Final Report

Water System Master Plan

Prepared for

City of Dundee Oregon

February 2016

ch2m

2020 SW 4th Avenue Suite 300
Portland, Oregon 97201-4973

in association with

GSI Water Solutions, Inc.

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Acronyms and Abbreviations

ADD	average day demand
AWWA	American Water Works Association
CIP	capital improvement plan
CRBG	Columbia River Basalt Group Formation
EDU	equivalent dwelling unit
EFU	Exclusive Farm Use
gpcd	gallons per capita per day
gpd	gallons per day
gpm	gallons per minute
HGL	hydraulic grade line
hp	horsepower
MDD	maximum daily demand
MG	million gallons
mgd	million gallons per day
msl	mean sea level
OAR	Oregon Administrative Rules
PHD	Peak Hour Demand
PRC	Population Research Center at Portland State University
PRV	pressure reducing valve
psi	pounds per square inch
PVC	polyvinyl chloride
PW	pumping well
SCADA	supervisory control and data acquisition
UGB	urban growth boundary

Executive Summary

Authorization

In July 2014, the City of Dundee authorized CH2M to prepare this Water System Master Plan.

Purpose

The purpose of this study is to perform a comprehensive analysis of the City of Dundee's water supply and distribution system, to identify system deficiencies, to determine future water distribution system supply requirements, and to recommend water system facility improvements that correct existing deficiencies and that provide for future system expansion.

Service Area

The study area for this plan is the existing City limits which include the City's entire urban growth boundary (UGB) area. The City of Dundee UGB, as defined by the City's comprehensive plan (CH2M, 1977), encompasses approximately 747 acres, while the City limits include approximately 900 acres. Approximately 153 acres of land inside the City limits is outside of the UGB and is designated as exclusive farm use (EFU). The City water system currently provides service to the area within the UGB as well as to 60 service connections outside of this boundary. The City's service area includes the Riverside District for which a master plan was developed in June 2011 (Angelo Planning Group, et al.). The Riverside District includes 360 acres in the southeasterly portion of the City inside the UGB.

Planning Period

The planning period for this master plan is 20 years, from 2015 through 2035. With the adoption of the Riverside District Master Plan, the City will have the potential to develop a total of 970 dwelling units at build-out on 273 acres within the Riverside District. The population projections provided by the Population Research Center, College of Urban and Public Affairs, Portland State University, include a 2035 City population of 4,970, which would mean development of 650 of the potential 970 residential units in the Riverside District. Additional population in the existing service area is projected to be minimal.

Water Supply Sources

The City of Dundee water service area currently serves a population of approximately 3,335 people and provides potable water to residential, commercial, and industrial services. The City is supplied water from ten groundwater wells located at five sites. Two of the wells are leased, the rest are owned by the City. The City owns an additional well, referred to as Well 4, which is inactive. The wells have a firm production capacity of approximately 527 gallons per minute (gpm) or 0.76 million gallons per day (mgd) under normal operating conditions, as shown in Table ES-1.

TABLE ES-1
Groundwater Well Pump Depth and Production Summary

Well[a]	Name	Horsepower	Total Well Depth (feet)	Approximate Existing Production Capacity (gpm)
1	Spring Well Site	15	103	53
2	Spring Well Site	10	200	54
3	Deep Well Site	7.5	471	35
5	Dundee Hills – Leased Well	7.5	160	100
6	Dundee Hills – Leased Well	7.5	160	100
7	Spring Well Site	10	215	80
8	Spring Well Site	10	304	130
9	First Street Well Site	20	385	55
10	Alder Street Well Site	10	482	50
13	Spring Well Site	20	586	250
Total Supply Source Production Capacity[b]				**907 (1.30 mgd)**
Total Firm Supply Source Production Capacity[c]				**527 (0.76 mgd)**

[a]Well 4 is not listed because it is no longer operational.

[b]Total supply source production capacity is the sum of the production capacities of all operational well pumps.

[c]Total firm supply source production capacity is the total pumping capacity of all operational well pumps with the largest well out of service. The total firm capacity shown is the sum of all operational wells with Well 8 out of service. Well 13 is a seasonal supply and is not included as firm capacity, pending demonstration of yield.

Pressure Zones

The City of Dundee's water service area is currently divided into three pressure zones. Pressure zones are typically defined by ground topography and designated by overflow elevations of water storage facilities, pump station discharge pressures, or outlet hydraulic grades of pressure reducing facilities serving the zone. A fourth pressure zone is recommended to serve the Riverside District.

Storage Reservoirs and Pump Stations

The City of Dundee's water system contains three storage reservoirs, with a total combined storage capacity of approximately 1.0 MG. The 2003 Water System Master Plan identified a deficit of storage in the system; however, because of additional storage being constructed and lower per capita water use by the City's customers, the City now has a relatively small storage deficit. As the Riverside District gets developed there will eventually be a need for 1.0 MG of additional storage to serve that area, increasing equalizing, standby, and fire storage and erasing the small existing deficit.

Distribution System

The City's water distribution system is composed of pipe made of various materials in sizes up to 12 inches in diameter. The total length of piping in the service area is approximately 117,482 feet or about 22.3 miles. The pipe materials include cast iron, ductile iron, galvanized iron, asbestos cement, steel, copper, and polyvinyl chloride (PVC). The largest portion of pipe in the system (83 percent) is ductile iron, cast iron or steel. Minimum pipe size of 8-inch for the distribution system is recommended, except for 6-inch pipes on dead-end pipes, such as in cul-de-sacs. The capital improvement plan includes planned replacements for steel, galvanized and asbestos cement pipe, as well as hydraulic improvements to increase fire flows.

Population Estimates

The City has 1,082 metered connections as follows: 1,011 residential connections, 6 multi-family connections, 48 commercial connections, 10 wineries, and 9 “other” connections that largely include public agencies. This equates to approximately 1,232 existing equivalent dwelling units (EDUs). Forecasted population estimates are presented in Table ES-2. The 2035 population forecast represents approximately 1,895 EDUs.

TABLE ES-2
Population History and Forecast Summary

Year	Population Inside City Limits	Population Outside City Limits	Population Total
2011	3,175	172	3,347
2012	3,175	157	3,332
2013	3,170	157	3,327
2014	3,180	150	3,330
2015	3,185	150	3,335
2020	3,427	153	3,579
2025	3,960	157	4,117
2030	4,468	162	4,630
2035	4,970	165	5,135

Water Demand Estimates

Water demand estimates were developed from a review of historical water consumption records and data provided by the City and from regional population forecasts specifically generated to reflect the City’s water service area, summarized in Table ES-3.

TABLE ES-3
Population Forecasts and Estimated Water Demand Summary

		Water Demand (mgd)	
Year	Population*	Average Day Demand	Maximum Day Demand
2015	3,335	0.358	0.692
2020	3,579	0.384	0.742
2025	4,117	0.442	0.854
2030	4,630	0.497	0.960
2035	5,135	0.551	1.065

*Includes 150-165 people outside of City Limits.

Because the per capita water use in the City on peak days has declined over the past decade, the average per capita use for the most recent 4 years was used to develop demand projections in Table ES-3. The change in per capita use is shown in Figure ES-1.

Water demand projections were further developed for each pressure zone based on the area served, population projections, and water use data. Table ES-4 presents a summary of these demands out to 2035.

TABLE ES-4
Pressure Zone Water Demand Summary in Year 2035

		Water Demand (mgd)		
Pressure Zone	**Population**	**Average Day Demand**	**Maximum Day Demand**	**Peak Hour Demand**
Upper	124	0.013	0.026	0.047
Intermediate	549	0.059	0.114	0.207
Lower	2,845	0.306	0.590	1.075
Riverside District*	1,617	0.173	0.335	0.610
All Zones	**5,135**	**0.551**	**1.065**	**1.939**

* Service to an estimated 300 connections will be transferred from the Lower Pressure Zone to the Riverside District Zone; the values shown indicate populations without the transfer.

Since Well 13 is expected to come on line in 2016 and will be available to meet peak summer demands at a flow rate of 250 gpm, a new water supply will be needed by 2025 to meet the maximum day demand projections.

Water Source Options Evaluated

An evaluation of water supply options was conducted as shown in Table ES-5. The evaluation was completed by the project team with input from the City Council. The recommended path was to prepare for construction of a surface water intake and water treatment plant on the Willamette River, but to continue to pursue a lower cost river bank filtration option over the next few years.

TABLE ES-5
City of Dundee Water Source Options

Category	Option Number	Source Option	Description
Wells	1	Develop Test Well	New 250 gpm seasonal well
	2	Additional Spring Area Wells	Additional 250 gpm seasonal well
	3	Additional In-town Wells	50 gpm well (conservative estimate)
	4	Vineyard Well North of Town (formerly Black Family)	50 gpm well (conservative estimate)
	5	Reactivate Well 4	Cleaning and new pump in existing well
	6	Replace Well 4	New 45 gpm well
Riverbank/ Surface Water	7	Riverbank Filtration Well	Riverbank filtration well closer to the river
	8	Ranney Collector Well - Dundee Side of River	1,750 gpm collector well
	9	Ranney Collector Well - Ash Island	1,750 gpm collector well
	10	Ranney Collector Well - Marion Co. Side of River	1,750 gpm collector well
	11	Surface Water Intake	1,750 gpm intake and water treatment plant
Regional	12	Newberg	Pipeline from existing Newberg plant to new ground level reservoir, public authority rate
	13	McMinnville W&L/Lafayette /Dayton/Carlton	Piping from City of Dayton, 2 times Newberg public authority rate
Reuse in Riverside District	14	Reuse for Large Irrigation Users	Storage and pumping at WWTP, distribution to City's largest water users for irrigation only
	15	Reuse for Parks Irrigation in Riverside District	Storage and pumping at WWTP, distribution to 3 parks in Riverside District
	16	Reuse for Parks and Residential Irrigation	Storage and pumping at WWTP, distribution to new residential development and 3 parks in Riverside District
Other	17	Aquifer Storage and Recovery	Must be done in conjunction with additional source of water – used Newberg for evaluation
	18	Conservation Program	Promoting conservation among customers
	19	Leak Recovery	Annual cost for leak detection and repair

WWTP = wastewater treatment plant.

System Improvements

A system analysis was performed on all elements of the City's water system, and served as the basis for improvement recommendations. Recommended capital improvements are summarized in Table ES-6, Capital Improvement Plan (CIP). The table indicates project priorities for the 20-year planning period, with projected schedules for completing each facility or improvement. The total project cost has been estimated for each improvement project. Project costs include construction costs and an allowance for administrative, engineering and other project related costs. Table ES-6 also shows the portion of each project that is eligible for SDC improvement fee calculations. A portion of the SDC calculation will be based on these improvement costs. Figure ES-2 shows the locations of the improvement projects.

Study Recommendations

It is recommended that the City take the following actions:

1. Formally adopt this plan as the City of Dundee's Water System Master Plan for the water service area
2. Adopt the recommended capital improvements described in Section 6 and specifically listed in Table ES-6 as the CIP for the water service area
3. Develop and adopt a financing plan to implement the capital improvements recommended in this study
4. Update the City's current system development charges (SDCs) to reflect the system improvements recommended in this plan and to collect the value of the capacity of existing system available to meet future needs
5. Adopt a water rate increase plan to fund needed system improvements
6. Review and update this plan within 5 to 7 years to accommodate changed or new conditions

TABLE ES-6
Recommended Improvements

	Project	Pipe Diameter (inches)	Length (feet)	Project Type	Streets	2015 Cost	Year Scheduled	Percent Expansion	Percent Existing	Growth CIP	Existing Customer CIP
Distribution Piping Projects											
DS-1A	Parkway Loop - Segment A	12	2,365	Parkway Extension	From SE 11th St. and Highway 99W to SE Parks Dr. and along SE Parks Dr. to SE Edwards Dr.	$682,000	2023, 2027, 2029	100%	0%	$719,000	$0
DS-1B	Parkway Loop - Segment B	8	695	Parkway Extension	Parallel existing 8-inch pipe along SE Edwards Dr. between SE Parks Dr. and wastewater treatment plant entrance	$134,000	2031	100%	0%	$125,000	$0
DS-1C	Parkway Loop - Segment C	12	3,428	Parkway Extension	Along planned alignment for Parkway Collector	$988,000	2022, 2031	100%	0%	$1,245,000	$0
DS-2	Viewmont - 10 inch	10	1,692	Fire Flow	Along NW Viewmont Dr. between NW Walnut St. and the reservoir	$407,000	2033	0%	100%	$0	$356,000
DS-3A	Reservoir Fill from New Source	12	1,535	Riverside Expansion	From SE 8th St. and SE Edwards along SE 8th St. to new reservoir site; also replaces some steel	$443,000	2031	100%	0%	$373,000	$0
DS-3B	Reservoir Discharge to Intermediate	10	879	Intermediate Zone Supply	Along SE 7th St. between Highway 99W and SE Maple St.	$211,000	2031	0%	100%	$0	$335,000
DS-4	9th Street - 8 inch	8	1,322	Fire Flow	Along SW 9th St. between Highway 99W and SW Alder St.	$254,000	2017, 2018	0%	100%	$0	$236,000
DS-5	99W - 10 inch	10	1316	Fire Flow	Along Highway 99W at multiple locations, developer installed	$316,000	2018, 2020, 2022, 2024	0%	100%	$0	$0
DS-6	Walnut - 8 inch	8	241	Fire Flow	Along SW Walnut St. between SW 1st St. and SW 2nd St.	$47,000	2035	0%	100%	$0	$47,000
DS-7	Hemlock - 8 inch	8	619	Fire Flow	Along SW Hemlock St between SW 1st St. and SW 3rd St.	$119,000	2035	0%	100%	$0	$111,000
DS-8	Elm - 8 inch	8	344	Fire Flow	Along SE Elm St. between SE 10th St. and SE 11th St.	$67,000	2019	0%	100%	$0	$64,000
DS-9	Worden Hill - 12 inch	12	3,970	Asbestos Cement Replacement	Replace remainder of 8-inch supply line from Spring Wells with 12-inch along NE Fairview Dr. and NE Worden Hill Rd.	$1,144,000	2026, 2028, 2030, 2032	0%	100%	$0	$954,000
DS-10A	Canyon Drive - 6 inch	6	387	Asbestos Cement Replacement	Along NW Canyon Dr. to SW 1st St.; along SW 1st St. between NW Alder St. and NW Walnut St.	$56,000	2035	0%	100%	$0	$58,000
DS-10B	1st Street - 8 inch	8	568	Asbestos Cement Replacement	Along NW Canyon Dr. to SW 1st St.; along SW 1st St. between NW Alder St. and NW Walnut St.	$110,000	2035	0%	100%	$0	$103,000
DS-11	Alder Terrace Hydrant	8	335	Asbestos Cement Replacement	From SW Alder St. through Alder Terrace Mobile Estates (does not run along any road)	$65,000	2035	0%	100%	$0	$62,000
DS-12	5th Street - 12 inch	12	688	Fire Flow	6-inch upsize to 12-inch along SW 5th St. across Dundee School/Billick Park frontage	$199,000	2020	0%	100%	$0	$168,000
DS-13	Alder Street - 8 inch	8	636	Steel Replacement	4-inch to 8-inch along NW Alder St. between NW Viewmont Dr. and SW 1st St.	$123,000	2025	0%	100%	$0	$116,000
DS-14a	Dogwood - 8 inch	8	917	Steel Replacement	6-inch to 8-inch along NW Dogwood Dr. between SW 1st St. and NW Viewmont Dr. and along NW Viewmont Dr. between NW Dogwood Dr. and NW Laurel St.	$177,000	2016	0%	100%	$0	$277,000
DS-14b	Viewmont - 8 inch	8	596	Steel Replacement	6-inch to 8-inch along NW Viewmont Dr. between NW Alder St. and NW Dogwood Dr.	$115,000	2021	0%	100%	0%	$115,000
DS-15	Locust - 8 inch	8	1,021	Steel Replacement	4-inch to 8-inch along SE Locust St. between SE 8th St. and SE 10th St.	$197,000	2016	0%	100%	$0	$125,000
DS-16	99W - 10 inch	10	604	Steel Replacement	4-inch to 10-inch along Highway 99 near SW 3rd St.	$145,000	2016	0%	100%	$0	$0
DS-17	99W - 10 inch	10	1,771	Steel Replacement	Along Highway 99 between SW 7th St. and SW 12th St.	$426,000	2016	0%	100%	$0	$0
DS-18	Walnut - 8 inch	8	683	Service Extension	Along NW Walnut St. between NW Viewmont Dr. and SW 1st St.	$132,000	2022	0%	100%	$0	$123,000
DS-19	Red Hill Line Extension	6	486	Service Extension	Extension along SW Red Hills Dr. to move service from PVC line on steep slope	$70,000	2018	0%	100%	$0	$74,000
DS-20	Red Hills Rd - 12 inch	12	1,752	Fire Flow	Replacement of 8-inch CIP from Asbestos Cement Replacement to Viewmont Drive Replacement	$505,000	2034	0%	100%	$0	$423,000
DS-21	Small Water Line Replacement	Varies	Varies	Annual Program	Replacement of small water lines ($30,000 every other year)	$300,000	Biennial	0%	100%	$0	$300,000

TABLE ES-6
Recommended Improvements

	Project	Pipe Diameter (inches)	Length (feet)	Project Type	Streets	2015 Cost	Year Scheduled	Percent Expansion	Percent Existing	Growth CIP	Existing Customer CIP
DS-22	Leak Reduction	Varies	Varies	Annual Program	Leak detection in distribution system ($10,000 every other year)	$100,000	Biennial	0%	100%	$0	$100,000
New Source Development Projects										**$0**	**$0**
	Project		**Capacity (gpm)**		**Description**						
SO-1	Source Evaluation		NA		Test Drilling for Ranney Well/Riverbank Filtration	$100,000	2018	100%	0%	$100,000	$0
SO-2	Source Evaluation		NA		Test Drilling for Ranney Well/Riverbank Filtration	$100,000	2019	100%	0%	$100,000	$0
SO-3	Source Evaluation		NA		Test Drilling for Ranney Well/Riverbank Filtration	$100,000	2020	100%	0%	$100,000	$0
SO-4	Source Development		730		Willamette River Intake, Water Treatment Plant (1 mgd), Asbestos Cement Pipe Replacement	$5,543,000	2025	40%	60%	$2,217,200	$3,325,800
New Storage and Booster Pump Projects											
	Project		**Capacity (gpm)**		**Description**						
ST-1	Tank/Booster Pump		2,500		New Ground Level Reservoir (1.0 MG) and Booster Pump for New Riverside District Zone	$1,500,000	2017	100%	0%	$1,500,000	$0
ST-2	Pressure Reducing Valve Stations (3)		2,500		Two New PRV Stations (one additional PRV is located in the Booster Pump Station)	$180,000	2017	100%	0%	$180,000	$0
Recycled Water Projects											
	Project	**Capacity (gpm)**		**Volume (gallons)**	**Description**						
RE-1	Reservoir and Pump Station	250		125,000	New Steel Reservoir and Pump Station for Recycled Water Supply	$800,000	2020	100%	0%	$800,000	$0

NA = not applicable.

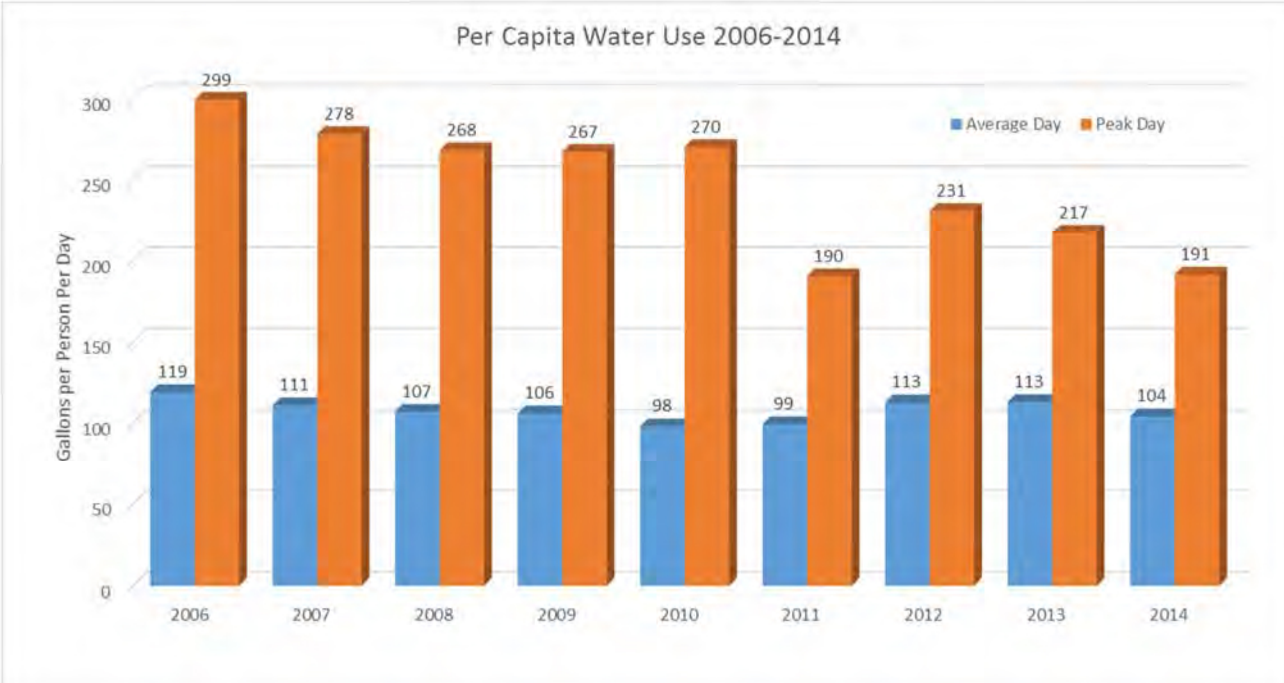


FIGURE ES-1
Per Capita Water Use 2006–2014

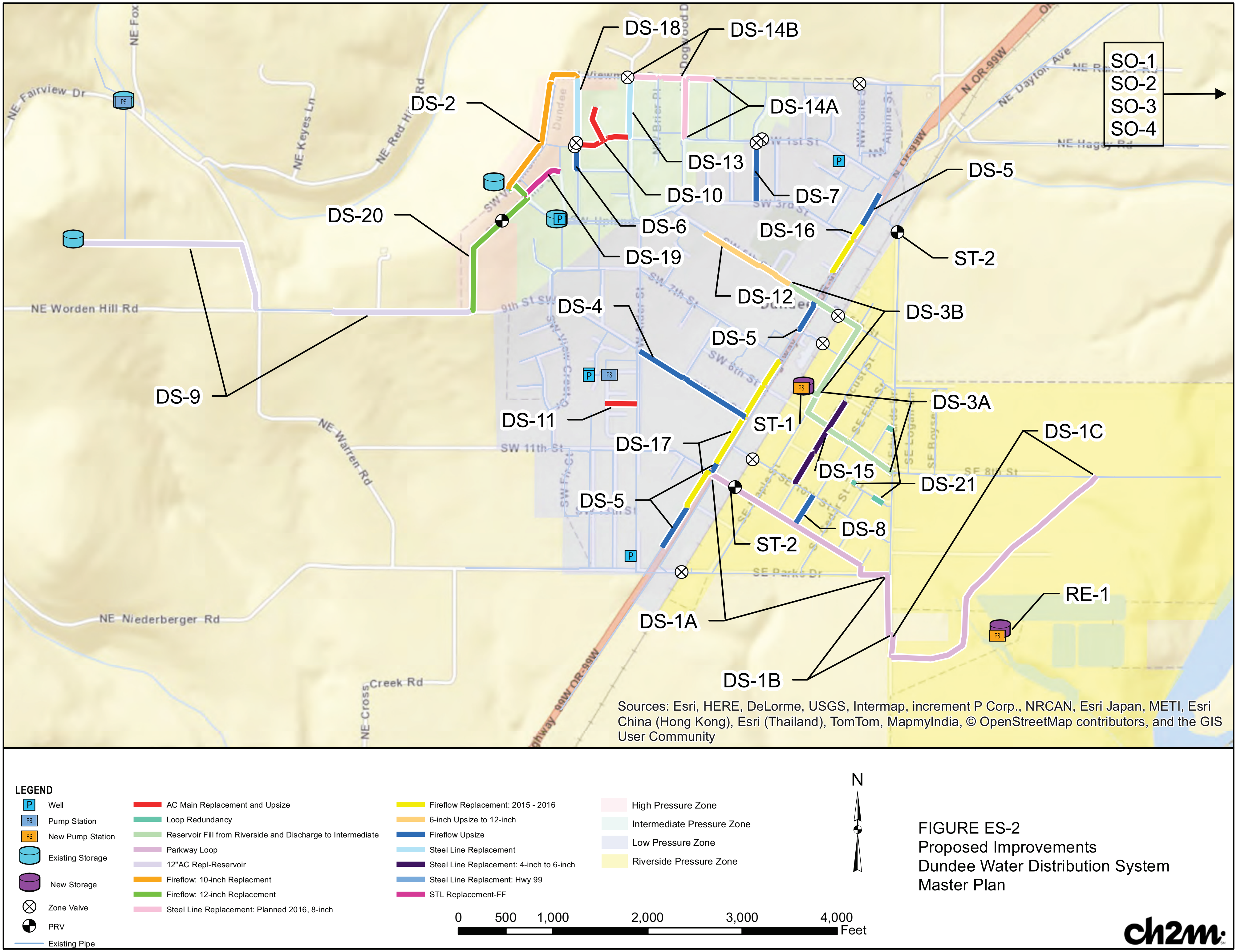


FIGURE ES-2
Proposed Improvements
Dundee Water Distribution System
Master Plan

SECTION 1

Introduction

1.1 Authorization

In July 2014, the City of Dundee authorized CH2M to prepare this water system master plan.

1.2 Purpose

The purpose of this master plan is to perform a comprehensive analysis of the City of Dundee's water supply and distribution system, to identify system deficiencies, to determine future water distribution system supply requirements, and to recommend water system facility improvements that correct existing deficiencies and provide for future system expansion. Since completion of the City's 2003 Water System Master Plan, the City has experienced accelerated growth within the community and witnessed the development of increasingly stringent regulatory requirements related to water system management. This plan provides guidance for sound stewardship of the City's water system over the next 20 years and beyond.

1.3 Compliance

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

1.4 Scope

The scope of work for development of this master plan includes the following work tasks:

- **Gather Data**—Compile and review existing maps, drawings, data, plans, studies, and reports related to all aspects of water system operations and functions.
- **Develop Inventory of Existing Facilities**—Prepare of an inventory of existing water system facilities including groundwater well supply, transmission and distribution piping, storage reservoirs, pumping stations, and telemetry and control systems.
- **Develop Water Demand Estimates**—Review information related to service area, land use, population distribution, and historical water demands. Develop population projections and water demand estimates for existing and undeveloped areas within the City's water service area.
- **Establish System Analysis and Planning Criteria**—Develop system performance criteria for distribution and transmission systems and storage, pumping, and supply source facilities. Develop analysis and planning criteria for pressure zone service pressure limits, for emergency fire suppression water needs, and for water quality goals as well as for other system performance parameters.
- **Develop and Calibrate Water System Hydraulic Model**—Prepare a computerized water distribution system hydraulic network analysis model using InfoWater hydraulic modeling software.
- **Perform Water System Analysis**—Perform a detailed analysis of the City's source, supply, transmission, and distribution systems; analyze storage and pumping capacity needs; and evaluate pressure zone limits.
- **Evaluate Unaccounted-for Water**—Evaluate unaccounted-for water based on historical City water sales, production, and purchase records.
- **Develop Recommended System Improvements**—Develop recommended water system facility improvements that correct existing deficiencies and that provide for future system expansion.

- **Prepare Capital Improvement Plan**—Develop estimated project costs for recommended improvements, recommended project sequencing, and the development of a capital improvement plan (CIP).
- **Prepare Water System Master Plan Document and System Plan Map**—Prepare a water system master plan that documents and describes the planning and analysis work efforts, including mapping and graphics identifying all existing and proposed water system facilities.
- **Calculate System Development Charges**—Calculate system development charges for growth-related CIP elements. This evaluation is presented in a separate document titled, *City of Dundee System Development Charge Methodology and Fees* (CH2M, 2016).

SECTION 2

Existing Water System

2.1 Introduction

This section describes the City of Dundee's water service area and water system facilities. Included in this section is a discussion of existing supply and transmission facilities, groundwater wells, pressure zones, storage and pumping facilities, distribution system piping, and telemetry and supervisory control systems.

2.2 Background and Study Area

The City of Dundee water service area currently serves a population of approximately 3,335 people and provides potable water to residential, commercial, and industrial services. The City is supplied water from ten groundwater wells located at five sites. Water from these wells is either pumped into water storage reservoirs, pumped into the water distribution system by onsite booster pumps, or pumped directly into the distribution system by the well pumps. The study area for this water system master plan is defined by the City's existing urban City limits which include the City's entire urban growth boundary (UGB) and land zoned Exclusive Farm Use (EFU), which is largely undevelopable. The study area is illustrated in Figure 2-1 (figures provided at the end of each section).

The City of Dundee's existing water system includes water storage reservoirs, distribution mains, pump stations, groundwater wells, and associated appurtenances such as control valves, isolation valves, pressure reducing valves (PRVs), meters, and fire hydrants. The City's water distribution system shown in Figure 2-2 is divided into three pressure zones. The zones are supplied by a combination of storage reservoirs, groundwater wells, and pumping facilities. Previously, a fourth zone was supplied through a PRV, but the services were transferred to the high pressure zone between 2013 and 2014, eliminating the need for the fourth zone.

Ground elevations for customer service connections within the City's water service area range from approximately 160 feet to 540 feet above mean sea level (msl). Figure 2-3 presents a hydraulic profile of the City's major water system facilities.

2.3 Supply Sources

The City is supplied water from ten groundwater wells located in and around the City that pump water from the Columbia River Basalt Group Formation (CRBG) aquifers. All but two of these wells are owned by the City. Use of the two wells not owned by the City is arranged through a lease agreement with the well owner. The City owns an additional well (Well 4) that is no longer operational. The ten wells currently in use have a total supply source production capacity of 907 gallons per minute (gpm) or 1.30 million gallons per day (mgd) and a total firm supply source production capacity of 527 gpm or 0.76 mgd under normal operating conditions.

Water from each well is pumped to a storage reservoir or into the water distribution system. All of the wells are equipped with submersible pumps and provided with liquid chlorine injection for disinfection. The groundwater wells are listed in Table 2-1 with pump depths and production summaries. The wells are briefly described below, followed by discussion about the City's surface water sources and associated water rights that are currently not being used.

TABLE 2-1
Groundwater Well Pump Depth and Production Summary

Well[a]	Name	Horsepower	Total Well Depth (feet)	Approximate Existing Production Capacity (gpm)
1	Spring Well Site	15	103	53
2	Spring Well Site	10	200	54
3	Deep Well Site	7.5	471	35
5	Dundee Hills – Leased Well	7.5	160	100
6	Dundee Hills – Leased Well	7.5	160	100
7	Spring Well Site	10	215	80
8	Spring Well Site	10	304	130
9	First Street Well Site	20	385	55
10	Alder Street Well Site	10	482	50
13	Spring Well Site	20	586	250
Total Supply Source Production Capacity[b]				**907 (1.30 mgd)**
Total Firm Supply Source Production Capacity[c]				**527 (0.76 mgd)**

[a]Well 4 is not listed because it is no longer operational.

[b]Total supply source production capacity is the sum of the production capacities of all operational well pumps.

[c]Total firm supply source production capacity is the total pumping capacity of all operational well pumps with the largest well out of service. The total firm capacity shown is the sum of all operational wells with Well 8 out of service. Well 13 is a seasonal supply and is not included as firm capacity, pending demonstration of yield.

2.3.1 Wells 1, 2, 7, and 8

The City operates four wells and a pumping facility on a parcel of land located approximately 1.25 miles west of the City limits. These are Wells 1, 2, 7, and 8, and are collectively referred to as the Spring Wells. Each well pumps water to a 6,000-gallon clearwell where it is chlorinated and then pumped by the Clearwell Booster Pump Station through a 6-inch diameter pipe to the Upper Zone 0.2-million-gallon (MG) Reservoir. The Clearwell Booster Pump Station is described in Section 2.11.1. The Spring Wells have a combined production capacity of approximately 317 gpm. Brief descriptions follow:

- Well 1 is capable of producing approximately 53 gpm of water. The well was constructed in 1971, has an 8-inch-diameter casing, a depth of approximately 103 feet, and a wellhead elevation of approximately 440 feet.
- Well 2 is capable of producing approximately 54 gpm of water. The well was constructed in 1973, has an 8-inch-diameter casing, a depth of approximately 200 feet, and a wellhead elevation of approximately 429 feet.
- Well 7 is capable of producing approximately 80 gpm of water. The well was constructed in 1988, has an 8-inch-diameter casing, a depth of approximately 215 feet, and a wellhead elevation of approximately 451 feet.
- Well 8 is capable of producing approximately 130 gpm of water. The well was constructed in 1991, has an 8-inch-diameter casing, a depth of approximately 304 feet, and a wellhead elevation of approximately 460 feet.

2.3.2 Well 3

Well 3, also referred to as the Deep Well, is located adjacent to the Lower Zone 0.4 MG Reservoir, near the intersection of SW Upland Drive and SW Red Hills Loop. This well has a current production capacity of approximately 35 gpm, a 16-inch-diameter casing, a depth of approximately 471 feet, and a wellhead elevation of approximately 400 feet. Water from Well 3 is chlorinated at the wellhead and pumped directly into the Lower Zone 0.4 MG Reservoir. The well was originally constructed in 1956 to a depth of approximately 385 feet and was increased to a depth of approximately 471 feet in 1960. This well had a production capacity of approximately 65 gpm in 1980, approximately 41 gpm in 1991, and a recorded production capacity of approximately 35 gpm in 2002. Because of its steadily declining water production rates, static water level data are being gathered on Well 3 to better assess the well's long-term production potential.

2.3.3 Wells 5 and 6

Wells 5 and 6, also referred to as the Dundee Hills Wells, are located on private property near the intersection of SW 9th Street and SW Alder Street and are leased by the City. The City has an agreement with the current property and well owners to purchase water from these wells during high water demand periods. Well 5 is capable of producing approximately 100 gpm of water. The well was constructed in 1977, has a 6-inch-diameter casing, a depth of approximately 160 feet, and a wellhead elevation of approximately 220 feet. Well 6 is capable of producing approximately 100 gpm of water. The well was also constructed in 1977, has a 6-inch-diameter casing, a depth of approximately 160 feet, and a wellhead elevation of approximately 220 feet. While other wells appear to have declining production yields, Wells 5 and 6 appear to be producing consistent yields over time. An air relief valve has been installed. Telemetry is used at the control panel at the Intermediate Zone Reservoir. In July 2014, the pump in Well 5 was replaced, and a conduit was added for future installation of a telemetry transducer for indicating water level.

2.3.4 Well 9

Well 9, also referred to as the First Street Well, is located in the northwest section of the City near the intersection of SW First Street and Highway 99W. This well became operational in 2002 and has an 8-inch-diameter casing, a depth of approximately 385 feet, and a wellhead elevation of approximately 220 feet. Water from Well 9 is chlorinated at the site and pumped directly into the Lower Pressure Zone at a rate of approximately 55 gpm. In 2010, a variable frequency drive and pump were installed; a data logger and flowmeter were also installed at that time.

2.3.5 Well 10

Well 10, also referred to as the Alder Street Well, is located near the southern edge of the City boundary and the intersection of SW Alder Street and SW Niederberger Road. This well became operational in 1991 and has an 8-inch-diameter casing, a depth of approximately 482 feet, and a wellhead elevation of approximately 180 feet. For approximately 9 years following well construction it produced approximately 100 gpm.

Recently, static water levels in the vicinity of Well 10 appear to be declining along with the well's production capacity. The well discharge is currently throttled such that the well currently produces approximately 50 gpm. Water from Well 10 is chlorinated at the site and pumped into the Lower Pressure Zone. In 2011, a variable frequency drive and new pump were installed; a data logger and flowmeter were also installed at that time.

2.3.6 Well 13

The City completed drilling a test well, Well 13, which became operational in 2015. This well is expected to provide a seasonal supply of 250 gpm for the summer months. The pump test was completed in 2014, and the well was subsequently outfitted with a 6-inch submersible pump and 20 horsepower (hp) motor. Approximately 1,800 feet of pipe was constructed to connect the well to the Spring Well site clearwell and Clearwell Booster Pump Station.

2.3.7 Southwest Inactive Surface Water Spring Sources

Before the development of the City's current groundwater supply wells, the City relied on surface water springs located west of the City. According to discussions with City staff, these spring sources consist of small cast-in-place concrete catchment tubs that have not been used for decades. A summary of water rights associated with these springs is presented in Appendix A.

2.4 Local Hydrogeologic Setting

The City of Dundee is located west of the Willamette River on a topographic bench at the edge of the Willamette Valley as shown in Figure 2-3. The elevation at the central part of the City is approximately 200 feet above msl. The local geology of the hills west of Dundee is dominated by a weathered basalt formation that has inspired the naming of these hills as the Red Hills of Dundee. These hills rise above the City to the west and northwest to an elevation of approximately 1,000 feet above msl. These highland areas supply the majority of recharge to streams and groundwater in the area from both rain and occasional snowmelt. Rainfall in the area is typical of the Willamette River Basin and averages over 40 inches per year. Presented below is a description of the local hydrogeologic setting as it relates to the City's groundwater supply including a discussion of the physical setting, regional geology, geologic units, and hydrogeologic conditions of the study area.

2.5 Local Geology

The general geologic units in the Dundee area are presented in Figure 2-4. These units are discussed in detail from youngest to oldest below.

2.5.1 Alluvium

This unit consists of stream channel sands, gravels, and silts deposited by the Willamette River and is annotated as "Qal" in Figure 2-4. The deposits can vary in thickness from less than 10 feet to almost 100 feet based on local water well logs. Under certain conditions this unit may contain productive zones similar to those in the City of Newberg's well field near the Willamette River.

2.5.2 Lacustrine and Fluvial Sediment

This unit, annotated as "Qs" in Figure 2-4, consists of unconsolidated to semi-consolidated clay silt sand and some gravel. The upper 30 to 40 feet of sediments, referred to locally as Willamette Silts, represent backwater sediments deposited by the Missoula Lake floods that scoured the lower Willamette Valley. The sediments present beneath the Willamette Silts may be lake sediments deposited when the Boring Lava dammed the Willamette River approximately 2.5 million years ago. This unit can be several hundred feet thick in places and typically consists of fine-grained material. Groundwater yields in the fine-grained sediments are typically less than 50 gpm.

2.5.3 Wanapum Basalt

This unit, annotated as "Tcw" in Figure 2-4, consists of a single flow of the CRBG that is approximately 15 million years old. In the Red Hills of Dundee, the Wanapum Basalt is thin and highly weathered. Under these local conditions, this unit is not typically suitable for groundwater development.

2.5.4 Grande Ronde Basalt

The Grande Ronde Basalt unit, annotated as "Tcg" in Figure 2-4, consists of a series of basalt flows that form the lower portion of the CRBG. The individual basalt flows of the Grande Ronde Basalt formation are approximately 15 million years old and can vary greatly in thickness from several feet to greater than 100 feet. The thickness of the Grande Ronde Basalt in this area may exceed 900 feet based on a review of water well logs in the area. For example, the thickness of the Grande Ronde Basalt in one local well is 952 feet. The sedimentary formation underlying the CRBG has been encountered as shallow as 500 to 600 feet below ground surface in places, indicating that the overall thickness of this unit is variable.

Groundwater in the basalt is predominantly derived from interflow zones, which represent the contact between individual basalt flows. These interflow zones are typically rubbly and porous, and thus can transmit water easily. Groundwater also is produced from fractured zones in the more massive interior flows if sufficient structural deformation and/or fracturing has occurred. Locally, in the Red Hills of Dundee, a very thick layer of Wanapum basalt, which can be several hundred feet in places, caps the Grande Ronde basalt formation. The clay cap of the Wanapum basalt represents weathered basalt that is important from a hydrogeologic perspective because precipitation does not easily percolate through the clays, thus limiting recharge to the underlying Grande Ronde basalt formation.

2.5.5 Marine Sediments

This unit, annotated as “Tsd” in Figure 2-4, consists of marine sediments that underlie the Grande Ronde Basalts. Groundwater present in the marine sediments commonly is saline and is typically not suitable for drinking water purposes.

2.6 Geologic Structures

Geologic structures have an important influence on groundwater flow in the basalts. Faults and folds influence groundwater flow by promoting or impeding both lateral and vertical groundwater flow. The hills west and northwest of Dundee are structurally controlled by northeast-trending normal faults. Existing City wells and yields are illustrated in Figure 2-5. A geologic cross section perpendicular to the structural geologic composition in the area is shown in Figure 2-6 and the location of the cross section is shown in Figures 2-4 and 2-5. The vertical scale of the cross section is exaggerated to better display subsurface conditions. Faulting has down-dropped the basalts to the southeast toward the Willamette River. Additional faults are most likely present in the hills, but their locations have not been confirmed. Most importantly, the faults may create blocks of basalt that compartmentalize water-bearing zones, and can limit recharge to a particular block. Thus, pumping can result in sustained water level declines because of the limited extent of the aquifer, particularly if recharge is restricted due to a clay cap, as is the case in the Dundee area.

2.7 Hydrogeology

The principal aquifer in the area is in the Grande Ronde Basalt unit of the CRBG, and the majority of groundwater flow within the basalt is concentrated in interflow zones. The basalts can be highly productive if permeable interflows are encountered and/or if secondary fracturing has enhanced the basalt permeability. Well yields in the basalts tend to increase with the depth drilled as more interflows are penetrated. Wells yielding several hundred gpm are not uncommon in basalts where permeable interflow zones within the basalt stratigraphy are intercepted by the wells.

Groundwater also is found in certain sediments and alluvium units along the Willamette River. The potential yield of the sediments can vary greatly depending on the amount of coarse-grained material encountered and the amount of cementation of the formation and its clay content.

The primary source of recharge to the local aquifers is by rainfall and, after cooler winters, by snowmelt. In the case of the Red Hills of Dundee, a clay cap inhibits direct recharge to the basalt aquifer by precipitation. The direction of groundwater flow in the basalt is typically southeasterly from the highlands toward the river. The depth to groundwater in the basalts in the upland portion of the study area is very near the ground surface; however, most of the wells completed in the upland areas are sealed to a depth of over 100 feet below ground surface, and, thus, the static water levels measured in these wells are representative of the confined and semi-confined aquifers hosted in the basalts. A geologic fault located along the base of the Red Hills, as shown in Figure 2-6, may act as a hydrogeologic barrier between the upland and valley hydrogeologic regimes.

In general, the water supply wells completed in basalts in the Dundee area typically have yields of less than 100 gpm. Most of these lower capacity wells do not penetrate the entire basalt thickness, and, thus, the limited yields of these wells are in part due to less than full penetration of the existing water-producing zones. Other factors that may influence the relatively low yield of existing wells include faulting and compartmentalization of the basalts, and the apparent lower permeability of the shallower interflow zones in the basalts.

2.8 Water Rights Summary

Water rights associated with each of the production wells are summarized in Appendix A. Also presented in this table are all water rights held by the City, including those for abandoned and non-operational wells as well as a surface water right on the Willamette River. Included in this table is Well 4, also referred to as the "River Well," which is no longer operational. This well was originally drilled in 1972 near the Willamette River floodplain to draw water from the Willamette alluvium geological formation. During the flooding in 1996, the wellhead and pump were completely submerged and damaged. This, in addition to steadily declining water production rates, prompted the City to abandon this well.

2.9 Pressure Zones

The City of Dundee's water service area is divided into three pressure zones. Pressure zones are usually determined by ground topography and defined by overflow elevations of water storage facilities or outlet hydraulic grades of pressure reducing facilities serving the zone.

The City's three existing pressure zones are described below with information about the service areas, storage facilities, pumping facilities, and groundwater wells. A fourth pressure zone is recommended to serve the Riverside District.

2.9.1 Upper Pressure Zone

The Upper Pressure Zone serves all customers above an approximate ground elevation of 500 feet. The zone encompasses approximately 23 acres and is composed of residential land use. Service to the Upper Pressure Zone is provided by the Upper Zone 0.2 MG Reservoir; overflow elevation is 688.7 feet. The reservoir is filled by water pumped from the Spring Well site. This zone operates at an approximate HGL of 689 feet.

2.9.2 Intermediate Pressure Zone

The Intermediate Pressure Zone is the second largest pressure zone in the City and serves all customers between approximate ground elevations of 300 and 500 feet. The zone operates at an HGL of approximately 583 feet, encompasses approximately 87 acres, and is composed of residential land use. Water is supplied by gravity to this zone by the Intermediate Zone 0.4 MG Reservoir, which has an overflow elevation of 582.5 feet. This reservoir receives water through 8-inch-diameter piping from the Upper Zone 0.2 MG Reservoir. An altitude valve at the inlet of the Intermediate Zone 0.4 MG Reservoir maintains the water level in the reservoir between approximately 575 and 582 feet. A small 10 acre area in the Intermediate Pressure Zone is served directly from the Upper Pressure Zone Reservoir through a PRV.

2.9.3 Lower Pressure Zone

The Lower Pressure Zone is the largest pressure zone in the City and serves all services below an approximate ground elevation of 300 feet. The zone operates at an approximate hydraulic grade line (HGL) of 430 feet. The zone encompasses approximately 376 acres and is composed of residential, commercial, and industrial land uses. Water service to the Lower Pressure Zone is provided by the Lower Zone 0.4 MG Reservoir and Wells 9 and 10. In periods of high demand, additional supply is provided by Wells 5 and 6. Under normal operating conditions, Well 3 supplies this zone through direct pumping into the Lower Zone 0.4 MG Reservoir, which has an overflow elevation of 429.9 feet.

2.10 Storage Reservoirs

The City of Dundee's water system contains three storage reservoirs, with a total combined storage capacity of approximately 1 MG. The 2003 Water System Master Plan identified a deficit of storage in the system; however, because of lower water use by the City's customers, the City has adequate storage now. The City also maintains a clearwell at the Spring Well site with a volume of approximately 6,000 gallons. As the Riverside District is developed, an additional 1.0 MG of storage will eventually be needed to serve that area and increase fire and emergency storage. Table 2-2 summarizes information about the City's existing storage reservoirs, including capacities, overflow elevations, and pressure zones served. Each reservoir is discussed briefly below.

TABLE 2-2
Reservoir Summary

Name	Pressure Zone Served	General Location	Overflow Elevation (feet)
Upper Zone 0.2 MG Reservoir	Upper and Intermediate	West of SW Fairview Drive	688.7
Intermediate Zone 0.4 MG Reservoir	Intermediate	SW Viewmont Drive	582.5
Lower Zone 0.4 MG Reservoir	Lower	SW Redhills Loop and SW	429.9

2.10.1 Spring Wells Clearwell

Well pumps at the Spring Wells (Wells 1, 2, 7, and 8) pump water into a clearwell located underneath the Clearwell Booster Pump Station. The concrete clearwell is 20 feet long, 5 feet wide, and 8 feet deep, and has a capacity of approximately 6,000 gallons.

Liquid chlorine is injected into the clearwell from storage containers housed in a structure adjacent to the pump house. The City is required to maintain a minimum chlorine residual of 0.2 milligrams per liter at the first customer.

2.10.2 Upper Zone 0.2 MG Reservoir

The Upper Zone 0.2 MG Reservoir is located approximately 1 mile west of Dundee City limits off of SW Fairview Drive. It has an overflow elevation of 688.7 feet and a floor elevation of approximately 660 feet. The reservoir is an at-grade, circular, welded-steel tank. It is 33 feet in diameter with a side wall height of approximately 32 feet. Water is pumped to the reservoir from the Spring Wells through a 6-inch-diameter cast iron pipe. This reservoir serves the Upper Pressure Zone. The water level in the Upper Zone 0.2 MG Reservoir is monitored and recorded at the Clearwell Booster Pump Station. The reservoir is not cathodically protected, but was recoated in 2011.

2.10.3 Intermediate Zone 0.4 MG Reservoir

The Intermediate Zone 0.4 MG Reservoir is located at the northwest edge of the City limits off of SW Viewmont Drive next to the Dundee Cemetery. It has an overflow elevation of 582.5 feet and a floor elevation of approximately 545 feet. The reservoir is an at-grade, circular, welded-steel reservoir built in 2010 and has a diameter of approximately 48 feet and a side wall height of approximately 37 feet. The Intermediate Zone 0.4 MG Reservoir is supplied water from the Upper Zone 0.2 MG Reservoir through a PRV, and it serves the Intermediate Pressure Zone. The reservoir is not cathodically protected and has no associated telemetry or SCADA controls. The reservoir is equipped with an overflow alarm.

2.10.4 Lower Zone 0.4 MG Reservoir

The Lower Zone 0.4 MG Reservoir is located just south of the intersection of SW Red Hills Loop and SW Upland Drive at an approximate ground elevation of 390 feet and has an overflow elevation of 429.9 feet. The reservoir is a partially buried cast-in-place concrete, circular reservoir approximately 61.5-foot in diameter with a side wall height of approximately 18 feet. This reservoir is supplied water directly from Well 3, which is located adjacent to the reservoir.

The reservoir is not controlled or monitored by telemetry or supervisory control and data acquisition (SCADA) facilities.

2.11 Pump Stations

2.11.1 Clearwell Booster Pump Station

The Clearwell Booster Pump Station is located on the Spring Well site adjacent to Wells 1, 2, 7, and 8, and houses two 25 hp vertical turbine pump units. Each pump has a pumping capacity of approximately 220 gpm. The vertical turbine pumps pump the water approximately 1,500 feet south through a 6-inch-diameter pipe to the Upper Zone 0.2 MG Reservoir. The site is equipped with a 90-kilowatt generator that can provide emergency power to this station in the event of power failure. This pump station has room within the structure, and the clearwell has capacity for a future third booster pump. The third booster pump was added when Well 13 was completed in 2015.

2.11.2 Dundee Hills Booster Pump Station

The Dundee Hills Booster Pump Station is a privately-owned facility that the City uses under an agreement between the City and the property owner. As previously discussed, Wells 5 and 6 are also located on this private property and are not owned by the City. Submersible well pumps in both wells convey water through a 6-inch-diameter header pipe to the Dundee Hills Booster Pump Station. The pump station houses a 7.5 hp pump in a wood frame structure adjacent to Well 6 that pumps water directly into the Lower Pressure Zone at a rate of approximately 250 gpm when both well pumps are operating. The City maintains and operates this station.

2.12 Distribution System

The City's water distribution system is composed of various pipe types in sizes up to 12 inches in diameter. The overall system, including pipe sizes, is shown in Figure 2-7. The total length of piping in the service area is approximately 117,482 feet, or 22.3 miles. The pipe types include cast iron, ductile iron, galvanized iron, asbestos cement (or transite), steel, copper, and polyvinyl chloride. The majority of the piping in the system is ductile iron, cast iron, and steel. The distribution system pipe types and diameters are quantified in Table 2-3. Pipe Materials are shown in Figure 2-8.

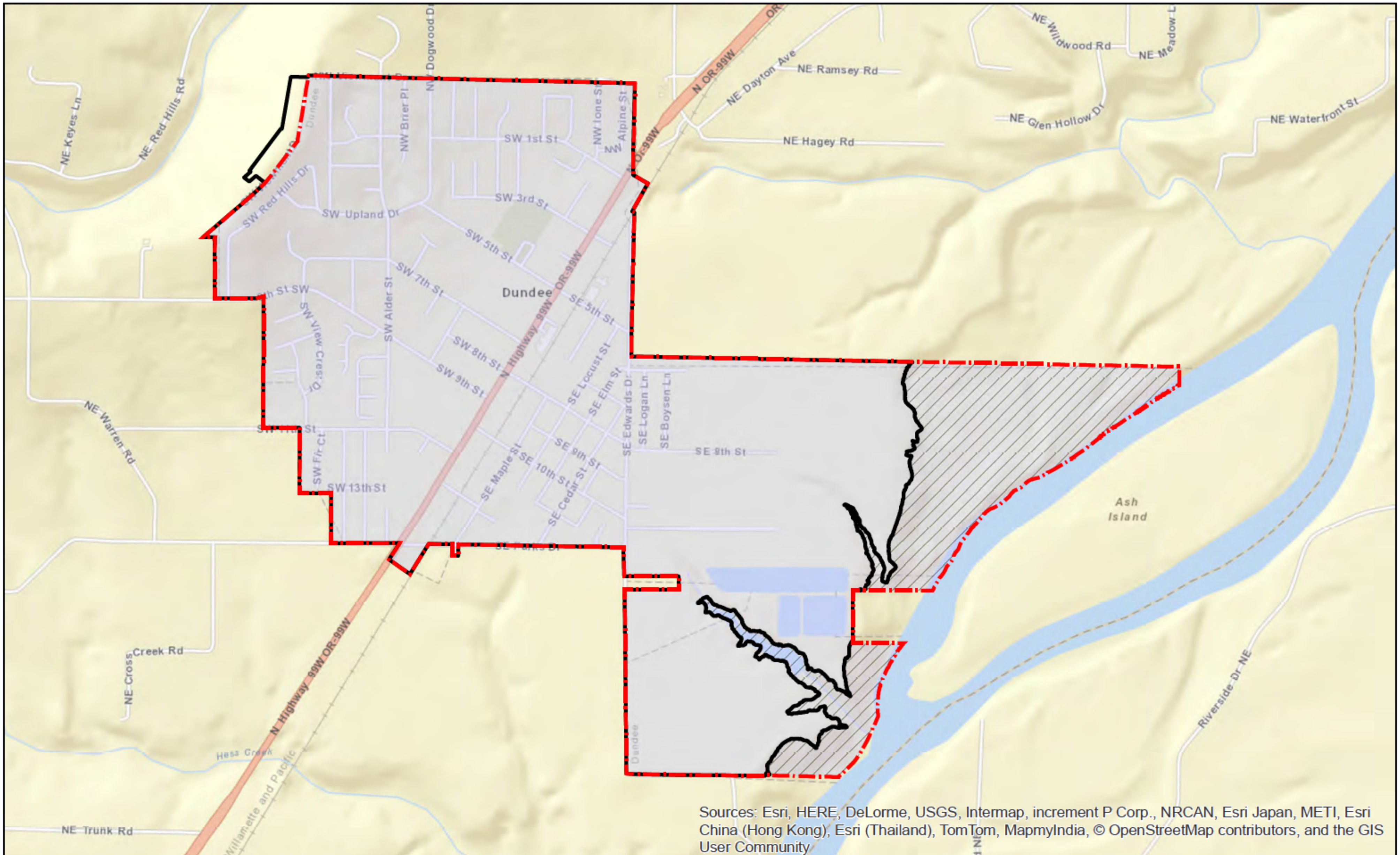
Minimum pipe size of 8-inch is recommended for the distribution system, except for 6-inch pipes on dead-end pipes, such as in cul-de-sacs. The CIP includes replacements for steel, galvanized, and asbestos cement pipe, as well as hydraulic improvements to increase fire flows.

TABLE 2-3
Distribution System Pipe Summary

	Materials (linear feet)						
Diameter (inch)	**Ductile Iron**	**Cast Iron**	**Steel**	**Asbestos Cement**	**Galvanized Iron**	**Polyvinyl Chloride**	**Total Length (linear feet)**
3 or less					8,591	5,060	13,651
4	6,981		10,578	950	100		18,609
6	17,900	7,911	1,570	2,693			30,074
8	13,800	28,400	750	5,000			47,950
10		850	840				1,690
12	5,108			400			5,508
Total	43,789	37,161	13,738	9,043	8,691	5,060	117,482

2.13 Telemetry and Supervisory Control System

The telemetry and SCADA system monitors reservoir water levels and pump operation status within the City's water distribution system. This system signals City staff over the local telephone system by pager when reservoirs or pumps operate outside of specified limits or levels. The telemetry system at the Clearwell Booster Pump Station monitors and stores water level data collected from the Upper Zone 0.2 MG Reservoir. Booster pumps at Wells 1, 2, 7, 8, and 13 are controlled by water level readings transmitted to the Clearwell Booster Pump Station from the Upper Zone 0.2 MG Reservoir. Pumps at Wells 3, 5, 6, and 10 are operated by signal in response to water level changes detected by water level sensors in the Lower Zone 0.4 MG Reservoir. Well 9 has no telemetry and is operated manually.



LEGEND

- City Limits
- Urban Growth Boundary
- City Territory
- Exclusive Farm Use

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE 2-1
City of Dundee Water System Master Plan
Dundee Water Service Study Area

ch2m

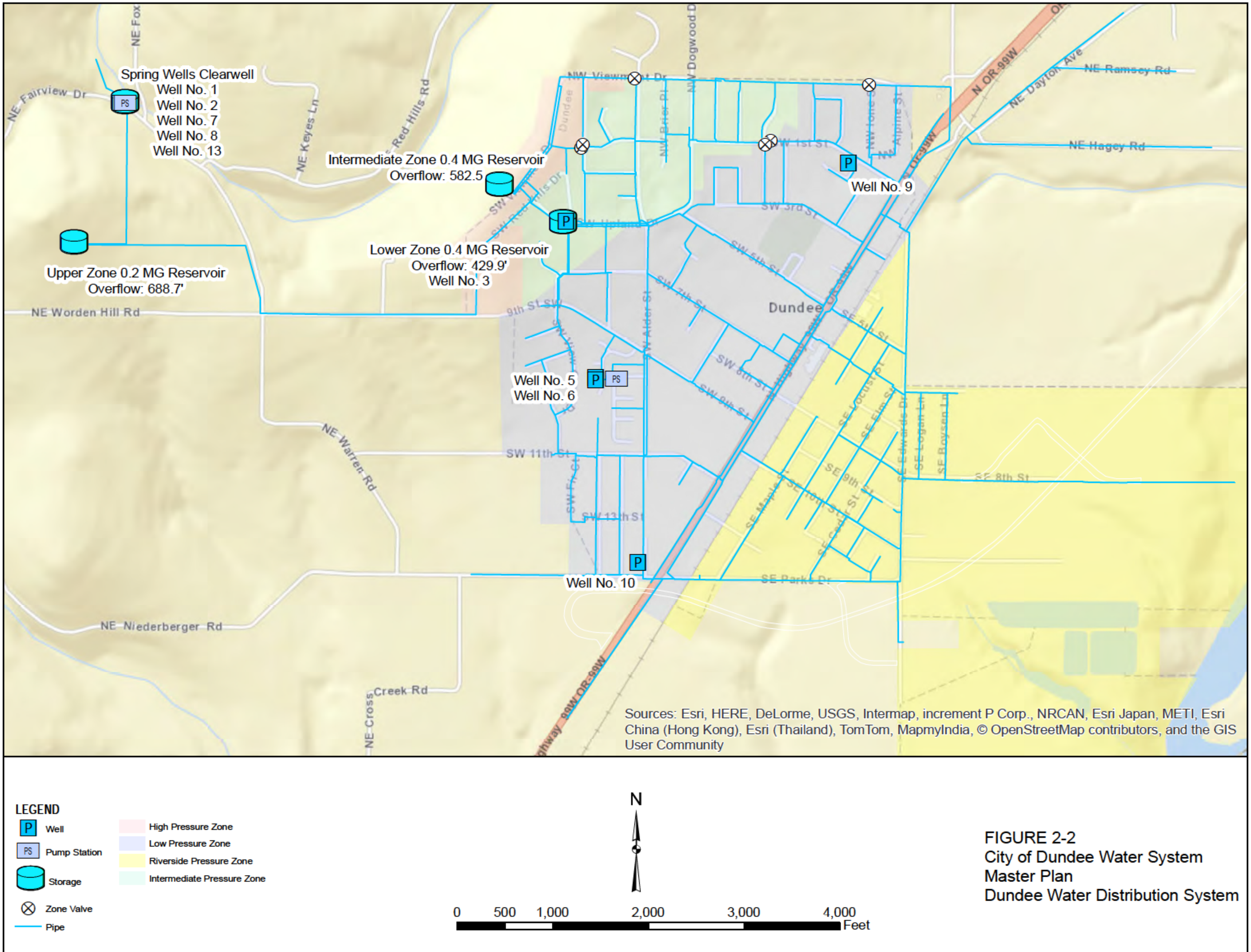
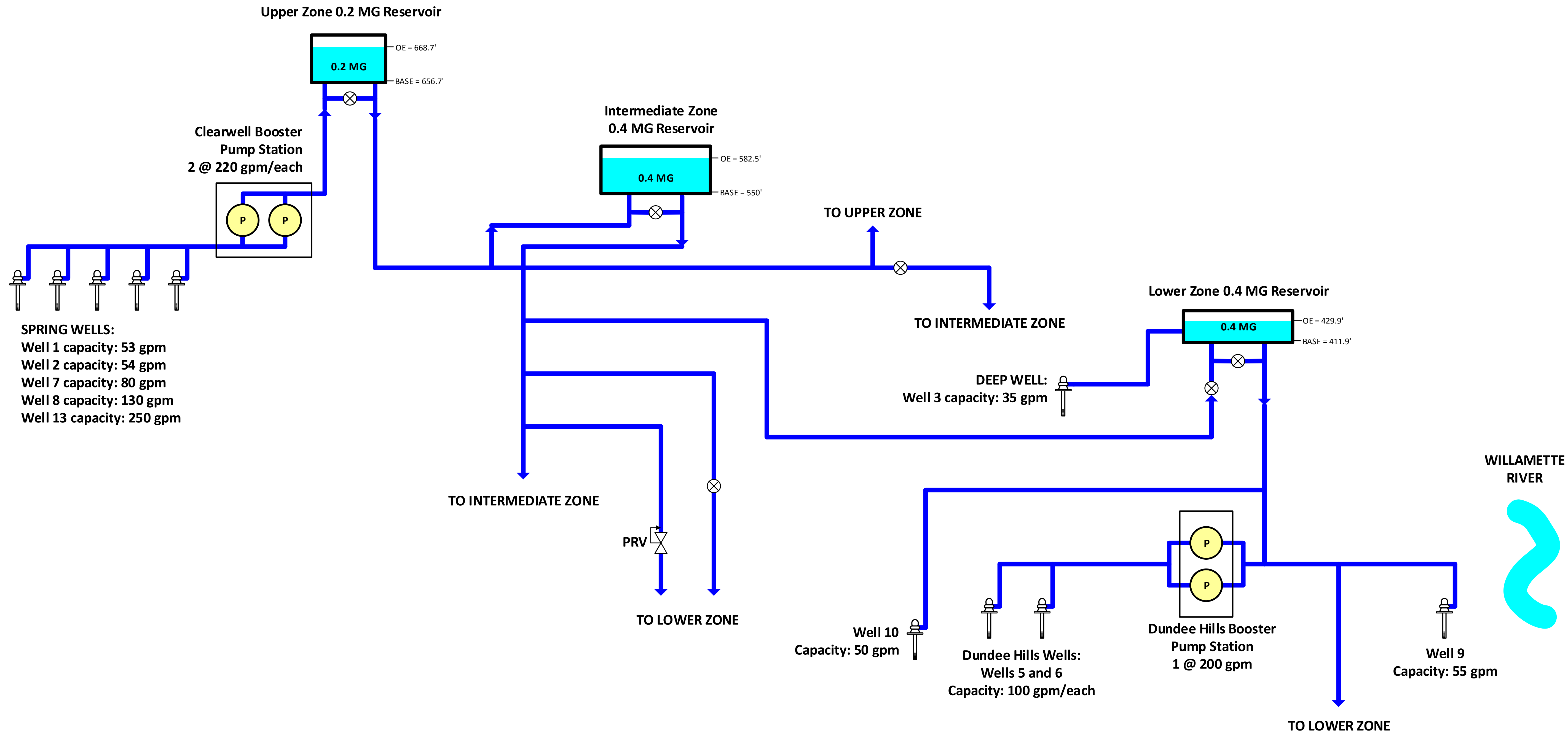
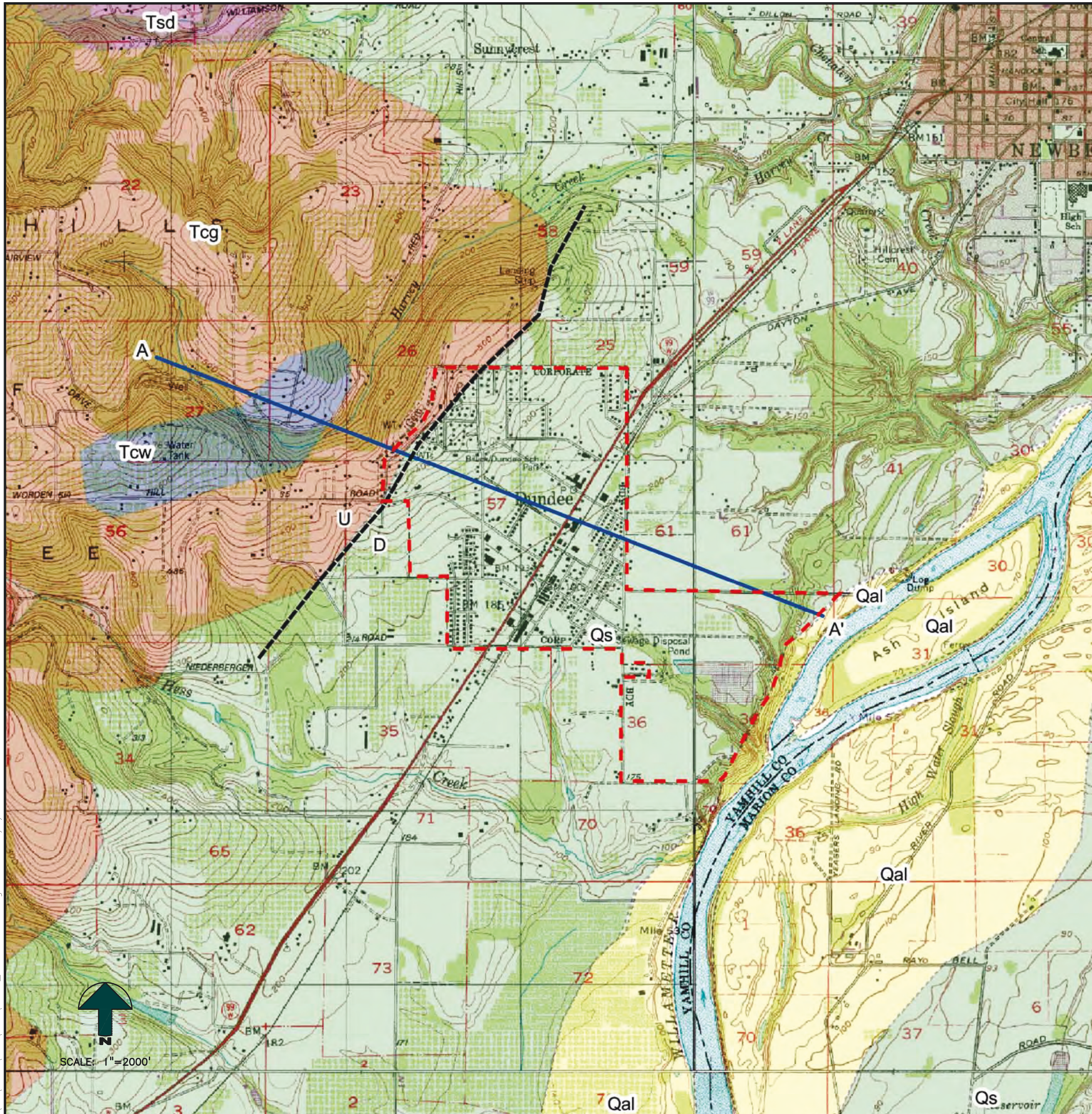


FIGURE 2-2
City of Dundee Water System
Master Plan
Dundee Water Distribution System



ch2m

FIGURE 2-3
Water Distribution System Hydraulic Profile
City of Dundee
Water System Master Plan



LEGEND

Geology

- Qal - Alluvium- sand, gravel, and silt
- Qs - Lacustrine and fluvial, unconsolidated to semiconsolidated clay, silt, sand, and gravel
- Tcw - Wanapum Basalt - gray to dark-gray
- Tcg - Grande Ronde Basalt - dark-gray to black
- Tsd - Marine shale siltstone, sandstone, and conglomerate

Note:
Based on USGS preliminary mapping

A —— A' Geologic Cross Section

U (upside)
D (downside)

City Limits

GSI Water Solutions, Inc.

FIGURE 2-4
Local Geologic Setting
City of Dundee
Water System Master Plan

G:\03\0597\106\CAD\9-03_FIGURE X-X.dwg 2-3 Jan/6/2005 16:32:30

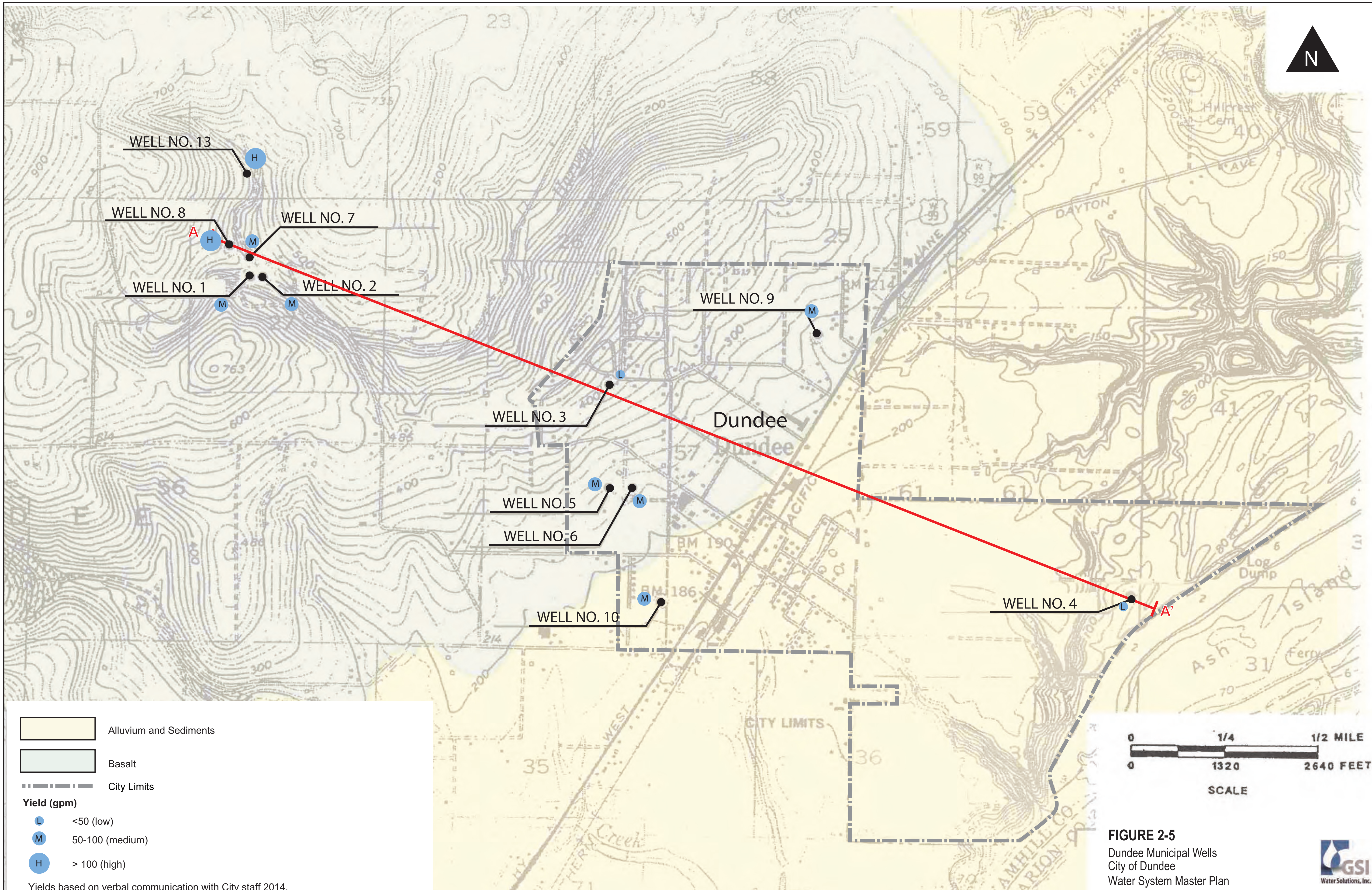


FIGURE 2-5
Dundee Municipal Wells
City of Dundee
Water System Master Plan

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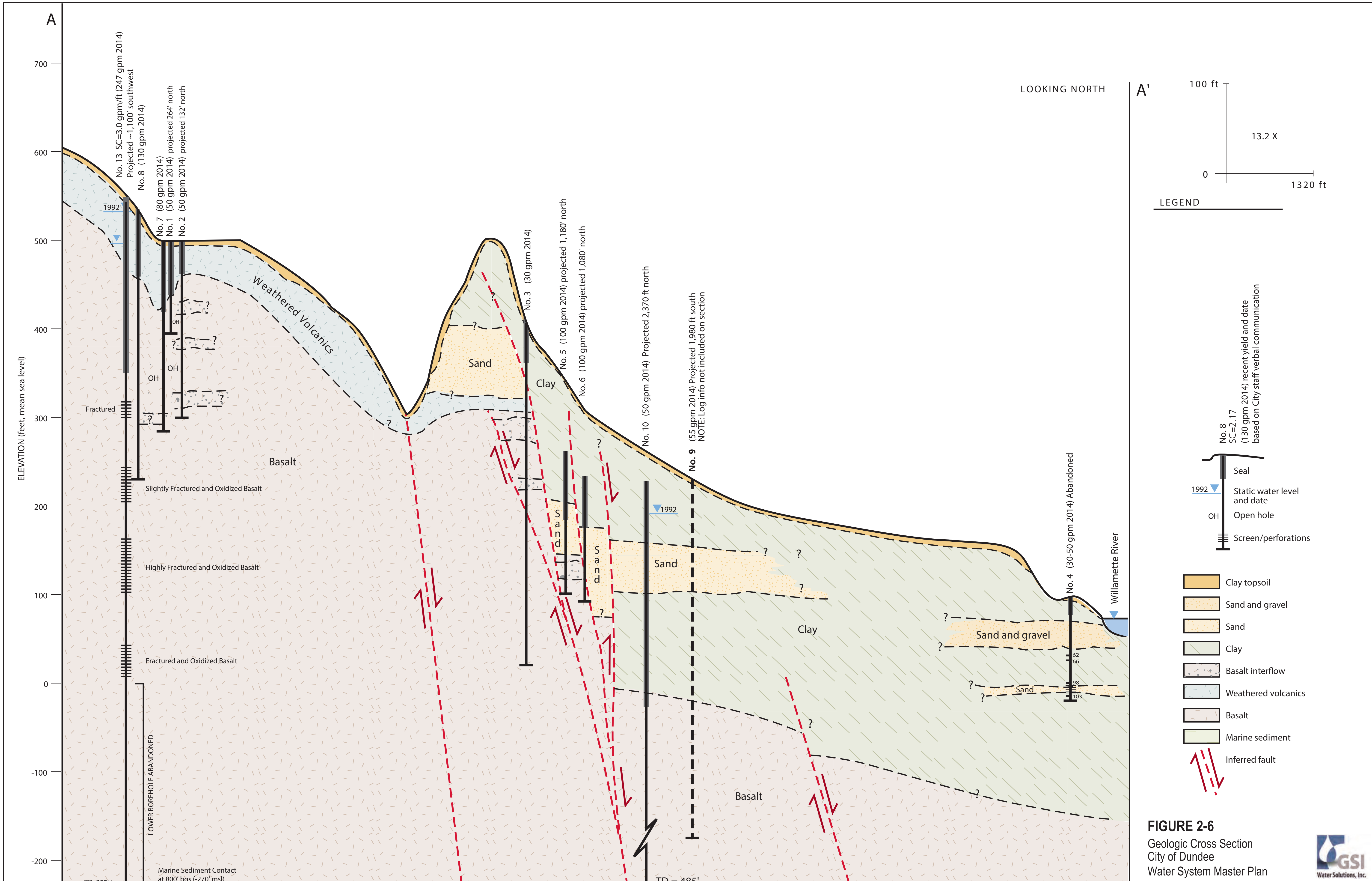

FIGURE 2-6
Geologic Cross Section
City of Dundee
Water System Master Plan

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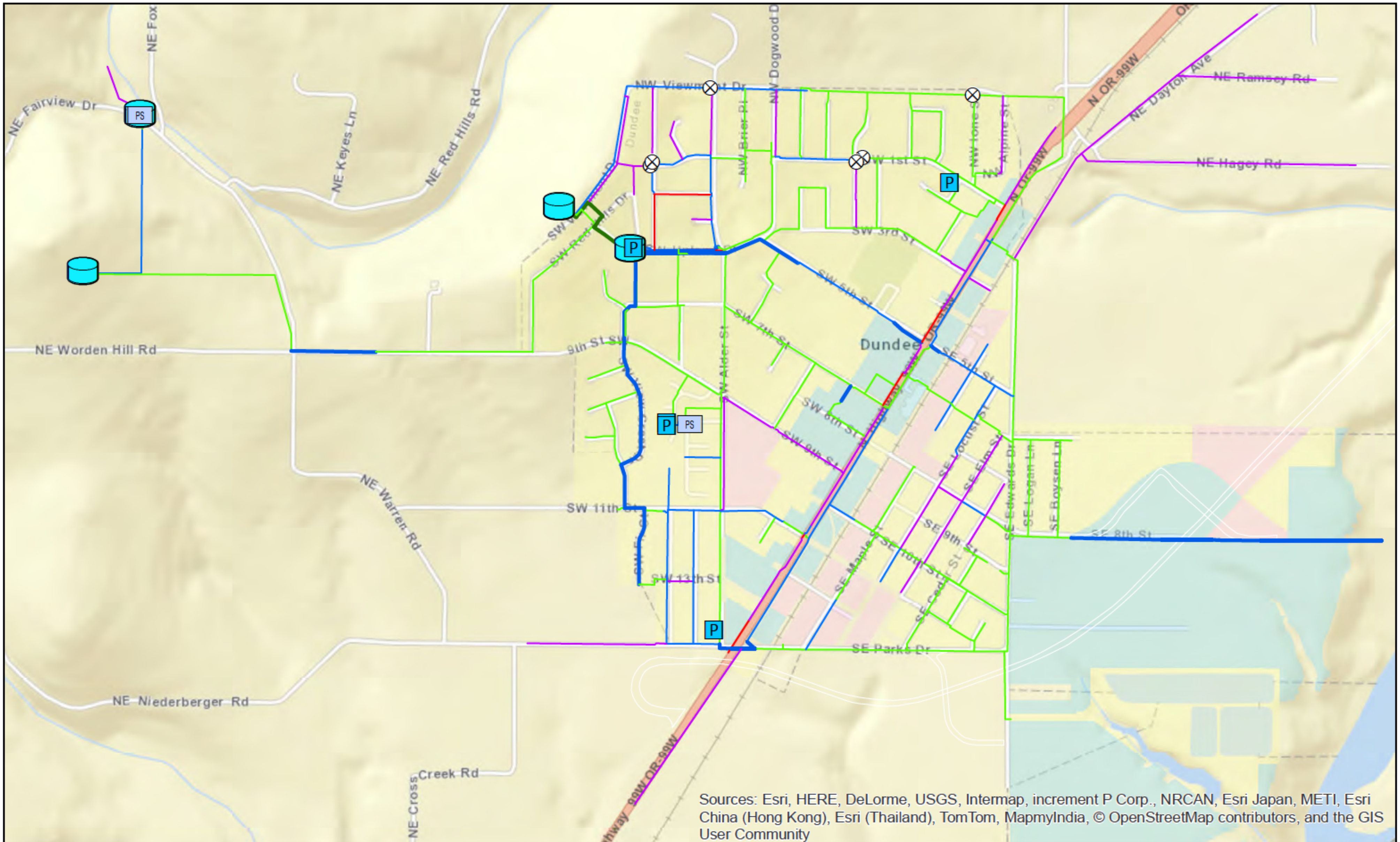


LEGEND

- Well
- Pump Station
- Storage
- Zone Valve

Pipe Diameter (In)

- < = 4
- 6
- 8
- 10
- 12
- 16

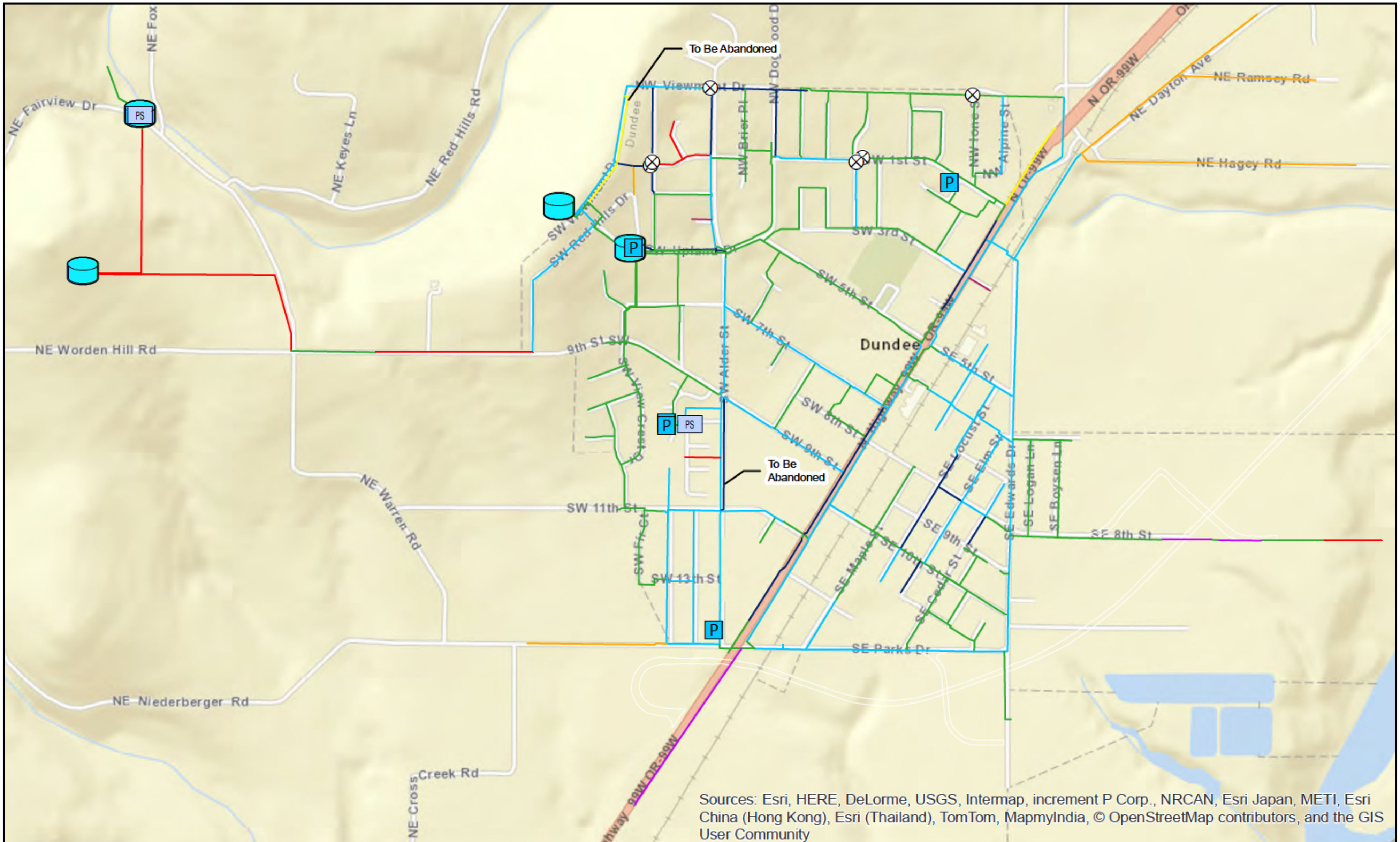
Required Fire Flow

- 1,000 GPM
- 3,000 GPM
- 4,000 GPM

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE 2-7
Water Distribution System by Pipe Size
City of Dundee Water System Master Plan



LEGEND

- P Well
- PS Pump Station
- Storage
- ⊗ Zone Valve

Material

- CIP
- AC
- STL
- HDPE
- DIP
- PVC
- GALV
- UNK
- COP

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE 2-8
Pipe Material
City of Dundee Water System Master Plan

ch2m

SECTION 3

Land Use and Water Requirements

3.1 Introduction

This section presents population projections and estimated water demands for Dundee's water service area. Population and water demand forecasts were developed from regional and City planning data, current land use designations, historical water demand records, and previous City water supply planning efforts. Also included in this section is a description of the current land use and zoning designations within the service area.

3.2 Service Area

The City of Dundee UGB, as defined by the City's comprehensive plan (CH2M, 1977), encompasses approximately 747 acres, while the City limits encompass approximately 900 acres. The difference is 153 acres; these acres consist of land zoned EFU, which is largely undevelopable.

Currently, the City water system serves the area within the UGB as well as several connections outside the UGB. Services outside the UGB have historically accounted for approximately 6 percent of the water demand and are anticipated to continue being served at this same level by the City throughout the planning period. There are currently 60 connections outside the UGB.

The City's service area includes the Riverside District for which a master plan was developed in June 2011 (Angelo Planning Group et al.). The Riverside District includes 360 acres in the southeasterly portion of the City inside the UGB.

3.3 Planning Period

The planning period for this master plan is 20 years, from 2015 through 2035. With the adoption of the Riverside District Master Plan, the City will have the potential to develop a total of 970 dwelling units at build-out on 273 acres within the Riverside District. The population projections provided by the Population Research Center (PRC), College of Urban and Public Affairs, Portland State University include a 2035 City population of 4,970, which would mean development of 650 of the potential 970 residential units in the Riverside District during the planning period.

3.4 Land Use

Land use and zoning classifications for Dundee's water service area are established under the City's comprehensive plan. Table 3-1 summarizes land uses and zoning classifications for the study area. Zoning classifications identified in Table 3-1 are in accordance with comprehensive plan designations. Table 3-2 shows the planned Riverside District land uses.

TABLE 3-1
Land Use Summary
Source: City of Dundee Zoning Map

Zone	Zone Description	Area within Dundee City Limits (gross acres)
R1	Single-Family Residential	207
R2	Single-Family Residential	48
R3	Medium Density Residential	61
C	Community Commercial	31
CBD	Central Business District	36
LI	Light Industrial	48
A	Agriculture	223
EFU	Exclusive Farm Use	201
P	Public	40
PO	Parks and Open Space	1
	Total	**896**

TABLE 3-2
Riverside District Planned Land Uses
Source: Riverside District Master Plan (Angelo Planning Group et al., 2011)

Land Use Description	Acres	Target Dwelling Units
Inside UGB		
Residential	100	970
Commercial	22	
Light Industrial	13	
Neighborhood Park	8	
Nature Park	24	
Roads	29	
Trails	23	
Newberg/Dundee Bypass Corridor	27	
Wastewater Treatment Plant	17	
Subtotal Inside UGB	263	
Outside UGB	97	
Riverside District Total	360	970

3.5 Population Estimates

3.5.1 Existing Population

Historical population estimates were obtained through the analysis of data provided by the City of Dundee and the PRC at Portland State University. The PRC data represent estimates of Dundee's population inside the existing City limits as of July 1 each year. Population estimates for the beginning of each decade are based on census counts published by the U.S. Census Bureau, while annual estimates between the census counts are derived by analyzing supplemental data, including economic changes, building permits issued, and annexations. Table 3-3 summarizes recent population estimates for the City's water supply area. Currently, the City of Dundee supplies water to approximately 3,335 people through approximately 1,082 metered service connections as follows: 1,011 residential connections, 6 multi-family connections, 46 commercial connections, 10 wineries, and 9 "other" connections that largely include public agencies. Based on current City data, there are approximately 2.7 persons per equivalent dwelling unit (EDU) within City limits and 2.5 person per EDU outside of City limits. This results in approximately 1,232 EDUs. Table 3-4 summarizes estimates of the existing population and EDUs within each pressure zone.

TABLE 3-3
Historical and Current Population Summary

Year	Population Inside City Limits	Population Outside City Limits	Population Total
2011	3,175	172	3,347
2012	3,175	157	3,332
2013	3,170	157	3,327
2014	3,180	150	3,330
2015	3,185	150	3,335

TABLE 3-4
Existing Population and Equivalent Dwelling Units Summary

Pressure Zone	Area (acres)	Equivalent Dwelling Units	Population
Upper	23.4	44	119
Intermediate	86.5	182	495
Lower	374.3	1,006	2,721
Total	**484.2**	**1,232**	**3,335**

3.5.2 Population Forecast

Table 3-5 presents a population forecast summary based on the PRC population forecast within the City limits and maintaining a constant population outside of the City limits.

TABLE 3-5
Population Forecast Summary

Year	Population Inside City Limits	Population Outside City Limits	Population Total
2015	3,185	150	3,335
2020	3,427	153	3,579
2025	3,960	157	4,117
2030	4,468	162	4,630
2035	4,970	165	5,135

3.6 Water Demand Estimates

Water demand estimates were developed from a review of historical water consumption records and data provided by the City and regional population forecasts specifically generated to reflect the water service area.

3.6.1 Historical Water Use

The term "water demand" refers to all the water requirements of the system including domestic, commercial, municipal, institutional, and industrial as well as unaccounted-for water. Demands are discussed in terms of gallons per unit of time such as gallons per day (gpd), mgd, or gpm. Demands are also related to per capita use as gallons per capita per day (gpcd). The City of Dundee maintains records of historical monthly water usage by customers.

Per capita water use in the City on peak days has declined over the past decade, as shown in Figure 3-1.

To recognize the trend of lower peak day demands, the average peak day per capita use for the most recent 4 years was used to develop demand projections. Table 3-6 summarizes these data for the years 2011 through 2014.

3.6.2 Existing Water Demands

Based on historical water usage patterns and historical population, the water service area’s average daily demand has been approximately 0.33 to 0.38 mgd with an average per capita consumption of approximately 99 to 113 gpcd. Recent maximum daily water demand usage has been as high as approximately 0.77 mgd in 2012. This is equivalent to a maximum per capita usage of approximately 231 gpcd.

TABLE 3-6
Historical Water Use Summary

		Water Demand (mgd)		Per Capita Water Demand (gpcd)	
Year	Water Service Area Population	Average Day Demand	Maximum Day Demand	Average Day	Maximum Day
2011	3,347	0.332	0.637	99	190
2012	3,332	0.376	0.769	113	231
2013	3.327	0.376	0.723	113	217
2014	3,330	0.347	0.637	104	191

3.6.3 Water Demand Projections

Future water demand estimates were developed by projecting historical flows using the same relative growth as the population. As growth continues, both residential infill and zoning expansions are expected, resulting in an increased population density and an overall higher water demand. For the purposes of this plan, estimated average daily water usage is assumed to be the average of 2011 through 2014:

- Average Day Per Capita Demand of 107 gpcd
- Maximum Day Per Capita Demand of 207 gpcd

Estimated average and maximum day water demands are developed by multiplying the estimated per capita usage by the anticipated population for that year. To provide an estimate of peak hourly usage, a factor of 1.5 was applied to the estimated maximum day water demands. This is consistent with water demand patterns of similar communities in the region. Population projections and anticipated water demands, in 5-year increments through saturation development, are summarized in Table 3-7.

TABLE 3-7
Population Forecasts and Estimated Water Demand Summary

		Water Demand (mgd)		
Year	**Population**	**Average Day Demand**	**Maximum Day Demand**	**Peak Hour Demand**
2015	3,335	0.358	0.692	1.259
2020	3,579	0.384	0.742	1.351
2025	4,117	0.442	0.854	1.554
2030	4,630	0.497	0.960	1.748
2035	5,135	0.551	1.065	1.939

Water demand projections were further developed for each pressure zone based on the area served, population projections, and water use data. Table 3-8 presents a summary of these projected demands in 2035, assuming nearly all growth occurs in the City’s new Riverside District. When the Riverside District Zone is created, service to an estimated 300 connections will be transferred from the Lower Pressure Zone to the Riverside District Zone. The effects of these transfers are shown in the lower portion of Table 3-8.

TABLE 3-8
Pressure Zone Water Demand Summary in Year 2035

		Water Demand (mgd)		
Pressure Zone	**Population**	**Average Day Demand**	**Maximum Day Demand**	**Peak Hour Demand**
Upper	124	0.013	0.026	0.047
Intermediate	549	0.059	0.114	0.207
Lower	2,845	0.306	0.590	1.075
Riverside District	1,617	0.173	0.335	0.610
All Zones	**5,135**	**0.551**	**1.065**	**1.939**
Lower Zone after service transfers to Riverside District	2,030	0.218	0.421	0.766
Riverside District after service transfers from Lower Zone	2,432	0.261	0.505	0.918

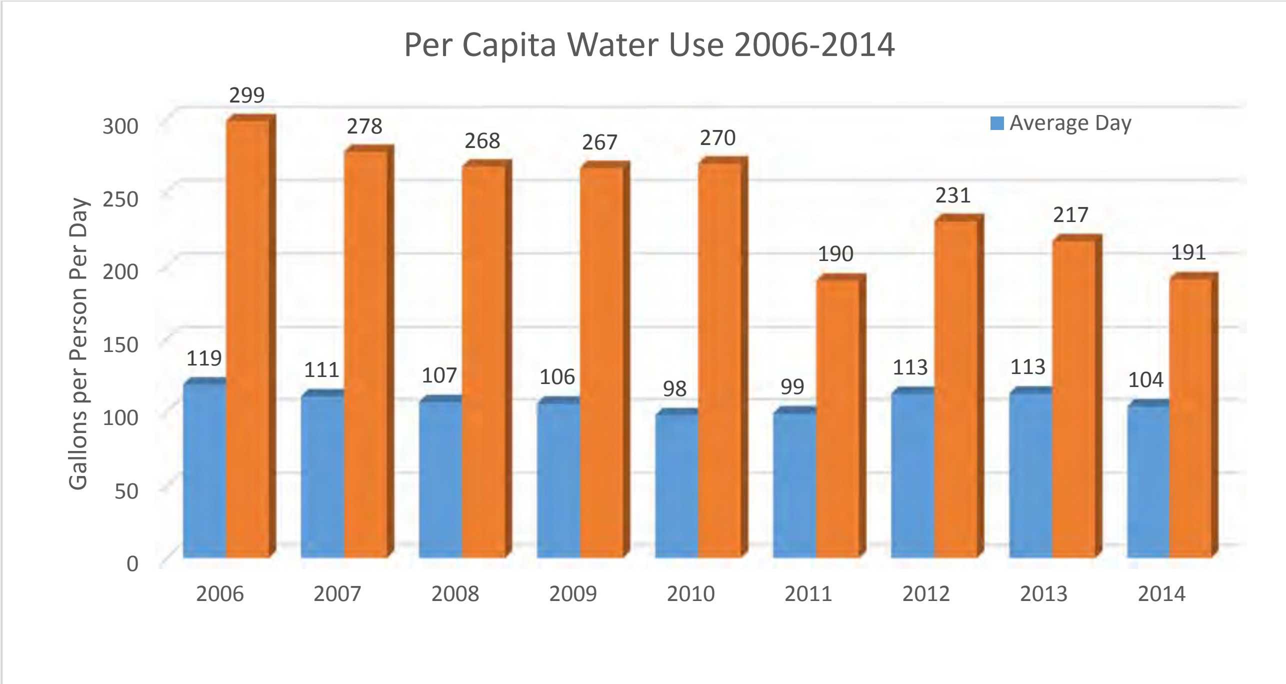


FIGURE 3-1
Per Capita Water Use 2006–2014

SECTION 4

Planning and Analysis Criteria

4.1 Introduction

This section presents the planning and analysis criteria used for the water system analysis. Criteria and planning assumptions are presented for the City of Dundee's supply system and groundwater wells, distribution system piping, pressure zones, and storage and pumping facilities. Recommendations of water needs for emergency fire suppression are also presented. The water demand forecasts developed in Section 3 are used with these criteria in Section 5 for the analysis of Dundee's water system.

4.2 Groundwater Supply System

As described in Section 2, the City's water is supplied by ten operational groundwater wells. Water from Wells 1, 2, 7, 8, and 13 is pumped into the Spring Wells clearwell and then booster pumps deliver water into the Upper Zone 0.2 MG Reservoir. Water from Well 3 is pumped into the Lower Zone 0.4 MG Reservoir before distribution by gravity into the water system. Water from Wells 5, 6, 9, and 10 is pumped directly into the Lower Pressure Zone. All of these wells must provide a firm supply source capacity equal to the maximum day demand as presented in Section 3 to the study area over the duration of the planning period. Firm supply source capacity is defined as the total production capacity of all operational wells with the largest capacity well out of service.

4.3 Distribution System

The water distribution system should be capable of operating within certain system performance limits, or guidelines, under several varying demand and operational conditions. The recommendations of this plan are based on the following performance guidelines, which have been developed through a review of State of Oregon requirements, American Water Works Association (AWWA) acceptable practice guidelines, operational practices of similar water providers, and discussions with City water system operations staff. The recommendations are as follows:

1. The distribution system should be capable of supplying the peak hourly demand while maintaining minimum service pressures of not less than approximately 85 to 90 percent of normal system pressures. Reservoirs are assumed to be approximately two-thirds full during peak hourly demand conditions.
2. The distribution system should be capable of providing the recommended fire flow to a given location while, at the same time, supplying the maximum daily demand and maintaining a minimum residual service pressure at any meter in the system of 20 pounds per square inch (psi). This is the minimum water system pressure required by Drinking Water Services of the Oregon Health Authority. Reservoirs are assumed to be approximately two-thirds full during fire flow events.

New water mains should be at least 8 inches in diameter in order to supply minimum fire flows. In special cases, 6-inch- or 4-inch-diameter mains are acceptable if no fire hydrant connection is required, there are limited services on the main, the main is dead-ended, and looping or future extension of the main is not anticipated.

4.4 Service Zone Pressures

As discussed in Section 2, the City is currently divided into three pressure zones. For planning and analysis purposes, and for the purposes of completing the distribution system hydraulic analysis, it is assumed that the HGLs of the Upper, Intermediate, and Lower Pressure Zones are approximately 689 feet, 583 feet, and 430 feet, respectively. These HGLs are based on the reservoir overflow level serving each zone. A detailed discussion regarding existing and future City water supply source options is presented with the summary of the system analysis results in Section 5.

As discussed in Section 2, water distribution systems are typically separated into pressure zones or service levels to provide service pressures to all customers within an acceptable range. Pressure zones are usually determined by ground topography and designated by overflow elevations of water storage facilities or outlet settings of pressure reducing facilities serving the zone. Typically, water from a reservoir will serve customers by gravity within a specified range of ground elevations so as to maintain acceptable minimum and maximum water pressures at individual service connections. When it is not feasible or practical to have a separate reservoir serving each pressure zone, pumping facilities or pressure reducing facilities are used to serve customers in different pressure zones from a single reservoir.

Generally, 100 psi is considered the desirable upper pressure limit and 45 psi the lower limit. Pressures in areas of the Lower Pressure Zone have historically been as high as 115 psi, and it has been the City's policy to require that pressure reducing assemblies be installed on all services when system pressure is above 90 psi. As such, for the purposes of this study, the maximum pressure limit for the Lower Pressure Zone will be 115 psi. Whenever feasible, it is desirable to achieve the 45 psi lower limit at the point of the highest fixture within a given building being served. Conformance to this pressure range may not always be possible or practical due to topography, existing system configurations, and economic considerations. Table 4-1 summarizes the service pressure criteria used in the analysis of the water system.

TABLE 4-1
Recommended Service Pressure Criteria

Condition	Pressure (psi)
Minimum Service Pressure Under Fire Flow Conditions	20
Minimum Normal Service Pressure	45
Maximum Service Pressure	115

4.5 Booster Station Pumping Capacity

The City's water system is supplied entirely by groundwater wells, seven of which feed into two booster pump stations. Firm booster station pumping capacity is defined as a station's pumping capacity with the largest pump out of service. The firm pumping capacity at each pump station should equal or exceed the total supply production capacity of the well(s) being served by that station.

4.6 Evaluation of Source Adequacy

The ability of existing sources to satisfy current maximum day demand (MDD) and projected MDD in 2020, 2025, 2030, and 2035 was evaluated. The capacity of each source (in gpd) for 2009, 2016, and 2030 was assumed to equal the current capacity (in gpm) multiplied by 1,440 minutes per day. The sum of available source capacities was then compared with current and projected MDDs to determine if the system has adequate source capacity over the 20-year planning period.

In addition to evaluating source adequacy over the 20-year planning period, the maximum number of EDUs that can be served by available sources was also calculated. The maximum number of EDUs is reached when the MDD is equal to the total available firm source capacity.

4.7 Source of Supply Considerations

A source of supply analysis was conducted to evaluate source capacity and/or water rights capacity in comparison to projected water demand. The source of supply analysis was used to evaluate and identify options for satisfying water demands other than installing a new production well and applying for new water rights for the new well. Options that were considered in the source of supply analysis included enhanced conservation measures, interties, artificial recharge, use of reclaimed water, developing a new surface water source that included a riverbank filtration option, and new wells with water right changes.

4.8 Evaluation of Storage Adequacy

The ability of existing storage facilities to satisfy current demand and projected demand through 2035 was evaluated for each system. The required volume of equalizing storage, standby storage, and fire flow storage (in gallons) was calculated for each system as described below.

Water storage facilities are typically provided for three purposes: equalization (or “operational”) storage, standby (or “emergency”) storage, and fire storage. Storage recommendations in each zone combine the operational, standby, and fire storage volume components.

4.8.1 Equalizing Storage

The recommended equalizing storage volume equals the greater of either 20 percent of the MDD for 1 day or the volume calculated from the following equation:

$$E.S. = 150 \text{ minutes} * (PHD - Q)$$

Where:

E.S. = Equalizing Storage (gallons)
PHD = Peak Hour Demand (gpm)
Q = Total Source Capacity (gpm)

4.8.2 Standby Storage

The recommended standby storage volume equals the greater of either the average day demand (ADD) multiplied by 2 days minus a multi-source credit (if applicable) or 200 gallons per EDU. A multi-source credit, in which the production well with the highest capacity is assumed out-of-service, applies to systems with multiple sources, reliable power supplies, and adequate hydraulic looping.

4.8.3 Fire Flow Storage

The required fire flow storage volume is usually based on minimum flow rate and duration requirements set by the City’s fire marshal.

While the water distribution system provides water for domestic uses, it is also expected to provide water for fire suppression. The amount of water recommended for fire suppression purposes is typically associated with the local building type or land use of a specific location within the distribution system. Fire flow recommendations are typically much greater in magnitude than the normal MDD present in any local area. Adequate hydraulic capacity must be provided for these large occasional fire flow demands.

A summary of fire flow recommendations by land use designation is presented in Table 4-2. The recommended fire flows presented in Table 4-2 were developed through a review of fire flow criteria adopted by similar communities, fire flow guidelines as developed by AWWA, the Insurance Services Office, and discussions with the Dundee Fire Department.

Water stored for fire suppression is typically provided to meet the single most severe fire flow demand within each zone. The recommended fire storage volume is determined by multiplying the fire flow rate by the duration of that flow. Table 4-3 summarizes recommended fire flow durations.

TABLE 4-2
Summary of Land Use and Recommended Fire Flows

City of Dundee Zoning Classification		Recommended Fire Flow (gpm)
R1	Single-Family Residential	1,000
R2	Single-Family Residential	1,000
R3	Medium Density Residential	1,000
R4.5	Residential (Low Density)	1,000
C	Community Commercial	3,000
CBD	Central Business District	3,000
LI	Light Industrial	4,000
A	Agriculture	3,000

TABLE 4-3
Recommended Fire Flow Duration Summary

Recommended Fire Flow (gpm)	Duration (hours)
Up to 3,000	2
3,000 to 4,000	3
Greater than 4,000	4

SECTION 5

Water System Analysis

5.1 General

This section presents an analysis of Dundee's water distribution system based on the criteria developed in Section 4. The analysis includes a supply source analysis, an evaluation of the system's existing pressure zones and storage and pumping capacity requirements, and presents the findings of a computerized hydraulic network analysis of the water distribution system.

Through these evaluations and analysis, deficiencies are identified and improvement options developed. Section 6 presents a recommended CIP that includes prioritized recommended improvements to correct deficiencies found through the analysis and which provides for system expansion.

Population forecasts and water use estimates presented in Section 3 are used to determine the need for certain improvements such as increased supply source and storage capacity, transmission system improvements, and pumping capacity improvements. All improvements to storage and pumping facilities, and distribution and transmission piping, are based on estimated maximum day water demands at saturation development unless otherwise noted.

As discussed in Section 3, water demand estimates for the entire service area were developed in 5-year increments through the year 2035. An estimate of the existing water demand within each pressure zone was also identified. Development of existing and future water demands by pressure zone provides an indication of where growth is anticipated to occur and assists in identifying the extent and timing of necessary improvements.

Table 5-1 summarizes water demand estimates in 5-year increments for the water service area. Table 5-2 summarizes water demand estimates for each pressure zone. These water demand estimates along with the planning criteria established in Section 4 are the basis for the analysis of the existing system and the development of recommended system improvements.

TABLE 5-1
Population Forecasts and Estimated Water Demand Summary

		Water Demand (mgd)		
Year	**Population**	**Average Day Demand**	**Maximum Day Demand**	**Peak Hour Demand**
2015	3,335	0.358	0.692	1.259
2020	3,579	0.384	0.742	1.351
2025	4,117	0.442	0.854	1.554
2030	4,630	0.497	0.960	1.748
2035	5,135	0.551	1.065	1.939

TABLE 5-2
Pressure Zone Water Demand Summary

	2015 (mgd)			2035 (mgd)		
Pressure Zone	**Average Day Demand**	**Maximum Day Demand**	**Peak Hour Demand**	**Average Day Demand**	**Maximum Day Demand**	**Peak Hour Demand**
Upper	0.013	0.025	0.045	0.013	0.026	0.047
Intermediate	0.053	0.103	0.187	0.059	0.114	0.207
Lower	0.292	0.565	1.028	0.306	0.590	1.075
Riverside District	-	-	-	0.173	0.335	0.610
Total	**0.358**	**0.692**	**1.259**	**0.551**	**1.065**	**1.939**

5.2 Supply Source Analysis

The City's existing groundwater wells have a firm pumping capacity of approximately 0.76 mgd. The water demand analysis in Section 3 projects an estimated maximum day water demand at 2035 of approximately 1.065 mgd. With a firm source production capacity of approximately 0.76 mgd, the City's supply wells are adequate to meet the current maximum day demands of approximately 0.69 mgd. With Well 13 being added to the system during 2015, the water supply should be adequate to serve water needs for a numbers of years. However, Well 13 will need to be run for one or more summer seasons to determine its actual yield and reliability of yield.

5.2.1 Water Source Evaluation

The water source options available to the City for adding capacity were identified and evaluated. CH2M evaluated nearly 20 options for increasing water supply and discussed the options with City staff and the City Council. The options considered and their evaluation are described here.

5.2.1.1 Riverbank Filtration

Among the potential sources identified was "riverbank filtration," which would use near-river groundwater or collector wells along the Willamette River for additional water supply. Water from this alluvial aquifer may require only limited treatment because groundwater, even if hydraulically connected to the river, would be filtered through the subsurface media. A small study was conducted to evaluate the potential for riverbank filtration along the Willamette River, near the City's Well 4.

To evaluate the potential of installing near-river groundwater well(s), a 6-inch-diameter pumping well (PW) was installed near Well 4, and a 2-inch-diameter observation well was installed between the PW and the Willamette River. A short-term, 24-hour pump test was completed to assess the hydraulic connection between the shallow sand and gravel alluvial aquifer and the Willamette River. The PW for this evaluation also was sited more than 200 feet from the river to comply with the Oregon Health Authority regulations related to groundwater under the direct influence of surface water. Specifically, the regulations require that the water supply well be more than 200 feet from the surface water body if the aquifer is composed of sand and gravel media, which is the case at this location based on existing well logs. The PW also needs to be within 500 feet of the river to transfer the surface water right to a groundwater point-of-diversion. These regulatory criteria and the desire to be near Well 4 and the 8th Street easement bracketed the location of the PW for the evaluation.

CH2M collected water quality samples during this exploratory phase for microscopic particulate analysis to assess the filtration provided by the alluvial aquifer and project water treatment requirements necessary to meet drinking water standards. The laboratory used the Consensus Method for Determining Groundwaters Under the Direct Influence of Surface Water Using Microscopic Particulate Analysis (MPA) developed by

EPA. Application of this method results in relative risk factors (scores) to determine the degree of risk associated with influence by surface water. The risk categories are:

- High risk – A lab-provided MPA result equal to or greater than 20.
- Moderate risk – A result equal to or greater than 10 and equal to or less than 19.
- Low risk – A result equal to or less than 9.

The result of the MPA was a score of 7 indicating a low risk of surface water influence from microbial contaminants. The riverbank filtration study found that there is not a strong hydraulic connection between the sand and gravel aquifer and the Willamette River. Recovery data from the observation well, coupled with stage data from the Willamette River, show a connection to the Willamette River; however, aquifer test data show that it is weak and that the river at this location may not contribute sufficient water to sustain pumping from the sand and gravel aquifer. Previous work on the east side of the Willamette River demonstrated that collector-type well systems are viable, and this is further supported in the development of the Newberg Wellfield. Finding a suitable site on the west side of the Willamette River would require more exploration work.

Based on available information, the City is encouraged to explore the option of a collector-type well system by completing additional exploration borings upgradient and downgradient of the Well 4 site. Geophysical exploration may prove to be a useful tool to refine the search area. Cost considerations, such as distance from the 8th Street waterline, would need to be evaluated, and it would be instructive to evaluate the cost of crossing the Willamette River with a water supply pipe because previous test data proved more favorable east of Ash Island. Finding a hydraulic connection between the shallow sand and gravel aquifer on the site of the Willamette River, similar to what is present in the Newberg Wellfield and what was found east of Ash Island will require additional exploration.

A copy of the complete report, *City of Dundee – Riverbank Filtration Preliminary Feasibility Assessment* (GSI Water Solutions, Inc., 2015) is provided in Appendix B.

5.2.1.2 Other Water Supply Options

In addition to riverbank filtration, a variety of other water supply options were identified. These included additional wells, a surface water source using the Willamette River, regional sources, reuse in the Riverside District, and miscellaneous options, such as aquifer storage and recovery, an enhanced conservation program, and leak recovery that would keep more of the pumped water in the distribution piping. CH2M and GSI presented water supply options to the City Council. Based on the input from that presentation, CH2M refined the options, and the resulting list of alternatives evaluated is shown in Table 5-3.

TABLE 5-3
Water Supply Source Options

Category	Option Number	Source Option
Wells	1	Develop Test Well
	2	Additional Spring Area Wells
	3	Additional In-town Wells
	4	Vineyard Well North of Town (formerly Black Family)
	5	Reactivate Well 4
	6	Replace Well 4

TABLE 5-3
Water Supply Source Options

Category	Option Number	Source Option
Riverbank/Surface Water	7	Riverbank Filtration Well
	8	Ranney Collector Well - Dundee Side of River
	9	Ranney Collector Well - Ash Island
	10	Ranney Collector Well - Marion Co. Side of River
	11	Surface Water Intake
Regional	12	Newberg
	13	McMinnville W&L/Lafayette /Dayton/Carlton
Reuse in Riverside District	14	Reuse for Large Irrigation Users
	15	Reuse for Parks Irrigation in Riverside District
	16	Reuse for Parks and Residential Irrigation
Other	17	Aquifer Storage and Recovery
	18	Conservation Program
	19	Leak Recovery

Source Evaluation Criteria

Criteria were developed to assist the City in evaluating source options. These included five non-financial criteria and cost criteria that included both capital and operating costs. These criteria were proposed to reflect issues that are important to the City and to help identify which sources performed best when measured against those criteria. The 12 criteria were grouped in four general categories. The following criteria were reviewed with the City Council and used to evaluate the source options.

- Technical
  - Amount of treatment required
  - Proximity to existing transmission/distribution
  - Ability to use existing distribution system
  - Water characteristics—compatible with existing wells
- Ease of Implementation
  - Permitting
  - Need for intergovernmental agreements
  - Time required/schedule
- Cost
  - Capital
  - Operating
- Other
  - Autonomy/control
  - Environmental impacts
  - Public acceptance

To ease evaluation of the capital and operating costs, the lifecycle costs were calculated, then annualized, and divided by the approximate capacity of the option. This resulted in an annual cost per gpm of capacity that could be compared among the options.

CH2M conducted a preliminary comparative evaluation process to assess the options and their relative performance, as measured against the criteria. *Best-Good-Worst* ratings were applied to indicate relative performance of the options to one another. The details of the evaluation are shown in Figure 5-1. A full-size version of this figure is in Appendix C.

A second means to evaluate the source options was to plot the non-financial value ratings against the financial annual cost per gpm capacity. This plot is shown in Figure 5-2. The most attractive options are those in the lower right corner of the plot, where the options with lower cost and highest value are located.

Figure 5-3 shows the comparison of the cost per GPM of each option, including developer-related costs.

The assessment of the source options was reviewed with City Council, and nine options were selected for further investigation. The selected options are briefly described in Table 5-4.

TABLE 5-4
Water Source Options Selected for Further Investigation

Category	Option Number From Table 5-3	Source Option	Description
Wells	1	Develop Test Well (Well 13)	This well was placed in service during the course of the master planning process. It is projected to provide 250 gpm of water and is planned for use in the summer period. The volume available from this well will allow development of approximately 430 EDUs.
	2	Additional Spring Area Wells	The viability of additional wells in this area can be evaluated after the Well 13 is brought online. Well 13 will need to be run for one or more summer seasons to determine its actual yield and reliability of yield. If viable, this area can be another increment in the water supply.
	5	Reactivate Well 4	This well has been out of service for several years due to questions about whether it is hydraulically connected to the Willamette River. It is estimated that this well could be reactivated at relatively low cost and provide an opportunity to evaluate whether it is under the influence of surface water—at the same time being an increment of additional supply.
Riverbank/ Surface Water	8	Ranney Collector Well—Dundee Side of River	Exploration of the riverbank filtration supply did not prove to be feasible based on the testing conducted in 2014. While additional testing could be conducted on that source, it is assumed to not be viable at this point. The Ranney Collector Well may provide an effective way to collect Willamette River water, but its suitability is not certain, and will require additional investigation. It is nearly certain that a new surface water intake and treatment plant could be constructed. (See Option 11).
	11	Surface Water Intake	The City holds water rights on the Willamette River making the certainty of this option very high, albeit with higher costs. Developing the incremental supplies described in this table will provide time to investigate viability of the Ranney Collector Well (Option 8).
Regional	12	Newberg	This would involve constructing a new pipeline between Dundee and Newberg, approximately 2 miles long. Options for using Newberg water could include summer peaking supply or supplying an aquifer storage recovery well during the winter season, which could be lower cost water. Intergovernmental agreements between the cities would be necessary to utilize this source.

TABLE 5-4
Water Source Options Selected for Further Investigation

Category	Option Number From Table 5-3	Source Option	Description
Reuse in Riverside District	16	Reuse for Parks and Residential Irrigation	Reuse for Parks and Residential Irrigation in Riverside District—Creating a reuse supply and distribution system that would deliver irrigation water to parks and to residential customers appears to the make the best use of resources. While the cost for this supply option is higher than others, it serves other City goals and objectives for sustainability, efficient resource use, and other values. Even if reuse is not anticipated in the near future, providing underground distribution piping while the Riverside District is being developed will avoid having to install the infrastructure later when streets are paved. It is anticipated that substantial portions of the distribution system will be constructed by developers.
Other	18	Conservation Program	It is anticipated that the City will continue to advance messages and/or programs aimed at efficient water use in homes and businesses. While this will have an impact on water demands and serves broader City goals, the water savings cannot be reasonably quantified.
	19	Leak Recovery	The City has replaced many segments of old asbestos cement and steel water lines, and will continue those replacements in conjunction with flow-improvement projects and street improvement projects. In addition to these ongoing pipeline replacement programs, a multi-year project to reduce leakage to meet standards of the Water Management and Conservation Plan is recommended to reduce leakage to approximately one-half of current losses.

Well 13 is projected to provide water to serve additional development in the City equivalent to 430 EDUs. It is recommended that the City develop additional water sources incrementally, which will allow the City to take advantage of relatively lower-cost sources to address water supply requirements in the near term. This strategy will give the City time to evaluate viability of longer-term solutions, which are most likely to include surface water sources, and to prepare financial plans to pay for the infrastructure that will be required to meet the longer-term needs. The additional customers will also create a larger customer base to help support the improvements.

Recommendations related to well rehabilitation supply source capacity expansion needs are presented in Section 6.

5.2.2 Source Water and Water Rights Assessment

While the source analysis found that continued reliance on and further development of groundwater supplies appears to offer the City adequate supplies to the end of the study period, completing the proposed exploratory well drilling program will provide valuable information and data critical to this assessment. The City of Dundee source water assessment is summarized in Table 5-5.

TABLE 5-5
City of Dundee Source Water Assessment

	Year				
Projected Population and EDUs*	**2015**	**2020**	**2025**	**2030**	**2035**
Population	3,335	3,579	4,117	4,630	5,135
Equivalent Dwelling Units (EDUs)	1232	1322	1520	1709	1895
Projected Water Demand (mgd)					
Average Day Demand (ADD)	0.358	0.384	0.442	0.497	0.551
Maximum Day Demand (MDD)	0.692	0.743	0.854	0.961	1.066
Peak Hour Demand (PHD)	1.259	1.341	1.519	1.690	1.858
Available Sources (mgd)					
1. Spring Well Site			0.076		
2. Spring Well Site			0.078		
3. Deep Well Site			0.050		
5. Dundee Hills - Leased Well			0.144		
6. Dundee Hills – Leased Well			0.144		
7. Spring Well Site			0.115		
8. Spring Well Site			0.187		
9. First Street Well Site			0.079		
10. Alder Street Well Site			0.072		
13. Spring Well Site			0.360		
Total Available with Largest Out of Service (mgd)			0.759		
Total Available Source (mgd)			1.306		

*EDU calculations are discussed in the methodology section. The projected EDU growth rate is based 2015 Metro Projections prepared by PSU.

5.3 Pressure Zone Analysis

5.3.1 Overall System

As discussed in Section 2, Dundee's distribution system is currently separated into three service areas, or pressure zones. The planning criteria developed in Section 4 established acceptable service pressure limits for existing and proposed pressure zones. These criteria are used to determine optimal operating elevations of existing and proposed reservoirs and to evaluate existing and proposed pressure zones.

Table 5-6 summarizes ground elevation service limits for pressure zones and reservoir overflow elevations assuming gravity supply to all pressure zones from storage reservoirs.

TABLE 5-6
Pressure Zone Service Elevation and Pressure Summary

Pressure Zone	Service Elevation (feet)	Reservoir Overflow Elevation (feet)	Pressure Range (psi)
Lower	160–300	430	55–115
Intermediate	300–500	583	35–120
Upper	500–540	689	45–80

5.3.2 Upper Pressure Zone

The 689-foot or Upper Pressure Zone serves all customers above an approximate ground elevation of 500 feet. The zone includes approximately 23 acres designated for residential land uses. Service to this zone is provided by the 0.2 MG Reservoir, which is supplied water pumped from the Spring Wells site. The 0.2 MG Reservoir has an overflow elevation of approximately 688.7 feet. At saturation development, the estimated population of this pressure zone is approximately 124 people.

5.3.3 Intermediate Pressure Zone

The Intermediate Pressure Zone is the second largest pressure zone in the City and serves all customers between approximate ground elevations of 300 and 500 feet. Water is supplied to this zone by gravity from the 0.05 MG Reservoir, which has an overflow elevation of approximately 582.5 feet. The 0.05 MG Reservoir receives water through 8-inch-diameter piping from the 0.2 MG Reservoir. At saturation development of the Intermediate Pressure Zone, it is estimated that this zone will serve approximately 549 people.

5.3.4 Lower Pressure Zone

The Lower Pressure Zone is the largest pressure zone in the City and serves all customers below an approximate ground elevation of 300 feet. The zone includes approximately 376 acres of residential, commercial, and industrially designated land uses. Service to this zone is provided by gravity from the 0.4 MG Reservoir, and pumped supply from Wells 9 and 10. In high demand periods, Wells 5 and 6, also referred to at the Dundee Hills wells, provide additional supply. Under normal operating conditions, water is pumped from Well 3 directly into the 0.4 MG Reservoir, which has an overflow elevation of approximately 429.9 feet. Water is also supplied to the 0.4 MG Reservoir from the 0.05 MG Reservoir under high demand conditions. At saturation development of the service area and without transfers to the Riverside District Zone as discussed below, it is estimated that approximately 2,845 people would be served in this zone. After transfer, an estimated 2,030 people will be served in this zone.

5.3.5 Proposed Riverside District Pressure Zone

A new pressure zone is proposed to serve the Riverside District. The plan calls for this new pressure zone to receive a new storage reservoir, booster pump station, and PRV stations so that the entire Riverside District area is served by a new pressure zone with pressures normally in the 50 to 70 psi range.

The Riverside District Pressure Zone should be formed when the first major subdivision is added to the Riverside District. The storage tank and booster pump station will be needed to supply fire flow to the existing commercial and light industrial facilities that will be included in the Riverside District zone.

Prior to the development of the Willamette Water Supply, water will be supplied to the Riverside District Zone through three PRVs – one located at the ground level storage tank, one at the south end of the pressure zone at the east side of the railroad tracks, and one at the north end of the pressure zone along the east side of the railroad tracks. A main line from the Lower Pressure Zone to the ground level storage tank will be the only pipeline on the east side of the railroad tracks that is operated on the Lower Pressure Zone head. That line will have bi-directional capabilities, feeding water from the Lower zone to the reservoir through the PRV, and feeding water from the reservoir to the Lower Pressure Zone, by using the booster pump station, when needed.

The booster pump station, located at the Riverside District reservoir will have pumps that can supply water to the Riverside District zone, as well as to the Lower Pressure Zone, when needed.

Once a new source is provided from the Willamette River, either as a surface supply or through riverbank filtration, the new source will feed directly into the Riverside District ground level reservoir. That supply can serve the Riverside District and the Lower Pressure Zone through the booster pump station.

When the Riverside District Zone is created, service to an estimated 300 connections will be transferred from the Lower Pressure Zone to the Riverside District Zone. The projected 2035 population of the Riverside District is estimated to be 1,617. After the 300 connections are transferred to the Riverside District Zone, the 2035 population is estimated at 2,432.

5.4 Storage Capacity Analysis

5.4.1 General

The storage capacity analysis evaluates existing storage capacities and determines recommended storage volume needs for the water service area and for each pressure zone. Reservoir capacity requirements are developed based on the planning criteria presented in Sections 3 and 4. Estimated reservoir storage volume requirements are based on equalization, standby (or “emergency”), and fire suppression storage volume needs. Table 5-7 summarizes existing storage volume needs and estimated needs for each 5-year period. Generally-accepted engineering practice is to incorporate standby storage within the fire flow storage, referred to as “nesting;” this approach was used to establish the required storage volume shown in Table 5-7. Table 5-8 compares the required 2015 and 2035 storage in each pressure zone with the existing storage.

TABLE 5-7
Storage Volume Analysis Summary

	Year				
	2015	**2020**	**2025**	**2030**	**2035**
Required Storage					
Equalizing Storage (gallons)	138,400	148,600	170,800	192,200	213,200
Standby Storage (gallons)	246,400	264,400	304,000	341,800	379,000
Fire Flow Storage (gallons)	960,000	960,000	960,000	960,000	960,000
Required Storage Volume > 30 psi (gallons)*	1,098,400	1,108,600	1,130,800	1,152,200	1,173,200
Existing Storage > 30 psi					
Upper Zone Reservoir (gallons)	200,000	200,000	200,000	200,000	200,000
Intermediate Zone Reservoir (gallons)	400,000	400,000	400,000	400,000	400,000
Lower Zone Reservoir (gallons)	400,000	400,000	400,000	400,000	400,000
Total Storage Available (gallons)	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000

*Standby storage is nested in fire flow storage.

TABLE 5-8
Storage Volume Comparison by Zone

Pressure Zone	Storage Requirements (MG)		Existing Storage Capacity (MG)*	Storage Deficit (MG)	
	Existing	2035		Existing	2035
Upper	0.12	0.13	0.2	-	-
Intermediate	0.14	0.24	0.6	-	-
Lower	1.07	1.08	1	0.07	0.08
Riverside District	NA	0.99			0.99

*Existing storage capacity for each zone includes storage in zones above it that is available through PRVs.

5.4.2 Upper Pressure Zone

The results of the storage capacity analysis indicate that there is sufficient storage volume capacity in the Upper Pressure Zone to serve this pressure zone under current conditions and at 2035 conditions. While some transmission main improvements have been made between the 0.2 MG Reservoir and the Upper Pressure Zone to provide adequate flow capacity during fire and emergency events, the pipeline upgrades need to be completed. These improvements are discussed later in Section 6.

5.4.3 Intermediate Pressure Zone

The results of the storage capacity analysis indicate that there is sufficient storage volume capacity in the Intermediate Pressure Zone to serve this pressure zone under current conditions and at 2035 conditions.

5.4.4 Lower Pressure Zone

The result of the storage capacity analysis indicates the existing storage volume of the Lower Pressure Zone is inadequate to serve existing and future needs. This deficit will be reduced when the Riverside District Zone is created and service to an estimated 300 connections are transferred from the Lower Pressure Zone to the Riverside District Zone. Upon further review of the storage requirements and the location of future growth in the City's system, it was determined that the storage needs of the Lower Pressure Zone could be best met by constructing a storage facility that could serve the Lower Pressure Zone and the Riverside District Pressure Zone.

5.4.5 Riverside District Pressure Zone

The Riverside District zone will be served with a new storage facility that will provide the equalization and fire flow storage requirements for the Riverside District Pressure Zone and the Lower Pressure Zone. As such, the Lower Zone and the Riverside District Zone would be counted together and not as two separate storage volumes. This storage facility will be a ground storage tank and will be equipped with a dual-zone pump station that can pump to both the Lower Pressure Zone and the Riverside District Pressure Zone. The primary source of supply to the new storage reservoir will be from the new supply source in the Riverside District. Transmission piping will be required to connect the reservoir to the zones that it will serve. One million (1,000,000) gallons of storage is recommended to provide fire storage in this pressure zone.

5.5 Distribution System Analysis

Evaluation of the Dundee water system was conducted by using a distribution system network analysis model. The network model utilizes a digital representation of the distribution system based upon the City's water network in AutoCAD. The software that was used for the distribution system analysis was Innovyze InfoWater, and the analysis results for system pressures and flow were reviewed in the ArcGIS environment. The distribution system was evaluated for a range of demand scenarios as defined in Section 3, and performance of the distribution system was evaluated against planning criteria presented in Section 4. In areas where the distribution system performance did not meet the planning criteria, deficiencies were identified, and system improvements were developed to alleviate those deficiencies.

5.5.1 Distribution System Piping

A summary of the distribution system piping by diameter and material was presented in Table 2-3. In this table, it is shown that 7,709 feet (6.3 percent) of the water distribution system piping is asbestos cement piping. This City desires to incorporate replacement of all asbestos cement piping as part of the master plan. Therefore, system improvements developed as part of the hydraulic modeling assessment also considered the opportunities for replacement of asbestos cement pipe and potentials for upsizing of that piping to alleviate any other observed deficiencies. Piping improvements that are solely to replace asbestos cement pipe are identified in Section 6.

5.5.2 Hydraulic Model

The hydraulic model was developed by importing the AutoCAD water network drawing into InfoWater. Because the AutoCAD file is primarily used for graphical representation of the water system, system connectivity had to be updated and verified through the water distribution system model. Diameter and material information was manually input into the hydraulic model based upon the annotation information shown on the City's AutoCAD file, and water demand was allocated spatially based upon the location of customer water meters. The customer demand was applied equally to the customer meters and then allocated to the hydraulic model.

Well, pump, reservoir, and valve features in the water distribution system were manually entered into the hydraulic model, and the hydraulic parameters such as capacity and size of these facilities were input into the hydraulic model.

5.5.3 Model Calibration

To confirm that a computer model simulates the field performance observed for a water distribution system, model calibration is conducted by comparing actual field conditions to the model performance. Hydrant flow tests are often included as part of the model calibration because the hydrant tests simulate a high flow condition to induce a pressure drop in the water distribution system. The pressure drop measured in the field is compared to the modeled pressure drop for the same conditions. When model results do not align with the field results, modifications to the model input are made to better match the field results.

City staff assisted in conducting five hydrant flow tests. Results from the hydrant flow tests were simulated by the hydraulic model. Only minor adjustments to the hydraulic model were required to bring the model within ten percent of the field test results. Based upon this level of calibration, the hydraulic model can be confidently applied for system planning evaluations.

5.5.4 Modeling Conditions

The hydraulic model was applied for a range of demand conditions to assess the capability of the distribution system to meet required pressures under existing and future demand scenarios. The demand projections for each of the planning horizons shown in Table 5-1 and Table 5-2 were applied in the hydraulic model for both MDD and peak hour demand and system pressures were assessed. For the peak demand conditions, system pressures were assessed against a minimum pressure of 45 psi and a maximum pressure of 115 psi. In addition to the peak usage simulations, available fire flow during MDD conditions was also assessed. The assessment for available fire flow was conducted based upon the fire flow required within the zoning boundaries. The required fire flow was assessed at a required pressure of 20 psi.

5.5.5 Modeling Results

5.5.5.1 System-wide Modeling

The results of the hydraulic modeling for the demand scenarios showed that the system can meet the minimum pressure criteria and that the areas along Highway 99W and to the south experience pressures greater than 115 psi under normal conditions. The pressures are elevated in these areas based upon the operating HGL of the water storage reservoir for this pressure zone. Figures showing the model predicted pressures for each of the demand scenarios are included in Appendix D.

To alleviate the high pressures in the low pressure zone, a subzone that operates at an HGL lower than the HGL of 429.9 feet of the 0.4 MG reservoir was considered.

5.5.5.2 Fire Flow Modeling

The results of the fire flow simulations indicated that improvements are required to meet the fire flow requirements identified in Table 4-2. Results showing the deficient areas of fire flow are shown in Appendix D. The improvements considered for meeting the fire flow requirements included upsizing of existing mains, creating hydraulic loops by connecting existing piping, and incorporating a new pump station to serve the Low Pressure Zone from the south rather than only having supply to this zone from the 0.4 MG Reservoir.

The specific fire flow improvements incorporated into the master plan are shown in Section 6.

5.5.5.3 System Expansion

Growth in the City's system is focused in the Low Pressure Zone, in the Riverside District. The evaluation of the growth in this area was accomplished by developing a new network of piping that builds upon existing piping to convey water into this developing area. The sizing of the piping in the system expansion area was done so that the system hydraulic performance meets the system criteria for pressure and required fire flow. The improvements that are a result of system expansion are specifically identified in Section 6.

5.5.5.4 Unaccounted-for Water Evaluation

A metric used in measuring effectiveness of a water system is unaccounted-for water. This includes water that leaks from the distribution system, water usage under-registered by inaccurate meters, and un-metered or unauthorized use of water. Typically, the volume of water produced is compared with the volume of water billed to determine what percentage of the water produced is unaccounted-for. A review of data for the previous 4 years showed that the annual average unaccounted-for water ranged between 18.5 percent and 28.5 percent. This level of unaccounted-for water is on the higher end of acceptable unaccounted-for water for a water system. It is recommended that the City review its water auditing approach and use the AWWA water auditing tools to review their performance against other utilities and also provide a systematic approach to identifying and reducing non-revenue water. One of the outcomes of the water audit is anticipated to be a leak detection survey and leak repair program, so this program is recommended to be included in the CIP.

5.5.5.5 Water Conservation Plan

In 2012, the City prepared a Water Management and Conservation Plan, which will need to be updated in 2017 to comply with Oregon Water Resources Department administrative rules. The 2012 plan included the following elements:

- ***Existing Condition Review and Facilities Inventory*** – Preparation of a system inventory including existing wells, distribution and transmission facilities, storage reservoirs, telemetry, pump stations and other water system facilities.
- ***Water Supply Element*** – Review information related to service area; land use and population distribution to develop population projections. Review City water right records, existing water production and demand data, patterns and estimates of future water usage, and compare the water supply to future projected water demands for the City's service area.

- ***Water Conservation Element*** – Documentation of the City's current water conservation program, review the program effectiveness through, and analysis of, historical per capita usage, and develop additional water conservation recommendations in accordance with OAR Division 86, including:
    - Source and customer metering
    - Water system audits
    - Leak detection and repair
    - On-going water main replacement
    - Water rate and billing practices
    - Public education
    - Wastewater reuse
- ***Water Curtailment Element*** – This task includes documenting, reviewing and updating the City's current water curtailment plan and related ordinances. Included in this effort is the development of a water curtailment plan that includes stages, triggers, curtailment goals and implementation measures.
- ***Evaluate Unaccounted-for Water*** – Calculate the City's unaccounted-for water, which includes such uses as firefighting, system flushing, line breaks and leaks, unmetered usage, improperly registering meters and possible unauthorized or unrecorded connections to the system. The system's level of unaccounted-for water was analyzed in the District's Water System Master Plan. Discrepancies were reported which prevented an accurate assessment of system water loss. Recommendations to quantify unaccounted for water were developed and presented.

Figure 5-1
City of Dundee
Water Source Options Evaluation
January 2015

Category	Option Number	Source Option	Capacity (gallons per minute/ million gallons per day)	Technical: Technical Aspects	Implementation: Ease of Implementation	Governance: Autonomy/Control (more is better)	Environment: Environmental impacts (less is better)	Customer: Public Acceptance (more is better)	Overall Non-Financial Value	Cost: Capital	Cost: Operating	Cost: Annual Cost per gpm of Capacity	Cost: Cost	Overall Combined Non-Financial Value and Cost	Value per 1000 Dollars (Annual Cost)	Notes
Wells	1	Develop Test Well	250 gpm/ 0.36 mgd	Best	Best	Best	Best	Best	Best	$ 500,000	$ 7,152	$176	Best	Best	130	Based on use as peaking supply
	2	Additional Spring Area Wells	250 gpm/ 0.36 mgd	Best	Good	Best	Best	Best	Best	$ 850,000	$ 7,152	$279	Best	Best	81	Based on use as peaking supply
	3	Additional In-town Wells	50 gpm/ 0.072 mgd	Best	Best	Best	Best	Best	Best	$ 850,000	$ 13,052	$1,512	Good	Best	16	
	4	Vineyard Well North of Town (formerly Black Family)	50 gpm/ 0.072 mgd	Best	Best	Best	Best	Best	Best	$ 500,000	$ 13,052	$997	Best	Best	23	
	5	Reactivate Well No. 4	45 gpm/ 0.065 mgd	Best	Best	Best	Best	Best	Best	$ 75,000	$ 11,747	$384	Best	Best	64	
	6	Replace Well No. 4	45 gpm/ 0.065 mgd	Best	Best	Best	Good	Best	Best	$ 850,000	$ 11,747	$1,651	Best	Best	13	
Riverbank/ Surface Water	7	Riverbank Filtration Well	0	Best	Good	Best	Good	Good	Good	-	-	-	N/A	N/A	N/A	Capacity unknown at this time
	8	Ranney Collector Well - Dundee Side of River	1750 gpm/ 2.52 mgd	Best	Good	Best	Good	Good	Best	$ 3,870,000	$ 130,524	$237	Best	Best	79	
	9	Ranney Collector Well - Ash Island	1750 gpm/ 2.52 mgd	Best	Worst	Best	Worst	Good	Good	$ 4,370,000	$ 130,524	$258	Best	Best	55	
	10	Ranney Collector Well - Marion Co. Side of River	1750 gpm/ 2.52 mgd	Good	Worst	Best	Worst	Good	Good	$ 7,870,000	$ 130,524	$405	Best	Best	33	
	11	Surface Water Intake	1750 gpm/ 2.52 mgd	Good	Good	Best	Worst	Good	Good	$ 6,500,000	$ 380,524	$491	Best	Best	31	
Regional	12	Newberg	1750 gpm/ 2.52 mgd	Best	Good	Worst	Good	Good	Good	$ 1,689,600	$ 116,086	$137	Best	Best	100	Based on use as peaking supply at 300 gpm
	13	McMinnville W&L/Lafayette/Dayton/Carlton	1750 gpm/ 2.52 mgd	Best	Good	Worst	Good	Good	Good	$ 3,379,200	$ 232,171	$275	Best	Best	48	Based on use as peaking supply at 300 gpm
Reuse in Riverside District	14	Reuse for Large Irrigation Users	226 gpm/ 0.325 mgd	Worst	Good	Best	Best	Best	Best	$ 3,538,000	$ 15,500	$1,220	Good	Good	16	
	15	Reuse for Parks Irrigation in Riverside District	43 gpm/ 0.062 mgd[1]	Worst	Worst	Best	Best	Best	Best	$ 3,310,000	$ 10,000	$5,897	Worst	Good	3	
	16	Reuse for Parks and Residential Irrigation in Riverside I	174 gpm/ 0.251 mgd	Worst	Good	Best	Best	Good	Good	$ 2,400,000	$ 10,000	$860	Good	Good	21	Capital cost is City-financed portion only
Other	17	Aquifer Storage and Recovery[2]	300 gpm/ 0.43 mgd	Best	Best	Best	Best	Best	Best	$ 850,000	$ 35,760	$328	Best	Best	72	Enhances reliability of existing wells; requires surface or regional supply
	18	Conservation Program	Unknown	Best	Best	Best	Best	Best	Best	-	-	-	N/A	N/A	N/A	
	19	Leak Recovery	22 gpm 0.032 mgd[3]	Best	Best	Best	Best	Best	Best	$ 75,000		$251	Best	Best	98	Assumes $15,000 per year investment for 5 years

Evaluation Relative to Other Options: (filled circle) **Best** (half circle) **Good** (empty circle) **Worst**

Notes
1. Based on three parks similar in size and use as Falcon Crest Park
2. Requires surface source
3. Based on leak reduction to achieve goal of Water Management and Conservation Plan

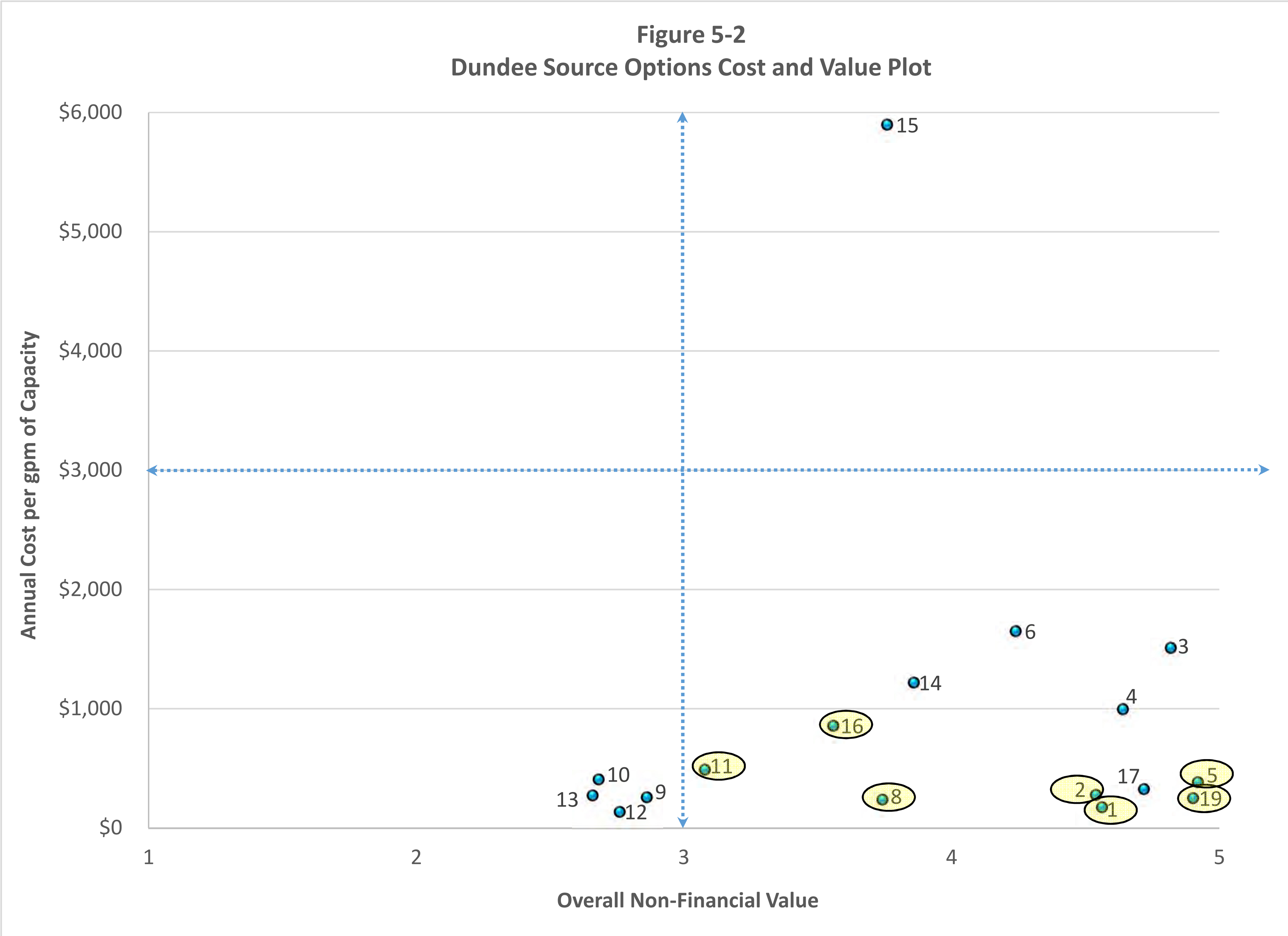
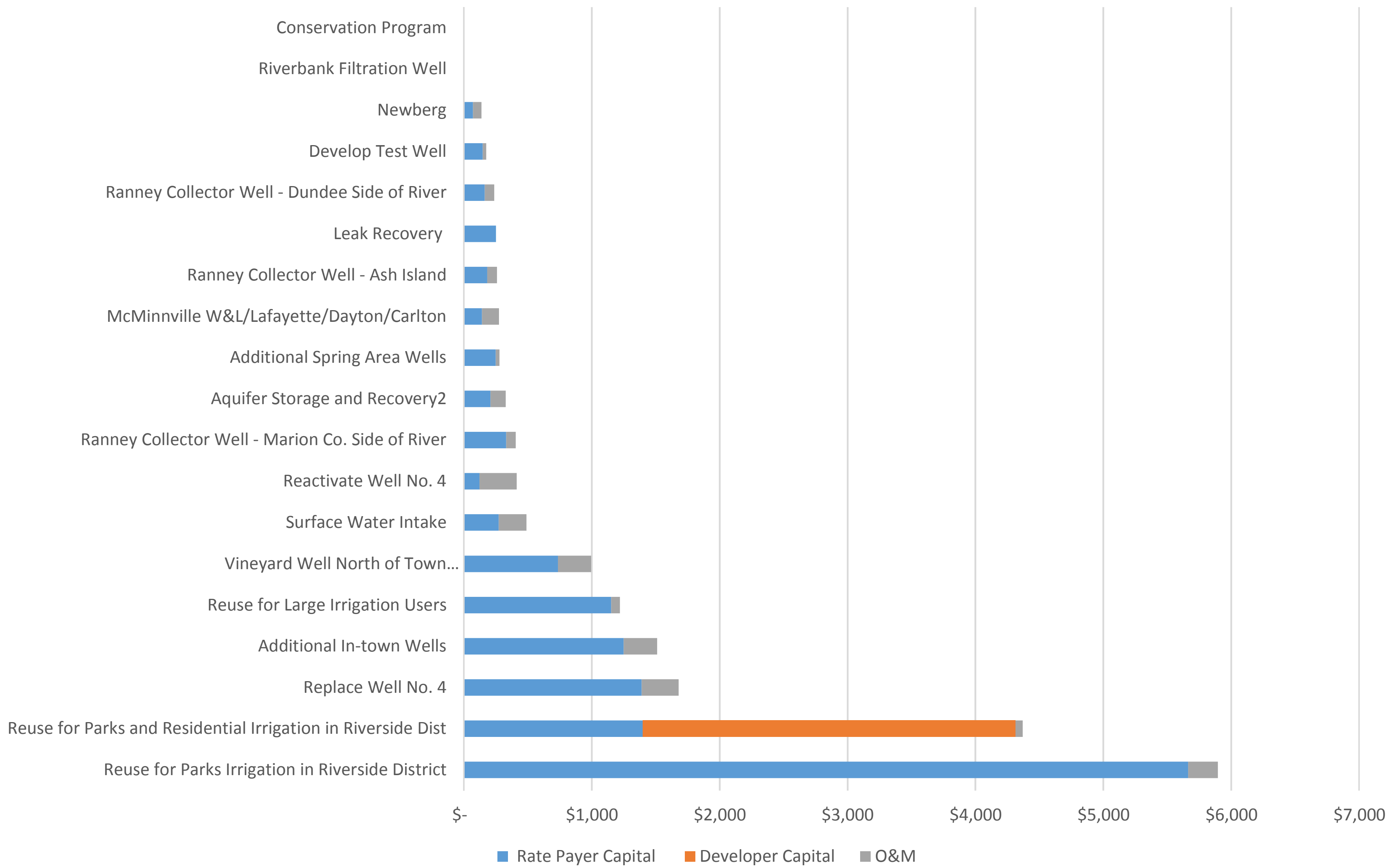


Figure 5-2
Dundee Source Options Cost and Value Plot
Annual Cost per gpm of Capacity
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
1
2
3
4
5
Overall Non-Financial Value
15
6
3
14
4
16
11
10
13
9
12
8
17
2
5
1
19

Figure 5-3
City of Dundee Water Supply Options
Annual Cost per gpm of Capacity



SECTION 6

Recommendations and Capital Improvement Plan

6.1 General

This section presents recommended water system improvements based on the analysis and findings presented in Section 5. These improvements include proposed supply source, reservoir, pump station and water line improvements. The recommended improvements are summarized in Table 6-1. The locations of the improvements are shown in Figure 6-1.

6.2 Cost Estimating Data

Cost estimates for the recommended improvements are summarized in Table 6-1. Additional cost estimating detail is provided in Appendix E, which includes a cost data summary for recommended water main improvements developed on a unit cost basis. Project costs include construction costs and an allowance for administrative, engineering and other project related costs.

The project cost estimates are given in 2015 dollars at an *Engineering News-Record* 20-City Construction Cost Index value of 10,092. Prior to finalizing funding for a project, it will be necessary to update the cost estimate to current costs and to develop a preliminary design to further define the project.

6.3 Recommended Improvements

6.3.1 General

Presented below are recommended water system improvements for supply sources, reservoirs, pump stations, distribution system water lines, and other facilities. The recommendations are presented by project type.

The recommended improvements are listed in Table 6-1 with cost estimates. Table 6-1 provides for prioritized project sequencing by showing fiscal year project needs for each facility or improvement category. The proposed improvements listed are phased and sequenced for construction over the planning period of 20 years.

Also presented is a discussion of other recommended improvements and programs.

6.3.2 Source Improvements

It is anticipated that the City will continue to seek a riverbank filtration option, as an alternative for developing the Willamette Water Supply. Additional sources are needed within the next 10 years, so the City has approximately 5 years to evaluate potential riverbank or horizontal collector well options before deciding on an approach for developing its next source of supply.

6.3.3 Riverside District Improvements

A new pressure zone will be created to serve the Riverside District. The plan calls for this new pressure zone to receive a new storage reservoir, booster pump station, and PRV stations so that the entire Riverside District area is served by a new pressure zone with pressures normally in the 50 to 70 psi range.

The Riverside District Pressure Zone should be formed when the first major subdivision is added to the Riverside District. The storage tank and booster pump station will be needed to supply fire flow to the existing commercial and light industrial facilities that will be included in the Riverside District zone.

Prior to the development of the Willamette Water Supply, water will be supplied to the Riverside District Zone through three PRVs – one located at the ground level storage tank, one at the south end of the pressure zone at the east side of the railroad tracks, and one at the north end of the pressure zone along the east side of the railroad tracks. A main line from the Lower Pressure Zone to the ground level storage tank will be the only pipeline on the east side of the railroad tracks that is operated on the Lower Pressure Zone head. That line will have bi-directional capabilities, feeding water to the reservoir through the PRV, and feeding water from the reservoir to the Lower Pressure Zone, by using the booster pump station, when needed.

The booster pump station, located at the Riverside District reservoir, will have pumps that can supply water to the Riverside District pressure, as well as to the Lower Pressure Zone, when needed.

Once a new source is provided from the Willamette River, either as a surface supply or through riverbank filtration, the new source will feed directly into the Riverside District ground level reservoir. That supply can serve the Riverside District and the Lower Pressure Zone through the Booster pump station.

6.3.4 Distribution System Improvements

The analysis found that distribution system water line improvements are needed to provide improved hydraulic transmission capacity within the distribution system, provide improved fire flow capacities, and provide for system expansion needs. Section 5 presented detailed evaluations of each pressure zone. The distribution piping, new source development, and new storage and booster pump improvement projects identified in that analysis are listed in the CIP. The recommended distribution system improvements are grouped into the following general categories:

Table 6-1 presents recommended water system improvements and the anticipated fiscal year construction is anticipated, up to fiscal year 2034. Each improvement is identified by category and includes an estimated project cost. Certain improvements are recommended for completion within the next 2 fiscal years. The recommended water line improvements are described briefly below.

6.3.5 Ongoing Water Main Replacement Program

It is recommended that the City's current water main replacement program continue. This program provides for the routine replacement of leaking, damaged, and older water mains throughout the water system. In most cases the existing mains have adequate capacity and will be replaced with the same diameter water mains. It is recommended that $30,000 be budgeted biennially for this program.

6.3.6 Leak Detection

It is recommended that the City continue to monitor its unaccounted-for water and continue leak detection and repair efforts. It is also recommended that the City continue its ongoing meter testing and replacement programs and its water main replacement program as previously discussed in this section. The recent completion of telemetry system improvements will also allow the City to more closely and accurately monitor its water production and consumption data, as well as improve operations.

6.3.7 Recycled Water Projects

The City developed a Recycled Water Feasibility Study in 2013 (Kennedy/Jenks Consultants, 2013), which recommended installation of 500,000 gallons of storage and 500 gpm of pumping capacity for recycled water at the City's Wastewater Plant. The CIP includes the first phase of this project by developing 250 gpm of pumping capacity and 125,000 gallons of storage. The City has adopted non-potable water distribution standards into its Improvement Design Standards manual, and these recycled water projects will allow the City to supply recycled water for irrigation systems within the Riverside District. All new developments within the Riverside District will install the necessary distribution system for recycled water to and through their development. Connection to and use of the recycled water system will be through a voluntary, incentive-based program that the City will develop. The City will need to re-assess the storage and pumping requirements of the recycled water system as development in the Riverside District occurs and the popularity of the recycled water systems can be ascertained.

6.4 Study Recommendations

Completion of the water system master plan study triggers recommendations for subsequent action by the City. The list below describes recommended actions for formal adoption of the plan, including the capital improvements in the CIP, and developing the finance plan and required water rates to fund the water system. The SDC component of the funding sources is presented in a separate document titled, *City of Dundee System Development Charge Methodology and Fees* (CH2M, 2016).

It is recommended that the City take the following actions:

1. Formally adopt this plan as the City of Dundee's Water System Master Plan for the water service area.
2. Adopt the recommended capital improvements described in Section 6 and specifically listed in Table 6-1 as the CIP for the water service area.
3. Develop and adopt a financing plan to implement the capital improvements recommended in this study.
4. Update the City's current system development charges (SDCs) to reflect the system improvements recommended in this plan and to collect the value of the capacity of existing system available to meet future needs.
5. Adopt a water rate increase plan to fund needed system improvements.
6. Review and update this plan within 5 to 7 years to accommodate changed or new conditions.

TABLE 6-1
Recommended Improvements

	Project	Pipe Diameter (inches)	Length (feet)	Project Type	Streets	2015 Cost	Year Scheduled	Percent Expansion	Percent Existing	Growth CIP	Existing Customer CIP
Distribution Piping Projects											
DS-1A	Parkway Loop - Segment A	12	2,365	Parkway Extension	From SE 11th St. and Highway 99W to SE Parks Dr. and along SE Parks Dr. to SE Edwards Dr.	$682,000	2023, 2027, 2029	100%	0%	$719,000	$0
DS-1B	Parkway Loop - Segment B	8	695	Parkway Extension	Parallel existing 8-inch pipe along SE Edwards Dr. between SE Parks Dr. and wastewater treatment plant entrance	$134,000	2031	100%	0%	$125,000	$0
DS-1C	Parkway Loop - Segment C	12	3,428	Parkway Extension	Along planned alignment for Parkway Collector	$988,000	2022, 2031	100%	0%	$1,245,000	$0
DS-2	Viewmont - 10 inch	10	1,692	Fire Flow	Along NW Viewmont Dr. between NW Walnut St. and the reservoir	$407,000	2033	0%	100%	$0	$356,000
DS-3A	Reservoir Fill from New Source	12	1,535	Riverside Expansion	From SE 8th St. and SE Edwards along SE 8th St. to new reservoir site; also replaces some steel	$443,000	2031	100%	0%	$373,000	$0
DS-3B	Reservoir Discharge to Intermediate	10	879	Intermediate Zone Supply	Along SE 7th St. between Highway 99W and SE Maple St.	$211,000	2031	0%	100%	$0	$335,000
DS-4	9th Street - 8 inch	8	1,322	Fire Flow	Along SW 9th St. between Highway 99W and SW Alder St.	$254,000	2017, 2018	0%	100%	$0	$236,000
DS-5	99W - 10 inch	10	1316	Fire Flow	Along Highway 99W at multiple locations, developer installed	$316,000	2018, 2020, 2022, 2024	0%	100%	$0	$0
DS-6	Walnut - 8 inch	8	241	Fire Flow	Along SW Walnut St. between SW 1st St. and SW 2nd St.	$47,000	2035	0%	100%	$0	$47,000
DS-7	Hemlock - 8 inch	8	619	Fire Flow	Along SW Hemlock St between SW 1st St. and SW 3rd St.	$119,000	2035	0%	100%	$0	$111,000
DS-8	Elm - 8 inch	8	344	Fire Flow	Along SE Elm St. between SE 10th St. and SE 11th St.	$67,000	2019	0%	100%	$0	$64,000
DS-9	Worden Hill - 12 inch	12	3,970	Asbestos Cement Replacement	Replace remainder of 8-inch supply line from Spring Wells with 12-inch along NE Fairview Dr. and NE Worden Hill Rd.	$1,144,000	2026, 2028, 2030, 2032	0%	100%	$0	$954,000
DS-10A	Canyon Drive - 6 inch	6	387	Asbestos Cement Replacement	Along NW Canyon Dr. to SW 1st St.; along SW 1st St. between NW Alder St. and NW Walnut St.	$56,000	2035	0%	100%	$0	$58,000
DS-10B	1st Street - 8 inch	8	568	Asbestos Cement Replacement	Along NW Canyon Dr. to SW 1st St.; along SW 1st St. between NW Alder St. and NW Walnut St.	$110,000	2035	0%	100%	$0	$103,000
DS-11	Alder Terrace Hydrant	8	335	Asbestos Cement Replacement	From SW Alder St. through Alder Terrace Mobile Estates (does not run along any road)	$65,000	2035	0%	100%	$0	$62,000
DS-12	5th Street - 12 inch	12	688	Fire Flow	6-inch upsize to 12-inch along SW 5th St. across Dundee School/Billick Park frontage	$199,000	2020	0%	100%	$0	$168,000
DS-13	Alder Street - 8 inch	8	636	Steel Replacement	4-inch to 8-inch along NW Alder St. between NW Viewmont Dr. and SW 1st St.	$123,000	2025	0%	100%	$0	$116,000
DS-14a	Dogwood - 8 inch	8	917	Steel Replacement	6-inch to 8-inch along NW Dogwood Dr. between SW 1st St. and NW Viewmont Dr. and along NW Viewmont Dr. between NW Dogwood Dr. and NW Laurel St.	$177,000	2016	0%	100%	$0	$277,000
DS-14b	Viewmont - 8 inch	8	596	Steel Replacement	6-inch to 8-inch along NW Viewmont Dr. between NW Alder St. and NW Dogwood Dr.	$115,000	2021	0%	100%	0%	$115,000
DS-15	Locust - 8 inch	8	1,021	Steel Replacement	4-inch to 8-inch along SE Locust St. between SE 8th St. and SE 10th St.	$197,000	2016	0%	100%	$0	$125,000
DS-16	99W - 10 inch	10	604	Steel Replacement	4-inch to 10-inch along Highway 99 near SW 3rd St.	$145,000	2016	0%	100%	$0	$0
DS-17	99W - 10 inch	10	1,771	Steel Replacement	Along Highway 99 between SW 7th St. and SW 12th St.	$426,000	2016	0%	100%	$0	$0
DS-18	Walnut - 8 inch	8	683	Service Extension	Along NW Walnut St. between NW Viewmont Dr. and SW 1st St.	$132,000	2022	0%	100%	$0	$123,000
DS-19	Red Hill Line Extension	6	486	Service Extension	Extension along SW Red Hills Dr. to move service from PVC line on steep slope	$70,000	2018	0%	100%	$0	$74,000
DS-20	Red Hills Rd - 12 inch	12	1,752	Fire Flow	Replacement of 8-inch CIP from Asbestos Cement Replacement to Viewmont Drive Replacement	$505,000	2034	0%	100%	$0	$423,000
DS-21	Small Water Line Replacement	Varies	Varies	Annual Program	Replacement of small water lines ($30,000 every other year)	$300,000	Biennial	0%	100%	$0	$300,000

TABLE 6-1
Recommended Improvements

	Project	Pipe Diameter (inches)	Length (feet)	Project Type	Streets	2015 Cost	Year Scheduled	Percent Expansion	Percent Existing	Growth CIP	Existing Customer CIP
DS-22	Leak Reduction	Varies	Varies	Annual Program	Leak detection in distribution system ($10,000 every other year)	$100,000	Biennial	0%	100%	$0	$100,000
New Source Development Projects										**$0**	**$0**
	Project		**Capacity (gpm)**		**Description**						
SO-1	Source Evaluation		NA		Test Drilling for Ranney Well/Riverbank Filtration	$100,000	2018	100%	0%	$100,000	$0
SO-2	Source Evaluation		NA		Test Drilling for Ranney Well/Riverbank Filtration	$100,000	2019	100%	0%	$100,000	$0
SO-3	Source Evaluation		NA		Test Drilling for Ranney Well/Riverbank Filtration	$100,000	2020	100%	0%	$100,000	$0
SO-4	Source Development		730		Willamette River Intake, Water Treatment Plant (1 mgd), Asbestos Cement Pipe Replacement	$5,543,000	2025	40%	60%	$2,217,200	$3,325,800
New Storage and Booster Pump Projects											
	Project		**Capacity (gpm)**		**Description**						
ST-1	Tank/Booster Pump		2,500		New Ground Level Reservoir (1.0 MG) and Booster Pump for New Riverside District Zone	$1,500,000	2017	100%	0%	$1,500,000	$0
ST-2	Pressure Reducing Valve Stations (3)		2,500		Two New PRV Stations (one additional PRV is located in the Booster Pump Station)	$180,000	2017	100%	0%	$180,000	$0
Recycled Water Projects											
	Project	**Capacity (gpm)**		**Volume (gallons)**	**Description**						
RE-1	Reservoir and Pump Station	250		125,000	New Steel Reservoir and Pump Station for Recycled Water Supply	$800,000	2020	100%	0%	$800,000	$0

NA = not applicable.

SECTION 7
References

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Appendix A
Dundee Water Rights

TABLE A-1. Water Rights Summary

City of Dundee

City Source Name	Oregon Water Resources Department Source Name	Permit Rate (cfs) (gpm)	Pump Capacity (gpm)	Application Number	Permit Number	Certificate Number	Status or Recommendation	Priority Date	Point of Use Identification	Use	Township, Range & Section	1/16 Section
Spring	A Spring, Otter/Harvey Creek[1]	0.25 (112)	0	9028	S5932	8781	Complete	6/20/23	11394	MU-A	3S.3W.27	NW NE
Spring	A Spring, Otter/Harvey Creek[1]	0.25 (112)	0						11396	MU-P	3S.3W.27	SE NW
Spring	A Spring 1, Otter/Harvey Creek[1]	0.05 (22)	0	12629	S8978	8817	Complete	3/25/29	11386	DO-P	3S.3W.27	NW NE
Spring	A Spring 1, Otter/Harvey Creek[1]	0.05 (22)	0						"	IM-A	3S.3W.27	NW NE
Spring	A Spring 2, Otter/Harvey Creek[1]	0.05 (22)	0						11387	DO-A	3S.3W.22	SW SE
Spring	A Spring 2, Otter/Harvey Creek[1]	0.05 (22)	0						"	IM-A	3S.3W.22	SW SE
Mossy Spring	Mossy Spring, Otter/Harvey Creek[1]	0.007 (3)	0	18173	S13880	14654	Complete	6/8/39	11395	DO-P	3S.3W.27	NW NE
Otter/Harvey Creek[1]	Otter/Harvey Creek[1]	0.25 (112)	0	22077	S17367	17145	Complete	11/7/46	11388	MU-P	3S.3W.22	SW SE
Willamette River	Willamette River	4.0 (1795)[2]	0	58951	S44462	-	Completion date is 10/1/2025[3]	7/24/79	30162	MU-P	3S.2W.30	SW SW
Well 1 Watershed	Well 1 (meter)	0.22 (100)	53	G6331	G6017	-	Completion date is 10/1/2025	4/22/74	30158	MU-P	3S.3W.27	NW NE
Well 2 Watershed	Well 3 (meter)	0.22 (100)	54						30160	MU-P	3S.3W.27	NW NE
Well 4 River Well	Well 2 (meter)	0.26 (115)	0						30159	MU-P	3S.2W.30	SW SW
Old River Well	Well 4 (abandoned)	0.27 (120)	0						30161	MU-P	3S.3W.36	NE NE
Well 3 Upper Well	Supply Well (meter)	0.18 (80)	35	G1217	G1263	29157	Complete	11/28/58	29157	MU-P	3S.3W.26	SW NE
Well 5 Pruitt	Well 5 (meter)	0.30 (135)	135	G10904	G10148	61759	Complete	3/24/83	11389	MU-P	3S.3W.26	NW SE
Well 6 Pruitt	Well 6 (meter)	0.30 (135)	135						11390	MU-P	3S.3W.26	NW SE
Well 7 Watershed	Well 7 (meter)	0.33 (148)	150	G11866	G11058	87588	Complete	10/31/88	21048	MU-P	3S.3W.27	NW NE
Well 8 Watershed	Well 7A (meter)	1.78 (799)[4]	140	G12568	G12685	-	Completion date is 10/1/2025	6/7/91	-	MU-P	3S.3W.27	NW NE
Well 9 1st Street	1st Street Well		145						-		3S.3W.25	SW NW
Well 10 Alder Street	Alder Street, Well (meter)		50						-		3S.3W.35	NW NE
Well 11 Watershed[5]	City Well 11	0.5 (225)[6]	-	G14066	G17484	-	Completion date is 10/1/2025	5/19/95	-	MU-P	3S.3W.27	NW NE
Well 13 Watershed	Test Well (YAMH 56803)		-						-		3S.3W.22	SW SE
Well 12 Watershed[7]	Well 12	0.5 (225)[6]	-	G14070	G17485	-	Completion date is 10/1/2025	5/19/95	-	MU-P	3S.3W.27	NW NE
Well 13 Watershed	Test Well (YAMH 56803)		-						-		3S.3W.22	SW SE

Notes:

1. The original water rights identify springs on Otter Creek (in 1929); the creek has since been renamed "Harvey Creek," which is the designation shown on the OWRD water rights website.
2. The City is authorized to use 1.55 cfs (696 gpm) from Permit S-44462. The City will need to show a demand for additional water (through an updated Water Management and Conservation Plan) in order to be authorized to use the full 4.0 cfs.
3. "Completion Date" is the deadline for the City to show proof of full and beneficial use of the water authorized under the Permit.
4. Permit G-12685 allows a combined rate of 1.78 cfs (799 gpm), with no specific rate assigned to individual wells.
5. Well 11 is a proposed point of appropriation under Permit G-17484.
6. A total rate of 0.5 cfs (225 gpm) is authorized under each Permit (G-17484 and G-17485). Therefore, Well 13 may use up to 1.0 cfs, as long as Wells 11 and 12 are not pumping.
7. Well 12 is a proposed point of appropriation under Permit G-17485.

Appendix B
City of Dundee—Riverbank Filtration Preliminary Feasibility Assessment

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Final

MEMORANDUM

City of Dundee – Riverbank Filtration Preliminary Feasibility Assessment

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CC Rob Daykin – City Administrator, City of Dundee

DATE: Final Draft October 23, 2014
Final Stamped December 4, 2015

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OREGON
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Exp 31-Dec-2015

Introduction

In 1972, the City of Dundee (City) drilled and installed a well near the Willamette River along 8th Street near the Chehalem Paddle Launch (see Figure 1). This well, referred to as Well No. 4 (YAMH 2660), was the first attempt by the City to develop an alluvial well near the City. Two other wells (YAMH 403 and YAMH 2672) were drilled by the City in the general location of Well No. 4 (exact locations are uncertain); one was temporarily abandoned and the other was completed deeper within the alluvial sediments. GSI's understanding is that all of these wells failed because of sanding issues, and apparently the wells also had ground settling problems. Well No. 4 has not been used by the City since the 1980s. It is also GSI's understanding that the state sent the City a letter addressing concerns about Well No. 4 being directly influenced by the river and that additional testing was needed. The City elected to stop using Well No. 4.

The City's water supply is from a series of groundwater wells completed in and around the City in the Columbia River Basalt Aquifer. Most of the wells are located in the Harvey Creek watershed. Yields from the basalt wells are modest and the City is interested in new sources to meet current and future demands. A new water source near Well No. 4 also would serve a portion of the City that is slated for future growth, as outlined in the City's Riverside District Master Plan.

Review of the existing well logs in this area indicates a sand and gravel unit is present from roughly 25 to 60 feet below ground surface (bgs). Well No. 4 and the other two alluvial wells drilled by the City did not specifically target this shallow sand and gravel unit, but perforated the casing in deeper sandy units (e.g., 98 to 103 feet bgs and 172 to 194 feet bgs). However, if this shallow sand and gravel unit is highly transmissive, and hydraulically connected to the Willamette River, then a shallow well, possibly with laterals, could be installed as a new source for the City. Moreover, water from this alluvial aquifer may have limited need for treatment because groundwater, even if hydraulically connected to the river, would be filtered through the subsurface media.

CH2M HILL collected water quality samples during this exploratory phase for micro particulate analysis (MPA) to assess (1) the filtration provided by the alluvial aquifer and (2) water treatment requirements necessary to meet drinking water standards. CH2M HILL's MPA will be presented separately.

Finally, the City has a surface water permit (S-44462) near Well No. 4 for up to 4 cubic feet per second (1,795 gallons per minute [gpm]) that could be transferred to a groundwater source that is in hydraulic connection with the Willamette River. The point-of-diversion for the City's Willamette River water right is near Well No. 4, as shown in Figure 1. Given the difficulty of obtaining a new water right from Oregon Water Resources Department (OWRD), developing water under this existing permit is preferable.

To evaluate the potential of installing near-river groundwater well(s), a 6-inch-diameter pumping well (PW) was installed near Well No. 4 and a 2-inch-diameter observation well was installed between the PW and the Willamette River (see Figure 1). A short-term, 24-pump test was completed to assess the hydraulic connection between the shallow sand and gravel alluvial aquifer and the Willamette River. The PW for this evaluation also was sited more than 200 feet from the river to comply with the Oregon Health Authority (OHA) regulations related to groundwater under the direct influence of surface water (GWUDI). Specifically, OHA's GWUDI regulations require that the water supply well be more than 200 feet from the surface water body if the aquifer is composed of sand and gravel media, which is the case at this location based on existing well logs. The PW also needs to be within 500 feet of the river to transfer the surface water right to a groundwater point-of-diversion. These regulatory criteria and the desire to be near Well No. 4 and the 8th Street easement bracketed the location of the PW for this evaluation.

This memorandum summarizes the findings from drilling and testing these wells.

Drilling Results

As shown in Figure 1, a PW (OWRD Log ID: YAMH 56885) and an observation well (YAMH 56886) were installed in near Well No. 4. The observation well was drilled first to explore the section, followed by the PW. (Note that the PW design is for testing the sand and gravel aquifer near the Willamette River not as a permanent production well.) The wells were drilled by Cascade Drilling LP in Clackamas, Oregon. A summary of findings follows.

Pumping Well

Figure 2 presents an as-built of the PW. Silt and sand were encountered from the ground surface to 30 feet bgs with sand and gravel from 30 to 50 feet bgs, underlain by sandy silt. A 6-inch-diameter PW was completed with 5 feet of 50-slot screen, a pea gravel pack, and a bentonite seal to the surface. A short screen was selected for the PW because of the limited saturated thickness of the sand and gravel unit to maximize the available drawdown with the pump set just above the screen section (the pump could not be installed inside the screen section because of size constraints). Soil samples were collected during drilling of the PW, and sieve analyses were performed to help select the slot size and gravel pack for the PW. The PW has an aboveground completion with three bollards.

Observation Well

Figure 3 presents an as-built of the observation well. Silt and sand were encountered from the ground surface to 23 feet bgs with sand and gravel from 23 to 46 feet bgs, underlain by silt. The observation well was drilled to 60 feet bgs to ensure no additional sand and gravel were present in the shallow section. A 2-inch-diameter observation well was completed with 25 feet of 20-slot screen, a gravel pack consisting of 8x12 Colorado Silica Sand, and a bentonite seal to the surface. The observation well has an aboveground completion with three bollards. Soil samples were collected during drilling of the observation well approximately every 5 feet or more, depending on conditions encountered.

Aquifer Testing

A temporary submersible pump was installed in the PW just above the screen interval at 43 feet bgs. A short-term step-rate test was conducted for roughly 1 hour (4 steps at approximately 15 minutes each) on the morning of August 13, 2014 to evaluate the aquifer yield and drawdown effects at different rates to help guide the longer-term constant-rate aquifer test. Based on step-rate test results, the 24-hour constant-rate test was run at 100 gpm from 1:40pm on August 13 to 1:30pm on August 14, 2014. The well was allowed to recover close to 93 percent of its original static water level before the submersible pump was pulled and the crew demobilized from the site on August 15, 2014. Water was discharged more than 300 feet from the PW by running a discharge hose parallel to 8th Street toward the Willamette River. The discharge water infiltrated into the soil and nearby vegetation that borders the river. Based on the observed hydraulic response, the constant-rate aquifer test was not short-circuited with discharge water infiltrating back into the aquifer near the PW because more than 30 feet of unsaturated fine sand and silt material overlies the sand and gravel aquifer being tested. The static water level in the PW indicated that at this location the sand and gravel aquifer is confined; toward the Willamette River the sand and gravel aquifer is unconfined.

Figure 4 presents a semi-log plot of the drawdown and recovery portion of the constant-rate aquifer test. Figures 5 and 6 are drawdown plots for the PW. Figures 7 and 8 are drawdown plots of the observation well. A discussion of the aquifer test and analysis follows.

Aquifer Test Discussion

Figure 5 presents the drawdown plot for the PW. The calculated transmissivity, based on late-time data, is approximately 24,000 gallons per day per foot (gpd/ft). The early-time data (see Figure 6) have a much higher transmissivity of roughly 132,000 gpd/ft. The latter transmissivity value is relatively high and matches the visual description of the sand and gravel material collected during drilling. In other words, the sand and gravel aquifer at this location is fairly transmissive, although limited in its vertical extent (20 feet +/- thick). However, at roughly 150 minutes, the drawdown curve steepens (lower transmissivity value calculated; see Figure 5), most likely related to a negative boundary that shows the limited lateral extent of the aquifer at this location (see Figure 6). A theoretical drawdown curve, shown in Figure 6, that projects the drawdown curve, assumes no negative boundary and that the drawdown cone reaches the Willamette River and provides a constant source to the aquifer. Unfortunately, the data do not indicate that a hydraulic connection was made between the sand and gravel aquifer and the Willamette River.

Figure 7 shows a drawdown plot for the observation well. Using these data, a second transmissivity value of 132,000 gpd/ft was calculated for the sand and gravel aquifer using late-time data from the observation well. A storativity value was calculated at 0.076, which is indicative of an unconfined aquifer (i.e., not under pressure). The negative boundary observed in the PW drawdown data also is shown in the observation well data at roughly 200 minutes (steepening of the drawdown curve with time). The interesting note about the plot is that the drawdown in the observation well continued after the pump was turned off, which means other stresses are acting on the aquifer. Also of note is that the well did not fully recover on multiple days, which means the Willamette River is influencing its recovery.

Figure 8 shows the observation well response to pumping with Willamette River stage. The recovery portion of the plot clearly shows some influence from the river, and the drawdown after the pump was shut off also could be explained by the Willamette River influence (drop in stage). Although the aquifer is showing a connection to the river by these plots, the connection is not strong given the drawdown curves because they did not flatten with time. In other words, the sand and gravel aquifer is connected to the Willamette River, but not strongly enough to provide a positive boundary and supply water to the aquifer that would limit or even stop the drawdown over time in the PW.

Figure 9 presents a conceptual cross section from the PW through the observation well to the Willamette River based on (1) drilling and aquifer testing findings and (2) data presented in previous reports by others, as described in the next section. The sand and gravel aquifer is present, as predicted, based on 1970 well reports, but unlike the Newberg Wellfield, the aquifer does not appear to be in strong hydraulic connection with the Willamette River at this location. Most likely, the sand and gravel aquifer represents a paleo-river channel that is separated from the current Willamette River channel by fine-grained sediments that restrict recharge to the aquifer from the river. The long recovery time after the pump was shut off also suggests a weak, if not limited, connection to the Willamette River.

Discussion of Previous Near-River Groundwater Studies in the Area

Previous groundwater evaluation reports found in GSI's archived files included:

- Early 1968 report by the firm Cornell, Howland, Hayes & Merryfield (precursor to CH2M HILL)
- 1968 and 1980 reports by Ranney Method Western Corporation
- 1993 and 1996 reports by CH2M HILL for the City of Newberg
- 2000 wellfield expansion report by CH2M HILL for the City of Newberg

The 1980 report by Ranney Method Western Corporation for the Tigard Water District is of particular interest because it focuses on evaluating collector wells near the Willamette River across from Ash Island (i.e., directly across from the study area). Test wells installed as part of these previous studies were not recorded with OWRD and thus are not in the OWRD's water well database. Re-evaluating the extensive data in this collection of reports is beyond the scope of this project; however, a cursory review focused mostly on findings. A copy of the executive summary of the compiled reports is included in Attachment A.

The Tigard Water District collector well evaluation, east of Ash Island, recommended two collector wells with capacities ranging from roughly 4 to 11 million gallons per day (mgd). The test wells were roughly 50 feet from the Willamette River (note that the setback criteria for wells near surface water bodies has changed since those studies were done), and data showed a similar sand and gravel unit, but in contrast to the current Dundee site, aquifer test data showed the unit to be more transmissive and indicated a strong hydraulic connection to the Willamette River east of Ash Island. GSI understands that City of Newberg Well 8, which is roughly 100 feet from the Willamette River, intercepted a similar sand and gravel aquifer, but the static water level is higher with more available drawdown; that well produces more than 2 mgd of capacity. In general, the sand and gravel aquifer present in the current study area is fairly extensive in the region, and if the unit is found to be thicker and deeper, it provides more available drawdown than what was found at this site. Moreover, if the sand and gravel unit has a stronger hydraulic connection to the Willamette River, it has been shown that near-river wells or collector wells are feasible in the general area along the Willamette River from Newberg up to Dundee.

Conclusion

The following conclusions are made based on the riverbank filtration preliminary assessment project:

- The sand and gravel aquifer is present from roughly 30 to 60 feet bgs and is overlain by fine-grained sand and underlain by similar fine-grained material near wells drilled for this project.
- The static water level relative to the bottom of the sand and gravel aquifer provides limited available drawdown (i.e., static water level of roughly 30 feet bgs and the bottom of the aquifer at roughly 50 feet provides only 20 feet of available drawdown).
- The sand and gravel are fairly coarse-grained, containing some silt, and are fully saturated at the PW (confined) and partially saturated at the observation well location (unconfined).
- Toward the City, the sand and gravel aquifer is possibly confined (under pressure), but toward the Willamette River the same unit becomes unconfined.
- The early-time transmissivity is roughly 120,000 gpd/ft, which matches the type of material encountered during drilling. However, the later-time data resulted in a much lower transmissivity of 24,000 gpd/ft. As a comparison, the sand and gravel aquifer near the Newberg Wellfield and in the area studied across the Willamette River assessed by Ranney Method Western Corporation indicate a transmissivity as high as 300,000 gpd/ft.
- At roughly 100 to 200 minutes into the constant-rate aquifer test, the drawdown in the PW and the observation well increased (steepened), possibly indicating a negative (less permeable) boundary.

- Other effects on the drawdown curve are that the PW is sited in a portion of the aquifer that is confined (water level above the overlying confining silt) and the observation well is in a portion of the aquifer that is unconfined (water level in the sand and gravel aquifer and a portion of that unit is unsaturated). The drawdown also may be reflecting delayed yield and a late-time unconfined response.
- However, the drawdown data show that there is not a strong hydraulic connection between the sand and gravel aquifer and the Willamette River during the 24-hour pumping period.
- Recovery data from the observation well, coupled with stage data from the Willamette River, show a connection to the Willamette River; however, aquifer test data show that it is weak and that the river at this location may not contribute sufficient water to sustain pumping from the sand and gravel aquifer.
- It is unknown if the sand and gravel aquifer, which most likely represents a paleo-river channel, has a stronger hydraulic connection with the Willamette River or is more transmissive either upstream or downstream of this location, but data from other reports by Ranney Method Western Corporation suggest hydraulic connectivity and high transmissivity on the east side of the Willamette River. The drillers' log for another test well completed for the City in 1978 (YAMH 2672, see Figure 1), approximately 500 feet southwest of Well No. 4, indicates a thicker section of sand and gravel and potentially more permeable geologic materials.

Based on the findings presented in this memorandum, GSI does not recommend developing a shallow vertical well or a Ranney collector-type well at this location. A Ranney collector-type well system (i.e., caisson well with horizontal laterals), with a series of lateral well screens running several hundred feet parallel to the Willamette River, could possibly work, but more exploration testing would be needed to find a site with a deeper unit (more head room) and a location with a strong hydraulic connection to the Willamette River than what was found at this location.

Recommendations

The City has a water right on the Willamette River for 4 cubic feet per second (Permit S-44462) or 1,795 gpm that could be transferred to a groundwater source that is in hydraulic connection with the Willamette River. This is a valuable water right because securing new rights from the Willamette River is becoming increasingly difficult and in some locations is not possible.

The testing done as part of this evaluation showed that the sand and gravel aquifer is present in this area, but unfortunately it is shallow, providing limited available drawdown and it did not exhibit a strong hydraulic connection to the Willamette River within the 24-hour pumping period. However, previous work on the east side of the Willamette River demonstrated that Ranney collector-type well systems are viable, and this is further supported in the development of the Newberg Wellfield. Finding a suitable site, other than where Well No. 4 is located, on the west side of the Willamette River would require more exploration work.

Given that a collector-type well system appears to be feasible in this area, and given the City's existing surface water right, GSI recommends that the City allocate a modest budget during the next 5 years to continue to explore sites that could host a Ranney collector-type well. In the meantime, the City can focus on developing its basalt groundwater rights within the Harvey Creek watershed to meet near-term demands. With that said, the City should preserve the test wells in this area for future potential monitoring.

A potentially cost-effective method for additional assessment near Well No. 4 may be for the City to install a small submersible pump in the newly constructed test well and conduct a 3- to 5-day aquifer test at roughly 100 gpm to evaluate if a hydraulic connection is made with the Willamette River at locations farther out, where the connection between the aquifer and the river might be stronger. Testing Well No. 4 and collecting data for MPA also is recommended.

Based on all available information, the City is encouraged to explore the option of a Ranney collector-type well system by completing additional exploration borings upgradient and downgradient of the Well No. 4 site. Geophysical exploration may prove to be useful tool to refine the search area. Cost considerations, as to a distance from the 8th Street waterline, would need to be evaluated and it would be instructive to evaluate the cost of crossing the Willamette River with a water supply pipe because previous test data proved more favorable east of Ash Island. Finding a hydraulic connection between the shallow sand and gravel aquifer on the site of the Willamette River, similar to what is present in the Newberg Wellfield and what was found east of Ash Island, is possible, but will require additional exploration near Well No. 4.

Figures

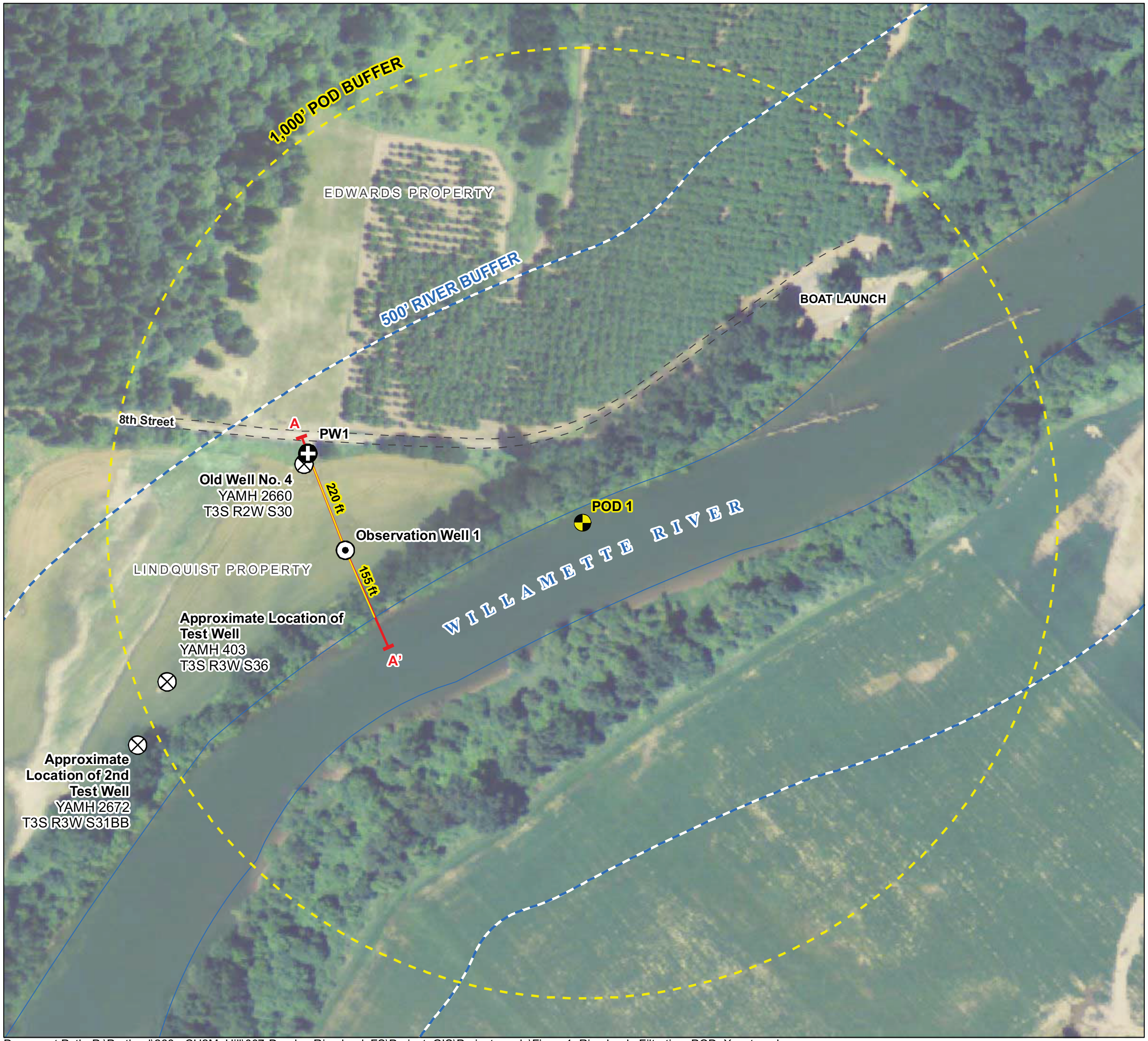


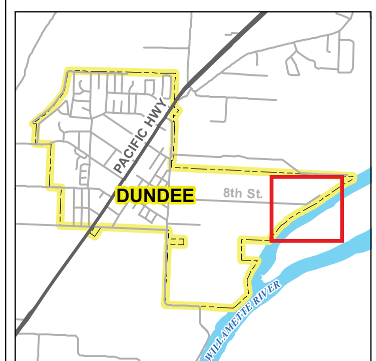
FIGURE 1

Riverbank Filtration Project

Dundee, Oregon

LEGEND

- Observation Well
- PW Well
- City Well
- Point of Diversion (POD)
- Cross Section Line
- Easement



N

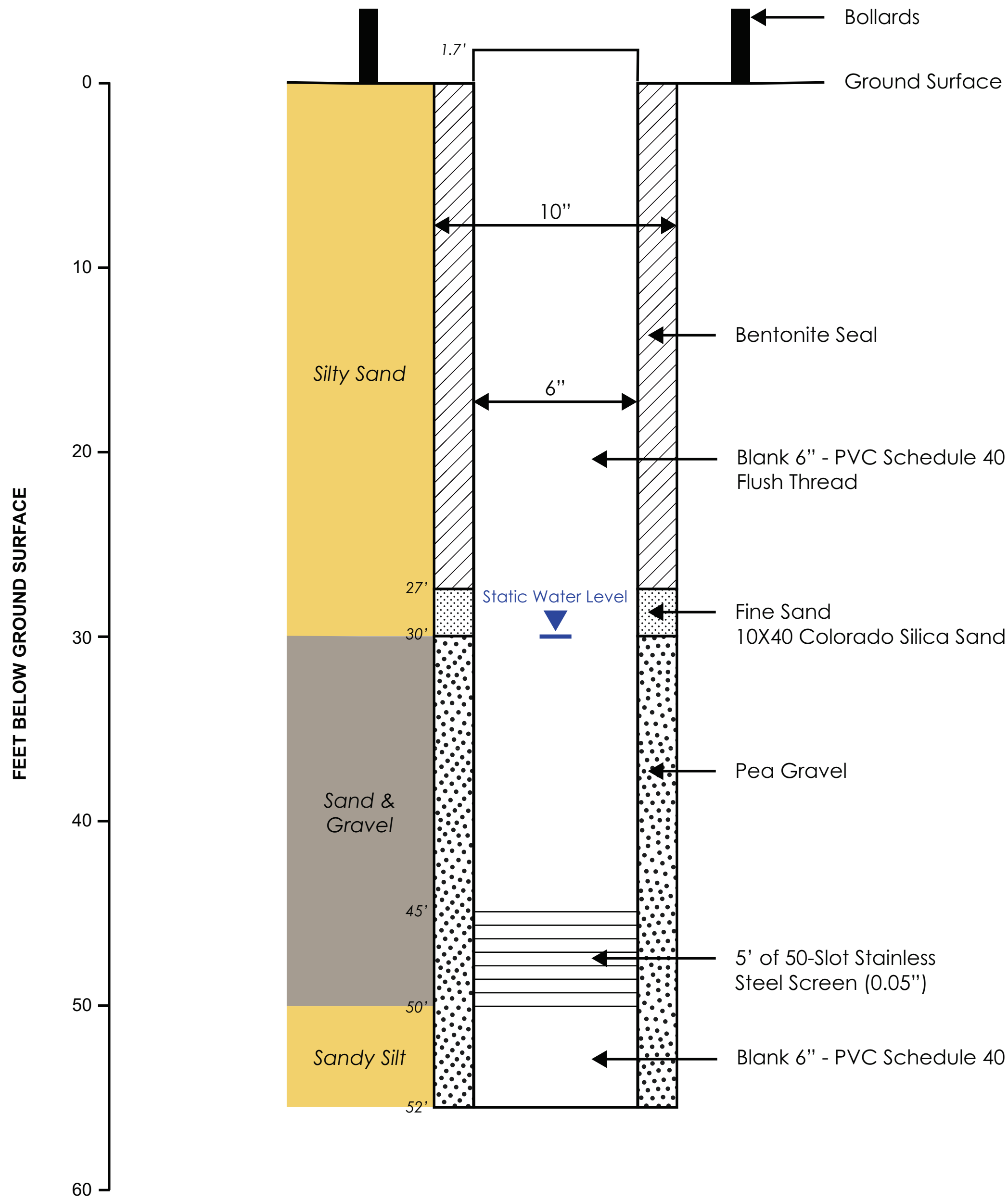
0 75 150 225 300

Feet

MAP NOTES:
Date: September 23, 2014
Data Sources: USDA 2012, ESRI

GSI Water Solutions, Inc.

Document Path: P:\Portland\268 - CH2M_Hill\007-Dundee Riverbank FS\Project_GIS\Project_mxds\Figure1_Riverbank_Filtration_POD_Xsect.mxd



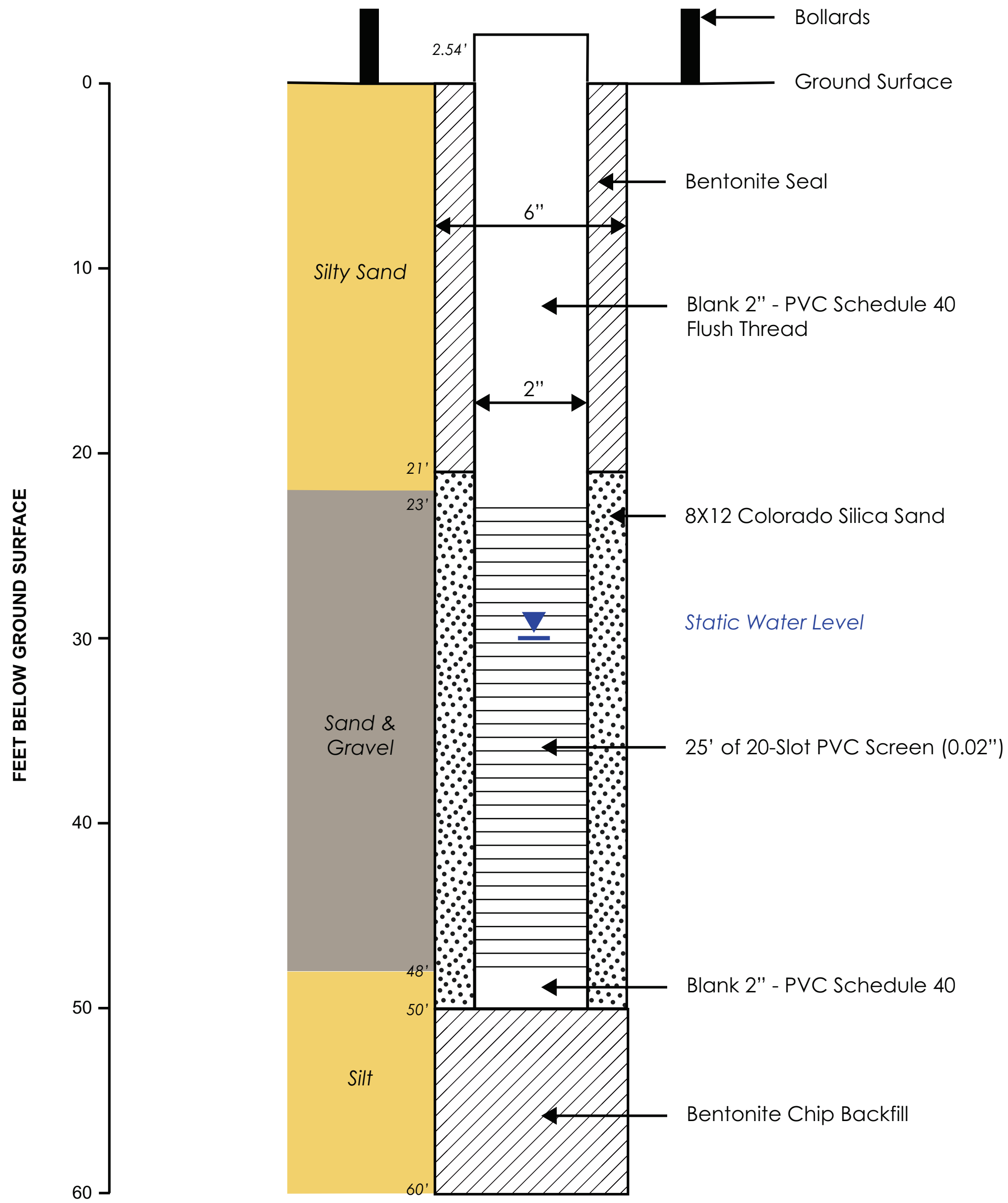
NOTES:
OWRD Well ID: YAMH 56885
Depth to Water: 29.7' bgs on 8/5/2014 (post drilling)
Not to scale horizontally.

FIGURE 2

PW-1 Well Diagram

Dundee Riverbank Well Feasibility Study

GSI Water Solutions, Inc.



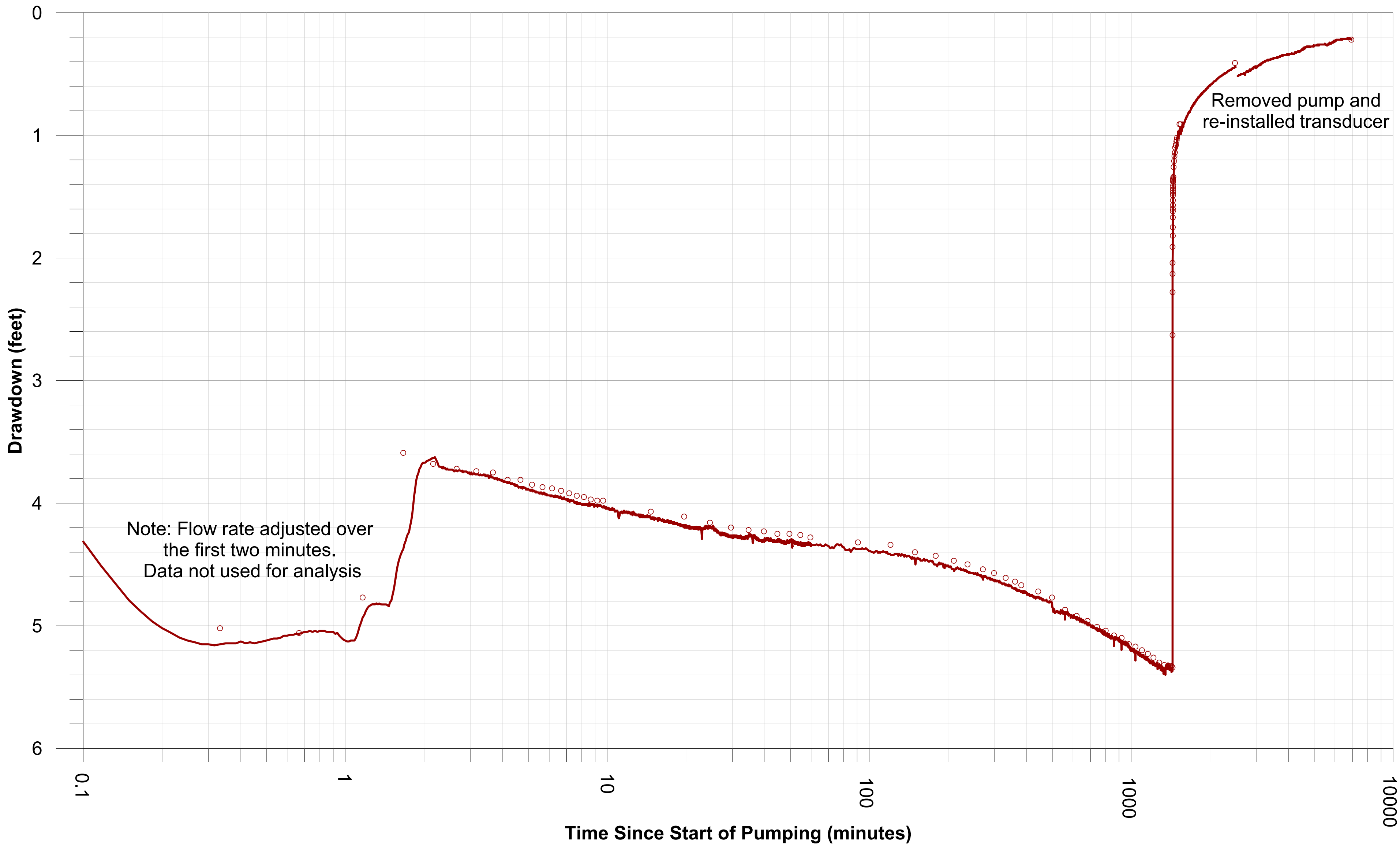
NOTES:
OWRD Well ID: YAMH 56886
Depth to Water: 31.49' bgs on 8/5/2014
Not to scale horizontally.

FIGURE 3

Observation Well Diagram

Dundee Riverbank Well Feasibility Study

GSI Water Solutions, Inc.



Legend:

Manual Water Levels

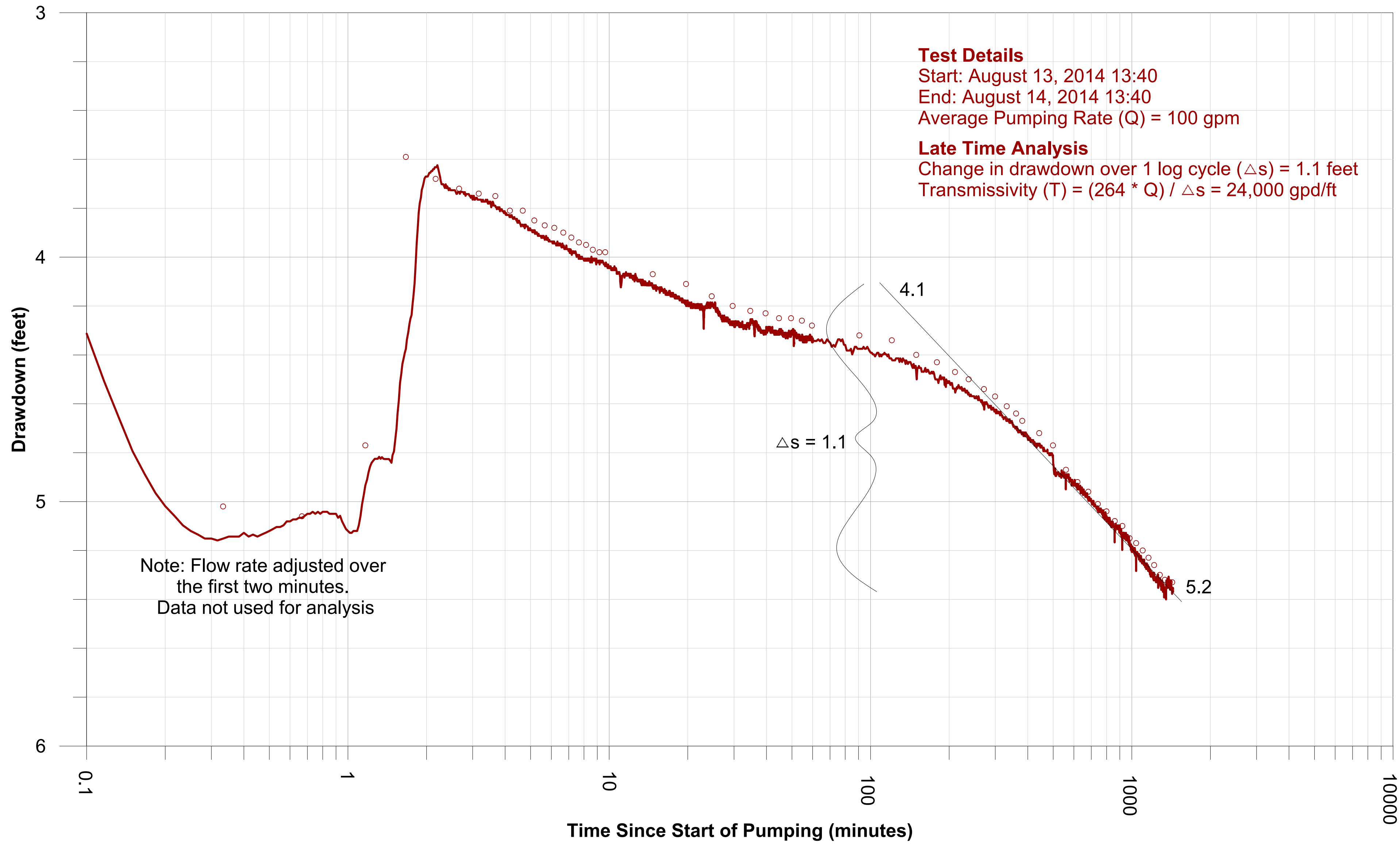
Transducer Data

FIGURE 4

Water Level Response in Pumping Well During Constant Rate Test and Recovery

Dundee, Oregon

GSI Water Solutions, Inc.



Legend:

- Manual Water Levels
- Transducer Data

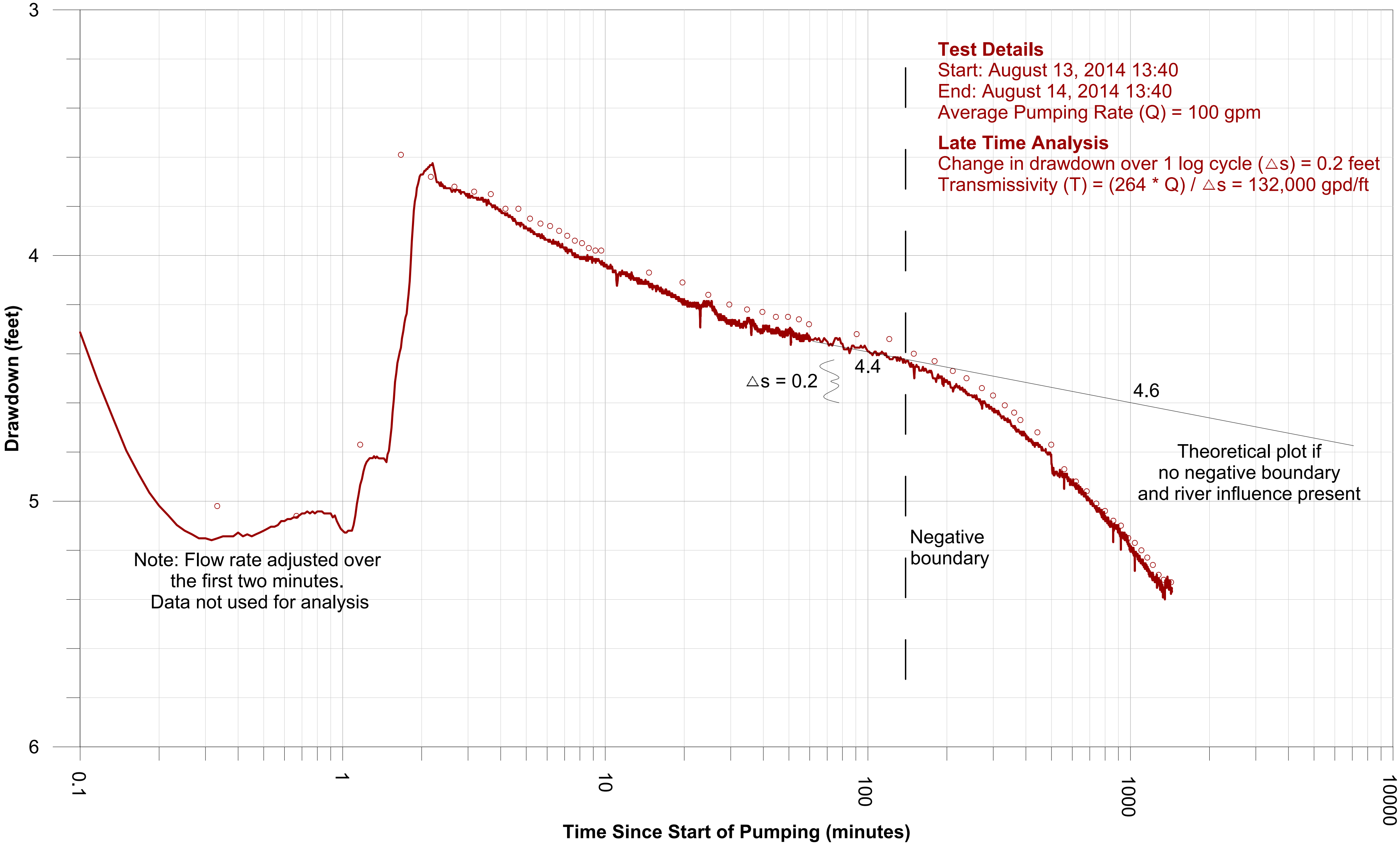
Notes:
gpd/ft = gallons per day per foot
gpm = gallons per minute

FIGURE 5

Water Level Response in Pumping Well During Constant Rate Test

Dundee, Oregon

GSI Water Solutions, Inc.



Legend:

Manual Water Levels

Transducer Data

Notes:

gpd/ft = gallons per day per foot

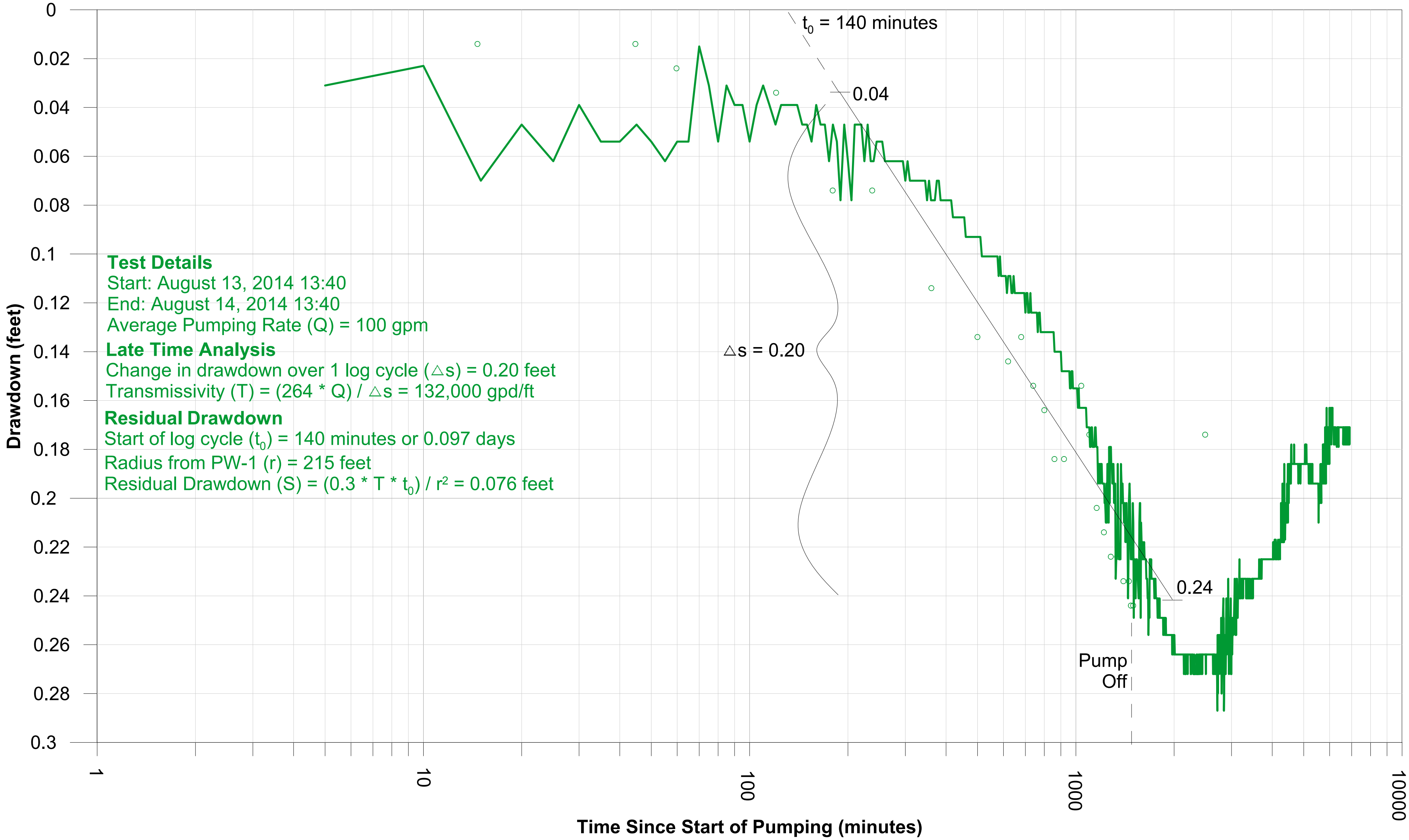
gpm = gallons per minute

FIGURE 6

Water Level Response in Pumping Well During Constant Rate Test with Theoretical Plot and Negative Boundary

Dundee, Oregon

GSI Water Solutions, Inc.



Legend:

○ Manual Water Levels

— Transducer Data

Notes:

gpd/ft = gallons per day per foot

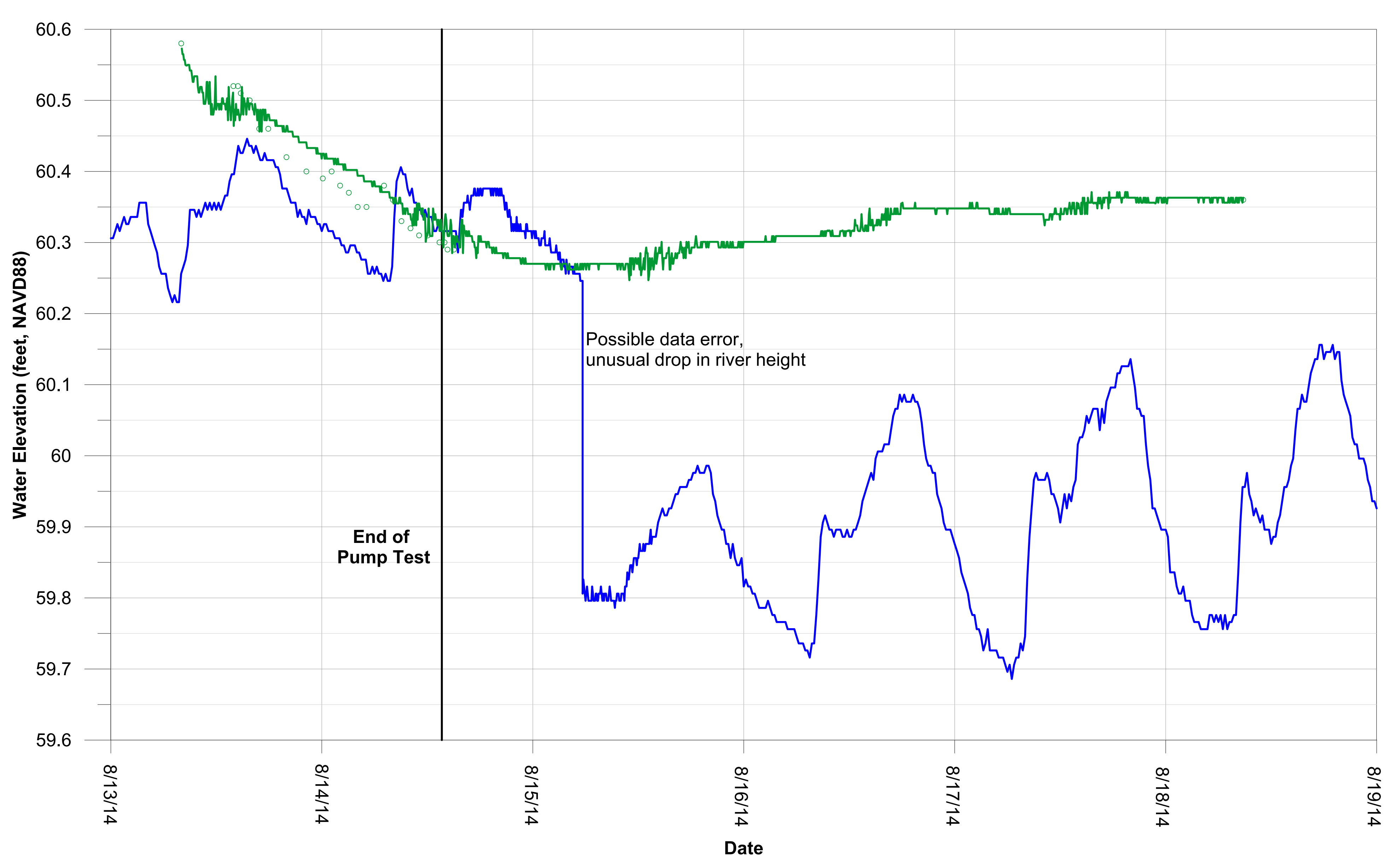
gpm = gallons per minute

FIGURE 7

Water Level Response in Observation Well During Constant Rate Test and Recovery

Dundee, Oregon

GSI Water Solutions, Inc.



Legend:

- Observation Well Manual Water Levels
- Observation Well Transducer Data
- Wilamette River

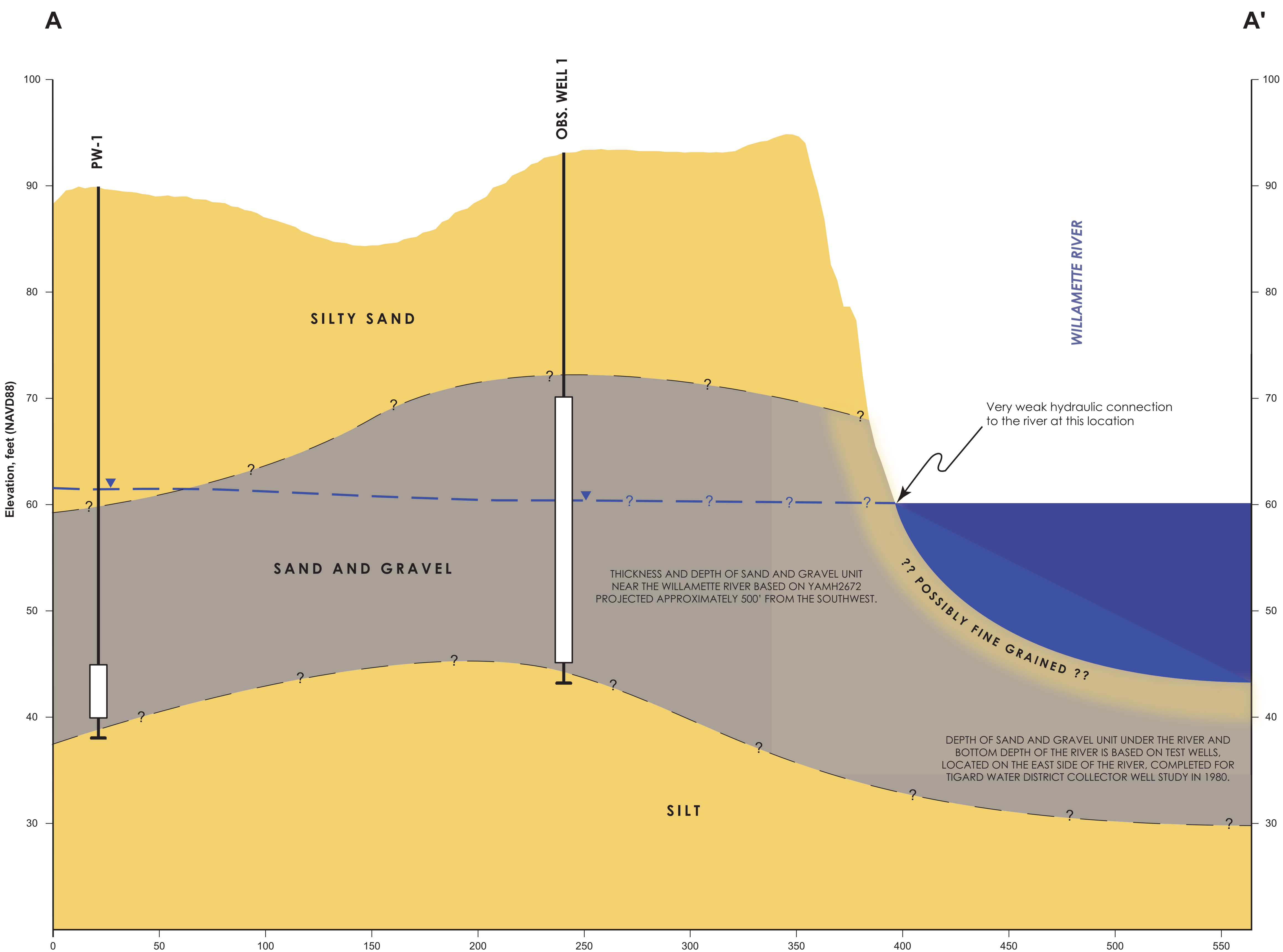
FIGURE 8
Water Levels in Observation Well and Willamette River
Dundee, Oregon

GSI Water Solutions, Inc.

FIGURE 9

Cross Section A-A'

Dundee Riverbank Well Feasibility Study



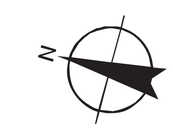
LEGEND

- Well
- Screen
- Static Water Level

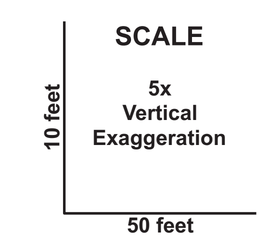
Geology

- Silt/Clay
- Sand & Gravel

NOTE:
Willamette river elevation measured at 60.28 feet (NAVD88) between 8:00 and 9:15 on August 8, 2014.



SCALE



MAP NOTES:
Date: September 23, 2014

GSI Water Solutions, Inc.

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Attachment A

Collection of Reports

Newberg Well Field

Previous Ranney Collector Evaluations

Prepared for

City of Newberg

August 1999

CH2MHILL

CH2M HILL
825 NE Multnomah, Suite 1300
Portland, OR 97232-2146

Contents

Introduction	**Summary of Findings**
	Informational Figures a. Proposed Future Groundwater Wells 1999 Water Master Plan Update/Well Field Evaluation Study b. Possible Well No. 7 and Ranney Collector Locations c. Conceptual Design Ranney Collector
Section 1 1968	**Groundwater Exploration Program Report** by Cornell, Howland, Hayes & Merryfield
Section 2 1968	**Groundwater Exploration Program Report – Attachment** by Ranney Method Western Corporation **Hydrogeological Survey - Ranney Collector Feasibility Report**
Section 3 October 24, 1980	**Tigard Water District** **Hydrogeological Survey - Ranney Collector Feasibility Report** by Ranney Method Western Corporation
Section 4 December 22, 1993	**City of Newberg** **Ranney Collector Feasibility Study** by CH2M HILL
Section 5 December 22, 1996	**Newberg Well Field Evaluation and Model Update – Technical Memorandum** by CH2M HILL

Summary of Findings

Section 1
1968

Groundwater Exploration Program Report
by Cornell, Howland, Hayes & Merryfield

Section 2
1968

Groundwater Exploration Program Report – Attachment
by Ranney Method Western Corporation
Hydrogeological Survey - Ranney Collector Feasibility Report

- Study focused upon the area southwest of the well field, across form Ash Island
- Suggests a collector with a 2.5 mgd (million-gallon per day) capacity can be constructed.
- Conclusions of the study also indicate two additional collectors could be built in this area with a minimum spacing of 1200 feet.
- Recommends focusing collection of groundwater from along the rivers side of the system and control groundwater flow from the inland side of the system to minimize dissolved iron issues.

Section 3
October 24, 1980

Tigard Water District
Hydrogeological Survey - Ranney Collector Feasibility Report
by Ranney Method Western Corporation

- Study focused upon a similar area to the southwest of the well field, across form Ash Island.
- Based upon this second study, two collectors can be installed in this area with minimum capacities of 11.6 and 4.2 mgd respectively.

Section 4
December 22, 1993

City of Newberg
Ranney Collector Feasibility Study
by CH2M HILL

Following completion of the 1992 update of the City's Water Master Plan, Newberg Staff requested that CH2M HILL complete a preliminary Ranney collector feasibility study for the Smith property. The master plan had identified several new water supply wells on the Dority property as part of the future wellfield expansion. It became apparent that wells located on or near the Dority property would be problematic because (1) the property owner at the time was uncooperative, (2) the purchase cost of the Dority property could have exceeded $1 million dollars, and (3) gaining site access to future wells could prove very difficult. It also became apparent that a possible single collection point (Ranney collector), as compared to multiple wells, may have been more acceptable to local farmers and Marion County. CH2M HILL prepared a Ranney Collector FS proposal, which was approved by City Council as Resolution No. 93-1772. A summary of the study includes:

- Study focused upon area to the east of the well field, in the deepest potions of the buried gravel deposits (Smith Property).
- Based upon this second study, one collector could be installed to the east of the wells along the river with a capacity of approximately 10 mgd estimated.
- Operation of a Ranney collector to the east of the well field would cause well interference and reduce the capacity of several of the wells during the peak summer demand periods.
- Public concern about capturing Willamette River water would be expected.

Section 5

December 22, 1996 **Newberg Well Field Evaluation and Model Update – Technical Memorandum**
by CH2M HILL

- Evaluated potential well-interference and travel time impacts associated with the addition of a 10 mgd Ranney collector east of the well field along the rivers edge.
- The operation of a Ranney collector caused negligible change in travel times from the river the existing wells.
- Operation of a 10 mgd Ranney collector to the east of the well field would using a worst-case scenario cause significant well interference and reduce, or temporarily eliminate, the capacity of several of the existing wells during the peak summer demand periods.
- The operations of a smaller collector system was not evaluated.

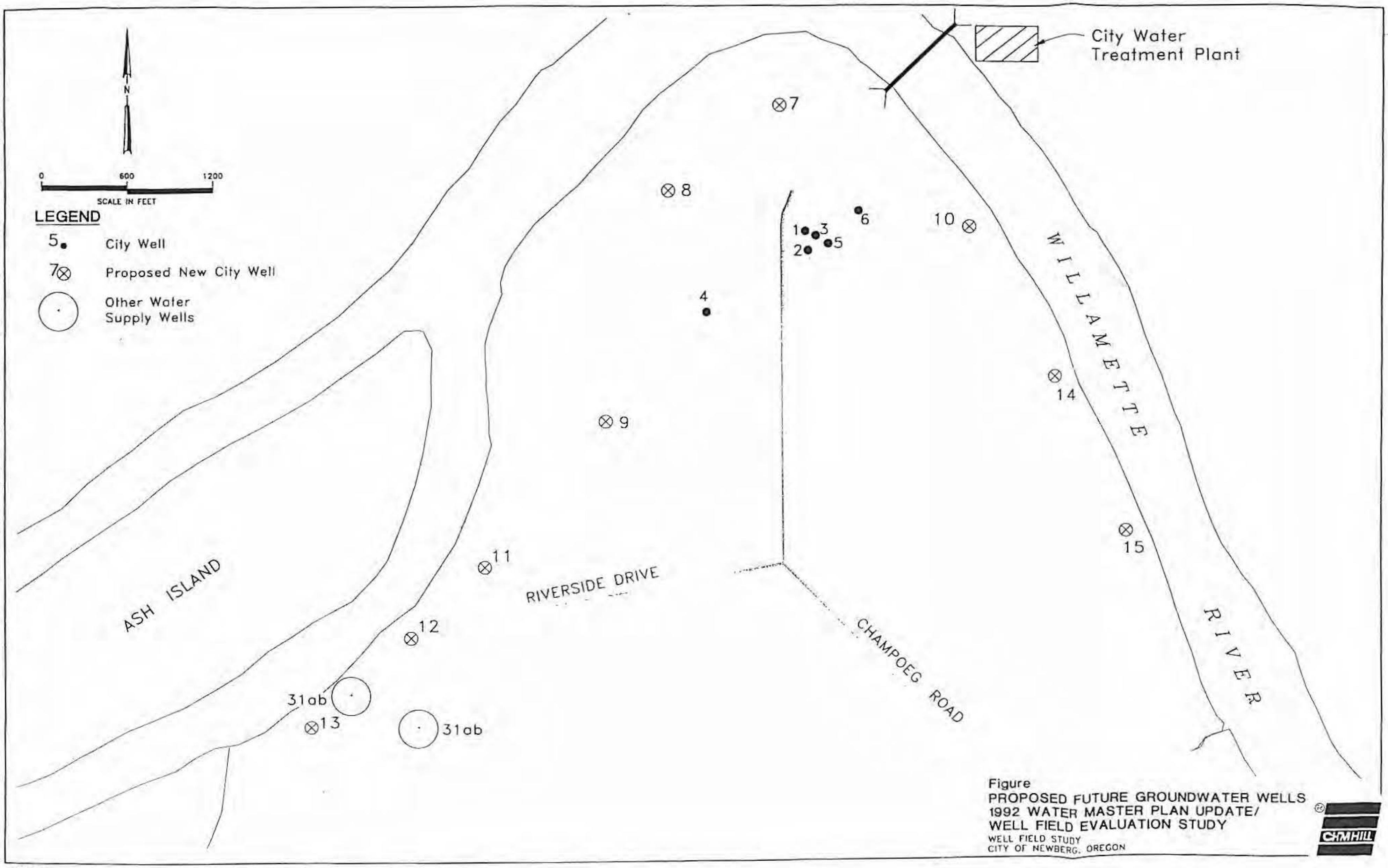


Figure
PROPOSED FUTURE GROUNDWATER WELLS
1992 WATER MASTER PLAN UPDATE/
WELL FIELD EVALUATION STUDY
WELL FIELD STUDY
CITY OF NEWBERG, OREGON

CH2MHILL

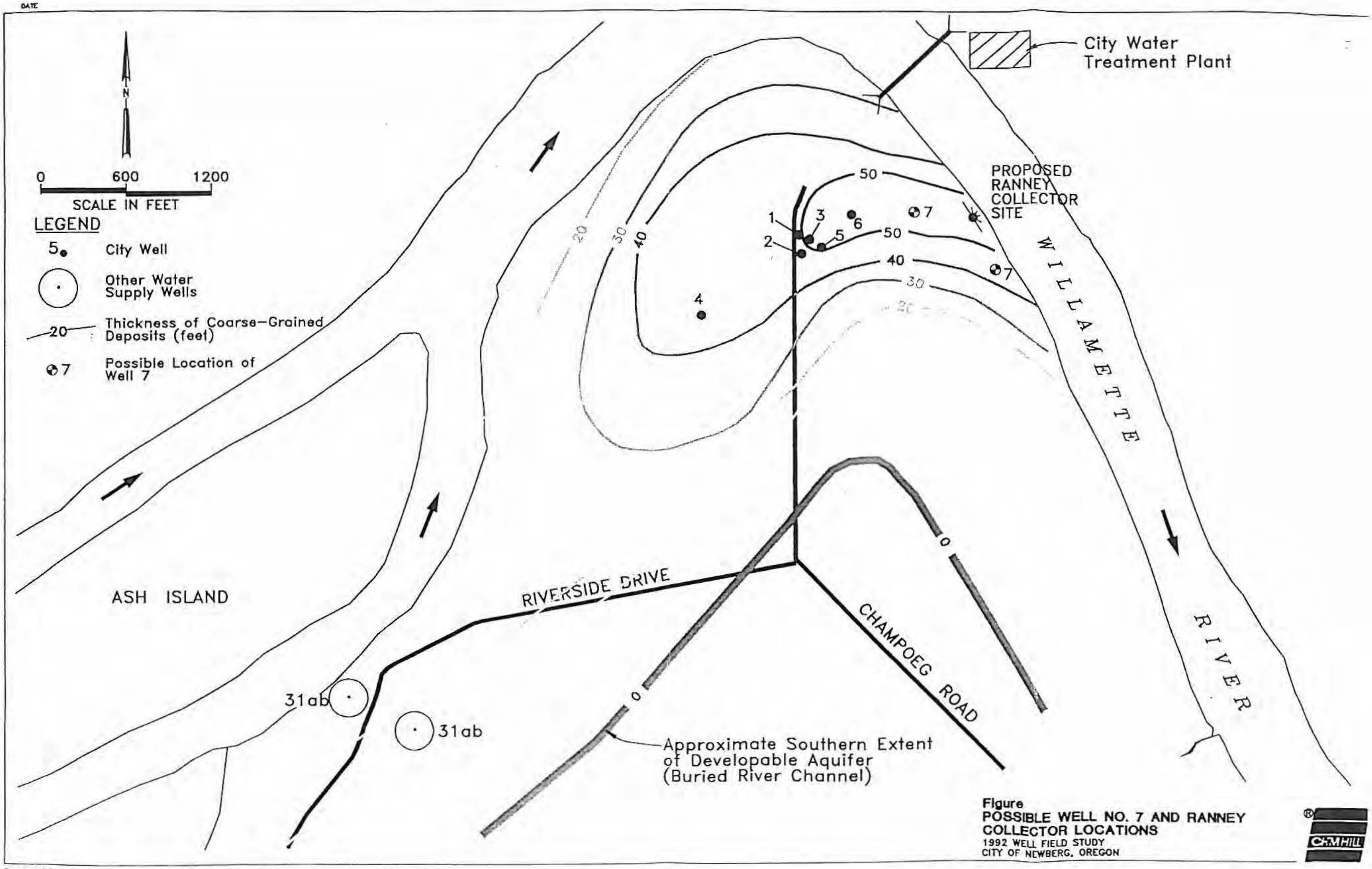
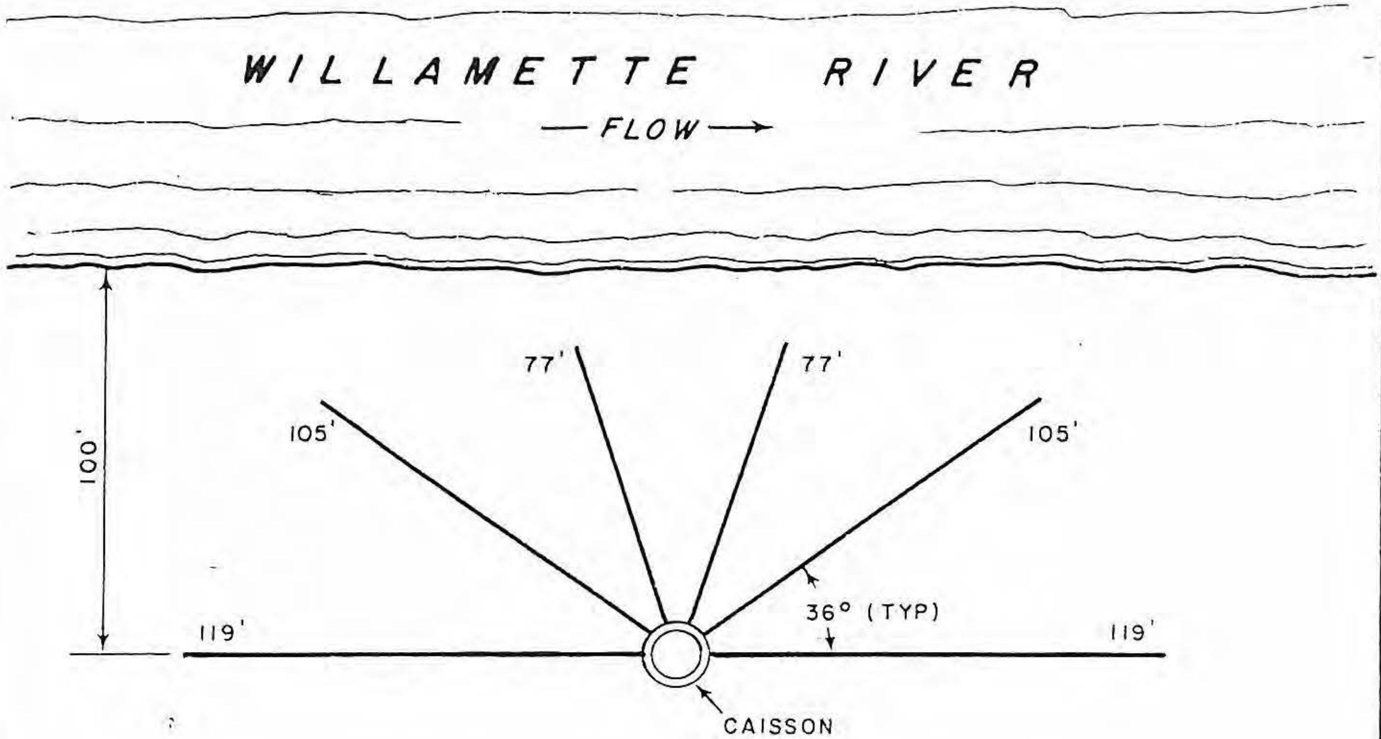


Figure
POSSIBLE WELL NO. 7 AND RANNEY COLLECTOR LOCATIONS
1992 WELL FIELD STUDY
CITY OF NEWBERG, OREGON



LATERAL PROJECTION DIAGRAM

SCALE: 1" = 50 FEET

	ELEVATION IN FEET (MSL)
TOP OF CAISSON	102
100-YEAR FLOOD STAGE	99
GROUND SURFACE	90
LOW RIVER STAGE	54
DESIGN PUMPING LEVEL	24
HORIZONTAL LATERALS	9
CUTTING SHOE	4

RANNEY METHOD WESTERN CORPORATION
KENNEWICK, WASHINGTON

CH2M HILL
CITY OF NEWBERG, OREGON
RANNEY COLLECTOR FEASIBILITY STUDY

CONCEPTUAL DESIGN
RANNEY COLLECTOR

DRAWN: MSE	APPROVED: FCM
DATE: 12-07-93	FIG.: SW-122-02

Appendix C
Best-Good-Worst Ratings Figure

Figure 1
City of Dundee
Water Source Options Evaluation
January 2015

Category	Option Number	Source Option	Capacity (gallons per minute/ million gallons per day)	Technical: Technical Aspects	Implementation: Ease of Implementation	Governance: Autonomy/Control (more is better)	Environment: Environmental impacts (less is better)	Customer: Public Acceptance (more is better)	Overall Non-Financial Value	Cost: Capital	Cost: Operating	Cost: Annual Cost per gpm of Capacity	Cost: Cost	Overall Combined Non-Financial Value and Cost	Value per 1000 Dollars (Annual Cost)	Notes
Wells	1	Develop Test Well	250 gpm/ 0.36 mgd	●	●	●	●	●	●	$ 500,000	$ 7,152	$176	●	●	130	Based on use as peaking supply
	2	Additional Spring Area Wells	250 gpm/ 0.36 mgd	●	◒	●	●	●	●	$ 850,000	$ 7,152	$279	●	●	81	Based on use as peaking supply
	3	Additional In-town Wells	50 gpm/ 0.072 mgd	●	●	●	●	●	●	$ 850,000	$ 13,052	$1,512	◒	●	16	
	4	Vineyard Well North of Town (formerly Black Family)	50 gpm/ 0.072 mgd	●	●	●	●	●	●	$ 500,000	$ 13,052	$997	●	●	23	
	5	Reactivate Well No. 4	45 gpm/ 0.065 mgd	●	●	●	●	●	●	$ 75,000	$ 11,747	$384	●	●	64	
	6	Replace Well No. 4	45 gpm/ 0.065 mgd	●	●	●	◒	●	●	$ 850,000	$ 11,747	$1,651	●	●	13	
Riverbank/ Surface Water	7	Riverbank Filtration Well	0	●	◒	●	◒	◒	◒	-	-	-	N/A	N/A	N/A	Capacity unknown at this time
	8	Ranney Collector Well - Dundee Side of River	1750 gpm/ 2.52 mgd	●	◒	●	◒	◒	●	$ 3,870,000	$ 130,524	$237	●	●	79	
	9	Ranney Collector Well - Ash Island	1750 gpm/ 2.52 mgd	●	○	●	○	◒	◒	$ 4,370,000	$ 130,524	$258	●	●	55	
	10	Ranney Collector Well - Marion Co. Side of River	1750 gpm/ 2.52 mgd	◒	○	●	○	◒	◒	$ 7,870,000	$ 130,524	$405	●	●	33	
	11	Surface Water Intake	1750 gpm/ 2.52 mgd	◒	◒	●	○	◒	◒	$ 6,500,000	$ 380,524	$491	●	●	31	
Regional	12	Newberg	1750 gpm/ 2.52 mgd	●	◒	○	◒	◒	◒	$ 1,689,600	$ 116,086	$137	●	●	100	Based on use as peaking supply at 300 gpm
	13	McMinnville W&L/Lafayette/Dayton/Carlton	1750 gpm/ 2.52 mgd	●	◒	○	◒	◒	◒	$ 3,379,200	$ 232,171	$275	●	●	48	Based on use as peaking supply at 300 gpm
Reuse in Riverside District	14	Reuse for Large Irrigation Users	226 gpm/ 0.325 mgd	○	◒	●	●	●	●	$ 3,538,000	$ 15,500	$1,220	◒	◒	16	
	15	Reuse for Parks Irrigation in Riverside District	43 gpm/ 0.062 mgd[1]	○	○	●	●	●	●	$ 3,310,000	$ 10,000	$5,897	○	◒	3	
	16	Reuse for Parks and Residential Irrigation in Riverside I	174 gpm/ 0.251 mgd	○	◒	●	●	◒	◒	$ 2,400,000	$ 10,000	$860	◒	◒	21	Capital cost is City-financed portion only
Other	17	Aquifer Storage and Recovery[2]	300 gpm/ 0.43 mgd	●	●	●	●	●	●	$ 850,000	$ 35,760	$328	●	●	72	Enhances reliability of existing wells; requires surface or regional supply
	18	Conservation Program	Unknown	●	●	●	●	●	●	-	-	-	N/A	N/A	N/A	
	19	Leak Recovery	22 gpm 0.032 mgd[3]	●	●	●	●	●	●	$ 75,000		$251	●	●	98	Assumes $15,000 per year investment for 5 years

Evaluation Relative to Other Options: ● **Best** ◒ **Good** ○ **Worst**

Notes
1. Based on three parks similar in size and use as Falcon Crest Park
2. Requires surface source
3. Based on leak reduction to achieve goal of Water Management and Conservation Plan

Appendix D
Modeling Results

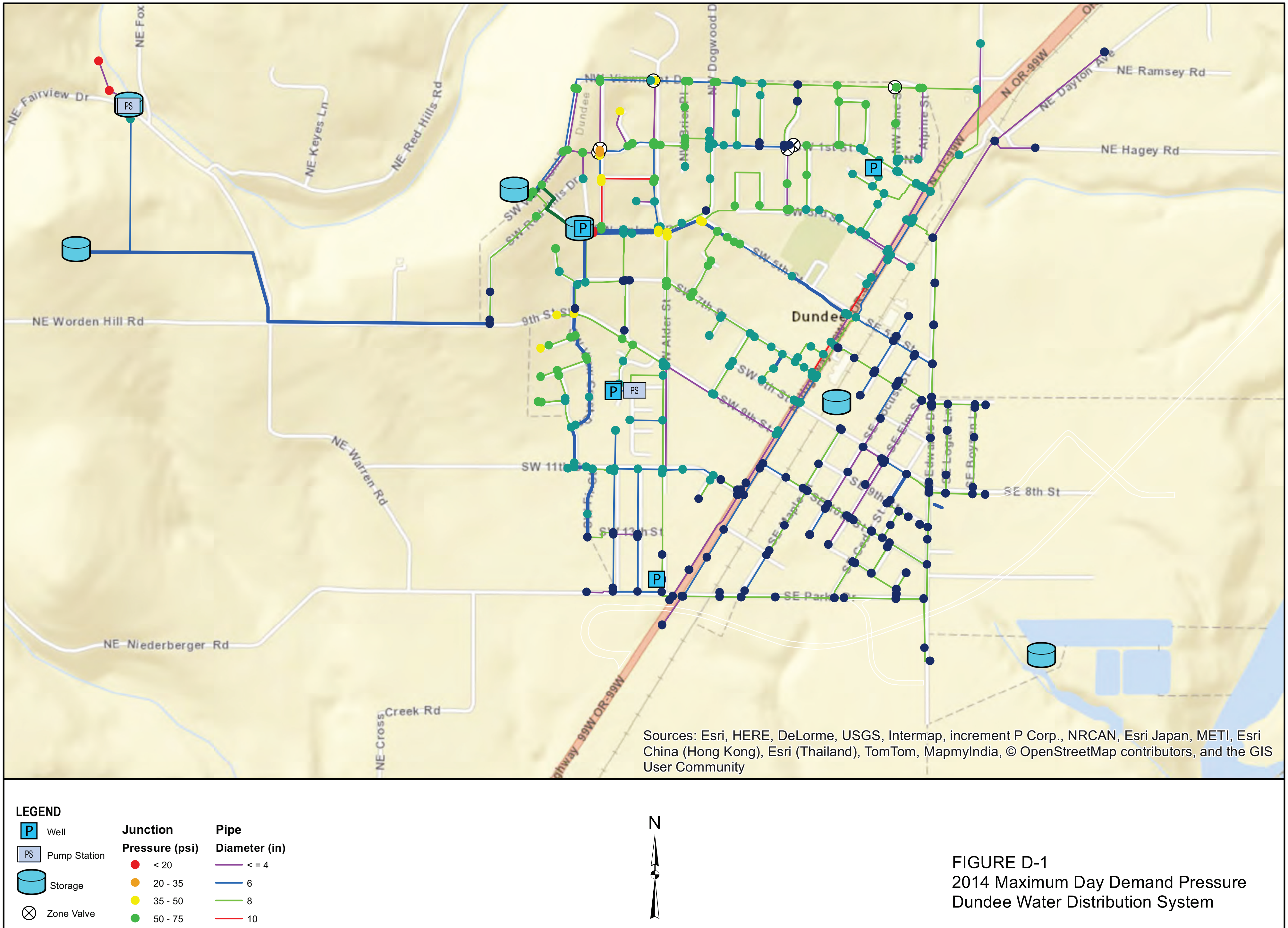
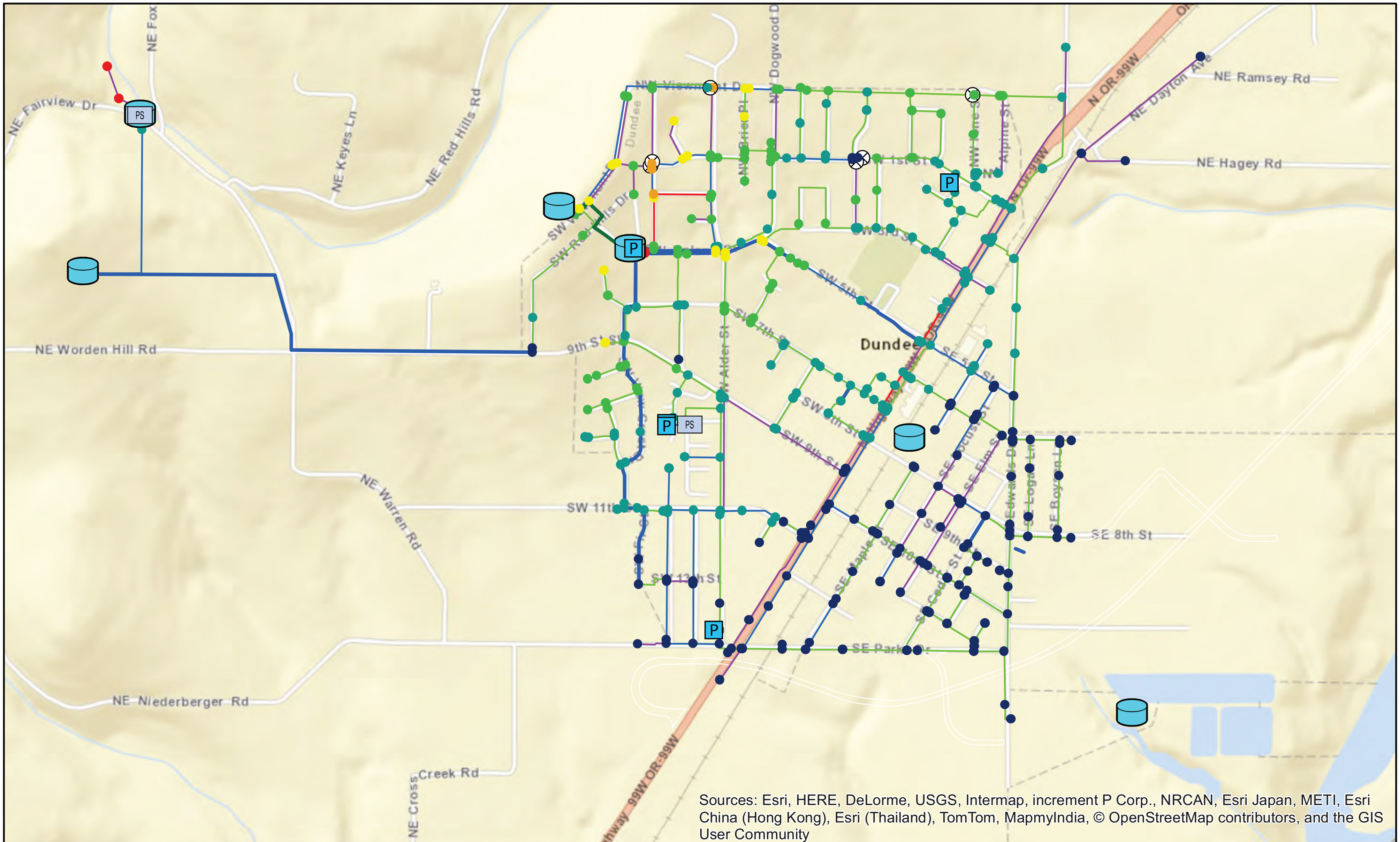


FIGURE D-1
2014 Maximum Day Demand Pressure
Dundee Water Distribution System

ch2m



LEGEND

- P Well
- PS Pump Station
- Storage
- ⊗ Zone Valve

Junction Pressure (psi)

- < 20
- 20 - 35
- 35 - 50
- 50 - 75
- 75 - 100
- > 100

Pipe Diameter (in)

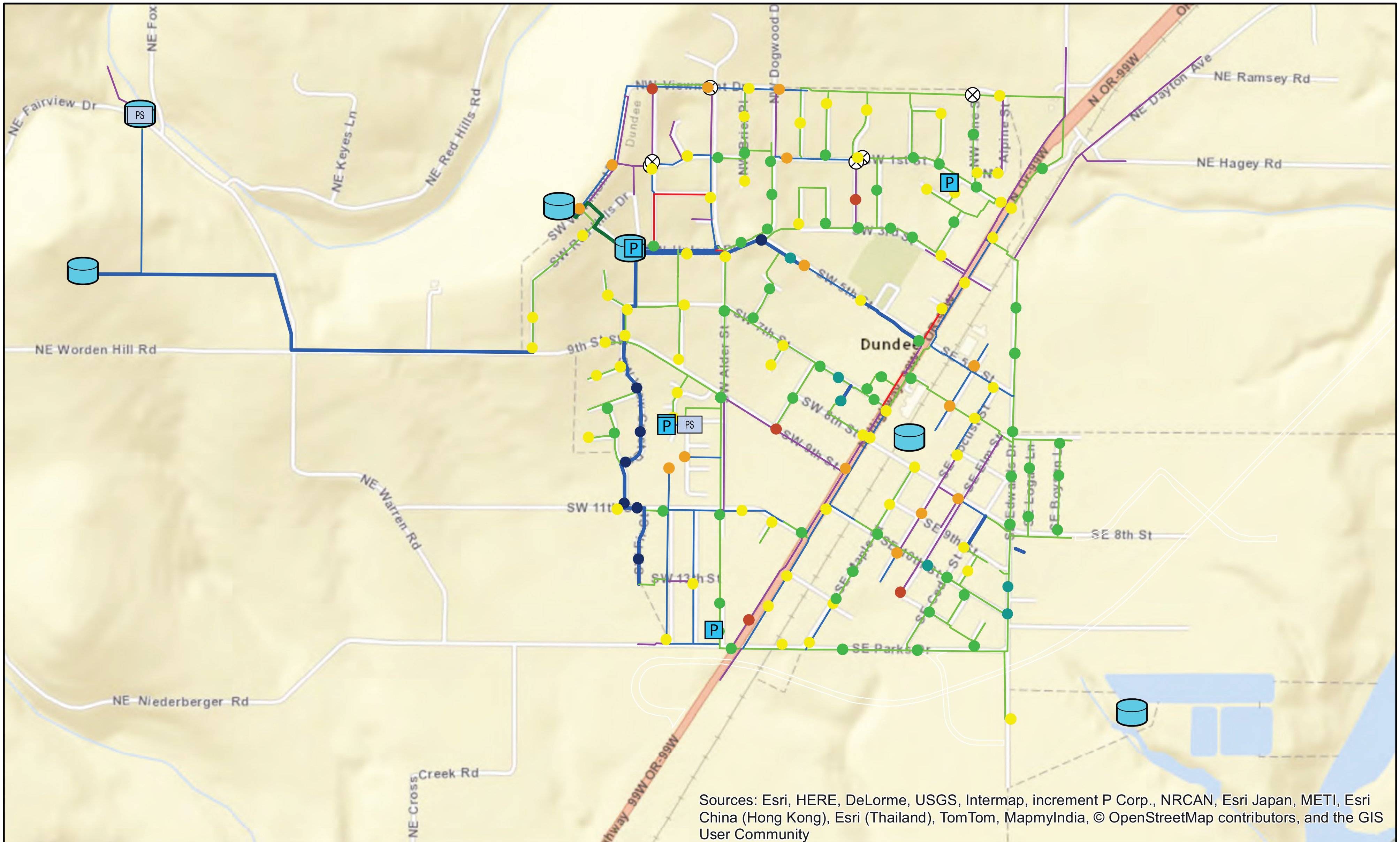
- < = 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-2
2014 Peak Hour Demand Pressure
Dundee Water Distribution System

ch2m



LEGEND

- P Well
- PS Pump Station
- Storage
- ⊗ Zone Valve

Junction
Available Fire Flow (gpm)

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- > 4000

Pipe
Diameter (in)

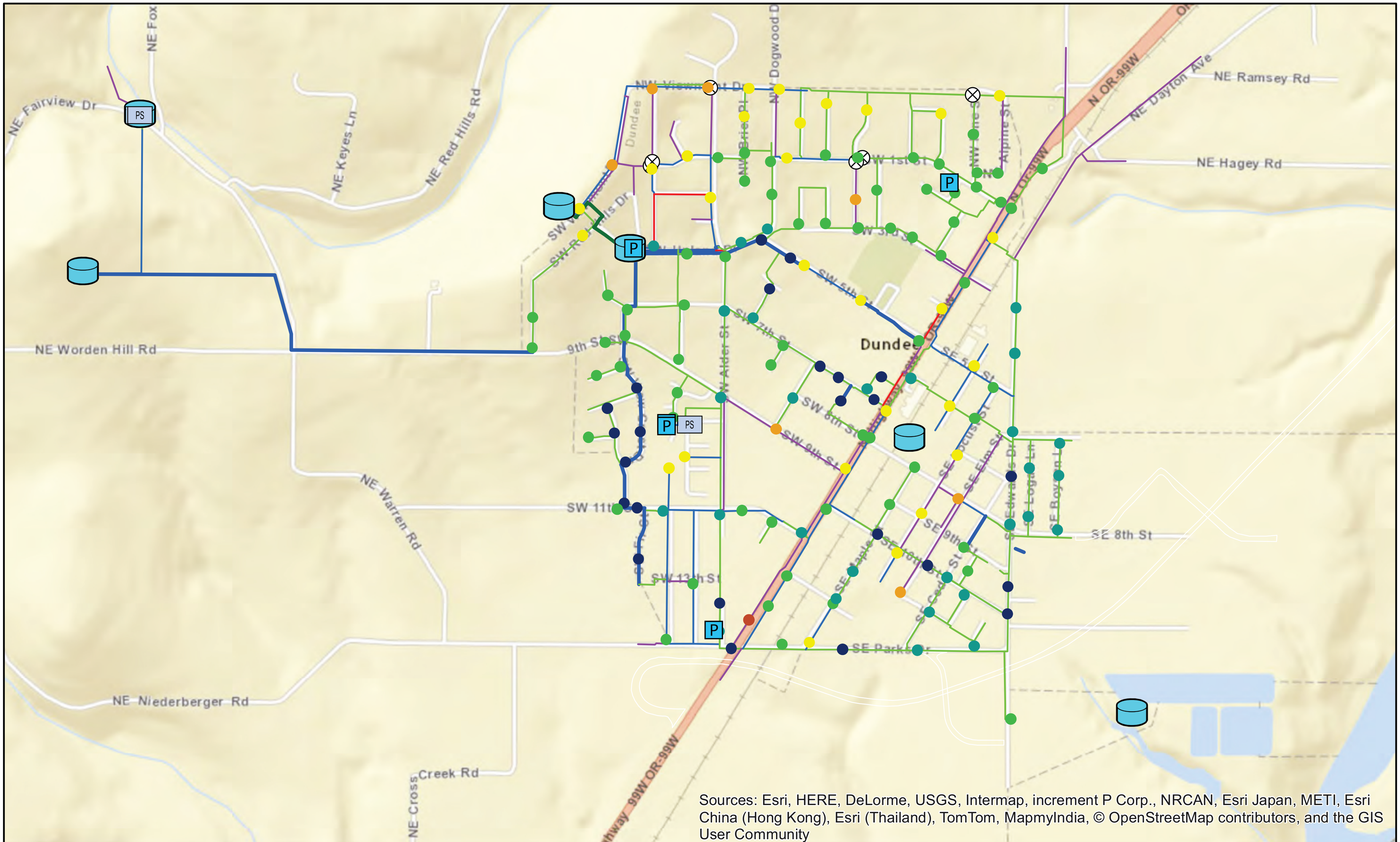
- < = 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-3
2014 Available Fire Flow
10 ft/sec Velocity Maximum
Dundee Water Distribution System

ch2m



LEGEND

- P Well
- PS Pump Station
- Storage
- ⊗ Zone Valve

Junction
Available Fire Flow (gpm)

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- > 4000

Pipe
Diameter (in)

- < = 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-4
2014 Available Fire Flow
15 ft/sec Velocity Maximum
Dundee Water Distribution System

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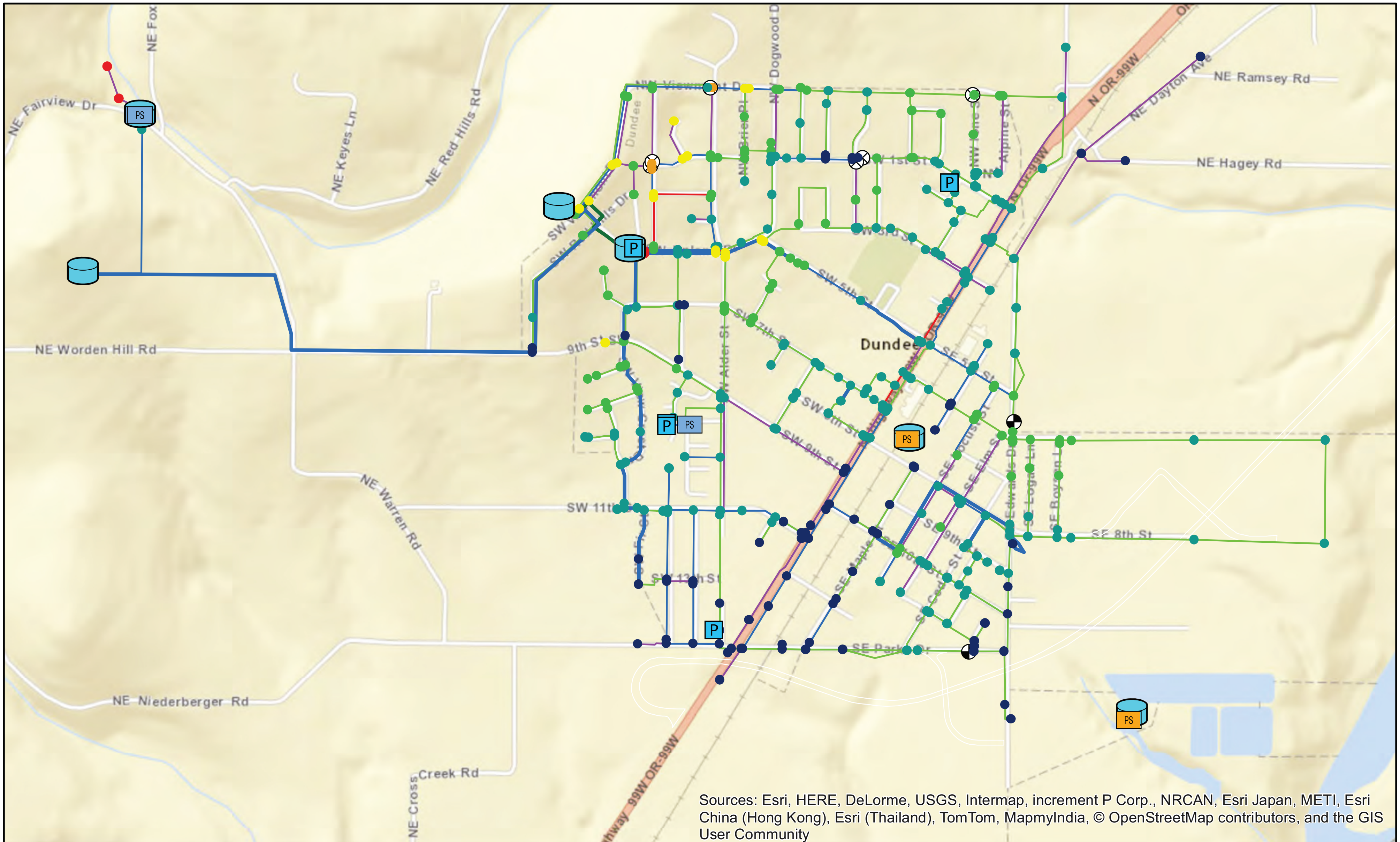

LEGEND

- Well
- Pump Station
- New Pump Station
- Storage
- Zone Valve
- PRV

Junction Pressure (psi)

- < 20
- 20 - 35
- 35 - 50
- 50 - 75
- 75 - 100
- > 100

Pipe Diameter (in)

- <= 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-5
2035 Maximum Day Pressure
with Improvements
Dundee Water Distribution System

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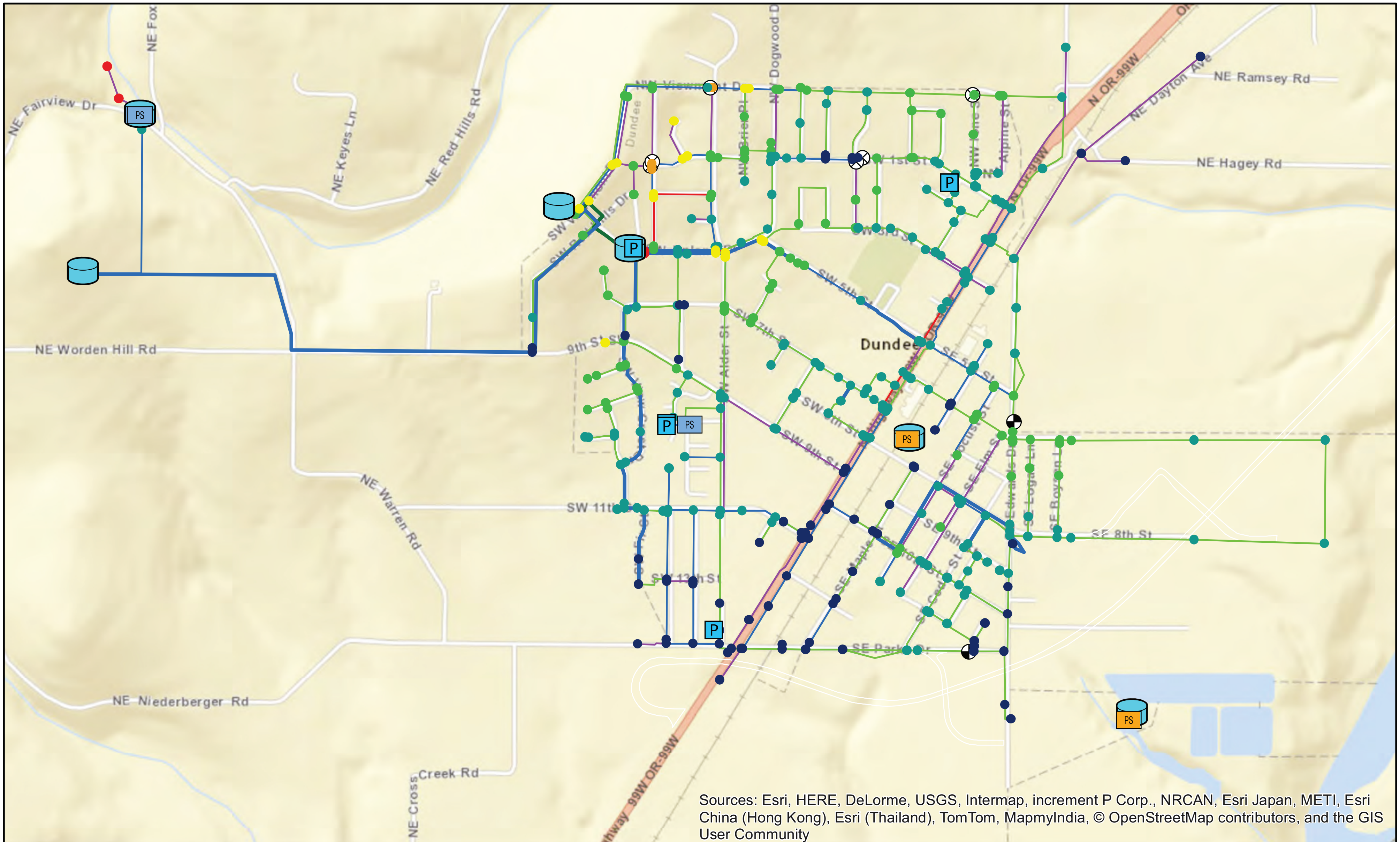

LEGEND

- P Well
- PS Pump Station
- PS New Pump Station
- Storage
- Zone Valve
- PRV

Junction Pressure (psi)	Pipe Diameter (in)
< 20	< = 4
20 - 35	6
35 - 50	8
50 - 75	10
75 - 100	12
> 100	16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-6
2035 Peak Hour Demand Pressure
with Improvements
Dundee Water Distribution System

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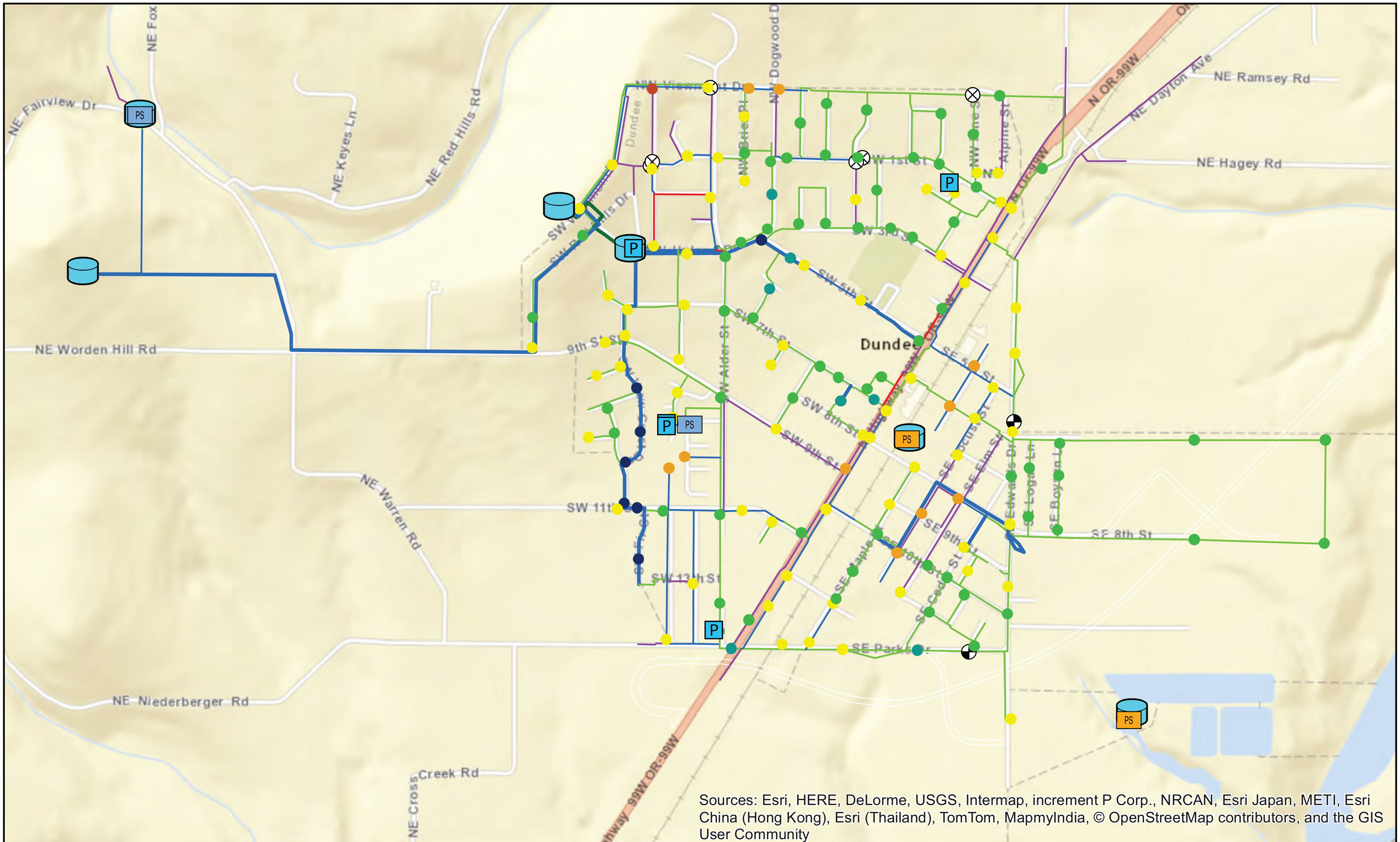

Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

LEGEND

- Well
- Pump Station
- New Pump Station
- Storage
- Zone Valve
- PRV

Junction Available Flow (gpm)

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- > 4000

Pipe Diameter (in)

- < = 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-7
2035 Available Fire Flow
10 ft/sec Velocity Maximum
Dundee Water Distribution System

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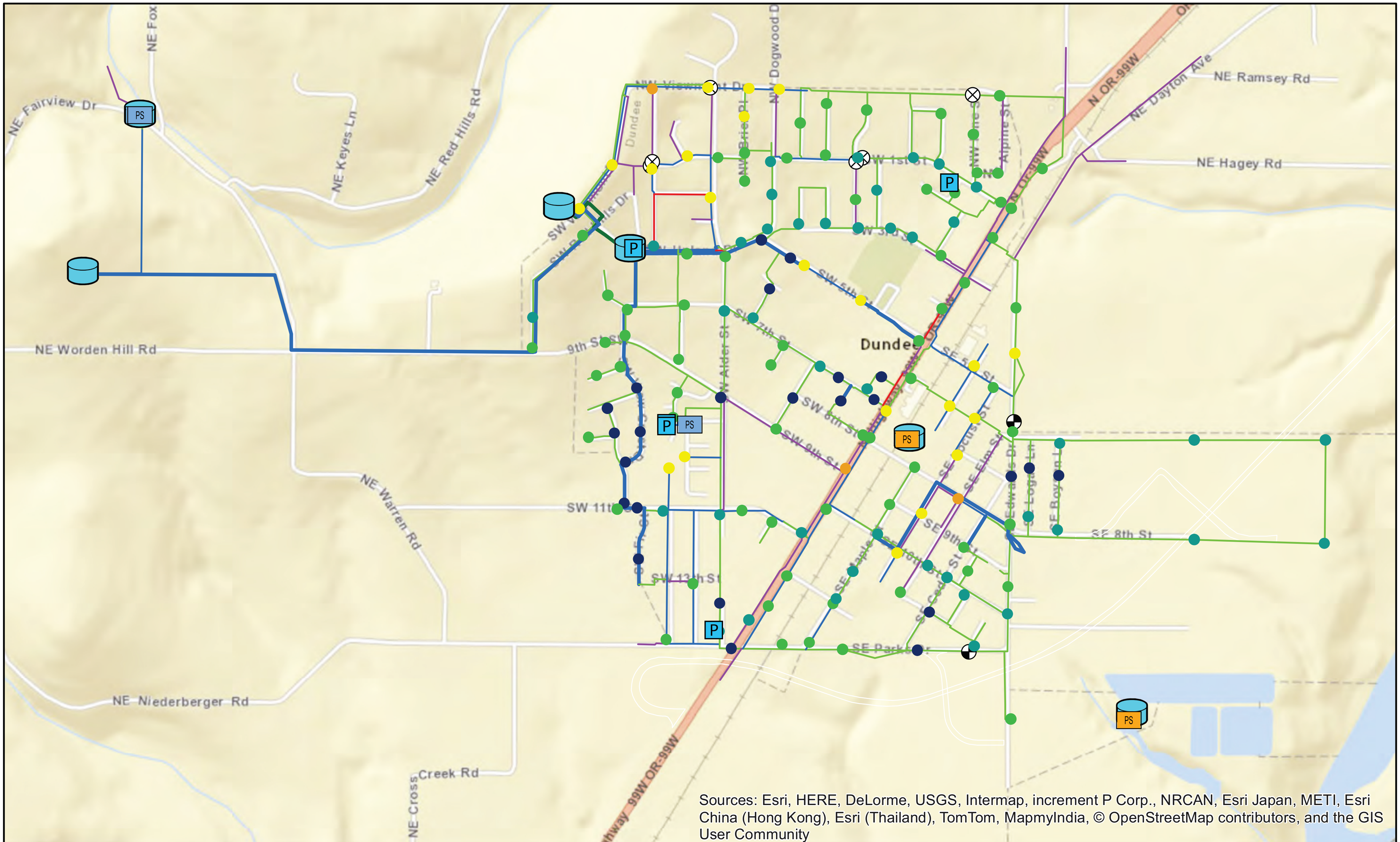

LEGEND

- P Well
- PS Pump Station
- PS New Pump Station
- Storage
- Zone Valve
- PRV

Junction

Available Fire Flow (gpm)

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- > 4000

Pipe

Diameter (in)

- <= 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-8
2035 Available Fire Flow
15 ft/sec Velocity Maximum
Dundee Water Distribution System

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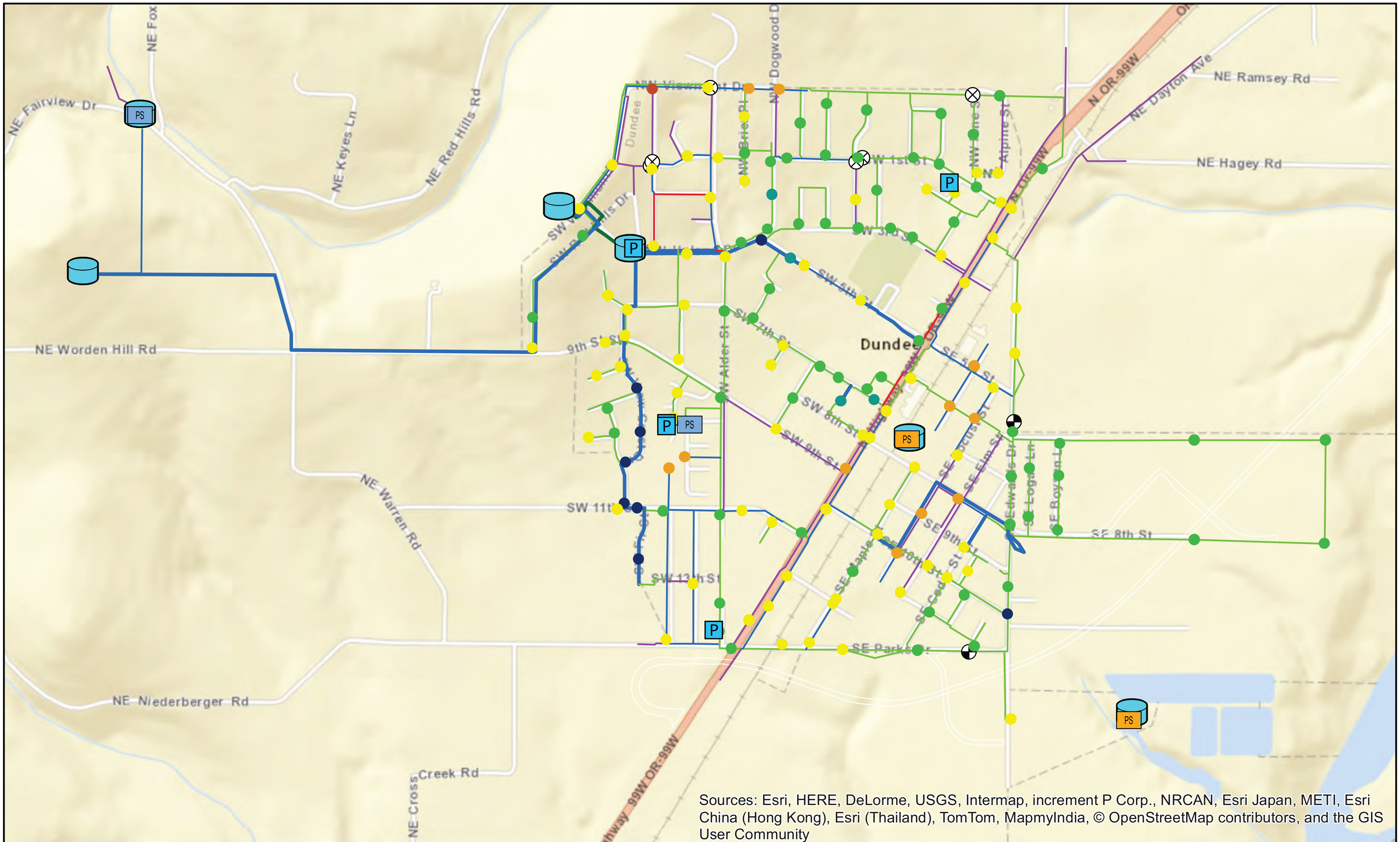

LEGEND

- P Well
- PS Pump Station
- PS New Pump Station
- Storage
- Zone Valve
- PRV

Junction

Available Fire Flow (gpm)

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- > 4000

Pipe

Diameter (in)

- < = 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-9
2035 Available Fire Flow-PRVs only
10 ft/sec Velocity Maximum
Dundee Water Distribution System

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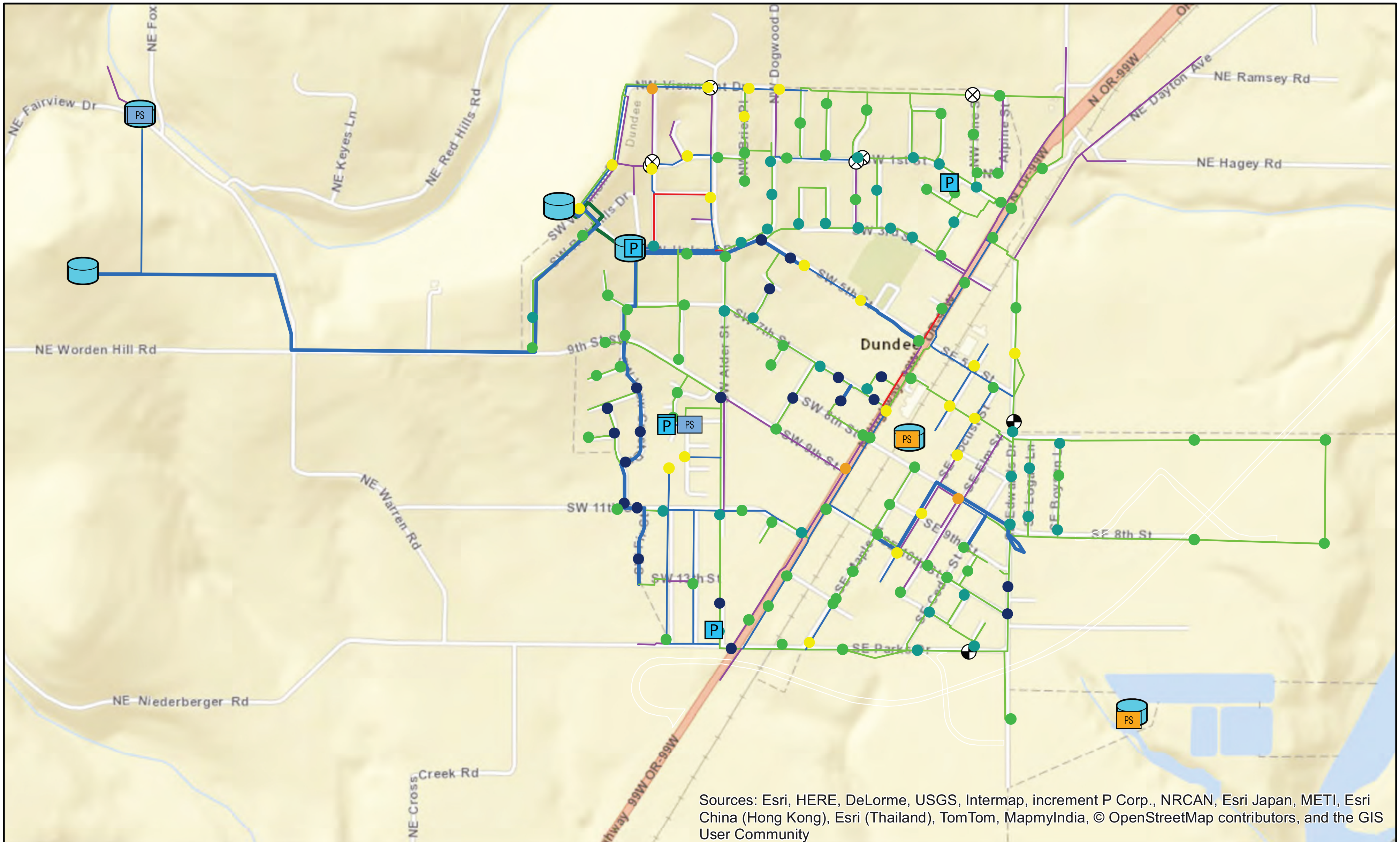

LEGEND

- P Well
- PS Pump Station
- PS New Pump Station
- Storage
- Zone Valve
- PRV

Junction Available Flow (gpm)

- < 500
- 500 - 1000
- 1000 - 2000
- 2000 - 3000
- 3000 - 4000
- > 4000

Pipe Diameter (in)

- < = 4
- 6
- 8
- 10
- 12
- 16

N

0 500 1,000 2,000 3,000 4,000 Feet

FIGURE D-10
2035 Available Fire Flow-PRVs only
15 ft/sec Velocity Maximum
Dundee Water Distribution System

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Appendix E
Cost Estimate

APPENDIX E

Cost Estimate

Pipeline costs estimates were prepared using a cost of $24 per inch diameter and per foot for pipelines, which includes pipeline materials, installation, road resurfacing, contractor overhead and profit, construction contingency, design, and construction inspection.

Storage projects were estimated at $1 per gallon of storage. Pump station projects were developed on a case-by-case basis.

Contractor mark-ups are 10% overhead, 5% profit, and 5% mobilization/bonding/insurance.

Construction contingency is 30%.

Design is 10%; services during construction is 3%.

Costs are all in December 2015 costs. *Engineering News-Record* 20-City Construction Cost Index of 10,092.