C.Y.	$2.55	$831
Hauling Excavation	714	B.C.Y.	$5.31	$3,791
8" Ductile Iron Piping	1850	L.F.	$96.13	$177,841
8" Gate Valve	6	Ea.	$1,300.00	$7,800
8" 90 Bend	1	Ea.	$872.69	$873
Fire Hydrant Assembly (Furnish and Install)	5	Ea.	$8,500.00	$42,500
Removal of Existing Fire Hydrant	5	Ea.	$500.00	$2,500
Pipeline Testing and Disinfection	1850	L.F.	$1.50	$2,775
Saddle & Tap for Service	35	Ea.	$1,700.00	$59,500

Segment Label	Laterals	Diam in	Depth ft
Old Orchard ct	16	8	4.0
SE Glen Echo Ave_2	9	8	4.0
SE Meldrum Ave	10	8	4.0

Mobilization	6%	$21,876
SWPPP (per LF)	$2	$3,700
Traffic Control (per Day)	$500	$3,500

Subtotal		$411,914
Construction Contingency	20%	$82,383
Construction Total		**$494,296**
Project Development	25%	$123,574
Project Cost		**$617,870**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1685	S.Y.	$9.74	$16,412
Hauling Pavement	234	L.C.Y.	$6.62	$1,549
Pavement Repair	223	Ton	$250.00	$55,750
Shoring	28520	SF Wall	$0.76	$21,675
Excavation-Trench	1190	B.C.Y.	$8.10	$9,639
Pipe Bedding (sand import)	555	L.C.Y.	$34.67	$19,242
Bedding Compaction	555	E.C.Y.	$3.90	$2,165
Native Backfill & Compaction	635	E.C.Y.	$4.32	$2,743
Water Compaction	635	E.C.Y.	$2.55	$1,619
Hauling Excavation	1428	B.C.Y.	$5.31	$7,583
12" Ductile Iron Piping	920	L.F.	$150.62	$138,570
8" Ductile Iron Piping	2645	L.F.	$96.13	$254,264
8" Gate Valve	8	Ea.	$1,300.00	$10,400
12" Gate Valve	2	Ea.	$1,800.00	$3,600
8" Tee	5	Ea.	$1,481.77	$7,409
Air Release Valve	2	Ea.	$6,000.00	$12,000
Fire Hydrant Assembly (Furnish and Install)	5	Ea.	$8,500.00	$42,500
Removal of Existing Fire Hydrant	5	Ea.	$500.00	$2,500
Pipeline Testing and Disinfection	3565	L.F.	$1.50	$5,348
8" Cross	1	Ea.	$1,787.16	$1,787
Saddle & Tap for Service	64	Ea.	$1,700.00	$108,800

Mobilization	6%	$43,533
SWPPP (per LF)	$2	$7,130
Traffic Control (per Day)	$500	$7,500

Segment Label	Laterals	Diam in	Depth ft
SE Hull Ave	48	8	4.0
SE Wilmont St	16	12	4.0

Subtotal		$819,995
Construction Contingency	20%	$163,999
Construction Total		**$983,994**
Project Development	25%	$245,999
Project Cost		**$1,229,993**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District
Project: 2020 Water Master Plan Update
Prepared By: SRS and HEF
Reviewed By: SBD and KLP
Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	2524	S.Y.	$9.74	$24,584
Hauling Pavement	351	L.C.Y.	$6.62	$2,324
Pavement Repair	341	Ton	$250.00	$85,250
Shoring	43640	SF Wall	$0.76	$33,166
Excavation-Trench	1751	B.C.Y.	$8.10	$14,183
Pipe Bedding (sand import)	791	L.C.Y.	$34.67	$27,424
Bedding Compaction	791	E.C.Y.	$3.90	$3,085
Native Backfill & Compaction	960	E.C.Y.	$4.32	$4,147
Water Compaction	960	E.C.Y.	$2.55	$2,448
Hauling Excavation	2102	B.C.Y.	$5.31	$11,162
8" Ductile Iron Piping	5455	L.F.	$96.13	$524,389
8" Gate Valve	16	Ea.	$1,300.00	$20,800
8" Tee	9	Ea.	$1,481.77	$13,336
Air Release Valve	4	Ea.	$6,000.00	$24,000
Fire Hydrant Assembly (Furnish and Install)	8	Ea.	$8,500.00	$68,000
Removal of Existing Fire Hydrant	8	Ea.	$500.00	$4,000
Pipeline Testing and Disinfection	5455	L.F.	$1.50	$8,183
Saddle & Tap for Service	52	Ea.	$1,700.00	$88,400

Segment Label	Laterals	Diam in	Depth ft
SE Maple St_2	19	8	4.0
SE Oak Grove	1	8	4.0
SE Risley	15	8	4.0
SE McLoughlin Blvd	17	8	4.0

Mobilization	6%	$57,533
SWPPP (per LF)	$2	$10,910
Traffic Control (per Day)	$500	$11,000

Subtotal		$1,086,267
Construction Contingency	20%	$217,253
Construction Total		**$1,303,520**
Project Development	25%	$325,880
Project Cost		**$1,629,400**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	2228	S.Y.	$9.74	$21,701
Hauling Pavement	310	L.C.Y.	$6.62	$2,052
Pavement Repair	302	Ton	$250.00	$75,500
Shoring	38480	SF Wall	$0.76	$29,245
Excavation-Trench	1544	B.C.Y.	$8.10	$12,506
Pipe Bedding (sand import)	697	L.C.Y.	$34.67	$24,165
Bedding Compaction	697	E.C.Y.	$3.90	$2,718
Native Backfill & Compaction	847	E.C.Y.	$4.32	$3,659
Water Compaction	847	E.C.Y.	$2.55	$2,160
Hauling Excavation	1853	B.C.Y.	$5.31	$9,839
8" Ductile Iron Piping	4810	L.F.	$96.13	$462,385
8" Gate Valve	16	Ea.	$1,300.00	$20,800
8" Tee	4	Ea.	$1,481.77	$5,927
8" 90 Bend	2	Ea.	$872.69	$1,745
Air Release Valve	3	Ea.	$6,000.00	$18,000
Fire Hydrant Assembly (Furnish and Install)	5	Ea.	$8,500.00	$42,500
Removal of Existing Fire Hydrant	5	Ea.	$500.00	$2,500
Pipeline Testing and Disinfection	4810	L.F.	$1.50	$7,215
8" Cross	2	Ea.	$1,787.16	$3,574
Saddle & Tap for Service	10	Ea.	$1,700.00	$17,000

Segment Label	Laterals	Diam in	Depth ft
SE McLoughlin Boulevard (so	9	8	4.0
McLoughlin (south of glen ec	0	8	4.0
Glen Echo (crossing)	0	8	4.0
SE Boardman Ave	0	8	4.0
Hull Ave (crossing)	0	8	4.0
SE McLoughlin Boulevard (so	1	8	4.0
McLoughlin (north of hull)	0	8	4.0

Mobilization	6%	$45,912
SWPPP (per LF)	$2	$9,620
Traffic Control (per Day)	$500	$7,500

Subtotal		$715,448
Construction Contingency	20%	$143,090
Construction Total		**$858,538**
Project Development	25%	$214,634
Project Cost		**$1,073,172**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	361	S.Y.	$9.74	$3,516
Hauling Pavement	50	L.C.Y.	$6.62	$331
Pavement Repair	49	Ton	$250.00	$12,250
Shoring	6240	SF Wall	$0.76	$4,742
Excavation-Trench	250	B.C.Y.	$8.10	$2,025
Pipe Bedding (sand import)	113	L.C.Y.	$34.67	$3,918
Bedding Compaction	113	E.C.Y.	$3.90	$441
Native Backfill & Compaction	137	E.C.Y.	$4.32	$592
Water Compaction	137	E.C.Y.	$2.55	$349
Hauling Excavation	300	B.C.Y.	$5.31	$1,593
8" Ductile Iron Piping	780	L.F.	$96.13	$74,981
8" Gate Valve	4	Ea.	$1,300.00	$5,200
8" Tee	1	Ea.	$1,481.77	$1,482
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	780	L.F.	$1.50	$1,170
Saddle & Tap for Service	10	Ea.	$1,700.00	$17,000

Segment Label	Laterals	Diam in	Depth ft
SE River Road	10	8	4.0

Mobilization	6%	$8,855
SWPPP (per LF)	$2	$1,560
Traffic Control (per Day)	$500	$1,500
Subtotal		$166,885
Construction Contingency	20%	$33,377
Construction Total		**$200,262**
Project Development	25%	$50,066
Project Cost		**$250,328**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	559	S.Y.	$9.74	$5,445
Hauling Pavement	78	L.C.Y.	$6.62	$516
Pavement Repair	75	Ton	$250.00	$18,750
Shoring	9680	SF Wall	$0.76	$7,357
Excavation-Trench	388	B.C.Y.	$8.10	$3,143
Pipe Bedding (sand import)	175	L.C.Y.	$34.67	$6,067
Bedding Compaction	175	E.C.Y.	$3.90	$683
Native Backfill & Compaction	213	E.C.Y.	$4.32	$920
Water Compaction	213	E.C.Y.	$2.55	$543
Hauling Excavation	466	B.C.Y.	$5.31	$2,474
8" Ductile Iron Piping	1210	L.F.	$96.13	$116,317
8" Gate Valve	6	Ea.	$1,300.00	$7,800
8" 90 Bend	1	Ea.	$872.69	$873
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	1210	L.F.	$1.50	$1,815
Saddle & Tap for Service	24	Ea.	$1,700.00	$40,800

Segment Label	Laterals	Diam in	Depth ft
Harold Ave	6	8	4.0
SE Gordon Street	2	8	4.0
Derry Lane	16	8	4.0

Mobilization	6%	$14,430
SWPPP (per LF)	$2	$2,420
Traffic Control (per Day)	$500	$2,500

Subtotal		$271,879
Construction Contingency	20%	$54,376
Construction Total		**$326,254**
Project Development	25%	$81,564
Project Cost		**$407,818**

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Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	79	S.Y.	$9.74	$769
Hauling Pavement	11	L.C.Y.	$6.62	$73
Pavement Repair	11	Ton	$250.00	$2,750
Shoring	1360	SF Wall	$0.76	$1,034
Excavation-Trench	55	B.C.Y.	$8.10	$446
Pipe Bedding (sand import)	25	L.C.Y.	$34.67	$867
Bedding Compaction	25	E.C.Y.	$3.90	$98
Native Backfill & Compaction	30	E.C.Y.	$4.32	$130
Water Compaction	30	E.C.Y.	$2.55	$77
Hauling Excavation	66	B.C.Y.	$5.31	$350
8" Ductile Iron Piping	170	L.F.	$96.13	$16,342
8" Gate Valve	1	Ea.	$1,300.00	$1,300
8" Tee	2	Ea.	$1,481.77	$2,964
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	170	L.F.	$1.50	$255

Segment Label	Laterals	Diam in	Depth ft
Mcloughlin (crossing at Chest	0	8	4.0
Hydrant 5-8	0	8	4.0

Mobilization	6%	$2,727
SWPPP (per LF)	$2	$340
Traffic Control (per Day)	$500	$0

Subtotal		$50,793
Construction Contingency	20%	$10,159
Construction Total		**$60,951**
Project Development	25%	$15,238
Project Cost		**$76,189**

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Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	202	S.Y.	$9.74	$1,967
Hauling Pavement	28	L.C.Y.	$6.62	$185
Pavement Repair	29	Ton	$250.00	$7,250
Shoring	3600	SF Wall	$0.76	$2,736
Excavation-Trench	136	B.C.Y.	$8.10	$1,102
Pipe Bedding (sand import)	58	L.C.Y.	$34.67	$2,011
Bedding Compaction	58	E.C.Y.	$3.90	$226
Native Backfill & Compaction	78	E.C.Y.	$4.32	$337
Water Compaction	78	E.C.Y.	$2.55	$199
Hauling Excavation	163	B.C.Y.	$5.31	$866
8" Ductile Iron Piping	90	L.F.	$96.13	$8,652
6" Ductile Iron Piping	360	L.F.	$88.02	$31,687
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	450	L.F.	$1.50	$675

Segment Label	Laterals	Diam in	Depth ft
Hydrant 6-11, Hydrant 6-10,	0	6	4.0
McLoughlin Boulevard Crossi	0	8	4.0

Mobilization	6%	$4,170
SWPPP (per LF)	$2	$900
Traffic Control (per Day)	$500	$500

Subtotal		$78,537
Construction Contingency	20%	$15,707
Construction Total		**$94,244**
Project Development	25%	$23,561
Project Cost		**$117,806**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	727	S.Y.	$9.74	$7,081
Hauling Pavement	100	L.C.Y.	$6.62	$662
Pavement Repair	99	Ton	$250.00	$24,750
Shoring	12560	SF Wall	$0.76	$9,546
Excavation-Trench	504	B.C.Y.	$8.10	$4,082
Pipe Bedding (sand import)	227	L.C.Y.	$34.67	$7,870
Bedding Compaction	227	E.C.Y.	$3.90	$885
Native Backfill & Compaction	277	E.C.Y.	$4.32	$1,197
Water Compaction	277	E.C.Y.	$2.55	$706
Hauling Excavation	604	B.C.Y.	$5.31	$3,207
8" Ductile Iron Piping	1570	L.F.	$96.13	$150,924
8" Gate Valve	7	Ea.	$1,300.00	$9,100
8" Tee	3	Ea.	$1,481.77	$4,445
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	1570	L.F.	$1.50	$2,355
Saddle & Tap for Service	29	Ea.	$1,700.00	$49,300

Segment Label	Laterals	Diam in	Depth ft
SE River Road (North)	2	8	4.0
SE River Road (south)	23	8	4.0
SE Glen Echo Ave	4	8	4.0

Mobilization	6%	$18,187
SWPPP (per LF)	$2	$3,140
Traffic Control (per Day)	$500	$4,000

Subtotal		$343,593
Construction Contingency	20%	$68,719
Construction Total		**$412,312**
Project Development	25%	$103,078
Project Cost		**$515,390**

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Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1383	S.Y.	$9.74	$13,470
Hauling Pavement	193	L.C.Y.	$6.62	$1,278
Pavement Repair	178	Ton	$250.00	$44,500
Shoring	22640	SF Wall	$0.76	$17,206
Excavation-Trench	1005	B.C.Y.	$8.10	$8,141
Pipe Bedding (sand import)	493	L.C.Y.	$34.67	$17,092
Bedding Compaction	493	E.C.Y.	$3.90	$1,923
Native Backfill & Compaction	512	E.C.Y.	$4.32	$2,212
Water Compaction	512	E.C.Y.	$2.55	$1,306
Hauling Excavation	1206	B.C.Y.	$5.31	$6,404
12" Ductile Iron Piping	1960	L.F.	$150.62	$295,215
8" Ductile Iron Piping	870	L.F.	$96.13	$83,633
8" Gate Valve	2	Ea.	$1,300.00	$2,600
12" Gate Valve	8	Ea.	$1,800.00	$14,400
8" 90 Bend	1	Ea.	$872.69	$873
12" 90 Bend	1	Ea.	$1,567.84	$1,568
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	9	Ea.	$8,500.00	$76,500
Removal of Existing Fire Hydrant	9	Ea.	$500.00	$4,500
Pipeline Testing and Disinfection	2830	L.F.	$1.50	$4,245
Saddle & Tap for Service	24	Ea.	$1,700.00	$40,800

Mobilization	6%	$38,632
SWPPP (per LF)	$2	$5,660
Traffic Control (per Day)	$500	$5,500

Segment Label	Laterals	Diam in	Depth ft
Kens Court	20	12	4.0
Vineyard Lane	0	8	4.0
SE Vineyard Road (East)	3	12	4.0
Protech Autoworks	1	8	4.0

Subtotal		$725,850
Construction Contingency	20%	$145,170
Construction Total		**$871,020**
Project Development	25%	$217,755
Project Cost		**$1,088,775**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
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Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	672	S.Y.	$9.74	$6,545
Hauling Pavement	92	L.C.Y.	$6.62	$609
Pavement Repair	92	Ton	$250.00	$23,000
Shoring	11600	SF Wall	$0.76	$8,816
Excavation-Trench	466	B.C.Y.	$8.10	$3,775
Pipe Bedding (sand import)	211	L.C.Y.	$34.67	$7,315
Bedding Compaction	211	E.C.Y.	$3.90	$823
Native Backfill & Compaction	255	E.C.Y.	$4.32	$1,102
Water Compaction	255	E.C.Y.	$2.55	$650
Hauling Excavation	558	B.C.Y.	$5.31	$2,963
8" Ductile Iron Piping	1450	L.F.	$96.13	$139,389
8" Gate Valve	5	Ea.	$1,300.00	$6,500
8" Tee	1	Ea.	$1,481.77	$1,482
Fire Hydrant Assembly (Furnish and Install)	4	Ea.	$8,500.00	$34,000
Removal of Existing Fire Hydrant	4	Ea.	$500.00	$2,000
Pipeline Testing and Disinfection	1450	L.F.	$1.50	$2,175
Saddle & Tap for Service	42	Ea.	$1,700.00	$71,400

Segment Label	Laterals	Diam in	Depth ft
SE Roethe Rd	7	8	4.0
SE Sandra Ave	9	8	4.0
SE Austin St	26	8	4.0

Mobilization	6%	$18,753
SWPPP (per LF)	$2	$2,900
Traffic Control (per Day)	$500	$2,500

Subtotal		$352,323
Construction Contingency	20%	$70,465
Construction Total		**$422,788**
Project Development	25%	$105,697
Project Cost		**$528,485**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District
Project: 2020 Water Master Plan Update
Prepared By: SRS and HEF
Reviewed By: SBD and KLP
Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	394	S.Y.	$9.74	$3,838
Hauling Pavement	55	L.C.Y.	$6.62	$364
Pavement Repair	53	Ton	$250.00	$13,250
Shoring	6800	SF Wall	$0.76	$5,168
Excavation-Trench	273	B.C.Y.	$8.10	$2,211
Pipe Bedding (sand import)	123	L.C.Y.	$34.67	$4,264
Bedding Compaction	123	E.C.Y.	$3.90	$480
Native Backfill & Compaction	150	E.C.Y.	$4.32	$648
Water Compaction	150	E.C.Y.	$2.55	$383
Hauling Excavation	328	B.C.Y.	$5.31	$1,742
8" Ductile Iron Piping	850	L.F.	$96.13	$81,711
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	850	L.F.	$1.50	$1,275
Saddle & Tap for Service	11	Ea.	$1,700.00	$18,700

Segment Label	Laterals	Diam in	Depth ft
SE Roethe Rd (west)	11	8	4.0

Mobilization	6%	$9,818
SWPPP (per LF)	$2	$1,700
Traffic Control (per Day)	$500	$1,500
Subtotal		$184,832
Construction Contingency	20%	$36,966
Construction Total		**$221,799**
Project Development	25%	$55,450
Project Cost		**$277,249**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	50	S.Y.	$9.74	$487
Hauling Pavement	7	L.C.Y.	$6.62	$46
Pavement Repair	7	Ton	$250.00	$1,750
Shoring	880	SF Wall	$0.76	$669
Excavation-Trench	34	B.C.Y.	$8.10	$275
Pipe Bedding (sand import)	14	L.C.Y.	$34.67	$485
Bedding Compaction	14	E.C.Y.	$3.90	$55
Native Backfill & Compaction	20	E.C.Y.	$4.32	$86
Water Compaction	20	E.C.Y.	$2.55	$51
Hauling Excavation	41	B.C.Y.	$5.31	$218
8" Ductile Iron Piping	50	L.F.	$96.13	$4,807
6" Ductile Iron Piping	60	L.F.	$88.02	$5,281
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	110	L.F.	$1.50	$165

Segment Label	Laterals	Diam in	Depth ft
Hydrant 1-32	0	8	4.0
Hydrant 3-91	0	6	4.0

Mobilization	6%	$1,943
SWPPP (per LF)	$2	$220
Traffic Control (per Day)	$500	$0
Subtotal		$36,157
Construction Contingency	20%	$7,231
Construction Total		**$43,388**
Project Development	25%	$10,847
Project Cost		**$54,235**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	139	S.Y.	$9.74	$1,354
Hauling Pavement	19	L.C.Y.	$6.62	$126
Pavement Repair	19	Ton	$250.00	$4,750
Shoring	2400	SF Wall	$0.76	$1,824
Excavation-Trench	96	B.C.Y.	$8.10	$778
Pipe Bedding (sand import)	43	L.C.Y.	$34.67	$1,491
Bedding Compaction	43	E.C.Y.	$3.90	$168
Native Backfill & Compaction	53	E.C.Y.	$4.32	$229
Water Compaction	53	E.C.Y.	$2.55	$135
Hauling Excavation	115	B.C.Y.	$5.31	$611
8" Ductile Iron Piping	300	L.F.	$96.13	$28,839
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Pipeline Testing and Disinfection	300	L.F.	$1.50	$450
Saddle & Tap for Service	6	Ea.	$1,700.00	$10,200

Segment Label	Laterals	Diam in	Depth ft
Maple St_2	6	8	4.0

Mobilization	6%	$3,213
SWPPP (per LF)	$2	$600
Traffic Control (per Day)	$500	$500
Subtotal		$60,544
Construction Contingency	20%	$12,109
Construction Total		**$72,653**
Project Development	25%	$18,163
Project Cost		**$90,817**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	162	S.Y.	$9.74	$1,578
Hauling Pavement	22	L.C.Y.	$6.62	$146
Pavement Repair	22	Ton	$250.00	$5,500
Shoring	2800	SF Wall	$0.76	$2,128
Excavation-Trench	112	B.C.Y.	$8.10	$907
Pipe Bedding (sand import)	51	L.C.Y.	$34.67	$1,768
Bedding Compaction	51	E.C.Y.	$3.90	$199
Native Backfill & Compaction	61	E.C.Y.	$4.32	$264
Water Compaction	61	E.C.Y.	$2.55	$156
Hauling Excavation	134	B.C.Y.	$5.31	$712
8" Ductile Iron Piping	350	L.F.	$96.13	$33,646
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	350	L.F.	$1.50	$525
Saddle & Tap for Service	6	Ea.	$1,700.00	$10,200

Segment Label	Laterals	Diam in	Depth ft
SE Vineyard Road (West)	6	8	4.0

Mobilization	6%	$4,700
SWPPP (per LF)	$2	$700
Traffic Control (per Day)	$500	$500
Subtotal		$88,143
Construction Contingency	20%	$17,629
Construction Total		**$105,771**
Project Development	25%	$26,443
Project Cost		**$132,214**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	454	S.Y.	$9.74	$4,422
Hauling Pavement	63	L.C.Y.	$6.62	$417
Pavement Repair	61	Ton	$250.00	$15,250
Shoring	7840	SF Wall	$0.76	$5,958
Excavation-Trench	315	B.C.Y.	$8.10	$2,552
Pipe Bedding (sand import)	142	L.C.Y.	$34.67	$4,923
Bedding Compaction	142	E.C.Y.	$3.90	$554
Native Backfill & Compaction	173	E.C.Y.	$4.32	$747
Water Compaction	173	E.C.Y.	$2.55	$441
Hauling Excavation	378	B.C.Y.	$5.31	$2,007
8" Ductile Iron Piping	980	L.F.	$96.13	$94,207
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	980	L.F.	$1.50	$1,470
Saddle & Tap for Service	15	Ea.	$1,700.00	$25,500

Segment Label	Laterals	Diam in	Depth ft
SE River Drive	15	8	4.0

Mobilization	6%	$10,743
SWPPP (per LF)	$2	$1,960
Traffic Control (per Day)	$500	$2,000
Subtotal		$202,704
Construction Contingency	20%	$40,541
Construction Total		**$243,245**
Project Development	25%	$60,811
Project Cost		**$304,057**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1247	S.Y.	$9.74	$12,146
Hauling Pavement	173	L.C.Y.	$6.62	$1,145
Pavement Repair	169	Ton	$250.00	$42,250
Shoring	21560	SF Wall	$0.76	$16,386
Excavation-Trench	865	B.C.Y.	$8.10	$7,007
Pipe Bedding (sand import)	391	L.C.Y.	$34.67	$13,556
Bedding Compaction	391	E.C.Y.	$3.90	$1,525
Native Backfill & Compaction	474	E.C.Y.	$4.32	$2,048
Water Compaction	474	E.C.Y.	$2.55	$1,209
Hauling Excavation	1038	B.C.Y.	$5.31	$5,512
8" Ductile Iron Piping	2695	L.F.	$96.13	$259,070
8" Gate Valve	6	Ea.	$1,300.00	$7,800
8" Tee	1	Ea.	$1,481.77	$1,482
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	6	Ea.	$8,500.00	$51,000
Removal of Existing Fire Hydrant	6	Ea.	$500.00	$3,000
Pipeline Testing and Disinfection	2695	L.F.	$1.50	$4,043
Saddle & Tap for Service	63	Ea.	$1,700.00	$107,100

Mobilization	6%	$32,537
SWPPP (per LF)	$2	$5,390
Traffic Control (per Day)	$500	$5,500

Segment Label	Laterals	Diam in	Depth ft
SE Poplar Place	11	8	4.0
Marian Street	31	8	4.0
Woodland Way	21	8	4.0

Subtotal		$612,817
Construction Contingency	20%	$122,563
Construction Total		**$735,381**
Project Development	25%	$183,845
Project Cost		**$919,226**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	1405	S.Y.	$9.74	$13,685
Hauling Pavement	195	L.C.Y.	$6.62	$1,291
Pavement Repair	190	Ton	$250.00	$47,500
Shoring	24280	SF Wall	$0.76	$18,453
Excavation-Trench	974	B.C.Y.	$8.10	$7,889
Pipe Bedding (sand import)	440	L.C.Y.	$34.67	$15,255
Bedding Compaction	440	E.C.Y.	$3.90	$1,716
Native Backfill & Compaction	534	E.C.Y.	$4.32	$2,307
Water Compaction	534	E.C.Y.	$2.55	$1,362
Hauling Excavation	1169	B.C.Y.	$5.31	$6,207
8" Ductile Iron Piping	3035	L.F.	$96.13	$291,755
8" Gate Valve	6	Ea.	$1,300.00	$7,800
8" Tee	2	Ea.	$1,481.77	$2,964
8" 90 Bend	3	Ea.	$872.69	$2,618
Air Release Valve	3	Ea.	$6,000.00	$18,000
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	3035	L.F.	$1.50	$4,553
Saddle & Tap for Service	53	Ea.	$1,700.00	$90,100

Segment Label	Laterals	Diam in	Depth ft
River Forest Road Loop	53	8	4.0

Mobilization	6%	$33,627
SWPPP (per LF)	$2	$6,070
Traffic Control (per Day)	$500	$6,000
Subtotal		$634,173
Construction Contingency	20%	$126,835
Construction Total		**$761,008**
Project Development	25%	$190,252
Project Cost		**$951,260**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	447	S.Y.	$9.74	$4,354
Hauling Pavement	62	L.C.Y.	$6.62	$410
Pavement Repair	60	Ton	$250.00	$15,000
Shoring	7720	SF Wall	$0.76	$5,867
Excavation-Trench	310	B.C.Y.	$8.10	$2,511
Pipe Bedding (sand import)	140	L.C.Y.	$34.67	$4,854
Bedding Compaction	140	E.C.Y.	$3.90	$546
Native Backfill & Compaction	170	E.C.Y.	$4.32	$734
Water Compaction	170	E.C.Y.	$2.55	$434
Hauling Excavation	372	B.C.Y.	$5.31	$1,975
8" Ductile Iron Piping	965	L.F.	$96.13	$92,765
8" Gate Valve	1	Ea.	$1,300.00	$1,300
8" 90 Bend	1	Ea.	$872.69	$873
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	965	L.F.	$1.50	$1,448
Saddle & Tap for Service	12	Ea.	$1,700.00	$20,400

Segment Label	Laterals	Diam in	Depth ft
SE Cottonwood	12	8	4.0

Mobilization	6%	$10,288
SWPPP (per LF)	$2	$1,930
Traffic Control (per Day)	$500	$2,000
Subtotal		$194,263
Construction Contingency	20%	$38,853
Construction Total		**$233,115**
Project Development	25%	$58,279
Project Cost		**$291,394**

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Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	528	S.Y.	$9.74	$5,143
Hauling Pavement	73	L.C.Y.	$6.62	$483
Pavement Repair	71	Ton	$250.00	$17,750
Shoring	9120	SF Wall	$0.76	$6,931
Excavation-Trench	366	B.C.Y.	$8.10	$2,965
Pipe Bedding (sand import)	165	L.C.Y.	$34.67	$5,721
Bedding Compaction	165	E.C.Y.	$3.90	$644
Native Backfill & Compaction	201	E.C.Y.	$4.32	$868
Water Compaction	201	E.C.Y.	$2.55	$513
Hauling Excavation	439	B.C.Y.	$5.31	$2,331
8" Ductile Iron Piping	1140	L.F.	$96.13	$109,588
8" Gate Valve	1	Ea.	$1,300.00	$1,300
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	1140	L.F.	$1.50	$1,710
Saddle & Tap for Service	25	Ea.	$1,700.00	$42,500

Segment Label	Laterals	Diam in	Depth ft
SE Cedar Ave	25	8	4.0

Mobilization	6%	$13,347
SWPPP (per LF)	$2	$2,280
Traffic Control (per Day)	$500	$2,500
Subtotal		$251,695
Construction Contingency	20%	$50,339
Construction Total		**$302,034**
Project Development	25%	$75,509
Project Cost		**$377,543**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	463	S.Y.	$9.74	$4,510
Hauling Pavement	64	L.C.Y.	$6.62	$424
Pavement Repair	63	Ton	$250.00	$15,750
Shoring	8000	SF Wall	$0.76	$6,080
Excavation-Trench	321	B.C.Y.	$8.10	$2,600
Pipe Bedding (sand import)	145	L.C.Y.	$34.67	$5,027
Bedding Compaction	145	E.C.Y.	$3.90	$566
Native Backfill & Compaction	176	E.C.Y.	$4.32	$760
Water Compaction	176	E.C.Y.	$2.55	$449
Hauling Excavation	385	B.C.Y.	$5.31	$2,044
8" Ductile Iron Piping	1000	L.F.	$96.13	$96,130
8" Gate Valve	2	Ea.	$1,300.00	$2,600
8" 90 Bend	1	Ea.	$872.69	$873
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	1000	L.F.	$1.50	$1,500
Saddle & Tap for Service	15	Ea.	$1,700.00	$25,500

Segment Label	Laterals	Diam in	Depth ft
Thornton Drive	15	8	4.0

Mobilization	6%	$11,329
SWPPP (per LF)	$2	$2,000
Traffic Control (per Day)	$500	$2,000
Subtotal		$213,582
Construction Contingency	20%	$42,716
Construction Total		**$256,298**
Project Development	25%	$64,074
Project Cost		**$320,372**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	144	S.Y.	$9.74	$1,403
Hauling Pavement	20	L.C.Y.	$6.62	$132
Pavement Repair	20	Ton	$250.00	$5,000
Shoring	2480	SF Wall	$0.76	$1,885
Excavation-Trench	100	B.C.Y.	$8.10	$810
Pipe Bedding (sand import)	45	L.C.Y.	$34.67	$1,560
Bedding Compaction	45	E.C.Y.	$3.90	$176
Native Backfill & Compaction	55	E.C.Y.	$4.32	$238
Water Compaction	55	E.C.Y.	$2.55	$140
Hauling Excavation	120	B.C.Y.	$5.31	$637
8" Ductile Iron Piping	310	L.F.	$96.13	$29,800
8" Gate Valve	1	Ea.	$1,300.00	$1,300
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	310	L.F.	$1.50	$465
Saddle & Tap for Service	5	Ea.	$1,700.00	$8,500

Segment Label	Laterals	Diam in	Depth ft
SE Diamond Lane	5	8	4.0

Mobilization	6%	$3,663
SWPPP (per LF)	$2	$620
Traffic Control (per Day)	$500	$500
Subtotal		$68,881
Construction Contingency	20%	$13,776
Construction Total		**$82,657**
Project Development	25%	$20,664
Project Cost		**$103,321**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	694	S.Y.	$9.74	$6,760
Hauling Pavement	96	L.C.Y.	$6.62	$636
Pavement Repair	94	Ton	$250.00	$23,500
Shoring	12000	SF Wall	$0.76	$9,120
Excavation-Trench	481	B.C.Y.	$8.10	$3,896
Pipe Bedding (sand import)	217	L.C.Y.	$34.67	$7,523
Bedding Compaction	217	E.C.Y.	$3.90	$846
Native Backfill & Compaction	264	E.C.Y.	$4.32	$1,140
Water Compaction	264	E.C.Y.	$2.55	$673
Hauling Excavation	577	B.C.Y.	$5.31	$3,064
8" Ductile Iron Piping	1500	L.F.	$96.13	$144,195
8" Gate Valve	4	Ea.	$1,300.00	$5,200
8" 90 Bend	2	Ea.	$872.69	$1,745
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	2	Ea.	$8,500.00	$17,000
Removal of Existing Fire Hydrant	2	Ea.	$500.00	$1,000
Pipeline Testing and Disinfection	1500	L.F.	$1.50	$2,250
Saddle & Tap for Service	26	Ea.	$1,700.00	$44,200

Segment Label	Laterals	Diam in	Depth ft
SE Sierra Vista Drive	26	8	4.0

Mobilization	6%	$16,725
SWPPP (per LF)	$2	$3,000
Traffic Control (per Day)	$500	$3,000
Subtotal		$315,411
Construction Contingency	20%	$63,082
Construction Total		**$378,493**
Project Development	25%	$94,623
Project Cost		**$473,117**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	204	S.Y.	$9.74	$1,987
Hauling Pavement	28	L.C.Y.	$6.62	$185
Pavement Repair	28	Ton	$250.00	$7,000
Shoring	3520	SF Wall	$0.76	$2,675
Excavation-Trench	141	B.C.Y.	$8.10	$1,142
Pipe Bedding (sand import)	64	L.C.Y.	$34.67	$2,219
Bedding Compaction	64	E.C.Y.	$3.90	$250
Native Backfill & Compaction	77	E.C.Y.	$4.32	$333
Water Compaction	77	E.C.Y.	$2.55	$196
Hauling Excavation	169	B.C.Y.	$5.31	$897
8" Ductile Iron Piping	440	L.F.	$96.13	$42,297
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	440	L.F.	$1.50	$660
Saddle & Tap for Service	11	Ea.	$1,700.00	$18,700

Segment Label	Laterals	Diam in	Depth ft
SE Britton Ave	11	8	4.0

Mobilization	6%	$5,409
SWPPP (per LF)	$2	$880
Traffic Control (per Day)	$500	$1,000
Subtotal		$101,937
Construction Contingency	20%	$20,387
Construction Total		**$122,325**
Project Development	25%	$30,581
Project Cost		**$152,906**

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Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	250	S.Y.	$9.74	$2,435
Hauling Pavement	35	L.C.Y.	$6.62	$232
Pavement Repair	34	Ton	$250.00	$8,500
Shoring	4320	SF Wall	$0.76	$3,283
Excavation-Trench	173	B.C.Y.	$8.10	$1,401
Pipe Bedding (sand import)	78	L.C.Y.	$34.67	$2,704
Bedding Compaction	78	E.C.Y.	$3.90	$304
Native Backfill & Compaction	95	E.C.Y.	$4.32	$410
Water Compaction	95	E.C.Y.	$2.55	$242
Hauling Excavation	208	B.C.Y.	$5.31	$1,104
8" Ductile Iron Piping	540	L.F.	$96.13	$51,910
8" Gate Valve	1	Ea.	$1,300.00	$1,300
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	540	L.F.	$1.50	$810
Saddle & Tap for Service	7	Ea.	$1,700.00	$11,900

Segment Label	Laterals	Diam in	Depth ft
SE Raintree	7	8	4.0

Mobilization	6%	$5,732
SWPPP (per LF)	$2	$1,080
Traffic Control (per Day)	$500	$1,000
Subtotal		$108,126
Construction Contingency	20%	$21,625
Construction Total		**$129,751**
Project Development	25%	$32,438
Project Cost		**$162,189**

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Client: Oak Lodge Water District
Project: 2020 Water Master Plan Update
Prepared By: SRS and HEF
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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	248	S.Y.	$9.74	$2,416
Hauling Pavement	34	L.C.Y.	$6.62	$225
Pavement Repair	34	Ton	$250.00	$8,500
Shoring	4280	SF Wall	$0.76	$3,253
Excavation-Trench	172	B.C.Y.	$8.10	$1,393
Pipe Bedding (sand import)	78	L.C.Y.	$34.67	$2,704
Bedding Compaction	78	E.C.Y.	$3.90	$304
Native Backfill & Compaction	94	E.C.Y.	$4.32	$406
Water Compaction	94	E.C.Y.	$2.55	$240
Hauling Excavation	206	B.C.Y.	$5.31	$1,094
8" Ductile Iron Piping	535	L.F.	$96.13	$51,430
8" Gate Valve	3	Ea.	$1,300.00	$3,900
8" Tee	1	Ea.	$1,481.77	$1,482
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	535	L.F.	$1.50	$803
Saddle & Tap for Service	3	Ea.	$1,700.00	$5,100

Segment Label	Laterals	Diam in	Depth ft
SE Walta Vista Drive	3	8	4.0

Mobilization	6%	$5,535
SWPPP (per LF)	$2	$1,070
Traffic Control (per Day)	$500	$1,000
Subtotal		$104,466
Construction Contingency	20%	$20,893
Construction Total		**$125,359**
Project Development	25%	$31,340
Project Cost		**$156,699**

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	551	S.Y.	$9.74	$5,367
Hauling Pavement	77	L.C.Y.	$6.62	$510
Pavement Repair	75	Ton	$250.00	$18,750
Shoring	9520	SF Wall	$0.76	$7,235
Excavation-Trench	382	B.C.Y.	$8.10	$3,094
Pipe Bedding (sand import)	172	L.C.Y.	$34.67	$5,963
Bedding Compaction	172	E.C.Y.	$3.90	$671
Native Backfill & Compaction	210	E.C.Y.	$4.32	$907
Water Compaction	210	E.C.Y.	$2.55	$536
Hauling Excavation	459	B.C.Y.	$5.31	$2,437
8" Ductile Iron Piping	1190	L.F.	$96.13	$114,395
8" Gate Valve	3	Ea.	$1,300.00	$3,900
8" 90 Bend	1	Ea.	$872.69	$873
Fire Hydrant Assembly (Furnish and Install)	3	Ea.	$8,500.00	$25,500
Removal of Existing Fire Hydrant	3	Ea.	$500.00	$1,500
Pipeline Testing and Disinfection	1190	L.F.	$1.50	$1,785
Saddle & Tap for Service	34	Ea.	$1,700.00	$57,800

Segment Label	Laterals	Diam in	Depth ft
SE Torbank	4	8	4.0
SE Lindenbrook	30	8	4.0

Mobilization	6%	$15,073
SWPPP (per LF)	$2	$2,380
Traffic Control (per Day)	$500	$2,000
Subtotal		$283,237
Construction Contingency	20%	$56,647
Construction Total		**$339,884**
Project Development	25%	$84,971
Project Cost		**$424,855**

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Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	51	S.Y.	$9.74	$497
Hauling Pavement	7	L.C.Y.	$6.62	$46
Pavement Repair	7	Ton	$250.00	$1,750
Shoring	880	SF Wall	$0.76	$669
Excavation-Trench	35	B.C.Y.	$8.10	$284
Pipe Bedding (sand import)	16	L.C.Y.	$34.67	$555
Bedding Compaction	16	E.C.Y.	$3.90	$62
Native Backfill & Compaction	19	E.C.Y.	$4.32	$82
Water Compaction	19	E.C.Y.	$2.55	$48
Hauling Excavation	42	B.C.Y.	$5.31	$223
8" Ductile Iron Piping	110	L.F.	$96.13	$10,574
8" Gate Valve	1	Ea.	$1,300.00	$1,300
8" 90 Bend	1	Ea.	$872.69	$873
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	110	L.F.	$1.50	$165

Segment Label	Laterals	Diam in	Depth ft
SE McLoughlin Blvd (dead en	0	8	4.0

Mobilization	6%	$1,568
SWPPP (per LF)	$2	$220
Traffic Control (per Day)	$500	$500
Subtotal		$29,722
Construction Contingency	20%	$5,944
Construction Total		**$35,667**
Project Development	25%	$8,917
Project Cost		**$44,583**

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Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
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Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	111	S.Y.	$9.74	$1,081
Hauling Pavement	15	L.C.Y.	$6.62	$99
Pavement Repair	15	Ton	$250.00	$3,750
Shoring	1920	SF Wall	$0.76	$1,459
Excavation-Trench	77	B.C.Y.	$8.10	$624
Pipe Bedding (sand import)	35	L.C.Y.	$34.67	$1,213
Bedding Compaction	35	E.C.Y.	$3.90	$137
Native Backfill & Compaction	42	E.C.Y.	$4.32	$181
Water Compaction	42	E.C.Y.	$2.55	$107
Hauling Excavation	92	B.C.Y.	$5.31	$489
8" Ductile Iron Piping	240	L.F.	$96.13	$23,071
8" Gate Valve	2	Ea.	$1,300.00	$2,600
Pipeline Testing and Disinfection	240	L.F.	$1.50	$360

Segment Label	Laterals	Diam in	Depth ft
Evergreen Street	0	8	4.0

Mobilization	6%	$2,110
SWPPP (per LF)	$2	$480
Traffic Control (per Day)	$500	$500
Subtotal		$40,020
Construction Contingency	20%	$8,004
Construction Total		**$48,025**
Project Development	25%	$12,006
Project Cost		**$60,031**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client: Oak Lodge Water District

Project: 2020 Water Master Plan Update

Prepared By: SRS and HEF

Reviewed By: SBD and KLP

Date 5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	37	S.Y.	$9.74	$360
Hauling Pavement	5	L.C.Y.	$6.62	$33
Pavement Repair	5	Ton	$250.00	$1,250
Shoring	640	SF Wall	$0.76	$486
Excavation-Trench	26	B.C.Y.	$8.10	$211
Pipe Bedding (sand import)	12	L.C.Y.	$34.67	$416
Bedding Compaction	12	E.C.Y.	$3.90	$47
Native Backfill & Compaction	14	E.C.Y.	$4.32	$60
Water Compaction	14	E.C.Y.	$2.55	$36
Hauling Excavation	31	B.C.Y.	$5.31	$165
8" Ductile Iron Piping	80	L.F.	$96.13	$7,690
Fire Hydrant Assembly (Furnish and Install)	1	Ea.	$8,500.00	$8,500
Removal of Existing Fire Hydrant	1	Ea.	$500.00	$500
Pipeline Testing and Disinfection	80	L.F.	$1.50	$120

Segment Label	Laterals	Diam in	Depth ft
McLoughlin	0	8	4.0

Mobilization	6%	$1,192
SWPPP (per LF)	$2	$160
Traffic Control (per Day)	$500	$0
Subtotal		$22,221
Construction Contingency	20%	$4,444
Construction Total		**$26,665**
Project Development	25%	$6,666
Project Cost		**$33,331**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Client:	Oak Lodge Water District
Project:	2020 Water Master Plan Update
Prepared By:	SRS and HEF
Reviewed By:	SBD and KLP
Date	5/20/2020

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Opinion of Probable Construction Cost

Item Description	Quantity	Units	Unit Cost	Total Item Cost
Sawcut & Remove	909	S.Y.	$9.74	$8,854
Hauling Pavement	126	L.C.Y.	$6.62	$834
Pavement Repair	123	Ton	$250.00	$30,750
Shoring	15720	SF Wall	$0.76	$11,947
Excavation-Trench	631	B.C.Y.	$8.10	$5,111
Pipe Bedding (sand import)	285	L.C.Y.	$34.67	$9,881
Bedding Compaction	285	E.C.Y.	$3.90	$1,112
Native Backfill & Compaction	346	E.C.Y.	$4.32	$1,495
Water Compaction	346	E.C.Y.	$2.55	$882
Hauling Excavation	757	B.C.Y.	$5.31	$4,020
8" Ductile Iron Piping	1965	L.F.	$96.13	$188,895
8" Gate Valve	3	Ea.	$1,300.00	$3,900
8" Tee	1	Ea.	$1,481.77	$1,482
8" 90 Bend	1	Ea.	$872.69	$873
Air Release Valve	1	Ea.	$6,000.00	$6,000
Fire Hydrant Assembly (Furnish and Install)	5	Ea.	$8,500.00	$42,500
Removal of Existing Fire Hydrant	5	Ea.	$500.00	$2,500
Pipeline Testing and Disinfection	1965	L.F.	$1.50	$2,948
Saddle & Tap for Service	24	Ea.	$1,700.00	$40,800

Segment Label	Laterals	Diam in	Depth ft
McLoughlin Blvd, north of Hol	7	8	4.0
Holly Avenue	17	8	4.0

Mobilization	6%	$21,887
SWPPP (per LF)	$2	$3,930
Traffic Control (per Day)	$500	$4,000
Subtotal		$412,839
Construction Contingency	20%	$82,568
Construction Total		**$495,406**
Project Development	25%	$123,852
Project Cost		**$619,258**

*Cost estimates are in 2020 dollars (ENR 20 City Average Construction Cost Index of 11392 for January 2020).

Project	Item	Description	Qty	Units	Price/Unit	Cost	Timing
C7 - Reseal Concrete Domes at Valley View Tanks							
C7	1	Mob/General Conditions	1	LS	$ 4,300.0	$ 5,000	Once every 10 years, not sure when last occurred
	2	Seal Coat Dome	42248	SF	$ 1.00	$ 43,000	
		Subtotal				$ 48,000	
		Contingency/CM/Admin			40%	$ 19,200	
		Total				$ 67,200	
C8 - Recoat Single Tank Exterior and Interior at Valley View							
C8	1	Mob/General Conditions	1	LS	$ 14,500	$ 15,000	Last coated in 2002 and 2013, so plan for 2023-2025, one tank/yr
	2	Coat Tank Exterior	24127.43	SF	$ 6.00	$ 145,000	
	3	Coat Tank Interior	24127.43	SF	$ -	$ -	
		Subtotal				$ 160,000	
		Contingency/CM/Admin			0%	$ -	
		Total				$ 160,000	
C9 - Replace Pump and Motors at Valley View							
C9	1	Mob/General Conditions	1	LS	$ 22,800	$ 23,000	Last replaced 2017; assume every 20 yr
	2	Replace 50 hp Pumps & Motors	3	EA	$ 75,000.00	$ 225,000	
	3	Recoat Pipes	419	SF	$ 6.00	$ 3,000	
		Subtotal				$ 251,000	
		Contingency/CM/Admin			50%	$ 125,500	
		Total				$ 376,500	
C10 - Replace Pump and Motors at View Acres							
C10	1	Mob/General Conditions	1	LS	$ 15,300	$ 16,000	Last replaced 2005; assume every 20 yr
	2	Replace 60 hp Pumps & Motors	1	EA	$ 90,000.00	$ 90,000	
	3	Replace 10 hp Pumps & Motor	2	EA	$ 30,000.00	$ 60,000	
	4	Recoat Pipes	419	SF	$ 6.00	$ 3,000	
		Subtotal				$ 169,000	
		Contingency/CM/Admin			50%	$ 84,500	
		Total				$ 253,500	
C11 - Upgrade SCADA system							
C11	1	Mob/General Conditions	1	LS	$ 1,900	$ 2,000	Cellular modems in 2013, PLC in 2019; assume every 10 yr
	2	Replace PLC	1	LS	$ 9,000.00	$ 9,000	
	3	Replace cellular modems	1	LS	$ 10,000.00	$ 10,000	
		Subtotal				$ 21,000	
		Contingency/CM/Admin			50%	$ 10,500	
		Total				$ 31,500	
C12 - Radio Telemetry							
C12	1	Mob/General Conditions	1	LS	$ 1,500	$ 2,000	Needed now.
	2	Upgrade Radios	4	EA	$ 2,500.00	$ 10,000	
	3	Programming	1	LS	$ 5,000.00	$ 5,000	
		Subtotal				$ 17,000	
		Contingency/CM/Admin			40%	$ 6,800	
		Total				$ 23,800	

Project	Item	Description	Qty	Units	Price/Unit	Cost	Timing
C13 - Rebuild PRVs							
C13	1	Mob/General Conditions	1	LS	$ 1,500	$ 2,000	Assume every 5 yr
	2	Rebuild PRVs	3	EA	$ 5,000.00	$ 15,000	
		Subtotal				$ 17,000	
		Contingency/CM/Admin			40%	$ 6,800	
		Total				$ 23,800	
C14 - Large Meter Testing and Replacement							
C14	1	Test 15% of all meters	20.5	EA	$ 500.00	$ 11,000	Assume 15% are tested/replaced every 3 years
	2	Replace 15% of 3" meters	1.65	EA	$ 1,000.00	$ 2,000	
	3	Replace 15% of 4" meters	3.45	EA	$ 1,500.00	$ 6,000	
	4	Replace 15% of 6" meters	5.1	EA	$ 2,000.00	$ 11,000	
	5	Replace 15% of 8" meters	1.65	EA	$ 3,000.00	$ 5,000	
	6	Replace 15% of 10" meters	0.45	EA	$ 4,000.00	$ 2,000	
		Subtotal				$ 37,000	
		Contingency/CM/Admin			30%	$ 11,100	
		Total				$ 48,100	
C15 - Large Meter Bypass							
C15	1	Add bypass to meters >4"	41	EA	$ 2,000.00	$ 82,000	Needed now.
		Contingency/CM/Admin			30%	$ 24,600	
		Total				$ 106,600	
C16 - Replace 4 1/2" Fire Hydrants							
C16	1	Replace 4 1/2" fire hydrants	49	EA	$ 5,000.00	$ 245,000	Needed now.
		Contingency/CM/Admin			30%	$ 73,500	
		Total				$ 318,500	

Appendix F. System Development Charge Analysis TM

FCS GROUP
Solutions-Oriented Consulting

| Memorandum

To: Scott Duren, PE **Date:** July 2, 2020

From: Wyatt Zimbelman, Senior Analyst
Doug Gabbard, Project Manager
John Ghilarducci, Principal

RE: Oak Lodge Water Services District Water SDC

INTRODUCTION

This section describes the policy context and project scope upon which this memorandum is based.

THE ENGAGEMENT

In 2018, the Oak Lodge Water Services District (District) hired Water Systems Consulting to develop the 2018 Water Master Plan (WMP), with FCS GROUP contracted to perform the financial portion of the greater master planning effort. This report summarizes our opinion of the District's maximum defensible system development charges for the water utility, based on the demand growth projections and capital improvement plan included in the WMP.

SYSTEM DEVELOPMENT CHARGE BACKGROUND

Oregon Revised Statutes (ORS) 223.297 to 223.314 authorize local governments to establish system development charges (SDCs), one-time fees on new development paid at the time of development. SDCs are intended to recover a fair share of the cost of existing and planned facilities that provide capacity to serve future growth.

ORS 223.299 defines two types of SDCs:

- A reimbursement fee designed to recover "costs associated with capital improvements already constructed, or under construction when the fee is established, for which the local government determines that capacity exists"
- An improvement fee designed to recover "costs associated with capital improvements to be constructed"

ORS 223.304(1) states, in part, that a reimbursement fee must be based on "the value of unused capacity available to future system users or the cost of existing facilities" and must account for prior contributions by existing users and any gifted or grant-funded facilities. The calculation must "promote the objective of future system users contributing no more than an equitable share to the cost of existing facilities." A reimbursement fee may be spent on any capital improvement related to the system for which it is being charged (whether cash-financed or debt-financed) and on the costs of compliance with Oregon's SDC law.

ORS 223.304(2) states, in part, that an improvement fee must be calculated to include only the cost of projected capital improvements needed to increase system capacity for future users. In other words, the cost of planned projects that correct existing deficiencies or do not otherwise increase

Firm Headquarters
Redmond Town Center
7525 166th Ave NE, Ste D-215
Redmond, Washington 98052

Locations
Washington | 425.867.1802
Oregon | 503.841.6543
Colorado | 719.284.9168

capacity for future users may not be included in the improvement fee calculation. An improvement fee may be spent only on capital improvements (or portions thereof) that increase the capacity of the system for which it is being charged (whether cash-financed or debt-financed) and on the costs of compliance with Oregon's SDC law.

SDC Calculation

This section provides our detailed calculations of the maximum defensible water SDC.

CALCULATION OVERVIEW

In general, SDCs are calculated by adding a reimbursement fee component and an improvement fee component—both with potential adjustments. Each component is calculated by dividing the eligible cost by growth in units of demand. The unit of demand becomes the basis of the charge. **Exhibit 1** shows this calculation in equation format:

Exhibit 1: SDC Equation

$$\frac{\text{Eligible costs of available capacity in existing facilities}}{\text{Units of growth in demand}} + \frac{\text{Eligible costs of capacity-increasing capital improvements}}{\text{Units of growth in demand}} = \text{SDC per unit of growth in demand}$$

Reimbursement Fee

The reimbursement fee is the cost of available capacity per unit of growth that such available capacity will serve. In order for a reimbursement fee to be calculated, unused capacity must be available to serve future growth. For facility types that do not have available capacity, no reimbursement fee may be calculated.

Improvement Fee

The improvement fee is the cost of planned capacity-increasing capital projects per unit of growth that those projects will serve. In reality, the capacity added by many projects serves a dual purpose of both meeting existing demand and serving future growth. To compute a compliant improvement fee, growth-related costs must be isolated, and costs related to meeting current demand must be excluded.

We have used the incremental approach to allocate costs to the improvement fee basis, based on data provided by the District's consulting engineer.

Adjustments

Fund Balance

All accumulated SDC revenue currently available in fund balance is also deducted from its corresponding cost basis. This practice prevents a jurisdiction from double charging for projects that were in the previous methodology's improvement fee cost basis but have not yet been constructed.

The District's practice is to use SDC revenue as the first source of funding for capital projects, and capital expenditures exceeded SDC revenues in both 2018 and 2019. Therefore, the District believes there is no unspent water SDC revenue, and we have not calculated an adjustment.

Compliance Costs

ORS 223.307(5) authorizes the expenditure of SDCs for "the costs of complying with the provisions of ORS 223.297 to 223.314, including the costs of developing system development charge methodologies and providing an annual accounting of system development charge expenditures." To avoid spending monies for compliance that might otherwise have been spent on growth-related projects, this report includes an estimate of compliance costs in the SDC calculation.

GROWTH

The growth calculation is the basis by which an SDC is charged. Growth for each system is measured in units that most directly reflect the source of demand. For water SDCs, the most applicable and administratively feasible unit of growth is the meter capacity equivalent (MCE). For the District, one MCE equals the flow capacity of a 5/8" x 3/4" water meter.

Current Demand

According to the District's records, the water utility had 8,777 customer accounts in 2017. Table 4-1 of the WMP provides the District's projected population growth from 2017 to 2022, which was used to project customer accounts for 2020. Applying the MCE flow factors provided by the American Water Works Association (AWWA), the District has 8,877 customer accounts in 2020 with a combined flow capacity of 13,634 MCEs, as shown in **Exhibit 2**:

Exhibit 2: Estimated 2020 Customer Data

Meter Size	2020 Accounts	MCE Factors	2020 MCEs
5/8"	8,342	1.0	8,342
3/4"	21	1.5	31
1"	224	2.5	560
1 1/2"	123	5.0	613
2"	91	8.0	732
3"	10	16.0	163
4"	21	25.0	529
6"	33	50.0	1,669
8"	10	80.0	762
10"	2	115.0	233
Total	**8,877**		**13,634**

Future Demand

Table 4-1 of the District's WMP includes a population growth forecast for the utility through 2037. Assuming that the distribution of meter sizes remains unchanged, and therefore MCEs increase in proportion to population growth, the District will serve 14,272 MCEs in 2037. The growth from 13,634 MCEs in 2020 to 14,272 MCEs in 2037 (i.e., 638 MCEs) is the denominator in the SDC equation (**Exhibit 3**).

Exhibit 3: Customer Growth

Growth Unit	2020	2037	Growth (2020-2037)	Growth Share
Meter Capacity Equivalents	13,634	14,272	638	4.5%

Any estimate of future demand involves uncertainty. Fortunately, the accuracy of this estimate is less important than its derivation from the same process that produced the project list described later. In other words, the defensibility the SDC rests more on the consistency of the growth estimate with the project list than with the accuracy of the growth estimate.

REIMBURSEMENT FEE COST BASIS

The reimbursement fee is the eligible cost of available capacity per unit of growth that such available capacity will serve. Calculation of the reimbursement fee begins with the historical cost of assets or recently completed projects that have unused capacity to serve future users. For each asset or project, the eligible cost is the cost portion of the asset or project that is available to serve future users.

To avoid charging future development for facilities provided at no cost to the District or its ratepayers, the reimbursement fee cost basis must be reduced by any grants or contributions used to fund the assets or projects included in the cost basis. Furthermore, unless a reimbursement fee will be specifically used to pay debt service, the reimbursement fee cost basis should be reduced by any outstanding debt related to the assets or projects included in the cost basis to avoid double charging for assets paid for by debt service in the rates.

The District's records list $17,586,255 in water fixed assets. We allocated these assets to six categories based on the function of each asset:

- Storage
- Pumping
- Water mains
- Meters and services
- Fire
- General plant

Of these six categories, storage, pumping, and water mains were determined to have available capacity for future users of the system.

Storage

The cost of unused capacity in storage facilities is $2,843,023. The detailed calculation of storage capacity is shown in **Exhibit 4**:

Exhibit 4: Storage Capacity

Storage Facility	Existing Storage	Required Storage	Excess Capacity	% Excess Capacity	Facility Cost	Eligible Cost
Valley View	10.0 MG	6.6 MG	3.4 MG	33.9%	$ 2,428,539	$ 823,275
View Acres	5.6 MG	2.7 MG	2.9 MG	51.3%	$ 3,940,973	$ 2,019,749
Total	**15.6 MG**	**9.3 MG**	**6.3 MG**	**44.6%**	**$ 6,369,512**	**$ 2,843,023**

Pumping

The cost of unused capacity in pumping facilities is $277,156. The detailed calculation of pumping capacity is shown in **Exhibit 5**:

Exhibit 5: Pumping Capacity

Pumping Facility	Firm Capacity	Required Capacity	Excess Capacity	% Excess Capacity	Facility Cost	Eligible Cost
Valley View	2,200 gpm	1,154 gpm	1,046 gpm	47.5%	$ 550,279	$ 261,633
View Acres	1,850 gpm	1,582 gpm	268 gpm	14.5%	$ 107,154	$ 15,523
Total	**4,050 gpm**	**2,736 gpm**	**1,314 gpm**	**42.2%**	**$ 657,433**	**$ 277,156**

Water Mains

Chapter 5.2.1 of the WMP indicates that the District's distribution system has no pressure deficiencies at service connections within the District's service area under future peak hour demands. Because the system is sufficient to serve future demands, the capacity share of the District's water mains is estimated to be equal to the District's growth share of 4.5 percent. By "growth share," we mean that portion of total future demand that will be new.

Reimbursement Fee Cost Calculation

The reimbursement fee cost basis is calculated by multiplying the capacity share of each asset category by the original cost asset value of that category. The detailed calculation is shown in **Exhibit 6:**

Exhibit 6: Reimbursement Fee Cost Basis

Asset Category	Original Cost	Less: Debt Principal	Net Asset Value	Available Capacity	Eligible Cost
Water Mains	$ 7,717,967	$ -	$ 7,717,967	4.5%	$ 345,227
Storage	6,369,512	-	6,369,512	44.6%	2,843,023
Pumping	657,434	-	657,434	42.2%	277,156
Meters & Services	461,838	(1,320,000)	-	0.0%	-
Fire	47,321	-	47,321	0.0%	-
General Plant	2,332,182	-	2,332,182	0.0%	-
Total	**$ 17,586,255**	**$ (1,320,000)**	**$ 17,124,417**	**20.2%**	**$ 3,465,406**

IMPROVEMENT FEE COST BASIS

An improvement fee is the eligible cost of planned projects per unit of growth that such projects will serve. The improvement fee cost basis is based on a specific list of planned capacity-increasing capital improvements. The portion of each project that can be included in the improvement fee cost basis is determined by the extent to which each new project creates capacity for future users. **Exhibit 7** shows how a total project cost of $24,050,600 reduces to an eligible cost of $3,219,594.

Exhibit 7: Improvement Fee Cost Basis

ID	Description	Project Cost	SDC Eligible	SDC Eligible Portion of Costs	Timing
C-1	SE Aldercrest Road	$ 885,500	9.7%	$ 85,919	Year 1-3
F-1	SE 28th Avenue, SE Lakewood Drive, Kellogg Lake Apartments	1,099,000	18.3%	201,650	Year 1-3
F-2	SE River Road	3,143,500	19.6%	614,781	Year 4-9
C-2	SE Lisa Lane	67,500	33.0%	22,291	Year 4-9
F-3	SE Vista Sunrise Court	116,400	9.8%	11,361	Year 4-9
C-3	SE Marcia Court	109,700	32.2%	35,295	Year 4-9
F-4	Jennings Avenue, Emerald Drive, Colina Vista Avenue, Clayson Ave	1,453,900	8.6%	125,399	Year 4-9
C-4	SE Ranstad Court and SE Cinderella Court	195,300	28.9%	56,472	Year 4-9
F-5	Alderway Avenue	323,800	33.9%	109,898	Year 10+
C-5	Oatfield	3,169,400	7.9%	249,947	Year 4-9
F-6	View Acres Road	530,600	11.4%	60,498	Year 10+
C-6	Round Oaks Court	56,900	6.4%	3,636	Year 10+
F-7	Old Orchard Court, SE Meldrum Avenue	593,800	15.6%	92,670	Year 10+
F-8	SE Hull Avenue	1,173,800	13.8%	161,414	Year 10+
F-9	McLoughlin Boulevard	1,557,400	9.9%	154,939	Year 10+
F-10	McLoughlin Boulevard	1,021,400	13.4%	136,619	Year 10+
F-11	River Road	240,100	9.2%	22,154	Year 10+
F-12	Harold Avenue, Derry Lane, and Gordon Street	392,000	8.8%	34,368	Year 10+
F-13	McLoughlin Boulevard	73,700	22.2%	16,342	Year 10+
F-14	McLoughlin Boulevard	103,500	39.0%	40,339	Year 10+
F-15	McLoughlin Boulevard, Glen Echo Avenue, River Road	494,600	9.0%	44,593	Year 10+
F-16	Vineyard Road, Vineyard Lane, commercial parking lot, Kens Cour	1,031,800	20.2%	208,541	Year 10+
F-17	Austin Street and Sandra Avenue and Roethe Road	509,600	8.1%	41,184	Year 10+
F-18	SE Roethe Road	266,300	9.1%	24,143	Year 10+
F-19	River Road, Oak Grove Boulevard	51,400	13.0%	6,701	Year 10+
F-20	SE Maple Street	86,900	9.8%	8,521	Year 10+
F-21	Vineyard Road	127,700	7.8%	9,941	Year 10+
F-22	SE River Drive	291,400	9.6%	27,835	Year 10+
F-23	Poplar Place	884,200	11.4%	100,695	Year 10+
F-24	River Forest Road, River Forest Drive, River Forest Court (loop)	911,100	9.5%	86,203	Year 10+
F-25	Cottonwood Court	278,700	9.8%	27,409	Year 10+
F-26	Cedar Avenue	362,800	8.9%	32,379	Year 10+
F-27	Thornton Drive	307,300	33.4%	102,708	Year 10+
F-28	SE Diamond Lane	99,300	32.1%	31,839	Year 10+
F-29	SE Sierra Vista Drive	453,300	9.4%	42,605	Year 10+
F-30	SE Britton Avenue	147,200	22.2%	32,694	Year 10+
F-31	Raintree Court	155,200	9.9%	15,338	Year 10+
F-32	Walta Vista Drive	149,600	10.2%	15,196	Year 10+
F-33	SE Torbank Road and SE Lindenbrook Court	409,300	8.3%	33,800	Year 10+
F-34	McLoughlin Boulevard	43,000	7.3%	3,124	Year 10+
F-35	SE Evergreen Street	56,900	43.3%	24,650	Year 10+
F-36	SE McLoughlin Blvd	32,300	23.8%	7,690	Year 10+
F-37	SE McLoughlin Blvd and Holly Ave	593,500	9.4%	55,812	Year 10+
	Total	***$ 24,050,600***		***$ 3,219,594***	

COMPLIANCE COSTS

Compliance costs are the sum of SDC methodology updates and annual administrative costs. In consultation with District staff, we estimate compliance costs at 1.3 percent of the combined reimbursement fee and improvement fee cost bases.

SDC FUND BALANCE

The District has advised us that it holds no unspent water SDC revenue. Had a fund balance existed, we would have deducted it from the SDC cost basis to avoid double-charging development.

CALCULATED SDC

Dividing the sum of the net cost bases by the projected growth results in the calculated SDC per MCE, as shown in **Exhibit 8**:

Exhibit 8: Water SDC per MCE

Reimbursement Fee Cost Basis	
Reimbursement Fee Cost Basis	$3,465,406
Growth to End of Planning Period	*638 MCEs*
Reimbursement Fee	**$5,428**
Improvement Fee Cost Basis	
Improvement Fee Cost Basis	$3,219,594
Growth to End of Planning Period	*638 MCEs*
Improvement Fee	**$5,043**
Total System Development Charge	
Reimbursement Fee	$5,428
Improvement Fee	$5,043
Compliance Fee (1.3%)	$137
Total System Development Charge per MCE	**$10,608**

SCHEDULE OF SDCS

In order to impose water SDCs on an individual property, the number of MCEs is determined by the size of the property's water meter. The MCE calculation used is based on AWWA flow factors as shown in **Exhibit 9** where one MCE is a 5/8" x 3/4" meter.

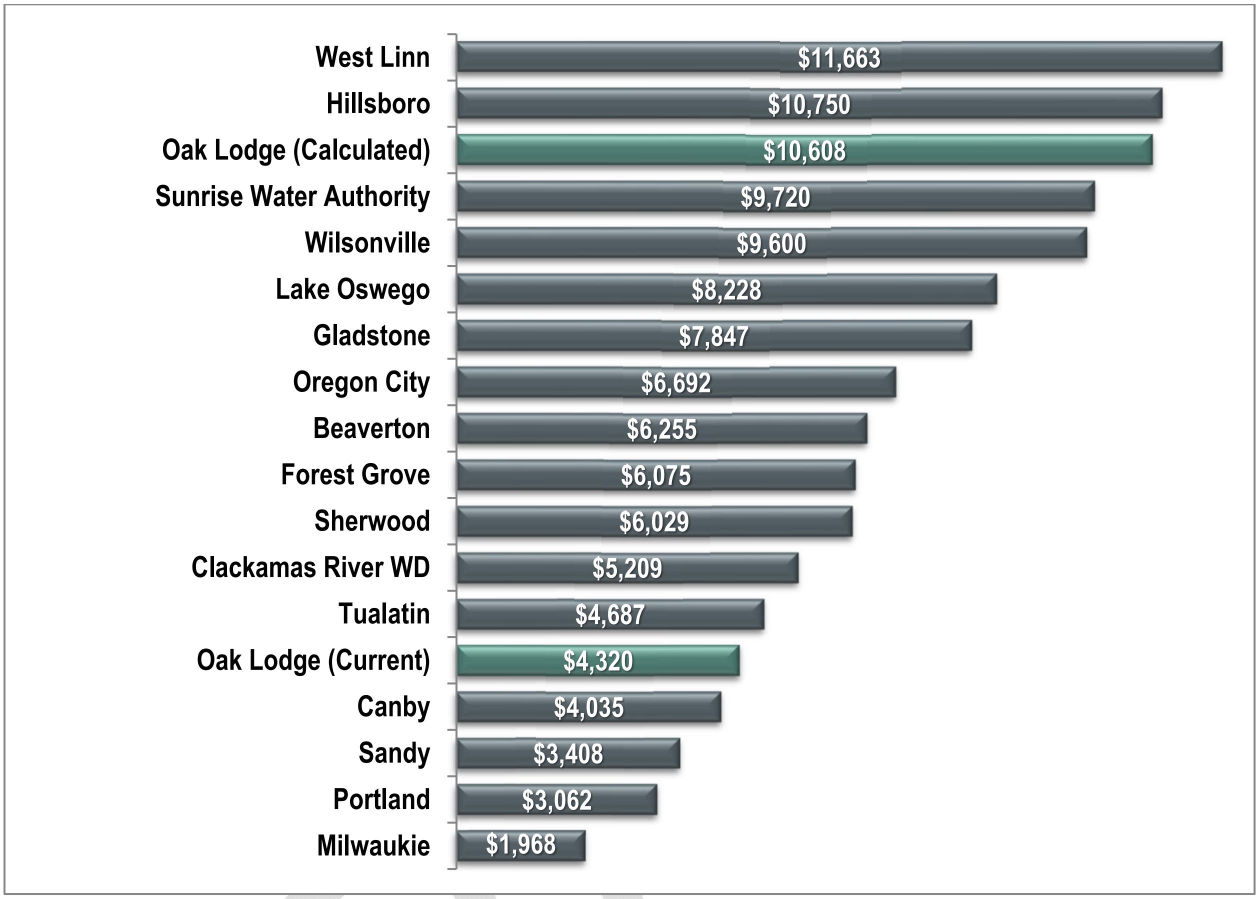
Exhibit 9: Water SDC Schedule

Meter Size	Flow Factor	Calculated SDC	Current SDC	Change
5/8" x 3/4"	1.0	$10,608	$4,320	+$6,288
3/4"	1.5	$15,912	$6,480	+$9,432
1"	2.5	$26,521	$10,800	+$15,721
1 1/2"	5.0	$53,042	$21,595	+$31,447
2"	8.0	$84,867	$34,555	+$50,312
3"	16.0	$169,733	$69,110	+$100,623
4"	25.0	$265,208	$107,985	+$157,223
6"	50.0	$530,416	$215,970	+$314,446
8"	80.0	$848,666	$345,550	+$503,116
10"	115.0	$1,219,958	$496,730	+$723,228

COMPARISONS

Exhibit 10 shows how the District's current and calculated 5/8" x 3/4" water SDCs compare with SDCs adopted by other water utilities.

Exhibit 10: Regional Comparison



SDC IMPLEMENTATION

FUNDING PLAN

The SDCs calculated in this report represent our opinion of the maximum water SDCs that the District can legally charge. However, even if the District imposes the full, calculated charge, the SDC will generate only 28 percent of the funds needed to complete the full project list, as shown in **Exhibit 11**.

Exhibit 11: Funding Plan

Capital Funding Plan	$	%
Requirements		
Capital Improvement Plan	$ 24,050,600	99.6%
Compliance Costs	87,406	0.4%
Total Requirements	**$ 24,138,006**	**100.0%**
Resources		
System Development Charges	$ 6,767,904	28.0%
Other District Resources	17,370,102	72.0%
Total Resources	**$ 24,138,006**	**100.0%**

The District is under no legal obligation to impose the full, calculated SDC. However, the District should be aware that any discounting or phase-in period that reduces SDC revenue will increase the funding requirement from other resources.

CREDITS

A credit is a reduction in the amount of the SDC for a specific development. ORS 223.304 requires that SDC credits be issued for the construction of a qualified public improvement which is: required as a condition of development approval; identified in the District's adopted SDC project list; and either "not located on or contiguous to property that is the subject of development approval," or located "on or contiguous to such property and is required to be built larger or with greater capacity than is necessary for the particular development project . . ."

Additionally, a credit must be granted "only for the cost of that portion of an improvement which exceeds the minimum standard facility size or capacity needed to serve" the particular project up to the amount of the improvement fee. For multi-phase projects, any "excess credit may be applied against SDCs that accrue in subsequent phases of the original development project."

INDEXING

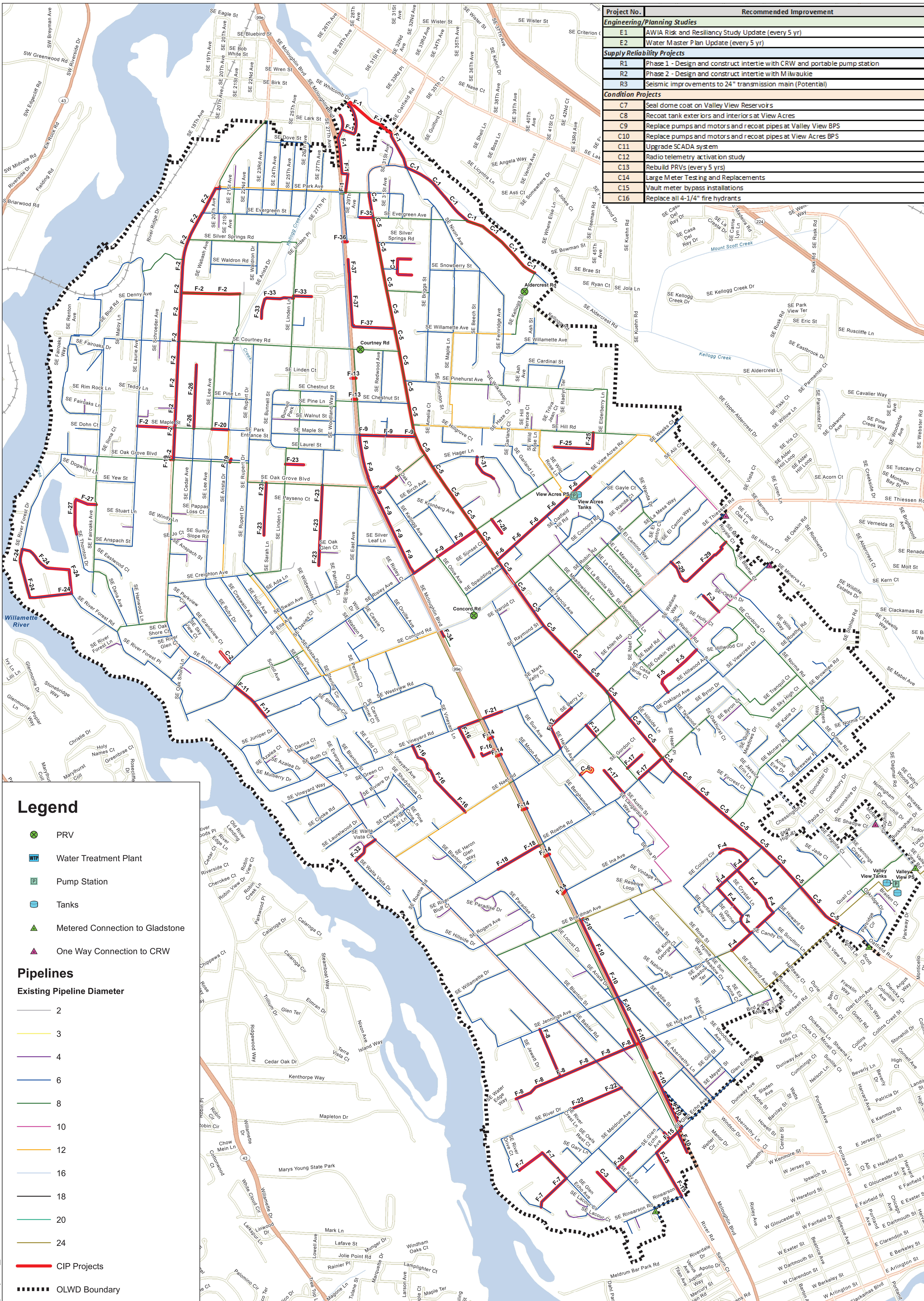
Oregon law (ORS 223.304) also allows for the periodic indexing of SDCs for inflation, as long as the index used is:

> (A) A relevant measurement of the average change in prices or costs over an identified time period for materials, labor, real property or a combination of the three;
> (B) Published by a recognized organization or agency that produces the index or data source for reasons that are independent of the system development charge methodology; and
> (C) Incorporated as part of the established methodology or identified and adopted in a separate ordinance, resolution or order.

We recommend that the District index its charges to the *Engineering News Record* Construction Cost Index for the City of Seattle and adjust its charges annually. There is no comparable Oregon-specific index.

Plate 1. Map of CIP Projects

Project No.	Recommended Improvement
Engineering/Planning Studies	
E1	AWIA Risk and Resiliancy Study Update (every 5 yr)
E2	Water Master Plan Update (every 5 yr)
Supply Reliability Projects	
R1	Phase 1 - Design and construct intertie with CRW and portable pump station
R2	Phase 2 - Design and construct intertie with Milwaukie
R3	Seismic improvements to 24" transmission main (Potential)
Condition Projects	
C7	Seal dome coat on Valley View Reservoirs
C8	Recoat tank exteriors and interiors at View Acres
C9	Replace pumps and motors and recoat pipes at Valley View BPS
C10	Replace pumps and motors and recoat pipes at View Acres BPS
C11	Upgrade SCADA system
C12	Radio telemetry activation study
C13	Rebuild PRVs (every 5 yrs)
C14	Large Meter Testing and Replacements
C15	Vault meter bypass installations
C16	Replace all 4-1/4" fire hydrants



Name: CIP_Projects_22x34

Date: 5/6/2019

OAK LODGE WATER SERVICES

Oak Lodge Water Services District
Water Master Plan Update
CIP Projects

WSC
Water Systems Consulting, Inc.