



Long Prairie Water District

Water System Master Plan

August 2024

Funded, in part, by grants from the Oregon Business Development Department:

- Water/Wastewater Technical Assistance Project S21001

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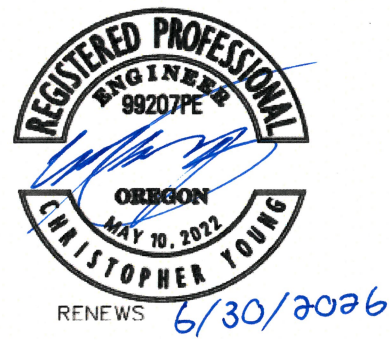
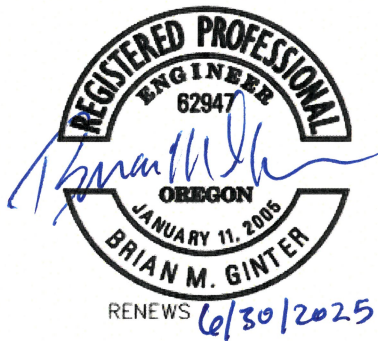
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Water System Master Plan

Long Prairie Water District

August 2024



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Tina Kotek, Governor

October 4, 2024

Brian Ginter, PE

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Via email: Brian.Ginter@consoreng.com

Re: **Master Plan Approval (PR#107-2024)**
Long Prairie Water District (PWS ID#00890)

Dear Brian:

Thank you for your submittal to the Oregon Health Authority's Drinking Water Services (DWS) of plan review information for the Water System Master Plan for the Long Prairie Water District. On August 26, 2024, our office received a copy of the plan. A plan review fee of \$825 was received on August 15, 2024.

The plan represents a 20-year planning horizon out to the year 2044. The plan includes system goals and description, future demand estimates, engineering evaluation, evaluations of options to meet future demand, financing, and list of recommended projects and cost estimates. A seismic risk assessment and mitigation plan was required and was included. Upon review of the plan, it appears the elements required in Oregon Administrative Rules (OAR) 333-061-0060(5) have been addressed.

Please note that OAR 333-061-0060 contains plan submission and review requirements for all major water system additions or modifications. Construction plans and specifications must be submitted to and approved by DWS before construction begins.

If you have any questions, please feel free to call me at (971) 201-9794.

Sincerely,



Carrie Gentry, PE

Regional Engineer

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cc: Clyde Wagner, Long Prairie Water District

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Appendix B Regional Water Supply Study
Appendix C Historical and Projected Demands
Appendix D Geotechnical Report

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Acronyms & Abbreviations

A	
AACE	Association for the Advancement of Cost Engineering International
AAGR	Average Annual Growth Rate
ADD	Average Day Demand
ALA	American Lifelines Alliance
ASCE	American Society of Civil Engineers
AWWA	American Water Works Association
B	
BPS	Booster Pump Station
C	
CCI	Construction Cost Index
CIP	Capital Improvement Program
City	City of Tillamook
CSZ	Cascadia Subduction Zone
D	
DBPR	Disinfectants/Disinfection Byproducts Rule
5-4	Oregon Department of Geology and Mineral Industries
DWPLF	Drinking Water Protection Loan Fund
DWS	Drinking Water Services
E	
ENR	Engineering News-Record
EPA	Environmental Protection Agency
F	
Feasibility Study	Groundwater Feasibility Study
FEMA	Federal Emergency Management Agency
FWD	Fairview Water District
G	
gpd	Gallons per Day
GSI	GSI Water Solutions, Inc.
H	
HGL	Hydraulic Grade Line
I	
IFA	Infrastructure Finance Authority
L	
LCR	Lead and Copper Rule
LF	Linear Feet
M	
M9	Magnitude 9.0
3-7	Maximum Contaminant Level

MDD	Maximum Day Demand
mg	Million Gallons
mgd	Million Gallons per Day
O	
OAR	Oregon Administrative Rules
OFC	Oregon Fire Code
OHA	Oregon Health Authority
ORP	Oregon Resilience Plan
P	
PF	Peaking Factor
PGA	Peak Ground Acceleration
PGD	Permanent Ground Deformation
PGV	Peak Ground Velocity
PHD	Peak Hour Demand
Port	Port of Tillamook Bay
PRV	Pressure Reducing Valve
psi	Pounds per Square Inch
PVC	Polyvinyl Chloride
PVWC	Pleasant Valley Water Company
R	
RR	Rate of Repair
RTCR	Revised Total Coliform Rule
S	
SDWA	Safe Drinking Water Act
SDWRLF	Safe Drinking Water Revolving Loan Fund
SPWA	South Prairie Water Association
STL	
Supply Study	Regional Water Supply Study
W	
WIFIA	Water Infrastructure Finance and Innovation Act of 2014
WSMP	Water System Master Plan

Introduction

The purpose of this Water System Master Plan (WSMP) is to perform an analysis of the Long Prairie Water District's (District) water system and:

- Evaluate the water system against industry performance criteria and state requirements for water systems.
- Estimate future water requirements based on population and water demand forecasts for a 20+ year planning horizon.
- Create a steady state hydraulic model of the distribution system.
- Identify deficiencies and recommend water facility improvements that correct deficiencies.
- Explore future supply options.
- Initiate seismic planning for the system.
- Examine operations and maintenance procedures.
- Develop the District's capital improvement program (CIP).

This report is divided into six chapters to address the goals described above.

In order to identify system deficiencies, existing water infrastructure inventoried in **Chapter 1** will be assessed based on the existing and future water needs summarized in **Chapter 2** and water system performance criteria described in **Chapter 3**.

Chapter 4 presents an analysis of the District's water distribution system based on the water system performance criteria and demand forecasts presented in prior chapters. **Chapter 5** details the District's seismic risk assessment of its existing water system. These chapters identify system deficiencies and vulnerabilities, recommending specific improvement and mitigative projects. **Chapter 6** outlines these recommendations and a 20-year capital improvement plan. The planning and analysis efforts presented in this WSMP are intended to provide the District with the information needed to inform long-term water supply and distribution infrastructure decisions.

How This Should be Used

This comprehensive WSMP is intended to be a useful day-to-day working tool that serves as a flexible, clear, and concise guide to the next 20+ years of water system operation, renewal, and potential water supply development. The WSMP was prepared concurrently with Regional Water Supply Study (Supply Study) and Groundwater Feasibility efforts and should be continually updated as the District continues to explore future supply options.

Compliance

This plan complies with water system master planning requirements established under Oregon Administrative Rules (OAR) for Public Water Systems, Chapter 333, Division 61 (OAR 333-061-0060(5)).

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Existing System Description

1.1 Service Area

The District is a public water system which supplies potable water to approximately 900 people through 286 residential and non-residential service connections. The existing service area includes the District boundaries, as illustrated in **Figure 1-1**.

1.2 Supply

The District is one of 12 systems that purchase treated water from the City of Tillamook (City). The District receives water through an 8-inch diameter supply line extending east from the Main Supply line (12-inch STL 1942) with a connection at Highway 101 and Long Prairie Road, as well as an 8-inch diameter supply line extending north from the Main Supply line near Brickyard Road and Clemens Corner Road. The City's source of supply is drawn from surface water, live flow and storage reservoirs, and groundwater sources. The City owns and operates a 2.0 million gallons per day (mgd) package filtration plant constructed in 1994 that treats water for turbidity and disinfects with chlorine.

1.2.1 City of Tillamook Wholesale Purchase

The District purchases water from the City with an annual average day demand (ADD) of 61,000 gallons per day (gpd). The District currently does not have a water supply contract with the City.

Upon initial development of this WSMP, the District, along with 10 of the 11 other rural water providers, was provided water that was designated as "surplus water" (City of Tillamook, Master Water Plan, 2014, Section 2.2.1). While there have been no recent interruptions of this supply to the water providers, the designation of "surplus water" suggests it could presumably be subject to interruptions or curtailments due to City emergencies (e.g., short-term), City growth (e.g., long-term), or excess demands by the providers.

In April 2024, the City approved a resolution to reclassify all outside Tillamook Water Districts to "Industrial Use", no longer classifying them as "surplus water" (Ref: City of Tillamook, Resolution No. R040124, April 1, 2024). As such, effective May 1st, 2024, the District is considered a regular customer and classified at an industrial rate rather than as a surplus water user.

1.2.2 Emergency Supply and Interties

The District currently has no emergency distribution interties with adjacent water systems. The District's water system is a single loop system with the only water connections being the existing supply from the City.

The City, however, has a 8-inch to 10-inch emergency intertie from Bay City. This intertie is located at the north end of Tillamook City's Highway 101, between Makinster Road and the Wilson River Bridge. The capacity and hydraulic grade line (HGL) of the supply from Bay City is unknown and is assumed to be limited in its ability to meet the City or the District's needs.

1.2.3 Water Rights

The District owns one water right from Mill Creek, summarized in **Table 1-1**.

Table 1-1 | District Water Rights

Source Type	Source	Use	Supply Amount (cfs)	Priority Date	Certificate
Surface Water	Mill Creek	Domestic	3.0	Feb 3, 1919	S2705 / 2191

1.2.4 Regional Water Supply Considerations

Although the District's sole current supply source is purchased wholesale water from the City, they are investigating, with other regional partners, the option of alternate water sources. The regional partners include the District, Pleasant Valley Water Company (PVWC), The Port of Tillamook Bay (Port), and South Prairie Water Association (SPWA). The Port holds two water use permits and a transfer that authorize the use of groundwater for municipal purposes.

In 2022, GSI Water Solutions, Inc. (GSI), with Consor as a subconsultant, was contracted to perform a Groundwater Feasibility Study (Feasibility Study) for the Port.

In 2023, Consor's contract to develop this WSMP was amended to include the Supply Study. This study considered the findings of the Feasibility Study to further explore options for alternate water sources and provide next steps in regional water supply development.

Chapter 4 provides an outline of the alternatives available to the regional partners, discusses the projected timeline for decision making, and will summarize the findings of the Supply Study as they relate to this WSMP. Additional details regarding the regional water supply planning effort can be found in the Ground Water Feasibility Study included in **Appendix A** and the Supply Study included in **Appendix B**.

1.3 Distribution System

1.3.1 Current Operation Summary

The District's existing water distribution system consists of a single pressure zone served at 70 pounds per square inch (psi), with the elevation of the system ranging from 20 to 260 feet. There is a small, privately-owned pump station on Redwood Way which serves a few customers located at a higher elevation where water pressure must be boosted to maintain service. If the pump station is out of service, those customers will lose service.

Figure 1-1 illustrates the District's water service area limits and water system facilities.

1.3.2 Pump Stations

The Redwood Way Booster Pump Station (BPS) is a privately-owned facility that serves customers located on a hill south of Chance Road on Redwood Way. The District does not own any pump stations.

1.3.3 Distribution Pipes

The District's water distribution system contains approximately 11 miles of piping composed of ductile iron, steel, and polyvinyl chloride (PVC) pipe in sizes up to 8 inches in diameter with installation dates ranging

from 1932 to 1990. It is mostly unknown what type of joint restraints were installed, if any, throughout the system. **Table 1-2** presents an inventory of existing pipes by diameter.

Table 1-2 | Distribution Piping

Pipe Diameter	Pipe Type	Pipe Length (ft)	Percent of System
4" and smaller	PVC	21,560	38%
4" and smaller	Ductile Iron Steel	845	2%
6"	PVC	19,890	35%
8"	PVC	14,375	25%
Total		56,670	100%

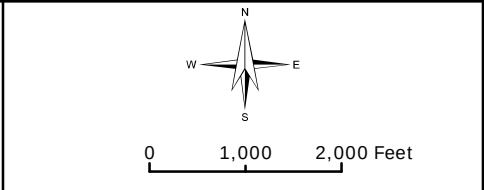
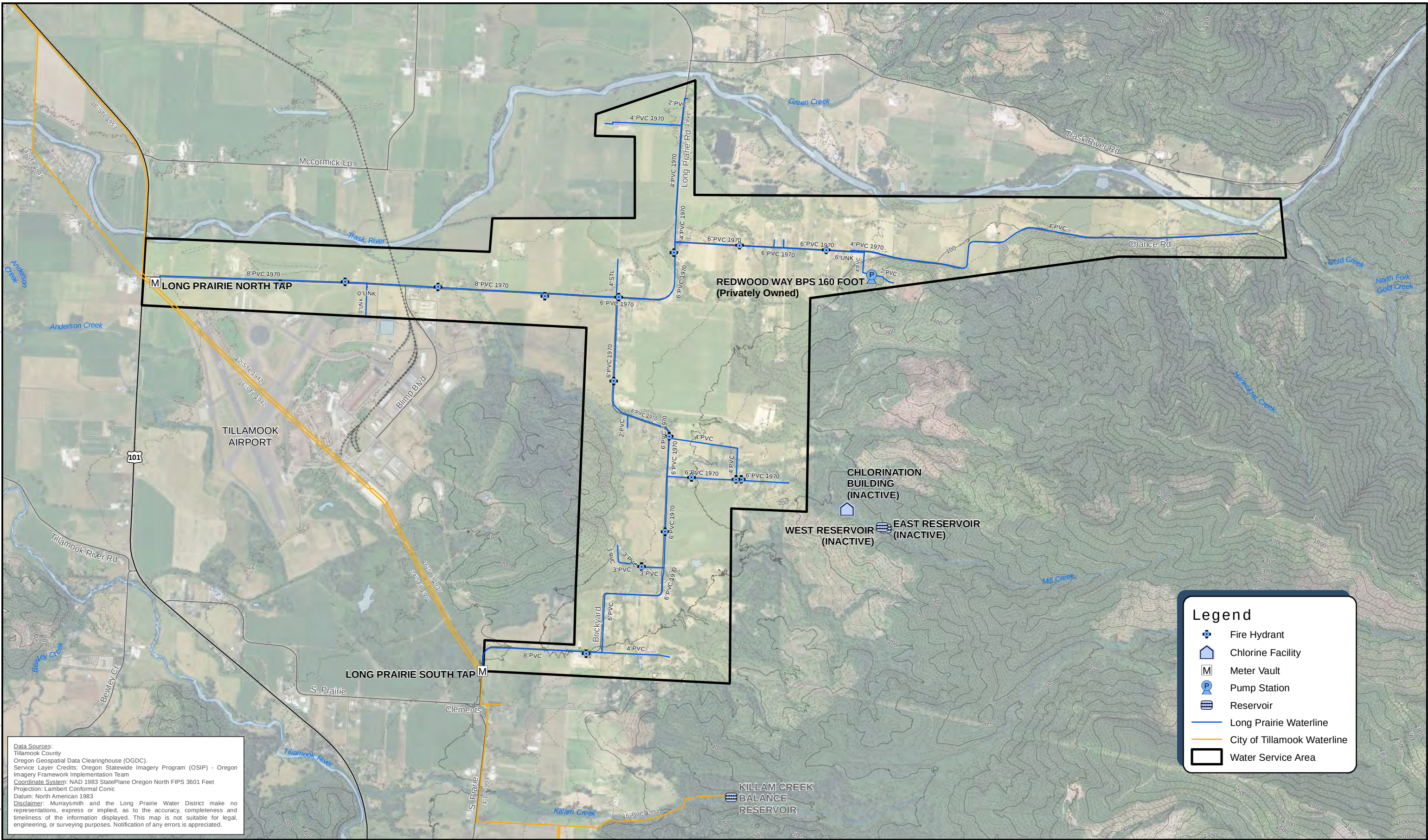
1.3.4 Known Deficiencies

There have been known pressure deficiencies on Burbank Road. Despite this, the District has not experienced problems meeting water demand during firefighting.

1.4 Summary

The District supplies drinking water to approximately 900 people through 286 service connections, with its sole supply source from the City. The water distribution network consists of approximately 11 miles of distribution piping, with some pipes dating back to 1932.

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Long Prairie Water District Water System Master Plan

Figure **1-1**
Existing Water System

Water Requirements

2.1 Introduction

This chapter presents historical and projected future water demands for the District's water service area. Water demands presented are used to evaluate the water system's ability to serve current customers and future growth. Demand forecasts are developed from historical water consumption and production as well as regional planning data.

Water infrastructure planning requires the development of future water demands. This information is used to identify the amount of water supply required and to accurately size piping and related water facilities. There are several possible methods for the development of future demands, depending on what forecasting information is available. The purpose of this chapter is to present population projections and water demand forecasts for the District's system which includes commercial, industrial, and residential customers.

It is recommended that the District regularly update demand forecasts in response to significant changes. This should include considerations such as the discovery of previously undocumented leaks, shifts in water use patterns, changes in the customer base, and population growth. By revising these forecasts, the District can ensure that its water system remains resilient and capable of meeting future demands.

A technical memorandum prepared by GSI provides additional detailed information on the District's historical and projected future water demands. It is included as **Appendix C**.

2.2 Definition of Terms

2.2.1 Demand

System demand refers to the total water supplied during a given period, required to meet the needs of domestic, commercial, industrial, and public use.

Flow rates can be described in any terms involving a volume of water delivered during a specific period. Flow rates pertinent to the analysis and design in this chapter are as follows.

- Average Day Demand (ADD): the total volume of water delivered to the system in a year, divided by 365 days.
- Maximum Day Demand (MDD): the maximum volume of water delivered to the system during any single day.
- Peak Hour Demand (PHD): the maximum volume of water delivered to the system during any single hour.

2.2.2 Peaking Factors

The relationships between the ADD and other demand parameters, such as the MDD or PHD are expressed as peaking factors (PFs). An ADD:MDD PF of 1.33 was used based on information reported by the District.

2.2.3 Consumption

Consumption refers to the actual volume of water sold, and typically billed to, customers, measured at their connections to the water distribution system. District consumption is measured in gallons.

2.2.4 Production

Production refers to the quantity of water delivered to District’s distribution system from the City’s water system. Water production is synonymous with the term “demand” for the purposes of this chapter.

2.3 Planning Period

The planning period for this WSMP is 20 years and is forecasted to the year 2042. Substantial improvements may be required beyond the planning period to accommodate water demands at saturation development. In such cases, phased improvements are recommended for facilities where incremental expansion is feasible. Unless otherwise noted, recommended improvements identified in this plan are sized for 2045 development conditions within the water system planning area.

2.4 Historical Data

A summary of the historical and current system conditions is provided, including number of connections and water use, service area population, water loss, and system production.

2.4.1 High Demand Users

High demand users within the District are listed in **Table 2-1** below.

Table 2-1 | High Demand Users

Name/Use	2020 Average Monthly Water Usage (gallons)
Lourenzo Dairy	14,000
Fish Hatchery	20,000
Orbist Farm	9,000
Hale Farm	15,000
Hale Farm	17,000
Beeler Farm	30,000
Justice Center	141,000
Hogan Farm	170,000

2.4.2 Service Connections and Water Use

The wide variety of customers served by the District are divided into two customer classes: large water users, with monthly average consumption of approximately 30,000 gallons per month or more, and typical water users, representing the remainder of District’s customers. These two groups are summarized based on the quantity of water service connections. Information on water use characteristics by customer class is summarized in **Table 2-2**.

Table 2-2 | Water Use Characteristics of the District's Large Water Users and Typical Water Users

Year	Large Water Users (Average use >30,000 gallons per month)			Typical Water Users (Average use <30,000 gallons per month)		
	Annual Consumption (MG)	Large Water User Connections	Consumption per Connection Per Day (g)	Annual Consumption (MG)	All other Water User Connections	Consumption per Connection Per Day (g)
2016	5.01	8	1,716	16.01	280	157
2017	7.80	8	2,670	16.23	284	157
2018	6.58	8	2,253	16.29	286	156
2019	5.48	8	1,877	15.16	287	145
2020	4.67	9	1,420	14.62	288	139

2.4.3 Water Consumption and Demand

Demand was measured by the annual water sales from the City. Annual consumption is measured in million gallons (mg), which accounts for all uses: commercial, residential, and water loss for each customer served. Annual water use can illustrate year-to-year trends but does not account for differences in customer mix, climate, rainfall, current economic conditions, or other factors which do not reflect a direct relationship to population or efficiency of use. **Table 2-3** summarizes system-wide demand trends from 2016 through 2020.

The annual water consumption remains fairly consistent throughout the 5-year range, with peak consumption in 2017. Annual consumption ranged from approximately 19 to 24 mg and ADD within the service area was approximately 58,000 to 73,000 gallons. Annual production had ranged from approximately 21 to 27 mg and MDD within the service area was approximately 77,000 to 97,000 gallons.

Table 2-3 | Annual Water Sales, Estimated Annual Production, and Average and Maximum Day Demand, 2016-2020

Year	Annual Consumption (MG)	Estimated Annual Production (MG) ¹	Average Day Demand (g) ²	Maximum Day Demand (g) ³
2016	21.0	23.1	63,291	84,042
2017	24.0	26.4	72,344	96,063
2018	22.9	25.1	68,857	91,434
2019	20.6	22.7	62,126	82,495
2020	19.3	21.2	58,046	77,078

Notes:

1. Annual demand was calculated by adding 11 percent to annual consumption total using the following formula:
2. $\text{Water Sales} \div (1 - 0.11) = \text{Water Production}$.
3. ADD was calculated by dividing annual demand by 365.
4. MDD was calculated by multiplying the ADD by 1.33, based on data provided by District.

2.5 Water Demand Projections

Growth is typically a primary factor influencing future water demands. The location of existing and new customer connections affects storage, transmission, and distribution of future water supplies. Two future demand conditions (ADD and PHD) were projected to a 20-year horizon. The future demand projections require identifying the service areas for these horizons, along with the amount of demand associated with the 5-year intervals.

2.5.1 Future Population and Demand

Table 2-4 shows the projected population and average annual growth rates for Tillamook County from 2020-2045, along with the projected number of service connections for the District as documented in the 2020 Coordinated Population Forecast for Tillamook County, published by Portland State University Population Research Center. For the large water users, it was assumed that the number of service connections and their water use would remain constant through the 20-year planning period.

Table 2-4 | Projected Population and Average Annual Growth Rates for Tillamook County, 2020-2045

	Actual	Forecast					
	2018	2020	2025	2030	2035	2040	2045
Tillamook County Population Forecast	--	26,076	26,423	26,810	27,184	27,570	27,987
Projected Average Annual Growth Rate (AAGR) for Tillamook County Total	--	0.26%	0.26%	0.29%	0.28%	0.28%	0.30%
Number of LPWD Typical Water Users' Service Connections	285	287	291	295	299	303	308

Water demands are projected from 2021 through 2041. **Table 2-5** shows population and water service connection projections using the estimated exponential average annual growth rates calculated in the Coordinated Population Forecast.

Table 2-5 | Projected Population and Average Annual Growth Rates for Tillamook County, 2021-2041

	Actual	Forecast				
	2018	2022	2027	2032	2037	2042
Tillamook County Population Forecast	--	26,214	26,577	26,959	27,338	27,736
Projected Average Annual Growth Rate (AAGR) for Tillamook County Total	--	0.26%	0.29%	0.28%	0.28%	0.30%
Number of LPWD Typical Water Users' Service Connections	285	288	292	297	301	305

Assumptions made for the demand forecast:

- Water use patterns for new water service connections would be similar to those of typical water users.
- Demands for typical water users would grow at the same rate as the population of Tillamook County is forecast to grow.
- Monthly water sales for typical water users would grow at the same rate as the County's forecasted population (see **Table 2-3**), while use by large water users would remain the same.

The water demand projection uses water sales in 2018 as the base year because it had the highest annual demand of any year from the historical water demand, representing a higher demand scenario for planning purposes. Projected production is estimated to be equal to water sales, plus a water loss of 11 percent, the

estimated loss reported by the District in 2020. **Table 2-6** shows 2018 actual and 2022 through 2042 projected water sales and demand.

Table 2-6 | 2018 Actual and 2021-2041 Projected Water Sales, Production, ADD, and MDD

	Actual	Forecast				
	2018	2022	2027	2032	2037	2042
Consumption by Typical Water Users (MG)	16.29	16.47	16.69	16.93	17.17	17.42
Consumption by Large Water Users (MG)	6.58	6.58	6.58	6.58	6.58	6.58
Total Annual Consumption (MG)	22.87	23.04	23.27	23.51	23.75	24.00
Total Annual Demand (MG) ¹	25.70	25.89	26.15	26.42	26.69	26.97
ADD (g) ²	70,405	70,938	71,640	72,378	73,110	73,880
MDD (g) ³	93,488	94,196	95,128	96,109	97,080	98,104

Notes:

1. Annual demand was calculated by adding 11 percent to annual consumption total using the following formula:

$$\text{Water Sales} \div (1 - 0.11) = \text{Water Demand.}$$
2. ADD was calculated by dividing annual demand by 365.
3. MDD was calculated by multiplying the ADD by 1.33, based on data provided by District.

This forecast projects total demand to increase by 4.9 percent from 2018 through 2042. The number of service connections is projected to increase by 6.9 percent over the same time period. As described above, the slower growth in water demands compared to growth in service connections is attributed to the assumption that there will be no additional large water users, resulting in a smaller proportional share of District's total customers' consumption over time by the large water users.

2.5.2 Future Population and Demand for Industrial Property

The Port owns an 80-acre tract of land located in the northeast corner of the Port. For the demand analysis an estimated 37.9 acres is considered buildable for full development. The remainder of the land use is excluded for environmental considerations and cannot be developed.

This industrial property falls within the District's service area and any future development within this parcel will be served by the District. The District assumes that this property will be fully developed by 2042 with customers within the light industry business sector. The Port's Water Management and Conservation Plan calculated water use factors to represent consumption on a per-acre basis for its existing water users. The District projects that the density of development within the industrial property will be similar to that of the Port. For the demand forecast a PF for ADD:MDD of 1.33 was used.

Following the Port's methodology, **Table 2-7** shows forecast demand from 2022 through 2042 assuming buildout of the industrial property at a constant rate under two scenarios:

- A low water demand scenario, in which 10 percent of the land is developed by high water use industry and 90 percent of the land is developed by low water use industry (resulting in an average of 439 gpd/acre).
- A high water demand scenario, in which 70 percent of the land is developed by high water use industry and 30 percent of the land is developed by low water use industry (resulting in an average of 1,525 gpd/acre).

Table 2-7 | Industrial Water Demand Forecast with Development of Industrial Property Under Low Water Demand and High Water Demand Scenarios

		Forecast				
		2022	2027	2032	2037	2042
Low Industrial Water Demand Scenario (439 gpd/acre)	MDD (gpd)	0	4,164	8,328	12,493	16,657
	ADD (gpd)	0	3,131	6,262	9,393	12,524
	Annual Demand (MG)	0	1.14	2.29	3.43	4.57
High Industrial Water Demand Scenario (1,887 gpd/acre)	MDD (gpd)	0	14,452	28,905	43,357	57,809
	ADD (gpd)	0	10,866	21,733	32,599	43,466
	Annual Demand (MG)	0	3.97	7.93	11.90	15.86

Table 2-8 shows combined forecast demand for the District’s current service area and addition of the developed industrial property.

Table 2-8 | Combined Forecast Water Demand for Current Service and With Development of Industrial Property

		Actual	Forecast				
		2018	2022	2027	2032	2037	2042
Low Industrial Water Demand Scenario (439 gpd/acre)	MDD (gpd)	93,488	94,196	99,293	104,437	109,573	114,760
	ADD (gpd)	70,405	70,938	74,771	78,640	82,503	86,404
	Annual Demand (MG)	25.70	25.89	27.29	28.70	30.11	31.54
High Industrial Water Demand Scenario (1,887 gpd/acre)	MDD (gpd)	93,488	94,196	109,581	125,014	140,437	155,913
	ADD (gpd)	70,405	70,938	82,506	94,111	105,709	117,346
	Annual Demand (MG)	25.70	25.89	30.11	34.35	38.58	42.83

The combined forecast projects that annual demands will rise by 67 percent compared to 2018 demands under the high water demand scenario and 23 percent under the low water demand scenario, with the overwhelming majority of the forecasted growth in demand attributable to the development of the industrial property.

2.6 Summary

The District’s historical customer accounts, service area population, water production, use, and loss were evaluated to determine trends in the system water requirements. Service area population is estimated as number of water users. Future population is based on the projected average annual growth rate for Tillamook County. Production from 2016-2020 was used to estimate per capita demands for future demand projections for 10-year and 20-year timeframes. Projections reflect modest growth in population and demand requirements with a 20-year change in ADD requirements from 70,938 gallons to 73,880 gallons and MDD from 94,196 gallons to 98,104 gallons. The projected demands for the next 20 years are used to evaluate the hydraulic capacity of the system and identify improvements. The actual timing of any improvements should be based primarily on when the system reaches certain demand thresholds instead of specific predetermined timelines.

Planning and Analysis Criteria

3.1 Introduction

This chapter documents the performance criteria used for the water system analysis presented in **Chapter 4**. Criteria are established for evaluating water supply, distribution system piping, service pressures, storage and pumping capacity, and fire flow availability under varying customer demand and operational conditions.

In 2022, GSI, with Consor as a subconsultant, was contracted to perform the Feasibility Study which evaluated the feasibility of developing a potable groundwater supply, leveraging the Port's groundwater rights from the perspectives of water demand, aquifer productivity, and groundwater quality. Within the Feasibility Study, a wellfield construction strategy was developed to build out a regional supply system in a way that mitigates the risks of insufficiently productive aquifers and groundwater quality impairment. Cost estimates were also provided for wellfield construction and operation and maintenance. The Feasibility Study is included as **Appendix A**.

Subsequent to the Feasibility Study, Consor developed the Supply Study, included as **Appendix B**. The Supply Study evaluated options for alternate water sources.

As regional supply efforts are currently being explored, it is noted that the planning and analysis criteria for the District described in this chapter depend on which long-term water supply alternative is selected. Two different "cases" of criteria are presented here:

1. Wholesale supply only (existing configuration): The existing Tillamook wholesale supply is reliable and adequate for the District's peak demand needs, so no backup storage or supply is required under this scenario.
2. Alternate supply (groundwater or alternate intertie) / New wholesale contract supply: This scenario assumes that the new supply configuration will not be sufficient to instantaneously supply peak demand, so storage and/or backup supply is necessary for demand equalizing and emergencies.

The recommendations of this WSMP are based on the analysis using the performance criteria summarized at the end of this chapter. These criteria have been developed through a review of State requirements, American Water Works Association (AWWA) acceptable practice guidelines, *Ten States Standards*, the *Washington Water System Design Manual*, the *Oregon Resilience Plan* (ORP), and practices of other water providers in the region.

3.2 Performance Criteria

3.2.1 Water Supply: Capacity and Transmission

As described in **Chapter 1**, the District's current sole supply is wholesale water purchased from the City. The City obtains water from several supplies including surface water, storage water, and groundwater. Relative to the District's long-term supply needs, this wholesale source is considered "unlimited" and there is no supply criterion applied for evaluating it.

Depending on the supply option determined from the findings of the Supply Study, the District may transfer its supply to an alternate source. Consistent with the *Ten State Standards* and the *Washington Water System Design Manual*, the system will be evaluated against its ability to provide MDD from its supply sources.

3.2.2 Distribution System

The distribution system will be evaluated under two demand scenarios: MDD plus fire flow and PHD. These two scenarios typically account for the largest instantaneous demands on the system. Evaluating the system under these conditions identifies deficiencies in the distribution network and improvements to be included in the capital improvement projects list in **Chapter 6**.

Typically, new water distribution mains should be at least 8 inches in diameter to supply minimum fire flows. However, 8-inch diameter mains may cause water quality problems in areas with small non-emergency demands and minimal looping. Mains that are 4 or 6-inch diameter are therefore acceptable on runs less than 300 feet if the line is a dead-end and a future extension of the main is not anticipated. Potential water quality issues will be considered on a case-by-case basis when sizing pipes during pre-design for any proposed water main improvements identified in this WSMP.

The following performance criteria are defined for the District's distribution system based on the sources listed above.

1. The distribution system should be capable of supplying PHD while maintaining minimum service pressures of at least 30 psi.
2. The distribution system should be capable of providing the recommended fire flow to a given location while at the same time supplying MDD and maintaining a minimum residual service pressure of 20 psi at any meter in the system. This is the minimum water system pressure required by the Oregon Health Authority (OHA).

3.2.3 Service Pressure

Water distribution systems are typically separated into pressure zones based on ground elevation to provide service pressures within an acceptable range to all customers. In most systems, water from a reservoir will serve customers by gravity within a specified range of ground elevations to maintain acceptable minimum and maximum water pressures at each individual service connection. When it is not feasible or practical to have a separate reservoir for each pressure zone, pump stations or pressure reducing valves (PRVs) are used to serve customers in different pressure zones from a single reservoir. Generally, 100 psi is considered the desirable upper pressure limit and 40 psi the lower limit. Whenever feasible, it is desirable to maintain at least 40 psi at the highest fixture within a given building being served.

The District's size and limited topographical variation allows the entire service area to be supplied by one pressure zone, with the exception of a few higher zones supplied a BPS (pressure is equalized by a pressure tank). Pressure in the District's system is maintained by the supply connection from the City.

Table 3-1 summarizes the service pressure criteria used in the analysis of the District's water system. Any future alternate supply sources and facilities should target these pressure criteria as part of their design. An evaluation of typical static pressures in the system is included in **Chapter 4**.

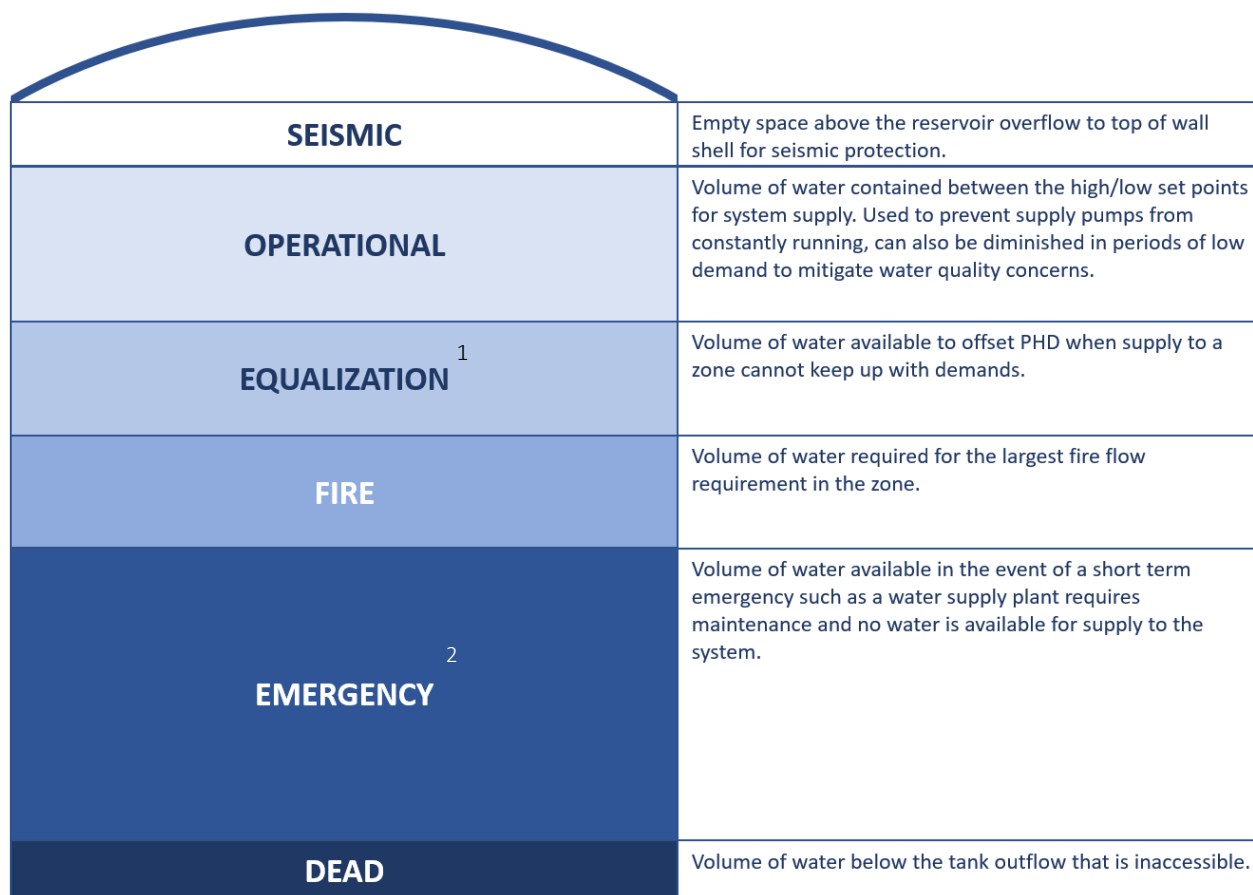
Table 3-1 | Recommended Service Pressure Criteria

Service Pressure Criterion	Pressure (psi)
Normal minimum, ADD	40
Normal maximum (Oregon Plumbing Specialty Code)	80
Minimum, during emergency or fire flow	20

3.2.4 Storage Capacity

While the District currently does not have a water storage reservoir, for future needs they should consider the following capacity criteria to provide operational storage, fire storage, and standby (emergency) storage. Additionally, dead storage and headroom for seismic sloshing should also be included in storage volume calculations, where tanks have not been constructed to include seismic slosh height. While storage is typically discussed as a volume, limiting factors may actually be based on vertical space in a tank, flow rates, or actual volume of water. Adequate storage capacity for each purpose must be provided for each pressure zone, although the volume may be divided among multiple tanks. **Figure 3-1** provides a visual of the six storage volume components and is followed by a brief discussion of each storage element below, based on the *Washington State Water System Design Manual* guidelines.

Figure 3-1 | Storage Volumes



Notes:

1. Equalization storage not included in the wholesale water supply option.
2. Emergency storage not included in the wholesale water supply option.

A brief discussion of each storage element is provided below. These capacity criteria for storage volume are commonly used by other water providers and by AWWA.

Recommended system wide storage is the sum of the operational, equalizing, fire, and emergency storage volume components. Available usable storage in existing storage facilities is the total volume minus any reductions for seismic sloshing or dead storage.

3.2.4.1 Operational Storage

Operational storage is the volume of water stored between the nominal on/off reservoir level set points for the supplying pump stations or supply valves. This volume is dedicated to supplying demand fluctuations throughout the day and minimizing pump cycling. Operational storage can be varied throughout the year to provide reservoir turnover – winter reservoir levels are normally set lower than summer levels to allow for continued turnover with lower winter demands.

Operational storage includes equalization storage which is required to meet water system demands when zone demands exceed supply delivery capacity. Equalizing storage is only applicable for the alternate water supply case, where supply is not evaluated as “unlimited.” The equalizing volume is calculated as the difference between PHD and the system’s supply capacity on a 2-1/2 hour basis, per Washington State.

The operational volume and the equalizing volume are “nested” for the analysis, which means that the larger of the two volumes is used to calculate the required total storage.

3.2.4.2 Fire Suppression Storage

Water stored for fire suppression is typically provided to meet the single most severe fire flow demand within the system. The fire storage volume is determined by multiplying the recommended fire flow rate by the expected duration of that flow consistent with the 2019 Oregon Fire Code (OFC). Specific fire flow quantity recommendations, duration, and location requirements are presented later in this chapter.

3.2.4.3 Emergency Storage

Emergency storage is provided to supply water during emergencies such as supply pipeline failures, equipment failures, power outages, or natural disasters. The amount of emergency storage provided can be highly variable depending upon an assessment of risk and the desired degree of system reliability. A volume equal to the MDD (for a day) is recommended by the Washington Water Design Manual, though the manual recommends higher or lower values for higher or lower risk, respectively.

For the wholesale water supply scenario, the fire storage volume is considered adequate for emergency storage (fire and emergency storage are typically nested) due to the high reliability of the City intertie. For the alternate supply scenario, emergency storage is calculated as MDD. If the District selects a supply alternative that consists of a single supply source (e.g. one groundwater well), a larger emergency storage volume should be used for sizing new tanks due to the higher risk of relying on one supply source.

3.2.4.4 Seismic Volume

Seismic volume is the volume of space between the maximum water surface and the base of the reservoir roof. This space is maintained as a buffer in the event of a seismic event to minimize forces on the reservoir caused by uplift and the resultant sloshing. For older reservoirs with inadequate freeboard, this volume of space may require the reservoir to be operated such that the maximum operational level is below the set overflow elevation of the reservoir. A freeboard depth of five feet will be assumed as the seismic slosh

depth, however during design this depth should be further evaluated based on the conditions of the reservoir site.

3.2.4.5 Dead Storage

Dead storage is the volume of storage lost due to the inaccessibility of water below the tank outflow.

3.2.5 Pump Stations

The District operates a small BPS located on Redwood Way, serving a few customers located at an elevation that cannot be served by the HGL of the wholesale tap. The pump station should be able to supply PHD since there is no backup storage to provide equalization during peak use. However, the pump station will not be evaluated to provide fire flow.

3.2.6 Required Fire Flow

The water distribution system is expected to provide water for fire suppression in addition to domestic use. The amount of water required for fire suppression purposes in this analysis is estimated based on the land use and zoning. Fire flow requirements are typically much greater in magnitude than the MDD in any local area. Adequate hydraulic capacity must be provided for these potentially large fire flow demands.

Emergency response in District’s area is provided by Tillamook Fire District, which establishes fire flow requirements for each building within its service area. General fire flow guidelines are described in the *Fire Code Applications Guide* consistent with the 2019 OFC: a minimum fire flow of 1,000 gpm for single-family. However, the District does not have adequate resources to provide this amount of flow within the planning period. Because of this, the District’s CIP includes upgrades that will work towards a long-term goal of providing 1,000 gpm along the system backbone and 500 gpm at key fire suppression locations specified by Tillamook Fire District, though this is not attainable until after the 20-year planning period.

The ORP defines the water system backbone as the essential infrastructure capable of supplying key 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. The water system backbone is further discussed in **Chapter 5**.

3.3 Performance Criteria Summary

Table 3-2 summarizes the system performance criteria described above and compares the two water supply alternatives. The difference between these alternatives lies in the calculation of storage capacity. The wholesale water supply option excludes equalizing or standby/emergency storage because the fire suppression storage is considered sufficient. By contrast, the alternate water supply option will include equalizing or standby/emergency storage because the fire suppression storage is considered insufficient.

Table 3-2 | Performance Criteria Summary

Water System Component	Evaluation Criterion	Wholesale Water Supply (Existing)	Alternate Water Supply	Design Standard/Guideline
Water Supply	Supply Capacity	No criterion; wholesale supply evaluated as “unlimited”	MDD ¹	-

Water System Component	Evaluation Criterion	Wholesale Water Supply (Existing)	Alternate Water Supply	Design Standard/Guideline
Service Pressure	Normal Range (during ADD ¹)	40-80 pounds per square inch (psi)		Ten State Standards
	Max	100 psi system pressure and 80 psi at service		Oregon Plumbing Specialty Code, Section 608.2
	Min, during MDD with Fire Flow	20 psi		2019 Oregon Fire Code, OAR 333-061
	Min, during PHD ¹	30 psi		Washington Water System Design Manual
Storage	Total Required Storage Capacity	Sum of operational, fire suppression (seismic and dead storage consider unusable)	Sum of operational or equalization (nested) and emergency storage volumes (seismic and dead storage consider unusable)	Washington Water System Design Manual
	Seismic Slosh Volume	Assume 5 feet sloshing depth		Typical Industry Criterion
	Operational Storage	Typical operating band per District		Typical Industry Criterion
	Equalizing Storage	None	ES = (PHD - Qs)(150 minutes)	Washington Water System Design Manual
	Standby/Emergency Storage	None	MDD (for one day) Nested with Fire Flow storage	Washington Water System Design Manual
	Fire Suppression	Required fire flow x flow duration		2019 Oregon Fire Code
Pump Stations	Min no. of Pumps	2		Ten State Standards
	Closed Zone Capacity ²	PHD No fire flow required in these zones		Washington Water System Design Manual
	Backup Power	At least two independent sources		Ten State Standards
Required Fire Flow and Duration	Single Family Residential	1,000 gpm for 1 hour along system backbone and 500 gpm at key fire suppression locations		District-defined criterion

Notes:

1. ADD: average daily demand, defined as the average volume of water delivered to the system during a 24-hour period = total annual demand/number of days per year. MDD: maximum day demand, defined as the maximum volume of water delivered to the system during any single day. PHD: peak hour demand, generally the peak hour of MDD.
2. Closed zone is defined as a pressure zone that is not supplied by gravity from a storage reservoir. All of the areas served by booster pumps in the District are closed zones.

3.4 Water Quality

3.4.1 Regulatory Compliance

As the provider of a public drinking water system, the District must follow state and federal regulations associated with water quality sampling, monitoring and reporting. Water quality standards regulate source water, water treatment, and distribution system water quality.

Within the State of Oregon, the OHA Drinking Water Services (DWS) rules for water quality standards and monitoring are adopted directly from the Environmental Protection Agency (EPA). The DWS is required to

adopt rules that are at least as stringent as federal rules. To date, DWS has not elected to implement more stringent water quality or monitoring requirements.

The District must adhere to the following water quality rules.

- Disinfectants/Disinfection Byproducts Rule (DBPR)
- Revised Total Coliform Rule (RTCR)
- Lead and Copper Rule (LCR)

As the source water provider, the City is responsible for sampling, monitoring, and compliance with numerous water quality regulations that do not need to be addressed directly by the District. As the wholesale water provider to the District, the City is responsible for meeting these regulatory requirements. If the District intends to pursue an alternative water supply source, they will be required to meet additional regulatory requirements.

3.4.2 Disinfectants/Disinfection Byproducts

The District is required to monitor for disinfectants/disinfection byproducts under stage 2 of the DBPR. This rule regulates exposure to disinfectants, disinfection byproducts, and precursors that may react with disinfectants to produce harmful chemicals. Disinfectants are added to drinking water to kill harmful pathogens. At low levels, these disinfectants keep our water safe and do not affect human health. At higher concentrations (such as typical concentrations in pool water), exposure could lead to nausea, vomiting, and diarrhea. Disinfection byproducts occur when disinfectants react with usually non-harmful nutrients in the water to produce contaminants. When these precursors are not present, there is nothing for the disinfectants to react with and so disinfection byproducts are not formed. Therefore, it is important to monitor for both the precursors and resultant contaminants. The DBPR regulates a number of contaminants.

Stage 2 of the DBPR requires that the maximum contaminant level (MCL) of the listed contaminants be calculated on the locational running annual average of samples taken quarterly. Compliance sites consist both of locations where high concentrations of disinfection byproducts are found (typically sites with long detention times), and sites with average detention times within the distribution system. The number of sites is based on the type of source water and population served. The rule also provides for reduced monitoring for systems with very low disinfection by-products based on two years of existing data.

3.4.3 Revised Total Coliform Rule (RTCR)

The RTCR identifies provisions for monitoring of total coliform as an indicator of bacteriological quality. Most coliforms are not disease causing. Rather, their presence indicates the sanitary conditions of the water and are one of the easiest indicator species to monitor. Total coliforms include both environmental and fecal coliforms. Both types are important to measure as both can indicate the presence of pathogens, although fecal coliforms are generally more concerning. *E. coli* bacteria is used to indicate fecal coliforms, as it is one of the major species of fecal coliforms that does not reproduce in the absence of fecal matter.

Sampling requirements vary according to population served and history of positive samples. The District is required to take two routine samples per month and test for total coliforms. If total coliforms are found to be present at any site, additional testing for *E. coli* is required to determine compliance.

3.4.4 Lead and Copper Rule (LCR)

The LCR was first established in 1991 to limit lead and copper exposure. Revisions were made to the rule in 2000, 2007, 2016 and 2021. The latest revisions alter how utilities implement corrosion control treatment, conduct compliance sampling, manage lead service lines, and communicate with customers. The revisions expanded the responsibility associated with privately owned service lines, sampling protocol, service line inventory, and full lead service line replacement requirements. They also expanded public outreach and education through more frequent customer contact and annual service line notification letters. The EPA's Guidance for Developing and Maintaining a Service Line Inventory provides essential information to help water systems comply with the LCR Revisions requirement to prepare and maintain an inventory of service line materials by October 16, 2024. The guidance document includes:

- Best practices for inventory development and communicating information to the public.
- A template for water systems, states, and Tribes to use or adapt to create their own inventory.
- Case studies on developing, reviewing, and communicating about inventories.
- Prioritization of inventory development in disadvantaged communities and where children live and play.
- Science-based testing protocols to find more sources of lead in drinking water.
- Trigger level to jumpstart mitigation earlier and in more communities.
- Directions for more and complete lead service line replacements.
- Testing requirements for schools and childcare facilities.
- Requirements to identify and make public the locations of lead service lines

Compliance with the LCR requires that samples at the customer's tap must not exceed the following action levels:

- Lead - 0.015 mg/L detected in the 90th percentile of all samples
- Copper -1.3 mg/L detected in the 90th percentile of all samples

The most common sources of lead in a water system are pipes, faucets, and plumbing fixtures. Therefore, testing within the distribution system, rather than just at the water source, is important. Water samples at the customer's tap are required to be taken at high-risk locations, which are defined as homes with the following conditions:

- Lead solder installed after 1982
- Lead service lines
- Lead interior piping

If action levels are exceeded for either lead or copper, there are additional requirements including source monitoring, public education, and corrosion control studies.

Water System Analysis

4.1 Introduction

This chapter describes the analysis of the District's water system components: distribution system, storage, and supply. The analysis is based on the water requirements developed in **Chapter 2** and the planning and analysis criteria outlined in **Chapter 3**. The analysis findings are developed into a CIP which is presented in **Chapter 6**.

4.1.1 Industrial Property Demand Impact

The Port currently owns a large industrial property located in the northeast corner of the Port. This industrial property falls within the District's service area and future development within this parcel may be served by District. The potential future development of the property will influence the District's demand, and thus, it is incorporated into the demand analysis. Details of the industrial property are summarized below.

- Based on multiple demand scenarios, the 80-acre tract of land would potentially add 4.57-15.86 MG of annual demand.
- Conservatively, a high water demand scenario was used for the analysis: 70 percent of the land is developed by high water use industry and 30 percent of the land is developed by low water use industry.
- While the conservative demand scenario was used in the analysis, the additional demand does not affect the required storage capacity of the wholesale supply alternative.
- Including the industrial property increases the buildout required storage by approx. 200,000 gallons.

4.2 Hydraulic Model

A steady-state hydraulic network analysis model is a computerized model that represents the distribution system as a series of lines (these represent pipes or "links") and nodes ("junctions"). The hydraulic model calculates instantaneous system flows through pipes and pressures at nodes based on the system's operating or "boundary" conditions. Boundary conditions refer to system operating assumptions including average or peak demand, reservoir geometry and water level, and pump curves and pump status. Diameter, length, and headloss coefficients are specified for each pipe and an approximate ground elevation is specified for each node. The hydraulic model was used to evaluate the performance of the District's existing distribution system and identify proposed piping improvements based on the criteria described in **Chapter 3**.

4.2.1 Modeled Water Demands

Customer demand was calculated from District-provided water use totals from the year 2018 and forecasted to 2042, as detailed in **Chapter 2** and **Appendix C**. Demands were distributed uniformly in the

model, except for demands associated with the high demand users listed in **Table 2-1**; these demands were assigned spatially by customer address.

4.2.2 Model Calibration

Conсор calibrated the hydraulic model in September 2021 based on fire flow tests conducted by the Tillamook Fire District in 2012 and 2015. Field test results were compared to pressure results obtained from modeled hydrant flows. Modeled static pressure was calibrated to within an average of 5 psi difference from the field, and modeled residual pressure drop during flow was calibrated to an average of 25 psi difference from the field. While this is a low-confidence calibration, it is adequate for fire flow and general hydraulic performance analysis of the system.

4.2.3 Facility Boundary Conditions

Though the District's supply source options are under review and subject to change, the existing supply configuration was used as the boundary condition behind this analysis. As discussed in **Chapter 1**, under normal operating conditions, the District is a wholesale water customer of the City and receives supply through two different master meters connected to the City's 24-inch transmission main fed by its water treatment plant.

For all hydraulic analyses performed in the model, an HGL of 218 feet was assumed at the North Tillamook Tap which corresponds to a PRV setting of 70 psi, and an HGL of 206 feet assumed at the South Tillamook Tap which corresponds to a PRV setting of 45 psi.

The Redwood Way BPS serves the customers located on a hill south of Chance Road on Redwood Way, was modeled as one design-point pump with a design head of 100 feet and a design flow of 100 gpm.

4.3 Supply Capacity Analysis

4.3.1 Existing Supply Analysis

As a wholesale customer from the City, all supply relies on the two taps on the City's transmission main. Because there is no storage facility in the District's system, these taps supply peak demands as well as average demands. The District does not have any alternative or backup supply sources, thus its supply connections from the City are critical.

4.3.2 Supply Alternatives

Regional Water Supply Planning was endorsed by four rural systems, collectively referred to as the "Partner Agencies", all of whom source their water from the City. The Partner Agencies participating in the Supply Study wish to evaluate the feasibility of the development of a regional water supply to provide them with long-term reliable, efficient, and effective water supply and transmission to their respective service areas.

A brief summary of the supply alternatives is outlined below.

4.3.2.1 Do Nothing

Under this alternative, the District would continue to purchase water from the City without a wholesale agreement. The existing contract allows the District to use surplus City water only, and to follow future rate increases that will be similar to recent increases.

4.3.2.2 City Wholesale Water Agreement

The District would negotiate a wholesale water agreement with the City with the objective of purchasing a certain annual volume of water based on firm water supply and future rates would be based on cost of service.

4.3.2.3 Fairview Water District

Located northeast of the District, Fairview Water District (FWD) has additional groundwater capacity and could supply the District as a wholesale customer through a new intertie. A new intertie would require the construction of pipeline(s), pumping, and related improvements as needed to purchase water on a wholesale basis. FWD's water is unchlorinated; the District would need to implement chlorination in order to receive supply.

4.3.2.4 New Groundwater Supply

The Port's existing groundwater rights can be used to construct new wells and related system improvements for a new groundwater supply system. A consideration is the Port's water rights are sufficient to supply all Partner Agencies and has the highest initial capital cost.

4.3.2.5 Combination

Combinations of supply sources, project timing, and capacities could be implemented to optimize supply investments and enhance the resiliency of a regional water supply system.

4.4 Storage Capacity Analysis

As discussed in **Chapter 3**, the total volume of storage required for the District's distribution system includes operational storage, emergency storage, equalization storage, and storage for fire suppression. The planned future tank was sized to provide storage for each component under 2040 demand conditions. The storage sizing is based on operational requirements during the higher demand summer months. The future storage tank will increase the system's reliability and help with pressures during a fire flow scenario.

The capacity analysis has two storage scenarios:

- The District continues to purchase wholesale water from the City,
- The District chooses an alternative supply source as discussed in the Supply Study or supply is limited due to new wholesale contract.

4.4.1 Capacity Analysis – Continued Wholesale Water Supply

Table 4-1 shows the storage capacity if the District continues to purchase wholesale water from the City. Wholesale water is assumed to be able to supply peak hour demands and therefore emergency and equalization storage are not included in the analysis. Over the 20-year planning horizon, there is an anticipated 2042 storage deficit of 60,000 gallons for the wholesale purchase water supply alternative. Recommendations for adding additional storage capacity are presented in **Chapter 6**.

Table 4-1 | Storage Capacity Analysis- Continued Wholesale

Year	Storage Components				Recommended Total Storage (Gal)	Existing Storage			Total Usable Storage	Storage Deficit (Gal)
	Operational (Gal)	Fire ¹ (Gal)	Equalization ² (Gal)	Emergency ² (Gal)		Nominal Storage (Gal)	Dead (Non- usable) (Gal)	Seismic (Non- usable) (Gal)		
Existing	0	60000	0	NA	60000	0	0	0	0	60000
10-Yr Demands	0	60000	0	NA	60000	0	0	0	0	60000
20-Yr Demands	0	60000	0	NA	60000	0	0	0	0	60000

Notes:

- Standby and Fire Storage are nested, so the Standby storage volume shown here represents the remaining standby storage not required for fire flow storage.
- No equalization or emergency for wholesale purchase

4.4.2 Capacity Analysis – Alternate Water Supply/New Wholesale Contract

Table 4-2 shows the capacity if the District uses an alternate mean for water supply. All storage components are utilized in this capacity method.

Table 4-2 | Storage Capacity Analysis – Alternate Water Supply

Year	Storage Components				Recommended Total Storage (Gal)	Existing Storage			Total Usable Storage	Storage Deficit (Gal)
	Operational (Gal)	Fire (Gal)	Equalization (Gal)	Emergency (Gal)		Nominal Storage (Gal)	Dead (Non- usable) (Gal)	Seismic (Non- usable) (Gal)		
Existing	38049	60000	14823	34196	147068	0	0	0	0	147068
10-Yr Demands	38049	60000	18636	65014	181699	0	0	0	0	181699
20-Yr Demands	38049	60000	22393	95913	216355	0	0	0	0	216355

Over the 20-year planning horizon, there is an anticipated 2042 storage deficit of nearly 220,000 gallons if the District pursues a new source of supply for the wholesale alternative. More additional storage capacity will be required than if the District continues to purchase water wholesale. As such, a new reservoir is recommended in the immediate term, in conjunction with the District's source and supply capacity improvements. Recommendations for adding additional storage capacity are presented in **Chapter 6**.

4.5 Fire Flow Analysis

Fire flow scenarios test the distribution system's ability to provide required fire flows at a given location while simultaneously supplying MDD and maintaining a minimum residual service pressure of 20 psi at all services without exceeding a maximum velocity of 14 feet per second in all pipes. The boundary conditions used for the analysis in the hydraulic model are stated earlier in this chapter.

The District's distribution system includes a large amount of older 4-inch and 6-inch diameter PVC pipes in single-family residential areas. The majority of hydrants in those areas are unable to deliver the minimum

required fire flow. To mitigate fire flow deficiencies in single-family residential areas, several short piping improvement projects are recommended to upgrade existing 4-inch mains to 6-inch or 8-inch mains.

The District’s low population density and minimal commercial zoning means that the value of a full retrofit of the water system to provide OFC minimum residential and/or commercial fire flow is not valuable or feasible, given the District’s resources. Furthermore, oversizing of system pipe in low-density areas can cause water quality problems. the District has worked with and should continue working with the Tillamook Fire District to pursue high-priority, high-value improvements that will provide fire flow to an acceptable level, given the area’s needs.

Generally, the 2022 OFC has been adopted as the standard. A summary of fire flow recommendations is presented in **Table 4-3**.

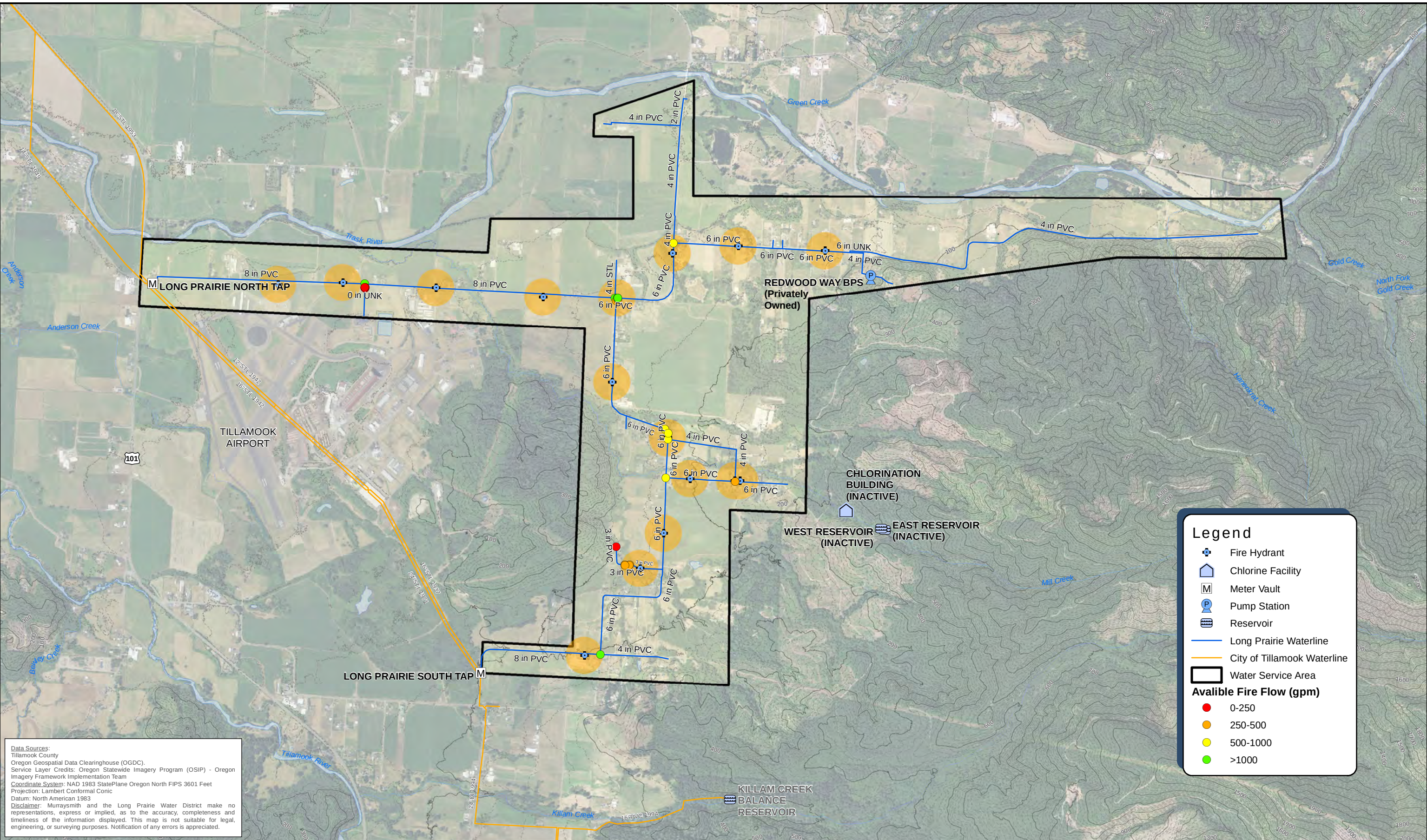
Table 4-3 | Summary of Recommended Fire Flows

Land Use Type	Recommended Fire Flow (gpm)	Duration (hours)
Single- or Two-Family Residential <=3,600 square feet	1,000 gpm	1
Residential >3,600 square feet and other Buildings	Use OFC criteria for building size and type up to a maximum of 3,000 gpm	3
Commercial and Industrial	Use OFC criteria for building size and type up to a maximum of 3,000 gpm	3

4.6 Summary

The water system capacity analysis identified the additional storage volume, pump capacity, and pipe upsizing required to meet the District’s service criteria for existing and future demand conditions. In addition to maintaining the existing pipe and facilities, the system also requires investment in additional infrastructure primarily replacing small diameter pipes to address existing fire flow deficiencies.

\\consor.local\ms\Portland\PD\Projects\21\3176 - Long Prairie WD - Water System Master Plan\GIS\MXD\21-3176-300-OR-LPWD FIRE FLOW MAP.mxd 7/2/2024 11:32:38 AM Katelyn McNulty



Seismic Resilience Evaluation

5.1 Introduction

Municipalities and utility providers throughout the region are increasingly aware of the risk to their infrastructure from potential seismic activity. Following recent seismic research which presented persuasive evidence on the eminent threat and extreme risk of a Cascadia Subduction Zone (CSZ) earthquake, the State of Oregon developed the ORP which established target timelines for water utilities to provide service following a seismic event. The ORP also recognized that, currently, water providers and existing water infrastructure are unable to meet these recovery goals. To improve existing water systems' seismic resilience, one of the ORP's key recommendations was for water utilities to complete a seismic risk assessment and mitigation plan as part of their periodic WSMP updates.

As part of this WSMP the District has completed a seismic risk assessment of their existing water system. The scope of this evaluation includes risk findings and general recommendations regarding seismic design standards for future water infrastructure. Delve Underground (dba. McMillen Jacobs) performed a geotechnical Seismic Hazards Study, which was written in December of 2021. The results will be discussed later in this chapter.

5.2 Key Water System Facilities

5.2.1 Critical Customers

Critical water system customers are those who require uninterrupted or swiftly restored water service, consistent with ORP guidelines. Service should be restored within one to three days following a seismic event, aligning with the ORP Target States of Recovery for the Water and Wastewater Sector of the Oregon Coast.

Chapter 8 of *The Oregon Resilience Plan for Reducing Risk and Improving Recover for the Next Cascadia Earthquake and Tsunami* includes a table that describes target states of recovery for different regions within the State. **Figure 5-1** describes the target state of recovery for water systems in the area including the City.

No critical customers were identified in the District's service area. As discussed in **Chapter 1**, the highest demand users in the District are predominately agricultural farms and residential use. Given the system's size and the relatively small number of customers, the District should prioritize the resilience of its largest transmission mains. This ensures that any future customers needing uninterrupted service will have a dependable system in place.

KEY TO THE TABLE											
TARGET TIMEFRAME FOR RECOVERY:											
<i>Desired time to restore component to 80–90% operational</i>											
<i>Desired time to restore component to 50–60% operational</i>											
<i>Desired time to restore component to 20–30% operational</i>											
<i>Current State (90% operational)</i>											

The ORP defines the water system backbone as the essential infrastructure capable of supplying key 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.

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illustrated in **Figure 5-2**. A priority for each key water facility was selected based on operational factors such as the relative number of customers served and the facility’s necessity to system-wide water distribution operations. Transmission and distribution mains related to each of the facilities shown in **Table 5-1** are considered Tier 1 mains for the purpose of assessing pipe fragility as described later in this chapter.

Table 5-1 | Key Water System Facilities (LP)

Priority	Facility Name	Critical Functions
1	Long Prairie North Tap	Supply to Entire System
1	Long Prairie South Tap	Supply to Entire System

Other water facilities shown on the water system backbone map in **Figure 5-2** represent service routes to specific critical customers or alternate routes through the distribution system to reservoirs and pump stations. Each of these facilities and mains share equal priority and are considered Tier 2 mains for the purpose of assessing pipe fragility as described later in this chapter.

In the District’s service area approximately 70 percent of the total length of pipe is classified as tier 1 mains and the remainder is tier 2. Due to the District’s small size, a majority of the pipes are essential to distribute water to the system.

5.3 Seismic Hazards Evaluation

The seismic hazards evaluation for the District’s service area was conducted by Delve Underground, as summarized in the following paragraphs. More detailed information is included as **Appendix D**.

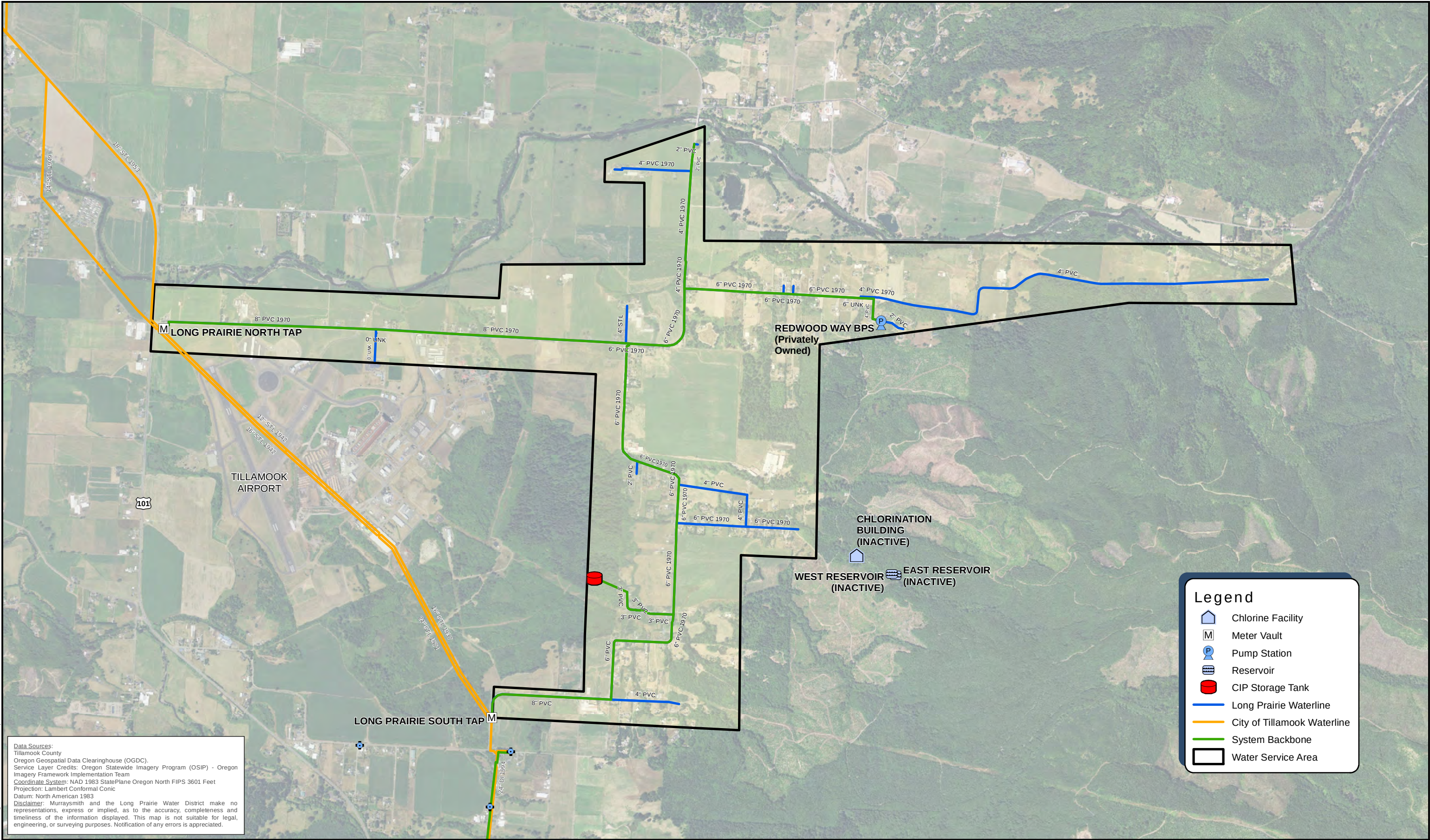
5.3.1 Seismicity and Earthquake Assessment

There are three main sources of seismicity in the District’s service area: crustal faults within the North American lithospheric plates that generate shallow crustal earthquakes, CSZ fault, and the Juan de Fuca-North American plate subduction zone interface that has the ability to generate large-magnitude megathrust earthquakes. For the purposes of this evaluation, seismic hazards to the water system are assessed under a CSZ magnitude 9.0 (M9) earthquake, in accordance with ORP guidelines, as this is regarded as the greatest threat to the region.

Paleoseismic evidence and historic tsunami studies indicate that the most recent CSZ event occurred in the year 1700, probably ruptured the full length of the CSZ, and may have reached a magnitude of 9.0. Recent seismological and geological research (Goldfinger et al., 2012) provides the best understanding of the CSZ megathrust earthquake hazard for Oregon and Washington. The magnitude of a CSZ earthquake depends on the rupture length along the subduction zone: full rupture will likely generate mega-magnitude 9.0 and above earthquake events, and partial rupture will likely cause large-magnitude 8.0 to 8.5 earthquakes.

These earthquake events are estimated to recur approximately every 500 years for the mega-magnitude full rupture events and 200 to 300 years for the large-magnitude partial rupture events. Thus, the probability of a future occurrence is high because the area is “past due” based on historic earthquakes documented in ocean sediments. The CSZ earthquake with a magnitude greater than 8.5, similar to recent events in Japan, Chile, and Indonesia, has an estimated 16 to 22 percent probability of occurring off the Oregon Coast in the next 50 years (Goldfinger and others, 2016).

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5.3.2 Subsurface Condition Assessment

A subsurface condition assessment was done from reviewed published geologic maps and available subsurface condition information in the vicinity of the water system. There is very limited geotechnical boring and site-specific geotechnical exploration data available for the Districts' service area, so well logs from the Oregon Water Resource Department's database were used. Where possible, this data was used to confirm or revise the extents of mapped geologic and hazard layers from the Oregon Department of Geology and Mineral Industries (DOGAMI) O-13-06 and to conduct soil liquefaction potential evaluation.

5.3.3 Seismic Hazard Findings

The likelihood and magnitude of four sources of seismic hazard were analyzed:

- Peak Ground Velocity (PGV)
- Liquefaction Probability
- Lateral Spreading
- Seismic Landslide

These hazards all have the potential to damage buried water mains and other water facilities.

To maintain consistency with the ORP approach, the M9.0 CSZ event was used as the basis of analyses. Seismic hazards that pose the most risk to the water system include strong ground shaking (PGV and accelerations), liquefaction, lateral spreading, and seismic-induced landslides. In hazard evaluations, the Water Districts' seismic backbone was overlaid onto the DOGAMI maps as a starting point. As discussed subsequently, the DOGAMI maps were refined and updated in areas considered appropriate based on field observations, subsurface data, and geotechnical engineering analysis.

5.3.3.1 Peak Ground Velocity

The intensity of ground shaking at a site is known as PGV. The magnitude of PGV is dependent on the magnitude and distance from the seismic source, and the ground material through which seismic waves pass. The rapid and extreme shaking during an earthquake can cause transient stress and strain in pipelines that can be damaging if the pipe material and joints are not strong enough to withstand the transient ground deformations. Damage from ground shaking occurs even when there is no permanent ground deformation (PGD).

The Peak Ground Velocity Map shows estimated PGV ranges for a CSZ M9 event in vicinity of the District. The map generally corresponds to the mapped geology areas with PGV values of up to 16 in/sec in stiffer Volcanic Soils, 17 to 21 in/sec in Marine Sediments and some Landslide Deposits, and 22- 28 in/sec in low-lying Alluvial Deposits soils and some Landslide Deposits. A majority of the District's service area has a PGV of 17 to 21 in/sec. PGV is shown in **Appendix D**.

5.3.3.2 Liquefaction Settlement

Liquefaction occurs when saturated soil experiences enough shaking that it loses its shear strength and transforms from a solid into a nearly liquid state. The results of soil liquefaction include loss of bearing capacity, loss of soil materials through sand boils or flow, flotation of buried chambers and pipes, and post-liquefaction reconsolidation (ground settlement).

Associated with soil liquefaction settlement, the liquefied soil and non-liquefied soil crust can generate horizontal movement known as lateral spreading. Lateral spreading generally occurs near and along river

banks, as well as other sloped ground. The potential for lateral spreading depends on the liquefaction potential of the soil, the seismic horizontal loading, the residual shear strength of the soil, and the area's topography.

The liquefaction and lateral spread hazard varies significantly across the service area. The potential for ground deformation is low in the higher elevation regions of the service area. Liquefiable soils are present in the rest of the project area, with the greatest probability for liquefaction occurring in the portions of the service area closest to the bay and the various sloughs, creeks, rivers and the dunes north of the bay. Ground deformations from liquefaction and lateral spread in the lowland areas are estimated to be between 12 to 14 feet. Ground deformations vary between 5 and 12 feet in the dunes in the north part of the service area, and between 3 and 5 feet at the higher elevations.

Liquefaction is a phenomenon in which ground shaking from an earthquake transforms soil from a solid state to a viscous fluid state. Soils that are susceptible to liquefaction are generally sands and non-plastic to low-plastic silts that are saturated (below groundwater level). Silts and silty soils with a plasticity index less than 7 are generally considered to be susceptible to liquefaction. The results of soil liquefaction include loss of shear strength, loss of soil materials through sand boils or flow, flotation of buried chambers/pipes, and post-liquefaction reconsolidation (settlement).

The Liquefaction Settlement Map shows the location of the water system backbone compared to seismic liquefaction settlement hazards. Within the study area, the sandy and silty soil zones within the Recent Alluvium are potentially liquefiable in a CSZ M9 event. A vertical displacement of up to 2 inches is possible across most of the District's system backbone. The only exceptions are the northern and western extremities of the District, close to the Trask River, where shallow groundwater and poorly consolidated soil conditions create additional liquefaction settlement hazard of up to 4 inches. This estimate is based on analysis of the log of well TILL_1316. The areas outside the Alluvial Deposits are unlikely to experience significant liquefaction settlement. The liquefaction settlement is shown in **Appendix D**.

5.3.3.3 Lateral Spreading

Liquefaction can result in progressive ground deformation known as lateral spreading which generally occurs along river/creek banks and within sloping ground areas. The lateral movement and loss of support of the liquefied soil breaks the overlying non-liquefied soil "crust" into blocks that progressively move downslope or toward a free face in response to the earthquake generated ground accelerations. Each cycle of loading from the earthquake incrementally pushes these blocks downslope. The potential 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. Lateral spreading can result in both vertical and horizontal components of PGD, but for discussion purposes and this screening-level of analysis, the reported estimates of PGD is considered horizontal.

The Liquefaction Lateral Spreading Map shows the location of the water system backbone compared to seismic liquefaction lateral spread hazards. Lateral spreading hazards are present and are high to very high, especially in the north of the District's backbone system (in the vicinity of Ginger Road, Long Prairie Road and Chance Road where DOGAMI's map indicates up to 10 feet of lateral spreading PGD may occur). There is high lateral spreading present along Brickyard Road – up to 5 feet of lateral spreading. The lateral spreading is shown in **Appendix D**.

5.3.3.4 Earthquake-Induced Landslides

The rapid and extreme shaking during an earthquake can cause transient stress and strain in pipelines that can be damaging if the pipe material and joints are not strong enough to withstand the shaking. Damage from ground shaking occurs even when there is no PGD. The intensity of ground shaking can be quantified with the peak ground acceleration (PGA) at a site due to an earthquake. The estimated ground shaking intensity depends on the subsurface materials. The ground shaking near the surface will be amplified by thick soil units overlying deep bedrock.

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.

The Seismic Landslide PGD Map shows the estimated levels of seismic landslide PGD in the vicinity of the District. The surrounding areas have from 0 to 40 feet of seismic landslide PGD. Within the District's service area, there are no seismic landslide hazards, which is shown in **Appendix D**.

5.3.3.5 Seismic Hazards Findings Summary

Seismic hazards are present for the District's water system.

- The critical backbone in the service area is located in a low seismic risk area.
- The north portion of the service area overlaps with mapped landslide terrain that has low potential for liquefaction and high potential for lateral spread.
- Overall, within the liquefaction and lateral spread hazard zones, PGD estimates are highest in lowland areas near bays, sloughs, and other minor water bodies.

5.4 Pipe Fragility Analysis

Pipeline fragility describes the likelihood of pipeline damage by estimating the necessary rate of repair (RR) per 1,000 feet of main following an earthquake. The estimated RR is based on the pipe material, installation, and surrounding ground conditions. While the actual location of pipeline damage cannot be predicted, pipeline fragility analysis provides a measure of the expected severity of damage to the water system backbone overall and may identify areas of higher relative risk where mitigation efforts should be focused first.

5.4.1 Analysis Method

This analysis focused on estimating RR for the water system backbone mains which were identified with District utility staff input. Due to the District's small size, the backbone mains are categorized as high-priority, Tier 1 mains. Tier 1 mains serve critical water system facilities.

Backbone pipeline fragility was evaluated using pipe data provided by the District, seismic geohazards described earlier in this chapter, and the Seismic Fragility Formulations for Water Systems guideline developed by the American Lifelines Alliance (ALA). The ALA is a partnership between the Federal Emergency Management Agency (FEMA) and the American Society of Civil Engineers (ASCE).

The ALA guideline damage algorithms used to calculate RR per 1,000 linear feet (LF) of pipe are based on empirical evidence catalogued after major earthquakes such as the 1989 Loma Prieta Earthquake in the

San Francisco Bay Area and the 1995 Great Hanshin earthquake in Hyogoken-Nanbu (Kobe), Japan. The guideline recommends using two pipe vulnerability functions, each of which addresses a different seismic hazard:

1. $RR = K1 * 0.00187 * PGV$

This function estimates a RR per 1,000 LF of pipe due to seismic wave propagation or ground shaking. The magnitude of ground shaking is represented by PGV.

2. $RR = K2 * 1.06 * PDG^{0.319}$

This function estimates a RR per 1,000 LF of pipe due to PGD which can be the result of landslide or lateral spreading due to soil liquefaction.

In the pipe vulnerability equations above, K1 and K2 are empirical fragility constants which are used to scale the RR for different pipe diameters, pipe materials, and joint types. K1 generally represents the strength and flexibility of the pipe material to withstand ground shaking. K2 generally represents the strength and flexibility of the pipe joint to resist separation during ground deformation. A larger K value correlates with higher material or joint vulnerability.

5.4.2 Pipe Installation and Materials (K Value Selection)

The ALA seismic fragility guideline provides a range of K values which scale estimated RR for different pipe materials and joint types. K values are estimated based on empirical damage evidence from previous earthquakes. Thus, the influence of some variables, such as pipe diameter, are inconclusive based on the currently available historical water main damage data. Selected K values for the District's water system backbone are summarized in **Table 5-2** based on the ALA guideline and the District's current water system data and mapping.

Generally, K1 represents the pipe material. The RR for some material types are also influenced by pipe diameter and soil corrosivity. This may be attributed to higher quality control during construction, fewer bends and lateral connections than smaller mains or lower soil loads as a function of pipe strength for the same depth of cover. The District's water system mapping data includes water main diameters for most pipes and pipe materials.

Generally, K2 represents the pipe joint and is selected based on joint type and pipe material. Joint type information was not available for the District's water system mains. Joint type is assumed based on pipe material and common construction methods typical during the period of installation.

Higher K values reflect pipe that has a great risk of breaks or join failures during a seismic event.

Table 5-2 | Pipe Fragility K Values

Material	Assumed Joint Type	Installation Date	Diameter	K1	K2
Asbestos Cement	Cement	All	All	1.0	1.0
Concrete	Cement	All	All	1.0	1.0
Ductile Iron	Rubber Gasket	All	All	0.5	0.5
Galvanized Iron/Steel	Rubber Gasket	All	Large	0.7	0.7
High Density Polyethylene	Welded or fused	All	All	0.15	0.15
Polyvinyl Chloride	Rubber Gasket	All	Small	0.5	0.8

Material	Assumed Joint Type	Installation Date	Diameter	K1	K2
Unknown	Unknown	All	All	1.0	1.0

Notes:

Small = 4- to 12-inch diameter

Large = 16-inch diameter and greater

5.4.3 Pipe Fragility Findings

Pipe fragility RR per 1,000 LF of pipe are calculated for the following seismic hazards.

- strong ground shaking related to PGV
- settlement due to liquefaction or landslide relative to PGD

Relative potential hazard levels for each of these four hazards are shown as negligible, low, medium, and high. Specific ranges for PGV and PGD values used in the pipe fragility RR calculations in **Table 5-3**.

Table 5-3 | Pipe Fragility Seismic Hazard Values

Seismic Hazard	Variable (units)	Low		Medium		High	
		Range	Pipe Fragility Value	Range	Pipe Fragility Value	Range	Pipe Fragility Value
Ground Shaking ¹	PGV (inches/second)	0 to 16	8	17 to 21	19	22 to 28	25
Liquefaction Settlement	PGD _{LIQ} (inches)	Up to 1	1	Up to 2	2	Up to 4	4
Landslide	PGD _{LAND} (inches)	Up to 60	60	Up to 120	120	Up to 480	480
Lateral Spreading	PGD _{LAT} (inches)	Up to 60	60	Up to 120	120	NA	NA

Notes:

Ground shaking provided as integer values rather than ranges. Pipe fragility values for ground shaking used in calculations are those integer values.

Buried pipeline damage caused by ground failure (liquefaction and lateral spreading) will be significantly more severe than damage caused by ground shaking. Empirical data used to develop the ALA's pipe fragility analysis method reveals RR that are two orders of magnitude higher for damage caused by ground failure. The HAZUS methodology used by FEMA to assess potential earthquake damage to buried pipelines also supports this conclusion. For pipeline repairs caused by ground failure, HAZUS assigns 80 percent of the repairs as "breaks" and 20 percent as "leaks." For ground shaking, 20 percent are considered breaks and 80 percent leaks.

Table 5-4 summarizes the total estimated water system backbone repairs due to both ground shaking and ground failure. Total repairs are split into potential breaks and leaks based on the 80 percent to 20 percent ratios described in the previous paragraph.

In the District's service area, lateral spreading presents the largest risk to backbone mains. For context, this analysis indicates that the average RR for the backbone piping is 2.6 repairs per 1,000 feet of pipe. If the same RR is applied to the distribution system excluding backbone, approximately 3 miles of pipe, the District should expect that there may be more than 40 required repairs following a seismic event.

Table 5-4 | Estimated Backbone Repairs

Length (LF)	Material	Ground Shaking	Ground Failure	Total Est. Leaks	Total Est. Breaks	Total Repairs	Rate Of Repairs
39,250	PVC	<1	106	17	90	106	2.7
4,840	UNK	<1	8	1	7	8	1.7
44,090		<1	114	18	97	114	2.6

5.5 Design Standards for Seismic Resilience

Oregon Structural Specialty and Mechanical Specialty Codes will dictate that all new water facility construction meet current earthquake standards which are based on an M9 event. Suggestions for District design and construction standards are included in this section.

5.5.1 Pipelines

Based on the seismic vulnerability of the District's water system, restrained joint ductile iron pipe provides the best balance of cost, performance, and life cycle. Fully restrained ductile iron pipe reduces the risk of separation at standard push-on joints and allows limited deflection from ground shaking and ground deformation.

For pipes smaller than 8-inch diameter, the District should consider PVC with self-restraining gaskets as a preferred pipe material. The selection of piping material, lining and coating system, and other design parameters should be made on a case-by-case basis with adequate consideration of specific alignment seismic hazards, hydraulics, performance and life-cycle expectations, soil considerations, etc.

5.5.2 Reservoirs

While the District does not have a reservoir, it is assumed that future reservoir structures will be designed to meet earthquake standards consistent with current Structural and Mechanical Specialty codes. There are two key design considerations associated with reservoir configuration and connections to the distribution system:

- Pipe to reservoir connections
- Automated isolation valves

5.5.2.1 Pipe to Reservoir Connections

At each distribution or transmission piping connection to the reservoir, significant stress can be placed on the pipe as a result of the difference in response to ground motion and deformation by the pipe and reservoir foundation. To minimize the risk of pipe breakage at these locations, it is recommended that a flexible expansion joint be installed at these interfaces. Flexible expansion joints must be capable of allowing axial expansion/contraction and differential movement that results in a vertical or horizontal offset.

5.5.2.2 Automated Isolation Valves

Automated isolation valving with seismic valve actuators should be considered at all reservoir piping connections. There are several considerations to be weighed in determining whether to use an automatic shut-off valve at each reservoir, as summarized in **Table 5-5**.

Table 5-5 | Automatic Shut-off Valve Considerations at Reservoirs

If a seismic valve actuator is used for automatic shut-off at reservoirs:	YES	NO
Water Available for Fire Suppression Immediately After Event?		✓
Reservoir Water Volume Preserved for Use During Recovery?	✓	
Requires Maintenance of Batteries for Valve Actuation?	✓	
Vulnerable to Accidental Closure due to False Alarm?	✓	

The District should consider the specific performance objectives of each reservoir associated with a seismic event and the anticipated response and recovery period to determine whether the installation of seismically actuated valves is warranted. For example, if two reservoirs serve a pressure zone, one may be equipped with seismic valves to preserve the water volume for future use during recovery while the other will remain connected to the system to provide fire suppression and emergency water with the risk that this volume may be lost through main breaks.

5.5.3 Pump Stations

Similar to reservoir structures, pipe connections at the pump station building present specific vulnerability as a result of differential movement and settlement. To minimize the risk of pipe breakage, it is recommended that a flexible expansion joint be installed at this interface. Flexible expansion joints must be capable of allowing axial expansion/contraction and differential movement that results in a vertical or horizontal offset.

5.6 Next Steps

While there is a need to focus on increasing the resilience of the District’s piping network, beginning with the backbone and eventually extending to the entire distribution system, the District’s current priority is to increase system resiliency through the development of a new long-term supply. As such, it is anticipated the District will assess this target recovery goal framework in its next WSMP Update, with a goal of identifying seismic resilience projects within the next 20-year period.

Seismic resilience projects should be reassessed in the next WSMP update. While seismic resilience CIP projects were not explicitly developed in this WSMP, opportunities to correlate pipe segments with the largest calculated RR were prioritized with the CIP in **Chapter 6**. It is recommended that the District incorporate seismic resilience considerations into the design and prioritization of future improvements.

5.7 Summary

In general, the majority of the District’s backbone water systems are in zones of moderate to high seismic hazard. Main seismic hazards are the moderate liquefaction settlement (about 2 to 4 inches) along the backbone pipelines and potentially high lateral spreading deformations in the north portion of the backbone system. Additional geotechnical and structural engineering evaluations are recommended to study this hazard and develop mitigation strategies if needed.

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Capital Improvement Program

6.1 Introduction

This chapter describes the recommended water system improvements for the District based on the analysis and findings presented in **Chapter 4** and **Chapter 5**. The remainder of the improvements needed were identified through discussions with the District; these include supply, storage reservoir, and water main projects. A summary of all improvement projects and estimated project costs is presented in **Table 6-1**.

6.1.1 Project Descriptions

Projects are recommended to maintain and improve the existing level of redundancy, flexibility, supply, and delivery of water in the system. The following improvements are recommended to address hydraulic deficiencies:

- New and upgraded water transmission or distribution pipelines
- New storage facility
- Planning projects
- Projects required should the district continue to explore alternative supply options. These projects are considered separate and additive to the District's CIP.

It is recommended that the District review this WSMP and associated CIP every five years to ensure projects meet current system requirements. CIP projects are listed later in this chapter.

6.1.2 Project Cost Estimates

An estimated project cost has been developed for each recommended improvement consistent with previously identified projects from the District's current CIP and current preliminary design work, as applicable. Cost estimates represent opinions of cost only, acknowledging that final costs of individual projects will vary depending on actual labor and material costs, market conditions for construction, regulatory factors, final project scope, project schedule, and other factors. The Association for the Advancement of Cost Engineering International (AACE) classifies cost estimates depending on project definition, end usage, and other factors. The cost estimates presented here are considered Class 5 with an end use being a study or feasibility evaluation and an expected accuracy range of -30 percent to +50 percent. As the project is better defined, the accuracy level of the estimates can be narrowed.

Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News-Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. For purposes of future cost estimate updating, the current 20-Board Average ENR CCI is 13,485.67 (September 2023).

Recommended pipeline diameters will vary based on final design requirements. Total project costs will depend on actual labor and material costs, site conditions, competitive market conditions, regulatory requirements, project schedule, and other factors. Therefore, project feasibility and risks should be

carefully reviewed prior to making specific financial decisions or establishing project budgets to help ensure proper project evaluation and adequate funding.

6.1.3 Timeframes

Table 6-1 provides a timeframe for project sequencing by showing prioritized projects for 5-year, 5 to 10-year and 10 to 40-year timeframes defined as follows:

- 5-year timeframe - recommended completion through 2028
- 6- to 10-year timeframe - recommended completion between 2029 and 2033
- 11- to 20-year timeframe - recommended completion between 2034 and 2044

6.2 Distribution Mains

In addition to meeting current and future demands, the recommended distribution main projects will:

- Enhance the efficiency, reliability, and resilience of municipal water supply networks.
- Distribute water to meet customer demands in the service area.
- Distribute water to meet fire flow demand in the service area.

Fire flow deficiencies were identified in **Chapter 4**, necessitating distribution main improvement projects. The CIP analysis reviewed two different scenarios for addressing these deficiencies:

- Distribution mains with the inclusion of proposed storage reservoir
- Distribution mains without a storage reservoir

It was found that the inclusion of a storage reservoir was the most cost-effective option to resolve system deficiencies. It is recommended to add a storage reservoir as it significantly reduces the required length of distribution mains to be replaced.

6.2.1 Prioritization of Proposed Mains

The District's recommended CIP main project includes upsizing the existing distribution mains to 8 or 12-inch PVC. PVC is recommended for its high resistance to corrosion and is a cost-effective pipe material.

The piping improvements are scheduled based on timeframe, as discussed earlier in this chapter. Immediate improvements resolve the deficiencies along the system backbone. Project D-1 specifically upsizes the existing distribution mains on Long Prairie Road and Brickyard Road.

Project D-2 encompasses the remaining improvements along the system backbone. Consideration was given to mains in the northeast of the District's service area. These would allow the District the option to connect to the FWD system in the future. The timing of this project allows the District additional time to make their decision on wholesale or alternate water purchase.

Recommended CIP projects for the District's water system improvements are shown in **Table 6-1**.

6.3 Storage Reservoirs

In addition to meeting current and future demands, the recommended storage reservoir projects will:

- Improve distribution system resilience by replacing aging infrastructure with new facilities built to modern seismic standards; and

- Distribute storage to better serve customers in the service area.

6.3.1 Proposed Reservoir

A storage reservoir project is recommended to be implemented as an effective method to add storage capacity to the District. The recommended storage reservoir project was included in the CIP. A storage facility is recommended as a near term improvement to fix system deficiencies. A 75,000 gallon capacity would be sufficient to meet demands, should the District continue with the wholesale supply scenario, assuming no wholesale contract.

Should the District pursue additional supply alternatives or potentially have limited supply capacity per a new wholesale contract, it is anticipated that a larger storage reservoir would be needed to meet the required storage capacity of the system. This is further discussed in **Section 6.5**.

6.4 Planning Studies

6.4.1 Water System Master Plan Update

An updated WSMP is required by the State of Oregon for a 20-year planning period. However, due to the District's small size it is not required. It is recommended that the District continue to update this WSMP every 10 years. As the population grows, it is prudent for the District to periodically evaluate capital investment, prioritize needs for the water system, and document its long-term water service strategy in the WSMP. An update has been included in the CIP for the 11-20-year timeframe and the future 2044 timeframe.

6.4.2 Financial Evaluation and Plan/Water Rate Analysis

The District may fund the water system capital maintenance and improvement programs from a variety of sources. It is anticipated that changes in rates will be required to keep pace with inflation and to fund the proposed improvements. A financial plan, including a water rate analysis, should be performed with the completion of this WSMP to determine specific funding needs and potential funding sources associated with the adopted CIP.

A financial plan and study in the 10-year timeframe is recommended, with an update to the study every ten years. A budget-level cost for a financial plan and rate study is \$20,000. It is also recommended the District include a budget level cost of a Rate Study of \$20,000 every 10 years.

6.5 Regional Supply Alternative Projects

Presented alongside the CIP in **Table 6-1** are the additional costs the District should expect to incur if it continues to pursue alternative supply options.

The costs of these alternative supply option projects are assumed to be additional to the District's CIP.

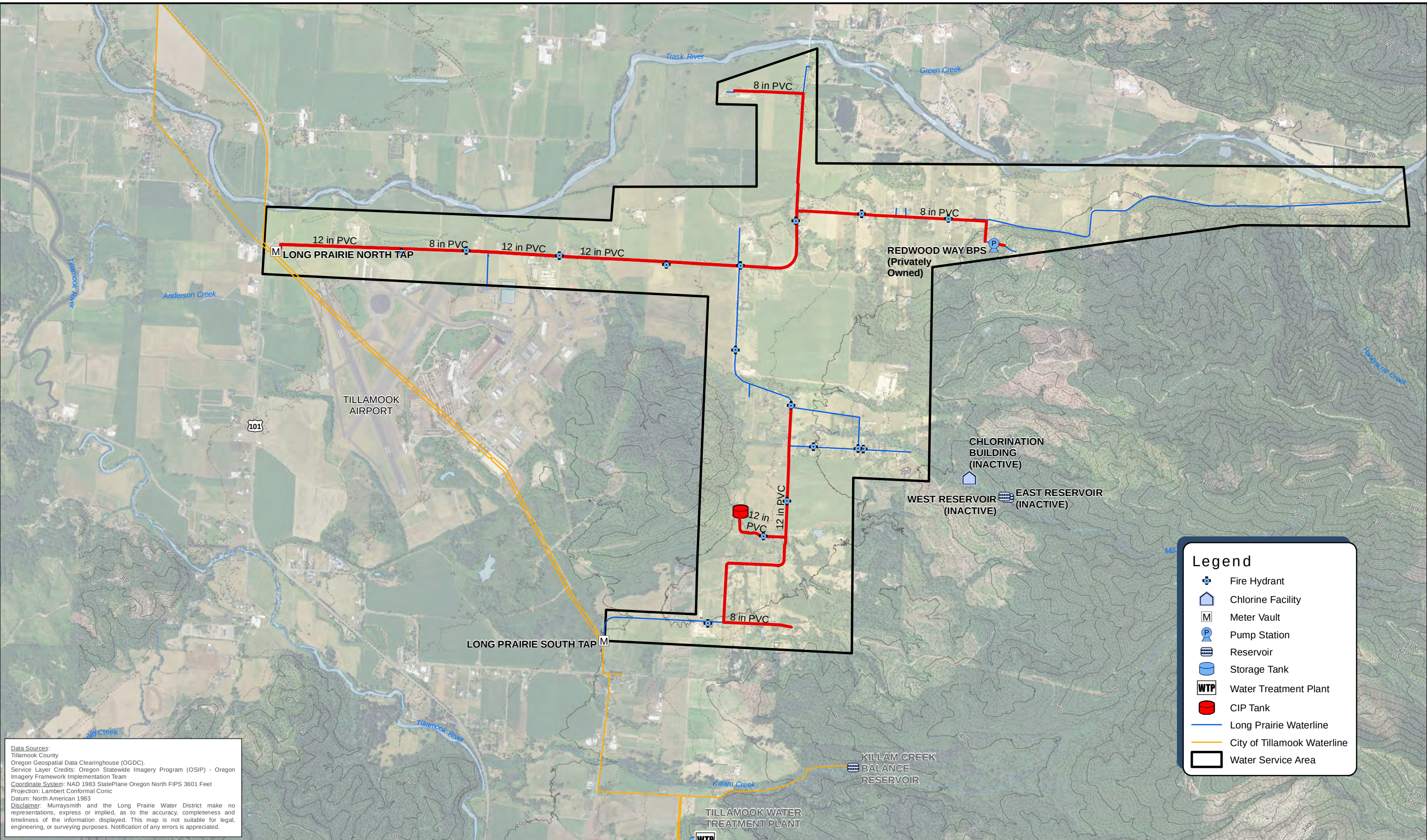
6.5.1 Regional Supply Planning Study

If the District moves forward with the alternate source supply, an additional planning study is anticipated.

Table 6-1| District Recommended CIP Improvements

Category	Project No.	Project Description	Project Location	CIP Schedule and Project Cost Summary (2024 Dollars)			
				Immediate	Near Term	Buildout	Estimated Project Cost
				2024 - 2028	2029 - 2033	2034 - 2043	
Distribution Main	D-1	3,180 LF of 12-inch PVC Pipe	Piping along System Backbone (Brickyard Rd / Long Prairie Rd)	\$1,700,000			\$1,700,000
	D-2	12,790 LF of 8-inch PVC Pipe	Remaining 8-inch improvements along System Backbone			\$4,950,000	\$4,950,000
	Distribution Main Subtotal			\$1,700,000		\$4,950,000	\$6,650,000
Storage Facility	R-1	75,000 gal Storage Reservoir and associated 12-inch PVC piping	Magnolia Dr & Brickyard Rd		\$1,250,000		\$1,250,000
	Storage Facility Subtotal				\$1,250,000		\$1,250,000
Planning Studies	P-1	Water System Master Plan Update			\$50,000	\$50,000	\$100,000
	P-2	Financial Evaluation and Plan / Water Rate Analysis		\$20,000		\$20,000	\$40,000
	Planning Studies Subtotal			\$20,000	\$50,000	\$70,000	\$140,000
CIP Total				\$1,720,000	\$1,300,000	\$5,020,000	\$8,040,000
Alternate Supply Source/Wholesale Supply Contract							
Feasibility	A-1	Feasibility study on the alternate supply source cost		\$20,000			\$20,000
Fairview Water District Connection	A-2	Initial capital cost to connect to Fairview Water (Shared Partner Agency Cost)			\$10,500,000		\$10,500,000
Storage Facility	A-3	Additional cost to Project R-1 for 250,000 gallon Storage Reservoir	Magnolia Dr & Brickyard Rd		\$800,000		\$800,000

\\consor.local\ms\Portland\PD\Projects\21\3176 - Long Prairie WD - Water System Master Plan\GIS\MXD\21-3176-300-OR-LPWD CIP MAP_2.mxd 7/2/2024 12:57:51 PM Katelyn McNulty



6.5.2 Fairview Water District Connection

Project A-2 entails the cost to connect to FWD, which is shown as cumulative and a shared cost between the District, PVWC, SPWA, and the Port as detailed in **Appendix B**.

6.5.3 250,000 Gallon Storage Reservoir

Should the District continue to pursue an alternative water supply option or have potentially limited supply capacity per a new wholesale contract, it is anticipated that a larger 250,000 gallon storage reservoir would be required to meet the required storage capacity of the system. The additional cost to upsize the 75,000 gallon reservoir to a 250,000 gallon storage reservoir is included as Project A-3.

6.6 Funding Sources

A preliminary analysis was performed to help determine the costs to fund the CIP with customer revenue alone. The annualized cost of the CIP is \$402,000 per year. In order to fund it with water rates alone, the District would need a required revenue of \$1,405 per metered connection.

Customer Revenue likely may not be sufficient to fully fund the CIP. As such, the District may consider raising rates or other potential opportunities. A variety of sources may contribute to the funding. In general, these sources can be summarized as: 1) governmental grant and loan programs; 2) publicly issued debt; and 3) cash resources and revenues. These sources are described below.

Funding programs should be considered with the District Financial Plan and Rate Study as described in **Section 6.4.2**.

6.6.1 Government Loan and Grant Programs

6.6.1.1 Oregon State Safe Drinking Water Financing Program

Annual grants from the EPA and matching state resources support the Safe Drinking Water Fund. The program is managed jointly by the OHA DWS and Business Oregon's Infrastructure Finance Authority (IFA). The Safe Drinking Water Fund program provides low-cost financing for construction and/or improvements of public and private water systems. This is accomplished through two independent programs: the Safe Drinking Water Revolving Loan Fund (SDWRLF) for collection, treatment, distribution, and related infrastructure, and the Drinking Water Protection Loan Fund (DWPLF) for sources of drinking water improvements prior to the water system intake.

The SDWRLF lends up to \$6 million per project, with a possibility of subsidized interest rates and principal forgiveness for a Disadvantaged Community. The standard loan term is 20 years or the useful life of project assets, whichever is less, with interest rates at 80 percent of the current state/local bond rate. The maximum award for the DWPLF is \$100,000 per project.

6.6.1.2 Special Public Works Fund

The Special Public Works Fund program provides funding for the infrastructure that supports job creation in Oregon. Loans and grants are made to eligible public entities for the purpose of studying, designing, and building public infrastructure that leads to job creation or retention.

Water systems are listed among the eligible infrastructure projects to receive funding. The Special Public Works Fund is comprehensive in terms of the types of project costs that can be financed. As well as actual

construction, eligible project costs can include those incurred in conducting feasibility and other preliminary studies and for the design and construction engineering.

The Special Public Works Fund is primarily a loan program. Grants can be awarded, up to the program limits, based on job creation or on a financial analysis of the applicant's capacity for carrying debt financing. The total loan amount per project cannot exceed \$10 million. The IFA is able to offer discounted interest rates that typically reflect low market rates for very good quality creditors. In addition, the IFA absorbs the associated costs of debt issuance thereby saving applicants even more on the overall cost of borrowing. Loans are generally made for 20-year terms but can be stretched to 25 years under special circumstances.

6.6.1.3 Water/Wastewater Fund

The Water/Wastewater Fund was created by the Oregon State Legislature in 1993. It was initially capitalized with lottery funds appropriated each biennium and with the sale of state revenue bonds since 1999. The purpose of the program is to provide financing for the design and construction of public infrastructure needed to ensure compliance with the Safe Drinking Water Act (SDWA) or the Clean Water Act.

Eligible activities include construction improvement costs for the expansion of drinking water, wastewater, or stormwater systems. To be eligible, a system must have received, or be likely to soon receive, a Notice of Non-Compliance by the appropriate regulatory agency, associated with the SDWA or the Clean Water Act. Projects also must meet other state or federal water quality statutes and standards. Funding criteria include projects that are necessary to ensure that municipal water and wastewater systems comply with the SDWA or the Clean Water Act.

In addition, other limitations apply, including:

- The project must be consistent with the acknowledged local comprehensive plan.
- The municipality will require the installation of meters on all new service connections to any distribution lines that may be included in the project.
- The funding recipient shall certify that a registered professional engineer will be responsible for the design and construction of the project.

The Water/Wastewater Fund provides both loans and grants, but it is primarily a loan program. The loan/grant amounts are determined by a financial analysis of the applicant's ability to afford a loan including the following criteria: debt capacity, repayment sources, and other factors.

The Water/Wastewater Fund financing program's guidelines, project administration, loan terms, and interest rates are similar to the Special Public Works Fund program. The maximum loan term is 25 years or the useful life of the infrastructure financed, whichever is less. The maximum loan amount is \$10 million per project through a combination of direct and/or bond funded loans. Loans are generally repaid with utility revenues or voter-approved bond issuance. A limited tax general obligation pledge may also be required. Certain entities may seek project funding within this program through the sale of state revenue bonds, although this can be a significant undertaking.

6.6.1.4 Water Infrastructure Finance and Innovation Act

The Water Infrastructure Finance and Innovation Act of 2014 (WIFIA) established the WIFIA program, a federal credit program administered by the EPA. The program can provide financing for a broad range of eligible water and wastewater projects or combinations of projects. Up to 49 percent of eligible project

costs can be financed through WIFIA, which can be combined with other local funding sources such as revenue bonds.

The WIFIA program offers the potential for substantial savings to municipalities on borrowing costs through a combination of lower interest rates, deferred payments, flexible payment structuring, and longer loan terms. Lower borrowing costs can reduce the level of rate increases needed to fund capital improvements.

The savings on borrowing costs begin with lower interest rates. The interest rate on WIFIA loans is fixed and is tied by statute to the 30-year Treasury rate as of closing, which is typically well below the market rate on revenue bond financing. Unlike with revenue bonds, funds from WIFIA loans are disbursed over time on a reimbursement basis as expenses are incurred. Interest accrues on WIFIA loan funds only as they are disbursed.

The WIFIA loans are set up for 30-year repayment periods, with the loan term beginning after substantial completion of construction. Payments can be deferred throughout the construction period and for up to 5 years after substantial completion. The result is a potential loan term of up to 35 years after substantial completion. The WIFIA program also allows for flexible payment structuring throughout the loan term to help the borrower manage the impact of loan payments on rate increase requirements.

Projects are selected to apply for WIFIA financing through a competitive annual process administered by the EPA. Appropriate related federal provisions apply under the loans, such as National Environmental Policy Act, Davis-Bacon, and American Iron and Steel.

6.6.2 Water Fund Cash Resources and Revenues

The District's financial resources available for capital funding include rates and cash reserves. Rates are the backbone of a municipal water system's revenue and are typically established to provide funds to capitalize improvement projects or to repay debt-financed improvement projects.

6.7 Summary

This chapter detailed recommendations for improvements to the District's storage reservoirs and distribution system. The total estimated project cost of these improvements is approximately \$8 million for the 20-year planning horizon. Additional project costs would be required if the District pursues an alternative supply source. Financial planning and analysis are recommended to evaluate overall water system financial needs and to identify funding options and alternatives.



Port of Tillamook Bay

Feasibility Evaluation for Development of a Potable Groundwater Supply

June 13, 2023

Prepared by:



GSI Water Solutions, Inc.

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Abbreviations and Acronyms

AACE	Association for the Advancement of Cost Engineering
AAGR	Average Annual Growth Rate
ADD	Average Day Demand
bgs	Below Ground Surface
cfs	Cubic Feet Per Second
CFU/0.1 L	Colony Forming Units per 0.1 Liters
DEQ	Department of Environmental Quality
DO	Dissolved Oxygen
ECSI	Environmental Cleanup Site Information
EPA	Environmental Protection Agency
GSI	GSI Water Solutions, Inc.
gpm	Gallons Per Minutes
GWUDI	Groundwater Under the Direct Influence
LPWD	Long Prairie Water District
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level
MDD	Maximum Day Demand
mg/L	Milligrams per Liter
µg/L	Micrograms per Liter
mV	Millivolts
OHA	Oregon Health Authority
ORP	Oxidation Reduction Potential
OWRD	Oregon Water Resources Department
PCB	Polychlorinated Biphenyl
POTB	Port of Tillamook Bay
PVWD	Pleasant Valley Water District
Qal	Quaternary Alluvium
SMCL	Secondary Maximum Contaminant Level
SPWA	South Prairie Water Association
SVOC	Semi-Volatile Organic Compound
Tal	Alsea Formation
TVA	Tillamook Valley Alluvial
uS/cm ²	Microsiemens Per Centimeter Squared
VOC	Volatile Organic Compound
WMCP	Water Management and Conservation Plan
WSMP	Water System Master Plan
YSI	Yellow Springs Instrument

1 Introduction

The Port of Tillamook Bay (the Port) is located two miles south of the City of Tillamook in Tillamook County, Oregon. The Port was built around former Naval Air Station Tillamook, the home of a blimp squadron from 1942 to 1948 during World War II. Currently, the Port comprises a 1,600 acre inland facility with a 200 acre industrial park, non-commercial Tillamook Municipal Airport, and the Tillamook Air Museum (Figure 1-1). The Port leases property to about 60 industrial and commercial businesses including shipping companies, lumber companies, operates an RV park, and a preschool facility (GSI, 2019).

Currently, the Port supplies potable water to approximately 65 customers using water purchased at industrial rates from the City of Tillamook (OHA, 2023a; GSI, 2019). Three nearby water systems also purchase water from the City of Tillamook, including:

- **Pleasant Valley Water District (PVWD).** PVWD serves a variety of customers, including farms, a bottling plant, and RV parks (GSI, 2023a). PVWD provides water to 268 customers (OHA, 2023b).
- **Long Prairie Water District (LPWD).** LPWD serves a farm, dairies, a jail, and a fish hatchery (GSI, 2023b). LPWD provides water to 274 customers (OHA, 2023c).
- **South Prairie Water Association (SPWA).** SPWA provides water to 159 customers (OHA, 2023d).

PVWD, LPWD, and SPWA are called “the partners” in this report. The Port holds water rights to appropriate groundwater and is evaluating the feasibility of developing a potable groundwater supply. Two groundwater development scenarios are under consideration: (1) the Port-Only Scenario, in which a potable groundwater supply is developed to serve Port customers only and (2) the Partnership Scenario, in which a potable groundwater supply is developed to serve Port customers as well as customers of the PVWD, LPWD, and SPWA. Both scenarios would develop the water supply infrastructure (wells, treatment systems, reservoirs, etc.) on Port property.

This report summarizes and evaluation of the feasibility of developing a potable groundwater supply at the Port from the perspectives of water rights and water demand (i.e., whether the Port holds sufficient water rights to meet forecasted water demand), aquifer productivity (i.e., whether the aquifer produces sufficient quantities of groundwater to meet forecasted water demand), and groundwater quality (i.e., whether groundwater quality meets, or can be treated to meet, potable drinking water standards). Based on the results of the feasibility evaluation, a wellfield construction strategy is developed to build out the water system in a way that mitigates the risks of insufficiently productive aquifers and groundwater quality impairment, and cost estimates are developed for wellfield construction and operation and maintenance.

The remainder of this report is organized as follows:

- **Section 2.** Water Demand Forecasts and Water Rights Review.
- **Section 3.** Aquifer Evaluation.
- **Section 4.** Conceptual Well Design and Wellfield Layout.
- **Section 5.** Wellfield Construction Sequence and Cost Estimate.
- **Section 6.** Conclusions.

2 Water Demand Forecasts and Water Rights Review

This section provides an overview of water demand associated with a potable groundwater supply at the Port and the availability of water rights to meet the demand. This section is organized as follows:

- Section 2.1: Water Demand Forecasts
- Section 2.2: Port of Tillamook Bay Water Rights
- Section 2.3: Demand and Supply Comparison

2.1 Water Demand Forecasts

As part of assessing the feasibility of developing a potable groundwater supply at the Port, GSI Water Solutions, Inc. (GSI) developed demand forecasts for the Port and the partners through 2042. These demand forecasts, in conjunction with the other analyses presented in this report, will help the Port define the design and costs associated with a water system constructed at the Port. The demand forecasts were conducted by GSI during development of: 1) the Port's 2019 Water Management and Conservation Plan (WMCP), 2) for the water master plans for Pleasant Valley and Long Prairie, and 3) as part of this feasibility study. A summary of the methodologies and results of the forecasts is presented in the following sections.

2.1.1 Port of Tillamook Bay Demand

The Port published its long-term water demands in its 2019 WMCP for the years 2028, 2038, and 2050 (GSI, 2019). In the WMCP, maximum day demands (MDD) were forecasted by estimating a rate of industrial development measured in acres per year and water use per acre based on average historical maximum day consumption volumes. The results of the forecast presented in the Port's WMCP are summarized in Table 2-1.

Table 2-1. POTB Projected Average Day Demand and Maximum Day Demand, 2028–2050

Year	Maximum Day Demand (cfs)
Max Historical	0.36
2028	0.60
2038	0.85
2050	1.13

Notes

cfs = cubic feet per second

POTB = Port of Tillamook Bay

GSI interpolated the demand forecast results of the WMCP to obtain MDD projections through 2042, the planning period of this feasibility study, by using the average annual growth rates (AAGRs)—an exponential growth rate formula—of MDD between time periods provided in the WMCP. As shown in Table 2-2, the AAGR between 2017 to 2022 is 6.1 percent, 2023 to 2032 is 4.5 percent, and 2033 to 2042 is 3.9 percent. Based on these values, MDD is projected to reach 0.94 cubic feet per second (cfs) by 2042.

Table 2-2. POTB Projected Maximum Day Demand, 2022–2042

Year	Maximum Day Demand		AAGR ¹
	cfs	mgd	
2017- 2022	0.47	0.30	6.1%
2023 - 2032	0.70	0.45	4.5%
2033 - 2042	0.94	0.61	3.9%

Notes
¹ From the base year 2017.

AAGR = Average Annual Growth Rate

cfs = cubic feet per second

POTB = Port of Tillamook Bay

2.1.2 Pleasant Valley Water District Demand

Pleasant Valley Water District projected demand until 2042 in a memorandum drafted as part of the District's Water System Master Plan (WSMP), which is currently under development (GSI, 2023a). In the memorandum, historical annual water demand from the year 2018 was grown in proportion to the forecasted population growth rate of Tillamook County¹ using the AAGR formula. The memorandum assumed that monthly water demand for typical water users would grow at the same rate as the County's forecasted population, while water use by PVWD's four largest customers would remain steady throughout the planning period.

Table 2-3 presents projected MDD for Pleasant Valley Water District from 2018-2042. MDD is projected to increase to 0.160 cfs from actual demand of 0.152 cfs in 2018. The AAGRs presented in Table 2-3 are the changes in growth of MDD from the base year 2018. These AAGRs are less than the AAGRs observed in Portland State University's (PSU's) County population forecast due to the influence of holding demand of the four largest customers steady over the planning period.

Table 2-3. PVWD Projected Maximum Day Demand, 2022–2042

Year	Maximum Day Demand		AAGR ¹
	mgd	cfs	
2018	0.098	0.152	—
2022	0.099	0.153	0.20%
2032	0.101	0.156	0.21%
2042	0.103	0.160	0.21%

Notes
¹ From base year 2018.

AAGR = Average Annual Growth Rate

cfs = cubic feet per second

mgd = million gallons per day

PVWD = Pleasant Valley Water District

¹ Portland State University. Population Research Center; Chun, Nicholas; Rancik, Kevin; Runge, Paul; Cunningham, Mac; Loftus, Deborah; and Rynerson, Charles; "[Coordinated Population Forecast for Tillamook County, its Urban Growth Boundaries \(UGB\), and Area Outside UGBs 2020-2070](#)" (Forthcoming publication).

2.1.3 Long Prairie Water District Demand

Long Prairie Water District projected demand until 2042 in a memorandum drafted as part of the development of the District's WSMP, which is currently under development (GSI, 2023b). LPWD's demand forecast distinguished between typical and large water users, and also projected potential demand for the development of an 80-acre tract of industrial-zoned property within LPWD's service area.

For typical water users (less than 30,000 gallons per month), LPWD's demand projections were estimated by applying forecasted population growth rates in Tillamook County to historical 2018 demand using AAGR. Water use by large water users (greater than 30,000 gallons per month) was assumed to be constant throughout the planning period.

Future demand for a partially-developed 80-acre tract of land that will be served by LPWD was added to the demand forecast. The undeveloped portion of the tract that likely will be developed by 2042 amounts to 37.9 acres. The methodology used to calculate demand for this portion of the tract was similar to that used in the demand forecast for the Port by calculating per acre water use factors based on existing water users at the Port. Demand projections for the tract are included in the demand projections presented in Table 2-4 below.

The results of these modifications to LPWD's future demand (holding existing large users demand steady into the future and the addition of new and large customers) show significant increase after 2022, reaching 0.341 cfs by 2042.

Table 2-4. LPWD Projected Maximum Day Demand, 2022–2042

Year	MDD (mgd)	MDD (cfs)	AAGR
2018	0.093	0.145	—
2022	0.094	0.146	0.19%
2032	0.125	0.243	3.78%
2042	0.156	0.341	3.63%

Notes

AAGR = Average Annual Growth Rate

cfs = cubic feet per second

LPWD = Long Prairie Water District

MDD = Maximum Day Demand

mgd = million gallons per day

2.1.4 South Prairie Water Association Demand

Future demand for South Prairie Water Association was held constant over the planning period at the request of SPWA to account for: 1) a lack of developable land within the service area of SPWA, 2) no opportunities to increase land density within SPWA's service area as a result of the County's land use zoning laws, and 3) SPWA's service area is not anticipated to change.

SPWA does not keep daily records of instantaneous use, so the Port estimated SPWA's demand for 2022 by averaging the annual demand per customer connection from PVWD and LPWD for the year 2018 and multiplying this number by the number of SPWA customer connections in the year 2022 as noted on the

Oregon Health Authority's website for this water provider.^{2,3} Average Day Demand (ADD) for the year 2022 was estimated by dividing estimated annual demand by 365 days. MDD for 2022 was estimated by multiplying ADD by a peaking factor of 1.325, which represents the average peaking factor of PVWD and LPWD for the same time period. Table 2-5 presents MDD demand for SPWA from 2022 to 2042.

Table 2-5. SPWA Projected Maximum Day Demand, 2022–2042

Year	MDD (mgd)	MDD (cfs)	AAGR
2022	0.055	0.086	0%
2032	0.055	0.086	0%
2042	0.055	0.086	0%

Notes

AAGR = Average Annual Growth Rate

cfs = cubic feet per second

mgd = million gallons per day

MDD = Maximum Day Demand

SPWA = South Prairie Water Association

2.1.5 Combined Demand Forecasts

Table 2-6 below presents a summary of the demand forecasts detailed above, and provides a total demand forecast for the Port and regional partners through 2042. Note that the MDD values in Table 2-6 have been rounded from the values presented in previous tables. In the year 2042, the Port and regional partners anticipate a combined MDD of 1.53 cfs (0.99 mgd).

Table 2-6. Combined Demand Forecasts for POTB, PVWD, LPWD, and SPWA, 2022–2042

Year	POTB MDD (cfs)	PVWD MDD (cfs)	LPWD MDD (cfs)	SPWA MDD (cfs)	MDD (cfs)	MDD (mgd)
2022	0.47	0.15	0.15	0.09	0.85	0.55
2032	0.70	0.16	0.24	0.09	1.19	0.77
2042	0.94	0.16	0.34	0.09	1.53	0.99

Notes

PVWD = Pleasant Valley Water District

LPWD = Long Prairie Water District

SPWA = South Prairie Water Association

POTB = Port of Tillamook Bay

cfs = cubic feet per second

mgd = million gallons per day

MDD = maximum day demand

² Oregon Public Health, Drinking Water Data Online, OR41 00892, South Prairie Water Association

³ Portland State University. Population Research Center; Chun, Nicholas; Rancik, Kevin; Runge, Paul; Cunningham, Mac; Loftus, Deborah; and Rynerson, Charles; "[Coordinated Population Forecast for Tillamook County, its Urban Growth Boundaries \(UGB\), and Area Outside UGBs 2020-2070](#)" (Forthcoming publication).

2.2 Port of Tillamook Bay Water Rights

The Port holds two water use permits (G-15966 and G-16311) and a transfer (T-9962) that authorize the use of groundwater for municipal purposes. These water rights are shown in Table 2-7. The Port's water rights are discussed in detail in its 2019 WMCP.

The Port's groundwater rights have a combined maximum authorized rate of appropriation of 3.13 cfs, which includes 0.33 cfs under Transfer T-9962, 2.0 cfs under Permit G-15966, and 0.8 cfs under Permit G-16311. However, conditions on the Port's transfer and on one of the permits impose limits on the use of these rights. Transfer (T-9962) is limited to an annual appropriation of 211.3 acre-feet and is only available for use during the irrigation season (March 1 through October 31). Permit G-15966 is available for use from December 1 through April 30. Currently only 0.05 cfs is available for appropriation under Permit G-15966 due to a development limitation imposed in the Final Order approving the Port's 2019 WMCP. (The Port will need to request access to an increased rate of appropriation under this permit in a new WMCP if use is required in excess of 0.05 cfs in the future.) **In consideration of these limitations, the Port can appropriate up to a maximum of 1.13 cfs (0.8 cfs + 0.33 cfs) during peak season (March 1 to October 31) under these permits.**

Table 2-7. Port of Tillamook Bay Water Rights

Application	Permit	Transfer/ Amendment	Certificate	Source	Priority Date	Period of Use	Type of Beneficial Use	Maximum Rate/Volume Allowed (cfs/AF)	Maximum Rate/Volume Used (cfs/AF)	5-Year Average Daily Diversion (cfs)	Completion Date
G-4891	G-4612	T-9962	46351	Well #1 (TILL 653); Well #2 (TILL 51981)	5/28/1969	Irrigation Season (March 1 - October 31)	Municipal	0.33 cfs, limited to 211.3 acre- feet	0	0	10/1/2025
G-15531	G-15966	—	—	A well in Trask River Basin (TILL 51981)	6/11/2001	December 1 through April 30	Municipal	2.0 cfs ¹	0	0	10/1/2065
G-16712	G-16311	—	—	Well 1, tributary to Mill Creek (TILL 51981); wells 2, 3, and 4	8/22/2006	Year-round	Municipal	0.80 cfs ²	0	0	10/1/2050

Notes

Source: POTB's 2019 WMCP

¹ Permit G-15966 has a development limitation of 0.05 cfs.

² The Port is authorized to appropriate the entirety of this permit.

2.3 Demand and Supply Comparison

GSI compared forecasted demand for the Port and its partners to the supply available under the Port's water rights. For this comparison, it is assumed that the MDD for the Port and its partners will occur during the summer months of each year. Accordingly, future demands were compared to the total rate of 1.13 cfs authorized by the Port's water rights available for appropriation during the peak (irrigation) season (Transfer T-9962 and Permit G-16311, March 1 to October 31). We conclude that:

- During times other than peak season, the authorized rate under the Port's water rights exceeds the combined non-peak season demand of all the partners through 2042. Specifically, the rate of the Port's water rights during non-peak season are equivalent to 2.8 cfs relative to the combined forecasted demand of 1.53 cfs by 2042, representing a supply excess of 1.27 cfs. Therefore, during the non-peak season, both the Port-Only Scenario and Partnership Scenario are feasible from the perspective of water rights.
- During the peak season (March 1 to October 31):
 - The Port's peak-season demands of 0.94 cfs in 2042 are anticipated to be met by its existing water rights (1.13 cfs) through the planning period. Therefore, during the peak season, the Port-Only Scenario is feasible from the perspective of water rights.
 - The combined MDD of the Port and its partners is forecast to reach 1.53 cfs (Table 2-6) by 2042, a rate that exceeds available peak season supply of 1.13 cfs by 0.4 cfs (Permits G-4612 and G-16311 in Table 2-7). Therefore, the Port's demands, coupled with the demands of its regional partners, will require access to additional supply in order to be feasible from the perspective of water rights.

Figure 2-1 shows a visual comparison of the Port and regional partners future MDD and available supply under the Port's water rights during the peak season.

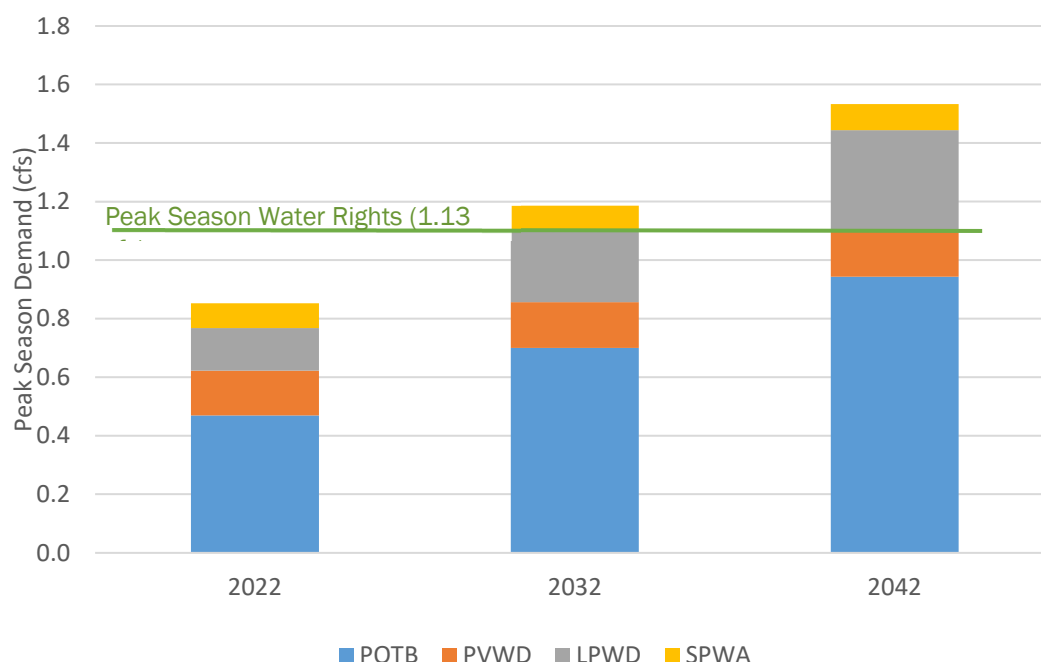


Figure 2-1. Peak Season Demands of Partners, 2022–2042

3 Aquifer Evaluation

This section summarizes an evaluation of the geology, hydrogeology, and groundwater quality in the vicinity of the Port. This section is organized as follows:

- Section 3.1: Geologic Setting
- Section 3.2: Hydrogeologic Setting
- Section 3.3: Groundwater Quality

3.1 Geologic Setting

The geology on the Port property consists of unconsolidated alluvial sediments overlying marine sedimentary rocks of the Alsea Formation, as shown in Figure 3-1 and the cross sections in Figure 3-2 and Figure 3-3 (Wells et. al, 1994; Snavely et al., 1975).

- The **Alluvium (Qal)**, shown by the yellow color in Figure 3-1, is present at ground surface within much of the Port Property. The Alluvium is an unconsolidated sand and gravel with silt and clay lenses that, in the vicinity of the Port, consists of geologically recent deposits from the Trask and Tillamook Rivers, and older alluvial fan deposits from rivers draining the coast range. As shown in the geologic cross section on Figure 3-2 and Figure 3-3, the alluvium is thickest on the northwest part of the Port property (reaching a thickness of up to about 140 feet⁴) and thins to the southeast against the Alsea Formation.
- The **Alsea Formation (Tal)**, shown by orange color in Figure 3-1, consists primarily of tuffaceous siltstones (i.e., a siltstone rich in volcanic ash) and fine-grained sandstones that were deposited in a marine environment during the Miocene Epoch and Oligocene Epoch. The Alsea Formation is present at ground surface on the eastern portion of Port property at Anderson Hill. Where not present at ground surface, the Alsea Formation generally occurs from about 40 feet below ground surface (bgs)⁵ to about 140 feet bgs⁶ (see cross sections in Figure 3-2 and Figure 3-3).

3.2 Hydrogeologic Setting

3.2.1 Target Aquifer

The primary aquifer in the Tillamook Valley and on the Port property is hosted by the Alluvium, which is referred as the Tillamook Valley Alluvial Aquifer (TVA Aquifer). The Port's existing well (TILL 51981, shown on Figure 3-1 and the cross section in Figure 3-3) and the Port's existing water rights are associated with the TVA Aquifer. While the underlying Alsea Formation is water-bearing, yields from wells completed in the Alsea Formation are low in comparison to the TVA Aquifer.

The TVA Aquifer is an unconfined to semi-confined aquifer, meaning that there is hydraulic communication between the aquifer and the surface. Evidence for the unconfined to semi-confined nature of the TVA Aquifer includes the absence of regional-scale, low permeability clay layers that overlie the aquifer⁷, and the presence of nitrate in wells completed in the TVA Aquifer.⁸

⁴ TILL 652

⁵ TILL 668

⁶ TILL 652

⁷ See cross sections in Figure 3-2 and Figure 3-3.

⁸ See Section 3.3

3.2.2 Well Yields

Well drillers sometimes estimate the yield after a well is constructed by conducting a short-term (about an hour) well test. The tests are reported on well driller logs, which are available from the Oregon Water Resource Department's (OWRD's) online well log database (OWRD, 2022). GSI downloaded logs for wells located within approximately 1 mile of Port property and compiled pumping tests from wells that are completed in the TVA Aquifer with the objective of developing an estimate of the potential yield for a new well installed by the Port (see Figure 3-1 for well locations). **Note that a dry well (TILL 669) is reported to be located on Port Property based on information on the well log. We assume that this well, which was constructed by the City of Tillamook in 1959, is incorrectly located. Therefore, we do not include TILL 669 in our analysis of well yields or groundwater development potential.**

The compiled well testing data, which are summarized in Table 3-1, include yields from 17 water wells. Yields from the wells generally fall within the range of 40 to 200 gallons per minute (gpm)⁹. Data from each well test are provided in Attachment A.

Table 3-1. Well Yields in the TVA Aquifer

N	Minimum	25 th Percentile	Median	75 th Percentile	Maximum
17	9 gpm	40 gpm	62 gpm	200 gpm	1,320 gpm

Note

gpm = gallons per minute

For the purpose of this groundwater development feasibility evaluation, we assume that a new, screened well that fully-penetrates the TVA Aquifer would potentially yield about 100 gpm. GSI's yield estimate is on the higher end of the range of well tests summarized in Table 3-1 because:

- **Inefficient Construction.** Most of the tested wells in Table 3-1 are completed with perforations, which are saw-cut or torch-cut openings in well casing that allow water to enter a well (see Attachment A for well completion details). These types of wells commonly are relatively inefficient, and thus typically yield less than wells that are completed with an engineered well screen designed to minimize entrance velocity and head losses. We recommend that a new well be completed with an engineered screen to maximize the potential that the yield will be on the higher end of the range reported in Table 3-1.
- **Partial Penetration.** As shown in Figure 3-2 and Figure 3-3, many of the tested wells partially-penetrate the TVA Aquifer (meaning that the wells were not advanced through the full thickness of the TVA Aquifer). Wells that partially-penetrate an aquifer generally are less efficient and do not produce as much groundwater as wells that fully penetrate an aquifer. We recommend that the Port's new wells be advanced through the entire thickness of the aquifer, which should increase the potential to achieve yields on the higher end of the range reported in Table 3-1.

The assumed yield of 100 gpm for a new well is for planning-purposes only, and would need to be verified with a test well(s) installed on Port property as part of an initial phase of wellfield construction.

It should be noted that the Port's new wells are not likely to produce groundwater long-term at the highest end of the range in Table 3-1 for three reasons. First, the well tests in Table 3-1 are generally short-term (one hour long) tests that are not representative of long-term well yield. Second, the highest-yielding well (TILL 654, owned by the City of Tillamook and tested at 1,320 gpm) is considered to be an outlier because the yield may be related to the well being located about 200 feet from the Trask River and completed in gravels

⁹ Based on the 25th percentile (40 gpm) and 75th percentile (187.5 gpm) yields.

that are potentially connected to the Trask River. Third, as discussed in the following sections, the most productive part of the TVA Aquifer on Port property (i.e., on the northwest portion of the property) is not being targeted for full development because of current and future land uses (the TVA Aquifer becomes thinner and, therefore, less productive to the southeast, which is where most groundwater development is targeted to occur).

Development of a potable groundwater supply appears to be feasible from the perspective of aquifer yield as the Port property is sufficiently large to accommodate enough wells spaced sufficiently far apart to minimize interference and meet the Port's and partners' forecasted water demand over the planning period (see Section 4 for a detailed conceptual wellfield layout). However, as discussed in Section 4, the Partnership Scenario will require that land uses (i.e., manure spreading) be discontinued in some areas of the property.

3.3 Groundwater Quality

This section presents an evaluation of groundwater quality in the TVA Aquifer based on Oregon Department of Environmental Quality (DEQ) studies and nearby municipal groundwater sources (Subsection 3.3.1), and a groundwater quality sample collected from the Port's existing water supply well in May 2022 (Subsection 3.3.2). Groundwater quality results are compared to Environmental Protection Agency (EPA) Maximum Contaminant Levels (MCLs) and Secondary Maximum Contaminant Levels (SMCLs). MCLs are legally-enforceable health-based concentration limits for constituents in drinking water; SMCLs are non-mandatory water quality standards for aesthetic considerations, including taste, color, and odor.

3.3.1 Fairview Water District Wells and DEQ Regional Studies

This section summarizes groundwater quality in the TVA Aquifer based on data from sampling of municipal supply wells owned by the Fairview Water District and a groundwater quality investigation of the TVA Aquifer completed by the Oregon Department of Environmental Quality (DEQ, 2004).

Fairview Water District Well No. 1 and No. 3

The Fairview Water District operates three water supply wells completed in the TVA Aquifer about two miles north of the Port [Well No. 1 (TILL 517), Well No. 3 (TILL 486), and Well No. 4]. As a public water system, the District routinely collects water samples from its wells for laboratory analysis and reports the results to the Oregon Health Authority (OHA)¹⁰. According to OHA, groundwater from the District's wells is untreated, so the water quality data represent raw groundwater quality (OHA, 2022). Detected analytes from the most recently-collected samples at each well are shown in Table 3-2.

Detected analyte concentrations are below MCLs and SMCLs; however, nitrate concentrations are elevated and indicative of an anthropogenic source (Dubrovsky et al., 2010). A single detection of toluene occurred at Well 4 in 2017, and likely represents a localized issue (i.e., as opposed to a TVA Aquifer-wide regional issue). Note that groundwater quality data for iron and manganese, which are commonly present at elevated concentrations in alluvial aquifers in Oregon, were not available from OHA's website for the Fairview Water District wells.

¹⁰ Fairview Water District is public water system OR41-00887

Table 3-2. Groundwater Quality in Fairview Water District Well No. 1, Well No. 3, and Well No. 4

Analyte	MCL or SMCL ¹	Fairview WD Well No. 1	Fairview WD Well No. 3	Fairview WD Well No. 4
Barium	2,000 µg/L	0.456 µg/L	0.513 µg/L	0.750 µg/L
Nitrate	10 mg/L	1.44 mg/L	4.13 mg/L	2.63 mg/L
Sodium	None	7.83 mg/L	8.78 mg/L	12.4 mg/L
Total Dissolved Solids	500 mg/L	86 mg/L	82 mg/L	--
Combined Uranium	30 µg/L	2.0 µg/L	4.0 µg/L	ND
Chromium	100 µg/L	2.6 µg/L	3.0 µg/L	2.0 µg/L
Fluoride	4 mg/L	ND	ND	0.16 mg/L
Toluene	1,000 µg/L	ND	ND	0.92 µg/L
Combined Radium	5 pCi/L	1.73 pCi/L	ND	ND

Notes
¹ Regulatory standards are MCLs with the exception of total dissolved solids, which is the SMCL.

µg/L = micrograms per liter

mg/L = milligrams per liter

pCi/L = picoCuries per liter

WD = water district

MCL = Maximum Contaminant Level

SMCL = Secondary Maximum Contaminant Level

-- = sample not collected

ND = analyte not detected

DEQ's 1997 and 1998 Groundwater Study

DEQ collected groundwater quality samples from wells completed in the TVA Aquifer during the late 1990s as part of DEQ's Statewide Ambient Groundwater Monitoring Program. Detected contaminants, average concentrations, and maximum concentrations are summarized in Table 3-3.

Groundwater samples were collected from 24 wells between November 1997 and April 1998 for analysis of nitrate, volatile organic compounds, and pesticides. Volatile organic compounds and pesticides were not detected, except for one low-level detection of ethylbenzene. Nitrate and select metals were detected in over two thirds of wells. The metals may be naturally-occurring in soil and groundwater, or may have leached from surficial soils due to land application of manure. While detected concentrations were below MCLs and SMCLs, nitrate concentrations are elevated and indicative of an anthropogenic source (Dubrovsky et al., 2010).

Table 3-3. DEQ (1998) Study of Groundwater Quality in the Tillamook Valley Alluvial Aquifer

Analyte	MCL or SMCL ¹	No. of Wells Detected out of 24 Wells Sampled	Average Concentration	Maximum Concentration
Event 1				
Nitrate	10 mg/L	16 (66.7%)	1.28 mg/L	8.60 mg/L
Bacteria		1 (4%)	12 CFU/0.1 L	280 CFU/0.1 L
Antimony	6 µg/L	16 (66.7%)	3.8 µg/L	6.9 µg/L
Lead	15 µg/L	4 (16.7%)	6.4 µg/L	11.4 µg/L
Barium	2,000 µg/L	24 (100%)	7.13 µg/L	52.7 µg/L
Chromium	100 µg/L	18 (75%)	11.8 µg/L	58.2 µg/L
Copper	1,300 µg/L	24 (100%)	39.1 µg/L	465 µg/L
Nickel		24 (100%)	1.43 µg/L	6.43 µg/L
Event 2				
Ethylbenzene	700 µg/L	1 (4%)	--	0.7 µg/L
Lead	15 µg/L	3 (12.5%)	--	22.1 µg/L
Antimony	6 µg/L	1 (4%)	--	3.9 µg/L
Barium	2,000 µg/L	5 (20.8%)	--	71.9 µg/L
Cadmium	5 µg/L	1 (4%)	--	0.13 µg/L
Chromium	100 µg/L	4 (16.7%)	--	0.45 µg/L
Copper	1,300 µg/L	5 (20.8%)	--	520 µg/L
Nickel		4 (16.7%)	--	1.82 µg/L

Notes
¹ Regulatory standards are MCLs with the exception of total dissolved solids

mg/L = milligrams per liter

µg/L = micrograms per liter

CFU/0.1 L = colony forming units per 0.1 liters

MCL = Maximum Contaminant Level

SMCL = Secondary Maximum Contaminant Level

3.3.2 Groundwater Quality on Port Property

On May 23, 2022, GSI collected a groundwater quality sample from the Port's existing well (TILL 51981), which is a shallow well open to the TVA Aquifer¹¹. The groundwater sample was collected using a low-flow sampling methodology (EPA, 2017), and was submitted to Eurofins Eaton Analytical (Monrovia, California) for analysis of the following constituents that are regulated under the Safe Drinking Water Act: general geochemical parameters; metals; microbiological parameters total coliform and *E. Coli*; pesticides and herbicides; volatile organic compounds (VOCs); semi-volatile organic compounds (SVOCs); radionuclides gross alpha, radium 226/228, and uranium; and total polychlorinated biphenyls (PCBs). Field parameters [temperature, pH, conductivity, dissolved oxygen (DO), and oxidation-reduction potential (ORP)] were measured in the field with a Yellow Springs Instrument (YSI) meter and flow-through cell. Table 3-4 summarizes detected analytes from the sampling. The laboratory analytical report is provided in Attachment

¹¹ TILL 51981 was drilled in 2009. The TILL 51981 driller log indicates that the well is completed in "Brown Clay with Small and Large Gravel" as an open hole from 38.5 feet bgs to 65 feet bgs. The groundwater sample was collected in general accordance with the low-flow (low-stress) method (EPA, 2017)

B. Note that iron is present at a concentration of 0.83 milligrams per liter (mg/L), above the SMCL of 0.3 mg/L. In addition, both nitrate and coliform bacteria were present in the well. According to discussions with the Port, elevated levels of iron in the TVA Aquifer are hit or miss, occurring in some wells but not others (personal communication, 2023).

Table 3-4. Groundwater Quality in POTB Well TILL 51981

Analyte	MCL or SMCL ⁽¹⁾	TILL 51981
Field Parameters		
Temperature	--	13.38 °C
pH	6.5 – 8.5	6.73 ⁽²⁾
Conductivity	--	174 uS/cm ²
Dissolved Oxygen	--	11.08 mg/L
Oxidation Reduction Potential	--	471.2 mV
Groundwater Quality (Only Detected Constituents with MCLs or SMCLs are Shown)		
Nitrate	10 mg/L	1.1 mg/L
Iron	0.3 mg/L	0.83 mg/L
Manganese	0.05 mg/L	0.0063 mg/L
Fluoride	4.0 mg/L	0.050 mg/L
Coliform, Total	absent	5.2 MPN/100 mL

Notes

⁽¹⁾ Regulatory standards are MCLs with the exception of pH, iron and manganese.

⁽²⁾ Note that the “Field pH” of 7.5 in the Eurofins lab report (Attachment B) was measured in the lab and is not considered as accurate as pH measured in the field; the field-measured pH is 6.73.

mg/L = milligrams per liter

mV = millivolts

°C = degrees Celsius

uS/cm² = microSiemens per square centimeter

MCL = Maximum Contaminant Level

MPN/100 ml = most probably number per 100 milliliters

SMCL = Secondary Maximum Contaminant Level

Based on the groundwater quality data from the Fairview Water District, DEQ (1998) study of groundwater quality in the TVA Aquifer, and sampling of the Port’s well (TILL 51981), it appears to be feasible to develop a groundwater supply source on Port property so long as the Port plan treat groundwater to remove nitrate, iron, and manganese, and chlorinate the groundwater for residual disinfection. While manganese was not detected above the SMCL of 0.05 mg/L in the Port’s well, we recommend treating for manganese because elevated manganese is common in alluvial aquifers in Oregon, particularly when elevated levels of iron are present. We also note that this evaluation is based on an analysis of manganese in a single water sample [because Fairview Water District and DEQ (1998) did not analyze for manganese]. In summary, groundwater at the Port has the potential to exceed the MCL or SMCL for these constituents based on water quality data from wells open to the TVA Aquifer and the Port’s existing well (TILL 51981).

4 Conceptual Well Design and Conceptual Wellfield Layout

This section evaluates the number of wells that are needed to meet the Port's water demand and presents a conceptual well design and wellfield layout. This section is organized as follows:

- Section 4.1: Number of Wells Needed to Meet the Target Water Demand
- Section 4.2: Conceptual Well Design
- Section 4.3: Conceptual Wellfield Layout

4.1 Number of Wells Needed to Meet Target Demand

As discussed in Section 3.2.2, we assume that a new water well at the Port will produce about 100 gpm. Note that this assumed yield is for planning-purposes only, and would need to be verified with a test well installed on Port property as part of an initial phase of wellfield construction.

Firm capacity for a groundwater source of supply is defined as the total capacity of the supply wells minus the capacity of the highest producing well. For the purposes of this evaluation, we have assumed that the Port will construct sufficient wells to supply a firm capacity that meets or exceeds the 2042 peak season MDD. Table 4-1 shows the number of wells that would need to be constructed to provide the firm capacity to meet the 2042 peak season MDD under the following two public water system scenarios:

- **Public Water System to Serve Port and Partners (Partnership Scenario).** Under this scenario, the Port develops a water system to supply demand from the Port and partners (Pleasant Valley Water District, Long Prairie Water District, South Prairie Water Association). As shown in Table 4-1, the 2042 peak season MDD demand under this scenario is 1.53 cfs (687 gpm).
- **Public Water System to Serve Port-Only (Port-Only Scenario).** Under this scenario, the Port develops a water system to meet only the Port's demand. As shown in Table 4-1, the 2042 peak season MDD demand under this scenario is 0.94 cfs (422 gpm).

As shown in Table 4-1, eight wells are assumed to be necessary to provide firm capacity to meet demand under the Partnership Scenario, while five wells are assumed to be necessary to provide firm capacity to meet demand under the Port-Only Scenario.

Table 4-1. Estimated Number of Wells Needed to Meet Groundwater Development Scenarios

	Demand	Number of Wells to Meet Firm Capacity
Partnership Scenario		
2042 Peak Season MDD	1.53 cfs (687 gpm)	8
Port-Only Scenario		
2042 Peak Season MDD	0.94 cfs (422 gpm)	5

Notes

cfs = cubic feet per second

gpm = gallons per minute

4.2 Conceptual Well Design

A conceptual well design for new Port well(s) is shown in Figure 4-1. The conceptual well design is based on the following design parameters:

- Well yield of 100 gpm.
- TVA Aquifer is about 120 feet thick, and semi-confined by overlying clays and silts.

The well fully-penetrates the TVA Aquifer and is constructed with a stainless steel wire-wrap screen to maximize efficiency. Note that the design is based on the highest observed thickness of the TVA Aquifer (which occurs in the northwestern portion of the property) in order to develop conservative cost estimates for well construction.

4.3 Conceptual Wellfield Layout

Selection of locations for municipal supply wells on the Port property takes into account setbacks that are established by regulatory agencies (i.e., OWRD and OHA) and proximity to potential sources of groundwater contamination (e.g., surface water bodies, which could be sources of virus and bacteriological contamination, and contaminated sites where commercial/industrial activities occurred). The following bullets provide details about how these criteria are used to identify areas of the Port property that are available to site a municipal water supply well.

- **OHA and OWRD Regulatory Setbacks.** Well locations must meet the following setbacks that are established by the OHA¹² and/or OWRD¹³:
 - At least 50 feet from gravity sanitary sewer lines and storm sewer lines.
 - At least 100 feet from the property boundary [to meet radius of control requirements in OAR 333-061-0050(2)(a)(B)].
 - At least 100 feet from solid waste sites (e.g., landfills), pressure sanitary sewer lines, roads/parking lots, confined animal feedlot operations, underground injection control devices, and sewage sludge disposal areas.

Because the Port utilizes a combination of gravity sewer lines (50 foot setback) and pressure sewer lines (100 foot setback), we selected well locations such that they would meet the more restrictive setback distance of 100 feet.

While OWRD and OHA may grant a variance from these setbacks, receiving a variance is unlikely in an unconfined aquifer like the TVA Aquifer. Therefore, we have located wells such that these setbacks are all met. Note that OHA and/or OWRD establish additional setbacks for several features that we did not include in our analysis because accurate locations are not included in publicly-available databases, including commercial above ground storage tanks (50 feet), septic tanks (50 feet), septic drain lines (100 feet), junk/auto/scrap yard (100 feet), stormwater disposal facilities (100 feet), chemical usage, storage, or application areas (100 feet), underground storage tanks (100 feet) hazardous waste storage areas (500 feet), and other potential contaminant sources. These setbacks will need to be further evaluated when selecting a final location for a well based on a site visit, conversations with Port staff, and/or additional records review (i.e., DEQ underground storage tank files).

- **Proximity to Surface Water Features.** Wells were not located: (1) within wetlands (which are problematic from a permitting perspective because of the need to place fill to support drill rigs and access roads) or (2) within 200 feet of surface water bodies [which could trigger an automatic requirement for evaluating the potential for groundwater under the direct influence of surface water (GWUDI) under OAR 333-61-032(7)(a)(A)]¹⁴.

¹² OAR 333-061-0050(2)

¹³ OAR 690-210-0030

¹⁴ Note that evaluation of whether a well is GWUDI may also be triggered by water quality sampling results.

- **Proximity to Potential Contamination Sources.** Locating water wells some distance from potential contamination sources is a strategy to mitigate against the risk of encountering contaminated groundwater. The potential contamination sources that were identified, shown in Figure 4-2, included Environmental Cleanup Site Information (ECSI) sites, Leaking Underground Storage Tank (LUST) sites, a former Mill Pond, the Tillamook Lumber Landfill site, biosolid spreading areas, the sanitary waste lagoons, the former Mill Ponds, and former underground storage tank area. A detailed evaluation of the ECSI and LUST sites is presented in Attachment C. The new wells were located at least 400 feet from these potential contamination sources.

Note that former manure spreading areas in Figure 4-2, despite being a potential contamination source, are considered to be available for a new well because pumped groundwater can be treated to remove nitrate contamination. In addition, ECSI 4607 and ECSI 4605 were considered to be available for a new well because the sites are included in the ECSI database only because a Phase I Environmental Site Assessment (ESA) has been conducted (see Attachment C) and no Recognized Environmental Conditions (RECs) were identified.

Note that the Federal Aviation Administration (FAA) establishes setbacks between runways and features such as well houses. The Port provided input on potential well locations to ensure that FAA setbacks would be met.

Based on these setbacks, locations for eight water supply wells were selected and are shown in Figure 4-3. Wells are separated by at least 1,000 feet to minimize interference during pumping. Special development requirements for each well location are provided on Table 4-2. Well Nos. 1 to 5 are intended for the Port-Only Scenario and Well Nos. 1 to 8 are intended for the Partnership Scenario.

Table 4-2. Special Development Requirements for Wells

Well ID	Special Requirements for Development
Well 1	
Well 2	
Well 3	
Well 4	
Well 5	
Well 6	Discontinue manure spreading activities. Well is located within 100-year flood zone; area around well shall be mounded and the top of well casing shall extend at least two feet above 100-year flood level.
Well 7	Discontinue manure spreading activities. Well is located within 100-year flood zone; area around well shall be mounded and the top of well casing shall extend at least two feet above 100-year flood level.
Well 8	Discontinue manure spreading activities. Well is located within 100-year flood zone; area around well shall be mounded and the top of well casing shall extend at least two feet above 100-year flood level.

Note that it may be possible to locate a well on the north side of Long Prairie adjacent to the railroad tracks on Port property. This location may have a higher yield due to being closer to the Trask River. However, the potential for groundwater impairment from the sanitary lagoons would need to be assessed (the location is downgradient of the lagoons) and the potential for groundwater under direct influence of surface water would need to be assessed.

5 Wellfield Construction Sequence and Cost Estimate

This section summarizes a wellfield construction sequence and estimates for wellfield capital improvement costs and operation and maintenance costs. This section is organized as follows:

- Section 5.1: Wellfield Construction Sequence
- Section 5.2: Class 5 Estimate for Capital Improvement Costs
- Section 5.3: Estimate for Operations and Maintenance Costs

Costs are provided for both the Port-Only Scenario and the Partnership Scenario, and for two alternatives: (1) groundwater treatment is required and (2) groundwater treatment is not required. The construction sequence and cost estimates assume that each well produces about 100 gpm (i.e., five wells are needed to provide sufficient firm capacity to meet the 2042 MDD of 422 gpm for the Port-Only Scenario and eight wells are needed to provide sufficient firm capacity to meet the 2042 MDD of 687 gpm for the Partnership Scenario). Because the Partnership Scenario requires that wells are located in manure spreading areas, manure spreading activities would need to be discontinued if the Partnership Scenario were to be developed. This would result in loss of revenue for the Port because the manure spreading areas are leased to local farmers. Therefore, the Partnership Scenario is not anticipated to be developed by the Port at this time. However, we provide a construction sequence and cost for developing the Partnership Scenario regardless with the objective of facilitating a comprehensive evaluation of wellfield development options.

5.1 Wellfield Construction Sequence

This section presents a wellfield construction sequence for the Port-Only and Partnership Wellfield Scenarios. The construction sequence adopts a step-wise approach to mitigate the risks associated with the aquifer not producing the sufficient water (due to the aquifer being less productive than anticipated) and groundwater quality impairment. Groundwater quality impairment is important to consider because the Port property has been used since 1939 for a variety of agricultural, commercial, and industrial purposes, and because the TVA Aquifer is a semi-confined to unconfined aquifer (and therefore vulnerable to surface contamination).

The construction sequence is divided into three phases:

- Phase I: Groundwater Quality Evaluation
- Phase II: Aquifer Yield Evaluation
- Phase III: Groundwater Source Development

These phases are discussed in detail in the following sections.

5.1.1 Phase I: Groundwater Quality Evaluation

The primary objective of Phase I is to evaluate project feasibility from the perspective of groundwater quality at future well locations. A secondary objective is to provide limited information about aquifer production potential at each future well location (i.e., saturated thickness of the aquifer and types of geologic materials).

While the evaluation will provide groundwater quality information at the site of each future well, it is important to note that uncertainties will remain about whether long-term pumping will draw contamination towards the wells. Specifically, Phase I consists of constructing monitoring wells that are co-located with “Well 1” through “Well 8” in Figure 4-3. We recommend construction of monitoring wells at all eight potential future well locations (even if the Partnership Scenario is not considered for development) because the

groundwater quality samples will facilitate the mapping of groundwater contaminant plumes (e.g., a nitrate plume from manure spreading activities) that may be intercepted by future Port-Only Scenario pumping wells.

The scope of Phase I is:

- Drill and construct eight groundwater monitoring wells that are co-located with future production wells.
- Evaluate hydrogeologic properties of subsurface materials (i.e., saturated thickness and lithology of geologic materials).
- Collect groundwater quality samples from each monitoring well and analyze them for a full Safe Drinking Water Act suite and per- and poly-fluoroalkyl substances (PFAS).
- Verify that the groundwater quality data are consistent with the groundwater treatment assumptions on which Phase III is based.

Based on the groundwater quality data and limited hydrogeologic property data, decide whether to proceed with the aquifer yield evaluation (Phase II).

5.1.2 Phase II: Aquifer Yield Evaluation

The purpose of the aquifer yield evaluation is to collect data that can be used to develop initial estimates of wellfield yield for a water supply scenario (e.g., 90 days). The scope of Phase II is:

- Drill a test well (i.e., at the location of Well No. 3). GSI's cost estimate assumes the well is completed as a finished production well.
- Conduct a long-term aquifer test (i.e., 72 hours) consisting of pumping the production well and monitoring groundwater levels in nearby monitoring wells.
- Develop an initial estimate of wellfield yield.

Based on the initial estimate of wellfield yield, determine whether or not to proceed with Phase III.

5.1.3 Phase III: Groundwater Source Development

Phase III consists of constructing and testing the remaining production wells to meet demands of the Port-Only Scenario [Phase III(a)] or the Partnership Scenario [Phase III(b)]. We assume that the scope of Phase III consists of constructing the production wells at the locations where the co-located monitoring wells were constructed (see Figure 4-3).

Phase III(a): Port-Only Scenario

The purpose of Phase III(a) is to develop a groundwater supply that provides firm capacity to meet the water demand of the Port-Only Scenario (2042 MDD). The scope of Phase III(a) includes:

- Obtain water rights and drill, complete, and test Production Well Nos. 1, 2, 4 and 5, so that a total of five wells have been constructed to meet the 2042 MDD of the Port-Only Scenario (recall that Well No. 3 was constructed as a part of Phase II).
- Two alternatives are provided for treatment of groundwater to remove iron, manganese, and nitrates: (1) treat groundwater (400 gpm capacity) and (2) do not treat groundwater.
- Construct raw water transmission piping and one million gallon treated water storage reservoir and booster pump station and pumps.

Phase III(b): Partnership Scenario

The purpose of Phase III(b) is to develop a groundwater supply that provides firm capacity to meet the water demand of the Partnership Scenario (2042 MDD). The scope of Phase III(b) includes:

- Obtain water rights and drill, complete, and test Production Well Nos. 1, 2, 4, 5, 6, 7, and 8, so that a total of eight wells have been constructed to meet the 2042 MDD of the Partnership Scenario (recall that Well No. 3 was constructed as a part of Phase II).
- Two alternatives are provided for treatment of groundwater to remove iron, manganese, and nitrates: (1) treat groundwater (700 gpm capacity) and (2) do not treat groundwater.
- Construct raw water transmission piping and one million gallon treated water storage reservoir and booster pump station and pumps.

5.2 Class 5 Estimate for Capital Improvement Costs

AACE International classifies cost estimates depending on project definition, end usage, and other factors. The cost estimates presented here are considered Class 5 with an end usage being a project concept report and an expected accuracy range of -30 percent to +80 percent. As the project is better defined, the accuracy level of the estimates can be narrowed. The costs include design and engineering costs (assumed to be 20% of construction costs) and a contingency (assumed to be 30% of construction costs)¹⁵. Detailed breakdowns for the costs under the Port-Only and Partnership Scenarios are provided in Section 5.2.1 (assuming no treatment), Section 5.2.2 (assuming treatment), and a cost overview is provided in Section 5.2.3.

5.2.1 Capital Costs Assuming No Treatment

Class 5 capital improvement costs for the Port-Only Scenario and Partnership Scenario assuming treatment for iron, manganese, and nitrate is not required are summarized in Table 5-1.

Table 5-1. Class 5 Estimate for Capital Improvement Costs, Treatment Excluded

Phase	Total Capital Costs Estimate	Conceptual Project Cost Estimate Range (-30% to +80%)
Phase I	\$0.49 M ¹	\$0.34 M to \$0.88 M
Phase II	\$0.36 M ²	\$0.25 M to \$0.65 M
Phase III(a) (Port-Only Scenario)	\$9.73 M ³	\$6.83 M to \$17.5 M
Phase III(b) (Partnership Scenario)	\$15.1 M ⁴	\$10.6 M to \$27.3 M
Total Port-Only Scenario Capital Costs	\$10.58 M	\$7.42 M to \$19.03 M
Total Partnership Scenario Capital Costs	\$15.95 M	\$11.19 M to \$28.83 M

Notes

(1) See Phase I in Attachment D.

(2) See Phase II in Attachment D.

(3) Includes \$8,400,000 for groundwater treatment, raw water piping, concrete reservoir, booster pump stations, and mobilization/bonds/insurance (see Table 2 of Attachment E) and \$1,300,000 for well construction [see Phase IIIa in Attachment D].

(4) Includes \$12,600,000 for groundwater treatment, raw water piping, concrete reservoir, booster pump stations, and mobilization/bonds/insurance (see Table 4 of Attachment E) and \$2,539,000 for well construction [see Phase IIIb in Attachment D].

¹⁵ Note that it may be more cost effective to use an elevated reservoir on the hill to gain the needed system pressure to eliminate the need for a booster pump station. However, the feasibility of an elevated reservoir is not known at this time, so the cost estimate has assumed that a booster pump station will be needed. This assumption may be revisited in the future.

5.2.2 Capital Costs Assuming Treatment

Class 5 capital improvement costs for the Port-Only Scenario and Partnership Scenario assuming treatment for iron, manganese, and nitrate is required are summarized in Table 5-2.

Table 5-2. Class 5 Estimate for Capital Improvement Costs, Treatment Included

Phase	Total Capital Costs Estimate	Conceptual Project Cost Estimate Range (-30% to +80%)
Phase I	\$0.49 M ¹	\$0.34 M to \$0.88 M
Phase II	\$0.36 M ²	\$0.25 M to \$0.65 M
Phase III(a) (Port-Only Scenario)	\$14.2 M ³	\$9.9 M to \$25.6 M
Phase III(b) (Partnership Scenario)	\$21.1 M ⁴	\$14.8 M to \$38.1 M
Total Port-Only Scenario Capital Costs	\$15.05 M	\$10.49 M to \$27.13 M
Total Partnership Scenario Capital Costs	\$21.95 M	\$15.39 M to \$39.63 M

Notes

(1) See Phase I in Attachment D.

(2) See Phase II in Attachment D.

(3) Includes \$12,900,000 for groundwater treatment, raw water piping, concrete reservoir, booster pump stations, and mobilization/bonds/insurance (see Table 1 of Attachment E) and \$1,300,000 for well construction [see Phase IIIa in Attachment D].

(4) Includes \$18,600,000 for groundwater treatment, raw water piping, concrete reservoir, booster pump stations, and mobilization/bonds/insurance (see Table 3 of Attachment E) and \$2,539,000 for well construction [see Phase IIIb in Attachment D].

5.2.3 Capital Cost Summary

A summary of the capital improvement costs for the Port-Only Scenario and Partnership Scenario, including the “treatment” and “no treatment” alternatives, is summarized in Table 5-3.

Table 5-3. Capital Improvement Costs Summary

Scenario	Total Capital Cost Estimate
Port-Only Scenario, No Treatment	\$10.6 M
Port-Only Scenario, Treatment	\$15.1 M
Partnership Scenario, No Treatment	\$16.0 M
Partnership Scenario, Treatment	\$22.0 M

5.3 Estimate for Operations and Maintenance Costs

Operations and maintenance costs include: (1) annual costs for nitrate and iron removal and corrosion control (cost breakdowns are provided in Attachment E) and (2) well rehabilitation assuming one well is rehabilitated mechanically each year. Note that there is not a hard and fast rule on the frequency of well rehabilitation due to differences in water chemistry, well construction, and well operation. However, we recommend conservatively assuming, for planning purposes, that one well will be rehabilitated each year. Operation and maintenance costs for the Port-Only and Partnership Scenarios, including the “treatment” and “no treatment” alternatives, are summarized in Table 5-4.

Table 5-4. Estimate for Operation and Maintenance Costs

Phase	Annual Estimated Cost
No Treatment, Same for Port-Only <u>and</u> Partnership (Rehabilitate One Well Annually)	\$50,000 ¹
Port Only With Treatment (Nitrate, Iron, Manganese Removal <u>and</u> Rehabilitate One Well Annually)	\$316,000 ²
Partnership With Treatment (Nitrate, Iron, Manganese Removal <u>and</u> Rehabilitate One Well Annually)	\$437,000 ³

Notes

(1) Assumes rehabilitation includes removal of pump, pre- and post-rehabilitation well video, clean out of accumulated sediment, brushing, and well disinfection. Does not include chemical rehabilitation, development of bid specifications for rehabilitation, or oversight by a consultant.

(2) See Table 6 in Attachment E for treatment costs. Assumes annual cost of \$50,000 for well rehabilitation.

(3) See Table 7 in Attachment E for treatment costs. Assumes annual cost of \$50,000 for well rehabilitation.

6 Conclusions

This feasibility evaluation for development of a potable groundwater supply under the Port-Only Scenario (i.e., groundwater supplies Port customers) and Partnership Scenario (i.e., groundwater supplies customers of the Port, SPWA, LPWD, and PVWD) found that:

- **Feasibility With Respect to Water Rights.** The authorized rate under the Port's water rights during the non-peak season is sufficient to meet forecasted water demand for both the Port-Only Scenario and Partnership Scenario. During the peak season (March 1 to October 31), however, the authorized rate under the Port's water rights is only sufficient to meet forecasted water demand for the Port-Only Scenario. Implementation of the Partnership Scenario would require an additional source of water during this time, although as discussed in additional detail below, the need for an additional source of water may change as more information is developed during project implementation (e.g., if the AAGR of 6.1% is updated).
- **Feasibility With Respect to Aquifer Productivity.** The Port is underlain by the TVA Aquifer. Assuming that a new, screened well that fully-penetrates the TVA Aquifer would potentially yield about 100 to 150 gpm, the Port would need to construct up to 5 wells to provide the firm capacity to meet the demand of the Port-Only Scenario, and up to 8 wells to provide the firm capacity to meet the demand of the Partnership Scenario. The Port property can accommodate the number of wells required by each scenario. However, in order to meet the demand of the Partnership Scenario, some of the wells would need to be located in areas where manure spreading occurs. Manure spreading activities would need to be discontinued in these areas.
- **Feasibility with Respect to Groundwater Quality.** Groundwater in the TVA Aquifer may need to be treated to remove nitrate, iron, and manganese. In addition, chlorine would need to be added to provide residual disinfection. While groundwater treatment for these constituents is feasible, it adds significant cost to the project if it is necessary.

It should that wellfield development is an iterative process, and as such, the findings summarized in the bullets above represent initial conclusions that will need to be revisited and, if necessary, updated as the project progresses. For example, the 6.1% AAGR for the Port (see Table 2.2) may be high given the relatively low growth in the Tillamook region and the significant impact the COVID pandemic had since 2019, when the AAGR was prepared. Therefore, the AAGR could be updated as a part of the regional supply study.

A phased approach to development of the groundwater supply is recommended to mitigate risks that impaired groundwater is present on Port property and the aquifer does not produce the anticipated quantity of groundwater. The first phase would involve construction of monitoring wells and groundwater quality sampling at the eight future well locations, and the second phase would involve construction of a test well to evaluate aquifer yield. The final phase would be to implement the Port-Only Scenario or the Partnership Scenario. Capital costs for the Port-Only Scenario range from 10.6 million dollars (no treatment) to 15.1 million dollars (treatment required) and capital costs for the Partnership Scenario range from 16.0 million dollars (no treatment) to 22.0 million dollars (treatment required). Class 5 cost estimates, as defined by AACE International, are developed with an end usage being a project concept report and an expected accuracy range of -30 percent to +80 percent, and are shown in Table 5-1 and Table 5-2. Operations and Maintenance costs are estimated to be about \$50,000 annually for the Port-Only and Partnership Scenario if treatment is not required. If treatment is required, maintenance costs are estimated to be about \$316,000 annually for the Port-Only Scenario and \$437,000 annually for the Partnership Scenario.

7 References

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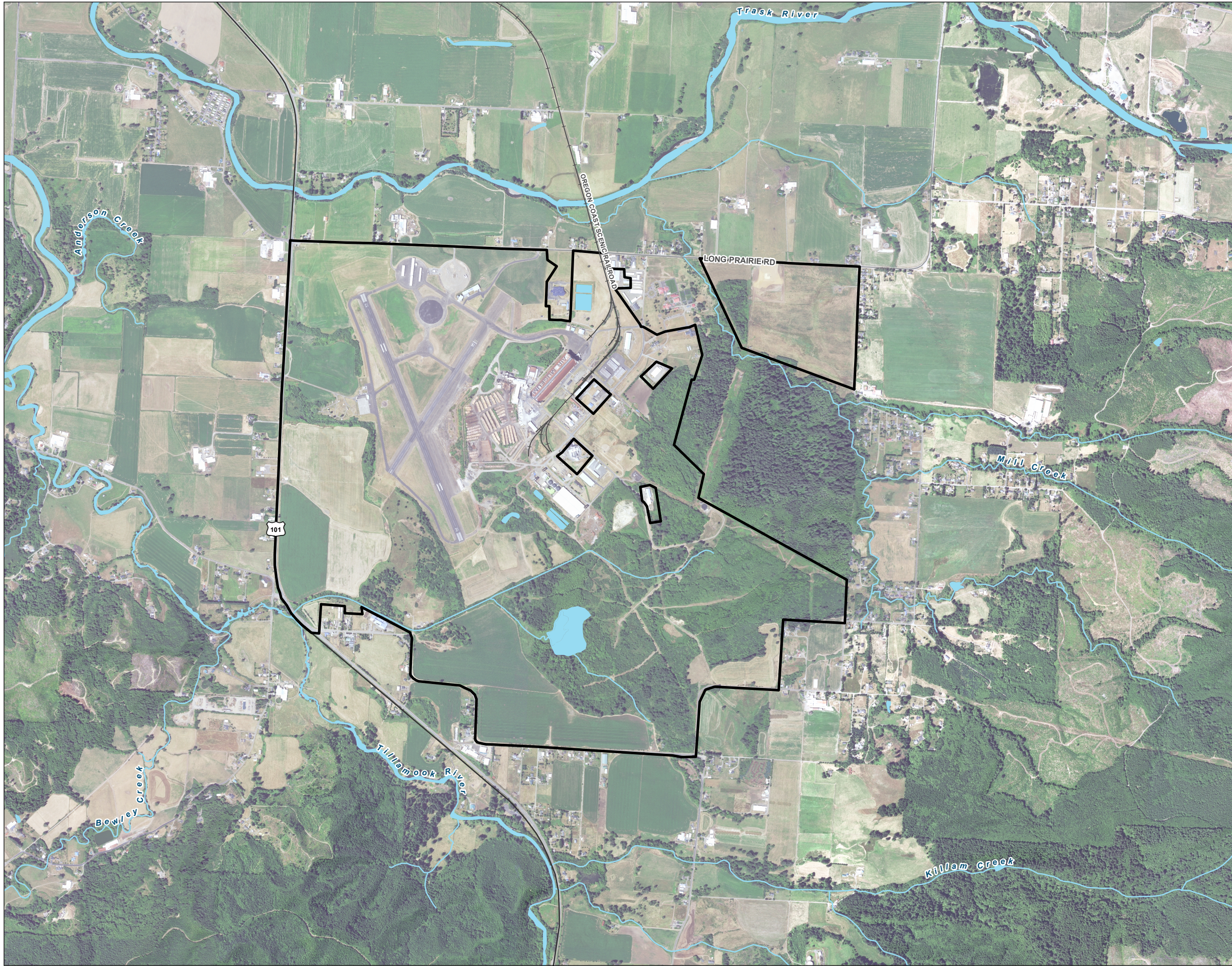
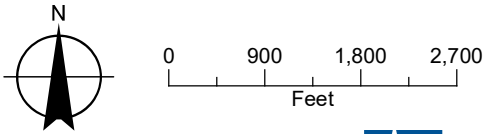


FIGURE 1-1
Overview Map
Port of Tillamook Bay
Groundwater Feasibility Study

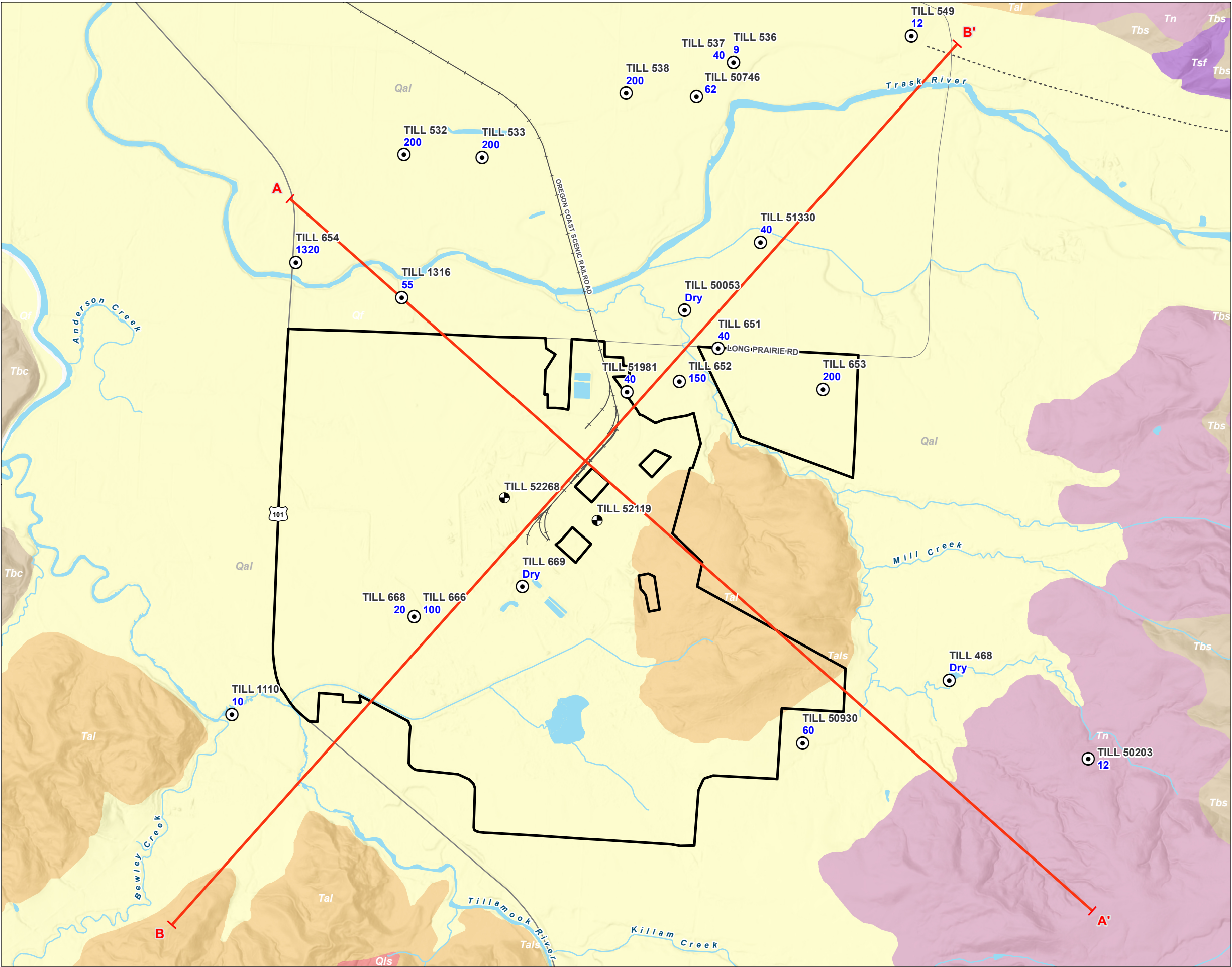
- LEGEND**
- Port of Tillamook Bay Property Boundary
 - Major Road
 - Railroad
 - Watercourse
 - Waterbody



Date: February 1, 2023
Data Sources: BLM, ESRI, ODOT, USGS,
OSIP Imagery (2018)



FIGURE 3-1
Surficial Geology and Well Logs
Port of Tillamook Bay
Groundwater Feasibility Study



LEGEND

- Geotechnical Hole
- Water Well
Yield (gpm)
- Cross Section Line
- Fault

Surficial Geology
Unconsolidated Sediments

- Alluvium (Qal)
- Landslide Deposits (Qfs)

Volcanic and Sedimentary Rocks

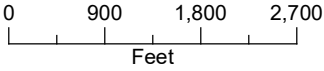
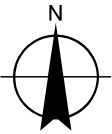
- Alesia Formation (Tal)
- Nestucca Formation (Tn)
- Basaltic Sandstone at Roy Creek (Tbs)
- Tillamook Volcanics (Tsf)

All Other Features

- Port of Tillamook Bay Property Boundary
- Major Road
- Railroad
- Watercourse
- Waterbody

NOTE

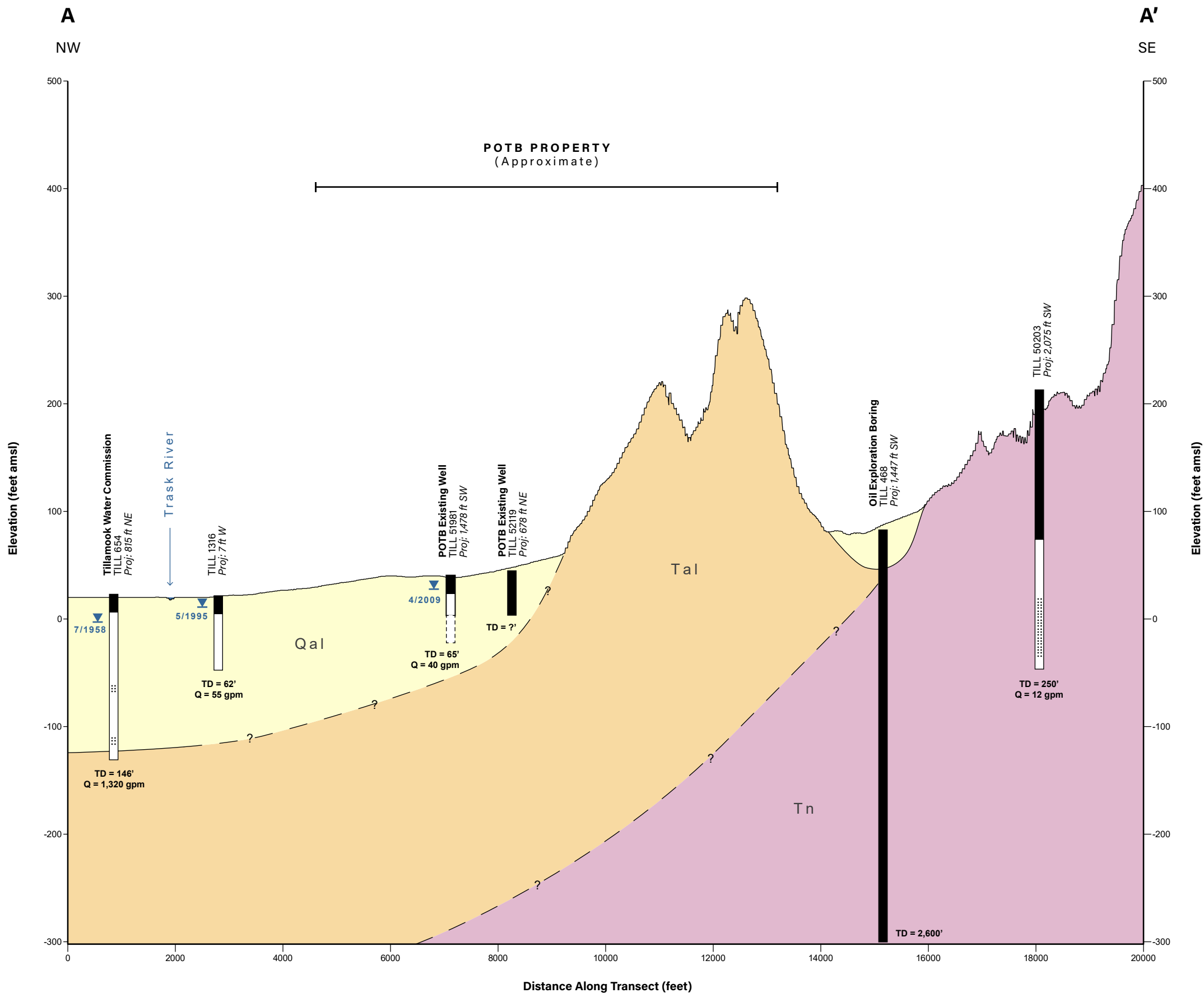
gpm: gallons per minute



Date: February 1, 2023
Data Sources: BLM, ESRI, ODOT, USGS, OWRD,
USFWS (2021), DOGAMI (2021)



FIGURE 3-2
Cross Section A-A'
Port of Tillamook Bay
Groundwater Feasibility Study



LEGEND

Surficial Geology

Unconsolidated Sediments

Alluvium (Qal)

Volcanic and Sedimentary Rocks

Alesia Formation (Tal)

Nestucca Formation (Tn)

Well Legend

Well Seal
Blank Casing
Perforated Casing
Wire-wrap screen
Open Borehole

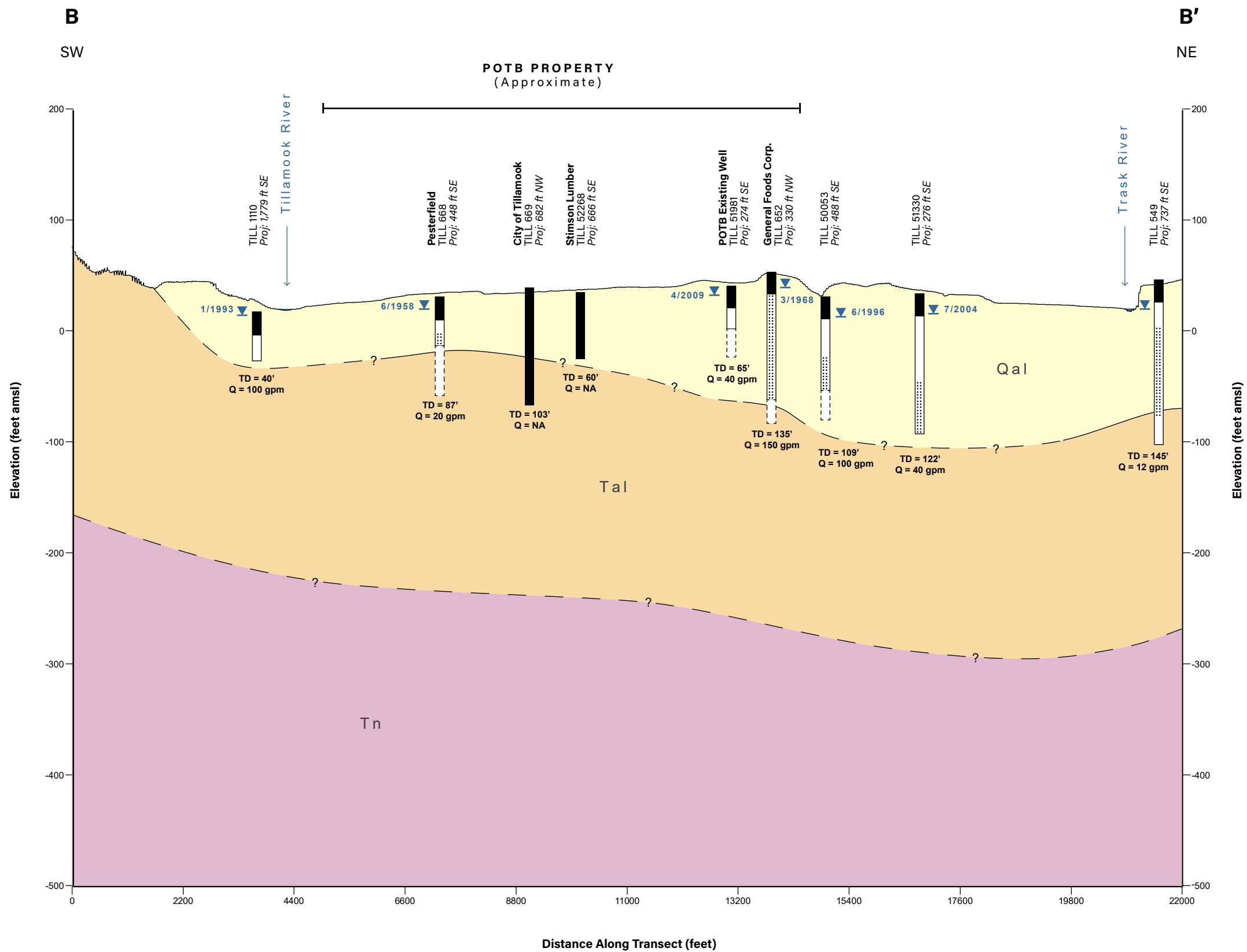
TD Total Well Depth
Q Well yield at time of construction
Static water level at time of construction

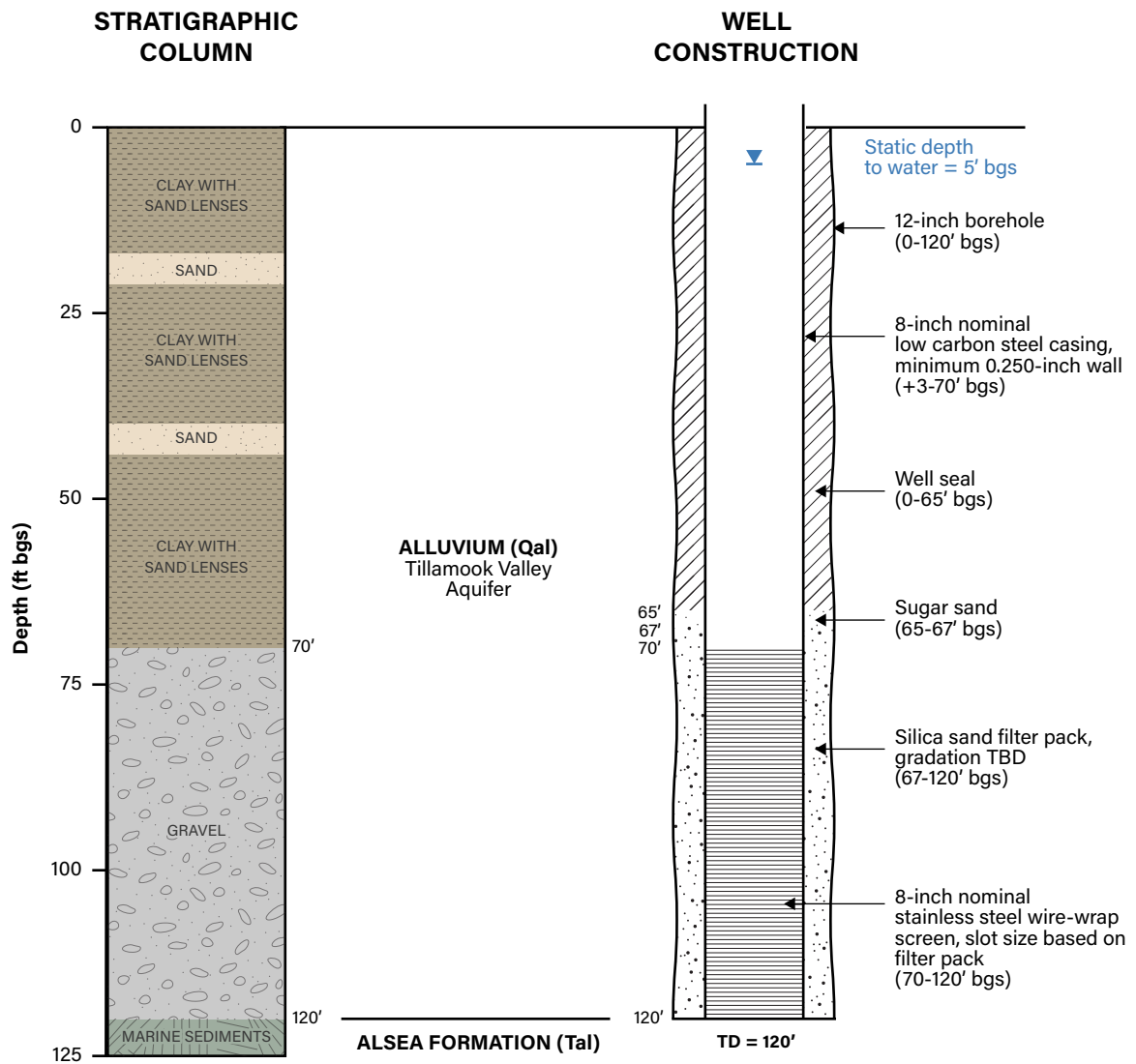
NOTES

amsl: above mean sea level
gpm: gallons per minute
POTB: Port of Tillamook Bay
TD: total depth
NA: no data available



FIGURE 3-3
Cross Section B-B'
Port of Tillamook Bay
Groundwater Feasibility Study





NOTES

Stratigraphic column is a generalization of the geology from the TILL 654, TILL 655, TILL 652, and TILL 51981 driller logs.

Notes for MSA:

1. Pumping capacity is assumed to be 100 to 150 gpm per well.
2. Assume pump is set above the screen at 69 feet bgs. Make necessary assumptions about net positive suction head to estimate pumping level.

bgs: below ground surface
gpm: gallons per minute
TBD: to be determined
TD: total depth

FIGURE 4-1

Conceptual Well Diagram
Port of Tillamook Bay

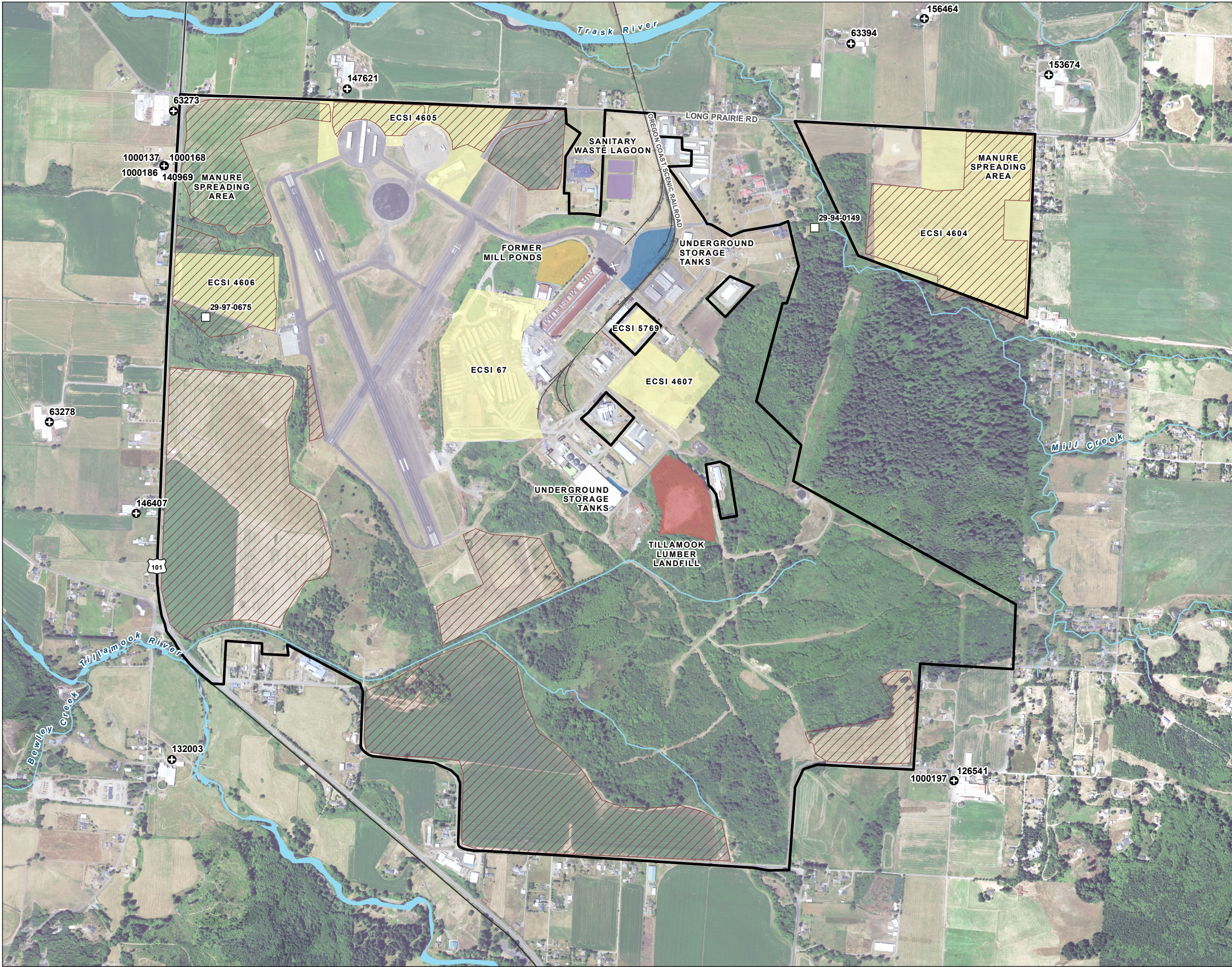


FIGURE 4-2
Potential Contaminant Sources
Port of Tillamook Bay
Groundwater Feasibility Study

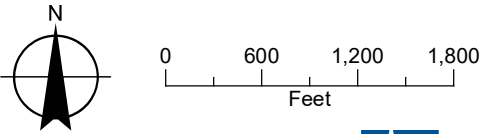
LEGEND

Potential Contaminant Sources

- ⊕ Confined Animal Feeding Operation (CAFOs)
- Leaking Underground Storage Tank (LUST)
- Yellow fill Environmental Cleanup Site Information (ECSI) Site
- Orange diagonal lines Former Mill Pond
- Red fill Timber Lumber Landfill
- Purple fill Sanitary Waste Lagoon
- Blue fill Underground Storage Tanks
- Orange diagonal lines Manure Spreading Area

All Other Features

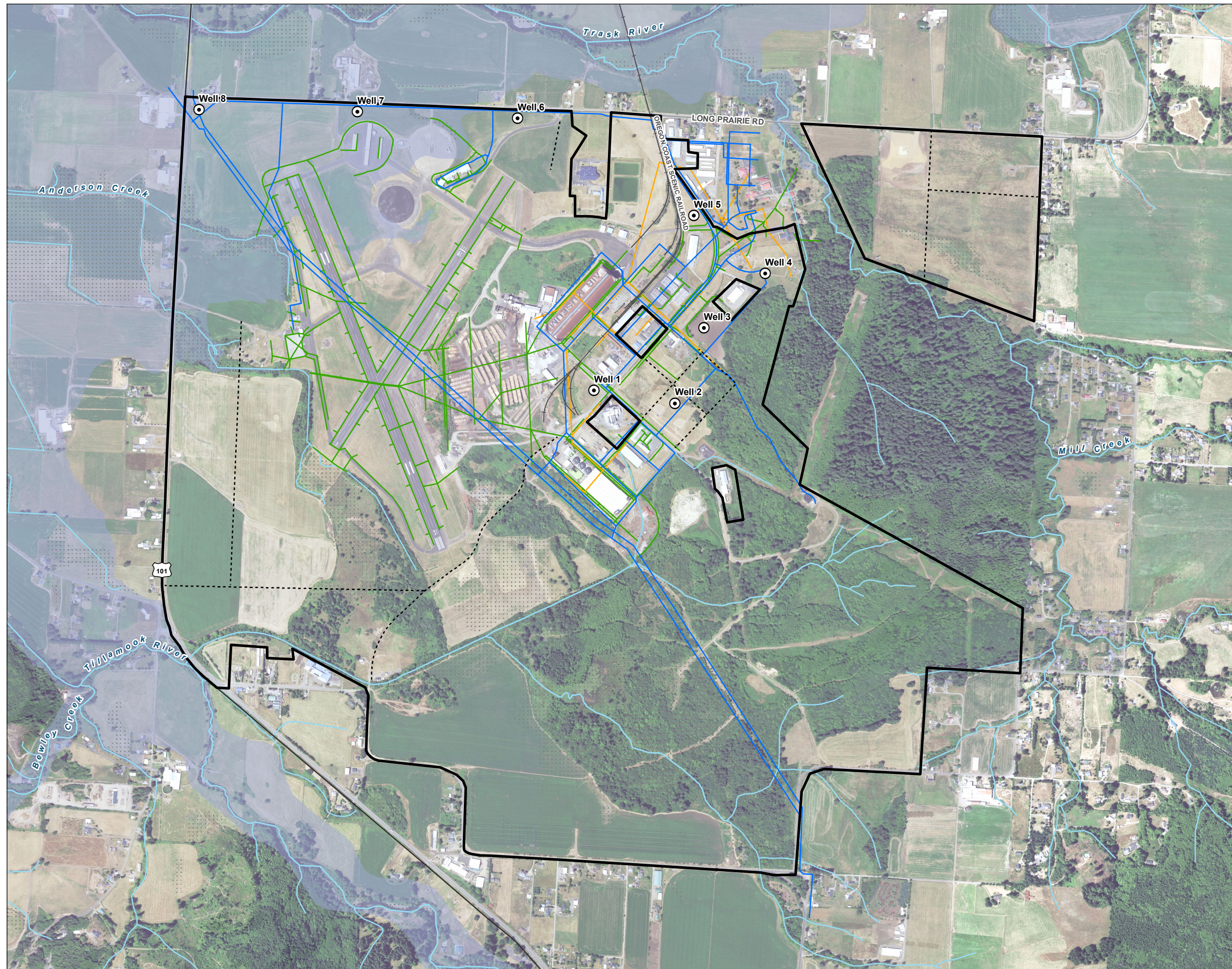
- Black outline Port of Tillamook Bay Property Boundary
- Thick black line Major Road
- Thin black line Railroad
- Blue line Watercourse
- Blue fill Waterbody



Date: June 8, 2023
Data Sources: BLM, ESRI, ODOT, USGS, OWRD,
OSIP Imagery (2018), DEQ (2022), POTB (2020),
FEMA (2021)



FIGURE 4-3
New Water Well Locations
 Port of Tillamook Bay
 Groundwater Feasibility Study



LEGEND

Well

Utilities

Stormwater

Water

Sanitary Sewer

All Other Features

Port of Tillamook Bay Property Boundary

Wetland

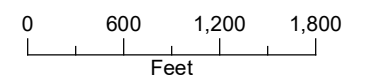
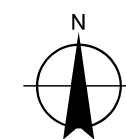
100-Year Floodplain

Major Road

Possible Road Option

Railroad

Watercourse



Date: June 8, 2023
 Data Sources: BLM, ESRI, ODOT, USGS, OWRD,
 OSIP Imagery (2018), DEQ (2022), POTB (2020),
 FEMA (2021)



ATTACHMENT A

Construction and Testing Data From Vicinity Water Wells

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Attachment A. Construction and Testing Data From Vicinity Water Wells.

Port of Tillamook Bay Groundwater Feasibility Study.

Well ID	TWN	RNG	SEC	Q	QQ	Well Depth (feet bgs)	Diameter	Completion	Test type	Well Yield (gpm)	Drawdown (feet)	Testing Notes	name_last	name_first	name_company	type_of_log	depth_first_water	post_static_water_level	complete_date
TILL 532	1S	9W	32	SE	SW	70	8-inch (casing)	–	Pumping	200	2		LEONNIG	ELBERT E		W		12	12/31/1951
TILL 533	1S	9W	32	SW	SE	118	8-inch (casing)	–	Pumping	200	4		JACOB	CYRIL A	JACOB, LORETTA	W		10	12/31/1938
TILL 536	1S	9W	33			70	6-inch (casing) 4-inch (perfs)	Perforations (40 - 70)	Airlift	9	37		RAY	KENNETH		W		23	11/27/1979
TILL 537	1S	9W	33			47	6-inch (casing)	Open Pipe	Airlift	40	15		TIPPEN	WILLIAM		W		20	3/17/1970
TILL 538	1S	9W	33	NW	SW	24	8-inch (casing)	–	Pumping	200	4		VAN LOO	ARTHUR W		W		15	12/31/1945
TILL 50746	1S	9W	33	NE	SW	120	8-inch (casing) 8-inch (perfs)	Perforations (31 - 95) Open Hole (114 - 120)	Airlift	62	90				SILVERMIST FARM	W	20	10	7/12/2000
TILL 651	2S	9W	4			68	6-inch (casing) 6-inch (perfs)	Perforations (63 - 68)	Airlift	40	30		ALCAZAR	PORFIRIO		W	45	8	9/26/1978
TILL 652	2S	9W	4	NE	SW	135	6-inch (casing) 6-inch (perfs)	Perforations (44 - 144) Open Hole (116 - 135)	Bailer	150	70				GENERAL FOODS CORP.; BIRDS EYE	W		25	3/21/1968
TILL 653	2S	9W	4	NE	SE	145	6-inch (casing) 6-inch (perfs)	Perforations (30 - 140)	Pumping	200	100				GENERAL FOODS CORP.; BIRDS EYE	W		8	3/2/1968
TILL 654	2S	9W	5	SW	NW	147	16-inch (casing) 16-inch (perfs)	Perforations (88 - 93) Perforations (135 - 140)	Pumping	1320	66	10-hour aquifer test			TILLAMOOK WATER COMMISSION	W		21	7/29/1958
TILL 666	2S	9W	8			140	6-inch (casing) 6-inch (perfs)	Perforations (26 - 66) Open Hole (66 - 140)	Bailer	100	85				GENERAL FOODS CORP.; BIRDS EYE	W		10	3/5/1968
TILL 668	2S	9W	8			60	6-inch (casing) 6-inch (perfs)	Perforations (32 - 43) Open Hole (47 - 87)	Bailer	20	26		PESTERFIELD	C		W		14	6/10/1958
TILL 1316	2S	9W	5	SE	NW	62	8-inch (casing)	Open Hole (52 - 62)	Airlift	55	41	1-hour test	DYCK	JOHN		W	11	9	5/30/1995
TILL 50053	2S	9W	4	SE	NW	109	8-inch (casing) 8-inch (perfs)	Perforations (57 - 81) Open Hole (84 - 109)	Airlift	100	–	1-hour test	PENNEY	DAVID	PENNEY, PATRICIA	W	22	22	6/20/1996
TILL 50930	2S	9W	9	SE	SE	105	8-inch (casing) 6-inch (perfs)	Perforations (105 - 160)	Airlift	60	75	1-hour test			SODINO PROPERTIES	W	12	15	10/23/2001
TILL 51330	2S	9W	4	NW	NE	122	6-inch (casing) 6-inch (perfs)	Perforations (80 - 118) Open Hole (118 - 122)	Airlift	40	71	1-hour test			TILL A BAY FARM	W	11	19	7/27/2004
TILL 51981	2S	9W	4	NW	SW	65	6-inch (casing)	Open Hole (38 - 65)	Airlift	40	45	1-hour test			PORT OF TILLAMOOK BAY	W	6	14	4/21/2009

ATTACHMENT B

Water Quality Data for the Port's Existing Well (TILL 51981)

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Attachment B. Water Quality Data from the Port's Existing Well (TILL 51981)

Port of Tillamook Bay Groundwater Feasibility Study.

	Analyte	Unit	MCL	TILL 51981	
				Result	Sampling Date
Synthetic Organic Compounds	1,2-Dibromo-3-Chloropropane	mg/L	0.0002	ND	5/23/2022
	2,4,5-TP	mg/L	0.05	ND	5/23/2022
	2,4-D	mg/L	0.07	ND	5/23/2022
	Atrazine	mg/L	0.003	ND	5/23/2022
	Benzo(A)Pyrene	mg/L	0.0002	ND	5/23/2022
	Bhc-Gamma	mg/L	0.0002	ND	5/23/2022
	Carbofuran	mg/L	0.04	ND	5/23/2022
	Chlordane	mg/L	0.002	ND	5/23/2022
	Dalapon	mg/L	0.2	ND	5/23/2022
	Di(2-Ethylhexyl) Adipate	mg/L	0.4	ND	5/23/2022
	Di(2-Ethylhexyl) Phthalate	mg/L	0.006	ND	5/23/2022
	Dinoseb	mg/L	0.007	ND	5/23/2022
	Diquat	mg/L	0.02	ND	5/23/2022
	Endothall	mg/L	0.1	ND	5/23/2022
	Endrin	mg/L	0.002	ND	5/23/2022
	Ethylene Dibromide	mg/L	0.00005	ND	5/23/2022
	Glyphosate	mg/L	0.7	ND	5/23/2022
	Heptachlor	mg/L	0.0004	ND	5/23/2022
	Heptachlor Epoxide	mg/L	0.0002	ND	5/23/2022
	Hexachlorobenzene	mg/L	0.001	ND	5/23/2022
	Hexachlorocyclopentadiene	mg/L	0.05	ND	5/23/2022
	Lasso	mg/L	0.002	ND	5/23/2022
	Methoxychlor	mg/L	0.04	ND	5/23/2022
	Oxamyl	mg/L	0.2	ND	5/23/2022
	Pentachlorophenol	mg/L	0.001	ND	5/23/2022
	Picloram	mg/L	0.5	ND	5/23/2022
	Simazine	mg/L	0.004	ND	5/23/2022
	Total Polychlorinated Biphenyls (PCB)	mg/L	0.0005	ND	5/23/2022
	Toxaphene	mg/L	0.003	ND	5/23/2022
Volatile Organic Compounds	1,1,1-Trichloroethane	mg/L	0.2	ND	5/23/2022
	1,1,2-Trichloroethane	mg/L	0.005	ND	5/23/2022
	1,1-Dichloroethylene	mg/L	0.007	ND	5/23/2022
	1,2,4-Trichlorobenzene	mg/L	0.07	ND	5/23/2022
	1,2-Dichloroethane	mg/L	0.005	ND	5/23/2022
	1,2-Dichloropropane	mg/L	0.005	ND	5/23/2022
	Benzene	mg/L	0.005	ND	5/23/2022
	Carbon Tetrachloride	mg/L	0.005	ND	5/23/2022
	Chlorobenzene	mg/L	0.1	ND	5/23/2022
	cis-1,2-Dichloroethylene	mg/L	0.07	ND	5/23/2022
	Dichloromethane	mg/L	0.005	ND	5/23/2022
	Ethylbenzene	mg/L	0.7	ND	5/23/2022
	o-Dichlorobenzene	mg/L	0.6	ND	5/23/2022
	p-Dichlorobenzene	mg/L	0.075	ND	5/23/2022
	Styrene	mg/L	0.1	ND	5/23/2022
	Tetrachloroethylene	mg/L	0.005	ND	5/23/2022
	Toluene	mg/L	1	ND	5/23/2022
	Trans-1,2-Dichloroethylene	mg/L	0.1	ND	5/23/2022
	Trichloroethylene	mg/L	0.005	ND	5/23/2022
	Vinyl Chloride	mg/L	0.002	ND	5/23/2022
	Xylenes, Total	mg/L	10	ND	5/23/2022

Attachment B. Water Quality Data from the Port's Existing Well (TILL 51981)

Port of Tillamook Bay Groundwater Feasibility Study.

	Analyte	Unit	MCL	TILL 51981	
				Result	Sampling Date
Rads	Combined Radium (-226 & -228)	PCI/L	5	ND	5/23/2022
	Combined Uranium	mg/L	0.03	ND	5/23/2022
	Gross Alpha, Excl. Radon & U	PCI/L	15	ND	5/23/2022
Metals	Antimony, Total	mg/L	0.006	ND	5/23/2022
	Arsenic	mg/L	0.01	ND	5/23/2022
	Arsenic	mg/L	2	ND	5/23/2022
	Beryllium, Total	mg/L	0.004	ND	5/23/2022
	Cadmium	mg/L	0.005	ND	5/23/2022
	Chromium	mg/L	0.1	ND	5/23/2022
	Cyanide	mg/L	0.2	ND	5/23/2022
	Fluoride	mg/L	4	0.05	5/23/2022
	Iron	mg/L	--	0.83	5/23/2022
	Magnesium	mg/L	--	4.9	5/24/2022
	Manganese	mg/L	--	0.0063	5/25/2022
	Mercury	mg/L	0.002	ND	5/23/2022
	Nickel	mg/L	0.1	ND	5/23/2022
	Nitrate ²	mg/L	10	1.1	5/23/2022
	Nitrate-Nitrite ²	mg/L	10	1.1	5/23/2022
	Nitrite	mg/L	1	ND	5/23/2022
	Selenium	mg/L	0.05	ND	5/23/2022
	Sodium	mg/L		8	5/23/2022
	Thallium, Total	mg/L	0.002	ND	5/23/2022
	Silver	mg/L	0.1	ND	5/23/2022
Microbial	Total Coliform ²	MPN/100mL	0	5.2	5/23/2022
Miscellaneous	Calcium	mg/L	--	12	5/23/2022
	Chloride	mg/L	--	4.4	5/23/2022
	Hardness as CaCO3	mg/L	--	50	5/23/2022
	pH ¹	--	--	6.67	5/23/2022
	Silica	mg/L	--	27	5/23/2022
	Sulfate	mg/L	--	1.2	5/23/2022
	Total Dissolved Solids (TDS) ²	mg/L	--	84	5/23/2022
	Total Organic Carbon (TOC)	mg/L	--	0.375	5/23/2022
	Total Suspended Solids (TSS) ²	mg/L	--	8	5/23/2022

Notes

¹ Field measured pH

² Measured outside of acceptable hold time

mg/L = milligrams per liter

MPN = most probable number

ANALYTICAL REPORT

Eurofins Eaton Monrovia
750 Royal Oaks Drive
Suite 100
Monrovia, CA 91016
Tel: (626)386-1100

Laboratory Job ID: 380-2284-1

Client Project/Site: Port of Tillamook

For:

Groundwater Solutions, Inc.
55 SW Yamhill Street
Portland, Oregon 97204

Attn: Rodrigo Prugue



Authorized for release by:

8/21/2022 1:07:23 PM

Vanessa Berry, Project Manager
(626)386-1100

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Results relate only to the items tested and the sample(s) as received by the laboratory.

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1. Laboratory is accredited in accordance with TNI 2016 Standards and ISO/IEC 17025:2017.
2. Laboratory certifies that the test results meet all TNI 2016 and ISO/IEC 17025:2017 requirements unless noted under the individual analysis
3. Test results relate only to the sample(s) tested.
4. This report shall not be reproduced except in full, without the written approval of the laboratory.
5. Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below. (DW,Water matrices)



Vanessa Berry
Project Manager
8/21/2022 1:07:23 PM

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Definitions/Glossary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Qualifiers

GC/MS VOA

Qualifier	Qualifier Description
*-	LCS and/or LCSD is outside acceptance limits, low biased.

GC/MS Semi VOA

Qualifier	Qualifier Description
*-	LCS and/or LCSD is outside acceptance limits, low biased.
*1	LCS/LCSD RPD exceeds control limits.
^3+	Reporting Limit Check Standard is outside acceptance limits, high biased
F1	MS and/or MSD recovery exceeds control limits.
F2	MS/MSD RPD exceeds control limits

GC Semi VOA

Qualifier	Qualifier Description
F1	MS and/or MSD recovery exceeds control limits.
p	The %RPD between the primary and confirmation column/detector is >40%. The lower value has been reported.

HPLC/IC

Qualifier	Qualifier Description
^3-	Reporting Limit Check Standard is outside acceptance limits, low biased.
H	Sample was prepped or analyzed beyond the specified holding time

Metals

Qualifier	Qualifier Description
^2	Calibration Blank (ICB and/or CCB) is outside acceptance limits.
J	Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

General Chemistry

Qualifier	Qualifier Description
^2	Calibration Blank (ICB and/or CCB) is outside acceptance limits.
B	Analyte was found in the associated method blank.
H	Sample was prepped or analyzed beyond the specified holding time
H3	Sample was received and analyzed past holding time.
HF	Field parameter with a holding time of 15 minutes. Test performed by laboratory at client's request.

Rad

Qualifier	Qualifier Description
F1	MS and/or MSD recovery exceeds control limits.
U	Result is less than the sample detection limit.

Biology

Qualifier	Qualifier Description
H	Sample was prepped or analyzed beyond the specified holding time
H3	Sample was received and analyzed past holding time.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
α	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)

Definitions/Glossary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Glossary (Continued)

Abbreviation	These commonly used abbreviations may or may not be present in this report.
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Job ID: 380-2284-1

Laboratory: Eurofins Eaton Monrovia

Narrative

Job Narrative 380-2284-1

Comments

No additional comments.

Receipt

The samples were received on 5/25/2022 11:00 AM. Unless otherwise noted below, the samples arrived in good condition, and where required, properly preserved and on ice. The temperatures of the 2 coolers at receipt time were 3.0° C and 3.8° C.

Receipt Exceptions

The Chain-of-Custody (COC) was incomplete as received and/or improperly completed. Missing Sample Site ID, collection date, and collection time. Information taken from bottles and vials received.

GC/MS VOA

Method 524.2: The LCS associated with batch 380-4928 recovered outside acceptance criteria, low biased, for several analytes. A minimum reporting limit (MRL) standard was analyzed, and the target analytes are detected. Since the associated samples were non-detect for the analyte(s), the data are reported with the appropriate flags. The holding time for the samples has now been exceeded.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

GC/MS Semi VOA

Method 525.2: The method blank for preparation batch 380-4751 and analytical batch 380-4924 contained Butylbenzylphthalate above the method detection limit (MDL). Associated samples were not re-analyzed because results were less than the reporting limit (RL).

Method 525.2: The laboratory control sample (LCS) and / or laboratory control sample duplicate (LCSD) for preparation batch 380-4751 and analytical batch 380-4924 recovered outside control limits for the following analytes: Caffeine. These analytes were biased low in the LCS. Samples are past hold time for re-extraction.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

HPLC/IC

Method 300.0: Sample 380-2284-AG-1 was flagged H out of hold time. Unsure when the sample was received, the afternoon analyst did not document if received within hold time or out of hold time.

Sample 380-2199-A-1 was used as the MS/MSD, the recovery for NO2 in the native sample was 0.0000 ppm, with a 5x dilution, and it was spiked at a concentration of 0.50ppm. The recovery for the MS was 71% and for the MSD 72%, the MS/MSD exceeded the acceptance range of 80-120%. Parent sample was flagged M2.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

GC Semi VOA

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

RAD

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Metals

Method 200.8: The continuing calibration blanks (CCB)s for analytical batch 4917 contained Silver above the reporting limit (RL). All reported samples associated with this CCB were either ND for this analyte or contained this analyte at a concentration greater than 10X the value found in the CCB; therefore, re-analysis of samples was not performed.

Methods 200.7, 200.7 Rev 4.4: The continuing calibration blank (CCB) for analytical batch 380-5299 contained Sodium above the method

Case Narrative

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Job ID: 380-2284-1 (Continued)

Laboratory: Eurofins Eaton Monrovia (Continued)

detection limit (MDL). All reported samples associated with this CCB were either ND for this analyte or contained this analyte at a concentration greater than 10X the value found in the CCB; therefore, re-analysis of samples was not performed.

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

General Chemistry

Method SM 5540C: Method 5540C required MS/MSD and/or duplicate QC were prepared and analyzed at required batch frequency for analytical batch 380-5547 using samples from other delivery groups, and are not reported with this project.

Sample 202205240011B was used for the MS/MSD recovery, the percent recoveries were, 88.5% and 80.6%.

The acceptable recovery range for MS/MSD is 80-120%.

The LCS/LCSD percent recoveries were, 99.2% and 103.1%.

The acceptable recovery ranges for LCS/LCSD are 90-110% recovery.

Method SM 5540C: The following sample(s) was analyzed outside of analytical holding time due to sample being received close to when the hold time was up for the bottle. The analyst was not alerted that the sample was close to being out of hold. Sample has been analyzed and flagged in this run: TILL51981_05.23.22 (380-2284-1).

Method SM 2540D: .

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Biology

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Organic Prep

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Detection Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Analyte	Result	Qualifier	RL	Unit	Dil Fac	D	Method	Prep Type
Chloride	4.4		0.50	mg/L	1		300.0	Total/NA
Nitrate as N	1.1	H ^3-	0.050	mg/L	1		300.0	Total/NA
Nitrate Nitrite as N	1.1	H ^3-	0.050	mg/L	1		300.0	Total/NA
Sulfate	1.2		0.25	mg/L	1		300.0	Total/NA
Calcium	12		1.0	mg/L	1		200.7	Total Recoverable
Iron	0.83		0.010	mg/L	1		200.7	Total Recoverable
Magnesium	4.9		0.10	mg/L	1		200.7	Total Recoverable
Silica	27		0.43	mg/L	1		200.7	Total Recoverable
Sodium	8.0	^2	1.0	mg/L	1		200.7	Total Recoverable
Manganese	6.3		2.0	ug/L	1		200.8	Total Recoverable
Hardness (as CaCO3)	50		3.0	mg/L	1		SM 2340B	Total/NA
Calcium hardness as CaCO3	30		2.5	mg/L	1		SM 2340B	Total/NA
Magnesium hardness as calcium carbonate	20		0.80	mg/L	1		SM 2340B	Total/NA
Total Cations	1.0		0.0010	meq/L	1		Total Cation	Total/NA
Total Cations	1.4			meq/L	1		1030E	Total/NA
Total Anions	1.3			meq/L	1		1030E	Total/NA
Percent Difference	3.1			%	1		1030E	Total/NA
Anion/Cation Balance	3.1			%	1		1030E	Total/NA
Calculated TDS	2.2			mg/L	1		1030E	Total/NA
TDS Ratio	39			NONE	1		1030E	Total/NA
pH of CaCO3 saturation (25C)	8.6			SU	1		None	Total/NA
Langelier Index at 25C	-1.1			NONE	1		None	Total/NA
Color, Apparent	10	H	2.0	Color Units	1		SM 2120B	Total/NA
Alkalinity	52		2.0	mg/L	1		SM 2320B	Total/NA
Bicarbonate Alkalinity as CaCO3	52	B ^2	2.0	mg/L	1		SM 2320B	Total/NA
Calcium	12			mg/L	1		SM 2330B	Total/NA
Alkalinity	52			mg/L	1		SM 2330B	Total/NA
Total Dissolved Solids	84			mg/L	1		SM 2330B	Total/NA
Langelier Index	-0.96			LangSU	1		SM 2330B	Total/NA
Field pH	7.5			SU	1		SM 2330B	Total/NA
Field Temperature	25			Celsius	1		SM 2330B	Total/NA
Total Dissolved Solids	84	H	20	mg/L	1		SM 2540C	Total/NA
Total Suspended Solids	8.0	H	5.0	mg/L	1		SM 2540D	Total/NA
Fluoride	0.050		0.050	mg/L	1		SM 4500 F C	Total/NA
pH	7.5	HF		S.U.	1		SM 4500 H+ B	Total/NA
Total Organic Carbon	0.375		0.200	mg/L	1		SM 5310C	Total/NA
Total Anions	1.3		0.0010	meq/L	1		Total Anions	Total/NA
Coliform, Total	5.2	H H3	1.0	MPN/100mL	1		9223B	Total/NA

NOTE: The "Field pH" of 7.5 was measured in the lab, and is therefore different than the pH of 6.73 measured in the field. In this report, Eurofins is assuming that the "Field pH" is equal to the "pH" measured in the lab.

This Detection Summary does not include radiochemical test results.

Eurofins Eaton Monrovia

Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: 524.2 - Volatile Organic Compounds (GC/MS)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Dichlorodifluoromethane	ND	*-	0.50	ug/L			06/02/22 18:22	1
Chloromethane (methyl chloride)	ND	*-	0.50	ug/L			06/02/22 18:22	1
Vinyl Chloride (VC)	ND	*-	0.30	ug/L			06/02/22 18:22	1
Bromomethane (Methyl Bromide)	ND	*-	0.50	ug/L			06/02/22 18:22	1
Chloroethane	ND	*-	0.50	ug/L			06/02/22 18:22	1
Trichlorofluoromethane (Freon 11)	ND	*-	0.50	ug/L			06/02/22 18:22	1
1,1-Dichloroethylene	ND		0.50	ug/L			06/02/22 18:22	1
Bromoethane	ND		0.50	ug/L			06/02/22 18:22	1
Trichlorotrifluoroethane	ND		0.50	ug/L			06/02/22 18:22	1
Carbon disulfide	ND		0.50	ug/L			06/02/22 18:22	1
Dichloromethane	ND		0.50	ug/L			06/02/22 18:22	1
trans-1,2-Dichloroethylene	ND		0.50	ug/L			06/02/22 18:22	1
Methyl-tert-butyl Ether (MTBE)	ND		0.50	ug/L			06/02/22 18:22	1
1,1-Dichloroethane	ND		0.50	ug/L			06/02/22 18:22	1
2-Butanone (MEK)	ND		5.0	ug/L			06/02/22 18:22	1
Diisopropyl ether	ND		3.0	ug/L			06/02/22 18:22	1
cis-1,2-Dichloroethylene	ND		0.50	ug/L			06/02/22 18:22	1
2,2-Dichloropropane	ND	*-	0.50	ug/L			06/02/22 18:22	1
Bromochloromethane	ND		0.50	ug/L			06/02/22 18:22	1
Chloroform (Trichloromethane)	ND		0.50	ug/L			06/02/22 18:22	1
Tert-butyl ethyl ether	ND		3.0	ug/L			06/02/22 18:22	1
1,1,1-Trichloroethane	ND		0.50	ug/L			06/02/22 18:22	1
1,2-Dichloroethane	ND		0.50	ug/L			06/02/22 18:22	1
1,1-Dichloropropene	ND		0.50	ug/L			06/02/22 18:22	1
Benzene	ND		0.50	ug/L			06/02/22 18:22	1
Carbon tetrachloride	ND	*-	0.50	ug/L			06/02/22 18:22	1
Tert-amyl methyl ether	ND		3.0	ug/L			06/02/22 18:22	1
Trichloroethylene (TCE)	ND		0.50	ug/L			06/02/22 18:22	1
1,2-Dichloropropane	ND		0.50	ug/L			06/02/22 18:22	1
Dibromomethane	ND		0.50	ug/L			06/02/22 18:22	1
Bromodichloromethane	ND		0.50	ug/L			06/02/22 18:22	1
cis-1,3-Dichloropropene	ND	*-	0.50	ug/L			06/02/22 18:22	1
trans-1,3-Dichloropropene	ND	*-	0.50	ug/L			06/02/22 18:22	1
Toluene	ND		0.50	ug/L			06/02/22 18:22	1
1,1,2-Trichloroethane	ND		0.50	ug/L			06/02/22 18:22	1
2-Hexanone	ND		10	ug/L			06/02/22 18:22	1
1,3-Dichloropropane	ND		0.50	ug/L			06/02/22 18:22	1
Chlorodibromomethane	ND	*-	0.50	ug/L			06/02/22 18:22	1
Tetrachloroethene (PCE)	ND		0.50	ug/L			06/02/22 18:22	1
Chlorobenzene	ND		0.50	ug/L			06/02/22 18:22	1
1,1,1,2-Tetrachloroethane	ND		0.50	ug/L			06/02/22 18:22	1
Ethylbenzene	ND		0.50	ug/L			06/02/22 18:22	1
m,p-Xylenes	ND		0.50	ug/L			06/02/22 18:22	1
Styrene	ND	*-	0.50	ug/L			06/02/22 18:22	1
o-Xylene	ND		0.50	ug/L			06/02/22 18:22	1
Bromoform	ND	*-	0.50	ug/L			06/02/22 18:22	1
1,1,2,2-Tetrachloroethane	ND		0.50	ug/L			06/02/22 18:22	1
1,2,3-Trichloropropane	ND		0.50	ug/L			06/02/22 18:22	1
Isopropylbenzene	ND		0.50	ug/L			06/02/22 18:22	1

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Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Bromobenzene	ND		0.50	ug/L			06/02/22 18:22	1
N-Propylbenzene	ND	*-	0.50	ug/L			06/02/22 18:22	1
o-Chlorotoluene	ND		0.50	ug/L			06/02/22 18:22	1
p-Chlorotoluene	ND		0.50	ug/L			06/02/22 18:22	1
1,3,5-Trimethylbenzene	ND	*-	0.50	ug/L			06/02/22 18:22	1
tert-Butylbenzene	ND		0.50	ug/L			06/02/22 18:22	1
1,2,4-Trimethylbenzene	ND	*-	0.50	ug/L			06/02/22 18:22	1
sec-Butylbenzene	ND	*-	0.50	ug/L			06/02/22 18:22	1
m-Dichlorobenzene (1,3-DCB)	ND		0.50	ug/L			06/02/22 18:22	1
p-Dichlorobenzene (1,4-DCB)	ND		0.50	ug/L			06/02/22 18:22	1
p-Isopropyltoluene	ND	*-	0.50	ug/L			06/02/22 18:22	1
o-Dichlorobenzene (1,2-DCB)	ND		0.50	ug/L			06/02/22 18:22	1
n-Butylbenzene	ND		0.50	ug/L			06/02/22 18:22	1
1,2,4-Trichlorobenzene	ND		0.50	ug/L			06/02/22 18:22	1
Naphthalene	ND		0.50	ug/L			06/02/22 18:22	1
Hexachlorobutadiene	ND		0.50	ug/L			06/02/22 18:22	1
1,2,3-Trichlorobenzene	ND		0.50	ug/L			06/02/22 18:22	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
1,2-Dichloroethane-d4 (Surr)	104		70 - 130		06/02/22 18:22	1
4-Bromofluorobenzene (Surr)	92		70 - 130		06/02/22 18:22	1
Toluene-d8 (Surr)	89		70 - 130		06/02/22 18:22	1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
2,4-Dinitrotoluene	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Acenaphthylene	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Alachlor (Alanex)	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
alpha-Chlordane	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Anthracene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 23:03	1
Atrazine	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Benz(a)anthracene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Benzo[a]pyrene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 23:03	1
Benzo[b]fluoranthene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 23:03	1
Benzo[g,h,i]perylene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Benzo[k]fluoranthene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 23:03	1
Bromacil	ND	*1	0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Butachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Butylbenzylphthalate	ND	^3+	0.00049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Caffeine	ND	*1 *-	0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Chrysene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 23:03	1
Di(2-ethylhexyl)adipate	ND		0.00059	mg/L		05/31/22 10:38	06/03/22 23:03	1
Bis(2-ethylhexyl) phthalate	ND		0.00059	mg/L		05/31/22 10:38	06/03/22 23:03	1
Diazinon (Qualitative)	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Dibenz(a,h)anthracene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Dieldrin	ND		0.00020	mg/L		05/31/22 10:38	06/03/22 23:03	1
Diethylphthalate	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Dimethoate	ND	*1 *-	0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Dimethylphthalate	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Di-n-butyl phthalate	ND		0.00098	mg/L		05/31/22 10:38	06/03/22 23:03	1

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Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Endrin	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Fluoranthene	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Fluorene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
gamma-Chlordane	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Heptachlor	ND	^3+	0.000039	mg/L		05/31/22 10:38	06/03/22 23:03	1
Heptachlor epoxide (isomer B)	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Hexachlorobenzene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Hexachlorocyclopentadiene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Indeno[1,2,3-cd]pyrene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Isophorone	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Lindane	ND		0.000039	mg/L		05/31/22 10:38	06/03/22 23:03	1
Methoxychlor	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Metolachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Metribuzin	ND	*1	0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Molinate	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1
Phenanthrene	ND		0.000039	mg/L		05/31/22 10:38	06/03/22 23:03	1
Propachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Pyrene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Simazine	ND	*1	0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Thiobencarb	ND		0.00020	mg/L		05/31/22 10:38	06/03/22 23:03	1
trans-Nonachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 23:03	1
Trifluralin	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 23:03	1

Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
2-Nitro-m-xylene	97		70 - 130	05/31/22 10:38	06/03/22 23:03	1
Triphenylphosphate	117		70 - 130	05/31/22 10:38	06/03/22 23:03	1
Perylene-d12	98		70 - 130	05/31/22 10:38	06/03/22 23:03	1

Method: 548.1 - Endothall (GC/MS)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Endothall	ND		0.0050	mg/L		05/27/22 13:32	06/06/22 16:18	1

Method: 505 - Organochlorine Pesticides/PCBs (GC)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Chlordane	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Endrin	ND		0.000010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Heptachlor	ND		0.000010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Heptachlor epoxide (isomer B)	ND		0.000010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Methoxychlor	ND		0.000050	mg/L		05/27/22 20:00	05/28/22 06:15	1
Lindane	ND		0.000010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Alachlor (Alanex)	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Toxaphene	ND		0.00050	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1016	ND		0.000070	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1221	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1232	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1242	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1248	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1254	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1
PCB-1260	ND		0.000070	mg/L		05/27/22 20:00	05/28/22 06:15	1
Polychlorinated biphenyls, Total	ND		0.00010	mg/L		05/27/22 20:00	05/28/22 06:15	1

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Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: 505 - Organochlorine Pesticides/PCBs (GC) (Continued)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Aldrin	ND		0.000010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Dieldrin	ND		0.000010	mg/L		05/27/22 20:00	05/28/22 06:15	1
Surrogate	%Recovery	Qualifier	Limits			Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene	121		70 - 130			05/27/22 20:00	05/28/22 06:15	1

Method: 515.4 - Herbicides (GC)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
2,4,5-TP (Silvex)	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 06:39	1
2,4,5-T	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 06:39	1
Dinoseb	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 06:39	1
2,4-D	ND		0.00010	mg/L		06/01/22 09:30	06/04/22 06:39	1
2,4-DB	ND		0.0020	mg/L		06/01/22 09:30	06/04/22 06:39	1
Bentazon	ND		0.00050	mg/L		06/01/22 09:30	06/04/22 06:39	1
Pentachlorophenol	ND		0.000040	mg/L		06/01/22 09:30	06/04/22 06:39	1
Dalapon	ND		0.0010	mg/L		06/01/22 09:30	06/04/22 06:39	1
3,5-Dichlorobenzoic acid	ND		0.00050	mg/L		06/01/22 09:30	06/04/22 06:39	1
Picloram	ND		0.00010	mg/L		06/01/22 09:30	06/04/22 06:39	1
Acifluorfen	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 06:39	1
Dicamba	ND		0.00010	mg/L		06/01/22 09:30	06/04/22 06:39	1
Dichlorprop	ND		0.00050	mg/L		06/01/22 09:30	06/04/22 06:39	1
Surrogate	%Recovery	Qualifier	Limits			Prepared	Analyzed	Dil Fac
2,4-Dichlorophenylacetic acid (Surr)	104		70 - 130			06/01/22 09:30	06/04/22 06:39	1

Method: 551.1 - Chlorinated Disinfection Byproducts and Solvents (GC)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ethylene Dibromide (EDB)	ND		0.0000099	mg/L		06/06/22 10:24	06/06/22 19:57	1
Dibromochloropropane (DBCP)	ND		0.0000099	mg/L		06/06/22 10:24	06/06/22 19:57	1
Surrogate	%Recovery	Qualifier	Limits			Prepared	Analyzed	Dil Fac
1,2-Dibromopropane (Surr)	109		80 - 120			06/06/22 10:24	06/06/22 19:57	1

Method: 300.0 - Anions, Ion Chromatography

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	4.4		0.50	mg/L			05/25/22 17:10	1
Nitrate as N	1.1	H ^3-	0.050	mg/L			05/25/22 17:10	1
Nitrate Nitrite as N	1.1	H ^3-	0.050	mg/L			05/25/22 17:10	1
Sulfate	1.2		0.25	mg/L			05/25/22 17:10	1
Nitrite as N	ND	H ^3-	0.050	mg/L			05/25/22 17:10	1

Method: 531.2 - Carbamate Pesticides (HPLC)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
3-Hydroxycarbofuran	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Aldicarb	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Aldicarb sulfone	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Aldicarb sulfoxide	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Baygon	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Carbaryl	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Carbofuran	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Methiocarb	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1

Eurofins Eaton Monrovia

Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: 531.2 - Carbamate Pesticides (HPLC) (Continued)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Methomyl	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Oxamyl	ND		0.50	ug/L		05/26/22 12:22	05/27/22 20:55	1
Surrogate	%Recovery	Qualifier	Limits			Prepared	Analyzed	Dil Fac
BDMC	105		70 - 130			05/26/22 12:22	05/27/22 20:55	1

Method: 547 - Glyphosate (DAI HPLC)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Glyphosate	ND		6.0	ug/L		06/01/22 09:36	06/01/22 15:44	1

Method: 549.2 - Diquat and Paraquat (HPLC)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Diquat	ND		0.00040	mg/L		05/27/22 18:16	06/01/22 23:36	1
Paraquat	ND		0.0020	mg/L		05/27/22 18:16	06/01/22 23:36	1

Method: 200.7 - Metals (ICP) - Total Recoverable

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	12		1.0	mg/L		06/03/22 12:45	06/07/22 19:11	1
Iron	0.83		0.010	mg/L		06/03/22 12:45	06/07/22 19:11	1
Magnesium	4.9		0.10	mg/L		06/03/22 12:45	06/07/22 19:11	1
Silica	27		0.43	mg/L		06/03/22 12:45	06/07/22 19:11	1
Sodium	8.0 ^2		1.0	mg/L		06/03/22 12:45	06/07/22 19:11	1

Method: 200.8 - Mercury (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Hg	ND		0.20	ug/L		06/01/22 11:50	06/02/22 15:32	1

Method: 200.8 - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		20	ug/L		06/01/22 11:50	06/02/22 15:32	1
Antimony	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Arsenic	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Barium	ND		2.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Beryllium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Cadmium	ND		0.50	ug/L		06/01/22 11:50	06/02/22 15:32	1
Chromium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Copper	ND		2.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Lead	ND		0.50	ug/L		06/01/22 11:50	06/02/22 15:32	1
Manganese	6.3		2.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Nickel	ND		5.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Selenium	ND		5.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Silver	ND		0.50	ug/L		06/01/22 11:50	06/02/22 15:32	1
Thallium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Uranium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:32	1
Zinc	ND		20	ug/L		06/01/22 11:50	06/02/22 15:32	1
Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	ND		0.67	pCi/L		06/01/22 11:50	06/02/22 15:32	1

Method: SM 2340B - Total Hardness (as CaCO3) by calculation

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Hardness (as CaCO3)	50		3.0	mg/L			06/27/22 14:11	1

Eurofins Eaton Monrovia

Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: SM 2340B - Total Hardness (as CaCO3) by calculation (Continued)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium hardness as CaCO3	30		2.5	mg/L			06/27/22 14:11	1
Magnesium hardness as calcium carbonate	20		0.80	mg/L			06/27/22 14:11	1

Method: Total Cation - Total Cations in meq/L

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Total Cations	1.0		0.0010	meq/L			08/05/22 17:04	1

General Chemistry

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Total Cations	1.4			meq/L			07/29/22 11:32	1
Total Anions	1.3			meq/L			07/29/22 11:32	1
Percent Difference	3.1			%			07/29/22 11:32	1
Anion/Cation Balance	3.1			%			07/29/22 11:32	1
Calculated TDS	2.2			mg/L			07/29/22 11:32	1
TDS Ratio	39			NONE			07/29/22 11:32	1
Cyanide	ND		0.025	mg/L			05/31/22 10:20	1
pH of CaCO3 saturation (25C)	8.6			SU			07/29/22 15:48	1
Langelier Index at 25C	-1.1			NONE			07/29/22 15:48	1
Color, Apparent	10	H	2.0	Color Units			05/25/22 21:35	1
Odor	ND	H H3	1.0	T.O.N.			05/25/22 15:57	1
Alkalinity	52		2.0	mg/L			05/27/22 19:02	1
Bicarbonate Alkalinity as CaCO3	52	B ^2	2.0	mg/L			05/27/22 19:02	1
Carbonate Alkalinity as CaCO3	ND		2.0	mg/L			05/27/22 19:02	1
Calcium	12			mg/L			07/20/22 15:10	1
Alkalinity	52			mg/L			07/20/22 15:10	1
Total Dissolved Solids	84			mg/L			07/20/22 15:10	1
Langelier Index	-0.96			LangSU			07/20/22 15:10	1
Field pH	7.5			SU			07/20/22 15:10	1
Field Temperature	25			Celsius			07/20/22 15:10	1
Total Dissolved Solids	84	H	20	mg/L			05/31/22 23:05	1
Total Suspended Solids	8.0	H	5.0	mg/L			06/11/22 05:09	1
Fluoride	0.050		0.050	mg/L			06/02/22 19:38	1
pH	7.5	HF		S.U.			05/27/22 19:02	1
Total Organic Carbon	0.375		0.200	mg/L			06/02/22 16:04	1
Methylene Blue Active Substances	ND	H	0.10	mg/L			05/26/22 08:16	1
Total Anions	1.3		0.0010	meq/L			08/05/22 18:04	1

Method: Ra226 Ra228 - Radium-226/Radium-228 (Gamma-ray Spectrometry)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	RL	Unit	Prepared	Analyzed	Dil Fac
Radium 226 and 228	0.000		NaN		1.00	NaN	pCi		07/20/22 14:45	1

Method: Ra226_Ra228 - Radium-226/Radium-228 (Gamma-ray Spectrometry)

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Ra-226	0.000	U	0.000		1.00	0.400	pCi/L	06/02/22 11:15	06/19/22 16:06	1
Ra-228	0.000	U	0.000		1.00	0.684	pCi/L	06/02/22 11:15	06/19/22 16:06	1

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Client Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Method: SM7110C - Gross Alpha by Co-Precipitation

Analyte	Result	Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Gross Alpha	0.970	U	1.65		3.00	1.98	pCi/L	06/14/22 10:57	06/25/22 11:44	1

Method: 9223B - Coliforms, Total, and E.Coli (Colilert - Quanti Tray)

Analyte	Result	Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Coliform, Total	5.2	H H3	1.0	MPN/100mL			05/25/22 19:44	1
Escherichia coli	<1.0	H H3	1.0	MPN/100mL			05/25/22 19:44	1

Surrogate Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS)

Matrix: Drinking Water

Prep Type: Total/NA

		Percent Surrogate Recovery (Acceptance Limits)		
Lab Sample ID	Client Sample ID	DCA	BFB	TOL
		(70-130)	(70-130)	(70-130)
380-2284-1	TILL51981_05.23.22	104	92	89
LCS 380-4928/11	Lab Control Sample	93	98	94
LCSD 380-4928/12	Lab Control Sample Dup	95	94	96
MB 380-4928/14	Method Blank	95	93	92
MRL 380-4928/10	Lab Control Sample	97	97	95
MRL 380-4928/13	Lab Control Sample	102	95	92
Surrogate Legend				
DCA = 1,2-Dichloroethane-d4 (Surr)				
BFB = 4-Bromofluorobenzene (Surr)				
TOL = Toluene-d8 (Surr)				

Method: 525.2 - Semivolatile Organic Compounds (GC/MS)

Matrix: Drinking Water

Prep Type: Total/NA

		Percent Surrogate Recovery (Acceptance Limits)		
Lab Sample ID	Client Sample ID	2NMX	TPP	PRY
		(70-130)	(70-130)	(70-130)
380-2069-F-2-A MS	Matrix Spike	102	111	98
380-2079-J-1-A DU	Duplicate	99	111	96
380-2284-1	TILL51981_05.23.22	97	117	98
LCS 380-4751/3-A	Lab Control Sample	102	107	97
LCSD 380-4751/4-A	Lab Control Sample Dup	102	107	98
MB 380-4751/1-A	Method Blank	102	109	93
MRL 380-4751/2-A	Lab Control Sample	100	106	92
Surrogate Legend				
2NMX = 2-Nitro-m-xylene				
TPP = Triphenylphosphate				
PRY = Perylene-d12				

Method: 505 - Organochlorine Pesticides/PCBs (GC)

Matrix: Drinking Water

Prep Type: Total/NA

		Percent Surrogate Recovery (Acceptance Limits)					
Lab Sample ID	Client Sample ID	TCX1					
		(70-130)					
380-2236-T-1-A MS	Matrix Spike	104					
380-2236-U-1-A MS	Matrix Spike	96					
380-2284-1	TILL51981_05.23.22	121					
MB 380-4725/4-A	Method Blank	112					
MRL 380-4725/2-A	Lab Control Sample	107					
MRL 380-4725/3-A	Lab Control Sample	95					
Surrogate Legend							
TCX = Tetrachloro-m-xylene							

Surrogate Summary

Client: Groundwater Solutions, Inc.

Job ID: 380-2284-1

Project/Site: Port of Tillamook

Method: 515.4 - Herbicides (GC)

Matrix: Drinking Water

Prep Type: Total/NA

		Percent Surrogate Recovery (Acceptance Limits)					
Lab Sample ID	Client Sample ID	DCPAA1 (70-130)					
380-2284-1	TILL51981_05.23.22	104					
380-2367-B-1-B MS	Matrix Spike	97					
380-2367-C-1-B MSD	Matrix Spike Duplicate	100					
MB 380-4767/9-A	Method Blank	107					
MRL 380-4767/8-A	Lab Control Sample	106					
Surrogate Legend							
DCPAA = 2,4-Dichlorophenylacetic acid (Surr)							

Method: 551.1 - Chlorinated Disinfection Byproducts and Solvents (GC)

Matrix: Drinking Water

Prep Type: Total/NA

		Percent Surrogate Recovery (Acceptance Limits)					
Lab Sample ID	Client Sample ID	DBPP1 (80-120)					
380-2284-1	TILL51981_05.23.22	109					
380-2194-HJ-1-B MS	Matrix Spike	102					
380-2236-AK-1-A DU	Duplicate	106					
LCS 380-4999/7-A	Lab Control Sample	103					
MB 380-4999/9-A	Method Blank	106					
MRL 380-4999/8-A	Lab Control Sample	106					
Surrogate Legend							
DBPP = 1,2-Dibromopropane (Surr)							

Method: 531.2 - Carbamate Pesticides (HPLC)

Matrix: Drinking Water

Prep Type: Total/NA

		Percent Surrogate Recovery (Acceptance Limits)					
Lab Sample ID	Client Sample ID	BDMC (70-130)					
380-2284-1	TILL51981_05.23.22	105					
380-2194-GU-1-A MS	Matrix Spike	104					
380-2194-GU-1-B MSD	Matrix Spike Duplicate	107					
LCS 380-4659/2-A	Lab Control Sample	107					
MB 380-4659/3-A	Method Blank	110					
MRL 380-4659/1-A	Lab Control Sample	113					
Surrogate Legend							
BDMC = BDMC							

QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS)

Lab Sample ID: MB 380-4928/14

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Dichlorodifluoromethane	ND		0.50	ug/L			06/02/22 16:21	1
Chloromethane (methyl chloride)	ND		0.50	ug/L			06/02/22 16:21	1
Vinyl Chloride (VC)	ND		0.30	ug/L			06/02/22 16:21	1
Bromomethane (Methyl Bromide)	ND		0.50	ug/L			06/02/22 16:21	1
Chloroethane	ND		0.50	ug/L			06/02/22 16:21	1
Trichlorofluoromethane (Freon 11)	ND		0.50	ug/L			06/02/22 16:21	1
1,1-Dichloroethylene	ND		0.50	ug/L			06/02/22 16:21	1
Bromoethane	ND		0.50	ug/L			06/02/22 16:21	1
Trichlorotrifluoroethane	ND		0.50	ug/L			06/02/22 16:21	1
Carbon disulfide	ND		0.50	ug/L			06/02/22 16:21	1
Dichloromethane	ND		0.50	ug/L			06/02/22 16:21	1
trans-1,2-Dichloroethylene	ND		0.50	ug/L			06/02/22 16:21	1
Methyl-tert-butyl Ether (MTBE)	ND		0.50	ug/L			06/02/22 16:21	1
1,1-Dichloroethane	ND		0.50	ug/L			06/02/22 16:21	1
2-Butanone (MEK)	ND		5.0	ug/L			06/02/22 16:21	1
Diisopropyl ether	ND		3.0	ug/L			06/02/22 16:21	1
cis-1,2-Dichloroethylene	ND		0.50	ug/L			06/02/22 16:21	1
2,2-Dichloropropane	ND		0.50	ug/L			06/02/22 16:21	1
Bromochloromethane	ND		0.50	ug/L			06/02/22 16:21	1
Chloroform (Trichloromethane)	ND		0.50	ug/L			06/02/22 16:21	1
Tert-butyl ethyl ether	ND		3.0	ug/L			06/02/22 16:21	1
1,1,1-Trichloroethane	ND		0.50	ug/L			06/02/22 16:21	1
1,2-Dichloroethane	ND		0.50	ug/L			06/02/22 16:21	1
1,1-Dichloropropene	ND		0.50	ug/L			06/02/22 16:21	1
Benzene	ND		0.50	ug/L			06/02/22 16:21	1
Carbon tetrachloride	ND		0.50	ug/L			06/02/22 16:21	1
Tert-amyl methyl ether	ND		3.0	ug/L			06/02/22 16:21	1
Trichloroethylene (TCE)	ND		0.50	ug/L			06/02/22 16:21	1
1,2-Dichloropropane	ND		0.50	ug/L			06/02/22 16:21	1
Dibromomethane	ND		0.50	ug/L			06/02/22 16:21	1
Bromodichloromethane	ND		0.50	ug/L			06/02/22 16:21	1
cis-1,3-Dichloropropene	ND		0.50	ug/L			06/02/22 16:21	1
trans-1,3-Dichloropropene	ND		0.50	ug/L			06/02/22 16:21	1
Toluene	ND		0.50	ug/L			06/02/22 16:21	1
1,1,2-Trichloroethane	ND		0.50	ug/L			06/02/22 16:21	1
2-Hexanone	ND		10	ug/L			06/02/22 16:21	1
1,3-Dichloropropane	ND		0.50	ug/L			06/02/22 16:21	1
Chlorodibromomethane	ND		0.50	ug/L			06/02/22 16:21	1
Tetrachloroethene (PCE)	ND		0.50	ug/L			06/02/22 16:21	1
Chlorobenzene	ND		0.50	ug/L			06/02/22 16:21	1
1,1,1,2-Tetrachloroethane	ND		0.50	ug/L			06/02/22 16:21	1
Ethylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
m,p-Xylenes	ND		0.50	ug/L			06/02/22 16:21	1
Styrene	ND		0.50	ug/L			06/02/22 16:21	1
o-Xylene	ND		0.50	ug/L			06/02/22 16:21	1
Bromoform	ND		0.50	ug/L			06/02/22 16:21	1
1,1,2,2-Tetrachloroethane	ND		0.50	ug/L			06/02/22 16:21	1
1,2,3-Trichloropropane	ND		0.50	ug/L			06/02/22 16:21	1

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: MB 380-4928/14

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Isopropylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
Bromobenzene	ND		0.50	ug/L			06/02/22 16:21	1
N-Propylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
o-Chlorotoluene	ND		0.50	ug/L			06/02/22 16:21	1
p-Chlorotoluene	ND		0.50	ug/L			06/02/22 16:21	1
1,3,5-Trimethylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
tert-Butylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
1,2,4-Trimethylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
sec-Butylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
m-Dichlorobenzene (1,3-DCB)	ND		0.50	ug/L			06/02/22 16:21	1
p-Dichlorobenzene (1,4-DCB)	ND		0.50	ug/L			06/02/22 16:21	1
p-Isopropyltoluene	ND		0.50	ug/L			06/02/22 16:21	1
o-Dichlorobenzene (1,2-DCB)	ND		0.50	ug/L			06/02/22 16:21	1
n-Butylbenzene	ND		0.50	ug/L			06/02/22 16:21	1
1,2,4-Trichlorobenzene	ND		0.50	ug/L			06/02/22 16:21	1
Naphthalene	ND		0.50	ug/L			06/02/22 16:21	1
Hexachlorobutadiene	ND		0.50	ug/L			06/02/22 16:21	1
1,2,3-Trichlorobenzene	ND		0.50	ug/L			06/02/22 16:21	1

Surrogate	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
1,2-Dichloroethane-d4 (Surr)	95		70 - 130		06/02/22 16:21	1
4-Bromofluorobenzene (Surr)	93		70 - 130		06/02/22 16:21	1
Toluene-d8 (Surr)	92		70 - 130		06/02/22 16:21	1

Lab Sample ID: LCS 380-4928/11

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Vinyl Chloride (VC)	5.00	3.10	*-	ug/L		62	70 - 130
Bromomethane (Methyl Bromide)	5.00	3.08	*-	ug/L		62	70 - 130
Trichlorofluoromethane (Freon 11)	5.00	3.35	*-	ug/L		67	70 - 130
1,1-Dichloroethylene	5.00	3.48		ug/L		70	70 - 130
Bromoethane	5.00	4.11		ug/L		82	70 - 130
Trichlorotrifluoroethane	5.00	3.98		ug/L		80	70 - 130
Carbon disulfide	5.00	3.90		ug/L		78	70 - 130
Dichloromethane	5.00	3.80		ug/L		76	70 - 130
trans-1,2-Dichloroethylene	5.00	3.66		ug/L		73	70 - 130
Methyl-tert-butyl Ether (MTBE)	5.00	4.02		ug/L		80	70 - 130
1,1-Dichloroethane	5.00	3.80		ug/L		76	70 - 130
2-Butanone (MEK)	50.0	37.6		ug/L		75	70 - 130
Diisopropyl ether	5.00	3.75		ug/L		75	70 - 130
2,2-Dichloropropane	5.00	3.32	*-	ug/L		66	70 - 130
Bromochloromethane	5.00	4.18		ug/L		84	70 - 130
Tert-butyl ethyl ether	5.00	3.98		ug/L		80	70 - 130
1,1,1-Trichloroethane	5.00	3.81		ug/L		76	70 - 130
1,2-Dichloroethane	5.00	3.72		ug/L		74	70 - 130
1,1-Dichloropropene	5.00	3.91		ug/L		78	70 - 130

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LCS 380-4928/11

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Benzene	5.00	3.83		ug/L		77	70 - 130
Carbon tetrachloride	5.00	3.33	*-	ug/L		67	70 - 130
Tert-amyl methyl ether	5.00	3.92		ug/L		78	70 - 130
Trichloroethylene (TCE)	5.00	3.88		ug/L		78	70 - 130
1,2-Dichloropropane	5.00	3.81		ug/L		76	70 - 130
Bromodichloromethane	5.00	3.61		ug/L		72	70 - 130
cis-1,3-Dichloropropene	5.00	3.23	*-	ug/L		65	70 - 130
trans-1,3-Dichloropropene	5.00	3.30	*-	ug/L		66	70 - 130
Toluene	5.00	3.55		ug/L		71	70 - 130
1,1,2-Trichloroethane	5.00	3.62		ug/L		72	70 - 130
2-Hexanone	50.0	39.9		ug/L		80	70 - 130
1,3-Dichloropropane	5.00	3.88		ug/L		78	70 - 130
Chlorodibromomethane	5.00	3.30	*-	ug/L		66	70 - 130
Tetrachloroethene (PCE)	5.00	3.48		ug/L		70	70 - 130
Chlorobenzene	5.00	3.76		ug/L		75	70 - 130
1,1,1,2-Tetrachloroethane	5.00	3.52		ug/L		70	70 - 130
Ethylbenzene	5.00	3.63		ug/L		73	70 - 130
m,p-Xylenes	10.0	7.43		ug/L		74	70 - 130
Styrene	5.00	3.41	*-	ug/L		68	70 - 130
o-Xylene	5.00	3.51		ug/L		70	70 - 130
Bromoform	5.00	3.10	*-	ug/L		62	70 - 130
1,1,2,2-Tetrachloroethane	5.00	3.95		ug/L		79	70 - 130
1,2,3-Trichloropropane	5.00	3.99		ug/L		80	70 - 130
Isopropylbenzene	5.00	3.71		ug/L		74	70 - 130
Bromobenzene	5.00	3.66		ug/L		73	70 - 130
N-Propylbenzene	5.00	3.47	*-	ug/L		69	70 - 130
o-Chlorotoluene	5.00	3.76		ug/L		75	70 - 130
p-Chlorotoluene	5.00	3.53		ug/L		71	70 - 130
1,3,5-Trimethylbenzene	5.00	3.40	*-	ug/L		68	70 - 130
tert-Butylbenzene	5.00	3.51		ug/L		70	70 - 130
1,2,4-Trimethylbenzene	5.00	3.38	*-	ug/L		68	70 - 130
sec-Butylbenzene	5.00	3.32	*-	ug/L		66	70 - 130
m-Dichlorobenzene (1,3-DCB)	5.00	3.83		ug/L		77	70 - 130
p-Dichlorobenzene (1,4-DCB)	5.00	3.72		ug/L		74	70 - 130
p-Isopropyltoluene	5.00	3.30	*-	ug/L		66	70 - 130
o-Dichlorobenzene (1,2-DCB)	5.00	3.89		ug/L		78	70 - 130
n-Butylbenzene	5.00	3.57		ug/L		71	70 - 130
1,2,4-Trichlorobenzene	5.00	4.32		ug/L		86	70 - 130
Naphthalene	5.00	4.18		ug/L		84	70 - 130
Hexachlorobutadiene	5.00	3.88		ug/L		78	70 - 130
1,2,3-Trichlorobenzene	5.00	4.16		ug/L		83	70 - 130

Surrogate	LCS %Recovery	LCS Qualifier	Limits
1,2-Dichloroethane-d4 (Surr)	93		70 - 130
4-Bromofluorobenzene (Surr)	98		70 - 130
Toluene-d8 (Surr)	94		70 - 130

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LCSD 380-4928/12

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Vinyl Chloride (VC)	5.00	3.43	*-	ug/L		69	70 - 130	10	20
Bromomethane (Methyl Bromide)	5.00	3.49		ug/L		70	70 - 130	12	20
Trichlorofluoromethane (Freon 11)	5.00	3.63		ug/L		73	70 - 130	8	20
1,1-Dichlorethylene	5.00	3.73		ug/L		75	70 - 130	7	20
Bromoethane	5.00	4.18		ug/L		84	70 - 130	2	20
Trichlorotrifluoroethane	5.00	4.37		ug/L		87	70 - 130	9	20
Carbon disulfide	5.00	4.30		ug/L		86	70 - 130	10	20
Dichloromethane	5.00	4.02		ug/L		80	70 - 130	6	20
trans-1,2-Dichloroethylene	5.00	4.19		ug/L		84	70 - 130	13	20
Methyl-tert-butyl Ether (MTBE)	5.00	4.61		ug/L		92	70 - 130	14	20
1,1-Dichloroethane	5.00	4.22		ug/L		84	70 - 130	10	20
2-Butanone (MEK)	50.0	45.1		ug/L		90	70 - 130	18	20
Diisopropyl ether	5.00	4.34		ug/L		87	70 - 130	14	20
2,2-Dichloropropane	5.00	3.76		ug/L		75	70 - 130	12	20
Bromochloromethane	5.00	4.39		ug/L		88	70 - 130	5	20
Tert-butyl ethyl ether	5.00	4.48		ug/L		90	70 - 130	12	20
1,1,1-Trichloroethane	5.00	4.14		ug/L		83	70 - 130	8	20
1,2-Dichloroethane	5.00	4.50		ug/L		90	70 - 130	19	20
1,1-Dichloropropene	5.00	4.36		ug/L		87	70 - 130	11	20
Benzene	5.00	4.15		ug/L		83	70 - 130	8	20
Carbon tetrachloride	5.00	3.87		ug/L		77	70 - 130	15	20
Tert-amyl methyl ether	5.00	4.25		ug/L		85	70 - 130	8	20
Trichloroethylene (TCE)	5.00	4.04		ug/L		81	70 - 130	4	20
1,2-Dichloropropane	5.00	4.15		ug/L		83	70 - 130	9	20
Bromodichloromethane	5.00	4.05		ug/L		81	70 - 130	11	20
cis-1,3-Dichloropropene	5.00	3.48		ug/L		70	70 - 130	7	20
trans-1,3-Dichloropropene	5.00	3.84		ug/L		77	70 - 130	15	20
Toluene	5.00	3.97		ug/L		79	70 - 130	11	20
1,1,2-Trichloroethane	5.00	4.05		ug/L		81	70 - 130	11	20
2-Hexanone	50.0	45.6		ug/L		91	70 - 130	13	20
1,3-Dichloropropane	5.00	4.45		ug/L		89	70 - 130	14	20
Chlorodibromomethane	5.00	3.46	*-	ug/L		69	70 - 130	5	20
Tetrachloroethene (PCE)	5.00	3.87		ug/L		77	70 - 130	11	20
Chlorobenzene	5.00	4.23		ug/L		85	70 - 130	12	20
1,1,1,2-Tetrachloroethane	5.00	3.81		ug/L		76	70 - 130	8	20
Ethylbenzene	5.00	4.08		ug/L		82	70 - 130	12	20
m,p-Xylenes	10.0	8.09		ug/L		81	70 - 130	9	20
Styrene	5.00	3.82		ug/L		76	70 - 130	11	20
o-Xylene	5.00	3.87		ug/L		77	70 - 130	10	20
Bromoform	5.00	3.21	*-	ug/L		64	70 - 130	3	20
1,1,2,2-Tetrachloroethane	5.00	4.46		ug/L		89	70 - 130	12	20
1,2,3-Trichloropropane	5.00	4.01		ug/L		80	70 - 130	1	20
Isopropylbenzene	5.00	3.86		ug/L		77	70 - 130	4	20
Bromobenzene	5.00	3.60		ug/L		72	70 - 130	2	20
N-Propylbenzene	5.00	3.78		ug/L		76	70 - 130	9	20
o-Chlorotoluene	5.00	3.94		ug/L		79	70 - 130	5	20
p-Chlorotoluene	5.00	3.92		ug/L		78	70 - 130	11	20
1,3,5-Trimethylbenzene	5.00	3.60		ug/L		72	70 - 130	6	20

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LCSD 380-4928/12

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
tert-Butylbenzene	5.00	3.70		ug/L		74	70 - 130	5	20
1,2,4-Trimethylbenzene	5.00	3.56		ug/L		71	70 - 130	5	20
sec-Butylbenzene	5.00	3.55		ug/L		71	70 - 130	7	20
m-Dichlorobenzene (1,3-DCB)	5.00	3.94		ug/L		79	70 - 130	3	20
p-Dichlorobenzene (1,4-DCB)	5.00	3.96		ug/L		79	70 - 130	6	20
p-Isopropyltoluene	5.00	3.51		ug/L		70	70 - 130	6	20
o-Dichlorobenzene (1,2-DCB)	5.00	4.05		ug/L		81	70 - 130	4	20
n-Butylbenzene	5.00	3.78		ug/L		76	70 - 130	6	20
1,2,4-Trichlorobenzene	5.00	4.52		ug/L		90	70 - 130	5	20
Naphthalene	5.00	4.41		ug/L		88	70 - 130	5	20
Hexachlorobutadiene	5.00	4.03		ug/L		81	70 - 130	4	20
1,2,3-Trichlorobenzene	5.00	4.37		ug/L		87	70 - 130	5	20

Surrogate	LCSD %Recovery	LCSD Qualifier	Limits
1,2-Dichloroethane-d4 (Surr)	95		70 - 130
4-Bromofluorobenzene (Surr)	94		70 - 130
Toluene-d8 (Surr)	96		70 - 130

Lab Sample ID: MRL 380-4928/10

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Vinyl Chloride (VC)	0.250	ND		ug/L		98	50 - 150
m,p-Xylenes	0.500	0.501		ug/L		100	50 - 150

Surrogate	MRL %Recovery	MRL Qualifier	Limits
1,2-Dichloroethane-d4 (Surr)	97		70 - 130
4-Bromofluorobenzene (Surr)	97		70 - 130
Toluene-d8 (Surr)	95		70 - 130

Lab Sample ID: MRL 380-4928/13

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Vinyl Chloride (VC)	0.500	0.458		ug/L		92	50 - 150
Bromomethane (Methyl Bromide)	0.500	0.518		ug/L		104	50 - 150
Trichlorofluoromethane (Freon 11)	0.500	ND		ug/L		82	50 - 150
1,1-Dichloroethylene	0.500	0.507		ug/L		101	50 - 150
Bromoethane	0.500	0.616		ug/L		123	50 - 150
Trichlorotrifluoroethane	0.500	0.579		ug/L		116	50 - 150
Carbon disulfide	0.500	ND		ug/L		92	50 - 150
Dichloromethane	0.500	0.524		ug/L		105	50 - 150
trans-1,2-Dichloroethylene	0.500	ND		ug/L		94	50 - 150
Methyl-tert-butyl Ether (MTBE)	0.500	0.527		ug/L		105	50 - 150
1,1-Dichloroethane	0.500	0.517		ug/L		103	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: MRL 380-4928/13

Matrix: Drinking Water

Analysis Batch: 4928

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
2-Butanone (MEK)	5.00	5.34		ug/L		107	50 - 150
Diisopropyl ether	0.500	ND		ug/L		108	50 - 150
2,2-Dichloropropane	0.500	ND		ug/L		95	50 - 150
Bromochloromethane	0.500	ND		ug/L		99	50 - 150
Tert-butyl ethyl ether	0.500	ND		ug/L		106	50 - 150
1,1,1-Trichloroethane	0.500	ND		ug/L		83	50 - 150
1,2-Dichloroethane	0.500	ND		ug/L		95	50 - 150
1,1-Dichloropropene	0.500	ND		ug/L		88	50 - 150
Benzene	0.500	ND		ug/L		98	50 - 150
Carbon tetrachloride	0.500	ND		ug/L		80	50 - 150
Tert-amyl methyl ether	0.500	ND		ug/L		96	50 - 150
Trichloroethylene (TCE)	0.500	ND		ug/L		96	50 - 150
1,2-Dichloropropane	0.500	ND		ug/L		99	50 - 150
Bromodichloromethane	0.500	ND		ug/L		93	50 - 150
cis-1,3-Dichloropropene	0.500	ND		ug/L		79	50 - 150
trans-1,3-Dichloropropene	0.500	ND		ug/L		66	50 - 150
Toluene	0.500	ND		ug/L		84	50 - 150
1,1,2-Trichloroethane	0.500	ND		ug/L		86	50 - 150
2-Hexanone	5.00	ND		ug/L		92	50 - 150
1,3-Dichloropropane	0.500	ND		ug/L		96	50 - 150
Chlorodibromomethane	0.500	ND		ug/L		88	50 - 150
Tetrachloroethene (PCE)	0.500	ND		ug/L		93	50 - 150
Chlorobenzene	0.500	ND		ug/L		84	50 - 150
1,1,1,2-Tetrachloroethane	0.500	ND		ug/L		76	50 - 150
Ethylbenzene	0.500	ND		ug/L		82	50 - 150
m,p-Xylenes	1.00	0.797		ug/L		80	50 - 150
Styrene	0.500	ND		ug/L		71	50 - 150
o-Xylene	0.500	ND		ug/L		77	50 - 150
Bromoform	0.500	ND		ug/L		75	50 - 150
1,1,2,2-Tetrachloroethane	0.500	ND		ug/L		99	50 - 150
1,2,3-Trichloropropane	0.500	0.508		ug/L		102	50 - 150
Isopropylbenzene	0.500	ND		ug/L		81	50 - 150
Bromobenzene	0.500	ND		ug/L		79	50 - 150
N-Propylbenzene	0.500	ND		ug/L		78	50 - 150
o-Chlorotoluene	0.500	ND		ug/L		85	50 - 150
p-Chlorotoluene	0.500	ND		ug/L		81	50 - 150
1,3,5-Trimethylbenzene	0.500	ND		ug/L		76	50 - 150
tert-Butylbenzene	0.500	ND		ug/L		77	50 - 150
1,2,4-Trimethylbenzene	0.500	ND		ug/L		74	50 - 150
sec-Butylbenzene	0.500	0.503		ug/L		101	50 - 150
m-Dichlorobenzene (1,3-DCB)	0.500	ND		ug/L		97	50 - 150
p-Dichlorobenzene (1,4-DCB)	0.500	ND		ug/L		88	50 - 150
p-Isopropyltoluene	0.500	0.501		ug/L		100	50 - 150
o-Dichlorobenzene (1,2-DCB)	0.500	ND		ug/L		96	50 - 150
n-Butylbenzene	0.500	ND		ug/L		87	50 - 150
1,2,4-Trichlorobenzene	0.500	0.647		ug/L		129	50 - 150
Naphthalene	0.500	0.557		ug/L		111	50 - 150
Hexachlorobutadiene	0.500	0.576		ug/L		115	50 - 150
1,2,3-Trichlorobenzene	0.500	0.598		ug/L		120	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 524.2 - Volatile Organic Compounds (GC/MS) (Continued)

Surrogate	MRL %Recovery	MRL Qualifier	Limits
1,2-Dichloroethane-d4 (Surr)	102		70 - 130
4-Bromofluorobenzene (Surr)	95		70 - 130
Toluene-d8 (Surr)	92		70 - 130

Method: 525.2 - Semivolatile Organic Compounds (GC/MS)

Lab Sample ID: MB 380-4751/1-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4751

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
2,4-Dinitrotoluene	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Acenaphthylene	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Alachlor (Alanex)	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
alpha-Chlordane	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Anthracene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 13:56	1
Atrazine	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Benz(a)anthracene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Benzo[a]pyrene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 13:56	1
Benzo[b]fluoranthene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 13:56	1
Benzo[g,h,i]perylene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Benzo[k]fluoranthene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 13:56	1
Bromacil	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Butachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Butylbenzylphthalate	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Caffeine	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Chrysene	ND		0.000020	mg/L		05/31/22 10:38	06/03/22 13:56	1
Di(2-ethylhexyl)adipate	ND		0.00059	mg/L		05/31/22 10:38	06/03/22 13:56	1
Bis(2-ethylhexyl) phthalate	ND		0.00059	mg/L		05/31/22 10:38	06/03/22 13:56	1
Diazinon (Qualitative)	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Dibenz(a,h)anthracene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Dieldrin	ND		0.00020	mg/L		05/31/22 10:38	06/03/22 13:56	1
Diethylphthalate	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Dimethoate	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Dimethylphthalate	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Di-n-butyl phthalate	ND		0.00098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Endrin	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Fluoranthene	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Fluorene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
gamma-Chlordane	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Heptachlor	ND		0.000039	mg/L		05/31/22 10:38	06/03/22 13:56	1
Heptachlor epoxide (isomer B)	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Hexachlorobenzene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Hexachlorocyclopentadiene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Indeno[1,2,3-cd]pyrene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Isophorone	ND		0.00049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Lindane	ND		0.000039	mg/L		05/31/22 10:38	06/03/22 13:56	1
Methoxychlor	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Metolachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Metribuzin	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Molinate	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1
Phenanthrene	ND		0.000039	mg/L		05/31/22 10:38	06/03/22 13:56	1

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: MB 380-4751/1-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4751

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Propachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Pyrene	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Simazine	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Thiobencarb	ND		0.00020	mg/L		05/31/22 10:38	06/03/22 13:56	1
trans-Nonachlor	ND		0.000049	mg/L		05/31/22 10:38	06/03/22 13:56	1
Trifluralin	ND		0.000098	mg/L		05/31/22 10:38	06/03/22 13:56	1

Surrogate	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
2-Nitro-m-xylene	102		70 - 130	05/31/22 10:38	06/03/22 13:56	1
Triphenylphosphate	109		70 - 130	05/31/22 10:38	06/03/22 13:56	1
Perylene-d12	93		70 - 130	05/31/22 10:38	06/03/22 13:56	1

Lab Sample ID: LCS 380-4751/3-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
2,4-Dinitrotoluene	0.00197	0.00164		mg/L		83	70 - 130
Acenaphthylene	0.00197	0.00199		mg/L		101	70 - 130
Alachlor (Alanex)	0.00197	0.00211		mg/L		107	70 - 130
alpha-Chlordane	0.00197	0.00203		mg/L		103	70 - 130
Anthracene	0.00197	0.00190		mg/L		96	70 - 130
Atrazine	0.00197	0.00196		mg/L		99	70 - 130
Benz(a)anthracene	0.00197	0.00214		mg/L		108	70 - 130
Benzo[a]pyrene	0.00197	0.00221		mg/L		112	70 - 130
Benzo[b]fluoranthene	0.00197	0.00219		mg/L		111	70 - 130
Benzo[g,h,i]perylene	0.00197	0.00212		mg/L		108	70 - 130
Benzo[k]fluoranthene	0.00197	0.00221		mg/L		112	70 - 130
Bromacil	0.00197	0.00172		mg/L		87	70 - 130
Butachlor	0.00197	0.00217		mg/L		110	70 - 130
Butylbenzylphthalate	0.00197	0.00219		mg/L		111	70 - 130
Caffeine	0.00197	0.000616	*-	mg/L		31	45 - 137
Chrysene	0.00197	0.00202		mg/L		102	70 - 130
Di(2-ethylhexyl)adipate	0.00197	0.00201		mg/L		102	70 - 130
Bis(2-ethylhexyl) phthalate	0.00197	0.00186		mg/L		94	70 - 130
Diazinon (Qualitative)	0.00197	0.00184		mg/L		93	15 - 132
Dibenz(a,h)anthracene	0.00197	0.00194		mg/L		98	70 - 130
Dieldrin	0.00197	0.00201		mg/L		102	70 - 130
Diethylphthalate	0.00197	0.00205		mg/L		104	70 - 130
Dimethoate	0.00197	0.000635	*-	mg/L		32	35 - 100
Dimethylphthalate	0.00197	0.00210		mg/L		106	70 - 130
Di-n-butyl phthalate	0.00395	0.00411		mg/L		104	70 - 130
Endrin	0.00197	0.00219		mg/L		111	70 - 130
Fluoranthene	0.00197	0.00200		mg/L		101	70 - 130
Fluorene	0.00197	0.00194		mg/L		98	70 - 130
gamma-Chlordane	0.00197	0.00206		mg/L		104	70 - 130
Heptachlor	0.00197	0.00209		mg/L		106	70 - 130
Heptachlor epoxide (isomer B)	0.00197	0.00200		mg/L		102	70 - 130

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LCS 380-4751/3-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Hexachlorobenzene	0.00197	0.00183		mg/L		93	70 - 130
Hexachlorocyclopentadiene	0.00197	0.00207		mg/L		105	70 - 130
Indeno[1,2,3-cd]pyrene	0.00197	0.00191		mg/L		97	70 - 130
Isophorone	0.00197	0.00221		mg/L		112	70 - 130
Lindane	0.00197	0.00192		mg/L		97	70 - 130
Methoxychlor	0.00197	0.00217		mg/L		110	70 - 130
Metolachlor	0.00197	0.00214		mg/L		108	70 - 130
Metribuzin	0.00197	0.00153		mg/L		77	70 - 130
Molinate	0.00197	0.00215		mg/L		109	70 - 130
Phenanthrene	0.00197	0.00185		mg/L		94	70 - 130
Propachlor	0.00197	0.00227		mg/L		115	70 - 130
Pyrene	0.00197	0.00201		mg/L		102	70 - 130
Simazine	0.00197	0.00190		mg/L		96	70 - 130
Thiobencarb	0.00197	0.00212		mg/L		108	70 - 130
trans-Nonachlor	0.00197	0.00216		mg/L		109	70 - 130
Trifluralin	0.00197	0.00193		mg/L		98	70 - 130

Surrogate	LCS %Recovery	LCS Qualifier	Limits
2-Nitro-m-xylene	102		70 - 130
Triphenylphosphate	107		70 - 130
Perylene-d12	97		70 - 130

Lab Sample ID: LCSD 380-4751/4-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
2,4-Dinitrotoluene	0.00198	0.00202		mg/L		102	70 - 130	20	20
Acenaphthylene	0.00198	0.00203		mg/L		103	70 - 130	2	20
Alachlor (Alanex)	0.00198	0.00216		mg/L		109	70 - 130	2	20
alpha-Chlordane	0.00198	0.00216		mg/L		109	70 - 130	6	20
Anthracene	0.00198	0.00196		mg/L		99	70 - 130	3	20
Atrazine	0.00198	0.00206		mg/L		104	70 - 130	5	20
Benz(a)anthracene	0.00198	0.00226		mg/L		114	70 - 130	6	20
Benzo[a]pyrene	0.00198	0.00230		mg/L		116	70 - 130	4	20
Benzo[b]fluoranthene	0.00198	0.00229		mg/L		116	70 - 130	4	20
Benzo[g,h,i]perylene	0.00198	0.00221		mg/L		112	70 - 130	4	20
Benzo[k]fluoranthene	0.00198	0.00240		mg/L		122	70 - 130	8	20
Bromacil	0.00198	0.00252	*1	mg/L		128	70 - 130	38	20
Butachlor	0.00198	0.00228		mg/L		115	70 - 130	5	20
Butylbenzylphthalate	0.00198	0.00231		mg/L		117	70 - 130	5	20
Caffeine	0.00198	0.00147	*1	mg/L		74	45 - 137	82	20
Chrysene	0.00198	0.00212		mg/L		107	70 - 130	5	20
Di(2-ethylhexyl)adipate	0.00198	0.00218		mg/L		110	70 - 130	8	20
Bis(2-ethylhexyl) phthalate	0.00198	0.00198		mg/L		100	70 - 130	6	20
Diazinon (Qualitative)	0.00198	0.00196		mg/L		99	15 - 132	6	20
Dibenz(a,h)anthracene	0.00198	0.00197		mg/L		99	70 - 130	1	20
Dieldrin	0.00198	0.00212		mg/L		107	70 - 130	5	20

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: LCSD 380-4751/4-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Diethylphthalate	0.00198	0.00212		mg/L		107	70 - 130	3	20
Dimethoate	0.00198	0.00141	*1	mg/L		71	35 - 100	76	20
Dimethylphthalate	0.00198	0.00218		mg/L		110	70 - 130	4	20
Di-n-butyl phthalate	0.00395	0.00414		mg/L		105	70 - 130	1	20
Endrin	0.00198	0.00206		mg/L		104	70 - 130	6	20
Fluoranthene	0.00198	0.00207		mg/L		105	70 - 130	3	20
Fluorene	0.00198	0.00201		mg/L		102	70 - 130	3	20
gamma-Chlordane	0.00198	0.00215		mg/L		109	70 - 130	5	20
Heptachlor	0.00198	0.00217		mg/L		110	70 - 130	4	20
Heptachlor epoxide (isomer B)	0.00198	0.00211		mg/L		107	70 - 130	5	20
Hexachlorobenzene	0.00198	0.00191		mg/L		97	70 - 130	4	20
Hexachlorocyclopentadiene	0.00198	0.00213		mg/L		108	70 - 130	3	20
Indeno[1,2,3-cd]pyrene	0.00198	0.00204		mg/L		103	70 - 130	7	20
Isophorone	0.00198	0.00241		mg/L		122	70 - 130	9	20
Lindane	0.00198	0.00195		mg/L		99	70 - 130	1	20
Methoxychlor	0.00198	0.00229		mg/L		116	70 - 130	5	20
Metolachlor	0.00198	0.00224		mg/L		114	70 - 130	5	20
Metribuzin	0.00198	0.00203	*1	mg/L		103	70 - 130	28	20
Molinate	0.00198	0.00226		mg/L		115	70 - 130	5	20
Phenanthrene	0.00198	0.00192		mg/L		97	70 - 130	4	20
Propachlor	0.00198	0.00233		mg/L		118	70 - 130	2	20
Pyrene	0.00198	0.00206		mg/L		104	70 - 130	3	20
Simazine	0.00198	0.00237	*1	mg/L		120	70 - 130	22	20
Thiobencarb	0.00198	0.00220		mg/L		111	70 - 130	3	20
trans-Nonachlor	0.00198	0.00230		mg/L		116	70 - 130	6	20
Trifluralin	0.00198	0.00201		mg/L		102	70 - 130	4	20

Surrogate	LCSD %Recovery	LCSD Qualifier	Limits
2-Nitro-m-xylene	102		70 - 130
Triphenylphosphate	107		70 - 130
Perylene-d12	98		70 - 130

Lab Sample ID: MRL 380-4751/2-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
2,4-Dinitrotoluene	0.0985	0.118		ug/L		119	50 - 150
Acenaphthylene	0.0985	ND		ug/L		91	50 - 150
Alachlor (Alanex)	0.0492	0.0582		ug/L		118	50 - 150
alpha-Chlordane	0.0492	0.0499		ug/L		101	50 - 150
Anthracene	0.0197	0.0209		ug/L		106	50 - 150
Atrazine	0.0492	ND		ug/L		99	50 - 150
Benz(a)anthracene	0.0492	0.0505		ug/L		103	50 - 150
Benzo[a]pyrene	0.0197	ND		ug/L		87	50 - 150
Benzo[b]fluoranthene	0.0197	0.0209		ug/L		106	50 - 150
Benzo[g,h,i]perylene	0.0492	0.0570		ug/L		116	50 - 150
Benzo[k]fluoranthene	0.0197	0.0215		ug/L		109	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: MRL 380-4751/2-A

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Bromacil	0.0985	0.112		ug/L		114	50 - 150
Butachlor	0.0492	0.0594		ug/L		121	50 - 150
Butylbenzylphthalate	0.148	ND	^3+	ug/L		159	50 - 150
Caffeine	0.0492	ND		ug/L		63	50 - 150
Chrysene	0.0197	0.0205		ug/L		104	50 - 150
Di(2-ethylhexyl)adipate	0.295	ND		ug/L		125	50 - 150
Bis(2-ethylhexyl) phthalate	0.591	0.662		ug/L		112	50 - 150
Diazinon (Qualitative)	0.0985	0.102		ug/L		103	15 - 132
Dibenz(a,h)anthracene	0.0492	0.0565		ug/L		115	50 - 150
Dieldrin	0.0985	ND		ug/L		119	50 - 150
Diethylphthalate	0.148	ND		ug/L		124	50 - 150
Dimethoate	0.0985	ND		ug/L		92	35 - 100
Dimethylphthalate	0.295	ND		ug/L		108	50 - 150
Di-n-butyl phthalate	0.295	ND		ug/L		122	50 - 150
Endrin	0.0985	0.133		ug/L		135	50 - 150
Fluoranthene	0.0492	ND		ug/L		102	50 - 150
Fluorene	0.0492	0.0506		ug/L		103	50 - 150
gamma-Chlordane	0.0492	0.0542		ug/L		110	50 - 150
Heptachlor	0.0394	0.111	^3+	ug/L		281	50 - 150
Heptachlor epoxide (isomer B)	0.0492	ND		ug/L		97	50 - 150
Hexachlorobenzene	0.0492	0.0588		ug/L		119	50 - 150
Hexachlorocyclopentadiene	0.0492	ND		ug/L		89	50 - 150
Indeno[1,2,3-cd]pyrene	0.0492	0.0602		ug/L		122	50 - 150
Isophorone	0.0985	ND		ug/L		111	50 - 150
Lindane	0.0492	0.0485		ug/L		99	50 - 150
Methoxychlor	0.0985	0.0981		ug/L		100	50 - 150
Metolachlor	0.0492	0.0547		ug/L		111	50 - 150
Metribuzin	0.0492	ND		ug/L		92	50 - 150
Molinate	0.0985	0.108		ug/L		110	50 - 150
Phenanthrene	0.0197	ND		ug/L		112	50 - 150
Propachlor	0.0492	0.0577		ug/L		117	50 - 150
Pyrene	0.0492	0.0511		ug/L		104	50 - 150
Simazine	0.0492	0.0538		ug/L		109	50 - 150
Thiobencarb	0.0985	ND		ug/L		119	50 - 150
trans-Nonachlor	0.0492	0.0532		ug/L		108	50 - 150
Trifluralin	0.0985	0.116		ug/L		118	50 - 150

Surrogate	MRL %Recovery	MRL Qualifier	Limits
2-Nitro-m-xylene	100		70 - 130
Triphenylphosphate	106		70 - 130
Perylene-d12	92		70 - 130

Lab Sample ID: 380-2069-F-2-A MS

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
2,4-Dinitrotoluene	ND		0.00197	0.00203		mg/L		103	70 - 130

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: 380-2069-F-2-A MS

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Acenaphthylene	ND		0.00197	0.00205		mg/L		104	70 - 130
Alachlor (Alanex)	ND		0.00197	0.00212		mg/L		108	70 - 130
alpha-Chlordane	ND		0.00197	0.00215		mg/L		109	70 - 130
Anthracene	ND		0.00197	0.00157		mg/L		80	70 - 130
Atrazine	ND		0.00197	0.00202		mg/L		102	70 - 130
Benz(a)anthracene	ND		0.00197	0.00217		mg/L		110	70 - 130
Benzo[a]pyrene	ND		0.00197	0.00217		mg/L		110	70 - 130
Benzo[b]fluoranthene	ND		0.00197	0.00227		mg/L		115	70 - 130
Benzo[g,h,i]perylene	ND		0.00197	0.00224		mg/L		114	70 - 130
Benzo[k]fluoranthene	ND		0.00197	0.00236		mg/L		120	70 - 130
Bromacil	ND	*1	0.00197	0.00250		mg/L		127	70 - 130
Butachlor	ND		0.00197	0.00227		mg/L		115	70 - 130
Butylbenzylphthalate	ND	^3+	0.00197	0.00227		mg/L		112	70 - 130
Caffeine	ND	*1 *-	0.00197	0.00192		mg/L		98	46 - 144
Chrysene	ND		0.00197	0.00209		mg/L		106	70 - 130
Di(2-ethylhexyl)adipate	ND		0.00197	0.00201		mg/L		102	70 - 130
Bis(2-ethylhexyl) phthalate	ND		0.00197	0.00220		mg/L		90	70 - 130
Diazinon (Qualitative)	ND		0.00197	0.00199		mg/L		101	15 - 132
Dibenz(a,h)anthracene	ND		0.00197	0.00204		mg/L		103	70 - 130
Dieldrin	ND		0.00197	0.00211		mg/L		107	70 - 130
Diethylphthalate	ND		0.00197	0.00207		mg/L		105	70 - 130
Dimethoate	ND	*1 *-	0.00197	0.00174		mg/L		88	34 - 111
Dimethylphthalate	ND		0.00197	0.00211		mg/L		107	70 - 130
Di-n-butyl phthalate	ND		0.00394	0.00423		mg/L		107	70 - 130
Endrin	ND		0.00197	0.00218		mg/L		111	70 - 130
Fluoranthene	ND		0.00197	0.00209		mg/L		106	70 - 130
Fluorene	ND		0.00197	0.00198		mg/L		100	70 - 130
gamma-Chlordane	ND		0.00197	0.00212		mg/L		107	70 - 130
Heptachlor	ND	^3+	0.00197	0.00217		mg/L		110	70 - 130
Heptachlor epoxide (isomer B)	ND		0.00197	0.00217		mg/L		110	70 - 130
Hexachlorobenzene	ND		0.00197	0.00190		mg/L		97	70 - 130
Hexachlorocyclopentadiene	ND		0.00197	0.00215		mg/L		109	70 - 130
Indeno[1,2,3-cd]pyrene	ND		0.00197	0.00200		mg/L		102	70 - 130
Isophorone	ND		0.00197	0.00233		mg/L		118	70 - 130
Lindane	ND		0.00197	0.00192		mg/L		97	70 - 130
Methoxychlor	ND		0.00197	0.00232		mg/L		118	70 - 130
Metolachlor	ND		0.00197	0.00222		mg/L		113	70 - 130
Metribuzin	ND	*1	0.00197	0.00212		mg/L		108	70 - 130
Molinate	ND		0.00197	0.00216		mg/L		110	70 - 130
Phenanthrene	ND		0.00197	0.00190		mg/L		97	70 - 130
Propachlor	ND		0.00197	0.00227		mg/L		116	70 - 130
Pyrene	ND		0.00197	0.00207		mg/L		105	70 - 130
Simazine	ND	*1	0.00197	0.00213		mg/L		108	70 - 130
Thiobencarb	ND		0.00197	0.00216		mg/L		110	70 - 130
trans-Nonachlor	ND		0.00197	0.00230		mg/L		117	70 - 130
Trifluralin	ND		0.00197	0.00201		mg/L		102	70 - 130

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: 380-2069-F-2-A MS

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4751

	MS	MS	
Surrogate	%Recovery	Qualifier	Limits
2-Nitro-m-xylene	102		70 - 130
Triphenylphosphate	111		70 - 130
Perylene-d12	98		70 - 130

Lab Sample ID: 380-2079-J-1-A DU

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Duplicate

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	Limit
2,4-Dinitrotoluene	ND		ND		mg/L		NC	20
Acenaphthylene	ND		ND		mg/L		NC	20
Alachlor (Alanex)	ND		ND		mg/L		NC	20
alpha-Chlordane	ND		ND		mg/L		NC	20
Anthracene	ND		ND		mg/L		NC	20
Atrazine	ND		ND		mg/L		NC	20
Benz(a)anthracene	ND		ND		mg/L		NC	20
Benzo[a]pyrene	ND		ND		mg/L		NC	20
Benzo[b]fluoranthene	ND		ND		mg/L		NC	20
Benzo[g,h,i]perylene	ND		ND		mg/L		NC	20
Benzo[k]fluoranthene	ND		ND		mg/L		NC	20
Bromacil	ND	*1	ND	*1	mg/L		NC	20
Butachlor	ND		ND		mg/L		NC	20
Butylbenzylphthalate	ND	^3+	ND		mg/L		NC	20
Caffeine	ND	*1 *-	ND	*1 *-	mg/L		NC	20
Chrysene	ND		ND		mg/L		NC	20
Di(2-ethylhexyl)adipate	ND		ND		mg/L		NC	20
Bis(2-ethylhexyl) phthalate	ND		ND		mg/L		NC	20
Diazinon (Qualitative)	ND		ND		mg/L		NC	20
Dibenz(a,h)anthracene	ND		ND		mg/L		NC	20
Dieldrin	ND		ND		mg/L		NC	20
Diethylphthalate	ND		ND		mg/L		NC	20
Dimethoate	ND	*1 *-	ND	*1 *-	mg/L		NC	20
Dimethylphthalate	ND		ND		mg/L		NC	20
Di-n-butyl phthalate	ND		ND		mg/L		NC	20
Endrin	ND		ND		mg/L		NC	20
Fluoranthene	ND		ND		mg/L		NC	20
Fluorene	ND		ND		mg/L		NC	20
gamma-Chlordane	ND		ND		mg/L		NC	20
Heptachlor	ND	^3+	ND		mg/L		NC	20
Heptachlor epoxide (isomer B)	ND		ND		mg/L		NC	20
Hexachlorobenzene	ND		ND		mg/L		NC	20
Hexachlorocyclopentadiene	ND		ND		mg/L		NC	20
Indeno[1,2,3-cd]pyrene	ND		ND		mg/L		NC	20
Isophorone	ND		ND		mg/L		NC	20
Lindane	ND		ND		mg/L		NC	20
Methoxychlor	ND		ND		mg/L		NC	20
Metolachlor	ND		ND		mg/L		NC	20
Metribuzin	ND	*1	ND	*1	mg/L		NC	20

Eurofins Eaton Monrovia

QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 525.2 - Semivolatile Organic Compounds (GC/MS) (Continued)

Lab Sample ID: 380-2079-J-1-A DU

Matrix: Drinking Water

Analysis Batch: 4924

Client Sample ID: Duplicate

Prep Type: Total/NA

Prep Batch: 4751

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	Limit
Molinate	ND		ND		mg/L		NC	20
Phenanthrene	ND		ND		mg/L		NC	20
Propachlor	ND		ND		mg/L		NC	20
Pyrene	ND		ND		mg/L		NC	20
Simazine	ND	*1	ND	*1	mg/L		NC	20
Thiobencarb	ND		ND		mg/L		NC	20
trans-Nonachlor	ND		ND		mg/L		NC	20
Trifluralin	ND		ND		mg/L		NC	20
Surrogate	%Recovery	DU Qualifier	DU	Limits				
2-Nitro-m-xylene	99			70 - 130				
Triphenylphosphate	111			70 - 130				
Perylene-d12	96			70 - 130				

Method: 548.1 - Endothall (GC/MS)

Lab Sample ID: MB 380-4697/1-A

Matrix: Drinking Water

Analysis Batch: 5023

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4697

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Endothall	ND		0.0050	mg/L		05/27/22 13:32	06/06/22 15:30	1

Lab Sample ID: LCS 380-4697/3-A

Matrix: Drinking Water

Analysis Batch: 5023

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4697

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits	
Endothall	0.0250	0.0223		mg/L		89	68.5 - 116.6	

Lab Sample ID: LCSD 380-4697/4-A

Matrix: Drinking Water

Analysis Batch: 5023

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 4697

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	Limit
Endothall	0.0250	0.0233		mg/L		93	68.5 - 116.6	4	30

Lab Sample ID: MRL 380-4697/2-A

Matrix: Drinking Water

Analysis Batch: 5023

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4697

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits	
Endothall	5.00	ND		ug/L		88	50 - 150	

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 548.1 - Endothall (GC/MS) (Continued)

Lab Sample ID: 380-2236-AG-1-A MS

Matrix: Drinking Water

Analysis Batch: 5023

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4697

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Endothall	ND	F1 F2	0.0250	0.00779	F1	mg/L		31	65.8 - 116.6

Lab Sample ID: 380-2236-AG-1-B MSD

Matrix: Drinking Water

Analysis Batch: 5023

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Prep Batch: 4697

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Endothall	ND	F1 F2	0.0250	0.0115	F1 F2	mg/L		46	65.8 - 116.6	38	30

Method: 505 - Organochlorine Pesticides/PCBs (GC)

Lab Sample ID: MB 380-4725/4-A

Matrix: Drinking Water

Analysis Batch: 9843

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4725

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Chlordane	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Endrin	ND		0.000010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Heptachlor	ND		0.000010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Heptachlor epoxide (isomer B)	ND		0.000010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Methoxychlor	ND		0.000050	mg/L		05/27/22 20:00	05/27/22 23:01	1
Lindane	ND		0.000010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Alachlor (Alanex)	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Toxaphene	ND		0.000050	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1016	ND		0.000070	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1221	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1232	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1242	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1248	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1254	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
PCB-1260	ND		0.000070	mg/L		05/27/22 20:00	05/27/22 23:01	1
Polychlorinated biphenyls, Total	ND		0.00010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Aldrin	ND		0.000010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Dieldrin	ND		0.000010	mg/L		05/27/22 20:00	05/27/22 23:01	1
Surrogate	MB %Recovery	MB Qualifier	Limits			Prepared	Analyzed	Dil Fac
Tetrachloro-m-xylene	112		70 - 130			05/27/22 20:00	05/27/22 23:01	1

Lab Sample ID: MRL 380-4725/2-A

Matrix: Drinking Water

Analysis Batch: 9843

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4725

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Endrin	0.0100	0.0124		ug/L		124	50 - 150
Heptachlor	0.0100	0.0132		ug/L		132	50 - 150
Heptachlor epoxide (isomer B)	0.0100	0.0132		ug/L		132	50 - 150
Methoxychlor	0.0500	ND		ug/L		92	50 - 150

Eurofins Eaton Monrovia

QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 505 - Organochlorine Pesticides/PCBs (GC) (Continued)

Lab Sample ID: MRL 380-4725/2-A

Matrix: Drinking Water

Analysis Batch: 9843

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4725

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Lindane	0.0100	0.0112		ug/L		112	50 - 150
Alachlor (Alanex)	0.100	0.106		ug/L		106	50 - 150
Aldrin	0.0100	0.0136		ug/L		136	50 - 150
Dieldrin	0.0100	0.0125		ug/L		125	50 - 150

Surrogate	MRL %Recovery	MRL Qualifier	Limits
Tetrachloro-m-xylene	107		70 - 130

Lab Sample ID: MRL 380-4725/3-A

Matrix: Drinking Water

Analysis Batch: 9843

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4725

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Chlordane	0.100	0.114		ug/L		114	50 - 150

Surrogate	MRL %Recovery	MRL Qualifier	Limits
Tetrachloro-m-xylene	95		70 - 130

Lab Sample ID: 380-2236-T-1-A MS

Matrix: Drinking Water

Analysis Batch: 9843

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4725

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Endrin	ND		0.0000198	0.0000237		mg/L		120	65 - 135
Heptachlor	ND		0.0000198	0.0000262		mg/L		132	65 - 135
Heptachlor epoxide (isomer B)	ND		0.0000198	0.0000253		mg/L		128	65 - 135
Methoxychlor	ND		0.0000989	0.0000937		mg/L		95	65 - 135
Lindane	ND		0.0000198	0.0000216		mg/L		109	65 - 135
Alachlor (Alanex)	ND		0.000198	0.000249		mg/L		126	65 - 135
Aldrin	ND	F1	0.0000198	0.0000274	p F1	mg/L		139	65 - 135
Dieldrin	ND		0.0000198	0.0000238		mg/L		120	65 - 135

Surrogate	MS %Recovery	MS Qualifier	Limits
Tetrachloro-m-xylene	104		70 - 130

Lab Sample ID: 380-2236-U-1-A MS

Matrix: Drinking Water

Analysis Batch: 9843

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4725

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Chlordane	ND		0.000492	0.000524		mg/L		107	65 - 135

Surrogate	MS %Recovery	MS Qualifier	Limits
Tetrachloro-m-xylene	96		70 - 130

Eurofins Eaton Monrovia

QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 515.4 - Herbicides (GC)

Lab Sample ID: MB 380-4767/9-A

Matrix: Drinking Water

Analysis Batch: 6292

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4767

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
2,4,5-TP (Silvex)	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 02:33	1
2,4,5-T	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 02:33	1
Dinoseb	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 02:33	1
2,4-D	ND		0.0010	mg/L		06/01/22 09:30	06/04/22 02:33	1
2,4-DB	ND		0.0010	mg/L		06/01/22 09:30	06/04/22 02:33	1
Bentazon	ND		0.00050	mg/L		06/01/22 09:30	06/04/22 02:33	1
Pentachlorophenol	ND		0.000040	mg/L		06/01/22 09:30	06/04/22 02:33	1
Dalapon	ND		0.0010	mg/L		06/01/22 09:30	06/04/22 02:33	1
3,5-Dichlorobenzoic acid	ND		0.00050	mg/L		06/01/22 09:30	06/04/22 02:33	1
Picloram	ND		0.00010	mg/L		06/01/22 09:30	06/04/22 02:33	1
Acifluorfen	ND		0.00020	mg/L		06/01/22 09:30	06/04/22 02:33	1
Dicamba	ND		0.00010	mg/L		06/01/22 09:30	06/04/22 02:33	1
Dichlorprop	ND		0.00050	mg/L		06/01/22 09:30	06/04/22 02:33	1

Surrogate	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
2,4-Dichlorophenylacetic acid (Surr)	107		70 - 130	06/01/22 09:30	06/04/22 02:33	1

Lab Sample ID: MRL 380-4767/8-A

Matrix: Drinking Water

Analysis Batch: 6292

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4767

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
2,4,5-TP (Silvex)	0.200	0.240		ug/L		120	50 - 150
2,4,5-T	0.200	0.239		ug/L		119	50 - 150
Dinoseb	0.200	ND		ug/L		99	50 - 150
2,4-D	0.100	0.140		ug/L		140	50 - 150
2,4-DB	2.00	ND		ug/L		91	50 - 150
Bentazon	0.500	ND		ug/L		87	50 - 150
Pentachlorophenol	0.0400	0.0476		ug/L		119	50 - 150
Dalapon	1.00	ND		ug/L		85	50 - 150
3,5-Dichlorobenzoic acid	0.500	0.537		ug/L		107	50 - 150
Picloram	0.100	ND		ug/L		99	50 - 150
Acifluorfen	0.200	0.260		ug/L		130	50 - 150
Dicamba	0.100	0.106		ug/L		106	50 - 150
Dichlorprop	0.500	0.551		ug/L		110	50 - 150

Surrogate	MRL %Recovery	MRL Qualifier	Limits
2,4-Dichlorophenylacetic acid (Surr)	106		70 - 130

Lab Sample ID: 380-2367-B-1-B MS

Matrix: Drinking Water

Analysis Batch: 6292

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4767

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
2,4,5-TP (Silvex)	ND		0.000750	0.000756		mg/L		101	70 - 130
2,4,5-T	ND		0.000750	0.000778		mg/L		104	70 - 130
Dinoseb	ND		0.000750	0.000693		mg/L		92	70 - 130

Eurofins Eaton Monrovia

QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 515.4 - Herbicides (GC) (Continued)

Lab Sample ID: 380-2367-B-1-B MS

Matrix: Drinking Water

Analysis Batch: 6292

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4767

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
2,4-D	ND		0.000375	ND		mg/L		NC	70 - 130
2,4-DB	ND		0.00750	0.00689		mg/L		92	70 - 130
Bentazon	ND		0.00188	0.00163		mg/L		87	70 - 130
Pentachlorophenol	ND		0.000150	0.000138		mg/L		92	70 - 130
Dalapon	ND		0.00375	0.00382		mg/L		102	70 - 130
3,5-Dichlorobenzoic acid	ND		0.00188	0.00205		mg/L		109	70 - 130
Picloram	ND		0.000375	0.000427		mg/L		114	70 - 130
Acifluorfen	ND		0.000750	0.000941		mg/L		125	70 - 130
Dicamba	ND		0.000375	0.000385		mg/L		89	70 - 130
Dichlorprop	ND		0.00188	0.00182		mg/L		97	70 - 130

Surrogate	MS %Recovery	MS Qualifier	Limits
2,4-Dichlorophenylacetic acid (Surr)	97		70 - 130

Lab Sample ID: 380-2367-C-1-B MSD

Matrix: Drinking Water

Analysis Batch: 6292

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Prep Batch: 4767

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
2,4,5-TP (Silvex)	ND		0.000750	0.000764		mg/L		102	70 - 130	1	30
2,4,5-T	ND		0.000750	0.000787		mg/L		105	70 - 130	1	30
Dinoseb	ND		0.000750	0.000712		mg/L		95	70 - 130	3	30
2,4-D	ND		0.000375	0.000380		mg/L		101	70 - 130	NC	30
2,4-DB	ND		0.00750	0.00688		mg/L		92	70 - 130	0	30
Bentazon	ND		0.00188	0.00173		mg/L		92	70 - 130	6	30
Pentachlorophenol	ND		0.000150	0.000131		mg/L		88	70 - 130	5	30
Dalapon	ND		0.00375	0.00395		mg/L		105	70 - 130	3	30
3,5-Dichlorobenzoic acid	ND		0.00188	0.00227		mg/L		121	70 - 130	10	30
Picloram	ND		0.000375	0.000421		mg/L		112	70 - 130	1	30
Acifluorfen	ND		0.000750	0.000951		mg/L		127	70 - 130	1	30
Dicamba	ND		0.000375	0.000398		mg/L		92	70 - 130	3	30
Dichlorprop	ND		0.00188	0.00187		mg/L		100	70 - 130	3	30

Surrogate	MSD %Recovery	MSD Qualifier	Limits
2,4-Dichlorophenylacetic acid (Surr)	100		70 - 130

Method: 551.1 - Chlorinated Disinfection Byproducts and Solvents (GC)

Lab Sample ID: MB 380-4999/9-A

Matrix: Drinking Water

Analysis Batch: 6515

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4999

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Ethylene Dibromide (EDB)	ND		0.000010	mg/L		06/06/22 10:24	06/06/22 18:11	1
Dibromochloropropane (DBCP)	ND		0.000010	mg/L		06/06/22 10:24	06/06/22 18:11	1

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 551.1 - Chlorinated Disinfection Byproducts and Solvents (GC) (Continued)

Lab Sample ID: MB 380-4999/9-A

Matrix: Drinking Water

Analysis Batch: 6515

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4999

	MB	MB								
Surrogate	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac				
1,2-Dibromopropane (Surr)	106		80 - 120	06/06/22 10:24	06/06/22 18:11	1				

Lab Sample ID: LCS 380-4999/7-A

Matrix: Drinking Water

Analysis Batch: 6515

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4999

			Spike	LCS	LCS				%Rec	
Analyte			Added	Result	Qualifier	Unit	D	%Rec	Limits	
Ethylene Dibromide (EDB)			0.000250	0.000257		mg/L		103	80 - 120	
Dibromochloropropane (DBCP)			0.000250	0.000256		mg/L		102	80 - 120	
Surrogate	%Recovery	Qualifier	Limits							
1,2-Dibromopropane (Surr)	103		80 - 120							

Lab Sample ID: MRL 380-4999/8-A

Matrix: Drinking Water

Analysis Batch: 6515

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4999

			Spike	MRL	MRL				%Rec	
Analyte			Added	Result	Qualifier	Unit	D	%Rec	Limits	
Ethylene Dibromide (EDB)			0.0100	0.0109		ug/L		109	50 - 150	
Dibromochloropropane (DBCP)			0.0100	0.0111		ug/L		111	50 - 150	
Surrogate	%Recovery	Qualifier	Limits							
1,2-Dibromopropane (Surr)	106		80 - 120							

Lab Sample ID: 380-2194-HJ-1-B MS

Matrix: Drinking Water

Analysis Batch: 6515

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4999

	Sample	Sample	Spike	MS	MS				%Rec	
Analyte	Result	Qualifier	Added	Result	Qualifier	Unit	D	%Rec	Limits	
Ethylene Dibromide (EDB)	ND		0.0000492	0.0000533		mg/L		108	80 - 120	
Dibromochloropropane (DBCP)	ND		0.0000492	0.0000549		mg/L		112	80 - 120	
Surrogate	%Recovery	Qualifier	Limits							
1,2-Dibromopropane (Surr)	102		80 - 120							

Lab Sample ID: 380-2236-AK-1-A DU

Matrix: Drinking Water

Analysis Batch: 6515

Client Sample ID: Duplicate

Prep Type: Total/NA

Prep Batch: 4999

	Sample	Sample		DU	DU					RPD
Analyte	Result	Qualifier		Result	Qualifier	Unit	D			Limit
Ethylene Dibromide (EDB)	ND			ND		mg/L			NC	20
Dibromochloropropane (DBCP)	ND			ND		mg/L			NC	20
Surrogate	%Recovery	Qualifier	Limits							
1,2-Dibromopropane (Surr)	106		80 - 120							

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: MB 380-6340/36

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	ND		0.50	mg/L			05/25/22 23:11	1
Sulfate	ND		0.25	mg/L			05/25/22 23:11	1

Lab Sample ID: MB 380-6340/4

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Chloride	ND		0.50	mg/L			05/25/22 09:22	1
Sulfate	ND		0.25	mg/L			05/25/22 09:22	1

Lab Sample ID: LCS 380-6340/7

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Chloride	25.0	25.3		mg/L		101	90 - 110
Sulfate	50.0	50.3		mg/L		101	90 - 110

Lab Sample ID: LCSD 380-6340/8

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Chloride	25.0	25.4		mg/L		102	90 - 110	0	20
Sulfate	50.0	50.5		mg/L		101	90 - 110	0	20

Lab Sample ID: MRL 380-6340/37

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Chloride	0.125	ND		mg/L		102	50 - 150
Sulfate	0.250	0.252		mg/L		101	50 - 150

Lab Sample ID: MRL 380-6340/5

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Chloride	0.125	ND		mg/L		103	50 - 150
Sulfate	0.250	ND		mg/L		99	50 - 150

Lab Sample ID: MRL 380-6340/6

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Chloride	0.500	ND		mg/L		95	50 - 150
Sulfate	1.00	0.991		mg/L		99	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 300.0 - Anions, Ion Chromatography

Lab Sample ID: 380-2284-1 MS

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: TILL51981_05.23.22

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Chloride	4.4		12.5	18.0		mg/L		109	80 - 120
Sulfate	1.2		25.0	27.9		mg/L		107	80 - 120

Lab Sample ID: 380-2284-1 MSD

Matrix: Drinking Water

Analysis Batch: 6340

Client Sample ID: TILL51981_05.23.22

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Chloride	4.4		12.5	18.1		mg/L		110	80 - 120	0	20
Sulfate	1.2		25.0	28.0		mg/L		107	80 - 120	0	20

Lab Sample ID: MB 380-6342/18

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Nitrate as N	ND		0.050	mg/L			05/25/22 09:22	1
Nitrate Nitrite as N	ND	^3-	0.050	mg/L			05/25/22 09:22	1
Nitrite as N	ND		0.050	mg/L			05/25/22 09:22	1

Lab Sample ID: MB 380-6342/35

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Method Blank

Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Nitrate as N	ND		0.050	mg/L			05/25/22 23:11	1
Nitrate Nitrite as N	ND	^3-	0.050	mg/L			05/25/22 23:11	1
Nitrite as N	ND		0.050	mg/L			05/25/22 23:11	1

Lab Sample ID: LCS 380-6342/21

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Nitrate as N	2.50	2.29	^3-	mg/L		92	90 - 110
Nitrate Nitrite as N	3.50	3.23	^3-	mg/L		92	90 - 110
Nitrite as N	1.00	0.938	^3-	mg/L		94	90 - 110

Lab Sample ID: LCSD 380-6342/22

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Nitrate as N	2.50	2.30	^3-	mg/L		92	90 - 110	0	20
Nitrate Nitrite as N	3.50	3.24	^3-	mg/L		93	90 - 110	0	20
Nitrite as N	1.00	0.940	^3-	mg/L		94	90 - 110	0	20

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 300.0 - Anions, Ion Chromatography (Continued)

Lab Sample ID: MRL 380-6342/19

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Nitrate as N	0.0125	ND		mg/L		88	50 - 150
Nitrate Nitrite as N	0.0250	ND	^3-	mg/L		0	50 - 150
Nitrite as N	0.0125	ND		mg/L		98	50 - 150

Lab Sample ID: MRL 380-6342/20

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Nitrate as N	0.0500	ND		mg/L		82	50 - 150
Nitrate Nitrite as N	0.100	ND	^3-	mg/L		0	50 - 150
Nitrite as N	0.0500	ND		mg/L		97	50 - 150

Lab Sample ID: MRL 380-6342/36

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Nitrate as N	0.0125	ND		mg/L		85	50 - 150
Nitrate Nitrite as N	0.0250	ND	^3-	mg/L		0	50 - 150
Nitrite as N	0.0125	ND		mg/L		102	50 - 150

Lab Sample ID: 380-2284-1 MS

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: TILL51981_05.23.22

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Nitrate as N	1.1	H ^3-	1.25	2.33		mg/L		99	80 - 120
Nitrate Nitrite as N	1.1	H ^3-	1.75	2.81		mg/L		98	80 - 120
Nitrite as N	ND	H ^3-	0.500	0.477		mg/L		95	80 - 120

Lab Sample ID: 380-2284-1 MSD

Matrix: Drinking Water

Analysis Batch: 6342

Client Sample ID: TILL51981_05.23.22

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Nitrate as N	1.1	H ^3-	1.25	2.33		mg/L		99	80 - 120	0	20
Nitrate Nitrite as N	1.1	H ^3-	1.75	2.81		mg/L		98	80 - 120	0	20
Nitrite as N	ND	H ^3-	0.500	0.479		mg/L		96	80 - 120	0	20

Method: 531.2 - Carbamate Pesticides (HPLC)

Lab Sample ID: MB 380-4659/3-A

Matrix: Drinking Water

Analysis Batch: 5434

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4659

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
3-Hydroxycarbofuran	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Aldicarb	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Aldicarb sulfone	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 531.2 - Carbamate Pesticides (HPLC) (Continued)

Lab Sample ID: MB 380-4659/3-A

Matrix: Drinking Water

Analysis Batch: 5434

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4659

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Aldicarb sulfoxide	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Baygon	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Carbaryl	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Carbofuran	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Methiocarb	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Methomyl	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1
Oxamyl	ND		0.50	ug/L		05/26/22 12:22	05/27/22 14:43	1

Surrogate	MB %Recovery	MB Qualifier	Limits	Prepared	Analyzed	Dil Fac
BDMC	110		70 - 130	05/26/22 12:22	05/27/22 14:43	1

Lab Sample ID: LCS 380-4659/2-A

Matrix: Drinking Water

Analysis Batch: 5434

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4659

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
3-Hydroxycarbofuran	5.00	4.91		ug/L		98	70 - 130
Aldicarb	5.00	4.83		ug/L		97	70 - 130
Aldicarb sulfone	5.00	5.35		ug/L		107	70 - 130
Aldicarb sulfoxide	5.00	4.60		ug/L		92	70 - 130
Baygon	5.00	5.18		ug/L		104	70 - 130
Carbaryl	5.00	5.06		ug/L		101	70 - 130
Carbofuran	5.00	5.20		ug/L		104	70 - 130
Methiocarb	5.00	5.21		ug/L		104	70 - 130
Methomyl	5.00	4.85		ug/L		97	70 - 130
Oxamyl	5.00	5.14		ug/L		103	70 - 130

Surrogate	LCS %Recovery	LCS Qualifier	Limits
BDMC	107		70 - 130

Lab Sample ID: MRL 380-4659/1-A

Matrix: Drinking Water

Analysis Batch: 5434

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4659

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
3-Hydroxycarbofuran	0.500	ND		ug/L		100	50 - 150
Aldicarb	0.500	ND		ug/L		98	50 - 150
Aldicarb sulfone	0.500	ND		ug/L		97	50 - 150
Aldicarb sulfoxide	0.500	0.518		ug/L		104	50 - 150
Baygon	0.500	ND		ug/L		100	50 - 150
Carbaryl	0.500	0.549		ug/L		110	50 - 150
Carbofuran	0.500	0.538		ug/L		108	50 - 150
Methiocarb	0.500	ND		ug/L		91	50 - 150
Methomyl	0.500	0.544		ug/L		109	50 - 150
Oxamyl	0.500	ND		ug/L		97	50 - 150

Surrogate	MRL %Recovery	MRL Qualifier	Limits
BDMC	113		70 - 130

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 531.2 - Carbamate Pesticides (HPLC)

Lab Sample ID: 380-2194-GU-1-A MS

Matrix: Drinking Water

Analysis Batch: 5434

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4659

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
3-Hydroxycarbofuran	ND		5.00	5.11		ug/L		102	70 - 130
Aldicarb	ND		5.00	5.12		ug/L		102	70 - 130
Aldicarb sulfone	ND		5.00	4.90		ug/L		98	70 - 130
Aldicarb sulfoxide	ND		5.00	4.89		ug/L		98	70 - 130
Baygon	ND		5.00	5.10		ug/L		102	70 - 130
Carbaryl	ND		5.00	4.90		ug/L		98	70 - 130
Carbofuran	ND		5.00	4.91		ug/L		98	70 - 130
Methiocarb	ND		5.00	5.21		ug/L		104	70 - 130
Methomyl	ND		5.00	5.15		ug/L		103	70 - 130
Oxamyl	ND		5.00	5.00		ug/L		100	70 - 130
MS MS									
Surrogate	%Recovery	Qualifier	Limits						
BDMC	104		70 - 130						

Lab Sample ID: 380-2194-GU-1-B MSD

Matrix: Drinking Water

Analysis Batch: 5434

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Prep Batch: 4659

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
3-Hydroxycarbofuran	ND		5.00	5.21		ug/L		104	70 - 130	2	30
Aldicarb	ND		5.00	5.06		ug/L		101	70 - 130	1	30
Aldicarb sulfone	ND		5.00	4.93		ug/L		99	70 - 130	1	30
Aldicarb sulfoxide	ND		5.00	5.03		ug/L		101	70 - 130	3	30
Baygon	ND		5.00	4.94		ug/L		99	70 - 130	3	30
Carbaryl	ND		5.00	4.95		ug/L		99	70 - 130	1	30
Carbofuran	ND		5.00	5.18		ug/L		104	70 - 130	5	30
Methiocarb	ND		5.00	5.22		ug/L		104	70 - 130	0	30
Methomyl	ND		5.00	5.15		ug/L		103	70 - 130	0	30
Oxamyl	ND		5.00	5.19		ug/L		104	70 - 130	4	30
MSD MSD											
Surrogate	%Recovery	Qualifier	Limits								
BDMC	107		70 - 130								

Method: 547 - Glyphosate (DAI HPLC)

Lab Sample ID: MB 380-4795/3-A

Matrix: Drinking Water

Analysis Batch: 5022

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4795

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Glyphosate	ND		6.0	ug/L		06/01/22 09:36	06/01/22 14:40	1

Lab Sample ID: LCS 380-4795/2-A

Matrix: Drinking Water

Analysis Batch: 5022

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4795

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Glyphosate	10.0	10.1		ug/L		101	80 - 120

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 547 - Glyphosate (DAI HPLC) (Continued)

Lab Sample ID: MRL 380-4795/1-A

Matrix: Drinking Water

Analysis Batch: 5022

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4795

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Glyphosate	6.00	6.19		ug/L		103	50 - 150

Lab Sample ID: 380-2422-AX-1-B MS

Matrix: Drinking Water

Analysis Batch: 5022

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4795

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Glyphosate	ND		10.0	10.1		ug/L		101	80 - 120

Lab Sample ID: 380-2422-AX-1-C MSD

Matrix: Drinking Water

Analysis Batch: 5022

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Prep Batch: 4795

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Glyphosate	ND		10.0	9.82		ug/L		98	80 - 120	3	20

Lab Sample ID: 380-2440-CS-1-B MS

Matrix: Drinking Water

Analysis Batch: 5022

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Prep Batch: 4795

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Glyphosate	ND		10.0	9.83		ug/L		98	80 - 120

Method: 549.2 - Diquat and Paraquat (HPLC)

Lab Sample ID: MB 380-4718/13-A

Matrix: Drinking Water

Analysis Batch: 5127

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4718

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Diquat	ND		0.00040	mg/L		05/27/22 18:16	06/01/22 21:58	1
Paraquat	ND		0.0020	mg/L		05/27/22 18:16	06/01/22 21:58	1

Lab Sample ID: LCS 380-4718/11-A

Matrix: Drinking Water

Analysis Batch: 5127

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4718

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Diquat	0.00499	0.00460		mg/L		92	70 - 130
Paraquat	0.00499	0.00507		mg/L		102	70 - 130

Lab Sample ID: MRL 380-4718/14-A

Matrix: Drinking Water

Analysis Batch: 5127

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4718

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Diquat	0.400	0.520		ug/L		130	50 - 150
Paraquat	0.400	ND		ug/L		144	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 549.2 - Diquat and Paraquat (HPLC) (Continued)

Lab Sample ID: MRL 380-4718/15-A
Matrix: Drinking Water
Analysis Batch: 5127

Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 4718

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Diquat	2.00	1.65		ug/L		83	50 - 150
Paraquat	2.00	ND		ug/L		92	50 - 150

Lab Sample ID: 380-2270-A-1-B MS
Matrix: Drinking Water
Analysis Batch: 5127

Client Sample ID: Matrix Spike
Prep Type: Total/NA
Prep Batch: 4718

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Diquat	ND		0.00500	0.00472		mg/L		94	70 - 130
Paraquat	ND		0.00500	0.00536		mg/L		96	70 - 130

Lab Sample ID: 380-2270-A-1-C MSD
Matrix: Drinking Water
Analysis Batch: 5127

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA
Prep Batch: 4718

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Diquat	ND		0.00498	0.00478		mg/L		96	70 - 130	1	20
Paraquat	ND		0.00498	0.00515		mg/L		92	70 - 130	4	20

Method: 200.7 - Metals (ICP)

Lab Sample ID: MB 380-4950/1-A
Matrix: Drinking Water
Analysis Batch: 5299

Client Sample ID: Method Blank
Prep Type: Total Recoverable
Prep Batch: 4950

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Calcium	ND		1.0	mg/L		06/03/22 12:45	06/07/22 18:53	1
Iron	ND		0.010	mg/L		06/03/22 12:45	06/07/22 18:53	1
Magnesium	ND		0.10	mg/L		06/03/22 12:45	06/07/22 18:53	1
Silica	ND		0.43	mg/L		06/03/22 12:45	06/07/22 18:53	1
Sodium	ND		1.0	mg/L		06/03/22 12:45	06/07/22 18:53	1

Lab Sample ID: LCS 380-4950/3-A
Matrix: Drinking Water
Analysis Batch: 5299

Client Sample ID: Lab Control Sample
Prep Type: Total Recoverable
Prep Batch: 4950

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Calcium	50.0	51.5		mg/L		103	85 - 115
Iron	5.00	5.19		mg/L		104	85 - 115
Magnesium	20.0	20.4		mg/L		102	85 - 115
Silica	21.4	20.2		mg/L		95	85 - 115
Sodium	50.0	50.0		mg/L		100	85 - 115

Lab Sample ID: LCSD 380-4950/4-A
Matrix: Drinking Water
Analysis Batch: 5299

Client Sample ID: Lab Control Sample Dup
Prep Type: Total Recoverable
Prep Batch: 4950

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Calcium	50.0	51.9		mg/L		104	85 - 115	1	20
Iron	5.00	5.22		mg/L		104	85 - 115	1	20

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 200.7 - Metals (ICP) (Continued)

Lab Sample ID: LCSD 380-4950/4-A

Matrix: Drinking Water

Analysis Batch: 5299

Client Sample ID: Lab Control Sample Dup

Prep Type: Total Recoverable

Prep Batch: 4950

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Magnesium	20.0	20.5		mg/L		103	85 - 115	1	20
Silica	21.4	20.4		mg/L		95	85 - 115	1	20
Sodium	50.0	50.3		mg/L		101	85 - 115	1	20

Lab Sample ID: LLCS 380-4950/2-A

Matrix: Drinking Water

Analysis Batch: 5299

Client Sample ID: Lab Control Sample

Prep Type: Total Recoverable

Prep Batch: 4950

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Calcium	1.00	1.02		mg/L		102	50 - 150
Iron	0.0100	0.0112		mg/L		112	50 - 150
Magnesium	0.100	0.0953	J	mg/L		95	50 - 150
Silica	0.428	ND		mg/L		95	50 - 150

Lab Sample ID: 380-1955-A-1-B MS

Matrix: Drinking Water

Analysis Batch: 5299

Client Sample ID: Matrix Spike

Prep Type: Total Recoverable

Prep Batch: 4950

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Calcium	43		50.0	95.0		mg/L		104	70 - 130
Iron	ND		5.00	5.37		mg/L		107	70 - 130
Magnesium	8.4		20.0	29.6		mg/L		106	70 - 130
Silica	11	^2	21.4	31.7		mg/L		97	70 - 130
Sodium	46	^2	50.0	96.2		mg/L		101	70 - 130

Lab Sample ID: 380-1955-A-1-C MSD

Matrix: Drinking Water

Analysis Batch: 5299

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total Recoverable

Prep Batch: 4950

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Calcium	43		50.0	95.7		mg/L		105	70 - 130	1	20
Iron	ND		5.00	5.44		mg/L		109	70 - 130	1	20
Magnesium	8.4		20.0	29.8		mg/L		107	70 - 130	1	20
Silica	11	^2	21.4	32.1		mg/L		99	70 - 130	1	20
Sodium	46	^2	50.0	97.0		mg/L		102	70 - 130	1	20

Method: 200.8 - Metals (ICP/MS)

Lab Sample ID: LLCS 380-4917/12

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Aluminum	20.0	19.8	J	ug/L		99	50 - 150
Antimony	1.00	1.07		ug/L		107	50 - 150
Arsenic	1.00	0.988	J	ug/L		99	50 - 150
Barium	2.00	1.98	J	ug/L		99	50 - 150
Beryllium	1.00	1.03		ug/L		103	50 - 150
Cadmium	0.500	0.520		ug/L		104	50 - 150
Chromium	1.00	ND		ug/L		78	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 200.8 - Metals (ICP/MS) (Continued)

Lab Sample ID: LLCS 380-4917/12

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Copper	2.00	2.05		ug/L		103	50 - 150
Lead	0.500	0.535		ug/L		107	50 - 150
Manganese	2.00	2.02		ug/L		101	50 - 150
Nickel	5.00	4.86	J	ug/L		97	50 - 150
Selenium	5.00	4.98	J	ug/L		100	50 - 150
Silver	0.500	0.636		ug/L		127	50 - 150
Thallium	1.00	1.02		ug/L		102	50 - 150
Uranium	1.00	1.02		ug/L		102	50 - 150
Zinc	20.0	19.7	J	ug/L		98	50 - 150
Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Uranium	0.67	0.681		pCi/L		102	50 - 150

Lab Sample ID: MB 380-4809/1-A

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Method Blank

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Aluminum	ND		20	ug/L		06/01/22 11:50	06/02/22 15:04	1
Antimony	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Arsenic	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Barium	ND		2.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Beryllium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Cadmium	ND		0.50	ug/L		06/01/22 11:50	06/02/22 15:04	1
Chromium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Copper	ND		2.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Lead	ND		0.50	ug/L		06/01/22 11:50	06/02/22 15:04	1
Manganese	ND		2.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Nickel	ND		5.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Selenium	ND		5.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Silver	ND		0.50	ug/L		06/01/22 11:50	06/02/22 15:04	1
Thallium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Uranium	ND		1.0	ug/L		06/01/22 11:50	06/02/22 15:04	1
Zinc	ND		20	ug/L		06/01/22 11:50	06/02/22 15:04	1
Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Uranium	ND		0.67	pCi/L		06/01/22 11:50	06/02/22 15:04	1

Lab Sample ID: LCS 380-4809/3-A

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Lab Control Sample

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Aluminum	100	104		ug/L		104	85 - 115
Antimony	50.0	51.8		ug/L		104	85 - 115
Arsenic	50.0	52.6		ug/L		105	85 - 115
Barium	50.0	52.4		ug/L		105	85 - 115
Beryllium	25.0	25.7		ug/L		103	85 - 115
Cadmium	25.0	25.6		ug/L		102	85 - 115

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 200.8 - Metals (ICP/MS) (Continued)

Lab Sample ID: LCS 380-4809/3-A

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Lab Control Sample

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Chromium	50.0	51.5		ug/L		103	85 - 115
Copper	50.0	52.5		ug/L		105	85 - 115
Lead	50.0	52.1		ug/L		104	85 - 115
Manganese	100	104		ug/L		104	85 - 115
Nickel	50.0	50.8		ug/L		102	85 - 115
Selenium	50.0	53.6		ug/L		107	85 - 115
Silver	25.0	23.6		ug/L		94	85 - 115
Thallium	50.0	50.6		ug/L		101	85 - 115
Uranium	50.0	50.7		ug/L		101	85 - 115
Zinc	50.0	52.7		ug/L		105	85 - 115
Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Uranium	34	34.0		pCi/L		101	85 - 115

Lab Sample ID: LCSD 380-4809/4-A

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Lab Control Sample Dup

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Aluminum	100	107		ug/L		107	85 - 115	3	20
Antimony	50.0	52.5		ug/L		105	85 - 115	1	20
Arsenic	50.0	53.4		ug/L		107	85 - 115	1	20
Barium	50.0	53.4		ug/L		107	85 - 115	2	20
Beryllium	25.0	25.7		ug/L		103	85 - 115	0	20
Cadmium	25.0	26.2		ug/L		105	85 - 115	2	20
Chromium	50.0	52.4		ug/L		105	85 - 115	2	20
Copper	50.0	53.3		ug/L		107	85 - 115	2	20
Lead	50.0	52.1		ug/L		104	85 - 115	0	20
Manganese	100	105		ug/L		105	85 - 115	1	20
Nickel	50.0	51.4		ug/L		103	85 - 115	1	20
Selenium	50.0	54.2		ug/L		108	85 - 115	1	20
Silver	25.0	24.5		ug/L		98	85 - 115	4	20
Thallium	50.0	51.6		ug/L		103	85 - 115	2	20
Uranium	50.0	51.5		ug/L		103	85 - 115	1	20
Zinc	50.0	53.2		ug/L		106	85 - 115	1	20
Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Uranium	34	34.5		pCi/L		103	85 - 115	1	20

Lab Sample ID: LLCS 380-4809/2-A

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Lab Control Sample

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Aluminum	20.0	21.9		ug/L		110	50 - 150
Antimony	1.00	1.03		ug/L		103	50 - 150
Arsenic	1.00	0.959	J	ug/L		96	50 - 150
Barium	2.00	2.01		ug/L		100	50 - 150
Beryllium	1.00	1.07		ug/L		107	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 200.8 - Metals (ICP/MS) (Continued)

Lab Sample ID: LLCS 380-4809/2-A
Matrix: Drinking Water
Analysis Batch: 4917

Client Sample ID: Lab Control Sample
Prep Type: Total Recoverable
Prep Batch: 4809

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Cadmium	0.500	0.519		ug/L		104	50 - 150
Chromium	1.00	ND		ug/L		60	50 - 150
Copper	2.00	2.17		ug/L		108	50 - 150
Lead	0.500	0.525		ug/L		105	50 - 150
Manganese	2.00	2.10		ug/L		105	50 - 150
Nickel	5.00	5.84		ug/L		117	50 - 150
Selenium	5.00	5.28		ug/L		106	50 - 150
Silver	0.500	0.488	J	ug/L		98	50 - 150
Thallium	1.00	1.03		ug/L		103	50 - 150
Uranium	1.00	1.02		ug/L		102	50 - 150
Zinc	20.0	21.6		ug/L		108	50 - 150
Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Uranium	0.67	0.683		pCi/L		102	50 - 150

Lab Sample ID: 380-1197-A-1-C MS
Matrix: Drinking Water
Analysis Batch: 4917

Client Sample ID: Matrix Spike
Prep Type: Total Recoverable
Prep Batch: 4809

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Aluminum	150		100	254		ug/L		106	70 - 130
Antimony	ND		50.0	54.6		ug/L		109	70 - 130
Arsenic	1.3		50.0	55.9		ug/L		109	70 - 130
Barium	100		50.0	153		ug/L		104	70 - 130
Beryllium	ND		25.0	27.3		ug/L		109	70 - 130
Cadmium	ND		25.0	25.5		ug/L		102	70 - 130
Chromium	ND		50.0	52.2		ug/L		104	70 - 130
Copper	3.4		50.0	52.4		ug/L		98	70 - 130
Lead	ND		50.0	49.5		ug/L		99	70 - 130
Manganese	9.4		100	111		ug/L		102	70 - 130
Nickel	ND		50.0	51.5		ug/L		98	70 - 130
Selenium	ND		50.0	54.7		ug/L		106	70 - 130
Silver	ND		25.0	23.0		ug/L		92	70 - 130
Thallium	ND		50.0	49.2		ug/L		98	70 - 130
Uranium	1.9		50.0	57.8		ug/L		112	70 - 130
Zinc	ND		50.0	51.7		ug/L		103	70 - 130
Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Uranium	1.3		34	38.7		pCi/L		112	70 - 130

Lab Sample ID: 380-1197-A-1-D MSD
Matrix: Drinking Water
Analysis Batch: 4917

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total Recoverable
Prep Batch: 4809

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Aluminum	150		100	248		ug/L		100	70 - 130	2	20
Antimony	ND		50.0	53.9		ug/L		108	70 - 130	1	20
Arsenic	1.3		50.0	54.4		ug/L		106	70 - 130	3	20
Barium	100		50.0	152		ug/L		102	70 - 130	1	20

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 200.8 - Metals (ICP/MS) (Continued)

Lab Sample ID: 380-1197-A-1-D MSD

Matrix: Drinking Water

Analysis Batch: 4917

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Beryllium	ND		25.0	26.4		ug/L		106	70 - 130	3	20
Cadmium	ND		25.0	25.1		ug/L		100	70 - 130	2	20
Chromium	ND		50.0	50.4		ug/L		101	70 - 130	3	20
Copper	3.4		50.0	51.2		ug/L		95	70 - 130	2	20
Lead	ND		50.0	48.8		ug/L		98	70 - 130	2	20
Manganese	9.4		100	110		ug/L		101	70 - 130	1	20
Nickel	ND		50.0	50.1		ug/L		95	70 - 130	3	20
Selenium	ND		50.0	53.2		ug/L		103	70 - 130	3	20
Silver	ND		25.0	22.6		ug/L		90	70 - 130	2	20
Thallium	ND		50.0	47.8		ug/L		96	70 - 130	3	20
Uranium	1.9		50.0	57.9		ug/L		112	70 - 130	0	20
Zinc	ND		50.0	50.3		ug/L		101	70 - 130	3	20
Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Uranium	1.3		34	38.8		pCi/L		112	70 - 130	0	20

Method: 200.8 - Mercury (ICP/MS)

Lab Sample ID: MB 380-4809/1-A

Matrix: Drinking Water

Analysis Batch: 4918

Client Sample ID: Method Blank

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Hg	ND		0.20	ug/L		06/01/22 11:50	06/02/22 15:04	1

Lab Sample ID: LCS 380-4809/3-A

Matrix: Drinking Water

Analysis Batch: 4918

Client Sample ID: Lab Control Sample

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Hg	0.750	0.736		ug/L		98	85 - 115

Lab Sample ID: LCSD 380-4809/4-A

Matrix: Drinking Water

Analysis Batch: 4918

Client Sample ID: Lab Control Sample Dup

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Hg	0.750	0.755		ug/L		101	85 - 115	3	20

Lab Sample ID: LLCS 380-4809/2-A

Matrix: Drinking Water

Analysis Batch: 4918

Client Sample ID: Lab Control Sample

Prep Type: Total Recoverable

Prep Batch: 4809

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Hg	0.200	0.200		ug/L		100	50 - 150

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 200.8 - Mercury (ICP/MS) (Continued)

Lab Sample ID: 380-1848-K-1-C MS
Matrix: Drinking Water
Analysis Batch: 4918

Client Sample ID: Matrix Spike
Prep Type: Total Recoverable
Prep Batch: 4809

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Hg	ND		0.750	0.727		ug/L		97	70 - 130

Lab Sample ID: 380-1848-K-1-D MSD
Matrix: Drinking Water
Analysis Batch: 4918

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total Recoverable
Prep Batch: 4809

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Hg	ND		0.750	0.717		ug/L		96	70 - 130	1	20

Method: 4500 CN F - Cyanide

Lab Sample ID: MB 380-4749/1
Matrix: Drinking Water
Analysis Batch: 4749

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Cyanide	ND		0.025	mg/L			05/31/22 10:20	1

Lab Sample ID: LCS 380-4749/3
Matrix: Drinking Water
Analysis Batch: 4749

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Cyanide	0.100	0.103		mg/L		103	90 - 110

Lab Sample ID: LCSD 380-4749/4
Matrix: Drinking Water
Analysis Batch: 4749

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Cyanide	0.100	0.100		mg/L		100	90 - 110	3	20

Lab Sample ID: MRL 380-4749/2
Matrix: Drinking Water
Analysis Batch: 4749

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Cyanide	0.0250	0.0282		mg/L		113	50 - 150

Lab Sample ID: 380-2155-A-1 MS
Matrix: Drinking Water
Analysis Batch: 4749

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Cyanide	ND	F1	0.100	0.0993		mg/L		99	80 - 120

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: 4500 CN F - Cyanide (Continued)

Lab Sample ID: 380-2155-A-1 MSD
Matrix: Drinking Water
Analysis Batch: 4749

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Cyanide	ND	F1	0.100	0.0977		mg/L		98	80 - 120	2	20

Method: SM 2120B - Color, Colorimetric

Lab Sample ID: MB 380-4631/1
Matrix: Drinking Water
Analysis Batch: 4631

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Color, Apparent	ND		2.0	Color Units			05/25/22 21:31	1

Method: SM 2150B - Odor

Lab Sample ID: MB 380-4604/1
Matrix: Drinking Water
Analysis Batch: 4604

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Odor	ND		1.0	T.O.N.			05/25/22 15:57	1

Method: SM 2320B - Alkalinity

Lab Sample ID: MB 380-4728/39
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	ND		2.0	mg/L			05/27/22 21:16	1
Bicarbonate Alkalinity as CaCO3	2.15	B	2.0	mg/L			05/27/22 21:16	1
Carbonate Alkalinity as CaCO3	ND		2.0	mg/L			05/27/22 21:16	1

Lab Sample ID: MB 380-4728/7
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	ND		2.0	mg/L			05/27/22 16:16	1
Bicarbonate Alkalinity as CaCO3	2.13	B	2.0	mg/L			05/27/22 16:16	1
Carbonate Alkalinity as CaCO3	ND		2.0	mg/L			05/27/22 16:16	1

Lab Sample ID: LCS 380-4728/37
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	100	97.9		mg/L		98	90 - 110

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 2320B - Alkalinity (Continued)

Lab Sample ID: LCS 380-4728/5
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	100	97.2		mg/L		97	90 - 110

Lab Sample ID: LCSD 380-4728/22
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Alkalinity	100	98.0		mg/L		98	90 - 110	1	20

Lab Sample ID: LLCS 380-4728/38
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	20.0	21.0		mg/L		105	90 - 110

Lab Sample ID: LLCS 380-4728/6
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	20.0	20.9		mg/L		104	90 - 110

Lab Sample ID: MRL 380-4728/40
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	2.00	2.22		mg/L		111	50 - 150

Lab Sample ID: MRL 380-4728/8
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	2.00	2.12		mg/L		106	50 - 150

Lab Sample ID: 380-2284-1 MS
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: TILL51981_05.23.22
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Alkalinity	52		100	150		mg/L		98	80 - 120

Lab Sample ID: 380-2284-1 MSD
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: TILL51981_05.23.22
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Alkalinity	52		100	150		mg/L		98	80 - 120	0	20

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 2320B - Alkalinity

Lab Sample ID: 380-2284-1 DU
Matrix: Drinking Water
Analysis Batch: 4728

Client Sample ID: TILL51981_05.23.22
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Alkalinity	52		52.0		mg/L		0.3	
Bicarbonate Alkalinity as CaCO3	52	B ^2	52.0	B	mg/L		0.3	
Carbonate Alkalinity as CaCO3	ND		ND		mg/L		NC	

Method: SM 2540C - Solids, Total Dissolved (TDS)

Lab Sample ID: MB 380-4784/1
Matrix: Drinking Water
Analysis Batch: 4784

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Total Dissolved Solids	ND		10	mg/L			05/31/22 23:05	1

Lab Sample ID: HLCS 380-4784/5
Matrix: Drinking Water
Analysis Batch: 4784

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	HLCS Result	HLCS Qualifier	Unit	D	%Rec	%Rec Limits
Total Dissolved Solids	700	564		mg/L		81	80 - 114

Lab Sample ID: LCS 380-4784/4
Matrix: Drinking Water
Analysis Batch: 4784

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Total Dissolved Solids	175	178		mg/L		102	80 - 114

Lab Sample ID: MRL 380-4784/2
Matrix: Drinking Water
Analysis Batch: 4784

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Total Dissolved Solids	10.0	ND		mg/L		70	50 - 150

Lab Sample ID: MRL 380-4784/3
Matrix: Drinking Water
Analysis Batch: 4784

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Total Dissolved Solids	10.0	ND		mg/L		80	50 - 150

Lab Sample ID: 380-2368-J-2 DU
Matrix: Drinking Water
Analysis Batch: 4784

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Total Dissolved Solids	290		288		mg/L		0	10

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 2540D - Solids, Total Suspended (TSS)

Lab Sample ID: MB 380-5598/1
Matrix: Drinking Water
Analysis Batch: 5598

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Total Suspended Solids	ND		10	mg/L			06/11/22 04:07	1

Lab Sample ID: LCS 380-5598/4
Matrix: Drinking Water
Analysis Batch: 5598

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Total Suspended Solids	175	164		mg/L		94	79 - 109

Lab Sample ID: LCSD 380-5598/5
Matrix: Drinking Water
Analysis Batch: 5598

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Suspended Solids	175	158		mg/L		90	79 - 109	4	10

Lab Sample ID: MRL 380-5598/2
Matrix: Drinking Water
Analysis Batch: 5598

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Total Suspended Solids	10.0	10.0		mg/L		100	50 - 150

Lab Sample ID: MRL 380-5598/3
Matrix: Drinking Water
Analysis Batch: 5598

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Total Suspended Solids	10.0	12.0		mg/L		120	50 - 150

Lab Sample ID: 380-2272-B-4 DU
Matrix: Drinking Water
Analysis Batch: 5598

Client Sample ID: Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
Total Suspended Solids	16		16.0		mg/L		0	10

Method: SM 4500 F C - Fluoride

Lab Sample ID: MB 380-4934/40
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Fluoride	ND		0.050	mg/L			06/02/22 18:35	1

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 4500 F C - Fluoride (Continued)

Lab Sample ID: LCS 380-4934/42
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Fluoride	1.00	0.947		mg/L		95	90 - 110

Lab Sample ID: LCSD 380-4934/43
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Fluoride	1.00	0.951		mg/L		95	90 - 110	0	10

Lab Sample ID: MRL 380-4934/41
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Fluoride	0.0500	ND		mg/L		93	50 - 150

Lab Sample ID: MRL 380-4934/7
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Fluoride	0.0500	ND		mg/L		96	50 - 150

Lab Sample ID: 380-2440-DP-1 MS
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Fluoride	0.28		1.00	1.23		mg/L		95	80 - 120

Lab Sample ID: 380-2440-DP-1 MSD
Matrix: Drinking Water
Analysis Batch: 4934

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Fluoride	0.28		1.00	1.21		mg/L		93	80 - 120	1	20

Method: SM 4500 H+ B - pH

Lab Sample ID: MB 380-4730/9
Matrix: Drinking Water
Analysis Batch: 4730

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
pH	5.9			S.U.			05/27/22 16:16	1

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 4500 H+ B - pH (Continued)

Lab Sample ID: LCDSRM 380-4730/23
Matrix: Drinking Water
Analysis Batch: 4730

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCDSRM Result	LCDSRM Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
pH	6.00	6.0		S.U.		100.2	98.3 - 101.7	0	

Lab Sample ID: LCSSRM 380-4730/10
Matrix: Drinking Water
Analysis Batch: 4730

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCSSRM Result	LCSSRM Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
pH	6.00	6.0		S.U.		100.2	98.3 - 101.7		

Lab Sample ID: 380-2284-1 DU
Matrix: Drinking Water
Analysis Batch: 4730

Client Sample ID: TILL51981_05.23.22
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	DU Result	DU Qualifier	Unit	D	RPD	RPD Limit
pH	7.5	HF	7.5		S.U.		0	10

Method: SM 5310C - TOC

Lab Sample ID: MB 380-4939/2
Matrix: Drinking Water
Analysis Batch: 4939

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	ND		0.200	mg/L			06/02/22 13:03	1

Lab Sample ID: MB 380-4939/36
Matrix: Drinking Water
Analysis Batch: 4939

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	ND		0.200	mg/L			06/02/22 22:28	1

Lab Sample ID: LCS 380-4939/38
Matrix: Drinking Water
Analysis Batch: 4939

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Organic Carbon	5.00	4.979		mg/L		100	90 - 110		

Lab Sample ID: LCS 380-4939/4
Matrix: Drinking Water
Analysis Batch: 4939

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Organic Carbon	5.00	4.939		mg/L		99	90 - 110		

Eurofins Eaton Monrovia

QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 5310C - TOC (Continued)

Lab Sample ID: LCSD 380-4939/19

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Organic Carbon	5.00	4.943		mg/L		99	90 - 110	1	20

Lab Sample ID: MRL 380-4939/3

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits		
Total Organic Carbon	0.200	ND		mg/L		71	50 - 150		

Lab Sample ID: MRL 380-4939/37

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits		
Total Organic Carbon	0.200	ND		mg/L		92	50 - 150		

Lab Sample ID: 380-2406-A-3 MS

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits		
Total Organic Carbon	0.506		4.00	4.546		mg/L		101	80 - 120		

Lab Sample ID: 380-2406-A-3 MSD

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Organic Carbon	0.506		4.00	4.495		mg/L		100	80 - 120	1	20

Lab Sample ID: 380-2415-C-3 MS

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits		
Total Organic Carbon	0.346		2.00	2.344		mg/L		100	80 - 120		

Lab Sample ID: 380-2415-C-3 MSD

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Organic Carbon	0.346		2.00	2.354		mg/L		100	80 - 120	0	20

Lab Sample ID: 380-2430-A-4 MS

Matrix: Drinking Water

Analysis Batch: 4939

Client Sample ID: Matrix Spike

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits		
Total Organic Carbon	2.06		4.00	6.170		mg/L		103	80 - 120		

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 5310C - TOC

Lab Sample ID: 380-2430-A-4 MSD
Matrix: Drinking Water
Analysis Batch: 4939

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Total Organic Carbon	2.06		4.00	6.159		mg/L		102	80 - 120	0	20

Method: SM 5540C - Methylene Blue Active Substances (MBAS)

Lab Sample ID: MB 380-5547/2
Matrix: Drinking Water
Analysis Batch: 5547

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	Unit	D	Prepared	Analyzed	Dil Fac
Methylene Blue Active Substances	ND		0.10	mg/L			05/26/22 08:16	1

Lab Sample ID: LCS 380-5547/1
Matrix: Drinking Water
Analysis Batch: 5547

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Methylene Blue Active Substances	0.200	0.199		mg/L		99	90 - 110

Lab Sample ID: LCS 380-5547/7
Matrix: Drinking Water
Analysis Batch: 5547

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec Limits
Methylene Blue Active Substances	0.200	0.203		mg/L		102	90 - 110

Lab Sample ID: LCSD 380-5547/10
Matrix: Drinking Water
Analysis Batch: 5547

Client Sample ID: Lab Control Sample Dup
Prep Type: Total/NA

Analyte	Spike Added	LCSD Result	LCSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Methylene Blue Active Substances	0.200	0.207		mg/L		103	90 - 110	2	20

Lab Sample ID: MRL 380-5547/3
Matrix: Drinking Water
Analysis Batch: 5547

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	MRL Result	MRL Qualifier	Unit	D	%Rec	%Rec Limits
Methylene Blue Active Substances	0.100	ND		mg/L		91	75 - 125

Lab Sample ID: MS 380-5547/5
Matrix: Drinking Water
Analysis Batch: 5547

Client Sample ID: Matrix Spike
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec Limits
Methylene Blue Active Substances			0.200	0.672		mg/L			

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM 5540C - Methylene Blue Active Substances (MBAS) (Continued)

Lab Sample ID: MSD 380-5547/6

Matrix: Drinking Water

Analysis Batch: 5547

Client Sample ID: Matrix Spike Duplicate

Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec Limits	RPD	RPD Limit
Methylene Blue Active Substances			0.200	0.656		mg/L					

Method: Ra226_Ra228 - Radium-226/Radium-228 (Gamma-ray Spectrometry)

Lab Sample ID: MB 380-4864/1-A

Matrix: Drinking Water

Analysis Batch: 7439

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 4864

Analyte	MB Result	MB Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Ra-226	0.0000	U	0.000		1.00	0.403	pCi/L	06/02/22 11:15	06/17/22 00:51	1
Ra-228	0.0000	U	0.000		1.00	0.584	pCi/L	06/02/22 11:15	06/17/22 00:51	1

Lab Sample ID: LCS 380-4864/2-A

Matrix: Drinking Water

Analysis Batch: 7439

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 4864

Analyte	Spike Added	LCS Result	LCS Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits
Ra-226	10.2	10.28			1.00	0.342	pCi/L	101	76 - 125
Ra-228	10.0	8.995			1.00	0.448	pCi/L	90	77 - 115

Lab Sample ID: LCSD 380-4864/3-A

Matrix: Drinking Water

Analysis Batch: 7439

Client Sample ID: Lab Control Sample Dup

Prep Type: Total/NA

Prep Batch: 4864

Analyte	Spike Added	LCSD Result	LCSD Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits	RER	RER Limit
Ra-226	10.2	11.34			1.00	0.340	pCi/L	111	76 - 125	NaN	
Ra-228	10.0	9.781			1.00	0.440	pCi/L	98	77 - 115	NaN	

Method: SM7110C - Gross Alpha by Co-Precipitation

Lab Sample ID: MB 810-21875/1-A

Matrix: Drinking Water

Analysis Batch: 22994

Client Sample ID: Method Blank

Prep Type: Total/NA

Prep Batch: 21875

Analyte	MB Result	MB Qualifier	Count Uncert. (2σ+/-)	Total Uncert. (2σ+/-)	RL	MDC	Unit	Prepared	Analyzed	Dil Fac
Gross Alpha	-0.2900	U	0.560		3.00	1.19	pCi/L	06/14/22 10:57	06/20/22 08:26	1

Lab Sample ID: LCS 810-21875/2-A

Matrix: Drinking Water

Analysis Batch: 22994

Client Sample ID: Lab Control Sample

Prep Type: Total/NA

Prep Batch: 21875

Analyte	Spike Added	LCS Result	LCS Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits
Gross Alpha	16.5	15.67			3.00	1.96	pCi/L	95	80 - 120

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QC Sample Results

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method: SM7110C - Gross Alpha by Co-Precipitation (Continued)

Lab Sample ID: 810-22816-I-1-A MS
Matrix: Drinking Water
Analysis Batch: 22994

Client Sample ID: Matrix Spike
Prep Type: Total/NA
Prep Batch: 21875

Analyte	Sample Result	Sample Qual	Spike Added	MS Result	MS Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits
Gross Alpha	0.410	U	16.4	22.44	F1		3.00	1.93	pCi/L	137	70 - 130

Lab Sample ID: 810-22816-I-1-A MS
Matrix: Drinking Water
Analysis Batch: 23269

Client Sample ID: Matrix Spike
Prep Type: Total/NA
Prep Batch: 21875

Analyte	Sample Result	Sample Qual	Spike Added	MS Result	MS Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits
Gross Alpha	0.620	U	16.4	21.94	F1		3.00	1.47	pCi/L	134	70 - 130

Lab Sample ID: 810-22816-I-1-B MSD
Matrix: Drinking Water
Analysis Batch: 22994

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA
Prep Batch: 21875

Analyte	Sample Result	Sample Qual	Spike Added	MSD Result	MSD Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits	RER	RER Limit
Gross Alpha	0.410	U	16.4	16.77			3.00	1.68	pCi/L	102	70 - 130	NaN	

Lab Sample ID: 810-22816-I-1-B MSD
Matrix: Drinking Water
Analysis Batch: 23269

Client Sample ID: Matrix Spike Duplicate
Prep Type: Total/NA
Prep Batch: 21875

Analyte	Sample Result	Sample Qual	Spike Added	MSD Result	MSD Qual	Total Uncert. (2σ+/-)	RL	MDC	Unit	%Rec	%Rec Limits	RER	RER Limit
Gross Alpha	0.620	U	16.4	13.21			3.00	1.17	pCi/L	80	70 - 130	NaN	

QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

GC/MS VOA

Analysis Batch: 4928

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	524.2	
MB 380-4928/14	Method Blank	Total/NA	Drinking Water	524.2	
LCS 380-4928/11	Lab Control Sample	Total/NA	Drinking Water	524.2	
LCSD 380-4928/12	Lab Control Sample Dup	Total/NA	Drinking Water	524.2	
MRL 380-4928/10	Lab Control Sample	Total/NA	Drinking Water	524.2	
MRL 380-4928/13	Lab Control Sample	Total/NA	Drinking Water	524.2	

GC/MS Semi VOA

Prep Batch: 4697

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	548.1	
MB 380-4697/1-A	Method Blank	Total/NA	Drinking Water	548.1	
LCS 380-4697/3-A	Lab Control Sample	Total/NA	Drinking Water	548.1	
LCSD 380-4697/4-A	Lab Control Sample Dup	Total/NA	Drinking Water	548.1	
MRL 380-4697/2-A	Lab Control Sample	Total/NA	Drinking Water	548.1	
380-2236-AG-1-A MS	Matrix Spike	Total/NA	Drinking Water	548.1	
380-2236-AG-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	548.1	

Prep Batch: 4751

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	525.2	
MB 380-4751/1-A	Method Blank	Total/NA	Drinking Water	525.2	
LCS 380-4751/3-A	Lab Control Sample	Total/NA	Drinking Water	525.2	
LCSD 380-4751/4-A	Lab Control Sample Dup	Total/NA	Drinking Water	525.2	
MRL 380-4751/2-A	Lab Control Sample	Total/NA	Drinking Water	525.2	
380-2069-F-2-A MS	Matrix Spike	Total/NA	Drinking Water	525.2	
380-2079-J-1-A DU	Duplicate	Total/NA	Drinking Water	525.2	

Analysis Batch: 4924

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	525.2	4751
MB 380-4751/1-A	Method Blank	Total/NA	Drinking Water	525.2	4751
LCS 380-4751/3-A	Lab Control Sample	Total/NA	Drinking Water	525.2	4751
LCSD 380-4751/4-A	Lab Control Sample Dup	Total/NA	Drinking Water	525.2	4751
MRL 380-4751/2-A	Lab Control Sample	Total/NA	Drinking Water	525.2	4751
380-2069-F-2-A MS	Matrix Spike	Total/NA	Drinking Water	525.2	4751
380-2079-J-1-A DU	Duplicate	Total/NA	Drinking Water	525.2	4751

Analysis Batch: 5023

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	548.1	4697
MB 380-4697/1-A	Method Blank	Total/NA	Drinking Water	548.1	4697
LCS 380-4697/3-A	Lab Control Sample	Total/NA	Drinking Water	548.1	4697
LCSD 380-4697/4-A	Lab Control Sample Dup	Total/NA	Drinking Water	548.1	4697
MRL 380-4697/2-A	Lab Control Sample	Total/NA	Drinking Water	548.1	4697
380-2236-AG-1-A MS	Matrix Spike	Total/NA	Drinking Water	548.1	4697
380-2236-AG-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	548.1	4697

QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

GC Semi VOA

Prep Batch: 4725

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	505	
MB 380-4725/4-A	Method Blank	Total/NA	Drinking Water	505	
MRL 380-4725/2-A	Lab Control Sample	Total/NA	Drinking Water	505	
MRL 380-4725/3-A	Lab Control Sample	Total/NA	Drinking Water	505	
380-2236-T-1-A MS	Matrix Spike	Total/NA	Drinking Water	505	
380-2236-U-1-A MS	Matrix Spike	Total/NA	Drinking Water	505	

Prep Batch: 4767

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	515.4	
MB 380-4767/9-A	Method Blank	Total/NA	Drinking Water	515.4	
MRL 380-4767/8-A	Lab Control Sample	Total/NA	Drinking Water	515.4	
380-2367-B-1-B MS	Matrix Spike	Total/NA	Drinking Water	515.4	
380-2367-C-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	515.4	

Prep Batch: 4999

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	551.1	
MB 380-4999/9-A	Method Blank	Total/NA	Drinking Water	551.1	
LCS 380-4999/7-A	Lab Control Sample	Total/NA	Drinking Water	551.1	
MRL 380-4999/8-A	Lab Control Sample	Total/NA	Drinking Water	551.1	
380-2194-HJ-1-B MS	Matrix Spike	Total/NA	Drinking Water	551.1	
380-2236-AK-1-A DU	Duplicate	Total/NA	Drinking Water	551.1	

Analysis Batch: 6292

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	515.4	4767
MB 380-4767/9-A	Method Blank	Total/NA	Drinking Water	515.4	4767
MRL 380-4767/8-A	Lab Control Sample	Total/NA	Drinking Water	515.4	4767
380-2367-B-1-B MS	Matrix Spike	Total/NA	Drinking Water	515.4	4767
380-2367-C-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	515.4	4767

Analysis Batch: 6515

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	551.1	4999
MB 380-4999/9-A	Method Blank	Total/NA	Drinking Water	551.1	4999
LCS 380-4999/7-A	Lab Control Sample	Total/NA	Drinking Water	551.1	4999
MRL 380-4999/8-A	Lab Control Sample	Total/NA	Drinking Water	551.1	4999
380-2194-HJ-1-B MS	Matrix Spike	Total/NA	Drinking Water	551.1	4999
380-2236-AK-1-A DU	Duplicate	Total/NA	Drinking Water	551.1	4999

Analysis Batch: 9843

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	505	4725
MB 380-4725/4-A	Method Blank	Total/NA	Drinking Water	505	4725
MRL 380-4725/2-A	Lab Control Sample	Total/NA	Drinking Water	505	4725
MRL 380-4725/3-A	Lab Control Sample	Total/NA	Drinking Water	505	4725
380-2236-T-1-A MS	Matrix Spike	Total/NA	Drinking Water	505	4725
380-2236-U-1-A MS	Matrix Spike	Total/NA	Drinking Water	505	4725

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QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

HPLC/IC

Filtration Batch: 4659

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	Filtration	
MB 380-4659/3-A	Method Blank	Total/NA	Drinking Water	Filtration	
LCS 380-4659/2-A	Lab Control Sample	Total/NA	Drinking Water	Filtration	
MRL 380-4659/1-A	Lab Control Sample	Total/NA	Drinking Water	Filtration	
380-2194-GU-1-A MS	Matrix Spike	Total/NA	Drinking Water	Filtration	
380-2194-GU-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	Filtration	

Prep Batch: 4718

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	549.2	
MB 380-4718/13-A	Method Blank	Total/NA	Drinking Water	549.2	
LCS 380-4718/11-A	Lab Control Sample	Total/NA	Drinking Water	549.2	
MRL 380-4718/14-A	Lab Control Sample	Total/NA	Drinking Water	549.2	
MRL 380-4718/15-A	Lab Control Sample	Total/NA	Drinking Water	549.2	
380-2270-A-1-B MS	Matrix Spike	Total/NA	Drinking Water	549.2	
380-2270-A-1-C MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	549.2	

Filtration Batch: 4795

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	Filtration	
MB 380-4795/3-A	Method Blank	Total/NA	Drinking Water	Filtration	
LCS 380-4795/2-A	Lab Control Sample	Total/NA	Drinking Water	Filtration	
MRL 380-4795/1-A	Lab Control Sample	Total/NA	Drinking Water	Filtration	
380-2422-AX-1-B MS	Matrix Spike	Total/NA	Drinking Water	Filtration	
380-2422-AX-1-C MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	Filtration	
380-2440-CS-1-B MS	Matrix Spike	Total/NA	Drinking Water	Filtration	

Analysis Batch: 5022

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	547	4795
MB 380-4795/3-A	Method Blank	Total/NA	Drinking Water	547	4795
LCS 380-4795/2-A	Lab Control Sample	Total/NA	Drinking Water	547	4795
MRL 380-4795/1-A	Lab Control Sample	Total/NA	Drinking Water	547	4795
380-2422-AX-1-B MS	Matrix Spike	Total/NA	Drinking Water	547	4795
380-2422-AX-1-C MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	547	4795
380-2440-CS-1-B MS	Matrix Spike	Total/NA	Drinking Water	547	4795

Analysis Batch: 5127

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	549.2	4718
MB 380-4718/13-A	Method Blank	Total/NA	Drinking Water	549.2	4718
LCS 380-4718/11-A	Lab Control Sample	Total/NA	Drinking Water	549.2	4718
MRL 380-4718/14-A	Lab Control Sample	Total/NA	Drinking Water	549.2	4718
MRL 380-4718/15-A	Lab Control Sample	Total/NA	Drinking Water	549.2	4718
380-2270-A-1-B MS	Matrix Spike	Total/NA	Drinking Water	549.2	4718
380-2270-A-1-C MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	549.2	4718

Analysis Batch: 5434

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	531.2	4659
MB 380-4659/3-A	Method Blank	Total/NA	Drinking Water	531.2	4659

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QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

HPLC/IC (Continued)

Analysis Batch: 5434 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LCS 380-4659/2-A	Lab Control Sample	Total/NA	Drinking Water	531.2	4659
MRL 380-4659/1-A	Lab Control Sample	Total/NA	Drinking Water	531.2	4659
380-2194-GU-1-A MS	Matrix Spike	Total/NA	Drinking Water	531.2	4659
380-2194-GU-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	531.2	4659

Analysis Batch: 6340

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	300.0	
MB 380-6340/36	Method Blank	Total/NA	Drinking Water	300.0	
MB 380-6340/4	Method Blank	Total/NA	Drinking Water	300.0	
LCS 380-6340/7	Lab Control Sample	Total/NA	Drinking Water	300.0	
LCSD 380-6340/8	Lab Control Sample Dup	Total/NA	Drinking Water	300.0	
MRL 380-6340/37	Lab Control Sample	Total/NA	Drinking Water	300.0	
MRL 380-6340/5	Lab Control Sample	Total/NA	Drinking Water	300.0	
MRL 380-6340/6	Lab Control Sample	Total/NA	Drinking Water	300.0	
380-2284-1 MS	TILL51981_05.23.22	Total/NA	Drinking Water	300.0	
380-2284-1 MSD	TILL51981_05.23.22	Total/NA	Drinking Water	300.0	

Analysis Batch: 6342

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	300.0	
MB 380-6342/18	Method Blank	Total/NA	Drinking Water	300.0	
MB 380-6342/35	Method Blank	Total/NA	Drinking Water	300.0	
LCS 380-6342/21	Lab Control Sample	Total/NA	Drinking Water	300.0	
LCSD 380-6342/22	Lab Control Sample Dup	Total/NA	Drinking Water	300.0	
MRL 380-6342/19	Lab Control Sample	Total/NA	Drinking Water	300.0	
MRL 380-6342/20	Lab Control Sample	Total/NA	Drinking Water	300.0	
MRL 380-6342/36	Lab Control Sample	Total/NA	Drinking Water	300.0	
380-2284-1 MS	TILL51981_05.23.22	Total/NA	Drinking Water	300.0	
380-2284-1 MSD	TILL51981_05.23.22	Total/NA	Drinking Water	300.0	

Metals

Prep Batch: 4809

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total Recoverable	Drinking Water	200.8	
MB 380-4809/1-A	Method Blank	Total Recoverable	Drinking Water	200.8	
LCS 380-4809/3-A	Lab Control Sample	Total Recoverable	Drinking Water	200.8	
LCSD 380-4809/4-A	Lab Control Sample Dup	Total Recoverable	Drinking Water	200.8	
LLCS 380-4809/2-A	Lab Control Sample	Total Recoverable	Drinking Water	200.8	
380-1197-A-1-C MS	Matrix Spike	Total Recoverable	Drinking Water	200.8	
380-1197-A-1-D MSD	Matrix Spike Duplicate	Total Recoverable	Drinking Water	200.8	
380-1848-K-1-C MS	Matrix Spike	Total Recoverable	Drinking Water	200.8	
380-1848-K-1-D MSD	Matrix Spike Duplicate	Total Recoverable	Drinking Water	200.8	

Analysis Batch: 4917

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total Recoverable	Drinking Water	200.8	4809
MB 380-4809/1-A	Method Blank	Total Recoverable	Drinking Water	200.8	4809
LCS 380-4809/3-A	Lab Control Sample	Total Recoverable	Drinking Water	200.8	4809
LCSD 380-4809/4-A	Lab Control Sample Dup	Total Recoverable	Drinking Water	200.8	4809

Eurofins Eaton Monrovia

QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Metals (Continued)

Analysis Batch: 4917 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LLCS 380-4809/2-A	Lab Control Sample	Total Recoverable	Drinking Water	200.8	4809
LLCS 380-4917/12	Lab Control Sample	Total/NA	Drinking Water	200.8	
380-1197-A-1-C MS	Matrix Spike	Total Recoverable	Drinking Water	200.8	4809
380-1197-A-1-D MSD	Matrix Spike Duplicate	Total Recoverable	Drinking Water	200.8	4809

Analysis Batch: 4918

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total Recoverable	Drinking Water	200.8	4809
MB 380-4809/1-A	Method Blank	Total Recoverable	Drinking Water	200.8	4809
LCS 380-4809/3-A	Lab Control Sample	Total Recoverable	Drinking Water	200.8	4809
LCSD 380-4809/4-A	Lab Control Sample Dup	Total Recoverable	Drinking Water	200.8	4809
LLCS 380-4809/2-A	Lab Control Sample	Total Recoverable	Drinking Water	200.8	4809
380-1848-K-1-C MS	Matrix Spike	Total Recoverable	Drinking Water	200.8	4809
380-1848-K-1-D MSD	Matrix Spike Duplicate	Total Recoverable	Drinking Water	200.8	4809

Prep Batch: 4950

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total Recoverable	Drinking Water	200.7	
MB 380-4950/1-A	Method Blank	Total Recoverable	Drinking Water	200.7	
LCS 380-4950/3-A	Lab Control Sample	Total Recoverable	Drinking Water	200.7	
LCSD 380-4950/4-A	Lab Control Sample Dup	Total Recoverable	Drinking Water	200.7	
LLCS 380-4950/2-A	Lab Control Sample	Total Recoverable	Drinking Water	200.7	
380-1955-A-1-B MS	Matrix Spike	Total Recoverable	Drinking Water	200.7	
380-1955-A-1-C MSD	Matrix Spike Duplicate	Total Recoverable	Drinking Water	200.7	

Analysis Batch: 5299

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total Recoverable	Drinking Water	200.7	4950
MB 380-4950/1-A	Method Blank	Total Recoverable	Drinking Water	200.7	4950
LCS 380-4950/3-A	Lab Control Sample	Total Recoverable	Drinking Water	200.7	4950
LCSD 380-4950/4-A	Lab Control Sample Dup	Total Recoverable	Drinking Water	200.7	4950
LLCS 380-4950/2-A	Lab Control Sample	Total Recoverable	Drinking Water	200.7	4950
380-1955-A-1-B MS	Matrix Spike	Total Recoverable	Drinking Water	200.7	4950
380-1955-A-1-C MSD	Matrix Spike Duplicate	Total Recoverable	Drinking Water	200.7	4950

Analysis Batch: 6967

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2340B	

Analysis Batch: 11925

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	Total Cation	

General Chemistry

Analysis Batch: 4604

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2150B	
MB 380-4604/1	Method Blank	Total/NA	Drinking Water	SM 2150B	

Eurofins Eaton Monrovia

QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

General Chemistry

Analysis Batch: 4631

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2120B	
MB 380-4631/1	Method Blank	Total/NA	Drinking Water	SM 2120B	

Analysis Batch: 4728

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2320B	
MB 380-4728/39	Method Blank	Total/NA	Drinking Water	SM 2320B	
MB 380-4728/7	Method Blank	Total/NA	Drinking Water	SM 2320B	
LCS 380-4728/37	Lab Control Sample	Total/NA	Drinking Water	SM 2320B	
LCS 380-4728/5	Lab Control Sample	Total/NA	Drinking Water	SM 2320B	
LCSD 380-4728/22	Lab Control Sample Dup	Total/NA	Drinking Water	SM 2320B	
LCSD 380-4728/54	Lab Control Sample Dup	Total/NA	Drinking Water	SM 2320B	
LLCS 380-4728/38	Lab Control Sample	Total/NA	Drinking Water	SM 2320B	
LLCS 380-4728/6	Lab Control Sample	Total/NA	Drinking Water	SM 2320B	
MRL 380-4728/40	Lab Control Sample	Total/NA	Drinking Water	SM 2320B	
MRL 380-4728/8	Lab Control Sample	Total/NA	Drinking Water	SM 2320B	
380-2284-1 MS	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2320B	
380-2284-1 MSD	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2320B	
380-2284-1 DU	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2320B	

Analysis Batch: 4730

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 4500 H+ B	
MB 380-4730/9	Method Blank	Total/NA	Drinking Water	SM 4500 H+ B	
LCDSRM 380-4730/23	Lab Control Sample Dup	Total/NA	Drinking Water	SM 4500 H+ B	
LCSSRM 380-4730/10	Lab Control Sample	Total/NA	Drinking Water	SM 4500 H+ B	
380-2284-1 DU	TILL51981_05.23.22	Total/NA	Drinking Water	SM 4500 H+ B	

Analysis Batch: 4749

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	4500 CN F	
MB 380-4749/1	Method Blank	Total/NA	Drinking Water	4500 CN F	
LCS 380-4749/3	Lab Control Sample	Total/NA	Drinking Water	4500 CN F	
LCSD 380-4749/4	Lab Control Sample Dup	Total/NA	Drinking Water	4500 CN F	
MRL 380-4749/2	Lab Control Sample	Total/NA	Drinking Water	4500 CN F	
380-2155-A-1 MS	Matrix Spike	Total/NA	Drinking Water	4500 CN F	
380-2155-A-1 MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	4500 CN F	

Analysis Batch: 4784

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2540C	
MB 380-4784/1	Method Blank	Total/NA	Drinking Water	SM 2540C	
HLCS 380-4784/5	Lab Control Sample	Total/NA	Drinking Water	SM 2540C	
LCS 380-4784/4	Lab Control Sample	Total/NA	Drinking Water	SM 2540C	
MRL 380-4784/2	Lab Control Sample	Total/NA	Drinking Water	SM 2540C	
MRL 380-4784/3	Lab Control Sample	Total/NA	Drinking Water	SM 2540C	
380-2368-J-2 DU	Duplicate	Total/NA	Drinking Water	SM 2540C	

Analysis Batch: 4934

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 4500 F C	

Eurofins Eaton Monrovia

QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

General Chemistry (Continued)

Analysis Batch: 4934 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
MB 380-4934/40	Method Blank	Total/NA	Drinking Water	SM 4500 F C	
LCS 380-4934/42	Lab Control Sample	Total/NA	Drinking Water	SM 4500 F C	
LCSD 380-4934/43	Lab Control Sample Dup	Total/NA	Drinking Water	SM 4500 F C	
MRL 380-4934/41	Lab Control Sample	Total/NA	Drinking Water	SM 4500 F C	
MRL 380-4934/7	Lab Control Sample	Total/NA	Drinking Water	SM 4500 F C	
380-2440-DP-1 MS	Matrix Spike	Total/NA	Drinking Water	SM 4500 F C	
380-2440-DP-1 MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	SM 4500 F C	

Analysis Batch: 4939

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 5310C	
MB 380-4939/2	Method Blank	Total/NA	Drinking Water	SM 5310C	
MB 380-4939/36	Method Blank	Total/NA	Drinking Water	SM 5310C	
LCS 380-4939/38	Lab Control Sample	Total/NA	Drinking Water	SM 5310C	
LCS 380-4939/4	Lab Control Sample	Total/NA	Drinking Water	SM 5310C	
LCSD 380-4939/19	Lab Control Sample Dup	Total/NA	Drinking Water	SM 5310C	
LCSD 380-4939/50	Lab Control Sample Dup	Total/NA	Drinking Water	SM 5310C	
MRL 380-4939/3	Lab Control Sample	Total/NA	Drinking Water	SM 5310C	
MRL 380-4939/37	Lab Control Sample	Total/NA	Drinking Water	SM 5310C	
380-2406-A-3 MS	Matrix Spike	Total/NA	Drinking Water	SM 5310C	
380-2406-A-3 MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	SM 5310C	
380-2415-C-3 MS	Matrix Spike	Total/NA	Drinking Water	SM 5310C	
380-2415-C-3 MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	SM 5310C	
380-2430-A-4 MS	Matrix Spike	Total/NA	Drinking Water	SM 5310C	
380-2430-A-4 MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	SM 5310C	

Analysis Batch: 5547

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 5540C	
MB 380-5547/2	Method Blank	Total/NA	Drinking Water	SM 5540C	
LCS 380-5547/1	Lab Control Sample	Total/NA	Drinking Water	SM 5540C	
LCS 380-5547/7	Lab Control Sample	Total/NA	Drinking Water	SM 5540C	
LCSD 380-5547/10	Lab Control Sample Dup	Total/NA	Drinking Water	SM 5540C	
MRL 380-5547/3	Lab Control Sample	Total/NA	Drinking Water	SM 5540C	
MS 380-5547/5	Matrix Spike	Total/NA	Drinking Water	SM 5540C	
MSD 380-5547/6	Matrix Spike Duplicate	Total/NA	Drinking Water	SM 5540C	

Analysis Batch: 5598

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2540D	
MB 380-5598/1	Method Blank	Total/NA	Drinking Water	SM 2540D	
LCS 380-5598/4	Lab Control Sample	Total/NA	Drinking Water	SM 2540D	
LCSD 380-5598/5	Lab Control Sample Dup	Total/NA	Drinking Water	SM 2540D	
MRL 380-5598/2	Lab Control Sample	Total/NA	Drinking Water	SM 2540D	
MRL 380-5598/3	Lab Control Sample	Total/NA	Drinking Water	SM 2540D	
380-2272-B-4 DU	Duplicate	Total/NA	Drinking Water	SM 2540D	

Analysis Batch: 9745

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	SM 2330B	

Eurofins Eaton Monrovia

QC Association Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

General Chemistry

Analysis Batch: 10830

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	1030E	

Analysis Batch: 10882

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	None	

Analysis Batch: 11954

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	Total Anions	

Rad

Prep Batch: 4864

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	RAD Prep	
MB 380-4864/1-A	Method Blank	Total/NA	Drinking Water	RAD Prep	
LCS 380-4864/2-A	Lab Control Sample	Total/NA	Drinking Water	RAD Prep	
LCSD 380-4864/3-A	Lab Control Sample Dup	Total/NA	Drinking Water	RAD Prep	

Prep Batch: 21875

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	RAD Prep	
MB 810-21875/1-A	Method Blank	Total/NA	Drinking Water	RAD Prep	
LCS 810-21875/2-A	Lab Control Sample	Total/NA	Drinking Water	RAD Prep	
810-22816-I-1-A MS	Matrix Spike	Total/NA	Drinking Water	RAD Prep	
810-22816-I-1-B MSD	Matrix Spike Duplicate	Total/NA	Drinking Water	RAD Prep	

Biology

Analysis Batch: 4655

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
380-2284-1	TILL51981_05.23.22	Total/NA	Drinking Water	9223B	

Lab Chronicle

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Analysis	524.2		1	4928	UKCP	EA MON	06/02/22 18:22
Total/NA	Prep	525.2			4751	OTM3	EA MON	05/31/22 10:38
Total/NA	Analysis	525.2		1	4924	UPAC	EA MON	06/03/22 23:03
Total/NA	Prep	548.1			4697	ULB4	EA MON	05/27/22 13:32
Total/NA	Analysis	548.1		1	5023	X8AA	EA MON	06/06/22 16:18
Total/NA	Prep	505			4725	ULRL	EA MON	05/27/22 20:00 - 05/27/22 22:00 ¹
Total/NA	Analysis	505		1	9843	UGB2	EA MON	05/28/22 06:15
Total/NA	Prep	515.4			4767	JB5V	EA MON	06/01/22 09:30
Total/NA	Analysis	515.4		1	6292	JB5V	EA MON	06/04/22 06:39
Total/NA	Prep	551.1			4999	DR5R	EA MON	06/06/22 10:24
Total/NA	Analysis	551.1		1	6515	DR5R	EA MON	06/06/22 19:57
Total/NA	Analysis	300.0		1	6340	P6LW	EA MON	05/25/22 17:10
Total/NA	Analysis	300.0		1	6342	P6LW	EA MON	05/25/22 17:10
Total/NA	Filtration	Filtration			4659	UXOU	EA MON	05/26/22 12:22
Total/NA	Analysis	531.2		1	5434	UXOU	EA MON	05/27/22 20:55
Total/NA	Filtration	Filtration			4795	UD4M	EA MON	06/01/22 09:36
Total/NA	Analysis	547		1	5022	UD4M	EA MON	06/01/22 15:44
Total/NA	Prep	549.2			4718	IQ42	EA MON	05/27/22 18:16
Total/NA	Analysis	549.2		1	5127	UD4M	EA MON	06/01/22 23:36
Total Recoverable	Prep	200.7			4950	NQM8	EA MON	06/03/22 12:45
Total Recoverable	Analysis	200.7		1	5299	LK6J	EA MON	06/07/22 19:11
Total Recoverable	Prep	200.8			4809	NQM8	EA MON	06/01/22 11:50
Total Recoverable	Analysis	200.8		1	4917	ULAL	EA MON	06/02/22 15:32
Total Recoverable	Prep	200.8			4809	NQM8	EA MON	06/01/22 11:50
Total Recoverable	Analysis	200.8		1	4918	ULAL	EA MON	06/02/22 15:32
Total/NA	Analysis	SM 2340B		1	6967	DHX7	EA MON	06/27/22 14:11
Total/NA	Analysis	Total Cation		1	11925	UWAH	EA MON	08/05/22 17:04
Total/NA	Analysis	1030E		1	10830	UWAH	EA MON	07/29/22 11:32
Total/NA	Analysis	4500 CN F		1	4749	GP4S	EA MON	05/31/22 10:20
Total/NA	Analysis	None		1	10882	UWAH	EA MON	07/29/22 15:48
Total/NA	Analysis	SM 2120B		1	4631	ZYV7	EA MON	05/25/22 21:35
Total/NA	Analysis	SM 2150B		1	4604	TB8G	EA MON	05/25/22 15:57
Total/NA	Analysis	SM 2320B		1	4728	D5MQ	EA MON	05/27/22 19:02
Total/NA	Analysis	SM 2330B		1	9745	UWAH	EA MON	07/20/22 15:10
Total/NA	Analysis	SM 2540C		1	4784	XLG4	EA MON	05/31/22 23:05
Total/NA	Analysis	SM 2540D		1	5598	XLG4	EA MON	06/11/22 05:09
Total/NA	Analysis	SM 4500 F C		1	4934	D5MQ	EA MON	06/02/22 19:38
Total/NA	Analysis	SM 4500 H+ B		1	4730	D5MQ	EA MON	05/27/22 19:02
Total/NA	Analysis	SM 5310C		1	4939	NBN5	EA MON	06/02/22 16:04
Total/NA	Analysis	SM 5540C		1	5547	PK4Q	EA MON	05/26/22 08:16
Total/NA	Analysis	Total Anions		1	11954	UWAH	EA MON	08/05/22 18:04
Total/NA	Analysis	Ra226 Ra228		1	9741	UWAH	EA MON	07/20/22 14:45

Eurofins Eaton Monrovia

Lab Chronicle

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Client Sample ID: TILL51981_05.23.22

Lab Sample ID: 380-2284-1

Date Collected: 05/23/22 13:30

Matrix: Drinking Water

Date Received: 05/25/22 11:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Analyst	Lab	Prepared or Analyzed
Total/NA	Prep	RAD Prep			4864	UMIH	EA MON	06/02/22 11:15
Total/NA	Analysis	Ra226_Ra228		1	7439	XBL3	EA MON	06/19/22 16:06
Total/NA	Prep	RAD Prep			21875	SS	EA SB	06/14/22 10:57
Total/NA	Analysis	SM7110C		1	23269	SS	EA SB	06/25/22 11:44 - 06/25/22 12:14 ¹
Total/NA	Analysis	9223B		1	4655	M8OF	EA MON	05/25/22 19:44 - 05/26/22 14:32 ¹

¹ Completion dates and times are reported or not reported per method requirements or individual lab discretion.

Laboratory References:

EA MON = Eurofins Eaton Monrovia, 750 Royal Oaks Drive, Suite 100, Monrovia, CA 91016, TEL (626)386-1100

EA SB = Eurofins Eaton South Bend, 110 S Hill Street, South Bend, IN 46617, TEL (574)233-4777

Accreditation/Certification Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Laboratory: Eurofins Eaton Monrovia

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Oregon	NELAP	4034	01-29-23
The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.			
Analysis Method	Prep Method	Matrix	Analyte
1030E		Drinking Water	Anion/Cation Balance
1030E		Drinking Water	Calculated TDS
1030E		Drinking Water	Percent Difference
1030E		Drinking Water	TDS Ratio
1030E		Drinking Water	Total Anions
1030E		Drinking Water	Total Cations
505	505	Drinking Water	Polychlorinated biphenyls, Total
524.2		Drinking Water	2-Butanone (MEK)
524.2		Drinking Water	2-Hexanone
524.2		Drinking Water	Bromoethane
524.2		Drinking Water	m,p-Xylenes
524.2		Drinking Water	o-Xylene
524.2		Drinking Water	Trichlorotrifluoroethane
525.2	525.2	Drinking Water	alpha-Chlordane
525.2	525.2	Drinking Water	Caffeine
525.2	525.2	Drinking Water	Dimethoate
525.2	525.2	Drinking Water	gamma-Chlordane
525.2	525.2	Drinking Water	Isophorone
525.2	525.2	Drinking Water	trans-Nonachlor
None		Drinking Water	Langelier Index at 25C
None		Drinking Water	pH of CaCO3 saturation (25C)
Ra226 Ra228		Drinking Water	Radium 226 and 228
SM 2320B		Drinking Water	Bicarbonate Alkalinity as CaCO3
SM 2320B		Drinking Water	Carbonate Alkalinity as CaCO3
SM 2330B		Drinking Water	Alkalinity
SM 2330B		Drinking Water	Calcium
SM 2330B		Drinking Water	Field pH
SM 2330B		Drinking Water	Field Temperature
SM 2330B		Drinking Water	Langelier Index
SM 2330B		Drinking Water	Total Dissolved Solids
SM 2340B		Drinking Water	Calcium hardness as CaCO3
SM 2340B		Drinking Water	Magnesium hardness as calcium carbonate
SM 2540D		Drinking Water	Total Suspended Solids
Total Anions		Drinking Water	Total Anions
Total Cation		Drinking Water	Total Cations

Laboratory: Eurofins Eaton South Bend

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
A2LA	ISO/IEC 17025	5794.01	07-31-22
Alabama	State	40700	06-30-22
Alaska	State	IN00035	06-30-22
Arizona	State	AZ0432	07-26-22
Arkansas (DW)	State	EPA IN00035	06-30-22

Eurofins Eaton Monrovia

Accreditation/Certification Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Laboratory: Eurofins Eaton South Bend (Continued)

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
California	State	2920	06-30-22
Colorado	State	IN00035	02-28-23
Connecticut	State	PH-0132	03-31-22 *
Delaware (DW)	State	IN00035	06-30-22
Florida	NELAP	E87775	06-30-22
Georgia (DW)	State	929	06-30-22
Hawaii	State	IN035	06-30-22
Idaho (DW)	State	IN00035	12-31-22
IL Dept. of Public Health (Micro)	State	17767	06-30-22
Illinois	NELAP	200001	09-30-22
Indiana	State	C-71-01	12-31-22
Indiana (Micro)	State	M-76-07	12-31-22
Iowa	State	IA Lab #098	11-01-23
Kansas	NELAP	E-10233	10-31-22
Kentucky (DW)	State	KY90056	12-31-22
Louisiana (DW)	State	LA180008	12-31-22
Maine	State	IN00035	05-01-23
Maryland	State	209	03-31-23
Massachusetts	State	M-IN035	06-30-22
MI - RadChem Recognition	State	9926	12-31-22
Michigan	State	9926	06-30-22
Minnesota	NELAP	1989807	12-31-22
Mississippi	State	IN00035	06-30-22
Missouri	State	880	09-30-24
Montana (DW)	State	CERT0026	01-01-23
Nebraska	State	NE-OS-05-04	06-30-22
Nevada	State	IN000352021-2	07-31-22
New Hampshire	NELAP	2124	11-05-22
New Jersey	NELAP	IN598	06-30-22
New Mexico	State	IN00035	06-30-22
New York	NELAP	11398	04-01-23
North Carolina (DW)	State	18700	06-28-22
North Dakota	State	R-035	06-30-22
Ohio	State	87775	06-30-22
Oklahoma	NELAP	D9508	08-31-22
Oregon	NELAP	4156	09-16-22
Pennsylvania	NELAP	68-00466	04-30-23
Puerto Rico	State	IN00035	04-01-23
Rhode Island	State	LAO00343	12-30-22
South Carolina	State	95005001	06-30-22
South Dakota (DW)	State	IN00035	12-31-22
Tennessee	State	TN02973	06-30-22
Texas	NELAP	T104704187-20-4	12-31-22
Texas	TCEQ Water Supply	TX207	06-30-22
USEPA Reg X SDWA	US Federal Programs	IN00035	08-20-22
USEPA UCMR 5	US Federal Programs	IN00035	12-31-25
Utah	NELAP	IN000352021-14	07-31-22
Vermont	State	VT-8775	11-15-22
Virginia	NELAP	460275	03-14-23
Washington	State	C837	07-31-22

* Accreditation/Certification renewal pending - accreditation/certification considered valid.

Eurofins Eaton Monrovia

Accreditation/Certification Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Laboratory: Eurofins Eaton South Bend (Continued)

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
West Virginia (DW)	State	9927 C	12-31-22
Wisconsin	State	999766900	08-31-22
Wisconsin (Micro)	State	10121	12-31-22
Wyoming	State	8TMS-L	08-23-22

Method Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method	Method Description	Protocol	Laboratory
524.2	Volatile Organic Compounds (GC/MS)	EPA-DW	EA MON
525.2	Semivolatile Organic Compounds (GC/MS)	EPA	EA MON
548.1	Endothall (GC/MS)	EPA	EA MON
505	Organochlorine Pesticides/PCBs (GC)	EPA	EA MON
515.4	Herbicides (GC)	EPA-DW	EA MON
551.1	Chlorinated Disinfection Byproducts and Solvents (GC)	EPA	EA MON
300.0	Anions, Ion Chromatography	EPA	EA MON
531.2	Carbamate Pesticides (HPLC)	EPA	EA MON
547	Glyphosate (DAI HPLC)	EPA	EA MON
549.2	Diquat and Paraquat (HPLC)	EPA	EA MON
200.7	Metals (ICP)	EPA	EA MON
200.8	Mercury (ICP/MS)	EPA	EA MON
200.8	Metals (ICP/MS)	EPA	EA MON
SM 2340B	Total Hardness (as CaCO3) by calculation	SM	EA MON
Total Cation	Total Cations in meq/L	None	EA MON
1030E	Cation Anion Balance	SM	EA MON
4500 CN F	Cyanide	SM	EA MON
None	Langelier Index at 25C	Lab SOP	EA MON
SM 2120B	Color, Colorimetric	SM	EA MON
SM 2150B	Odor	SM	EA MON
SM 2320B	Alkalinity	SM	EA MON
SM 2330B	Corrosivity, LSI Calculation	SM	EA MON
SM 2540C	Solids, Total Dissolved (TDS)	SM	EA MON
SM 2540D	Solids, Total Suspended (TSS)	SM	EA MON
SM 4500 F C	Fluoride	SM	EA MON
SM 4500 H+ B	pH	SM	EA MON
SM 5310C	TOC	SM	EA MON
SM 5540C	Methylene Blue Active Substances (MBAS)	SM	EA MON
Total Anions	Total Anions in meq/L	None	EA MON
Ra226 Ra228	Radium-226/Radium-228 (Gamma-ray Spectrometry)	GIT	EA MON
Ra226_Ra228	Radium-226/Radium-228 (Gamma-ray Spectrometry)	GIT	EA MON
SM7110C	Gross Alpha by Co-Precipitation	SM	EA SB
9223B	Coliforms, Total, and E.Coli (Colilert - Quanti Tray)	SM	EA MON
200.7	Preparation, Total Recoverable Metals	EPA	EA MON
200.8	Preparation, Total Recoverable Metals	EPA	EA MON
505	Extraction, Organochlorine Pesticides/PCBs	EPA	EA MON
515.4	Extraction of Chlorinated Acids	EPA-DW	EA MON
525.2	Extraction of Semivolatile Compounds	EPA	EA MON
548.1	Extraction of Endothall	EPA-DW	EA MON
549.2	Extraction of Diquat and Paraquat	EPA	EA MON
551.1	Extraction of Chlorinated Disinfection Byproducts and Chlorinated Solvents	EPA	EA MON
Filtration	Sample Filtration	None	EA MON
RAD Prep	Preparation, Radiologicals	None	EA MON
RAD Prep	Preparation, Radiologicals	None	EA SB

Protocol References:

EPA = US Environmental Protection Agency

EPA-DW = "Methods For The Determination Of Organic Compounds In Drinking Water", EPA/600/4-88/039, December 1988 And Its Supplements.

GIT = Georgia Institute of Technology

Lab SOP = Laboratory Standard Operating Procedure

None = None

SM = "Standard Methods For The Examination Of Water And Wastewater"

Eurofins Eaton Monrovia

Method Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Method	Method Description	Protocol	Laboratory
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Laboratory References:

EA MON = Eurofins Eaton Monrovia, 750 Royal Oaks Drive, Suite 100, Monrovia, CA 91016, TEL (626)386-1100

EA SB = Eurofins Eaton South Bend, 110 S Hill Street, South Bend, IN 46617, TEL (574)233-4777

Sample Summary

Client: Groundwater Solutions, Inc.
Project/Site: Port of Tillamook

Job ID: 380-2284-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received
380-2284-1	TILL51981_05.23.22	Drinking Water	05/23/22 13:30	05/25/22 11:00

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eurofins

3/21/2022

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Bottle Order Information

Bottle Order: Port of Tillamook
 Bottle Order #: 1152
 Request From Client: 5/19/2022
 Date Order Posted: 5/19/2022 11:44:25AM
 Order Status: Ready To Process
 Prepared By: Vanessa Berry
Deliver By Date: 5/20/2022 11:59:00PM
 Lab Project Number: 38001100
 PWSID:

Order Completion Information

Creator: Vanessa Berry
 Filled by:
 Sent Date:
 Sent Via:
 Tracking #:

Sets	Bottles/Set	Qty	Bottle Type Description	Preservative	Method	Matrix	Sample Type	Comments	Lot #
1	1	1	Amber Plastic 1L - Na2S2O3	Sodium Thiosulfate	549.2_PREC - 549 Diquat ✓	Drinking W	Normal		
1	1	1	Amber Glass 125mL - Sodium Thiosulfate	Sodium Thiosulfate	548.1_PREC - 548 Endothall ✓	Drinking W	Normal		
1	3	3	Voa Vial 40ml Amber - Sodium thiosulfate	Sodium Thiosulfate	505_PREC - 505 Pesticides ✓	Drinking W	Normal		
1	4	4	Plastic 1 liter - Nitric Acid	Nitric Acid	GIT_RA226_RA228 - GIT - RA226 & 228 ✓	Drinking W	Normal		
1	1	1	Amber Glass 125mL - Sulfuric Acid	Sulfuric Acid	5310C - TOC ✓	Drinking W	Normal		
1	1	1	Plastic 250ml - unpreserved	None	SM4500_H+ - Local Method ✓	Drinking W	Normal		
1	1	1	Plastic 500ml - with Nitric Acid	Nitric Acid	2320B - (MOD) All Forms Alkalinity ✓	Drinking W	Normal		
1	1	1	Plastic 500ml - with Nitric Acid	Nitric Acid	200.8_Hg - Mercury ✓	Drinking W	Normal		
1	1	1	Plastic 500ml - with Nitric Acid	Nitric Acid	200.8_SDWA - (MOD) 200.8 Metals + Uranium ✓	Drinking W	Normal		
1	1	1	Plastic 500ml - with Nitric Acid	Nitric Acid	200.7_SDWA - (MOD) Custom ✓	Drinking W	Normal		
1	3	3	Voa Vial 60 mL Amber -NaPhos/KPhos+NH4Cl	Sodium Phos/K Phos + Ammonium Chloride	551.1_MOD - 551.1 EDB and DBCP ✓	Drinking W	Normal		
1	0	0	No Container	None	SM2330B - Corrosivity	Drinking W	Normal		
1	0	0	No Container	None	Lang_Index_25C - Langelier Index at 25C	Drinking W	Normal		
1	0	0	No Container	None	Anion_Tot_Calc - Local Method	Drinking W	Normal		
1	0	0	No Container	None	Cation_Tot_Calc - Local Method	Drinking W	Normal		
1	0	0	No Container	None	Cat_Anion_Mon - Local Method	Drinking W	Normal		
1	0	0	No Container	None	GIT_RA_Calc - Local Method	Drinking W	Normal		
1	0	0	No Container	None	SM2340B - Total Hardness (as CaCO3) ✓	Drinking W	Normal		
1	2	2	Voa Vial 60ml Amber - Sodium Sulfite	Sodium Sulfite	515.4_PREC - 515 Herbicides ✓	Drinking W	Normal		

Please notify your PM immediately if an error is found in shipment. When returning samples, please return all provided QC samples.

1	3	3	Voa Vial 40mL Amber - NaThio + C6H7KO7	Sodium Thiosulfate/K Dihydrogen Citrate	531.2_PPREC - 531.2 Carbamates ✓	Drinking W	Normal
1	1	1	Amber Glass 1 liter - unpreserved	None	SM2150_Odor_B - Odor ✓	Drinking W	Normal
1	3	3	Plastic 500ml - unpreserved	None	2120B - Color, Apparent ✓	Drinking W	Normal
					5540C - Local Method ✓	Drinking W	Normal
					2540C_Calcd - Total Dissolved Solids ✓	Drinking W	Normal
					2540D - Total Suspended Solids ✓	Drinking W	Normal
1	3	3	Voa Vial 40ml Amber - Ascor. Acid & HCL	Ascorbic Acid and Hydrochloric Acid	524.2_Pres_PREC - 524.2 SDWA ✓	Drinking W	Normal
1	2	2	Amber Glass 1 Liter- Sodium Sulfite/HCl	Sodium Sulfite w/HCl	525.2_PREC - 525 SVOC ✓	Drinking W	Normal
1	1	1	Sterile w/thio 100 mL	Sodium Thiosulfate	9223B_CIQT24_DW - Coliforms, Total, and E.Coli ✓	Drinking W	Normal
1	1	1	Plastic 250ml - Ascorbic Acid w/NAOH	Ascorbic Acid and Sodium Hydroxide	4500_CN_F - Total Cyanide ✓	Drinking W	Normal
1	1	1	Amber Glass 125mL - unpreserved	None	547_PREC - Glyphosate ✓	Drinking W	Normal
1	2	2	Plastic 125mL - unpreserved	None	300_OF_48H_PREC - Nitrite, Nitrate, and Nitrite+Nitrate ✓	Drinking W	Normal
					300_OF_28D_PREC - Chloride and Sulfate ✓	Drinking W	Normal
					4500_F_C - Fluoride ✓	Drinking W	Normal
1	1	1	Plastic 1 liter - Nitric Acid	Nitric Acid	SM7110C - Gross Alpha ✓	Drinking W	Normal

Please notify your PM immediately if an error is found in shipment. When returning samples, please return all provided QC samples.

Phone: 626-386-1100

Abstract

**Environment Testing
America**

8/21/2022

Login Sample Receipt Checklist

Client: Groundwater Solutions, Inc.

Job Number: 380-2284-1

Login Number: 2284

List Source: Eurofins Eaton Monrovia

List Number: 1

Creator: Ngo, Theodore

Question	Answer	Comment
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	False	No sample date and/or time on COC, logged in per container labels.
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Samples do not require splitting or compositing.	True	
Container provided by EEA	True	

Login Sample Receipt Checklist

Client: Groundwater Solutions, Inc.

Job Number: 380-2284-1

Login Number: 2284

List Source: Eurofins Eaton South Bend

List Number: 2

List Creation: 05/31/22 12:34 PM

Creator: Spurgeon, Sheri

Question	Answer	Comment
The cooler's custody seal, if present, is intact.	True	
Sample custody seals, if present, are intact.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Samples do not require splitting or compositing.	True	
Container provided by EEA	False	Client provided containers

ATTACHMENT C

Evaluation of Potential Contaminant Sources

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Potential Contaminant Sources Evaluation

Environmental Contamination

Areas of the Port property that were potential contaminant sources were identified based on a search of DEQ's Environmental Cleanup Site Information (ECSI) database, Leaking Underground Storage Tank (LUST) database, Confined Animal Feeding Operation (CAFO) database, and conversations with Port personnel to identify manure spreading areas, former landfills, and sanitary treatment lagoons. The areas of the Port property considered to be potential contaminant sources are shown on Figure 4-2 in the main text of the report.

LUST and ECSI sites were only considered to be potential contaminant sources if mobile chemicals were used (even if not detected in groundwater), or chemicals have been detected in groundwater. ECSI and LUST sites were not considered to be potential contaminant sources if only soil is reported as being impacted, chemicals used are not environmentally mobile (e.g., heating oil, lead), and/or no contamination was found.

The sites on Figure 4-2 were taken into consideration when evaluating a conceptual wellfield layout. It is important to note that some LUST sites could not be accurately located (these sites are listed in attached table, and are not shown in Figure 4-2). We recommend a file review to accurately locate the sites prior to finalizing a well location. While these sites pose a low risk to groundwater quality site-wide (because they involve relatively low mobility petroleum hydrocarbons), the site of the former UST may pose a risk to a water well because DEQ commonly allows residual contamination to remain at contaminated sites.

- **LUST File No. 29-93-0194.** This is a release that involves leaking USTs from four tank farms that were used for fuel storage. Leaks impacted soil and groundwater, and were closed using risk-based methods (implying that DEQ allowed contamination to remain in-place). DEQ (2010) indicates that “ . . . No use shall be made of the shallow groundwater, by extraction through wells or by other means involving consumption, within tank sites one and three” (DEQ, pg. 6, 2010).
- **LUST File Nos. 29-90-0148, 29-94-0149, 29-97-0675.** DEQ did not provide coordinates for 29-90-0148, and the coordinates provided for 26-94-0149 and 29-97-0675 do not appear to be accurate (i.e., tanks are located far from buildings or other infrastructure).

Attachment C. Evaluation of ECSI and LUST Sites.

Port of Tillamook Bay Groundwater Feasibility Study.

Site Type	Site ID	Status	Confidence in Location	Comments
ECSI	67	Suspect Site Requiring Investigation	Moderate Confidence	Compounds of concern (phenol and formaldehyde) are mobile and may have impacted groundwater if released (although no evidence of release was reported). In addition, contamination that <i>has</i> been detected (oil) is not generally mobile and was found in soil.
ECSI	1704	Suspect Site Requiring Investigation	NA (site-wide, duplicative)	This ECSI database entry is site-wide for the "Tillamook Naval Air Station" and, therefore, is not shown on Figure 4-2. The ECSI database entry refers to leaking USTs, landfills, wastewater treatment system, and school district maintenance facilities, which appear to be covered by other ECSI and LUST sites. Due to the site-wide nature of the ECSI database site entry, no risk conclusion is determined.
ECSI	4604	Suspect Site Requiring Investigation	High Confidence	Site included in the ECSI database based on a Phase I Environmental Site Investigation prepared by PBS Environmental in 2005 as part of the State of Oregon Certified Industrial Lands program. Site was a former skeet, shotgun and rifle range (No Further Action determination by DEQ based on sampling of PAHs and heavy metals) and was the location of a 300 gallon diesel fuel tank (limited soil contamination was observed, and any groundwater contamination appears to be very limited). Recommend located well in the southeast portion of the property (away from former shot deposition area) to minimize risk.
ECSI	4605	No Further Action Required	High Confidence	Site included in the ECSI database based on a Phase I Environmental Site Investigation prepared by PBS Environmental in 2005 as part of the State of Oregon Certified Industrial Lands program.
ECSI	4606	No Further Action Required	High Confidence	Site included in the ECSI database based on a Phase I Environmental Site Investigation prepared by PBS Environmental in 2005 as part of the State of Oregon Certified Industrial Lands program.
ECSI	4607	No Further Action Required	High Confidence	Site included in the ECSI database based on a Phase I Environmental Site Investigation prepared by PBS Environmental in 2005 as part of the Oregon Certified Industrial Lands Program. A dispensary building and a brig structure were once located in this section of the property (when it was a Naval Base from the 1930s through the 1940s).
ECSI	5769	Suspect Site Requiring Investigation	High Confidence	Recognized Environmental Conditions (RECs) include former gas station, wash rack (potential solvent source), chemical storage, and potential drycleaner were present in this area. Environmental sampling has not occurred at the site.
LUST	29-90-0148	Closed	Low Confidence (No Coordinates Provided by DEQ, Not Shown on Figure 4-2)	Diesel was released from a UST and impacted soil. Cleanup ended in 1990.
LUST	29-93-0194	Closed	Low Confidence (Multiple Locations, No Coordinates Provided by DEQ, Not Shown on Figure 4-2)	Concerns four tank sites: Tank Site No. 1 (seven 50,000 gallon USTs), Tank Site No. 2 (a single 4,000 gallon UST), Tank Site No. 3 (a single 1,500 gallon UST), and Tank Site No. 4 (a single 1,400 gallon UST). Some tank sites were leaking while others were not, and soil only was impacted at some sites while soil and groundwater were impacted at others. A file review of closure records is recommended. Specifically, groundwater use within 100 feet of Tank Site No. 1 and Tank Site No. 3 is prohibited.
LUST	29-94-0149	Closed	Low Confidence	Cleanup ended in 1996. No report of which media type was impacted.
LUST	29-97-0675	Closed	Low Confidence	Miscellaneous gasoline released from two, 1,000 gallon aviation fuel underground storage tanks. Soil was the only media affected and was removed. Tank has been decommissioned. Cleanup ended in 1999.

ATTACHMENT D

Cost Estimates for Well Construction

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Attachment D. Cost Estimates for Well Construction.

Port of Tillamook Bay Groundwater Feasibility Study.

Phase I						
Install 8 groundwater monitoring wells to evaluate groundwater quality at future well locations and provide limited information about groundwater production potential						
Wells are 2-inch diameter PVC, 120 feet deep, Screened from 70 to 120 feet bgs (50 feet), cased from +3 to 70 feet bgs (73 feet), sealed from 0-65 feet bgs, filter packed 65 to 120 feet bgs (55 feet)						
Item	Units	Unit Cost	No. Units		Total Cost	Source
Mobilization to Tillamook	LS	\$35,000	1.0		\$35,000	
Erosion Control & Water Management	LS	\$1,500	1.0		\$1,500	
Drill 6-inch permanent borehole	FT	\$75	960.0		\$72,000	
Furnish and install 2-inch blank casing	FT	\$30	584.0		\$17,520	
Furnish and install 2-inch 20 slot screen	FT	\$35	400.0		\$14,000	
Furnish and install filter pack	FT	\$35	440.0		\$15,400	
Furnish and install well seal	FT	\$35	520.0		\$18,200	
Well Development	HR	\$950	32.0		\$30,400	
Well Disinfection	LS	\$2,200	8.0		\$17,600	
Well Completion	LS	\$1,900	8.0		\$15,200	
Groudwater quality samples	EA	\$2,500	16.0		\$40,000	
TOTAL CONSTRUCTION COST					\$276,820	
30% Contingency					\$83,046	
Drilling Oversight, Logging, and Groundwater Sampling					\$130,000	
TOTAL PHASE I CAPITAL COSTS					\$489,866	
CONCEPTUAL PROJECT COST ESTIMATE RANGE (-30% to +80%)			\$342,906	to	\$881,759	
Phase II						
Drill test well (Well No. 3), conduct an aquifer test, develop an initial estimate of wellfield yield. Well construction per Figure 4-1.						
Item	Units	Unit Cost	No. Units		Total Cost	Source
Mobilization to Tillamook	LS	\$49,000	1.0		\$49,000	50th Percentile Cost
Erosion Control	LS	\$7,604	1.0		\$7,604	75th Percentile Cost
Site Prep	LS	\$13,536	1.0		\$13,536	75th Percentile Cost
Drill 12-inch borehole to 120 feet bgs	FT	\$450	120.0		\$54,000	50th Percentile Cost for 16-inch borehole drilling
Furnish 8-inch Screen Assembly, 70' to 120'	FT	\$193	50.0		\$9,650	50th Percentile Cost for 12-inch SS screen, wire wrap
Furnish 8-inch casing, +3 to 70'	FT	\$101	73.0		\$7,373	50th Percentile cost for 12-inch low carbon steel casing
Furnish and Install Filter Pack, 65 to 120	FT	\$34	55.0		\$1,870	75th Percentile Cost for filter Pack
Furnish and Install Seal, 0 to 65	FT	\$105	65.0		\$6,825	75th percentile seal
Well Development	HR	\$800	16.0		\$12,800	75th percentile development cost
Install Aquifer Test Equipment	LS	\$16,457	1.0		\$16,457	75th percentile aquifer test equipment installation
Step Rate Test	HR	\$413	8.0		\$3,304	75th percentile step rate test
Constant Rate Test (72 hour) + 24 hour recovery	HR	\$303	96.0		\$29,088	75th percentile aquifer test
Plumbness and Alignment Test	LS	\$3,570	1.0		\$3,570	75th percentile P&A
Video Survey	LS	\$2,000	1.0		\$2,000	50th percentile well video
Disinfection	LS	\$2,049	1.0		\$2,049	50th percentile disinfection
Wellhead Protection	LS	\$2,673	1.0		\$2,673	75th percentile wellhead protection
Mound up ground around wellhead	LS	\$20,000	1.0		\$20,000	
TOTAL CONSTRUCTION COST					\$241,799	
30% Contingency					\$72,540	
Design and Engineering (20% of Construction)					\$48,360	
TOTAL PHASE II CAPITAL COSTS					\$362,699	
CONCEPTUAL PROJECT COST ESTIMATE RANGE (-30% to +80%)			\$253,889	to	\$652,857	

Phase III(a)						
Drill Well Nos. 1, 2, 4 and 5 (4 new wells) per the well construction diagram in Figure 4-1.						
Item	Units	Unit Cost	No. Units		Total Cost	Source
Mobilization to Tillamook	LS	\$49,000	4.0		\$196,000	50th Percentile Cost
Erosion Control	LS	\$7,604	4.0		\$30,416	75th Percentile Cost
Site Prep	LS	\$13,536	4.0		\$54,144	75th Percentile Cost
Drill 12-inch borehole to 120 feet bgs	FT	\$450	480.0		\$216,000	50th Percentile Cost for 16-inch borehole drilling
Furnish 8-inch Screen Assembly, 70' to 120'	FT	\$193	200.0		\$38,600	50th Percentile Cost for 12-inch SS screen, wire wrap
Furnish 8-inch casing, +3 to 70'	FT	\$101	292.0		\$29,492	50th Percentile cost for 12-inch low carbon steel casing
Furnish and Install Filter Pack, 65 to 120	FT	\$34	220.0		\$7,480	75th Percentile Cost for filter Pack
Furnish and Install Seal, 0 to 65	FT	\$105	260.0		\$27,300	75th percentile seal
Well Development	HR	\$800	64.0		\$51,200	75th percentile development cost
Install Aquifer Test Equipment	LS	\$16,457	4.0		\$65,828	75th percentile aquifer test equipment installation
Step Rate Test	HR	\$413	32.0		\$13,216	75th percentile step rate test
Constant Rate Test (72 hour) + 24 hour recovery	HR	\$303	384.0		\$116,352	75th percentile aquifer test
Plumbness and Alignment Test	LS	\$3,570	4.0		\$14,280	75th percentile P&A
Video Survey	LS	\$2,000	4.0		\$8,000	50th percentile well video
Disinfection	LS	\$2,049	4.0		\$8,196	50th percentile disinfection
Wellhead Protection	LS	\$2,673	4.0		\$10,692	75th percentile wellhead protection
Mound up ground around wellhead	LS	\$20,000	0.0		\$0	
TOTAL CONSTRUCTION COST					\$887,196	
30% Contingency					\$266,159	
Design and Engineering (20% of Construction)					\$177,439	
TOTAL PHASE III(a) CAPITAL COSTS					\$1,330,794	
CONCEPTUAL PROJECT COST ESTIMATE RANGE (-30% to +80%)			\$931,556	to	\$2,395,429	

Phase III(b)						
Drill Well Nos. 1, 2, 4, 5, 6, 7 and 8 (7 wells)						
Item	Units	Unit Cost	No. Units		Total Cost	Source
Mobilization to Tillamook	LS	\$49,000	7.0		\$343,000	50th Percentile Cost
Erosion Control	LS	\$7,604	7.0		\$53,228	75th Percentile Cost
Site Prep	LS	\$13,536	7.0		\$94,752	75th Percentile Cost
Drill 12-inch borehole to 120 feet bgs	FT	\$450	840.0		\$378,000	50th Percentile Cost for 16-inch borehole drilling
Furnish 8-inch Screen Assembly, 70' to 120'	FT	\$193	350.0		\$67,550	50th Percentile Cost for 12-inch SS screen, wire wrap
Furnish 8-inch casing, +3 to 70'	FT	\$101	511.0		\$51,611	50th Percentile cost for 12-inch low carbon steel casing
Furnish and Install Filter Pack, 65 to 120	FT	\$34	385.0		\$13,090	75th Percentile Cost for filter Pack
Furnish and Install Seal, 0 to 65	FT	\$105	455.0		\$47,775	75th percentile seal
Well Development	HR	\$800	112.0		\$89,600	75th percentile development cost
Install Aquifer Test Equipment	LS	\$16,457	7.0		\$115,199	75th percentile aquifer test equipment installation
Step Rate Test	HR	\$413	56.0		\$23,128	75th percentile step rate test
Constant Rate Test (72 hour) + 24 hour recovery	HR	\$303	672.0		\$203,616	75th percentile aquifer test
Plumbness and Alignment Test	LS	\$3,570	7.0		\$24,990	75th percentile P&A
Video Survey	LS	\$2,000	7.0		\$14,000	50th percentile well video
Disinfection	LS	\$2,049	7.0		\$14,343	50th percentile disinfection
Wellhead Protection	LS	\$2,673	7.0		\$18,711	75th percentile wellhead protection
Mound up ground around wellhead	LS	\$20,000	7.0		\$140,000	
TOTAL CONSTRUCTION COST					\$1,692,593	
30% Contingency					\$507,778	
Design and Engineering (20% of Construction)					\$338,519	
TOTAL PHASE III(b) CAPITAL COSTS					\$2,538,890	
CONCEPTUAL PROJECT COST ESTIMATE RANGE (-30% to +80%)			\$1,777,223	to	\$4,570,001	

ATTACHMENT E

Conсор (2023) Technical Memorandum: Water Supply System
Capital Improvement and Operations and Maintenance Costs

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Technical Memorandum

Date: June 13th, 2023

Project: Groundwater Feasibility Study – Port of Tillamook Bay

To: Matt Kohlbecker, RG
GSI Water Solutions, Inc.

From: Chris Young, P.E.

Reviewed By: Brian Ginter, P.E.

Re: Water Supply System Capital Improvement and Operations and Maintenance Costs



Introduction

Consor was authorized by GSI Water Solutions, Inc. (GSI) in December 2022 to prepare Water Supply System Capital Improvement and Operations and Maintenance (O&M) costs to support the feasibility of developing a groundwater supply system for the Port of Tillamook Bay (Port) and potential adjacent drinking water supply partners. The objective of this Technical Memorandum is to present feasibility-level costing with conservative assumptions regarding the necessary infrastructure to develop a new groundwater supply system.

Background

GSI is preparing a feasibility evaluation for the development of a potable groundwater supply system for the Port of Tillamook Bay, including the exploration and drilling of groundwater supply wells and associated water supply infrastructure including wellhead improvements, pumping, storage and water treatment systems. The summary of required capital improvement and O&M costs is intended to be incorporated into GSI's overall evaluation of feasibility.

As part of the feasibility evaluation a phased construction sequence for the wellfield is proposed, as described below.

- Phase I and Phase II are considered initial project feasibility phases:
 - Phase I consists of constructing and evaluating monitoring wells located at eight potential production well locations,
 - Phase II consists of drilling one test well (that would serve as the first of up to eight production wells) and determining an initial estimate of potential wellfield yield.
- Phase III consists of constructing and testing the remaining production wells. The full development of a groundwater supply system in Phase III considers two potential development scenarios:
 - Phase III(a) considers the construction and testing needed to meet the water demand of the Port-Only Scenario (2042 MDD)



- Phase III(b) considers the construction and testing needed to meet the water demand of the Partnership Scenario (2042 MDD).

In coordination with GSI, Consor developed a preliminary conceptual groundwater supply system. This Technical Memorandum summarizes the required capital improvements for each of the proposed Phase III development scenarios.

Cost Estimating Data

An estimated conceptual level project cost has been developed for each scenario presented in Phase III. Cost estimates represent opinions of cost only, acknowledging that final costs of individual projects will vary depending on actual labor and material costs, market conditions for construction, regulatory factors, final project scope, project schedule and other factors.

The Association for the Advancement of Cost Engineering International (AACE International) classifies cost estimates depending on project definition, end usage and other factors. The cost estimates presented here are considered Class 5 with an end usage being a project concept report and an expected accuracy range of -30 percent to +80 percent. As projects are better defined the accuracy level of the estimates can be narrowed. Estimated project costs include approximate construction costs and an allowance for administrative, engineering and other project-related costs as well as contingencies.

The estimated costs included in this plan are feasibility study level budget estimates presented in 2023 dollars. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. For purposes of future cost estimate updating the recent ENR CCI for Seattle, Washington is 15106 (March 2023).

Water Supply System Capital Improvement Costs

Capital Improvement Costs were developed for a Port-Only scenario and a Partnership scenario. **Figure 1** illustrates the conceptual groundwater supply system, including treatment facilities (for the removal of iron, manganese, nitrates, and the addition of chlorine to provide residual disinfection), a 1.0 million gallon (MG) treated water storage reservoir, and phase III(a) and phase III(b) raw water transmission piping required to connect the eight (8) proposed well locations. **Figure 2** illustrates a more detailed conceptual layout for the treatment plant and reservoir located near proposed Well 3.

Figure 1 - Conceptual Groundwater Supply System

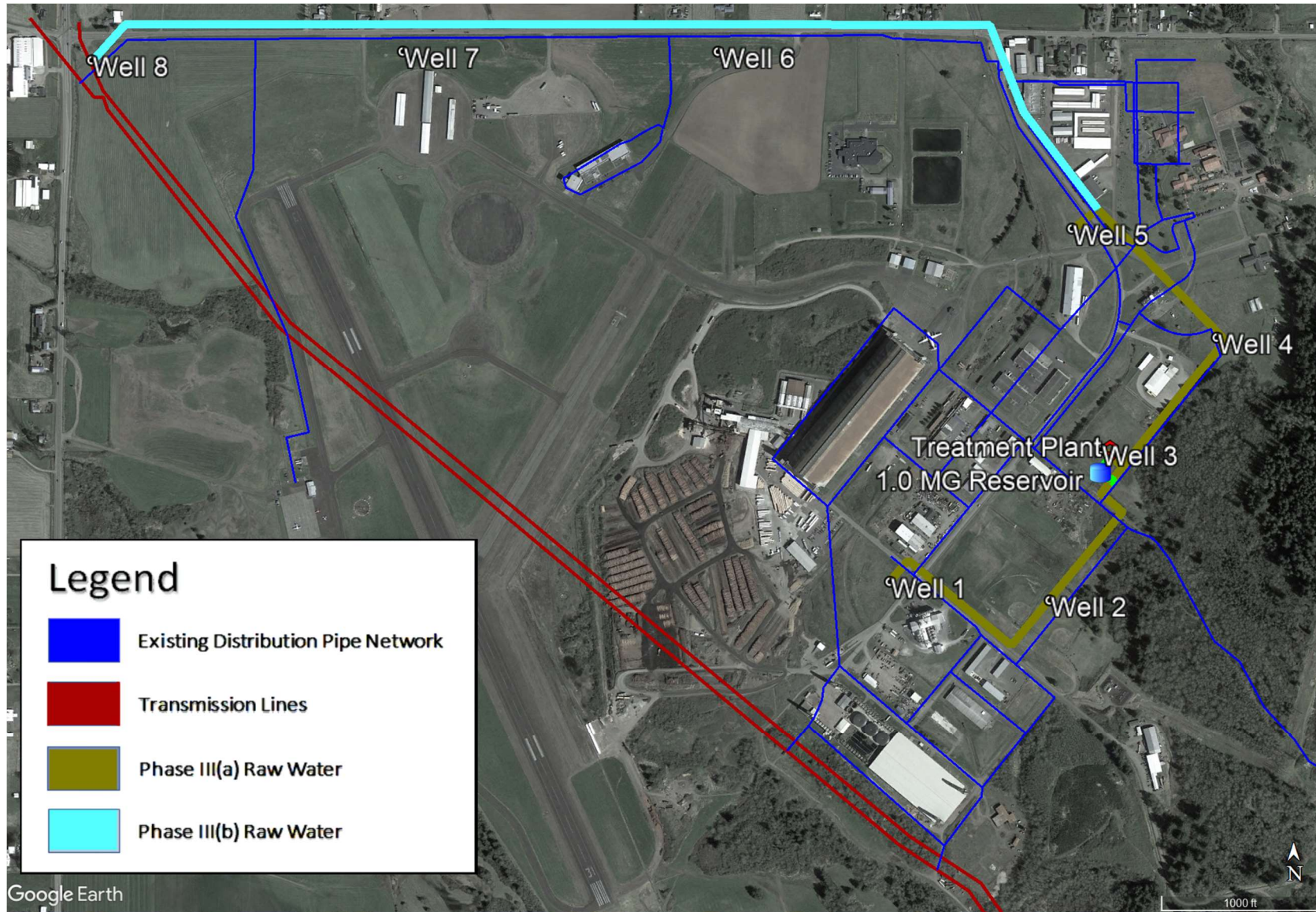
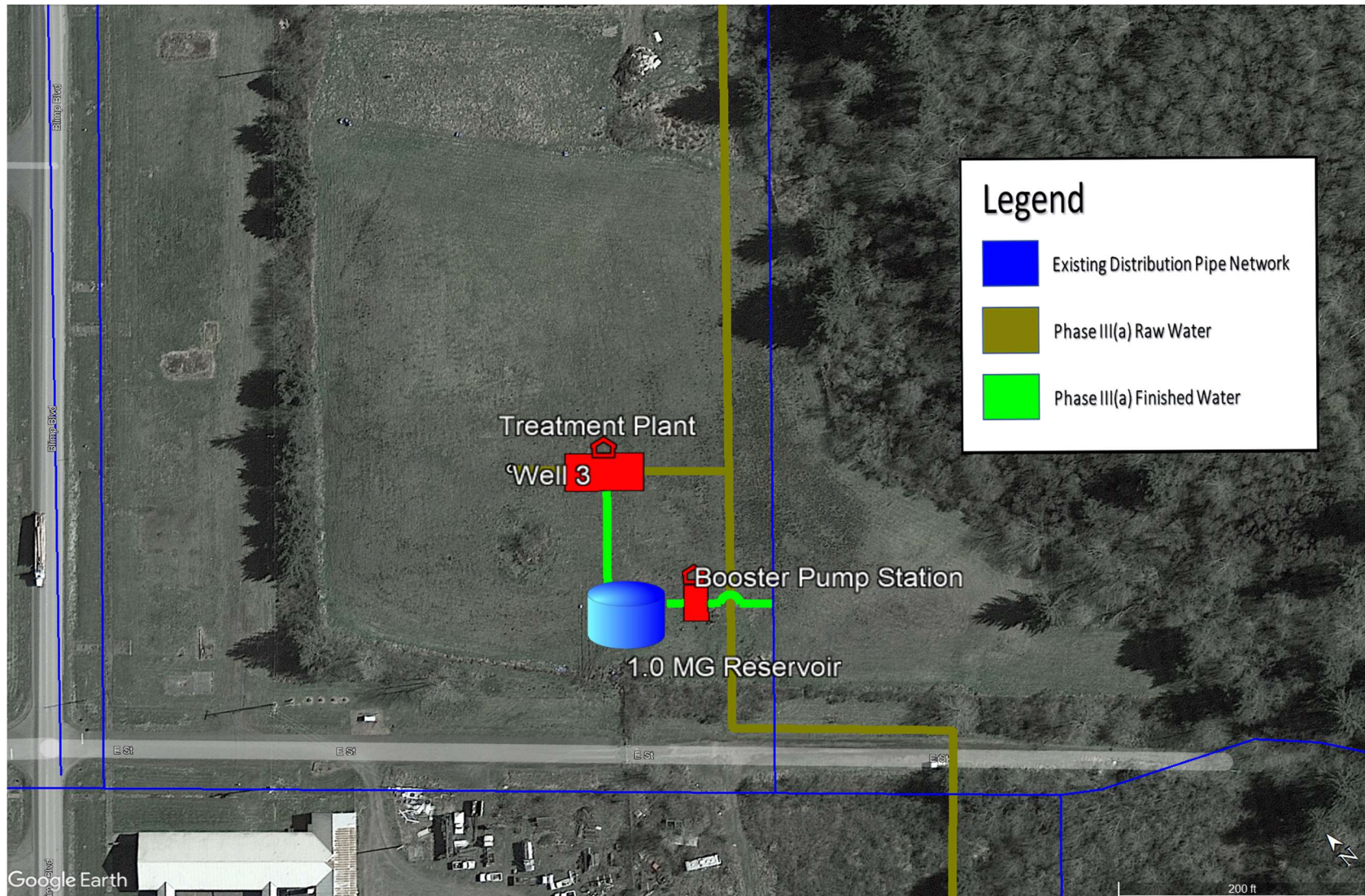


Figure 2 - Conceptual Treatment Plant and Reservoir





Assumptions and Alternatives

Several key assumptions were made for the proposed conceptual groundwater supply system. If the Port chooses to continue with the development of a regional groundwater supply system, these assumptions should be validated as alternative approaches are considered with further analysis and design.

The list below outlines the key assumptions for the proposed conceptual groundwater supply system made during the development of capital and O&M cost estimates. While alternative options are acknowledged, they have not been explored further and thus have not been incorporated into the estimates provided.

- Project cost estimates are not included for Phase I and Phase II exploration nor Phase III well drilling.
- One treatment plant is assumed in both Phase III(a) and Phase III(b) scenarios.
 - *Potential Alternative:* For the Phase III(b) partnership scenario, a second treatment plant may be considered in lieu of a single larger capacity treatment plant. This alternative would reduce the length of transmission piping. However, the construction cost of a second treatment plant will vary based on the required treatment processes and may outweigh the benefits of reducing transmission piping.
- The cost estimates assume that the existing distribution system is adequate to convey the full groundwater supply to Port facilities and to potential partners. As such, the cost to upsize existing system piping costs are not included in this analysis.
- The groundwater supply will be transmitted to the distribution system by a constant pressure booster pump station located near the treatment plant and 1.0 MG reservoir, adjacent to proposed Well 3.
 - *Potential Alternative:* If there is sufficient property available, the 1.0 MG reservoir may be constructed at a higher elevation. This would allow the groundwater supply to be distributed through gravity, eliminating the need for a constant pressure booster pump station. However, pumping capacity would still be necessary to fill the reservoir.
- For the purpose of this feasibility analysis. Costs have been conservatively included for treatment of Nitrates, Iron, and pH adjustment. The need for these facilities should be confirmed in future phases of regional groundwater supply planning and development.
 - The proposed concept for treatment of the groundwater supply considers the potential need for nitrate removal and for iron removal. The assumed capacity for treatment is 400 gpm in the Phase III(a) (Port-Only) scenario and 700 gpm for the Phase III(b) (Partnership) scenario.

Phase III(a) – Port-Only Scenario

The purpose of Phase III(a) is to meet the water demand of the Port facilities and customers (2042 MDD). Conceptual project cost estimates for the development of a groundwater supply system with five new production wells (numbers 1, 2, 3, 4 and 5) to meet the Port-Only system scenario are presented below in **Table 1**. The capital cost estimate includes treatment facilities, a ground level finished water storage reservoir, finished water booster pump station, and raw water piping to connect the wells to the treatment facility. Conceptual project cost estimates for the groundwater supply system without a groundwater treatment plant are shown in **Table 2**.

Table 1 – Port-Only Scenario Capital Costs Estimate

Description	Construction Cost Estimate
Wells ¹ (1-5)	
Ground work ² , Pump/Motor/Wellhead, Well house and Control Panel	\$80,000 each
Groundwater Treatment Plant	
Nitrate Treatment (400 GPM)	\$1,300,000
Iron Treatment (400 GPM)	\$230,000
Corrosion control	\$200,000
Process and Mechanical	\$770,000
Building and Site work	\$360,000
Raw Water Piping (8" Ductile Iron)	\$1,560,000
1.0 MG reservoir (Prestressed Concrete)	\$2,750,000
Booster Pump Station/Pumps	\$290,000
Mobilization/Bonds/Insurance	\$780,000
Construction Costs Estimate Subtotal³	\$8,600,000
Design and Engineering (20%)	\$1,720,000
30% Contingency	\$2,580,000
Total Capital Costs Estimate	\$12,900,000
Conceptual Project Cost Estimate Range (-30% to +80%)	\$9.0M - \$23.2M

1. Cost to drill well not included
2. Wells 1-5 are anticipated to be sited at locations above the 100-year floodplain.
3. Rounded to the nearest \$100,000

Table 2 - Port-Only Scenario Capital Costs Estimate (Disinfection Only - No Treatment Plant)

Description	Construction Cost Estimate
Wells ¹ (1-5)	
Ground work ² , Pump/Motor/Wellhead, Well house and Control Panel, Disinfection	\$100,000 each
Raw Water Piping (8" Ductile Iron)	\$1,560,000
1.0 MG reservoir (Prestressed Concrete)	\$2,750,000
Booster Pump Station/Pumps	\$290,000
Mobilization/Bonds/Insurance	\$500,000
Construction Costs Estimate Subtotal³	\$5,600,000
Design and Engineering (20%)	\$1,120,000
30% Contingency	\$1,680,000
Total Capital Costs Estimate	\$8,400,000
Conceptual Project Cost Estimate Range (-30% to +80%)	\$5.9M - \$15.1M

1. Cost to drill well not included
2. Wells 1-5 are anticipated to be sited at locations above the 100-year floodplain.
3. Rounded to the nearest \$100,000

Phase III(b) – Partnership Scenario

The objective of Phase III(b) development of the groundwater supply system is to meet the water demand of the Partnership scenario (2042 MDD). Conceptual project cost estimates for the development of a groundwater supply system with three additional new production wells (in addition to the Phase III(a) facilities described above) to meet the Partnership scenario are presented below in **Table 3**. The estimates include the costs described in Phase III(a) – Port-Only Scenario and include additional costs for a larger treatment plant, the development of proposed Wells 6, 7 and 8, and additional raw water piping to transmit supply from these wells to the treatment facility. Conceptual project cost estimates for the groundwater supply system without a groundwater treatment plant are shown in **Table 4**.

Table 3 - Partnership Scenario Capital Costs Estimate

Description	Construction Cost Estimate
Wells ¹ (1-5)	
Ground work ² , Pump/Motor/Wellhead, Well house and Control Panel	\$80,000 each
Wells ¹ (6, 7 and 8)	
Ground work ³ , Pump/Motor/Wellhead, Well house and Control Panel	\$90,000 each
Groundwater Treatment Plant	
Nitrate Treatment (700 GPM)	\$1,700,000
Iron Treatment (700 GPM)	\$300,000
Corrosion control	\$200,000
Process and Mechanical	\$1,000,000
Building and Site work	\$600,000
Phase III(a) Piping (8" Ductile Iron)	\$1,560,000
Additional Phase III(b) Piping (8" Ductile Iron)	\$2,130,000
1.0 MG reservoir (Prestressed Concrete)	\$2,750,000
Booster Pump Station/Pumps	\$340,000
Mobilization/Bonds/Insurance	\$1,130,000
Construction Costs Estimate Subtotal⁴	\$12,400,000
Design and Engineering (20%)	\$2,480,000
30% Contingency	\$3,720,000
Total Capital Costs Estimate	\$18,600,000
Conceptual Project Cost Estimate Range (-30% to +80%)	\$13.0M - \$33.5M

1. Cost to drill well not included
2. Wells 1-5 are anticipated to be sited at locations above the 100-year floodplain.
3. 3' of mounding included – Wells 6-8 locations within 100-year floodplain
4. Rounded to the nearest \$100,000

Table 4 - Partnership Scenario Capital Costs Estimate (Disinfection Only - No Treatment Plant)

Description	Construction Cost Estimate
Wells ¹ (1-5)	
Ground work ² , Pump/Motor/Wellhead, Well house and Control Panel, Disinfection	\$100,000 each
Wells ¹ (6, 7 and 8)	
Ground work ³ , Pump/Motor/Wellhead, Well house and Control Panel, Disinfection	\$110,000 each
Phase III(a) Piping (8" Ductile Iron)	\$1,560,000
Additional Phase III(b) Piping (8" Ductile Iron)	\$2,130,000
1.0 MG reservoir (Prestressed Concrete)	\$2,750,000
Booster Pump Station/Pumps	\$340,000
Mobilization/Bonds/Insurance	\$760,000
Construction Costs Estimate Subtotal⁴	\$8,400,000
Design and Engineering (20%)	\$1,680,000
30% Contingency	\$2,520,000
Total Capital Costs Estimate	\$12,600,000
Conceptual Project Cost Estimate Range (-30% to +80%)	\$8.8M - \$22.7M

1. Cost to drill well not included
2. Wells 1-5 are anticipated to be sited at locations above the 100-year floodplain.
3. 3' of mounding included – Wells 6-8 locations within 100-year floodplain
4. Rounded to the nearest \$100,000

Comparative Cost Analysis of Scenarios

Total Capital Cost Estimates are the sum of construction costs, design and engineering, and contingency. As aforementioned in **"Cost Estimating Data"**, cost estimates are considered Class 5 with an end usage being a project concept report and an expected accuracy range of -30 percent to +80 percent. Cost estimates should be reevaluated as the projects are better defined in order to narrow the accuracy level of the estimates.

For comparative purposes, Total Capital Costs Estimates are shown below in **Table 5** excluding the above accuracy range.

Table 5 - Comparative Cost Analysis of Scenarios

Scenario	Total Capital Costs Estimate
Port-Only Scenario – Groundwater Treatment Plant Included	\$12,900,000
Port-Only Scenario (Disinfection Only – No Treatment Plant)	\$8,400,000
Partnership Scenario – Groundwater Treatment Plant Included	\$18,600,000
Partnership Scenario (Disinfection Only – No Treatment Plant)	\$12,600,000



Operation and Maintenance Costs

A preliminary estimate of the Operation & Maintenance (O&M) costs for nitrate removal and iron and manganese removal for both the Port-Only Scenario and Partnership Scenario are provided in **Table 6** and **Table 7** below, respectively.

Phase III(a) – Port-Only Scenario Annual O&M Costs

Table 6 – Annual Costs for Corrosion Control, Nitrate and Iron Removal (400 GPM)

Item	Annual Quantity	Unit Cost*	Annual Cost Estimate
Energy Consumption, kWh (Nitrate)	50,000	\$ 0.10/kWh	\$5,000
Well Production, kWh	66,200	\$ 0.10/kWh	\$6,620
Booster Pumping, kWh	52,900	\$ 0.10/kWh	\$5,290
Acetic acid (80%), gallons	23,000	\$ 5.50/gallon	\$126,500
Phosphoric acid (75%), gallons	450	\$ 8.30/gallon	\$3,735
Sodium Hydroxide	1200	\$5.50/gallon	\$ 6,600
Energy Consumption, kWh (Iron)	400	\$ 0.10/kWh	\$40
Chlorine (12%), gallons	3400	\$ 2.50/gallon	\$8,500
Additional O&M Labor for Full Plant (Direct Salary only)	365 days (2080 Hrs)	\$ 50/hr	\$104,000
<i>Estimate of Total Annual Cost</i>			\$266,285

Phase III(b) – Partnership Scenario Annual O&M Costs

Table 7 - Annual Costs for Corrosion Control, Nitrate and Iron Removal (700 GPM)

Item	Annual Quantity	Unit Cost*	Annual Cost Estimate
Energy Consumption, kWh (Nitrate)	87,500	\$ 0.10/kWh	\$8,750
Well Production, kWh	116,000	\$ 0.10/kWh	\$11,600
Booster Pumping, kWh	93,000	\$ 0.10/kWh	\$9,300
Acetic acid (80%), gallons	40,000	\$ 5.50/gallon	\$220,000
Phosphoric acid (75%), gallons	800	\$ 8.30/gallon	\$6,640
Sodium Hydroxide	2100	\$5.50/gallon	\$ 11,550
Energy Consumption, kWh (Iron)	700	\$ 0.10/kWh	\$70
Chlorine (12%), gallons	6000	\$ 2.50/gallon	\$15,000
Additional O&M Labor for Full Plant (Direct Salary only)	365 days (2080 Hrs)	\$ 50/hr	\$104,000
<i>Estimate of Total Annual Cost</i>			\$386,910



LONG PRAIRIE WATER DISTRICT
PLEASANT VALLEY WATER COMPANY
SOUTH PRAIRIE WATER ASSOCIATION
PORT OF TILLAMOOK BAY

Regional Water Supply Study

February 2024

Funded, in part, by grants from the Oregon Business Development Department (OBDD):

- Water/Wastewater Technical Assistance Project V23008 with Long Prairie Water District, and
- Sustainable Infrastructure Planning Project R22011 with Pleasant Valley Water Company

PREPARED BY:

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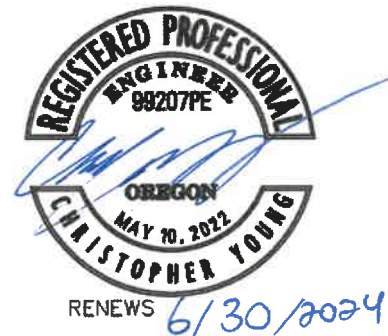
PREPARED FOR:

Long Prairie Water District
Pleasant Valley Water Company
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Regional Water Supply Study

Long Prairie Water District / Pleasant Valley Water Company

February 2024



Conсор

One SW Columbia Street
Suite 1700
Portland, OR 97204



Technical Memorandum – Regional Water Supply Study

Date: February 2024
Project: Regional Water Supply Plan
To: Rick Stelzig, LPWD
Nonda Zwald, PVWC
Coby Rieger, SPWA
Michele Bradley, Port of Tillamook Bay
Mark Knudson, SDAO

From: Chris Young, P.E.
Reviewed By: Brian Ginter, P.E.
Re: Regional Water Supply Study

Introduction

In 2021, a Memorandum of Understanding (MOU) for Regional Water Supply Planning was endorsed by four rural systems, collectively referred to as the “Partner Agencies”, all of whom source their water from the City of Tillamook. This cooperative agreement was initiated to explore a Regional Water Supply Planning Initiative. The Partner Agencies participating in this Regional Water Supply Planning effort include:

- Long Prairie Water District (LPWD)
- Pleasant Valley Water Company (PVWC)
- The Port of Tillamook Bay (Port)
- South Prairie Water Association (SPWA)

The Regional Water Supply Planning effort includes four separate projects:

- Long Prairie Water District Water System Master Plan
- Pleasant Valley Water Company Water System Master Plan
- Port of Tillamook Bay Groundwater Feasibility Study
- Regional Water Supply Study

In 2021, Consor (formerly Murraysmith), entered into a contract with the Long Prairie Water District and the Pleasant Valley Water Company (Water Systems) to develop their Water System Master Plans (WSMPs). The plans are being developed in collaboration with the Regional Water Supply Planning efforts of the Partner Agencies. The WSMPs are in progress, with the expectation that the plans’ proposed infrastructure

improvements will incorporate the next steps needed to integrate the preferred regional water supply alternative as the systems' future source of supply.

In 2022, GSI Water Solutions, Inc. (GSI), with Consor as a subconsultant, was contracted to perform a Groundwater Feasibility Study (Feasibility Study) for the Port. The findings of the Feasibility Study were considered in this Regional Water Supply Study.

In 2023, Consor's contract to develop the Water Systems' WSMPs was amended for Consor to develop this Regional Water Supply Study.

Background

The Port, LPWD, PVWC and SPWA are located approximately 2-4 miles south of the City of Tillamook (City) in Tillamook County, Oregon. The Partner Agencies are four of the twelve water systems that purchase water from the City of Tillamook.

The Partner Agencies purchase water from the City of Tillamook and supply potable water to a variety of customers, as summarized in **Table 1** below.

Table 1 | Partner Agencies: Customers

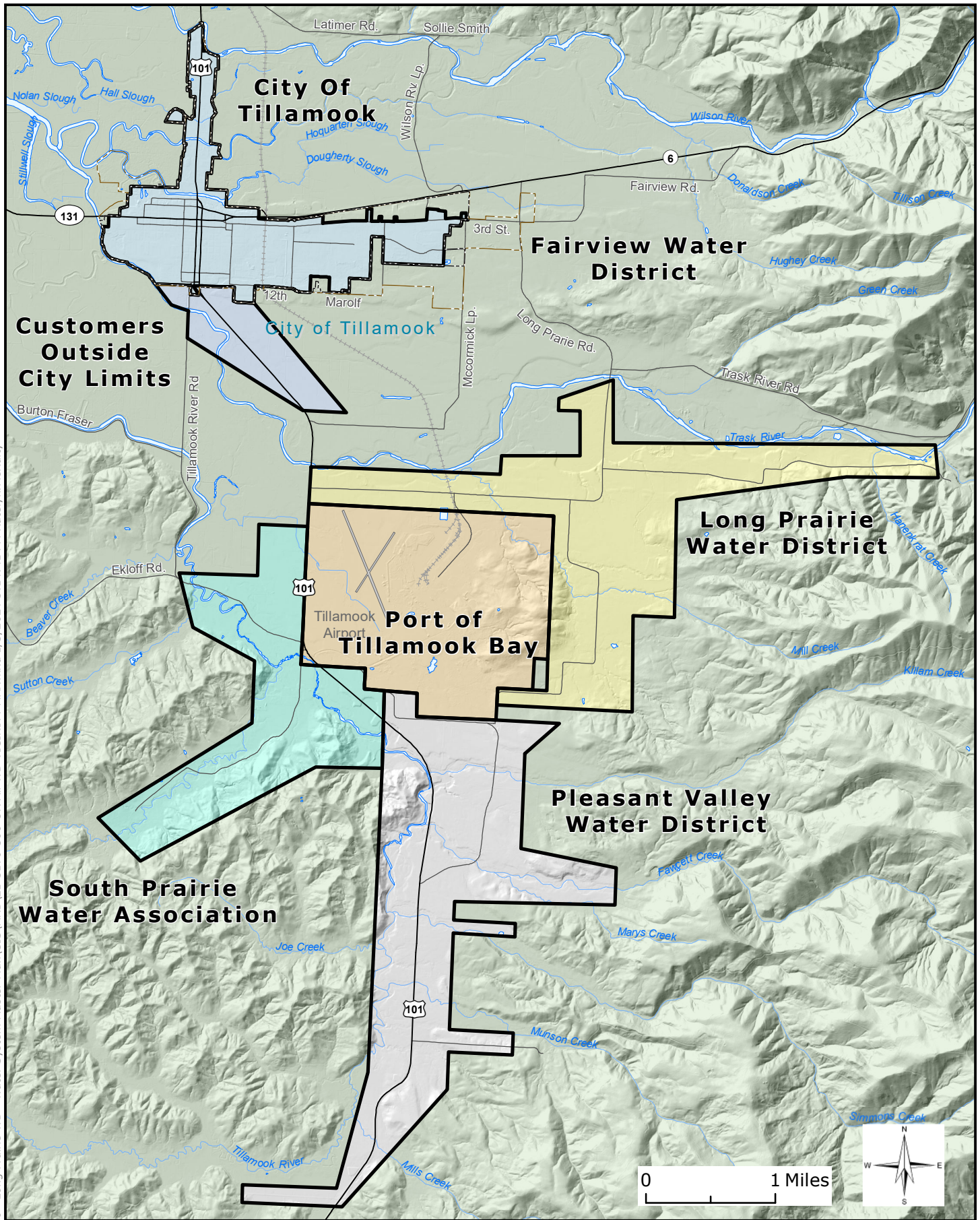
Water System	Population (Approximate) ¹	Customers (Connections) ¹
Port of Tillamook Bay ^{1a}	250	65
Long Prairie Water District ^{1b}	998	274
Pleasant Valley Water Company ^{1c}	900	268
South Prairie Water Association ^{1d}	435	159

1. OHA, 2023. Oregon Public Health Drinking Water Data Online. Accessed by Consor October 2023
 - a. OR41-01329 Port of Tillamook Bay. Available online at: <https://yourwater.oregon.gov/inventory.php?pwsno=01329>.
 - b. OR41-00890 Long Prairie Water District. Available online at: <https://yourwater.oregon.gov/inventory.php?pwsno=00890>.
 - c. OR41-00884 Pleasant Valley Water Company. Available online at <https://yourwater.oregon.gov/inventory.php?pwsno=00884>.
 - d. South Prairie Water Association. Available online at: <https://yourwater.oregon.gov/inventory.php?pwsno=00892>.

Additionally, the Fairview Water District (Fairview), while not currently a Partner Agency, has expressed interest in participating in a Regional Water Supply Planning effort and will be considered as a potential water supplier or partner in regional supply development in the alternatives evaluation.

Figure 1 below shows the geographic locations of the four Partner Agencies, Fairview Water District, and the City of Tillamook.

G:\PDX_Projects\21\3176 - Long Prairie WD - Water System Master Plan\GIS\WXD\21-3176-300-OR-All-WD VICINITY MAP.mxd 1/3/2024 3:14:41 PM Katelyn.McNulty



Regional Water Supply Plan: Partner Agencies

**Figure 1 | Partner
Agencies Map**

City of Tillamook Water Supply

The four Partner Agencies currently purchase finished water from the City of Tillamook and have no other existing source of water supply.

The City provides water to eleven rural water providers, which it designates as “surplus water” (Ref: City of Tillamook, Master Water Plan, 2014, Section 2.2.1). While there have been no recent interruptions of this supply to the water providers, the designation of “surplus water” suggests it could presumably be subject to interruptions or curtailments due to City emergencies (e.g., short-term), City growth (e.g., long-term), or excess demands by the providers.

The Partner Agencies do not currently have a wholesale agreement or water supply contract with the City. Generally the Partner Agencies’ rates are significantly higher than they are for residential customers within the City, despite the Partner Agencies receiving a lower level of service than in-City customers.

The City’s rates to supply the LPWD, PVWC, and the SPWA are established as rates for “outside” customers. The monthly fixed charge “meter rate” paid by the District is currently about 11% higher than the City’s in-city residential rate and the variable charge “consumption rate” paid by the is roughly 26.6% higher than the in-city residential rate. The City’s rate resolution (Ref: City of Tillamook, Resolution No. 1754, April 16, 2018) establishes a five-year rate schedule for the period of 5/1/2018 through 4/30/2023, and includes an anticipated 5% increase in the fixed “meter rate” and a 20% increase in the variable “consumption rate” effective 5/1/2021, and an additional 5% increase in the monthly fixed charge and 15% increase in the variable rate effective 5/1/2022.

In 2020, the City modified its billing practice to extend the City’s “commercial rate” to include the Port of Tillamook Bay. This change in the City’s billing practice was intended to provide one rate for all commercial customers served by the City. This reclassification of the Port as a commercial customer resulted in a 14% increase in the Port’s monthly fixed meter charge and a 48% decrease in the variable consumption rate as compared to the rates previously paid by the Port and the rates paid by the other “outside” rural water providers. This change in the City’s billing practice was not formalized by City Council action.

In February 2022, the Partner Agencies formally requested the City temporarily freeze the water rate increase for 2022 as planned under City Resolution 1754 “until the City complete a rate study to identify a fair rate structure for wholesale water supply ... based on cost-of-service principles.” At that same time, the City provided a Letter of Commitment expressing “that the City of Tillamook is committed to studying the issues at hand together, in an inclusive environment that looks all water providers in a fair and representative manner.” On April 18, 2022, the City Council accepted the Partner’s proposal to put a hold on all water providers next scheduled rate increase. The City Council also directed the City Manager to conduct a water rate study. Since that time, the Partners have received no further information from the City on wholesale supply planning or a wholesale rate study other than an email from the City in November 2023 indicating the reason for higher outside rates is because “City of Tillamook users have Paid SDC fees and taxes.”

Regional Water Supply Study Purpose

The Partner Agencies wish to evaluate the feasibility of the development of a regional water supply to provide them with long-term reliable, efficient and effective water supply and transmission to their respective service areas.

In 2020 the Partner Agencies contacted the Special Districts Association of Oregon (SDAO) Consulting Services Program (CSP) to identify and evaluate alternative concepts to reduce the cost of purchased water. The SDAO CSP developed a memorandum, *Concepts to Reduce the Cost of Purchased Water*, summarizing 10 potential options to reduce the Cost of Purchased Water. While the document was written for the LPWD and summarized steps the District could implement, it also recommended developing the aforementioned MOU with other water systems whose source of water supply is from the City of Tillamook.

The purpose of this Regional Water Supply Study is to further the development and analysis of water supply alternatives available to the Partner Agencies. This includes comparing the technical and economic feasibility of the Partner Agencies supplying and operating their own water and operating their supply system exclusively.

Water Supply Requirements

Port of Tillamook Bay Water Rights

The Port's existing water rights are discussed in detail in the Port's *Final Water Management and Conservation Plan* (GSI Water Solutions, Inc., February 2019) and the *Port of Tillamook Bay Groundwater Feasibility Study* (GSI Water Solutions, Inc., June 13th, 2023). The Port holds two water use permits (G-15966 and G-16311) and a transfer (T-9962) that authorize the use of groundwater for municipal purposes.

The Port's groundwater rights have a combined maximum authorized rate of appropriation of 3.13 cfs, which includes 0.33 cfs under Transfer T-9962, 2.0 cfs under Permit G-15966, and 0.8 cfs under Permit G-16311. However, conditions on the Port's transfer and on one of the permits impose limits on the use of these rights. Transfer (T-9962) is limited to an annual appropriation of 211.3 acre-feet and is only available for use during the irrigation season (March 1 through October 31). Permit G-15966 is available for use from December 1 through April 30. Currently only 0.05 cfs are available for appropriation under Permit G-15966 due to a development limitation imposed in the Final Order approving the Port's 2019 WMCP. The Port will need to request access to an increased rate of appropriation under this permit in a new WMCP if use is required in excess of 0.05 cfs in the future.

In consideration of these limitations, the Port can appropriate up to a maximum of 1.13 cfs (0.8 cfs + 0.33 cfs) or 0.73 mgd during peak season (March 1 to October 31) under these permits. While the Port has indicated no interest in managing a water supply system, initial discussions suggest the Port would be open to making the rights available to a regional partnership, provided the Partner Agencies establish a plan to develop them.

Long Prairie Water District Water Rights

LPWD holds a certificated water right for 3.0 cubic feet per second (cfs) on Mill Creek (Certificate 2191, priority date 2/3/1919). The District discontinued routine use of the Mill Creek supply in the early 1980's due to the cost of improvements required for regulatory compliance and supply reliability concerns.

At the beginning of this study, Mill Creek was explored as a potential supply alternative. Due to the high capital costs and regulatory hurdles of developing a new surface water supply, combined with observed limitations in peak supply reliability during site visits, the feasibility of relying on Mill Creek as a primary supply source was ruled out. While the Mill Creek Water Right could provide value, serving as a supplementary source for Partner Agencies' water supply or to negotiate expanded alternative water supply rights within the region, it is not considered a viable primary source supply option.

Fairview Water District Water Rights

The Fairview Water District (Fairview), though not a current Partner Agency, has expressed interest in supplying water to the Partner Agencies. While there have been ongoing discussions between the Partner Agencies and Fairview concerning water availability and anticipated water rates, further exploration of details for a future agreement with Fairview is necessary. Preliminarily, Fairview has conveyed optimism regarding its capability, both in terms of water supply and financial capacity, to meet the needs of the Partner Agencies.

Fairview's water rights are presented in **Table 2** below and have a combined maximum authorized rate of appropriation of 4.37 cfs which includes approximately 0.96 cfs in unused surface water (SW) rights. Of its available 3.41 cfs in groundwater (GW) rights, Fairview has indicated that it is currently able to produce approximately 2.06 cfs and in the early stages of further well development.

Fairview acquired an additional 1.2 cfs of groundwater rights when the District merged with the Wilson River Water District. This additional 1.2 cfs would equate to an available total of 4.61 cfs of Fairview Water District's total available groundwater supply rights. This additional capacity is not considered in this study but should be further explored should the Partner Agencies elect to explore Alternative 3 further. As such, this additional capacity is not reflected in **Table 2** below.



Table 2 | Fairview Water District Water Rights¹

Application #	Permit #	Certificate	Transfer	Source	Use	Priority Date	Authorized Rate (cfs)	Authorized Rate (gpm)	Authorized Volume (AF)	Use status	Comments
Surface Water											
R-13824	R-644	30206	-	Unnamed tributary of Wilson River	Storage of Water for Domestic Use	11/12/1930	-	-	0.61	Not in use	
S-13850	S-9989	30207	-	Unnamed streams and reservoir constructed under Permit R-644	Domestic	12/1/1930	0.729	327.2	-	Not in use	
S-9996	S-6665	8073	T-6644	Donaldson Creek	Domestic	2/12/1925	0.23	103.2	-	Not in use	2005 transfer application to change to irrigation of 14 acres was rejected. Original Certificate remains available for use.
Total							0.959	430.4	-		
Groundwater											
G-7366	G-6897	82342	-	Well 3	Quasi-Municipal	5/13/1976	1.3	583.4	-	In use	
G-1220	G-1115	-	T-12190	Wells 1 and 4	Municipal	8/27/1958	1.23	552.0	-	In use	T-12190 replaced Well 2 with Well 4.
G-1220	G-1115	96968	-	Well 2	Municipal	8/27/1958	0.88	394.9	-	In use	FO for partial reversion of T-12190 of 0.88 cfs from Well 4 to Well 2 issued 3/15/2023.
Total							3.41	1530.4	-		

1. Additional 1.2 cfs of groundwater rights when Fairview merged with the Wilson River Water District is not included.



Water Demand Summary

GSI, as a subconsultant to Consor, created demand forecasts for the LPWD and the PVWC as part of the development of the Water Systems' WSMPs. Additionally, GSI presented current and forecasted water requirements for the SPWA and the Port in the *Port of Tillamook Bay Groundwater Feasibility Study*. These demands are summarized in **Table 3** below.

Given the uncertainties surrounding future population growth and economic conditions, the demand forecasts are inherently conservative, with forecasted demands potentially taking decades to materialize. However, as the alternatives under consideration necessitate significant investments from the Partner Agencies in building 100-year infrastructure, conservative demand planning is essential.

The term "water demand" refers to all the water requirements of the Partner Agencies including domestic, commercial, municipal, institutional, as well as unaccounted-for water. Existing water demands were developed from a review of historical water billing records and operations data, such as metered connections and pump station flows, provided by the Partner Agencies.

Average day demand (ADD) equals the total annual demand divided by 365 days. Maximum day demand (MDD) equals the highest system demand that occurs on any single day during a calendar year. MDD is estimated differently for each water system and is further described in the Groundwater Feasibility Study.

Table 3 | Combined demand forecasts for Partner Agencies (POTB, PVWD, LPWD, and SWPA), 2022-2042

Year	POTB ¹ ADD (cfs) ²	PVWC ¹ ADD (cfs)	LPWD ¹ ADD (cfs) ²	SPWA ¹ ADD (cfs)	POTB ¹ MDD (cfs)	PVWC ¹ MDD (cfs)	LPWD ¹ MDD (cfs)	SPWA ¹ MDD (cfs)	Total MDD (cfs)	MDD (mgd)
2022	0.19	0.115	0.110	.065	0.47	0.15	0.15	0.09	0.85	0.55
2032	0.27	0.156	0.183	.065	0.70	0.16	0.24	0.09	1.19	0.77
2042	0.38	0.159	0.256	.065	0.94	0.16	0.34	0.09	1.53	0.99

Notes:

- POTB = Port of Tillamook Bay
PVWC = Pleasant Valley Water Company
LPWD = Long Prairie Water District
SPWA = South Prairie Water Association
cfs = cubic feet per second
Mgd = million gallons per day
MDD = maximum day demand
ADD = average day demand
- Average Day Demand extrapolated from *Final Water Management and Conservation Plan* (GSI Water Solutions, Inc., February 2019, page 5-2)

Water Supply versus Expected Demand

The forecasted demand for the Partner Agencies was compared to the supply available under the Port's water rights. For this comparison, it is assumed that the MDD for the Port and its partners will occur during the summer months of each year. Accordingly, future demands were compared to the total rate of **1.13 cfs** authorized by the Port's water rights available for appropriation during the peak (irrigation) season (Transfer T-9962 and Permit G-16311, March 1 to October 31).

From this comparison of the Port's water rights to the Partner Agencies' forecasted demands, the following conclusions can be made:

- During times other than peak season, the authorized rate under the Port's water rights exceeds the combined non-peak season demand of all the partners through 2042. Specifically, the rate of the Port's water rights during non-peak season are equivalent to 2.8 cfs relative to the combined forecasted demand of 1.53 cfs by 2042, representing a supply excess of 1.27 cfs.

During the non-peak season, a regional groundwater supply based on the Port's water rights is feasible from the perspective of water rights.

- During the peak season (March 1 to October 31): The Port's peak-season demands of 0.94 cfs in 2042 could be met by its existing water rights (1.13 cfs) through the planning period. However, the combined MDD of the Partner Agencies is forecasted to reach 1.53 cfs by 2042, a rate that exceeds available peak season supply of 1.13 cfs by 0.4 cfs (Permits G-4612 and G-16311 in Table 2-7).

The Port's available water rights alone are insufficient to meet the Partner Agencies' forecasted long-term demand. For a new groundwater supply to be a viable alternative, the Partner Agencies require additional supply beyond the Port's available water rights.

Additionally, the forecasted demand for the Partner Agencies was compared to the cumulative supply of both the Port's water rights and Fairview's water rights. For this comparison, Fairview's water rights were limited to its groundwater rights. Fairview's surface water rights were not considered as they are assumed to involve a higher capital cost to develop, entail additional development time and risks, and result in higher long-term operations and maintenance costs. As such, a rate of 3.41 cfs authorized by Fairview's groundwater rights available for appropriation was used for a cumulative total rate of **4.54 cfs** between the Port and Fairview.

Fairview has indicated that their current customer demand is approximately 1.55 cfs (1.0 MGD). From **Table 3** above, the Partner Agencies' future MDD is anticipated to increase from 0.85 cfs in 2022 to 1.19 cfs in 2032, subsequently to 1.53 cfs in 2042. This equates to a 39% and 29% increase over those periods, respectively. Applying the same percentage increases, Fairview Water District MDD would increase from 1.55 cfs to 2.15 cfs in 2032, subsequently to 2.76 cfs in 2042.

Figure 2 below illustrates the comparison of the cumulative forecasted demand of the Fairview Water District and the Partner Agencies, against the total available supply from 1) the Port, 2) Fairview and 3) the Port + Fairview.

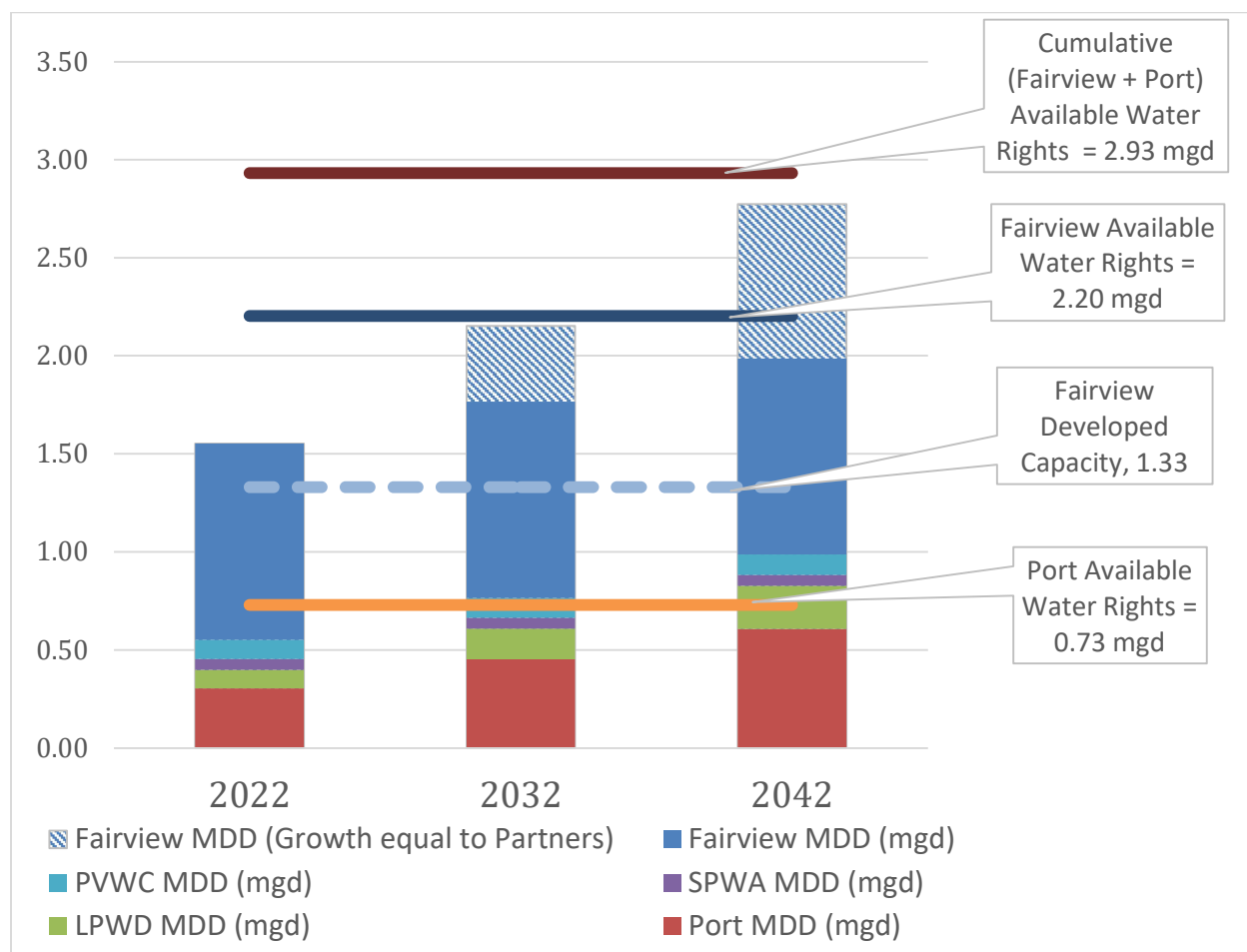
For comparative purposes, the figure includes 1) an assumption that there will be no increase in Fairview Water District demand over the 20-year period and 2) an assumption that Fairview Water District's demand increases at the same rate as the Partner Agencies over the 20-year period. As future growth and forecasted

demand for Fairview is currently unknown, additional exploration of Fairview’s anticipated growth is necessary to determine the relative viability of the Partner Agencies leveraging Fairview water supply.

For illustrative purposes, **Figure 2** depicts the demand and supply capacities in million gallons per day (mgd).

As aforementioned, Fairview acquired an additional 1.2 cfs of groundwater rights when the District merged with the Wilson River Water District. This additional capacity is not considered in this study and not included in **Figure 2**. However, the additional capacity should be further explored should the Partner Agencies elect to further explore Alternative 3.

Figure 2 | Expected Demand Versus Available Supply¹



1. Additional 1.2 cfs of groundwater rights when Fairview merged with the Wilson River Water District is not included.

Supply Source Alternatives Analysis

Description of Alternatives

The purpose of this Regional Water Supply Study is to provide further development and analysis of water supply alternatives available to the Partner Agencies, including a comparison of the feasibility of the Partner Agencies supplying and operating their own water and operating their system exclusively.

The potential water supply conceptual alternatives are summarized below:

Potential Water Supply Conceptual Alternatives
1. Baseline / Do Nothing / Status Quo– Continue to purchase water from the City of Tillamook, under existing conditions of no contract (surplus water only and future rate increases similar to recent increases).
2. City Wholesale Agreement ⁽¹⁾ – Continue to purchase water from the City of Tillamook, but under new conditions of a regional water supply agreement assuming firm water supply and future rates based on cost of service.
3. Purchased Water from Fairview Water District ⁽²⁾ – Construct pipeline(s), pumping and related improvements as needed to purchase water from FWD on a wholesale basis.
4. New Groundwater Supply – Make use of the Port of Tillamook Bay’s existing groundwater rights to construct new wells and related system improvements for a new groundwater supply system.
5. Combinations – Identify combinations of supply sources, project timing, and capacities to optimize supply investments and enhance the resiliency of a regional water supply system.

- (1) While the City of Tillamook (City) is not a funding Partner Agency, the City has offered to collaborate with one or more of the Partner Agencies to develop a regional water supply strategy using the City’s existing supply source and planned improvements to the City supply system.
- (2) Fairview Water District (FWD) is not a funding Partner agency on this project; however, FWD has offered to provide water on a wholesale basis to one or more of the project Partners from FWD’s existing well source.

Evaluation Criteria

Each alternative has also been evaluated based on characteristics important to the Partner Agencies. These include ownership potential, supply reliability and project cost. The source alternatives were also analyzed for fatal flaws that may cause the alternative to be less desirable or indicate a need to remove it from further consideration. The following criteria and evaluation questions were developed to assess the feasibility of each of the supply alternatives:

- Water Supply Availability and Reliability:
 - What quantity of water and water rights are potentially available to Partner Agencies in the short-term?
 - Is this source able to fulfill the long-term supply needs of a Regional Partnership?
 - Is this supply's consistency affected by seasonal effects or other factors?
- Control of Supply and Management/Governance Considerations
 - Source ownership potential: Does the supply alternative allow the Partner Agencies to own (or partially own) the water rights, intake and treatment facilities?
 - Are new contractual and/or management mechanisms required for the supply alternative?
- Implementation Complexity:
 - How difficult would it be to implement the supply alternative?

- How scalable is the supply alternative; Does the supply alternative offer the Partner Agencies the ability to grow the systems over time?
- Is the supply alternative achievable in multiple phases?
- Are there potential benefits to other water systems than the Partner Agencies?
- Environmental, legal, property and permit requirements:
 - Is land acquisition for treatment or well facilities a requirement to develop this supply source?
 - Which environmental and land-use permits are required to develop this source, and how difficult is it likely to be to obtain these permits?
 - Potential legal or other environmental considerations
- Estimated cost for supply alternative:
 - What is the initial capital cost?
 - What is the cost of annual Operations and Maintenance?
 - What is the Long-term life Cycle Cost?
 - What is the estimated life of the alternative?

Alternative Benefits and Limitations

Seven potential water supply alternatives are outlined in **Table 4**. The table presents the following information for each alternative:

- **Alternative Number** – alternatives are presented in no priority. Option five is further subdivided in order to evaluate different combinations of prior alternatives.
- **Description** – truncated titles of the alternatives, previously described in “Description of Alternatives”
- **Requirements** – a non-exhaustive list of key steps required to begin implementation of the water supply alternative.
- **Short Term Supply** – indicates whether the supply alternative is anticipated to provide enough available supply to meet today’s (2022) cumulative demand.
- **Long-term Supply** – indicates whether the supply alternative is anticipated to provide enough available supply to meet future 2042 cumulative demand
- **Benefits and limitations** – a preliminary outline of the potential benefits and limitations of each alternative from the Partner Agencies’ perspectives
- **Risks, Assumptions, Unknowns** – a non-exhaustive list of current unknowns and assumptions associated with each supply alternative.

Table 4 | Alternatives Benefits and Limitations

Alt.	Description	Requirements	Short Term Supply	Long Term Supply	Benefits and limitations	Risks, Assumptions, Unknowns
1	Do nothing – Status Quo	• No new effort • Continue ongoing approach and pricing by City			+ Minimal effort + No initial capital cost - No direct benefits - No cost savings - High relative life cycle cost - Only surplus water: both supply and service - Lack of supply ownership potential	• Only surplus water: both supply and service • Supply not guaranteed without wholesale agreement
2	City Wholesale Agreement	• Approach City with proposal for new wholesale contract • Negotiate firm supply	✓	✓	+ Guaranteed supply per agreement + Ongoing cost savings + Scalable: Can negotiate higher firm supply in the future and potential to be part of City Planning; improved reliability + No initial capital cost - Potential strong opposition by City - Potential adverse effect on Port's rate - No ownership potential	• Uncertain of City response / ease of negotiations • Risk of City transparency in rate setting (unknown if a Cost of Service Study will be performed)
3	Purchased Water from Fairview Water District	• Approach Fairview Water District with proposal for new	✓	Unknown	+ Guaranteed supply per agreement	• Uncertain of anticipated Fairview anticipated growth and demand

Alt.	Description	Requirements	Short Term Supply	Long Term Supply	Benefits and limitations	Risks, Assumptions, Unknowns
		wholesale contract • Negotiate firm supply • Construct infrastructure to connect to Fairview (Pipeline, PRV Stations, Reservoirs)			+ Anticipated lower water purchase rate / Long-term cost savings + Shared infrastructure between Fairview and Partner Agencies - Reliance on Fairview Water District in lieu of City 0: Initial capital cost present, but relatively lower than New Groundwater Supply alternative 0: Fairview Water District is unchlorinated. Supply from Fairview would need to be chlorinated should it be blended with other water supply alternatives	• Uncertain of Fairview Water District response / ease of negotiations • Uncertainty/Risk of Schedule to implement
4.	New Groundwater Supply	• Further exploration of water quality / characterization of level of treatment • Develop Governance and Management/ Operations Regional agreements between some or	Unknown		+ Source ownership potential - Port water rights not sufficient to supply all Partner Agencies - Establishment of management and operations of supply required - Highest initial capital cost - Not enough supply to provide benefit to other water systems outside of Partner Agencies or to meet long-term partner needs	• Treatment costs are highly variable, Level of treatment unknown • Until exploratory wells are drilled, there is uncertainty in capacity • Challenges and risks associated with Construction, siting, and implementation of major new supply and associated treatment and transmission

Alt.	Description	Requirements	Short Term Supply	Long Term Supply	Benefits and limitations	Risks, Assumptions, Unknowns
		all Partner Agencies				
5.a	Alternatives 2 and 3: Wholesale Agreements with Fairview and City	Similar to Alternative 2 but supplement with Fairview Water	✓	✓	+ Increased reliability of regional water supply by creating access to multiple supply sources for the Partners + Shared infrastructure between Fairview and Partner Agencies - Two wholesale agreements likely required - Initial capital cost present, but relatively lower than New Groundwater Supply alternative. May not provide return on investment if Fairview is a secondary supply	- Uncertain of anticipated Fairview anticipated growth and demand - Uncertainty of two entities' response / ease of negotiations - Uncertainty/Risk of Schedule to implement - Risk of City transparency in rate setting (unknown if a Cost of Service Study will be performed)
5.b	Alternatives 2 and 4: Wholesale Agreements with City, supplement with new Groundwater Supply System	Similar to Alternative 2 but supplement with new Port groundwater supply	✓	✓	+ Increased reliability of regional water supply by creating access to multiple supply sources for the Partners + Shared infrastructure between Fairview and Partner Agencies + Ownership Potential - Wholesale agreement AND new water supply system governance, management, and operations required	- Uncertain of City response / ease of negotiations - Risk of City transparency in rate setting (unknown if a Cost of Service Study will be performed) - Treatment costs are highly variable, Level of treatment unknown - Until exploratory wells are drilled, there is uncertainty in capacity - Challenges and risks associated with Construction, siting, and

Alt.	Description	Requirements	Short Term Supply	Long Term Supply	Benefits and limitations	Risks, Assumptions, Unknowns
					- High initial capital cost, but lower than the Partner Agencies “going it alone”	implementation of major new supply and associated treatment and transmission
5.c	Alternatives 3 and 4: Wholesale Agreements with Fairview, supplement with new Groundwater Supply System	Similar to Alternative 3 but supplement with new Port groundwater supply	✓	✓	+ Access to multiple supply sources for the Partners + Shared infrastructure between Fairview and Partner Agencies + Ownership Potential - Initial capital cost present, but relatively lower than New Groundwater Supply alternative.	- Uncertain of anticipated Fairview anticipated growth and demand - Uncertain of Fairview Water District response / ease of negotiations - Uncertainty/Risk of Schedule to implement - Treatment costs are highly variable, Level of treatment unknown - Until exploratory wells are drilled, there is uncertainty in capacity - Challenges and risks associated with Construction, siting, and implementation of major new supply and associated treatment and transmission

Alternatives Decision Matrix

A decision matrix was developed and presented in **Table 5** below.

Water Supply alternatives were evaluated based on the criteria discussed previously. Each alternative was assigned relative scoring as compared to others with the following symbols:

- A “+” indicates the alternative that is more favorable relative to other alternatives for the criteria
- A “-” indicates the alternative that is less favorable relative to other alternatives for the criteria
- A “0” indicates the alternative was neither more nor less favorable than other alternatives for the criteria
- An “NA” indicates the criteria is not applicable to the alternative

Due to the variable level of treatment required with a new groundwater treatment facility in Alternatives 4, 5b, and 5c, these alternatives were further subdivided into i) “New Treatment Plant” – assuming a higher level of treatment and therefore a higher cost and ii) “Disinfection Only” – assuming a lower level of treatment.

The matrix resulted in a cumulation of +’s and -’s for each supply alternative. Cumulative +’s and -’s were used to narrow alternatives, but not to establish a ranking among them.

Based on the evaluation and discussions with the Partner Agencies, the following alternatives are recommended for further study and exploration:

- **Alternative 2:** Develop a wholesale agreement with the City
- **Alternative 3:** Purchase Fairview Water District water supply
- **Alternative 5a – Combination of Alternatives 2 and 3:** Develop a wholesale agreement with the City and purchase Fairview Water District water supply
- **Alternative 5b.ii – Combination of Alternatives 2 and 4:** Develop a wholesale agreement with the City and construct new groundwater facilities using Port water rights
- **Alternative 5c.ii – Combination of Alternatives 3 and 4:** Purchase Fairview Water District water supply construct new groundwater facilities using Port water rights.

Table 5 | Supply Alternative Decision Matrix

Option		Baseline / Do Nothing / Status Quo		City Wholesale Agreement		Purchase water from Fairview		New Groundwater Supply		Combination	
		Alternative 1	Alternative 2	Alternative 3	Alternative 4.i	Alternative 4.ii	Alternative 5a	Alternative 5b.i	Alternative 5b.ii	Alternative 5c.i	Alternative 5c.ii
Description		City Water, No Contract	City Wholesale Agreement	Purchase Fairview WD	Port GW Supply (New Treatment Plant)	Port GW Supply (Disinfection ONLY)	Combination of Alternatives 2 and 3 (Purchase BOTH from City and Fairview)	Combination of Alternatives 2 and 4. (New Treatment Plant)	Combination of Alternatives 2 and 4. (Disinfection ONLY)	Combination of Alternatives 3 and 4. (New Treatment Plant)	Combination of Alternatives 3 and 4. (Disinfection ONLY)
Water Supply Availability and Reliability	Short Term Water Availability	NA	+	+	0	0	+	+	+	+	+
	Long-Term Water Availability	NA	+	0	-	-	+	+	+	+	+
	Seasonal effects or other factors?	0	0	0	0	0	+	0	0	0	0
Control of Supply and Management / Governance Considerations	Source ownership potential	-	-	-	+	+	-	+	+	+	+
	New contractual and/or management mechanisms?	+	-	-	-	-	-	-	-	0	0
Implementation Complexity	Difficulty of Implementation	+	0	0	-	-	-	-	-	-	-
	Alternative Scalability	NA	+	0	-	-	0	+	+	+	+
	Alternative achievable in multiple phases?	NA	NA	0	+	+	-	0	0	0	0
	Potential benefits to other water systems	-	-	-	-	-	0	+	+	+	+
	Property and permit requirements	+	+	0	-	-	+	-	-	-	-
Estimated cost for supply alternative	Initial Capital Cost	+	+	0	-	0	-	-	0	-	0
	Annual O&M	NA	NA	0	-	0	NA	-	0	-	0
	Long-term life Cycle Cost	-	+	+	0	+	+	0	+	0	+
	Estimated life of the alternative	-	+	0	0	0	+	0	0	0	0
Summary		Number of +'s = 4 Number of -'s = 4	Number of +'s = 7 Number of -'s = 3	Number of +'s = 2 Number of -'s = 3	Number of +'s = 2 Number of -'s = 8	Number of +'s = 3 Number of -'s = 6	Number of +'s = 6 Number of -'s = 5	Number of +'s = 5 Number of -'s = 5	Number of +'s = 6 Number of -'s = 3	Number of +'s = 5 Number of -'s = 4	Number of +'s = 6 Number of -'s = 2



Project Costs

Cost Estimating Data

An estimated capital project cost has been developed for each alternative. Cost estimates represent opinions of cost only, acknowledging that final costs of individual projects will vary depending on actual labor and material costs, market conditions for construction, regulatory factors, final project scope, project schedule and other factors. The Association for the Advancement of Cost Engineering International (AACE International) classifies cost estimates depending on project definition, end usage and other factors. The cost estimates presented here are considered Class 5 with an end usage being a project concept report and an expected accuracy range of -30 percent to +50 percent. As projects are better defined the accuracy level of the estimates can be narrowed. Estimated project costs include approximate construction costs and an allowance for administrative, engineering and other project related costs as well as contingencies.

The estimated costs included in this plan are planning-level budget estimates presented in 2023 dollars. Since construction costs change periodically, an indexing method to adjust present estimates in the future is useful. The Engineering News Record (ENR) Construction Cost Index (CCI) is a commonly used index for this purpose. For purposes of future cost estimate updating the recent ENR CCI for Seattle, Washington is 13497.97 (October 2023).

Total Cost Analysis

Figure 3 below illustrates a comparison of 20-year analysis of total costs of Alternatives 1-4, with Alternative 4 further divided into a higher cost, “New Treatment Plant” alternative and a lower cost, “Disinfection Only” alternative.

Assumptions

- The Analysis in **Figure 3** includes 20 years of costs to the Partner Agencies
 - Costs are presented in 2023 dollars
 - Initial Capital assumed to be paid Year 1 in full
 - The analysis does not include renewal and replacement costs associated with infrastructure past 20 years.
- **Do-Nothing Scenario:**
 - Water rates are assumed to increase in price 5% annually over the 20-year period.
 - Existing rates were assumed as follows:
 - LPWD, PVWC, SPWA: \$234.99/month fixed + \$13.85/thousand gallons
 - Port: \$234.99/month fixed + \$5.75/thousand gallons
 - Forecasted demand and the additional cost associated were stepwise increased in year 10 and year 20.

➤ **City Wholesale Agreement:**

- For LPWD, PVWC, and SPWA: assumed a negotiated rate equal to Port's current rate.
- Water rates are assumed to increase in price 5% annually over the 20-year period.
- Future demand and additional associated costs were stepwise increased at years 10 and 20.

➤ **Purchase Fairview Water District Water Supply:**

- Per conversations with Fairview Water District, water rates assumed at the current District rate \$5.37 / thousand gallons.
- Water rates are assumed to increase in price 5% annually over the 20-year period.
- Future demand and additional associated costs were stepwise increased at years 10 and 20.
- Initial Capital cost for Partner Agencies to connect to Fairview Water District: approximately \$10,500,000.
 - Approximately \$10,000,000 for 17,000 LF of 8-inch diameter piping, including a 400 linear foot trenchless river crossing.
 - Transmission main is assumed to connect into Fairview Water near the intersection of Hodgdon and Hughey Ln.
 - The assumed route for the transmission main includes Trask River Rd and Long Prairie Rd, ultimately connecting to the existing 8" LPWD at the intersection of Long Prairie Rd and Blimp Blvd.
 - Additional Improvements and considerations connections to PVWD and SPWA will be required and were not considered for this cost comparison.
 - Approximately \$200,000 for a pressure reducing valve station.
 - Approximately \$450,000 included for chlorination

➤ **Construct New Groundwater Facilities to Make Use of Port Water Rights:**

- Costs as described in the *Port of Tillamook Bay Groundwater Regional Feasibility Study*, (GSI Water Solutions, Inc., June 13th, 2023).
 - New Treatment Plant
 - Initial capital cost: \$18,600,000
 - Operations and Maintenance: \$386,000 year 1, increasing 3% annually
 - Disinfection Only
 - Initial capital cost: \$12,600,000
 - Operations and Maintenance: \$100,000 year 1, increasing 3% annually

Figure 3 | 20-Year Cost Analysis – Initial Capital Costs Paid in Full Year 1 (Millions)

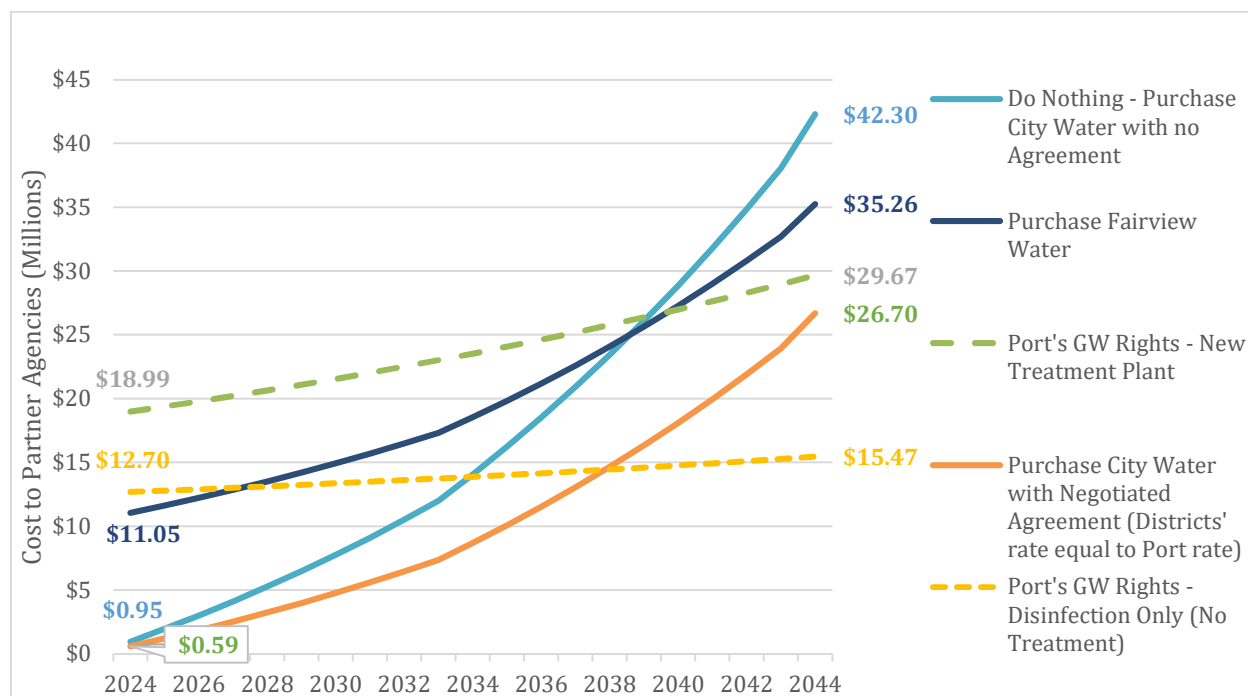
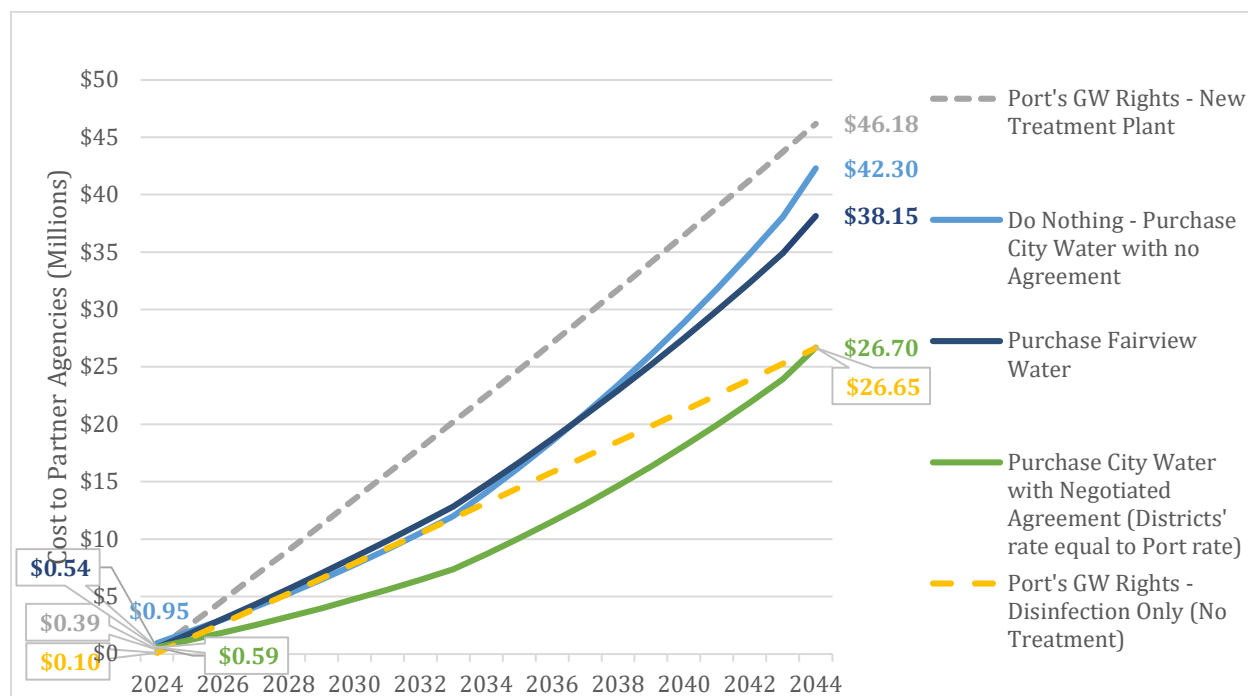


Figure 4 below illustrates a comparison of 20-year total costs, similar to Figure 3. Figure 4 includes the assumption that the Partner Agencies borrow for the initial capital costs of Alternative 3: Purchase from Fairview and Alternative 4: Construct new Groundwater Facilities. For this comparison, it is assumed that the loan is a 20-year loan, compounded yearly, and paid annually.

Figure 4 | 20-Year Cost Analysis: 20-Year Loan (Millions)



Next Steps

As mentioned earlier, it is recommended the Partner Agencies pursue further exploration of the following alternatives:

- **Alternative 2:** Develop a wholesale agreement with the City
- **Alternative 3:** Purchase Fairview Water District water supply
- **Alternative 5a – Combination of Alternatives 2 and 3:** Develop a wholesale agreement with the City and purchase Fairview Water District water supply
- **Alternative 5b. ii – Combination of Alternatives 2 and 4:** Develop a wholesale agreement with the City and construct new groundwater facilities using Port water rights
- **Alternative 5c. ii – Combination of Alternatives 3 and 4:** Purchase Fairview Water District water supply construct new groundwater facilities using Port water rights.

At the outset of this study, it was indicated that this project is the initial phase of a multiphase project, resulting in the negotiation of additional agreements and the implementation of water supply improvements to meet the long-term water supply needs of the participating water providers.

When the overall Regional Water Supply Plan *Project Management Plan* (SDAO, March 29th, 2021) was presented, the work was outlined in three phases:

- Phase 1 – Conduct planning and feasibility studies, including master plans and feasibility evaluation of the Port of Tillamook Bay’s potential groundwater supply, and evaluate the technical and economic feasibility of an alternative source of supply to meet the long-term water demands of the partner agencies.
- Phase 2 – Prepare an intergovernmental agreement (IGA) to implement the recommended water supply plan; this may include individual agreements between the partner agencies and the City of Tillamook, and/or an agreement between the partner agencies for the development of an alternative source of supply.
- Phase 3 – Complete the preliminary design, final design and construction of recommended water supply system improvements.

This study is intended to be viewed as the completion of Phase 1, with the Partner Agencies transitioning to Phase 2 of the Regional Water Supply Plan. This study supports the idea that, at the moment, there is not one definitively most favorable water supply alternative and that the best approach for the Partner Agencies is likely a combination of different available supply options.

Moving forward, it is recommended the Partner Agencies should continue several steps in parallel:

- 1) Continue negotiations with the City, progressing towards a firm supply agreement at a negotiated rate.
- 2) Explore water supply agreements Fairview Water District, developing an understanding of Fairview Water District’s anticipated future growth, required capital investments, and partnership versus wholesale supply opportunities.

Based on the outcomes of items 1 and 2 above,

- 3) Evaluate whether exploration of groundwater development under the Port's water rights is needed to meet the Partner's long-term supply needs, or may be lower cost than negotiated water supply rates with the City and/or Fairview.
- 4) Based on the findings of Items 1 and 2, develop an Implementation Plan for regional water supply that incorporates the required agreements and capital infrastructure development needed.



FINAL TECHNICAL MEMORANDUM

Long Prairie Water District Historical and Projected Demands

To: Brian Ginter, Murraysmith
Chris Young, Murraysmith

From: Owen McMurtrey, GSI Water Solutions, Inc.
Tim Henkle, GSI Water Solutions, Inc.

Date: July 22, 2024

Introduction

As part of Murraysmith Incorporated's (Murraysmith) development of a Water System Master Plan for Long Prairie Water District (LPWD) in Tillamook County, Oregon, Murraysmith subcontracted with GSI Water Solutions, Incorporated (GSI) to document historical demands and perform a forecast of future demands for LPWD through 2042. This technical memorandum summarizes the results of these efforts.

The following terms are used throughout this memorandum:

Consumption is equal to metered water sales at LPWD customer service connections.

Demand is the quantity of water delivered to LPWD's distribution system from the City of Tillamook water system.

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

Maximum day demand (MDD) equals the highest system demand that occurs on any single day during a calendar year. MDD is estimated from ADD using a peaking factor of 1.33 based on information reported by LPWD.

Historical Water Consumption and Demand

Table 1 summarizes LPWD water consumption and estimated water demand from the 2016 through 2020 calendar years. Annual demand has been estimated using annual water sales, assuming 11 percent water loss, equal to LPWD's reported water loss in 2020.

LPWD serves a variety of customers, including farm, dairies, a jail, and a fish hatchery. For the purposes of this evaluation, LPWD customers have been classified into two groups: large water users, with monthly average consumption of approximately 30,000 gallons per month or more, and typical water users, representing the remainder of LPWD's customers. There are five large water users with a combined eight water service connections, including a bottling plant, RV Park, and three farms. **Table 2** shows water use characteristics of these large water users and typical water users.

Table 1: Annual water sales, estimated annual demand, and average and maximum day demand, 2016 through 2020.

Year	Annual Consumption (MG)	Estimated Annual Demand (MG) ¹	Average Day Demand (g) ²	Maximum Day Demand (g) ³
2016	21.0	23.1	63,291	84,042
2017	24.0	26.4	72,344	96,063
2018	22.9	25.1	68,857	91,434
2019	20.6	22.7	62,126	82,495
2020	19.3	21.2	58,046	77,078

Table notes:

¹ Annual demand was calculated by adding 11 percent to annual consumption total using the following formula:

Water Sales ÷ (1 - 0.11) = Water Demand.

² Average day demand was calculated by dividing annual demand by 365.

³ Maximum day demand was calculated by multiplying the average day demand by 1.33, based on data provided by LPWD.

Table 2: Water use characteristics of LPWD's large water users and typical water users.

Year	Large Water Users (Average use >30,000 gallons per month)			Typical Water Users (Average use <30,000 gallons per month)		
	Annual Consumption (MG)	Connections	Consumption per Connection Per Day (g)	Annual Consumption (MG)	Connections	Consumption per Connection Per Day (g)
2016	5.01	8	1,716	16.01	280	157
2017	7.80	8	2,670	16.23	284	157
2018	6.58	8	2,253	16.29	286	156
2019	5.48	8	1,877	15.16	287	145
2020	4.67	9	1,420	14.62	288	139

Demand Forecast

GSI completed a 20 year demand forecast for LPWD, distinguishing between typical and large water users. As part of this forecast, GSI also projected additional potential demand for development of an 80-acre tract of industrial-zoned property within LPWD. This is discussed in greater detail following discussion of projected demands *without* development of the industrial property.

For the demand forecast, GSI made the following assumptions for the group of typical water users. GSI assumed water use patterns for new water service connections would be similar to those of typical water users. Therefore, GSI used annual water sales for typical water users as the baseline for projecting future demands. GSI also assumed that demands for typical water users would grow at the same rate as the population of Tillamook County is forecast to grow, as documented in the 2020 Coordinated Population Forecast for Tillamook County published by Portland State University Population Research Center¹. **Table 3** shows the projected population and average annual growth rates for Tillamook County from 2020-2045, along

¹ Portland State University. Population Research Center; Chun, Nicholas; Rancik, Kevin; Runge, Paul; Cunningham, Mac; Loftus, Deborah; and Rynerson, Charles; "[Coordinated Population Forecast for Tillamook County, its Urban Growth Boundaries \(UGB\), and Area Outside UGBs 2020-2070](#)" (Forthcoming publication).

with the projected number of service connections for LPWD. For the five large water users, GSI assumed that the number of large water user service connections (8) and their water use would remain constant through the 20-year planning period.

Table 3: Projected population and average annual growth rates for Tillamook County, 2020 – 2045.

	Actual	Forecast					
	2018	2020	2025	2030	2035	2040	2045
Tillamook County Population Forecast	--	26,076	26,423	26,810	27,184	27,570	27,987
Projected Average Annual Growth Rate (AAGR) for Tillamook County Total	--	0.26%	0.26%	0.29%	0.28%	0.28%	0.30%
Number of LPWD Typical Water Users' Service Connections	285	287	291	295	299	303	308

The Tillamook County population forecast projects population growth based on 5-year intervals (beginning in 2020). This memorandum projects water demands from 2022 through 2042. **Table 4** shows interpolated population and water service connection projections using the estimated exponential average annual growth rates calculated in the Coordinated Population Forecast.

Table 4: Projected population and average annual growth rates for Tillamook County, 2022 – 2042.

	Actual	Forecast				
	2018	2022	2027	2032	2037	2042
Tillamook County Population Forecast	--	26,214	26,577	26,959	27,338	27,736
Projected Average Annual Growth Rate (AAGR) for Tillamook County Total	--	0.26%	0.29%	0.28%	0.28%	0.30%
Number of LPWD Typical Water Users' Service Connections	285	288	292	297	301	305

The water demand projection uses water sales in 2018 as the base year for future demands. 2018 represents a higher demand scenario for planning purposes. As previously described, GSI assumed that monthly water sales for typical water users would grow at the same rate as the County's forecasted population (see Table 3), while water use by large water use would remain the same. Projected demand is estimated to be equal to water sales, plus a water loss factor of 11 percent, the estimated loss reported by LPWD in 2020. **Table 5** shows 2018 actual and 2022 through 2042 projected water sales and water demand. Maximum day demand was calculated using a peaking factor of 1.33 based on 2020 data reported by LPWD.

Table 5: 2018 actual and 2022 through 2042 forecast water sales, average day demand, and maximum day demand.

	Actual	Forecast				
	2018	2022	2027	2032	2037	2042
Consumption by Typical Water Users (MG)	16.29	16.47	16.69	16.93	17.17	17.42
Consumption by Large Water Users (MG)	6.58	6.58	6.58	6.58	6.58	6.58
Total Annual Consumption (MG)	22.87	23.04	23.27	23.51	23.75	24.00
Total Annual Demand (MG) ¹	25.70	25.89	26.15	26.42	26.69	26.97
Average Day Demand (g) ²	70,405	70,938	71,640	72,378	73,110	73,880
Maximum Day Demand (g) ³	93,488	94,196	95,128	96,109	97,080	98,104

Table notes:

¹ Annual demand was calculated by adding 11 percent to annual consumption total using the following formula:
 $\text{Water Sales} \div (1 - 0.11) = \text{Water Demand}$.

² Average day demand was calculated by dividing annual demand by 365.

³ Maximum day demand was calculated by multiplying the average day demand by 1.33, based on data provided by LPWD.

This forecast projects total demand to increase by 4.9 percent from 2018 actual demands through 2042. The number of service connections is projected to increase by 6.9 percent over the same time period. As described above, the slower growth in water demands compared to growth in service connections is attributed to the assumption that there will be no additional large water users, resulting in a smaller proportional share of LPDW total customers' consumption over time by the large water users.

Forecast for Development of Industrial Property

The Port of Tillamook Bay (Port) owns an 80 acre tract of land in the northeast corner of the Port. This industrial property falls within LPWD's service area and any future development within this parcel will be served by LPWD. The demand generated by development within this property is added to LPWD's forecast presented above. LPWD assumes that this property will be fully developed within the next 20 years (by 2042) with customers within the light industry business sector. In order to forecast water demand for this property, GSI followed the methodology of the Port's 2019 Water Management and Conservation Plan (WMCP). The Port's WMCP calculated water use factors to represent consumption on a per-acre basis for existing water users at the Port. LPWD projects that the density of development within the industrial property will be similar to that of the Port. The Port calculated a low water use factor of 0.0004 cubic feet per second per acre (cfs/acre) (259 gallons per day [gpd]) and a high water use factor of 0.0032 cfs/acre (2,068 gpd) for industrial users under peak demands. Following the Port's methodology, **Table 6** shows forecast demand from 2022 through 2042 assuming buildout of the industrial property at a constant rate under two scenarios:

- A low water demand scenario, in which 10 percent of the land is developed by high water use industry and 90 percent of the land is developed by low water use industry (resulting in an average of 439 gpd/acre).

- A high water demand scenario, in which 70 percent of the land is developed by high water use industry and 30 percent of the land is developed by low water use industry (resulting in an average of 1,525 gpd/acre).²

In order to estimate average day industrial demand, GSI divided forecast maximum day demands by LPWD's current peaking factor of 1.33,

It is important to note that both scenarios anticipate full development of an estimated 37.9 buildable acres within the industrial property. Of the original 80 acres, the following amounts are excluded:

- A 10.8-acre parcel developed by Braxling beginning in 2018, and thus incorporated into existing water demands
- 7.1 acres for a proposed road location providing access within the property;
- 24.4 acres in the vicinity of Mill Creek assumed to be unbuildable or wetlands.

The forecast assumes the remaining 37.9 acres will be developed by 2042.

Table 6: Industrial water demand forecast with development of industrial property under low water demand and high water demand scenario.

		Forecast				
		2022	2027	2032	2037	2042
Low Industrial Water Demand Scenario (439 gpd/acre)	Maximum Day Demand (gpd)	0	4,164	8,328	12,493	16,657
	Average Day Demand (gpd)	0	3,131	6,262	9,393	12,524
	Annual Demand (MG)	0	1.14	2.29	3.43	4.57
High Industrial Water Demand Scenario (1,887 gpd/acre)	Maximum Day Demand (gpd)	0	14,452	28,905	43,357	57,809
	Average Day Demand (gpd)	0	10,866	21,733	32,599	43,466
	Annual Demand (MG)	0	3.97	7.93	11.90	15.86

Table 7 shows combined forecast demand for the current LPWD service area (from Table 5) and development of the 80-acre industrial property (from Table 6).

Table 7: Combined forecast water demand for current service and with development of industrial property under low industrial water demand scenario and high industrial water demand scenario.

		Actual	Forecast				
		2018	2022	2027	2032	2037	2042
Low Industrial Water Demand Scenario (439 gpd/acre)	Maximum Day Demand (gpd)	93,488	94,196	99,293	104,437	109,573	114,760
	Average Day Demand (gpd)	70,405	70,938	74,771	78,640	82,503	86,404
	Annual Demand (MG)	25.70	25.89	27.29	28.70	30.11	31.54
	Maximum Day Demand (gpd)	93,488	94,196	109,581	125,014	140,437	155,913

² The 70 percent to 30 percent ratio of high water demand to low water demand development actually corresponds to the Port's moderate industrial water demand scenario rather than its high industrial water demand scenario. However, this is appropriate for LPWD's high water demand scenario for LPWD because the industrial property to be developed is zoned light industrial and the Port's high demand water users tend to be heavy industries.

Long Prairie Water District Historical and Projected Demands

High Industrial Water Demand Scenario (1,887 gpd/acre)	Average Day Demand (gpd)	70,405	70,938	82,506	94,111	105,709	117,346
	Annual Demand (MG)	25.70	25.89	30.11	34.35	38.58	42.83

The combined forecast projects that annual demands will rise by 67 percent compared to 2018 demands under the high water demand scenario and 23 percent under the low water demand scenario, with the overwhelming majority of the forecast growth in demand attributable to the development of the entire industrial property.

Technical Memorandum

To:	Chris Young, Murraysmith, Inc.	Project:	Long Prairie and Pleasant Valley Water Districts Seismic Hazards Study
From:	Wolfe Lang, PE, GE, & Devin Roth, PE	cc:	
Date:	August 2	Job No.:	6276.0
Subject:	Seismic Hazards Evaluation		

1.0 Introduction

The Long Prairie Water District and Pleasant Valley Water Co. (Water Districts) are updating their water system master plans. The Water Districts have contracted Murraysmith, Inc. (Murraysmith) to provide professional services for the master plan updates and resilience study. As part of the study, a seismic resiliency evaluation of the water system is required in conjunction with the Oregon Resilience Plan (ORP). Murraysmith has retained Delve Underground to conduct seismic hazard evaluation and backbone pipe vulnerability assessment.

This memorandum presents the results of our evaluation. Delve Underground completed the following tasks in accordance with our scope of work:

1. Compile and Review of available local and regional geological information;
2. Review of DOGAMI seismic hazard maps for a magnitude 9.0 CSZ event in the Water Districts' service area;
3. Review of available well log to verify DOGAMI seismic hazard maps;
4. Develop estimates of strong ground shaking, liquefaction-induced settlement, lateral spreading displacement, seismic landslide slope instability, and develop maps illustrating these hazards in relation to the Water Districts' backbone system and;
5. Develop this memorandum summarizing the results of our evaluations and including seismic hazards and fragility maps.

Delve Underground completed these tasks at the identified critical water facilities and backbone pipes as shown on Figures 1 to 5. In the following sections, we present the results of the data review, seismic hazards evaluation, and a summary of geotechnical hazards along the backbone system.

2.0 Background Information Review and Site Reconnaissance

Delve Underground performed background information review in the vicinity of the Long Prairie and Pleasant Valley Water Districts. These tasks included review of mapped seismic hazards, geologic and

seismic hazards literature, historic well logs, for the Long Prairie and Pleasant Valley water systems and in adjacent areas.

2.1 Geologic Setting

Five major rivers drain into Tillamook Bay, from north to south and they are the Miami, Kilchis, Wilson, Trask and Tillamook Rivers. The lower valleys of the Wilson, Trask and Tillamook rivers merge to form a broad alluvial plain on the southern portion of Tillamook Bay. The Wilson-Trask-Tillamook floodplain geology is dominated by alluvial deposits. The oldest and deepest sediments are dominated by semi-consolidated basaltic gravel and cobbles with interstratified sand, silt and clay. The older deposits are in most areas mantled by young alluvial flood deposits consisting of fine sandy to clayey silt and silty clay soils, which may locally incorporate significant organic material (Elliott, n.d.).

The Geologic Map (Figure 1) describes the mapped surficial geologic units in the vicinity of the Water Districts' backbone and is based on the DOGAMI Oregon Geologic Data Compilation Release 7 (OGDC-7). The ODGC-7 geology map shows 3 types of soils in the vicinity of the Water Districts. However, the majority of the pipelines are in Alluvial Deposits of the Trask and Tillamook Rivers, and their tributaries. Limited extents of the pipeline and several facilities are within Marine Sedimentary Rocks. Additionally, Landslide Deposits are present in the surrounding area, but not within the boundaries of the Water Districts.

2.2 Subsurface Data

Delve Underground reviewed published geologic maps and available subsurface condition information in the vicinity of the water system. There is very limited geotechnical boring and site-specific geotechnical exploration data available for the Water Districts' service area, so we used well logs from the Oregon Water Resource Department's (ORWD) database. Where possible, we used this data to confirm or revise the extents of mapped geologic and hazard layers from the DOGAMI O-13-06 and to conduct soil liquefaction potential evaluation.

We also reviewed available historical geotechnical and well logs in the vicinity of the backbone of the Water Districts' distribution system. We show a summary of 12 well logs. The table lists values for groundwater depths, where available. Several logs note the presence of a shallow, perched groundwater table within the Alluvial Deposits, but such shallow water is often ignored by water well drillers and may be present even where not recorded here.

Table 1 lists values for groundwater depths, where available. Several logs note the presence of a shallow, perched groundwater table within the Alluvial Deposits, but such shallow water is often ignored by water well drillers and may be present even where not recorded here.

Table 1: Geotechnical and ORWD Well Logs

	Well Log	District	Geologic Unit	Boring Depth (Feet bgs)	GWT (Feet bgs)
1	TILL_649	Long Prairie	Alluvial Deposits	200	96

2	TILL_651	Long Prairie	Alluvial Deposits	68	45
3	TILL_1316	Long Prairie	Alluvial Deposits	62	11
4	TILL_51168	Long Prairie	Alluvial Deposits	245	15 (perched)
5	TILL_52193	Long Prairie	Alluvial Deposits	105	71
6	TILL_52794	Long Prairie	Alluvial Deposits	50	No data
7	TILL_683	Pleasant Valley	Alluvial Deposits	75	No data
8	TILL_688	Pleasant Valley	Marine Sediments	40	No data
9	TILL_694	Pleasant Valley	Alluvial Deposits	45	No data
10	TILL_698	Pleasant Valley	Alluvial Deposits	85	60
11	TILL_1366	Pleasant Valley	Alluvial Deposits	150	12
12	TILL_52312	Pleasant Valley	Alluvial Deposits	58	45

3.0 Seismic Hazard Evaluation and Mapping

Recent earthquakes in Japan, New Zealand, Chile and elsewhere, and an increased understanding of the Cascadia Subduction Zone (CSZ), have increased the recognition of the earthquake hazard in Oregon. In 2011, Oregon legislature passed a resolution directing the Oregon Seismic Safety Policy Advisory Commission (OSSPAC) to prepare the Oregon Resilience Plan (ORP). The purpose of the ORP is to set policy direction for protecting lives and maintaining economic and commercial activity following a magnitude 9.0 CSZ earthquake (Oregon Resilience Plan 2013). As part of the ORP, in 2013 DOGAMI published Open File Report O-13-06, which includes updated hazard maps and GIS data for the entire state of Oregon (DOGAMI 2013)

Recent studies indicate that there have been numerous large-magnitude earthquakes generated from the CSZ (Goldfinger et al., 2012). These records extend as far back as approximately 10,000 years and indicate an average recurrence of about 500 to 530 years for great earthquakes (larger than M 8.0) that rupture along the entire length of the CSZ (from Cape Mendocino, California to Northern Vancouver Island, British Columbia). The previous CSZ earthquake occurred in January 1700 (Satake, et al., 1996) and is estimated to have been a M 9.0 event. Studies by the USGS (Goldfinger et al., 2012; OSSPAC, 2013) indicate that there is a 7 to 12 percent probability of a great CSZ event impacting the entire Pacific Northwest region. A more recent study by University of Oregon (Goldfinger et al., 2016) estimates that a CSZ earthquake with a magnitude greater than 8.5 has a probability of occurrence on the order of 16 to 22 percent over the next 50 years.

Earthquake hazards within the Project area include earthquakes generated from several sources:

- Crustal faults;
- Within the deep subducted portion of the Juan de Fuca Plate, along the CSZ (referred to as intraslab sources); and
- Along the locked zone of the Cascadia Subduction Zone fault interface capable of producing great, megathrust events.

Large subduction zone earthquakes generate a long duration of significant ground shaking. The 2010 subduction zone earthquake in Maule, Chile resulted in approximately 100 seconds of significant ground shaking. The 2011 subduction zone earthquake in Tohoku, Japan resulted in between about 2 to 3 minutes

of significant ground shaking. For comparison, crustal earthquakes with similar seismogenic characteristics exhibited significant ground shaking for about 10 to 20 seconds (specifically the 2010-2011 Christ Church, New Zealand sequences, 1999 Chi-Chi, Taiwan, and 1983 Coalinga, California earthquakes).

Due to the long duration of ground shaking, a CSZ earthquake is expected to cause higher levels of permanent ground deformation (PGD) than crustal and intraslab sources. Permanent ground deformations pose critical seismic risks to the Water Districts' water system seismic backbone.

In some instances, for structures and facilities (pump stations, treatment plants, reservoir, dam), the seismic design criteria are governed by other code-based procedures (ASCE 7-16, OSSC 2014, Oregon Dam Safety). Typically, these code-based procedures require use of the Maximum Considered Earthquake (MCE) ground motion. The MCE ground motion is derived from USGS Seismic Hazard Maps and represents the most severe earthquake effects. The MCE is a probabilistically derived composite event that is aggregated from all potential earthquake sources that could impact a site and having a return interval of 2,475 years. For comparison, the ORP M9.0 scenario is roughly analogous to a 500-year return interval event.

As part of the ORP, The OSSPAC created a Cascadia Earthquake Scenario workgroup which was charged with developing a description of the likely ground motions (velocity and accelerations) and permanent ground deformations (PGD) to be expected from a M9.0 CSZ event. The workgroup, along with the Oregon Department of Geology and Mineral Industries (DOGAMI), developed M9.0 earthquake scenario maps, which are included in the DOGAMI Open-File Report O-13-06. Of primary interest in these earthquake scenario maps are the following seismic hazards, which formed the baseline levels in our evaluations of seismic hazards:

- Peak Ground Velocity (DOGAMI O-13-06 Plate 2)
- Liquefaction Probability (DOGAMI O-13-06 Plate 3)
- Lateral Spreading PGD (DOGAMI O-13-06 Plate 4)
- Seismic Landslide PGD (DOGAMI O-13-06 Plate 6)

We used the M9.0 CSZ event as the basis of our analyses to be consistent with the ORP approach. Seismic hazards that pose the most risk to the water system include strong ground shaking (peak ground velocity and accelerations), liquefaction, lateral spreading, and seismic-induced landslides. In our hazard evaluations, we overlaid the Water Districts' seismic backbone onto the DOGAMI maps as a starting point. As discussed subsequently, we refined and updated the DOGAMI maps in areas that we found appropriate based on field observations, subsurface data, and geotechnical engineering analysis.

3.1 Geologic Map

The Geologic Map (Figure 1) shows the mapped surficial geologic units in the vicinity of the Water Districts and is based on the DOGAMI Oregon Geologic Data Compilation Release 7 (OGDC-7). These mapped units correspond to the generalized descriptions discussed in Section 2.1.

The primary soils encountered in the vicinity of The Long Prairie and Pleasant Valley Water Districts are Recent Alluvial Deposits, Marine Sediments, Volcanic Rocks and Landslide Deposits. The Water Districts are primarily located within soils deposited by the Tillamook River and Trask River, and their tributaries. Based on geologic mapping and well log data (Table 1) the Alluvial Deposits are typically composed of a mixture of poorly consolidated fine (clay and silt) and coarse-grained materials (sand and gravel) in varying compositions. Because this soil is deposited by water channels that migrate across the valley floor, the material composition of this soil varies greatly with both location and depth and site-specific investigation is required for a more detailed understanding of the soil properties.

The Pleasant Valley Water District is primarily within the Recent Alluvial Deposits soil zone, with small sections in the Marine Sedimentary Rocks zone. The Long Prairie Water District is primarily within the Recent Alluvial soil zone, with small sections in the Marine Sedimentary Rocks zone and Volcanic Rocks zone. There are no major mapped Landslide Deposit zones in either district, however small or unmapped landslide may be present in areas with steep slopes.

3.2 Peak Ground Velocity

The intensity of ground shaking at a site is known as peak ground velocity (PGV). The magnitude of PGV is dependent on the magnitude and distance from the seismic source, and the ground material through which seismic waves pass. The rapid and extreme shaking during an earthquake can cause transient stress and strain in pipelines that can be damaging if the pipe material and joints are not strong enough to withstand the transient ground deformations. Damage from ground shaking occurs even when there is no permanent ground deformation.

The Peak Ground Velocity (Figure 2) shows estimated PGV ranges for a CSZ 9.0 event in vicinity of the Water Districts. The map generally corresponds to the mapped geology areas with PGV values of up to 16 in/sec in stiffer Volcanic Soils, 17 to 21 in/sec in Marine Sediments and some Landslide Deposits, and 22 - 28 in/sec in low-lying Alluvial Deposits soils and some Landslide Deposits.

3.3 Liquefaction Settlement

Liquefaction is a phenomenon in which ground shaking from an earthquake transforms soil from a solid state to a viscous fluid state. Soils that are susceptible to liquefaction are generally sands and non-plastic to low-plastic silts that are saturated (below groundwater level). Silts and silty soils with a plasticity index less than 7 are generally considered to be susceptible to liquefaction. The results of soil liquefaction include loss of shear strength, loss of soil materials through sand boils or flow, flotation of buried chambers/pipes, and post-liquefaction reconsolidation (settlement).

The Liquefaction Settlement Map (Figure 3) shows the location of the water system backbone compared to seismic liquefaction settlement hazards. Within the study area, the sandy and silty soil zones within the Recent Alluvium are potentially liquefiable in a CSV 9.0 event. A vertical displacement of up to 2 inches is possible across most of the system backbone. The only exceptions are the northern and western extremities of the Long Prairie Water District, close to the Trask River, where shallow groundwater and poorly consolidated soil conditions create additional liquefaction settlement hazard of up to 4 inches. This estimate is based on analysis of the log of well TILL_1316. The areas outside the Alluvial Deposits are unlikely to experience significant liquefaction settlement. A site-specific seismic settlement study should

be performed to characterize the hazard and develop mitigation strategies, as discussed in more detail later in this memo.

3.4 Lateral Spreading

Liquefaction can result in progressive ground deformation known as lateral spreading. Lateral spreading generally occurs along river/creek banks and within sloping ground areas. The lateral movement and loss of support of the liquefied soil breaks the overlying non-liquefied soil “crust” into blocks that progressively move downslope or toward a free face in response to the earthquake generated ground accelerations. Each cycle of loading from the earthquake incrementally pushes these blocks downslope. The potential 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. Lateral spreading can result in both vertical and horizontal components of PGD, but for discussion purposes and this screening-level of analysis, the reported estimates of PGD is considered horizontal.

The Liquefaction Lateral Spreading Map (Figure 4) shows the location of the water system backbone compared to seismic liquefaction lateral spread hazards. Within the study area, we used historic well logs to verify the liquefaction lateral spreading estimates presented by DOGAMI. Based on a review of available well logs (shown on map and listed in Table 1), lateral spreading PGD in the Alluvial Deposit zones is less prevalent than DOGAMI’s assessment. Although the Alluvial Deposits are potentially liquefiable, lateral spreading requires mild slopes to develop, where the topography is generally flat and greater than 1000 feet away from steep slopes and surface water, we reduced the lateral spreading hazard layer. However, where lateral spreading hazards are present, they are high to very high, especially in the north of Long Prairie’s backbone system (in the vicinity of Gienger Rd, Long Prairie Rd and Chance Rd where DOGAMI’s map indicates up to 10-foot of lateral spreading PGD may occur). A site-specific lateral spreading study should be performed to characterize the hazard and develop mitigation strategies, as discussed in more detail later in this memo.

3.5 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.

The Seismic Landslide PGD map (Figure 5) shows the estimated levels of seismic landslide PGD in the vicinity of the Water Districts. There is no seismic landslide hazard in the vicinity of the Districts’ water system or storage facilities.

4.0 Conclusions and Recommendations

In general, the majority of the Long Prairie and Pleasant Valley’s backbone water systems are in zones of moderate to high seismic hazard. Main seismic hazards are the moderate liquefaction settlement (about 2 to 4 inches) of liquefaction settlement along the backbone pipelines of both water Districts and potentially high lateral spreading deformations in the north portion of the Long Prairie Water District’s backbone

system. Additional geotechnical and structural engineering evaluations are recommended to study this hazard and develop mitigation strategies if needed.

DELVE UNDERGROUND

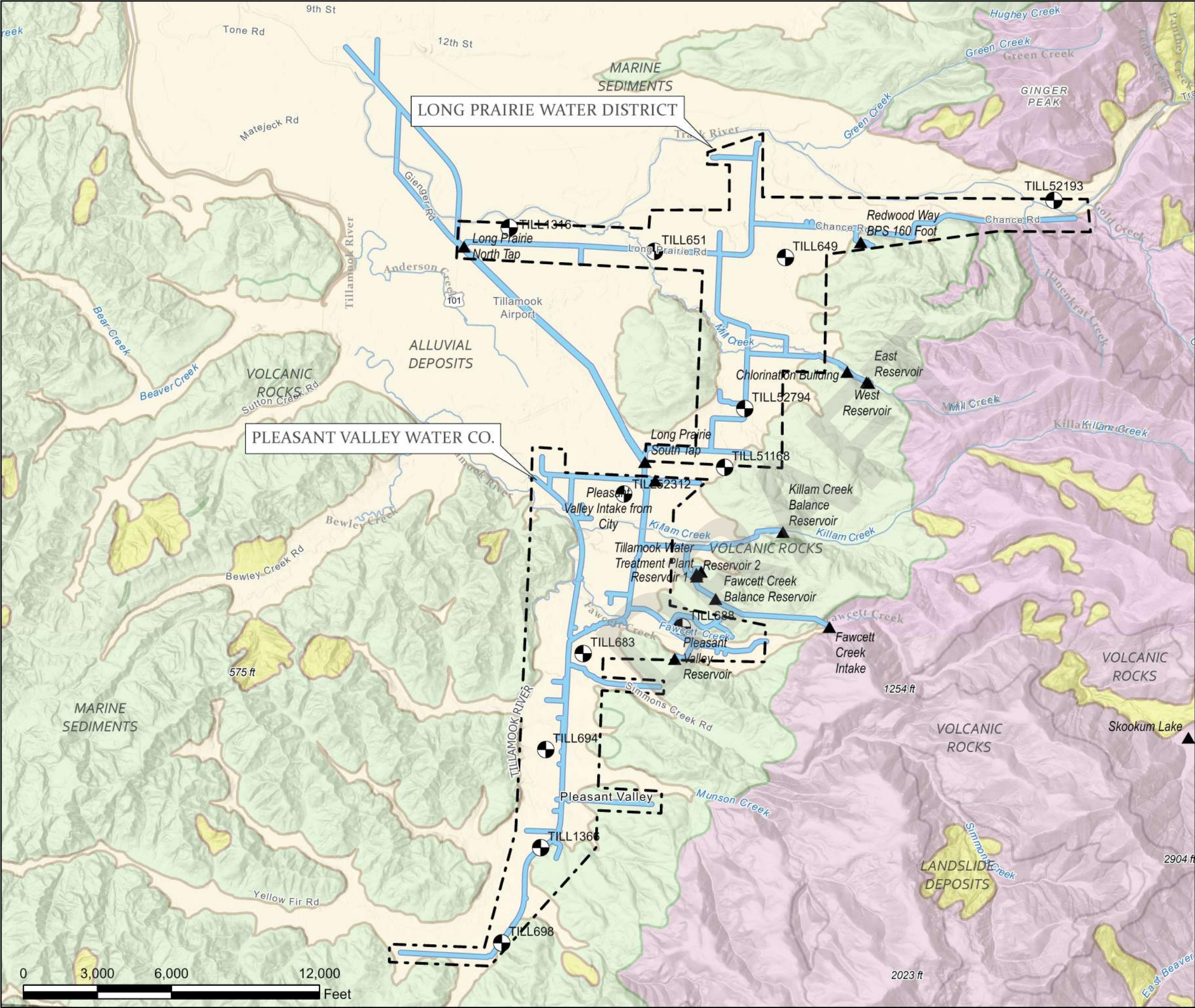
Yuxin “Wolfe” Lang, P.E., G.E.
Principal Engineer

Devin Roth, P.E.
Project Engineer

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Figures



Legend

Backbone Waterlines

ORWD Well Reports

Geology

Alluvial Deposits

Landslide Deposits

Marine Sedimentary Rocks

Volcanic Rocks

NOTES:
SCALE: 1 inch equals 4,000 feet

DATA SHOWN ARE BASED ON DATA FROM DOGAMI Open File Report O-13-06 and ODGC7 AND HAVE NOT BEEN VERIFIED.

LONG PRAIRIE & PLEASANT VALLEY
SEISMIC RESILIENCE EVALUATION

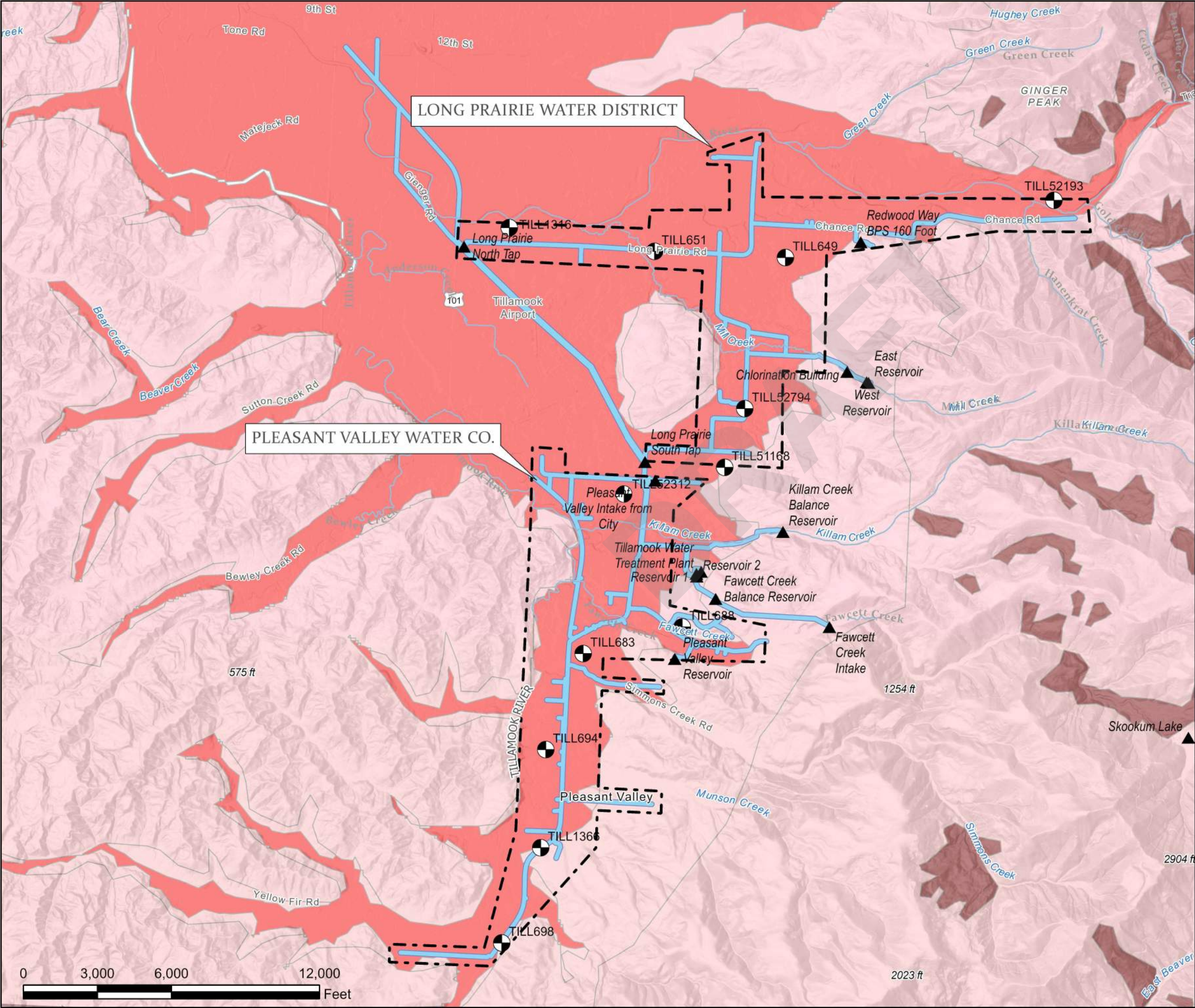
GEOLOGY MAP

Project Location

N

AUG 2024

FIGURE 1



Legend

- Backbone Waterlines
- ORWD Well Reports

PGV (in/sec)

- Up to 16 in/sec
- 17 - 21 in/sec
- 22 - 28 in/sec

NOTES:
SCALE: 1 inch equals 4,000 feet

DATA SHOWN ARE BASED ON DATA FROM DOGAMI Open File Report O-13-06 and ODGC7 AND HAVE NOT BEEN VERIFIED.

LONG PRAIRIE & PLEASANT VALLEY
SEISMIC RESILIENCE EVALUATION

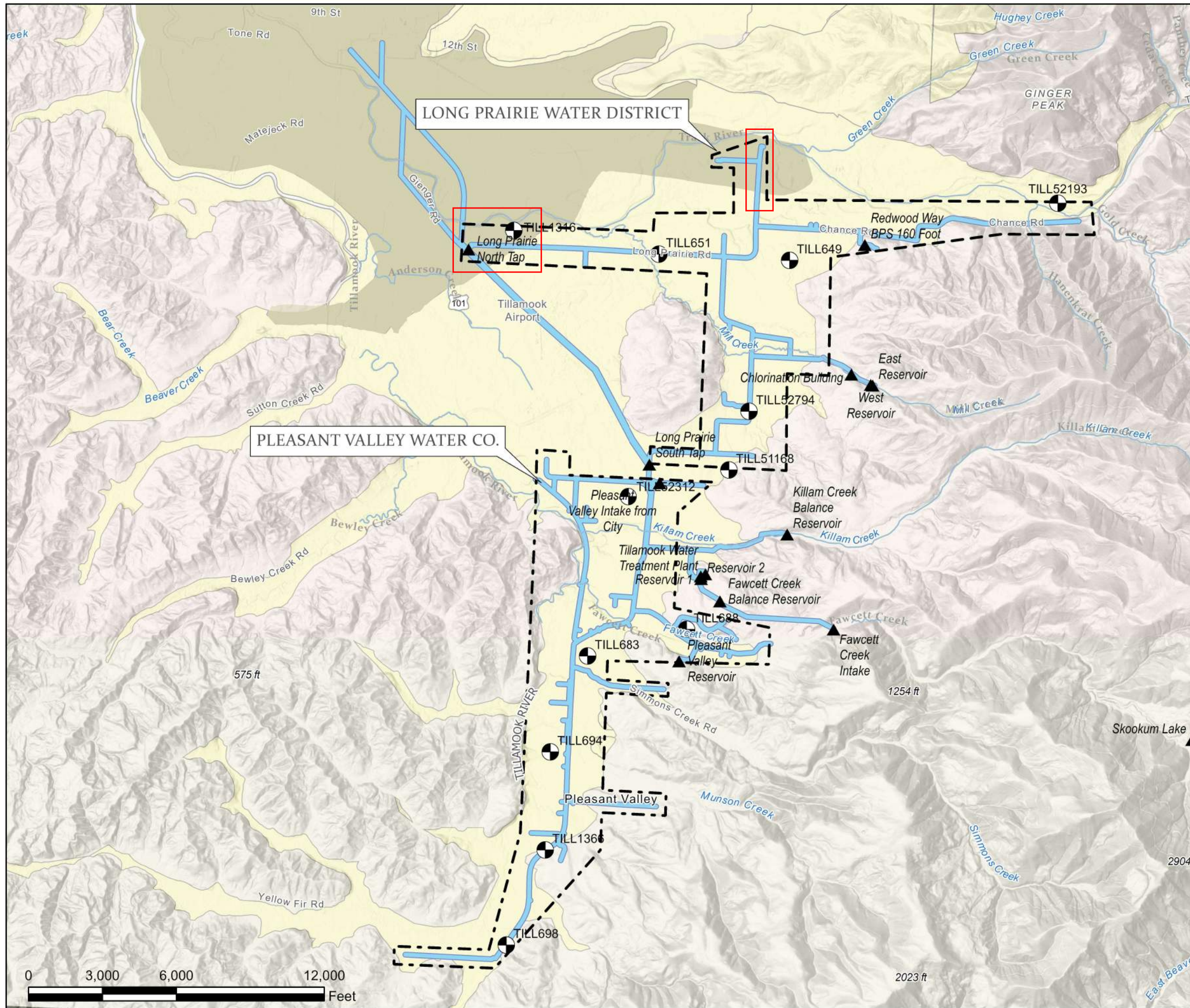
PEAK GROUND VELOCITY MAP

Project Location

N

AUG 2024

FIGURE 2



Legend

Backbone Waterlines

ORWD Well Reports

Liquefaction Settlement (in)

Less than 1 in.

Up to 2 in.

Up to 4 in.

NOTES:
SCALE: 1 inch equals 4,000 feet

DATA SHOWN ARE BASED ON DATA FROM DOGAMI Open File Report O-13-06 and ODGC7 AND HAVE NOT BEEN VERIFIED.

LONG PRAIRIE & PLEASANT VALLEY
SEISMIC RESILIENCE EVALUATION

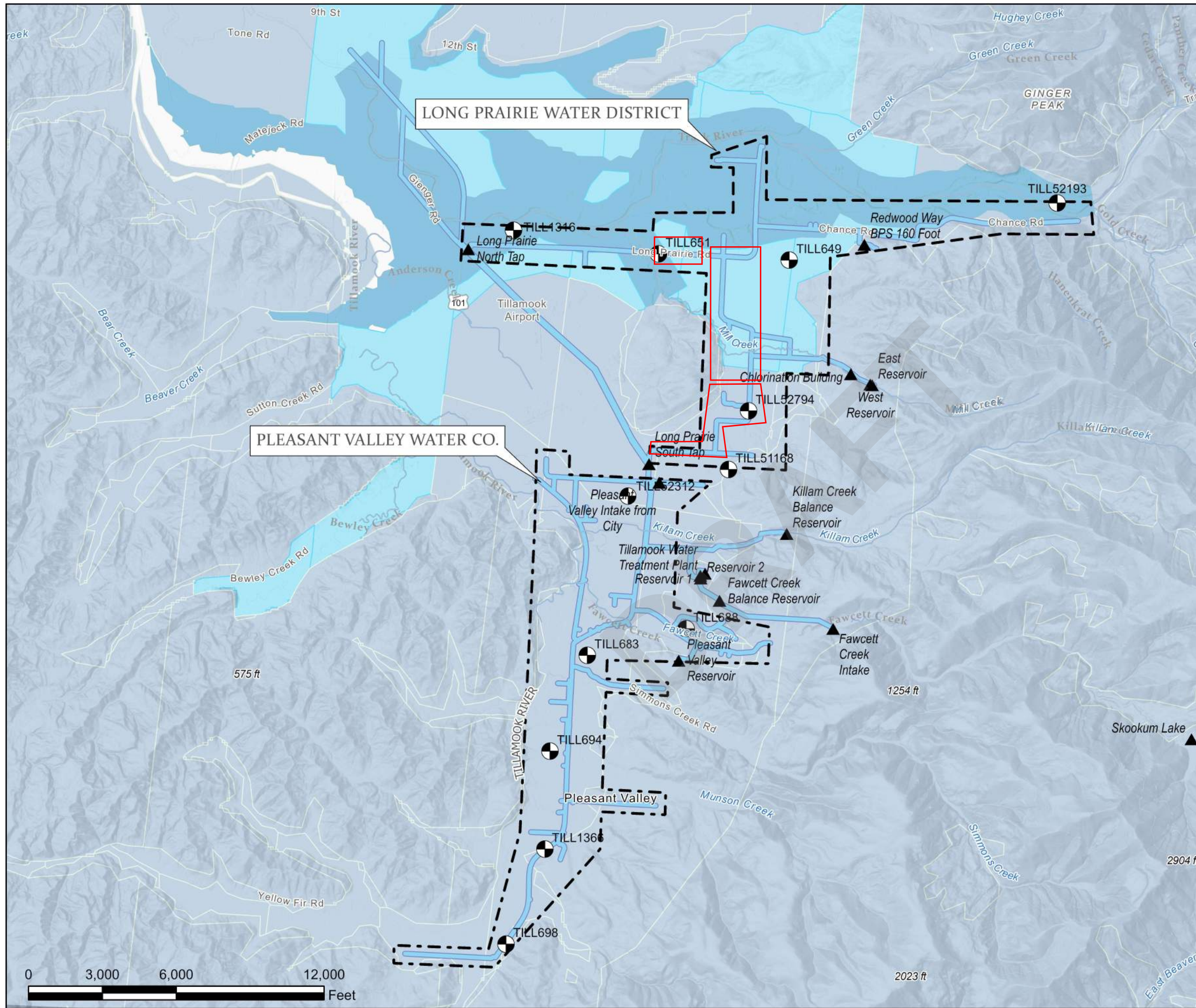
SEISMIC SETTLEMENT MAP

Project Location

N

AUG 2024

FIGURE 3



Legend

- Backbone Waterlines
- ORWD Well Reports

Seismic Lateral Spread (in)

- No PGD
- Up to 60 in (5 ft)
- Up to 120 in (10 ft)

NOTES:
SCALE: 1 inch equals 4,000 feet

DATA SHOWN ARE BASED ON DATA FROM DOGAMI Open File Report O-13-06 and ODGC7 AND HAVE NOT BEEN VERIFIED.

LONG PRAIRIE & PLEASANT VALLEY
SEISMIC RESILIENCE EVALUATION

SEISMIC LATERAL SPREADING PGD MAP

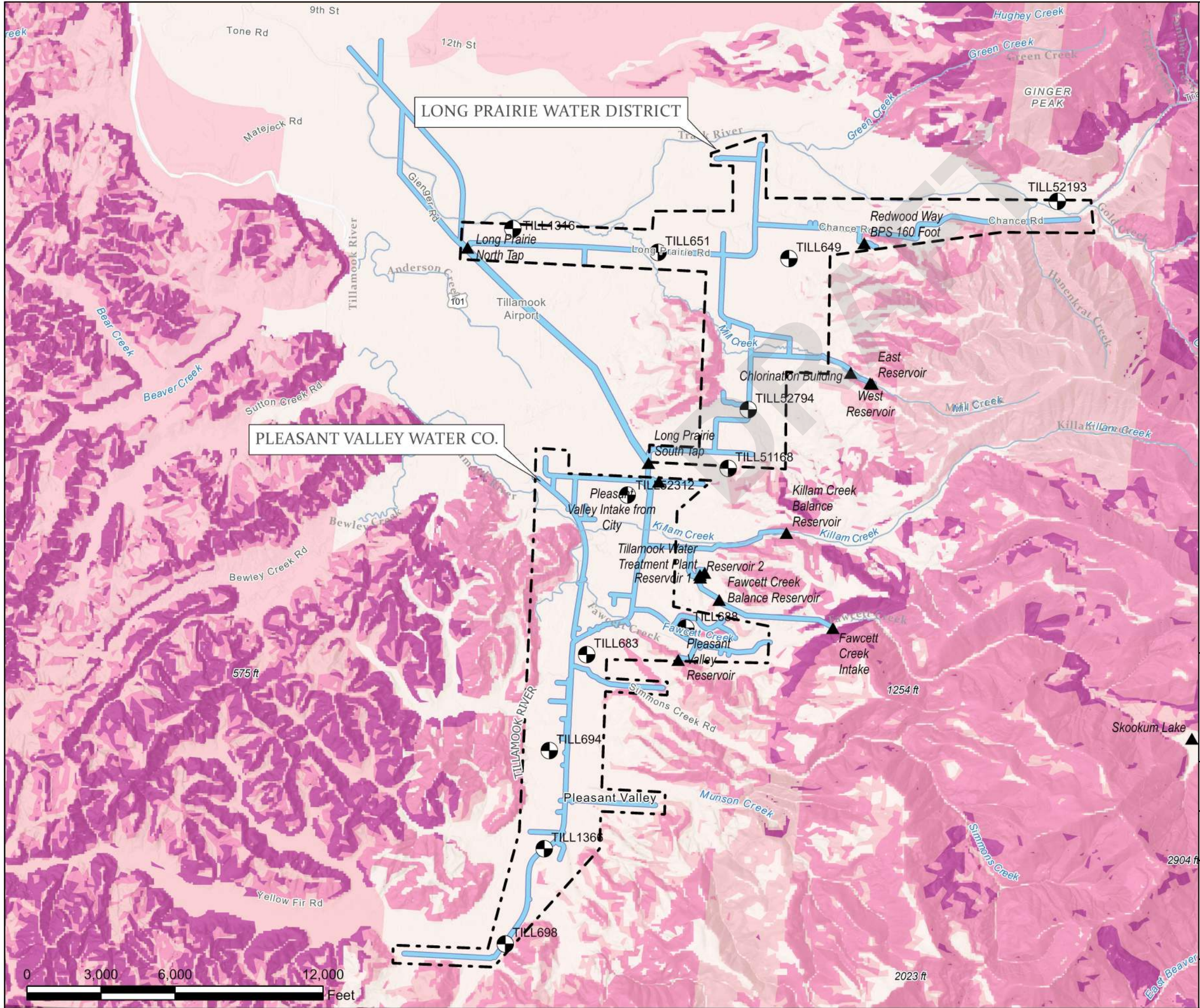
Project Location

AUG 2024

DELVE
underground

AUG 2024

FIGURE 4



Legend

Backbone Waterlines

ORWD Well Reports

Seismic Landslide PGD (in)

- No PGD
- Up to 60 in (5 ft)
- Up to 120 in (10 ft)
- Up to 480 in (40 ft)

NOTES:
SCALE: 1 inch equals 4,000 feet

DATA SHOWN ARE BASED ON DATA FROM DOGAMI Open File Report O-13-06 and ODGC7 AND HAVE NOT BEEN VERIFIED.

LONG PRAIRIE & PLEASANT VALLEY
SEISMIC RESILIENCE EVALUATION

SEISMIC LANDSLIDE PGD MAP

Project Location

N

AUG 2024

DELVE
underground

AUG 2024

FIGURE 5