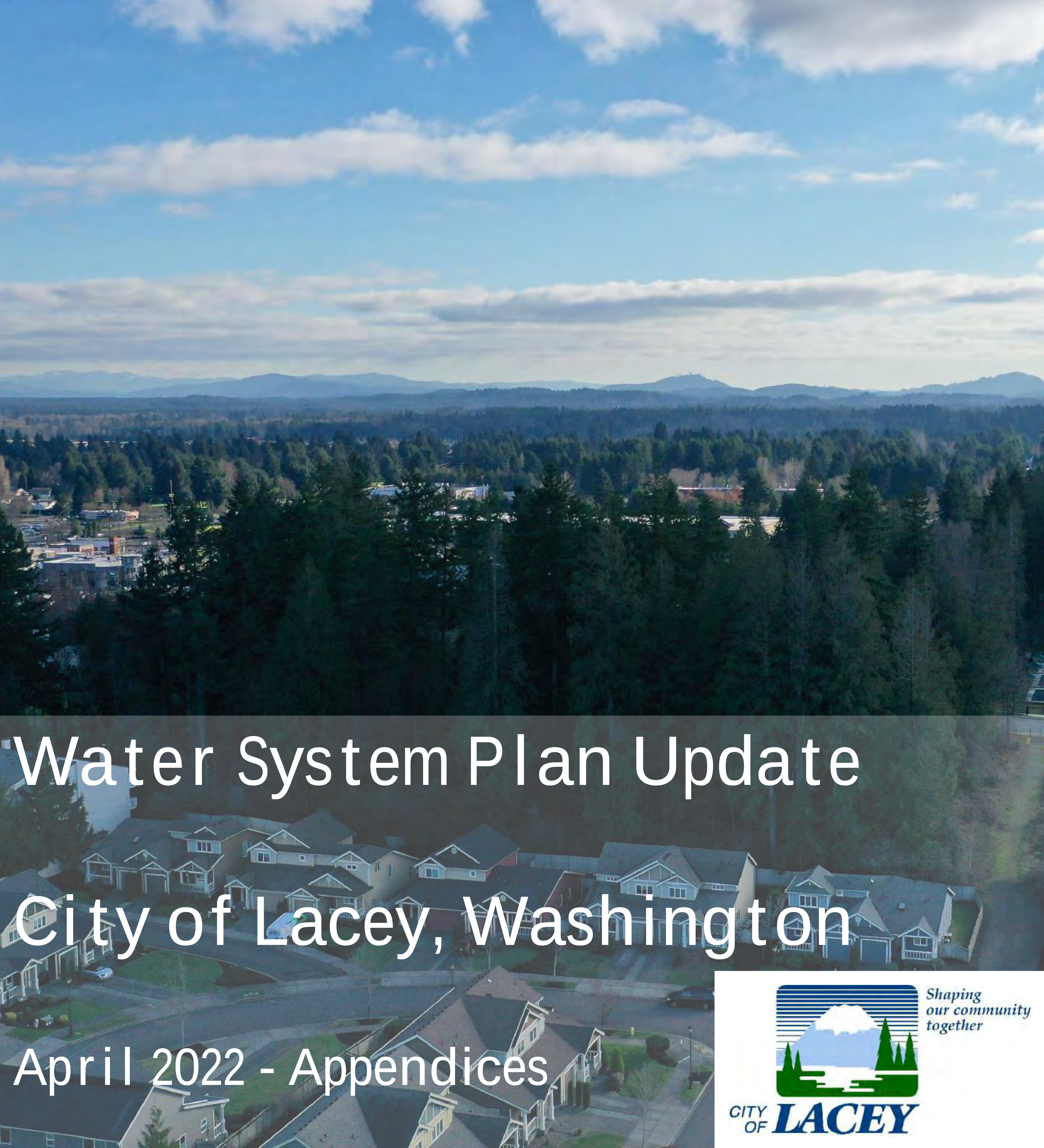

Water System Plan Update

City of Lacey, Washington

April 2022 - Appendices

Shaping our community together

CITY OF LACEY

City of Lacey

Water System Plan Update

Appendices

Appendix A

Water Facilities Inventory Form

WATER FACILITIES INVENTORY (WFI) FORM

Washington State Department of Health
Division of Environmental Health
Office of Drinking Water

ONE FORM PER SYSTEM

Quarter: 1
Updated: 03/23/2018
Printed: 10/11/2019
WFI Printed For: On-Demand
Submission Reason: Source Update

RETURN TO: Central Services - WFI, PO Box 47822, Olympia, WA, 98504-7822

1. SYSTEM ID NO.	2. SYSTEM NAME	3. COUNTY	4. GROUP	5. TYPE
43500 Y	LACEY WATER DEPARTMENT	THURSTON	A	Comm

6. PRIMARY CONTACT NAME & MAILING ADDRESS	7. OWNER NAME & MAILING ADDRESS	8. OWNER NUMBER: 003131
PETER C. BROOKS [MANAGER] 420 COLLEGE ST SE LACEY, WA 98503-1238	LACEY, CITY OF TERRY R. CARGIL 420 COLLEGE ST SE LACEY, WA 98503-1272	MANAGER
STREET ADDRESS IF DIFFERENT FROM ABOVE	**STREET ADDRESS IF DIFFERENT FROM ABOVE**	
ATTN ADDRESS CITY STATE ZIP	ATTN ADDRESS CITY STATE ZIP	

9. 24 HOUR PRIMARY CONTACT INFORMATION		10. OWNER CONTACT INFORMATION	
Primary Contact Daytime Phone:	(360) 438-2675	Owner Daytime Phone:	(360) 413-4395
Primary Contact Mobile/Cell Phone:	(360) 878-0303	Owner Mobile/Cell Phone:	
Primary Contact Evening Phone:	(xxx)-xxx-xxxx	Owner Evening Phone:	(xxx)-xxx-xxxx
Fax: (360) 456-7799	E-mail: xxxxxxxxxxxxxxxxxxxx	Fax: (360) 456-0813	E-mail: xxxxxxxxxxxxxxxxxxxx

11. SATELLITE MANAGEMENT AGENCY - SMA (check only one)

- [x] Not applicable (Skip to #12)
- [ ] Owned and Managed
- [ ] Managed Only
- [ ] Owned Only

SMA NAME: ______________________ SMA Number:

12. WATER SYSTEM CHARACTERISTICS (mark all that apply)

- [ ] Agricultural
- [x] Commercial / Business
- [x] Day Care
- [x] Food Service/Food Permit
- [x] 1,000 or more person event for 2 or more days per year
- [x] Hospital/Clinic
- [x] Industrial
- [x] Licensed Residential Facility
- [x] Lodging
- [x] Recreational / RV Park
- [x] Residential
- [x] School
- [ ] Temporary Farm Worker
- [x] Other (church, fire station, etc.): ______________________

13. WATER SYSTEM OWNERSHIP (mark only one)

- [ ] Association
- [x] City / Town
- [ ] County
- [ ] Federal
- [ ] Investor
- [ ] Private
- [ ] Special District
- [ ] State

14. STORAGE CAPACITY (gallons)

12,847,000

- SEE NEXT PAGE FOR A COMPLETE LIST OF SOURCES -

WATER FACILITIES INVENTORY (WFI) FORM - Continued

1. SYSTEM ID NO.	2. SYSTEM NAME	3. COUNTY	4. GROUP	5. TYPE
43500 Y	LACEY WATER DEPARTMENT	THURSTON	A	Comm

15	16 SOURCE NAME	17 INTERTIE	18 SOURCE CATEGORY										19 USE			20	21 TREATMENT						22 DEPTH	23	24 SOURCE LOCATION			
Source Number	LIST UTILITY'S NAME FOR SOURCE AND WELL TAG ID NUMBER. Example: WELL #1 XYZ456 IF SOURCE IS PURCHASED OR INTERTIED, LIST SELLER'S NAME Example: SEATTLE	INTERTIE SYSTEM ID NUMBER	WELL	WELL FIELD	WELL IN A WELL FIELD	SPRING	SPRING FIELD	SPRING IN SPRINGFIELD	SEA WATER	SURFACE WATER	RANNEY / INF. GALLERY	OTHER	PERMANENT	SEASONAL	EMERGENCY	SOURCE METERED	NONE	CHLORINATION	FILTRATION	FLUORIDATION	IRRADIATION (UV)	OTHER	DEPTH TO FIRST OPEN INTERVAL IN FEET	CAPACITY (GALLONS PER MINUTE)	1/4, 1/4 SECTION	SECTION NUMBER	TOWNSHIP	RANGE
S01	College & 32nd AAA936		X										X			Y		X					100	300	NW SW	28	18N	01W
S02	College & 32nd AAB878 WW				X								X			Y							194	500	NW SW	28	18N	01W
S03	College & 32nd AAA935 WW				X								X			Y							187	230	NW SW	28	18N	01W
S04	Golf Club Estates AAA932		X										X			Y	X	X					66	775	SW NW	04	17N	01W
S05	InAct 02/01/1988 Stanfield & 35th		X										X										100	0	NW SE	27	18N	01W
S06	Judd Hill AAA940		X										X			Y		X					190	250	SE SW	21	18N	01W
S07	Fire Station AAA930		X										X			Y	X	X					428	1800	SE NW	21	18N	01W
S08	InAct 12/13/1990 Tanglewilde East		X										X										300	520	SW NW	12	18N	01W
S09	Little Prairie AAB880		X										X			Y		X					224	700	SW SW	33	18N	01W
S10	Mt Greens AAB881		X										X			Y		X					177	1000	SE SW	33	18N	01W
S11	InAct 02/01/1988 Panorama		X										X										82	0	NW SE	20	18N	01W
S13	InAct 01/01/1990 Meridian Acres #1		X										X										242	250	SE SE	12	18N	01W
S14	InAct 11/20/2006 Meridian Acres #2 A		X										X			Y							272	250	SE SE	12	18N	01W
S15	Beachcrest #1 AAA941 WW				X								X			Y							115	200	SE SW	25	19N	01W
S16	Beachcrest AAA942 WW				X								X			Y							113	220	SE SW	25	19N	01W
S17	WF (S015 & 16) Beachcrest			X									X			Y		X					113	515	SE SW	25	19N	01W
S18	WF(S02 & 3)College & 32nd			X									X			Y		X					187	800	NW SW	28	18N	01W
S19	Hawks Prairie Well #1 AAB877				X								X			Y							585	600	NW SW	35	19N	01W
S20	McAllister AAY302		X										X			Y		X					180	600	NE SW	24	18N	01W
S21	Madrona 1 ABY233 WW				X								X			Y							263	1600	NW NW	24	18N	01W
S22	Madrona 2 ACR769 WW				X								X			Y							265	1600	NW NW	24	18N	01W
S23	WF (S21 & 22) Madrona			X									X			Y		X					263	3200	NE NW	24	18N	01W
S24	Lacey Nisq S01 Well #19A AAA938		X										X			Y		X					98	80	NW SW	09	18N	01E
S25	Lacey Nisq SO2 Well #19C AAA937		X										X			Y		X					58	220	NW SW	09	18N	01E
S26	InAct 12/03/2007 495681/Capital City		X											X		Y							100	350	SW NE	04	17N	01W
S27	Evergreen Est Well #24 AGP478		X										X			Y		X					256	750	NE NW	25	18N	01W
S28	Madrona 3 AEC883		X										X			Y		X					259	1600	NW NW	24	18N	01W
S29	Betti AEC941		X										X			Y		X					297	1000	NW SW	02	18N	01W
S30	63450/Olympia, City of(Pacific Ave)	63450 6													X	Y								1400	NW NE	20	18N	01W
S31	Hawks Prairie Well #2 BAM406 24"				X								X			Y							495	800	NW SW	35	19N	01W
S32	Hawks Prairie WF (S19, S31) CL Req.			X									X			Y		X	X				495	1600	NW SW	35	19N	01W

WATER FACILITIES INVENTORY (WFI) FORM - Continued

1. SYSTEM ID NO.	2. SYSTEM NAME	3. COUNTY	4. GROUP	5. TYPE
43500 Y	LACEY WATER DEPARTMENT	THURSTON	A	Comm

	ACTIVE SERVICE CONNECTIONS	DOH USE ONLY! CALCULATED ACTIVE CONNECTIONS	DOH USE ONLY! APPROVED CONNECTIONS
25. SINGLE FAMILY RESIDENCES (How many of the following do you have?)		29599	Unspecified
A. Full Time Single Family Residences (Occupied 180 days or more per year)	23331		
B. Part Time Single Family Residences (Occupied less than 180 days per year)	0		
26. MULTI-FAMILY RESIDENTIAL BUILDINGS (How many of the following do you have?)			
A. Apartment Buildings, condos, duplexes, barracks, dorms	908		
B. Full Time Residential Units in the Apartments, Condos, Duplexes, Dorms that are occupied more than 180 days/year	6268		
C. Part Time Residential Units in the Apartments, Condos, Duplexes, Dorms that are occupied less than 180 days/year	0		
27. NON-RESIDENTIAL CONNECTIONS (How many of the following do you have?)			
A. Recreational Services and/or Transient Accommodations (Campsites, RV sites, hotel/motel/overnight units)	0	0	
B. Institutional, Commercial/Business, School, Day Care, Industrial Services, etc.	940	940	
28. TOTAL SERVICE CONNECTIONS		30539	

29. FULL-TIME RESIDENTIAL POPULATION

A. How many residents are served by this system 180 or more days per year? 70638

30. PART-TIME RESIDENTIAL POPULATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A. How many part-time residents are present each month?												
B. How many days per month are they present?												

31. TEMPORARY & TRANSIENT USERS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A. How many total visitors, attendees, travelers, campers, patients or customers have access to the water system each month?	760	760	760	760	760	1200	1200	1200	760	760	760	1200
B. How many days per month is water accessible to the public?	31	28	31	30	31	30	31	31	30	31	30	31

32. REGULAR NON-RESIDENTIAL USERS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
A. If you have schools, daycares, or businesses connected to your water system, how many students daycare children and/or employees are present each month?	5500	5500	5500	5500	5500	4620	4620	4620	5500	5500	5500	5500
B. How many days per month are they present?	31	28	31	30	31	30	31	31	30	31	30	31

33. ROUTINE COLIFORM SCHEDULE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
* Requirement is exception from WAC 246-290	80	80	80	80	80	80	80	80	80	80	80	80

34. NITRATE SCHEDULE	QUARTERLY	ANNUALLY	ONCE EVERY 3 YEARS
(One Sample per source by time period)			

35. Reason for Submitting WFI:

☐ Update - Change ☐ Update - No Change ☐ Inactivate ☐ Re-Activate ☐ Name Change ☐ New System ☐ Other ____________

36. I certify that the information stated on this WFI form is correct to the best of my knowledge.

SIGNATURE: ______________________ DATE: ______________________

PRINT NAME: ______________________ TITLE: ______________________

WS ID	**WS Name**
43500	LACEY WATER DEPARTMENT

Total WFI Printed: 1

Washington State Department of
Health
Division of Environmental Health
Office of Drinking Water

Water Facilities Inventory (WFI)

Report Create Date:	10/11/2019		
Water System Id(s):	43500		
Print Data on Distribution Page:	ALL		
Print Copies For:	DOH Copy		
Water System Name:	ALL		
County:	-- Any --		
Region:	ALL		
Group:	ALL		
Type:	ALL		
Permit Renewal Quarter:	ALL		
Water System Is New:	ALL		
Water System Status:	ALL		
Water Status Date From:	ALL	**To:**	ALL
Water System Update Date From:	ALL	**To:**	ALL
Owner Number:	ALL		
SMA Number:	ALL		
SMA Name:	ALL		
Active Connection Count From:	ALL	**To:**	ALL
Approved Connection Count From:	ALL	**To:**	ALL
Full-Time Population From:	ALL	**To:**	ALL
Water System Expanding Services:	ALL		
Source Type:	ALL		
Source Use:	ALL		
WFI Printed For:	On-Demand		

Appendix B

DOH Water System Plan Checklist and Submittal Form

Department of Health, Office of Drinking Water
Southwest Drinking Water Operations
Pre-Plan meeting

Water System: Lacey Water Department, ID #43500

Date: October 26, 2017

Water System Plan Expiration Date: May 30, 2019

Operating Permit Color: Green

Water System Plan Submittal Date: 2018

Attendees: Peter Brooks, Scott Egger, Teri O'Neal, Brandon McAllister, Julie Rector, Terry Cargil, Kay Rottell, Mark Mazeski

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The purpose of this Pre-Plan is to:

1. Determine the scope and level of detail of the WSP update.
2. Establish a schedule for submittal of the WSP update.

Water System Plan Format:
The following sections refer to information that needs to be included in the WSP and provides a proposed outline. You may choose a different format, but all of the elements identified below must be included.

Water System Plan (WSP) Checklist

	√Required	*Content Description*	*WSP Page #*
Chapter 1		**Description of Water System**	
	(√)	Updated WFI, signed and dated	Appendix A
	(√)	Ownership and management	Section 1.6
	(√)	System history and background	Section 2.2.1
	(√)	Inventory of existing facilities, including Sources, Distribution, Storage, Pump Stations, PRVs and Treatment. The inventory should also be shown in map form.	Section 2.4, Fig 2-7
	(√)	Description of and discussion about related plans: CWSP, groundwater management plan, WRIA and City/County land use plans & zoning.	Section 1.3
	(√)	Service Area Maps: ***This is often missing from first submissions, but is a very important element of a WSP.*** *These maps or map should clearly show the service area, including the retail service area, future service area – this should be as shown in the County's Coordinated Water System Plan, and water rights place of use. These can be depicted on one map if properly labeled.* • *Please see Publication DOH 331-432*	Section 2 figures, particularly Figure 2-7
	(√)	Policies: Service area, SMA, conditions of service, annexation • *Please see Publication DOH 331-438*	Section 3.2
	(√)	Duty to serve requirement: procedures, conditions, appeals • *Please see Publication DOH 331-366*	Section 3.2
	(√)	Consistency from local planning agency (LGC statement) Please have this reviewed and signed by the City and County Planning Departments. LGC form is at: http://www.doh.wa.gov/Portals/1/Documents/Pubs/331-568.docx	Appendix C

Chapter 2		**Planning Data**	
	(√)	• Demand analysis based on water use	Chapter 4
		• Include analysis of population, service connections & ERUs	Section 4.3 & 4.4
		• Source and service meter data (preferably three or more, typically 6 years). Provide monthly and annual production and consumption totals.	Table 4-1 & 4-2
		• Provide usage by customer class. Analyze industrial and commercial demands separate from the residential demand and multifamily structures separate from the single family residences.	Table 4-6, Figure 4-6
		• Define ERU	Section 4.2.5.1
		• Provide data and assumptions (including DSL) for calculating MDD, PHD and ADD	Section 4.4.2
		• Demand analysis per pressure zone and the whole system	Section 4.4.5
		• Consider also water supplied to other systems	N/A
		• Since >1000 connections, also include seasonal variations in consumption by customer class	Figure 4-3 & 4-4
	(√)	Provide 10 & 20 year projections for population, service connections, & ERUs • Provide 10 & 20 year projections for demand forecasts with and without expected efficiency savings (conservation)	Pop. – Section 4.3.1 Conns – Section 4.4.3 ERUs – Section 4.4.4 Demand – Sec. 4.4.5
	(√)	Interties – discussion of all existing and proposed interties and copies of agreements	Section 2.3.1, App. E
	(√)	Provide 10 & 20 year projections for land use and zoning	Section 4.3
	(√)	Distribution System Leakage percentage and volume expressed in ERUs	Section 4.2.6
Chapter 3		**System Analysis**	
	(√)	Provide assumptions and basis of analysis	
		• System design standards	Section 3.6
		• Policies on operations and expected level of service (such as standby storage, pumping restrictions and emergency back-up power)	Section 3.3
		• Fire flow requirements and if nesting is allowed. Provide confirmation from the local fire authority on Fire flow requirements.	Section 3.4
	(√)	System inventory and description	Section 2.4
	(√)	Capacity analysis (legal and physical capacity)	
		• Limiting factor analysis (WSDM worksheet 6-1) *Please see Publication DOH 331-123*	Section 8.8.6
		• Include the results of the limiting factor analysis in a table format	Table 8-20
		• Show source, pumping, water rights, treatment, storage, and distribution capacities • Analysis per pressure zone and the whole system	Sections 6.2, 6.8, 8.5, 8.6, and 8.7
		• Water rights analysis- include water right self-assessment form for existing, 10 & 20-year projections, including copies of water right certificate(s)	Sections 6.2, 6.3, & 6.4
		• http://www.doh.wa.gov/Portals/1/Documents/Pubs/331-372-F.docx The above link takes you to the self-assessment form	Self- Assess: App. J
	(√)	Hydraulic analysis of distribution system.	
		• Describe the model used	Section 8.1
		• Evaluate the system based on PHD and MDD + Fire flow	Section 8.7
		• Evaluate the current conditions, and 10- and 20-year planning periods	Section 8.7
		• Check minimum pressures and maximum velocities	Section 8.7
		• Include assumptions of model, pressure zone boundary conditions, and a summary of model input information. Storage assumptions should be based on minimum reservoir levels.	Sections 8.5 – 8.7
		• Include verification and calibration methods and results.	Section 8.7, App. G & App. S
		• Summary of system deficiencies	Section 8.7.2

	(√)	Analysis of possible improvement projects	Section 8.7.3
Chapter 4		**Water Use Efficiency Program**	
	(√)	Water Use Efficiency (WUE) Program per WAC 246-290-810	
		• Describe the current WUE program	Section 5.4 & 5.5
		• Describe WUE goal & document public adoption process *Please see Publication DOH 331-402*	Section 5.3
		• Describe measures that will be implemented to achieve the goal & include schedule & costs in the budget	Section 5.6
		• Describe process used to evaluate the WUE measures you did not implement	Section 5.4 & 5.6
		• Describe yearly consumer education	Section 5.5.1
		• Estimate projected water savings from selected measures	Table 5-2
		• Describe process that will be used to determine effectiveness of the program	Section 5.7
		≥ 1000 Connections	
		• Estimate water saved from efficiency measures over the past 6 years	Section 4.2
		• Quantitative evaluation of measures to determine if they are cost-effective, include marginal costs of water production	Table 5-2
		• Evaluate measures for cost-effectiveness if shared with other systems	N/A
		• Quantitative or qualitative evaluation of measures to determine if they are cost-effective from the societal perspective	Section 5.4.1
	(√)	Source & Service Meters - or schedule for installation w/activities to minimize leakage *Ten percent of all service meters should be replaced annually to maintain 10 year life span.*	Section 10.6.2.3 and 10.6.2.4
	(√)	Water Loss Action Control Plan WAC 246-290-820 *This is required if DSL is greater than 10%*	N/A
	(√)	Water supply characteristics, description & discussion on effect of water use	Chapter 6
	(√)	Source of supply analysis and evaluation of supply alternatives	Section 6.3, 6.4, & 6.5
	(√)	≥1,000 connections explore reclaimed water opportunities☆	Section 6.2.3
Chapter 5		**Source Water Protection**	
	(√)	Wellhead protection program	Chapter 7 & App. P
		2 year update (contaminant inventory, letters and map)	
		Susceptibility assessments to determine how susceptible the source(s) are to contamination.	App. Q
		▪ Delineation of 6-month, 1-year, 5-year, and 10-year time of travel zones that show the land area contributing water (and potential contamination) to the source.	App. Q
		▪ Inventory of potential contaminant sites (names and addresses), which must be updated every two years. If septic systems drainfields are utilized, these are potential sources of contaminants.	App. Q
		▪ Documentation of notification letters to: ▪ Owners and operators of potential contaminant sites (*septic systems*) ▪ Regulatory agencies ▪ Local emergency responders	App. Q
		Contingency plan that makes provisions in case of a drinking water emergency.	App. R
	(√)	Analysis and discussion of Water Quality	Section 6.6
Chapter 6		**Operation and Maintenance Program**	
	(√)	Water system management and personnel	Section 10.2
	(√)	Operator certification *Please list the operators' name, certification numbers and expiration dates.*	Section 10.3

	(√)	Routine operating procedures and preventive maintenance • Standard Operating Procedures (SOP Manual-Surface Water Treatment Plant)	Section 10.4, 10.5 & 10.6
	(√)	Water quality sampling procedures & program *See new WQMS information at:* *https://fortress.wa.gov/doh/eh/portal/odw/si/Intro.aspx*	Sections 10.8, 6.6, & App. N
	(√)	Coliform monitoring plan, including maps (and triggered source monitoring plan) The Revised Total Coliform Rule (RTCR) went into effect on April 1, 2016. Please update the Coliform Monitoring Plan (CMP) consistent with RTCR. Please visit our website at: http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/Contaminants/Coliform/RevisedTotalColiformRuleRTCR	Section 10.8 & App. K
	(√)	Emergency response plan • We have a fill in the blank template at: http://www.doh.wa.gov/Portals/1/Documents/Pubs/331-211.pdf • Water system contacts • Vendor Contacts (Equipment replacement, water haulers, etc.) • Example notices (water outages, BWA, coliform MCL, emergency conservation) • Emergency government officials contact info for Office of Drinking Water (ODW - please list 360-236-3030 for Regional Engineer), County Health Dept., State and County Emergency Operations Centers • List of emergency sources and interties • Emergency response planning activities to ensure preparedness	Section 10.9 & App. R
	(√)	Water shortage response plan and service reliability (See WAC 246-290-420)	Section 10.9.5 & App. I
	(√)	Cross-connection control program (See WAC 246-290-490) • Provide status of implementing Cross Connection Control Program. • Provide copy of CCC ordinance/resolution. • Provide for shutting off water if appropriate back flow devices are not installed, maintained and tested? In the alternative to shutting off water, provide authority for ***City*** to install BFPs and bill landowner for instillation? • Provide an inventory of service connections where you rely upon backflow preventers to protect the public water system, type of backflow protection, the assessed degree of hazard, and history of annual testing for each assembly • Include your Annual Summary Report • Provide a summary of the evaluation of existing service connections for degree of potential hazard to the water system	Section 10.11 & App. T
	(√)	Recordkeeping, reporting, and customer complaint program	Section 10.12
	(√)	Summary of O&M deficiencies	Section 10.15
Chapter 7		**Distribution Facilities Design and Construction Standards**	
	(√)	Standard construction specification for distribution mains	Section 3.6
Chapter 8		**Capital Improvement Program**	
	(√)	Capital improvement schedule for 10 and 20 years • Include inventory and assessment of existing system components	Chapter 9
Chapter 9		**Financial Program**	
	(√)	Financial program, including demonstration of financial viability by providing: *i.* A summary of past income and expenses; *(This should include past 2 to 3 years data at a minimum)* ii. A 10-year balanced operational budget; iii. A plan for collecting the revenue necessary to maintain cash flow stability and to fund the capital improvement program and emergency improvements; *Existing and future loan payments need to be included in*	Chapter 11

		the budget. For example, if part of the CIP will be paid by loan, those payments should be included in budget. List the current water rate. iv. An evaluation that has considered: A. The affordability of water rates; and B. The feasibility of adopting and implementing a rate structure that encourages water demand efficiency. Analysis of connection fees should include costs of additional infrastructure required to serve those additional connections and buy-in to the existing infrastructure costs.	
Chapter 10		**Miscellaneous Documents**	
	(√)	The WSP review requires 3 actions; adoption by the City Council, a meeting of the consumers, and a WUE public forum. The WSP must to be approved by the **City Council** before the WSP can be approved by DOH. Water System plan must be presented at a meeting of the consumers. Water Use Efficiency requires that the WUE Goal setting must be addressed at a public forum, after proper Public Notice. • The WUE Goal setting public forum may be combined with the meeting of the consumers and public hearing for WSP adoption. However, the WUE Goal setting forum must include a WUE public notice. • *The WUE public forum must be published and the notice must specifically state that the Water Use Efficiency Goal will be discussed.* • *Please provide copy of minutes showing the WUE Goal setting was addressed at the public forum.* • *The **City** may post WUE public notice on DOH website in order to meet public forum notice requirements for WUE program. Please see WUE Public Forum Posting Form at the following link:* *http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/WaterSystemDesignandPlanning/WaterUseEfficiency.aspx* • *Please provide the notice and minutes from the hearing for WSP adoption and the meeting of the consumers.*	________
	(√)	County/Adjacent Utility Correspondence *(provide a copy of WSP to adjacent water utilities and local governments with jurisdiction or provide notice with link to WSP on website)*	________
	(√)	Since ≥1000 connections - State Environmental Policy Act (SEPA) Determination is required since the water system has more than 1,000 connections. Provide copy of the SEPA Environmental Checklist, SEPA Determination and the notice in paper and on the Ecology SEPA Registry.	________
	(√)	Agreements: franchise, wheeling, mutual aid, inter-local and other agreements (if any exist)	________
	(√)	Satellite Management Program – See additional Checklist for SMAs	________

Submittal Process

Here are some items the Office of Drinking Water (ODW) must have with your submittal:

1. A complete Water System Plan Submittal Form, current Water Facilities Inventory Form (WFI) signed and dated along with existing, 10 and 20 year Water Rights Self-Assessment Forms.
2. Three (3) copies of the WSP are required – two for ODW use and one to be routed to the Department of Ecology (Ecology).

- Three-ring binders are preferable to comb binders as it allows for page revisions to be added in the draft.
- Tabbed chapters are preferred for ease of review.

3. ODW will complete the WSP review within 90-days from the date of complete submittal.
    - ODW will conduct a detailed review and if necessary, issue a comment letter.
    - If the system is not responsive to our comments, the project can be cancelled and returned to the purveyor.

Appendix C

Adopting Resolutions and Comment Letters

<TO FOLLOW>

Appendix D

SEPA Checklist and DNS

<TO FOLLOW>

Appendix E

Olympia and Meadows

Emergency Intertie Agreements

CITY OF OLYMPIA
P.O. BOX 1967
OLYMPIA, WA 98507-1967

Document Title(s) *(or transactions contained therein)*: Water Supply Agreement Between the Cities of Lacey and Olympia For the Use of Emergency Water System Intertie
Reference Number(s) of Documents assigned or released: *(on page____ of document(s))* N/A
Grantor 1. **CITY OF LACEY,** a non-charter, optional municipal code city of the State of Washington 2. **CITY OF OLYMPIA,** a non-charter, optional municipal code city of the State of Washington
Grantee(s) *(Last name first, then first name and initials)* **1. THE PUBLIC**
Legal Description *(abbreviated: i.e. lot, block, plat or section, township, range)* N/A
Assessors Property Tax Parcel/Account Number N/A

The Auditor/Recorder will rely on the information provided on this form. The staff will not read the document to verify the accuracy or completeness of the indexing information provided herein.

I am requesting an emergency nonstandard recording for an additional fee as provided in RCW 36.18.010. I understand that the recording processing requirements may cover up or otherwise obscure some part of the text of the original document.

Lindsay Marquez

Signature of Requesting Party

4634516 Pages: 6
07/02/2018 12:00 PM Agreement
Thurston County Washington
CITY OF OLYMPIA

AGREEMENT
Water Supply Agreement Between the Cities of Lacey and Olympia For the Use of Emergency Water System Intertie

THIS AGREEMENT is made and entered into this 8 day of June, 2018 by and between the City of Lacey, a municipal corporation of the State of Washington, hereinafter referred to as "Lacey," and the City of Olympia, a municipal corporation of the State of Washington, hereinafter referred to as "Olympia", collectively hereinafter referred to as the "parties".

WHEREAS, the Parties recognize that water resources are finite and vulnerable, and the prudent use and management of these resources requires cooperation among water utilities, and

WHEREAS, the purpose of this Agreement between the Parties is to provide for immediate assistance and coordinated interconnection of the respective potable water system of each city with the other to maintain levels of service during temporary periods of water production insufficiency; and

WHEREAS, this Agreement is authorized under Chapter 39.34 RCW, WAC 246-290-131 and WAC 246-290-132; and

WHEREAS, Olympia provided wholesale water to Lacey until June 30, 2016 under an Intergovernmental Agreement for the Sale of Water through the intertie covered by the Agreement, and

WHEREAS, the Parties recognize entering into this agreement does not provide a guarantee of water resource availability, and

WHEREAS, this Agreement is consistent with the North Thurston County Coordinated Water System Plan;

NOW, THEREFORE, the parties agree to this Agreement as follows:

I. SPECIFIC CONDITIONS

1. Each signatory to this Agreement agrees that for purposes of this Agreement a water supply emergency is defined as an emergency resulting from a major water line break, contamination to the water supply system, mechanical equipment failure, electrical equipment failure or any other mutually agreed upon emergency affecting the water supply system.

2. Olympia agrees in the event that Lacey requests potable water service to address a water supply emergency as defined in item 1 above to provide potable water service to Lacey if Olympia has the capacity to do so. Neither agency is obligated under this agreement to provide potable water service to the other in all circumstances.

3. Water may be provided to Lacey following a mutually agreed to water supply emergency by Olympia whenever water is requested and available, but the water use will never exceed water rights (unless permitted by law or by the Department of Ecology), taking into consideration water stored in reservoirs. Washington Department of Health requirements for minimum water storage and minimum water line pressures will also be maintained (unless permitted by law or the Department of Health).

4. Water use by Lacey under this Agreement shall be limited to up to two million gallons per day of water during the months of November through June, and up to one million gallons per day of water during the months of July through October. Such water supply limitations may be revised by Olympia at its discretion and do not represent a guarantee to Lacey of water availability. There are no additional water conservation programs, data collection, water demand forecasting, and other operational matters required by this Agreement.

5. The aforementioned potable water service shall be supplied through an emergency water system intertie located at Mountain Aire Location A (Exhibit A). The Parties agree said intertie shall be utilized only in a mutually agreed to water supply emergency unless converted by mutual agreement to a regular wholesale service.

6. Activation of said emergency intertie for water used under this Agreement shall be coordinated and administered by Olympia's and Lacey's Public Works Departments. Activation of the emergency intertie may occur only after the duration of time, the amount of water and any other conditions deemed appropriate to apply have been mutually agreed to.

7. No emergency intertie activation shall take place without a representative from Olympia and Lacey present at the emergency intertie location at the time of activation.

8. The purpose of this Agreement is for the benefit of Lacey; therefore, there shall be a service charge for water service provided.

9. Starting from the beginning of water service provided to Lacey under this Agreement, Olympia shall be reimbursed for water used based on the most

recent Olympia wholesale water rates for Lacey in effect at the time of water use under this Agreement, adjusted annually at the same rate as the published Seattle Consumer Price Index (CPI). The most recent Olympia wholesale water rate for the City of Lacey is a fixed monthly charge of $16,852.32 plus volume charges of $0.220 per ccf (hundred cubic feet), prorated for the actual amount of time water is used, provided that a weekly fixed charge, plus volume, will serve as the minimum charge for water used under this Agreement. The wholesale water rate will be re-evaluated by December 31, 2020.

10. Lacey shall, to the extent feasible, implement conservation measures that restrict non-emergency water consumption to levels that will not impinge on water service levels necessary to protect health and safety, and to meet the reasonable expectations of the customers of Olympia.

11. Olympia shall retain the right to deny or withdraw some or all of its resources at any time should assistance to Lacey impinge on the protection of property and life in Olympia, as determined by Olympia.

II. INTERLOCAL ELEMENTS:

1. Duration. This agreement shall be "on-going" until terminated by the parties as provided by paragraph 6 of this section.

2. No separate legal entity is created by this agreement.

3. No joint organization whatsoever is created.

4. No common budget is to be established.

5. No personal or real property is to be jointly acquired.

6. This Water Supply Agreement shall be effective immediately upon signature by both parties and shall remain in effect indefinitely, unless terminated by either:

   A. Unilateral written notice by one party to the other that it intends to withdraw from this Agreement, in which case the termination will be effective immediately, unless otherwise specified, or

   B. Written agreement signed by both parties, in which case the termination shall be effective immediately upon signature by both parties, unless another termination date mutually agreed to by both parties is specified.

7. The Contract Administrator for Olympia shall be the Olympia Water Resources Director. The Contract Administrator for Lacey shall be the Lacey Water Resources Manager.

8. This agreement shall be recorded with the Thurston County Auditor's Office prior to being effective, and in accordance with the requirements of RCW 39.34.040.

9. Each party shall be responsible for its own finances and for its own personal and real property.

III. GENERAL CONDITIONS

1. All lawsuits whatsoever in regards to this agreement shall be brought in Thurston County Superior Court. The governing law shall be laws of Washington State.

2. All notices with regard to this agreement shall be sent in addition to any other legal requirement to:

City of Olympia:

City of Olympia Public Works
Attention: Andy Haub, P.E., Water Resources Director
PO Box 1967
Olympia, WA 98507

City of Lacey:

City of Lacey
Attention: Peter C. Brooks, P.E., Water Resources Manager
420 College Street SE
Lacey, WA 98509-3400

CITY OF LACEY	CITY OF OLYMPIA
By: ____________ City Manager	By: ____________ City Manager

ATTEST:

By: ____________ City Clerk	By: ____________ City Clerk

APPROVED AS TO FORM:

By: ______________________
City Attorney

By: ______________________
~~Assistant~~ City Attorney

PURCHASE AND SALE AGREEMENT
FOR THE WATER SERVICE AREA, WELL SITE, EASEMENTS AND WATER RIGHTS

THIS AGREEMENT is made and entered into this 30th day of Nov., 1995, by and between the City of Lacey, a municipal corporation, hereinafter called "Lacey" and the Meadows Water Company, Inc., a Washington corporation, hereinafter called "Meadows".

BACKGROUND

Lacey and Meadows agree the following recitals are material to the understanding of this agreement:

A. Meadows maintains a water service area designated in the Thurston County Coordinated Water System Plan (See Exhibit "A"). This area includes substantially all of the area encompassed by the preliminary plat of Madrona Park (See Exhibit "B") and is subject to the conditions of service described by Meadows in a letter to the developer dated April 29, 1994 (See Exhibit "C").

B. Meadows does not own any property rights in the area encompassed by the Madrona Park preliminary plat except those rights and responsibilities it has as a designated water purveyor pursuant to the Thurston County Coordinated Water System Plan, the Public Water System Coordination Act, RCW 70.116, and the Thurston County preliminary plat approval for Madrona Park, Case No. 524.

C. Lacey has drilled a test well in the Madrona Park preliminary plat area and has found the site has the potential for one or two wells each with a production capacity of 500 to 1,000 gallons per minute. In addition, the Madrona Park preliminary plat area is approved for about 400 lots and a school site and Lacey will be entitled to charge general facility charges for each water hookup during the development of Madrona Park after this area is transferred to the Lacey water service area.

D. Meadows owns a non-operating well hereinafter called "Well No. 7" which is located in Open Space/Community Area Tract "A" of the plat of the Ridge, Division 2, as approximately shown in the attached plat map (See Exhibit "D"). This well site is subject to a 100-foot radius protective covenant that is recorded under Thurston County Auditor File No. 9202030154 (See Exhibit "E").

E. Lacey wishes to purchase the Well No. 7 well site from Meadows and certain waterline easements to allow Lacey to connect Well No. 7 to its existing watermain on Steilacoom Road. It is anticipated Well No. 7 will produce at least 440 gallons per minute (gpm) which will be determined by Lacey at its cost prior to closing. As part of the installation of the permanent well by Lacey, Lacey shall install a meter to measure the water withdrawn from said well. Meadows shall have the right to monitor such meter, however, Meadows shall not protest any production from said well which exceeds that production covered by the water right purchased herein, the water right purchased as a result of the option granted herein, or production that is possible because of additional water rights obtained by Lacey from sources other than the Meadows unless Meadows can scientifically demonstrate that such additional production will detrimentally impact production from wells owned by Meadows which exist on the date of this agreement and are used to supply the service area designated for Meadows.

F. It is not intended by either party that the sale of the Well No. 7 well site will in any way change the Meadows service area. Lacey will not negotiate any agreement with Janette Wentjar and/or her successors in interest in order to obtain a waterline easement that will be conditioned upon said property being changed from the Meadows to the Lacey Water Service Area.

G. Meadows owns the following property rights in the Ridge, Division 2, as established in the plat of the Ridge, Division 2 recorded under Thurston County Auditor File No. 9202210021:

> The water distribution system in this subdivision is owned by the Meadows Water Company, Inc., its successors and assigns. A perpetual, non-exclusive easement is granted to the Meadows Water Company, Inc., it successors and assigns, over, under and across all of the following designated areas on the final plat of the Ridge, Division 2: "Open Space/Community Area" tracts; "Park Area" tracts; "Street", Right-of-Ways; and "Drainage", "Path", and "Sanitary Sewer" easement premises for the purpose of constructing, installing, operating, maintaining and replacing water lines, mains, wells, pumps, hydrants and all other water system appurtenances necessary for the proper operation of a municipal type water system. All water rights in this subdivision are owned by the Meadows Water Company, Inc.

H. Lacey desires easement rights for a waterline to connect Well No. 7 with its existing watermain on Steilacoom Road. Meadows will provide a 15-foot wide waterline easement from Well No. 7 to Deerbrush Drive and the north boundary of the Ridge, Division 2, subdivision within the "Open Space/Community Area Tract A" of the Ridge, Division 2 and "Open Space/Community Area Tract A" of the Meadows, Division 3-D, to Well No. 7 as legally described in the attached Exhibit "F".

I. Meadows owns the following property rights in"Open Space/Community Tract A" of the Meadows, Division 3-D, recorded under Thurston County Auditor File No. 8502050091 and 8502080050 respectively:

> <u>AF #8502050091</u>
> Easement rights granted to the Meadows Water Supply Company for the maintenance, operation and construction of water facilities.
>
> <u>AF #8502080050</u>
> All water rights to the properties. All improvements and facilities built or to be built by the Meadows Water System for whatever purpose deemed necessary by the Grantor (i.e. Hodges Homes, Inc., whose successor is Meadows Water Company, Inc. per Deed filed under Thurston County Auditor File No. 8709300032). An easement for the maintenance, repair, operation and construction of improvements

and water facilities for the benefit of the Meadows Water System as deemed necessary by the Grantor (i.e. Hodges Homes, Inc., whose successor is Meadows Water Company, Inc. per Deed filed under Thurston County Auditor File No. 8709300032.)

J. In addition to the easement rights for a waterline to connect Well No. 7 as described above, Meadows will provide Lacey a "construction license" for the period from the date closing of this agreement until May 1, 1997 to use open space areas described above for the purpose of making Well No. 7 operable and constructing and installing the necessary waterlines and other necessary appurtenances to connect Well No. 7 to its existing water system. This "construction license" shall not exceed the scope of rights granted to the Meadows for use of the open space areas and Lacey agrees to indemnify and hold Meadows harmless from any claims, suits, actions, damages or liability whatsoever which relates to work that will be done by Lacey and/or its agents on these open space areas and agrees to reimburse the Meadows for any damages to its facilities and/or equipment caused by Lacey and/or its agents. Further, Lacey shall indemnify and hold the Meadows and the fee owners of the open space areas from and against any mechanic's or other liens or claims that may be filed or asserted against the properties or Meadows or the fee owners of the properties by any actions taken by Lacey and/or its agents in connection with its use of the properties.

K. Meadows desires an 8" waterline intertie between its water system and the water distribution system that will be installed in the Madrona Park plat. This intertie shall be installed as part of the construction of the Madrona Park distribution system and at no cost to Meadows adjacent watermain at Shadberry Drive. The purpose of this intertie will be to provide emergency water supplies to either system and to allow for the sale of water from either Lacey or the Meadows to the other. This intertie is material to this agreement because it assures Meadows it will have immediate access to water in the event Lacey's use of Well No. 7 reduces the water supply to the wells used by Meadows to supply its customers. Lacey agrees it will sell water on an emergency basis to the Meadows in the event Meadows requires this water due to a scientifically demonstrated reduction in its water supply as a result of Lacey's use of Well No. 7 or on a temporary basis not exceeding ten (10) days to allow Meadows to maintain its system. The rate charged in such case shall be in accordance with rates charged by Lacey to other water purveyors. Upon mutual agreement, both parties may use the intertie to sell water or purchase water, as the case may be.

AGREEMENT

Lacey and Meadows agree:

1. Meadows agrees to sell and Lacey agrees to purchase the following assets of the Meadows Water Company, Inc.:

   A. That certain well and well site known as Well No. 7 and located within "Open Space/Community Area Tract A" of the Ridge, Division 2 (See Exhibit "D"). Said well site shall include a well site protection easement lying within a circle having a radius of 100 feet, with the center of said circle being the actual well (See Exhibit "E"). Said center point shall be the well as it exists at the date of this agreement or as it shall be relocated by Lacey within 20 feet of its current location. (Note: To ensure a 100 foot radius the well must be relocated either directly north or directly south of the existing well.) The easement shall include a restriction against the storage, disposal or application in the easement area of any source of contamination without the written permission of Lacey.

B. Distribution easements from Well No. 7 to Deerbrush Drive and to the north boundary of the Ridge, Division 2 subdivision. A construction license from Meadows to Lacey described in and subject to the terms and conditions in paragraph "J" above. Legal descriptions of the real property constituting the well site, the well protection easement and easements for distribution lines shall be attached hereto as Exhibit "F".

C. Rights of the Meadows to withdraw water associated with Well No. 7 to the extent of 440 gallons per minute (gpm) but no more than 132 acre feet of water per year represented under Water Rights Permit No. G 2-26623 P issued by the Department of Ecology with a priority date of November 29, 1984.

D. All service area rights granted to or designated for the Meadows Water Company, Inc. over the real property within the Preliminary Plat of Madrona Park. Said real property is legally described on Exhibit "B", attached hereto and made a part hereof.

2. Meadows shall, upon closing, convey said assets to Lacey by bill of sale, warranty deed, assignment or appropriate instrument either directly or by other appropriate parties, conveying clear title to all assets free of any encumbrances, taxes, whether assessed now or in the future for periods of time prior to closing and any other lien or encumbrance against the assets whatsoever. In addition, the Meadows shall provide any necessary approvals to the assignment of easements, franchises, water rights or other assets to be conveyed or assigned. Meadows shall provide title insurance insuring that the title to said assets is free and clear as set forth in this paragraph and by signing this agreement, authorizes Lacey to order preliminary commitment for said title insurance.

3. The purchase price shall be Three Hundred Seventy-Five Thousand Dollars ($375,000), which sum shall be paid by Lacey to Meadows upon closing. The purchase price shall be full compensation for all assets purchased herein and for all commitments and agreement made by Meadows as part of this agreement with exception of the option granted to Lacey for the purchase of additional water rights as set forth subsequent hereto.

4. Meadows shall not protest, object to or in any other manner hinder the granting to Lacey of a permit or permits for the withdrawal of water from wells located or to be located within the preliminary plat of Madrona Park, more fully described on Exhibit "B" provided the withdrawals do not exceed 2,000 gpm and 1,200 acre feet of water per year.

5. Lacey shall not protest, object to or in any other manner hinder the granting to the

Meadows of a permit or permits for the withdrawal of water from wells located or to be located within the Meadows Service Area, excluding the Madrona Park Preliminary Plat Area, more fully described in Exhibit "A" unless Lacey can scientifically demonstrate that such additional production will detrimentally impact production from Well No. 7 being purchased by Lacey pursuant to this agreement. Provided, however, the total of such withdrawal or withdrawals shall not exceed 2000 gpm and 630 acre feet of water per year reduced by the amount of the "gpm" and "acre feet" of water right purchased under this agreement by Lacey.

6. Lacey, as a condition of service of providing water to the area encompassed by the preliminary plat of Madrona Park, shall require the owners or developers of the property to install an eight inch (8") waterline intertie to the existing Meadows watermain adjacent to Madrona Park at Shadberry Drive. The intertie will be installed at no cost to Meadows and shall contain a gate valve and meter and be used for the purposes described above in paragraph "K".

7. This agreement is contingent upon the following:

   A. The testing of Well No. 7 by Lacey resulting in at least 440 gpm capacity for said well and water quality sufficient to pass Washington State Department of Health potable water standards without treatment;

   B. The testing of Well No. 7 by Lacey indicating to Meadows that production of 440 gpm from Well No. 7 will not detrimentally impact other existing Meadows' wells; and

   C. A grant of permission by Puget Sound Power and Light for Lacey to construct a well house upon said Well No. 7 and under power lines belonging to Puget Power.

   D. The obtaining by Meadows of a written release of liability signed by the owners and/or developers of Madrona Park releasing the Meadows and Lacey from any liability as a result of the transfer of the Madrona Park Service Area from the Meadows to Lacey.

8. Meadows further grants unto Lacey the option to purchase up to an additional 200 gpm of water rights under existing Water Rights Permit or Permits held by Meadows and issued by the Department of Ecology. Such permitted water rights shall be capable of being utilized by Lacey in conjunction with production from Well No. 7. Said option shall be exercised by Lacey within one year after the date of closing of the purchase and sale called for herein by mailing a letter exercising the option to Meadows Water Company, Inc., c/o Nick Adams at 7852 Delphi Rd S.W., Olympia, Washington 98512-2158. Within 10 days of exercising said option, Lacey shall pay to Meadows a sum of $125.00 for each gallon per minute of withdrawal rights purchased which exceeds the original 440 gpm purchase called for in this agreement. Each one (1) gpm purchased will be subject to a three-tenths (3/10) of one acre feet

of water per year production limit or a maximum of sixty (60) acre feet of water per year in the event 200 gpm are purchased. At time of payment, Meadows shall provide Lacey the appropriate instruments of transfer for said asset free of any encumbrances and taxes, including any necessary governmental approvals for said transfer.

9. The date of closing of the purchase and sale set forth herein shall occur within thirty (30) days after the contingencies set forth in paragraph 7 are met. If said contingencies have not been satisfied prior to March 1, 1996, or otherwise waived by Lacey or Meadows, as the case may be, this agreement shall be null and void. In the event the closing date is scheduled prior to January 1, 1996 under the terms herein, Meadows shall be entitled to extend closing to on or before January 15, 1996.

DATED the day and date first above written

CITY OF LACEY:

~~BY:~~ [signature]
City Manager

Approved as to form:

BY: [signature]
~~Lacey City~~ Attorney

MEADOWS WATER COMPANY, INC.:

BY: James W. Hodges
James W. Hodges, President

BY: Nicholas Adams
Nicholas Adams, Secretary

STATE OF WASHINGTON)
) ss.
County of Thurston)

On this day personally appeared before me JAMES W. HODGES and NICHOLAS ADAMS, to me known to be the President and Secretary, respectively, of the corporation that executed the within and foregoing instrument, and acknowledged the said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated that they were authorized to execute the said instrument.

GIVEN under my hand and official seal this 30th day of November, 1995.

[signature]

NOTARY PUBLIC in and for the State of Washington, residing at Olympia
My Commission Expires: 9/1/99

Addendum to
PURCHASE AND SALE AGREEMENT
for the
WATER SERVICE AREA, WELL SITE, EASEMENTS AND WATER RIGHTS
1-11-96

THIS ADDENDUM is made January 11, 1996 by and between the MEADOWS WATER COMPANY, INC., JAMES W. HODGES and KEITH HODGES, as the seller, and the CITY OF LACEY, as the purchaser, for a certain water service area, well site, easements and water rights described in an agreement signed November 30, 1995 by the officers of the Meadows Water Company, Inc. (attached hereto as Exhibit "A" and incorporated herein by reference).

This addendum incorporates and ratifies the above referenced agreement in Exhibit "A" (hereinafter referred to as the "agreement") but modifies it as follows:

1. The ownership of certain assets listed in said agreement as owned by the Meadows Water Company, Inc. are in fact owned by James W. Hodges and Keith Hodges. These assets include the following:

    a. Rights of the Meadows to withdraw water associated with Well No. 7 to the extent of 440 gallons per minute (gpm) but no more than 132 acre feet of water per year represented under Water Rights Permit No. G2-26623 P issued by the Department of Ecology with a priority date of November 29, 1984 (see item "C" on page of 4 of the agreement).

    b. All service area rights granted to or designated for the Meadows Water Company, Inc. over the real property within the Preliminary Plat of Madrona Park. Said real property is legally described on Exhibit "B" of the agreement (see item "D" on page 4 of the agreement).

    c. Rights to an additional 200 gpm of water rights under existing Water Rights Permit or Permits held by the Meadows Water Company, Inc. and issued by the Department of Ecology (see item "8" on page 8 of the agreement).

2. The purchase price of the assets described in the agreement, including items "a" and "b" above, shall be $375,000.00, which sum shall be paid by Lacey to the Meadows Water Company, Inc., James W. Hodges and Keith Hodges upon closing. Said price shall be allocated as follows:

Well No. 7	-	$ 12,500 (payable to the Meadows)
Item "a" above	-	$ 55,000 (payable to J.W. and K. Hodges)
Well No. 7 Easements	-	$ 1,500 (payable to the Meadows)
Item "b" above	-	<u>$306,000</u> (payable to J.W. and K. Hodges)
		$375,000

3. In the event Lacey exercises its option described in item "8" on page 5 of the agreement for the purchase of up to an additional 200 gpm of water rights at the rate of $125.00 per 1 gpm of water rights, the purchase price shall be paid to J.W. Hodges and K. Hodges.

4. All other terms and conditions of the agreement shall remain the same and in force.

CITY OF LACEY:

BY: ______________________
City Manager

Approved as to form:

BY: ______________________
Lacey City Attorney

MEADOWS WATER COMPANY, INC.

BY: ______________________
Keith Hodges, President

BY: ______________________
Nicholas Adams, Secretary

______________________ By Keith Hodges as his Attorney in fact
James W. Hodges

____
Keith Hodges

Transfer of Water Rights & Service Area

THIS INSTRUMENT is made this 11th day of July, 1996, by and between **JAMES W. HODGES**, hereinafter called "JWH", **KEITH HODGES**, hereinafter called "KH" and the **CITY OF LACEY**, a municipal corporation, hereinafter called "Lacey".

The following recitals of fact are a material part of this instrument:

A. On January 1, 1995, the Meadows Water Company, Inc. transferred the ownership of certain properties known as "Water Rights for Well No. 7" and "Madrona Park Water Service Area" to its stockholders James W. Hodges and Keith Hodges. The property transferred is described as follows:

> Water Rights for Well No. 7:
>
> Rights of the Meadows to withdraw water associated with Well No. 7 to the extent of 440 gallons per minute (gpm) but no more than 132 acre feet of water per year represented under Water Rights Permit No. G2-26623 P issued by the Department of Ecology with a priority date of November 29, 1984. Plus, rights to an additional 200 gpm of water rights, subject to a maximum of sixty (60) acre feet of water per year production, for use at Well No. 7, under existing Water Rights Permit or Permits held by the Meadows Water Company, Inc. and issued by the Department of Ecology.
>
> Madrona Park Water Service Area:
>
> All service area rights granted to or designated for the Meadows Water Company, Inc. as a designated water purveyor pursuant to the Thurston County Coordinated Water System Plan, the Public Water System Coordination Act, RCW 70.116, and the Thurston County preliminary plat for Madrona Park, Case No. 524, over the real property within the Preliminary Plat of Madrona Park.

B. Pursuant to a "Purchase and Sale Agreement for the Water Service Area, Well Site, Easements and Water Rights", dated November 30, 1995, and "Addendum to Purchase and Sale Agreement for the Water Service Area, Well Site, Easements and Water Rights" dated January 11, 1996, between Lacey, as purchaser, and Meadows, JWH and KH, as sellers, it was agreed JWH and KH would sell to Lacey the water rights (440 gpm) associated with Well No. 7 and the water service area for the Madrona Park Preliminary Plat and that the Meadows would sell a portion of its easement rights in Tract A of the Ridge, Division 2, Tract A of the Meadows, Division 3-D and Lot 211 of the Meadows, Division 3-A and the well site in the "Open Space/Community Area Tract "A" of the Ridge, Division 2 known as "Well No. 7". Also included was a 100 foot radius well protection covenant area surrounding "Well No. 7" in the Ridge Open Space Property.

NOW, THEREFORE, in consideration of the above and other valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the following transfers are made:

AGREEMENT

1. TRANSFER OF WATER RIGHTS. JWH and KH hereby quit claim, grant, sell, transfer and deliver to Lacey, its successors and assigns, the following:

> Water Rights for Well No. 7:
>
> Rights of the Meadows Water Company, Inc. to withdraw water associated with Well No. 7 to the extent of 440 gallons per minute (gpm) but no more than 132 acre feet of water per year represented under Water Rights Permit No. G2-26623 P issued by the Department of Ecology with a priority date of November 29, 1984.

JWH and KH represent that they are the lawful owners of the above water rights and that they have good right to sell said rights and will warrant and defend the rights against lawful claims and demands of all persons.

2. TRANSFER OF WATER SERVICE AREA. JWH and KH hereby quit claim, grant, sell, transfer and deliver to Lacey, its successors and assigns, the following:

> Madrona Park Water Service Area:
>
> All service area rights granted to or designated for the Meadows Water Company, Inc. as a designated water purveyor pursuant to the Thurston County Coordinated Water System Plan, the Public Water System Coordination Act, RCW 70.116, and the Thurston County preliminary plat for Madrona Park, Case No. 524, over the real property within the Preliminary Plat of Madrona Park.

JWH and KH represent that they are the lawful owners of the above water service area and that they have good right to sell said service area and will warrant and defend the right against lawful claims and demands of all persons.

3. CONSTRUCTION. The rule of strict construction does not apply to this instrument. The transfer of title and rights and other provisions of this instrument shall be given a reasonable construction so that the intention of the parties herein is carried out.

4. SURVIVAL OF PURCHASE AND SALE AGREEMENT AND ADDENDUM THERETO. Except as this instrument partially fulfills that certain Purchase and Sale Agreement for the Water Service Area, Well Site, Easements and Water Rights between the parties dated November 30, 1995 and the Addendum to Purchase and Sale Agreement for the Water Service Area, Well Site, Easements, and Water Rights dated January 11, 1996, said Agreement, the Addendum thereto, and the rights and obligations set forth therein, shall remain valid and binding and shall survive the closing and transfer contemplated by this instrument.

IN WITNESS WHEREOF, the undersigned, are parties to this instrument.

MEADOWS WATER COMPANY, INC.*

By: Keith Hodges
Its President

By: Nicholas Adams
Its Secretary

CITY OF LACEY

By: [signature]
Its City Manager

Approved as to form:

By: [signature]
Its City Attorney

HODGES HOMES, INC.*

By: Keith Hodges
Its President

By: Nicholas Adams
Its Secretary

JAMES W. HODGES

James W. Hodges
Seller

KEITH HODGES

Keith Hodges
Seller

* These parties confirm and ratify the ownership of James W. Hodges and Keith Hodges of the properties transferred by JWH and KH to Lacey in this instrument.

MWCwater.066

STATE OF WASHINGTON)
)SS:
COUNTY OF THURSTON)

ON this 11th day of July, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Keith Hodges and Nicholas Adams, to me known (or proven on the basis of satisfactory evidence) to be the President and Secretary, respectively of Meadows Water Co Inc, a Washington corporation, the corporation that executed the within and foregoing instrument, and acknowledged said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated they were authorized to execute said instrument and that the seal affixed, if any, is the corporate seal of said corporation.

Given under my hand and official seal this 11th day of July, 1996.

Terecia A Hart
Notary Public in and for the State of
Washington, residing at Olympia
Print Name: Terecia A. Hart
My Commission Expires 9/1/99

STATE OF WASHINGTON)
)SS:
COUNTY OF THURSTON)

ON this 11th day of July, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Keith Hodges and Nicholas Adams, to me known (or proven on the basis of satisfactory evidence) to be the President and Secretary, respectively of Hodges Homes Inc, a Washington corporation, the corporation that executed the within and foregoing instrument, and acknowledged said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated they were authorized to execute said instrument and that the seal affixed, if any, is the corporate seal of said corporation.

Given under my hand and official seal this 11th day of July, 1996.

Terecia A Hart
Notary Public in and for the State of
Washington, residing at Olympia
Print Name: Terecia A. Hart
My Commission Expires 9/1/99

STATE OF WASHINGTON)
)SS:
COUNTY OF THURSTON)

ON this 23rd day of July, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Greg J. Cuoio and —, to me known (or proven on the basis of satisfactory evidence) to be the City Manager ~~and~~ , ~~respectively~~ of The City of Lacey, a municipal corporation, the corporation that executed the within and foregoing instrument, and acknowledged said instrument to be the free and voluntary act and deed of said corporation, for the uses and purposes therein mentioned, and on oath stated ~~they were~~ he was authorized to execute said instrument and that the seal affixed, if any, is the corporate seal of said corporation.

Given under my hand and official seal this 23rd day of July.

[signature]
Notary Public in and for the State of Washington, residing at ~~Olympia~~ Lacey
Print Name: Kenneth N. Ault
My Commission Expires 8-27-96

STATE OF WASHINGTON)
) ss.
County of Thurston)

On this 11th day of July, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared James W. Hodges to me known to be the individual_ described in and who executed the foregoing instrument, and acknowledged to me that _he_ signed and sealed this said instrument as his free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this 11th day of July, 1996

[signature]
Notary Public in and for the State of Washington residing at Olympia
My commission expires 9/1/99.

STATE OF WASHINGTON)
) ss.
County of Thurston)

On this 11th day of July, before me, the undersigned, a Notary Public in and for the State of Washington, duly commissioned and sworn, personally appeared Keith Hodges to me known to be the individual_ described in and who executed the foregoing instrument, and acknowledged to me that _he_ signed and sealed this said instrument as his free and voluntary act and deed for the uses and purposes therein mentioned.

Given under my hand and official seal this 11th day of July, 1996.

[signature]
Notary Public in and for the State of Washington residing at Olympia.
My commission expires 9/1/99.

Appendix F

Detailed Facility Sheets and Well Logs

Judd Hill Reservoir

Facility Information

Description	Comments
Address	2400 Judd St. SE
Year Constructed	1964
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	0.5
Gallons/Foot	6,791
Diameter (ft)	34
Base Elevation (ft)	236.41
Overflow Elevation (ft)	311
Shell Height (ft)	75
Pressure Zone	337
Roof	Single column supported cone roof; 3/4":12" roof slope
Floor	1/4" plate; crowned 0.33'
Foundation	42" concrete ring wall
Anchorage	Anchor straps
Inlet/Outlet Pipe	8" separate inlet/outlet
Roof Vent	20" Ø
Roof Access	1 - square access hatch, 24"x24"
Shell Access	1 - 24" Ø manhole
Overflow Pipe	4" pipe, day lighted on-site
Interior Ladder	Basic ladder
Exterior Ladder	"Saf-T-Climb" device
Inlet/Outlet Vault	None
Altitude Valve	6" 210G-17ABCS
Meter	Meter in booster station
Design Standards	Unknown
Mixing System	None
Minimum Water Level (ft)	10 (booster pump lock-out)
Dead Storage (MG)	0.07
Notes	Tank drains directly to Judd Hill Booster Station. Altitude valve located in S06 well house. Tank fills from S06 directly, can also fill from the distribution system by manual operation. Max operating level has been reduced to 50' due to seismic stability concerns.

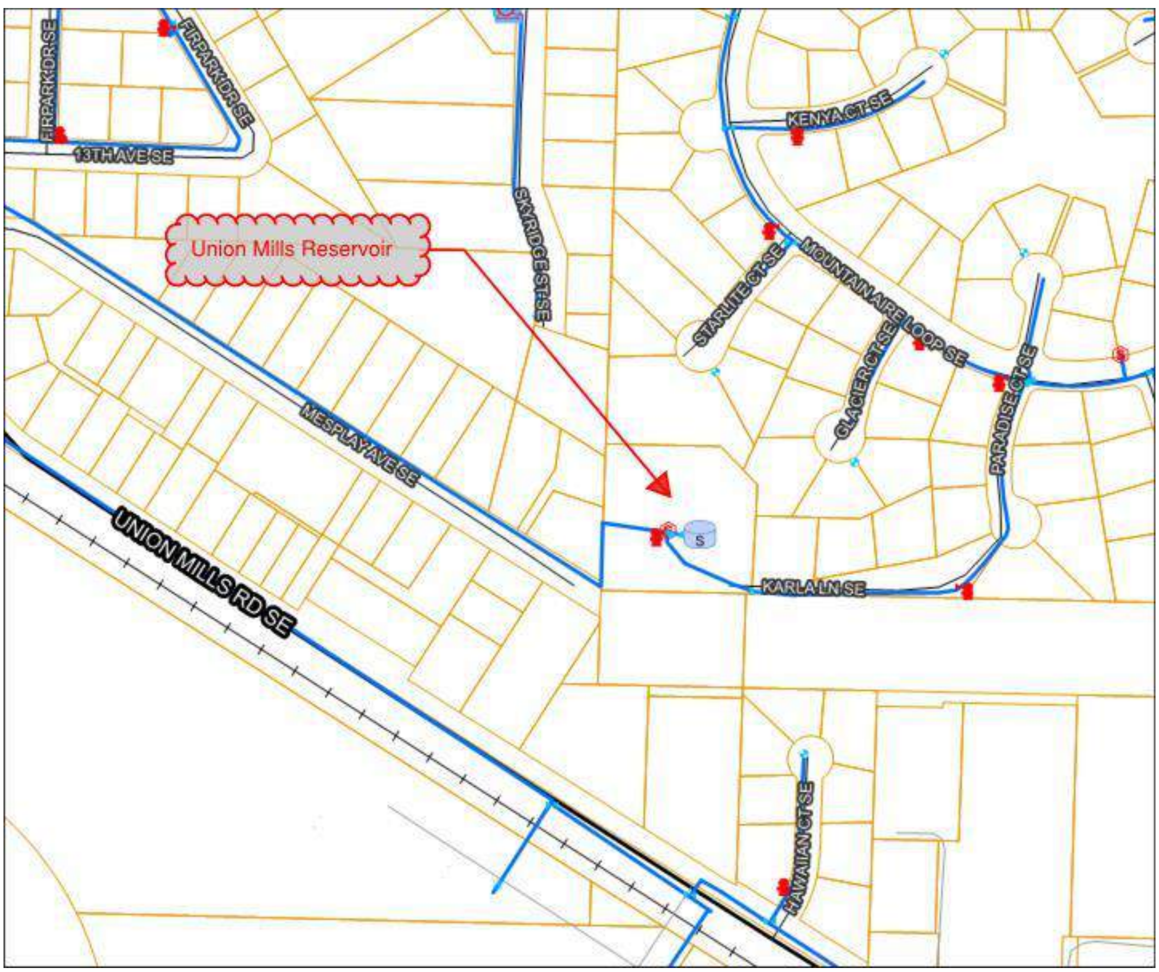
Judd Hill Reservoir

Union Mills Reservoir

Facility Information

Description	Comments
Address	1349 Paradise Ct. SE
Year Constructed	1969
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	2.2
Gallons/Foot	33,933
Diameter (ft)	76
Base Elevation (ft)	271.62
Overflow Elevation (ft)	337.5
Shell Height (ft)	56.5
Pressure Zone	337
Roof	Ellipsoidal, 20' high
Floor	1/4" plate; crowned 0.5'
Foundation	Concrete ring wall
Anchorage	1/2" annular floor plate
Inlet/Outlet Pipe	18" common pipe
Roof Vent	36" Ø
Roof Access	1 - square access hatch, 42"x42"
Shell Access	1 - 36" Ø manhole 1 - 24" Ø manhole
Overflow Pipe	8" exterior pipe
Interior Ladder	Ladder to interior platform
Exterior Ladder	"Saf-T-Climb", cage at upper most 16'
Inlet/Outlet Vault	None
Altitude Valve	16" 210G-65ABC (in separate valve vault)
Meter	None
Design Standards	Unknown
Mixing System	None
Minimum Water Level (ft)	39
Dead Storage (MG)	1.31
Notes	HGL Control for the 337 Pressure Zone Seismic Upgrades (2019)

Union Mills Reservoir

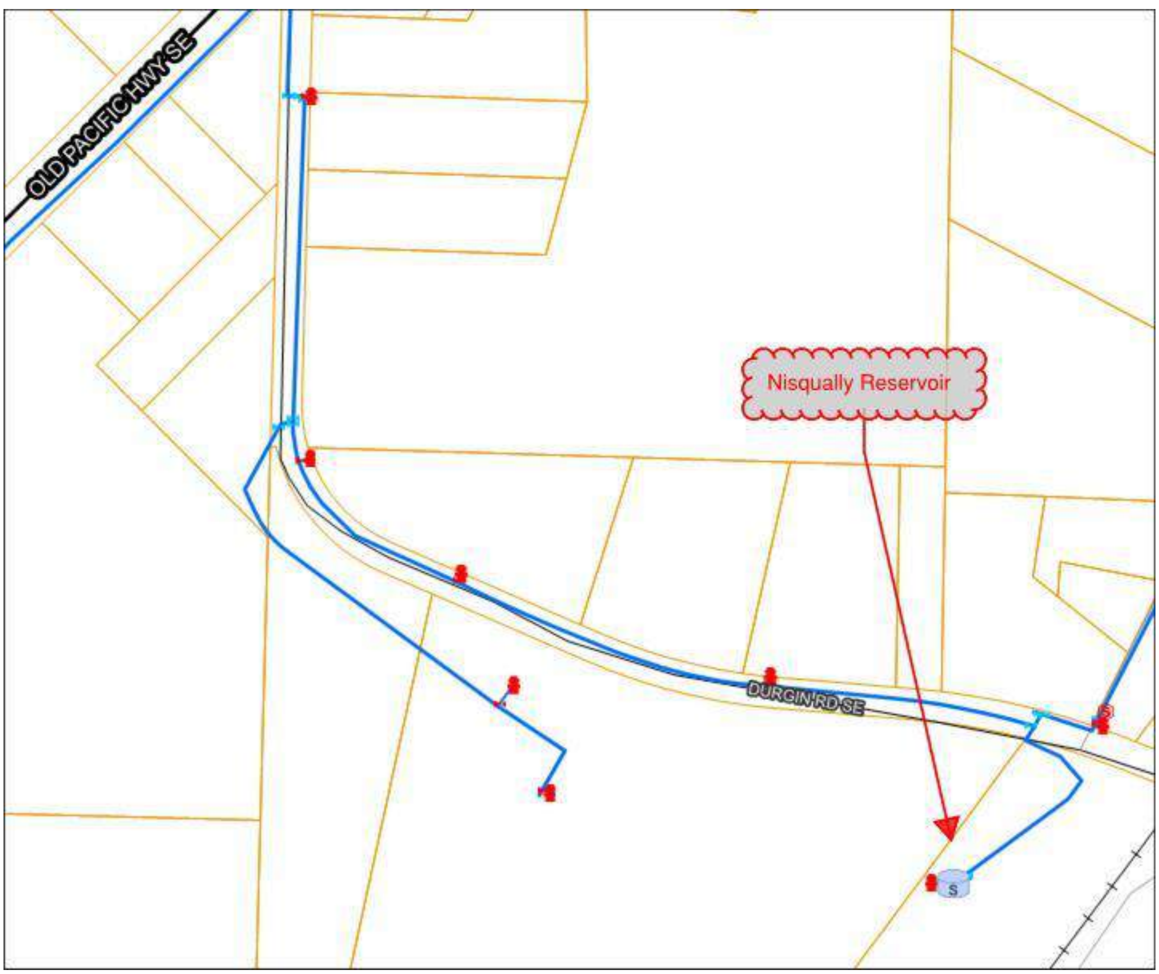


Nisqually Reservoir

Facility Information

Description	Comments
Address	11155 Durgin Rd.SE
Year Constructed	1977
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	0.15
Gallons/Foot	5,465
Diameter (ft)	30.5
Base Elevation (ft)	162.20
Overflow Elevation (ft)	189
Shell Height (ft)	28
Pressure Zone	188
Roof	Single column supported cone roof; 3/4":12" roof slope
Floor	1/4" plate; crowned
Foundation	Concrete ring wall
Anchorage	N/A
Inlet/Outlet Pipe	10" common pipe
Roof Vent	12"
Roof Access	1 - square access hatch
Shell Access	1 - 36" Ø manholes
Overflow Pipe	6" exterior; 4" drain to atmosphere
Interior Ladder	Basic ladder
Exterior Ladder	Ladder with safety climb
Inlet/Outlet Vault	None
Altitude Valve	None
Meter	None
Design Standards	Unknown
Mixing System	None
Minimum Water Level (ft)	0
Dead Storage (MG)	0
Notes	HGL Control for the 188 Pressure Zone

Nisqually Reservoir

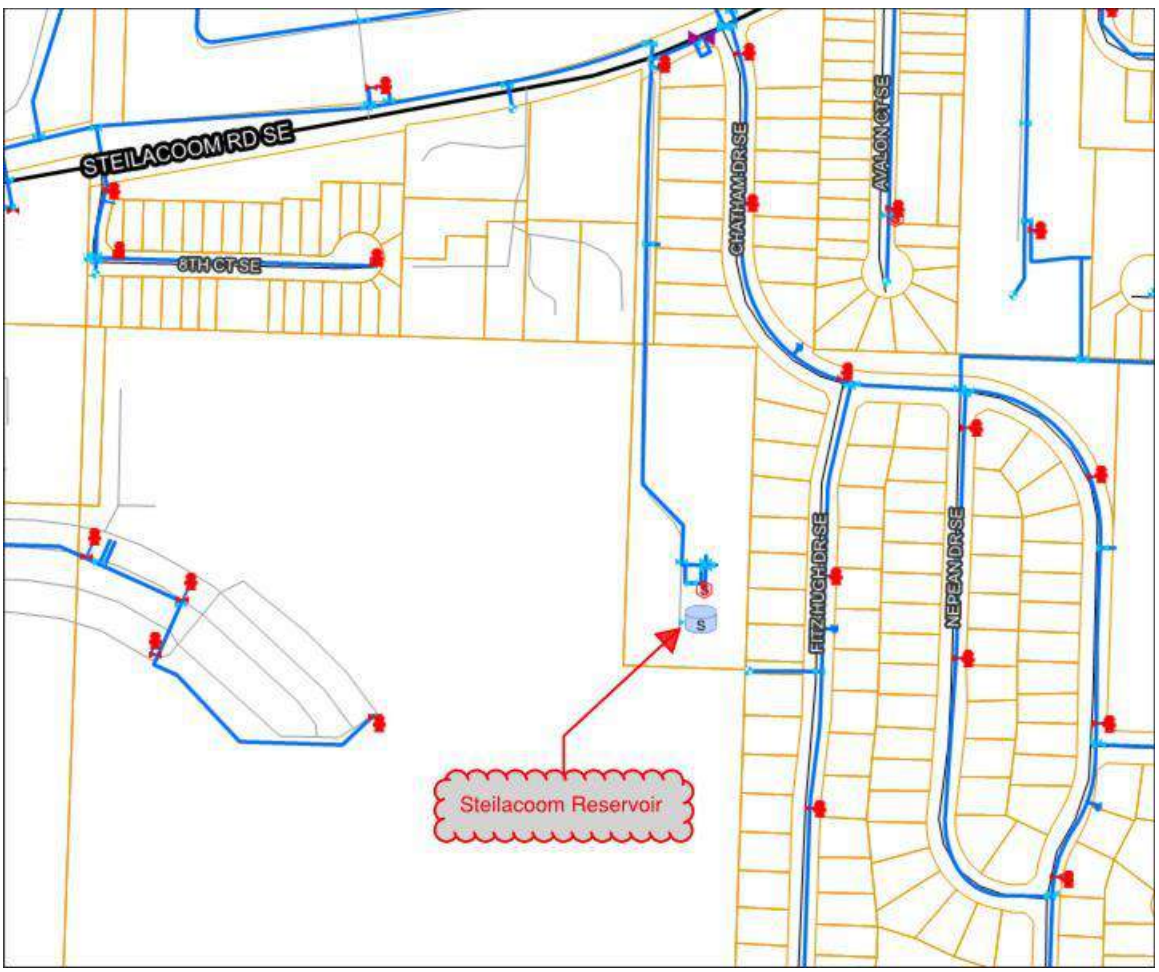


Steilacoom Reservoir

Facility Information

Description	Comments
Address	8705 Steilacoom Rd. SE
Year Constructed	1986
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	3.0
Gallons/Foot	41,452
Diameter (ft)	84
Base Elevation (ft)	264.85
Overflow Elevation (ft)	337.5
Shell Height (ft)	71
Pressure Zone	337
Roof	Single column supported cone roof; 3/4":12" roof slope; 30" knuckle
Floor	1/4" plate; crowned 0.5'
Foundation	24" ring wall, on 7'-6" spread footing
Anchorage	Welded anchor straps
Inlet/Outlet Pipe	18" common pipe
Roof Vent	24" Ø
Roof Access	1 - square access hatch, 36"x36"
Shell Access	2 - 36" Ø manholes
Overflow Pipe	12" pipe to detention pond
Interior Ladder	Basic ladder
Exterior Ladder	"Saf-T-Climb" device
Inlet/Outlet Vault	None
Altitude Valve	16" 210G (in separate valve vault)
Meter	None
Design Standards	Unknown
Mixing System	None
Minimum Water Level (ft)	45
Dead Storage (MG)	1.87
Notes	HGL Control for the 337 Pressure Zone

Steilacoom Reservoir

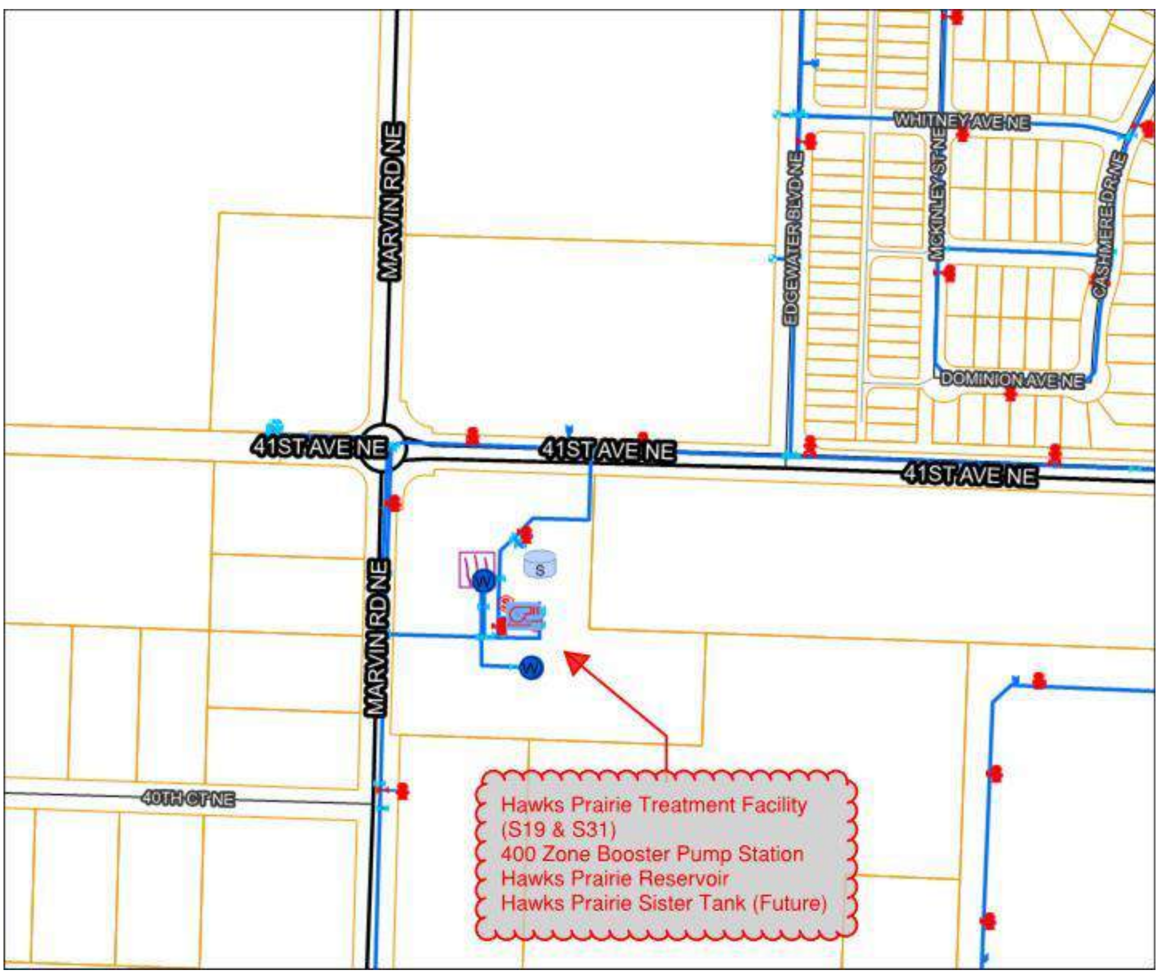


Hawks Prairie Reservoir

Facility Information

Description	Comments
Address	4040 Marvin Rd. NE
Year Constructed	1995
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	4.0
Gallons/Foot	47,586
Diameter (ft)	90
Base Elevation (ft)	294.87
Overflow Elevation (ft)	380
Shell Height (ft)	88
Pressure Zone	400
Roof	Single column supported cone roof; 3/4":12" roof slope
Floor	1/4" plate; crowned 1.0'
Foundation	30" ring wall, 6'-0" high on 14' spread footing, 5'-0" thick
Anchorage	2-1/2" Ø @ 4' o.c.
Inlet/Outlet Pipe	12" with 90° base elbow in vault
Roof Vent	30"
Roof Access	2-rectangular access hatches, 36"x30"
Shell Access	2 - 36" Ø manholes
Overflow Pipe	12" Steel, piped to detention pond
Interior Ladder	"Saf-T-Climb" device
Exterior Ladder	Stairway
Inlet/Outlet Vault	13.75' x 7.0' x 6.5'
Altitude Valve	12" 210G-09BD
Meter	10" magnetic
Design Standards	AWWA D100-84 (1996); Seismic Zone 3; 25 psf snow load; 100 mph wind load-exposure B
Mixing System	Tideflex
Minimum Water Level (ft)	10 (booster pump lock-out)
Dead Storage (MG)	0.48
Notes	Separate inlet and outlet piping. Typically drains directly to the 400 Zone booster station, but can also drain to the distribution system via check-valve. Altitude valve controls fill cycle via pressure sustaining feature.

Hawks Prairie Reservoir

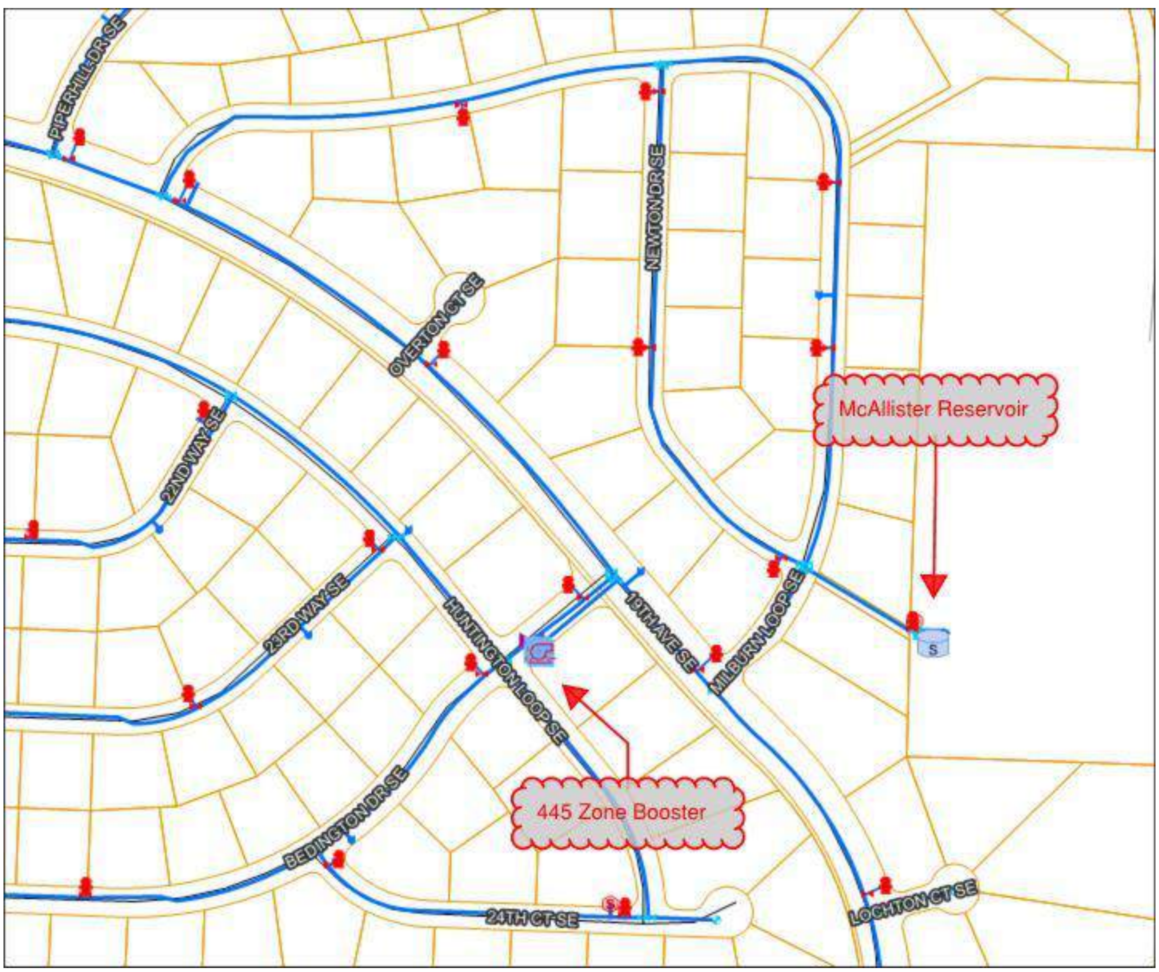


McAllister Reservoir

Facility Information

Description	Comments
Address	9707 Piper Hill Dr. SE
Year Constructed	1998
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	1.2
Gallons/Foot	11,896
Diameter (ft)	45
Base Elevation (ft)	300.26
Overflow Elevation (ft)	400
Shell Height (ft)	102
Pressure Zone	400
Roof	Cone roof; 3/4":12" roof slope
Floor	1/4" plate; crowned 0.7'
Foundation	Reinforced concrete mat, 66' Ø x 4'-6" thick, 0.7' center crown
Anchorage	2 1/2" Ø @ 4' o.c.
Inlet/Outlet Pipe	12" with 90° elbow cast in concrete
Roof Vent	2'-6" Ø, AWWA type
Roof Access	2 - rectangular access hatches, 38"x30"
Shell Access	2 - 36" Ø manholes
Overflow Pipe	12" with 60° and 45° elbows, piped to storm sewer
Interior Ladder	"Saf-T-Climb" device
Exterior Ladder	Stairway
Inlet/Outlet Vault	None
Altitude Valve	12" 210G-09BDS (in separate valve vault)
Meter	None
Design Standards	AWWA D100-96; Seismic Zone 3; 25 psf snow load; 100 mph wind load-exposure B
Mixing System	None
Minimum Water Level (ft)	56
Dead Storage (MG)	0.67
Notes	HGL Control for the 400 Pressure Zone. Provides fire-flow and standby storage for the 445 Pressure Zone.

McAllister Reservoir

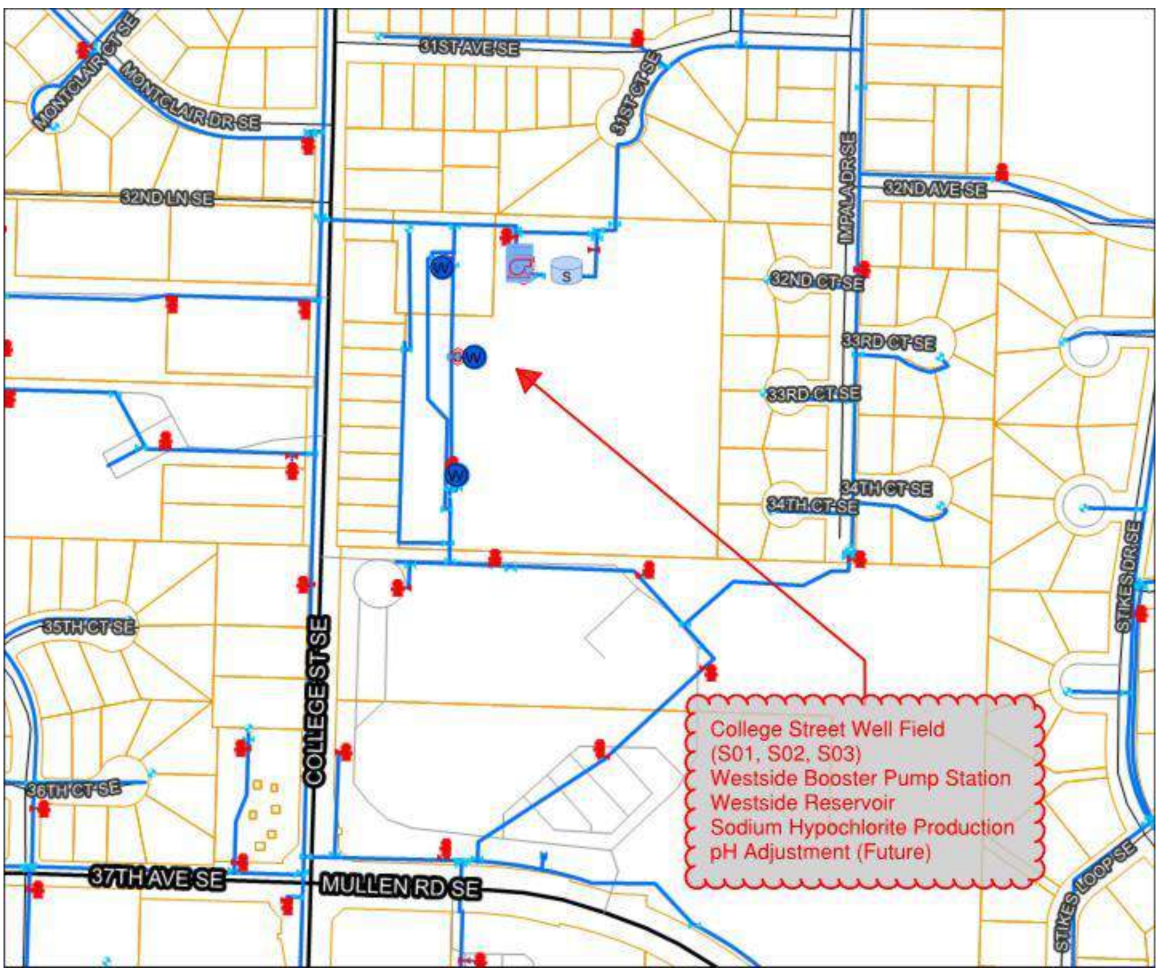


Westside Reservoir

Facility Information

Description	Comments
Address	3140 College St. SE
Year Constructed	2002
Type	Above Ground Stand Pipe
Tank Construction	Welded Steel
Capacity (MG)	2.0
Gallons/Foot	47,586
Diameter (ft)	90
Base Elevation (ft)	232.53
Overflow Elevation (ft)	274.5
Shell Height (ft)	45
Pressure Zone	337
Roof	Single column supported cone roof; 3/4":12" roof slope
Floor	1/4" plate; crowned 0.5'
Foundation	24" concrete ring wall
Anchorage	3/8" annular plate
Inlet/Outlet Pipe	12" with 90° elbow
Roof Vent	24" Ø, AWWA type
Roof Access	2 - rectangular access hatches, 36"x30"
Shell Access	2 - 36" Ø manholes
Overflow Pipe	12" exterior pipe to detention pond
Interior Ladder	"Saf-T-Climb" device
Exterior Ladder	Stairway
Inlet/Outlet Vault	16'-0" x 7'-0" x 5'-8"
Altitude Valve	12" 100G-103
Meter	Inlet – 8" magnetic Outlet – 12" magnetic
Design Standards	AWWA D100-96; Seismic Zone 3; 25 psf snow load; 100 mph wind load-exposure B
Mixing System	None
Minimum Water Level (ft)	10 (booster pump lock-out)
Dead Storage (MG)	0.48
Notes	Drains directly to the Westside booster station.

Westside Reservoir

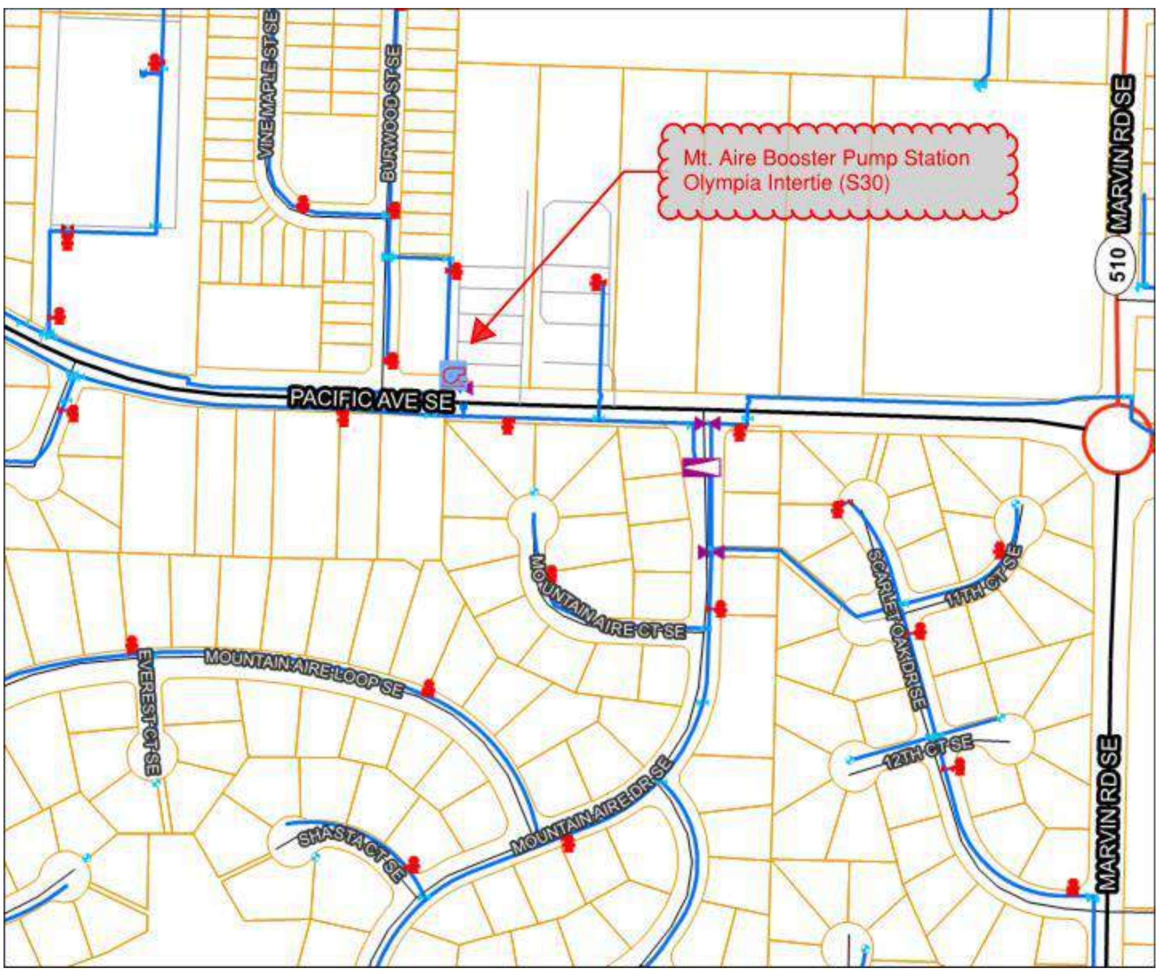


Mountain Aire Booster

Facility Information

Description	Pump #1	Pump #2
Address	8002 Pacific Ave. SE	
Year Constructed	1988	
Pressure Zone	337	
Floor Elevation	204.06	
Source	City of Olympia (S30)	
Pump Type	In-line Centrifugal	
Pump Manufacturer	Paco	Paco
Pump Model	16-50957-140101-1852 VL	16-50957-140101-1852 VL
Pump Serial #	RXB 87A01039A	RXB 87A01039B
Control Valves	None	None
Settings	None	None
Pressure Relief	None	
Motor Manufacturer	GE	GE
Motor Model	256-JM	256-JM
Horsepower (hp)	20	20
Speed (rpm)	1750	1750
Shutoff Head (ft)	97	97
Design Head (ft)	70	70
Design Flow (gpm)	750	750
Total Design Flow (gpm)	1500	
Meter	14” magnetic	
Notes	Pumps directly from City of Olympia transmission main to the 337 Zone. Starts controlled by reservoir level.	

Mountain Aire Booster



Judd Hill Booster

Facility Information

Description	Pump #1
Address	2400 Judd St. SE
Year Constructed	1993
Pressure Zone	337
Floor Elevation	236.37
Source	Judd Hill Reservoir
Pump Type	End suction
Pump Manufacturer	Paco
Pump Model	10-40127-1A0001-1872 LC
Pump Serial #	STG-92A000923
Control Valves	6" 92G-02BD
Settings	CRD: 46 psi
Pressure Relief	None
Motor Manufacturer	US Electric
Motor Model	U74TE
Horsepower (hp)	25
Speed (rpm)	1765
Shutoff Head (ft)	112
Design Head (ft)	58
Design Flow (gpm)	1200
Total Design Flow (gpm)	1200
Meter	Mechanical
Notes	Pumps directly from the Judd Hill Reservoir to the 337 Zone. Starts controlled by timer or local pressure.

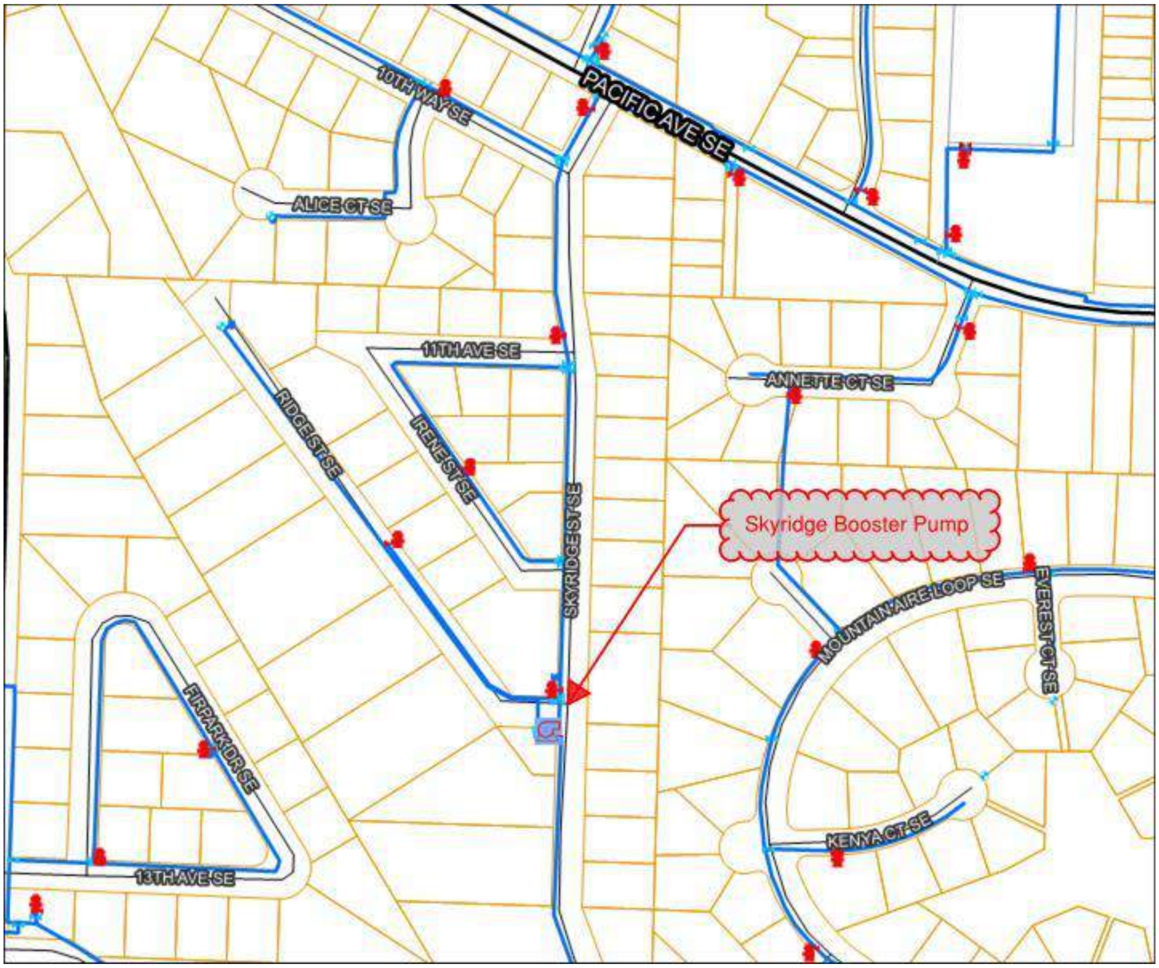
Judd Hill Booster

Skyridge Booster

Facility Information

Description	Pump #1	Pump #2
Address	1223 Ridge St. SE	
Year Constructed	2001	
Pressure Zone	422	
Floor Elevation	235.47	
Source	337 Zone	
Pump Type	End suction	
Pump Manufacturer	Peerless (Aqua-pac)	Peerless (Aqua-pac)
Pump Model	610-5 (DAP-1-5)	610-5 (DAP-1-5)
Pump Serial #	562451-A	562451-B
Control Valves	None	None
Settings	VFD set-point 80 psi	VFD set-point 80 psi
Pressure Relief	None	
Motor Manufacturer	US Motor	US Motor
Motor Model	5073A	5073A
Horsepower (hp)	5	5
Speed (rpm)	3500 (VFD)	3500 (VFD)
Shutoff Head (ft)	128	128
Design Head (ft)	104	104
Design Flow (gpm)	110	110
Total Design Flow (gpm)	110	
Meter	None	
Notes	Pumps from the 337 Zone to the 422 Zone for domestic pressure only. Starts controlled by local pressure. Single pump operation only.	

Skyridge Booster

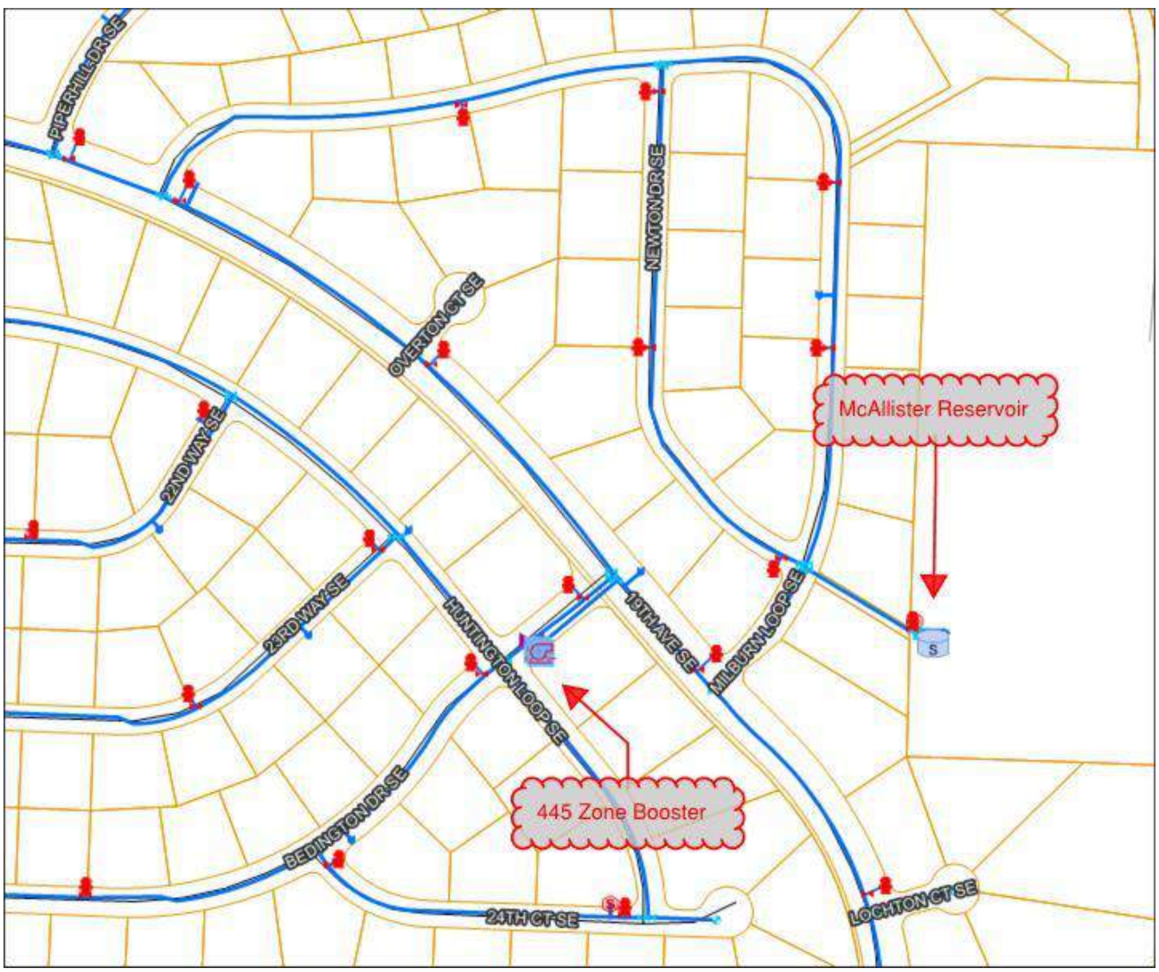


445 Zone Booster

Facility Information

Description	Pump #1	Pump #2
Address	2040 Huntington Lp. SE	
Year Constructed	2002	
Pressure Zone	445	
Floor Elevation	280.90	
Source	400 Zone	
Pump Type	In-line Centrifugal	
Pump Manufacturer	Grundfos	Grundfos
Pump Model	ME CRE 45-1	ME CRE 45-1
Pump Serial #	N/A	N/A
Control Valves	None	None
Settings	VFD set-point 70 psi	VFD set-point 70 psi
Pressure Relief	None	
Motor Manufacturer	N/A	N/A
Motor Model	N/A	N/A
Horsepower (hp)	7.5	7.5
Speed (rpm)	3450 (VFD)	3450 (VFD)
Shutoff Head (ft)	122	122
Design Head (ft)	80	80
Design Flow (gpm)	250	250
Total Design Flow (gpm)	250	
Meter	None	
Notes	Pumps from the 400 Zone to the 445 Zone for domestic pressure only. Starts controlled by local pressure.	

445 Zone Booster

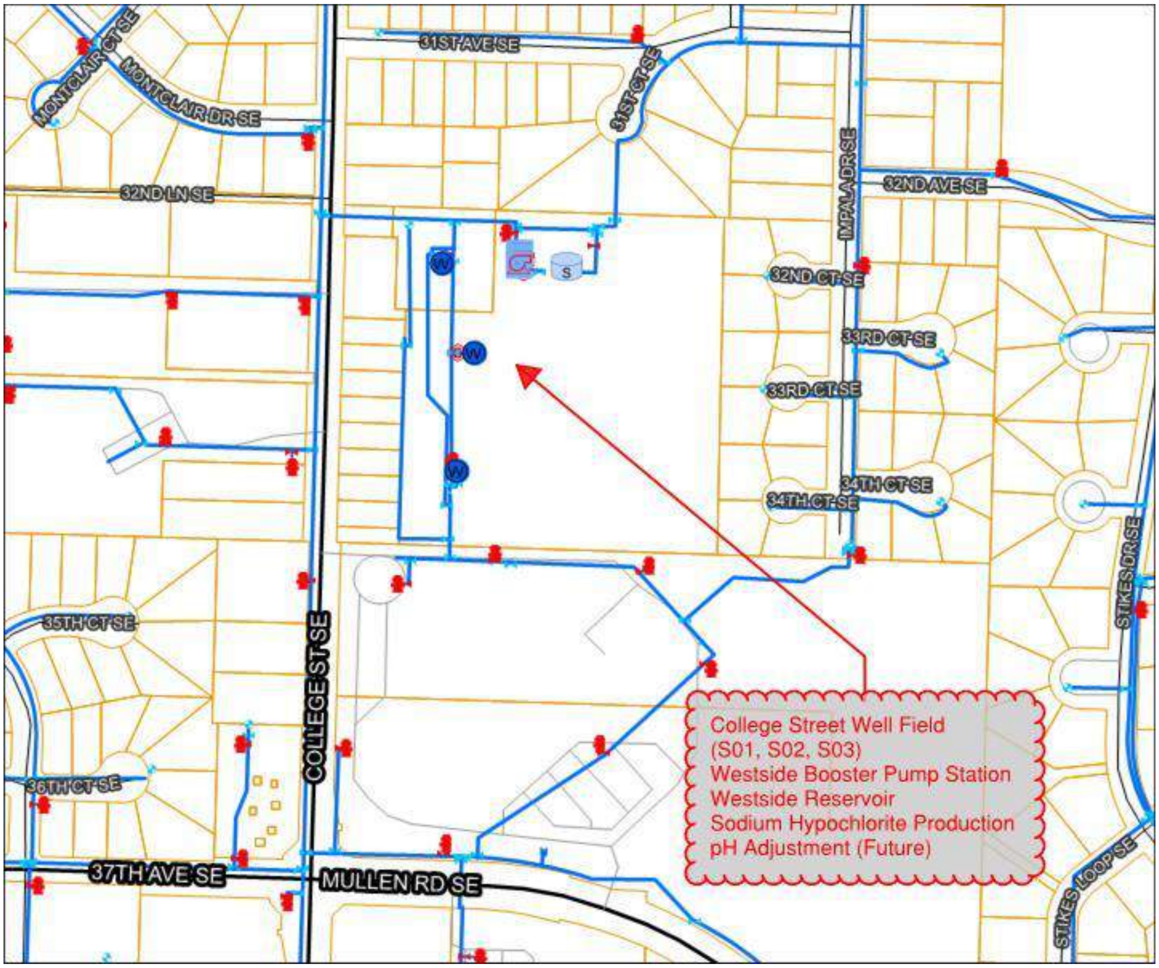


Westside Booster

Facility Information

Description	Pump #1 (Jockey)	Pump #2	Pump #3	Pump #4
Address	3140 College St. SE			
Year Constructed	2002			
Pressure Zone	337			
Floor Elevation	232.58			
Source	Westside Reservoir			
Pump Type	Horizontal split case			
Pump Manufacturer	Peerless	Peerless	Peerless	Peerless
Pump Model	5AE14N	6AE14G	6AE14G	6AE14G
Pump Serial #	581441	581440B	581440A	581440C
Control Valves	VFD	VFD	10" 692G-01YBCSDKC	10" 692G-01YBCSDKC
Settings	Start: 38 psi Target: 41 psi	Start: 36 psi Target: 41 psi	CRL: 79 psi CRD: 54 psi	CRL: 79 psi CRD: 54 psi
Pressure Relief	6" 52G-03BKC CRL: 59 psi CRA: 25 psi			
Motor Manufacturer	US Electric	US Electric	US Electric	US Electric
Motor Model	326TS	405TS	405TS	405TS
Horsepower (hp)	50	100	100	100
Speed (rpm)	1775	1780	1780	1780
Shutoff Head (ft)	175	175	175	175
Design Head (ft)	145	145	145	145
Design Flow (gpm)	700	1900	1900	1900
Total Design Flow (gpm)	4500			
Meter	Reservoir Outlet: 12” magnetic Bypass: 6” magnetic			
Notes	Pumps directly from the Westside Reservoir to the 337 Zone. Starts controlled local pressure, stops controlled by flow rate.			

Westside Booster

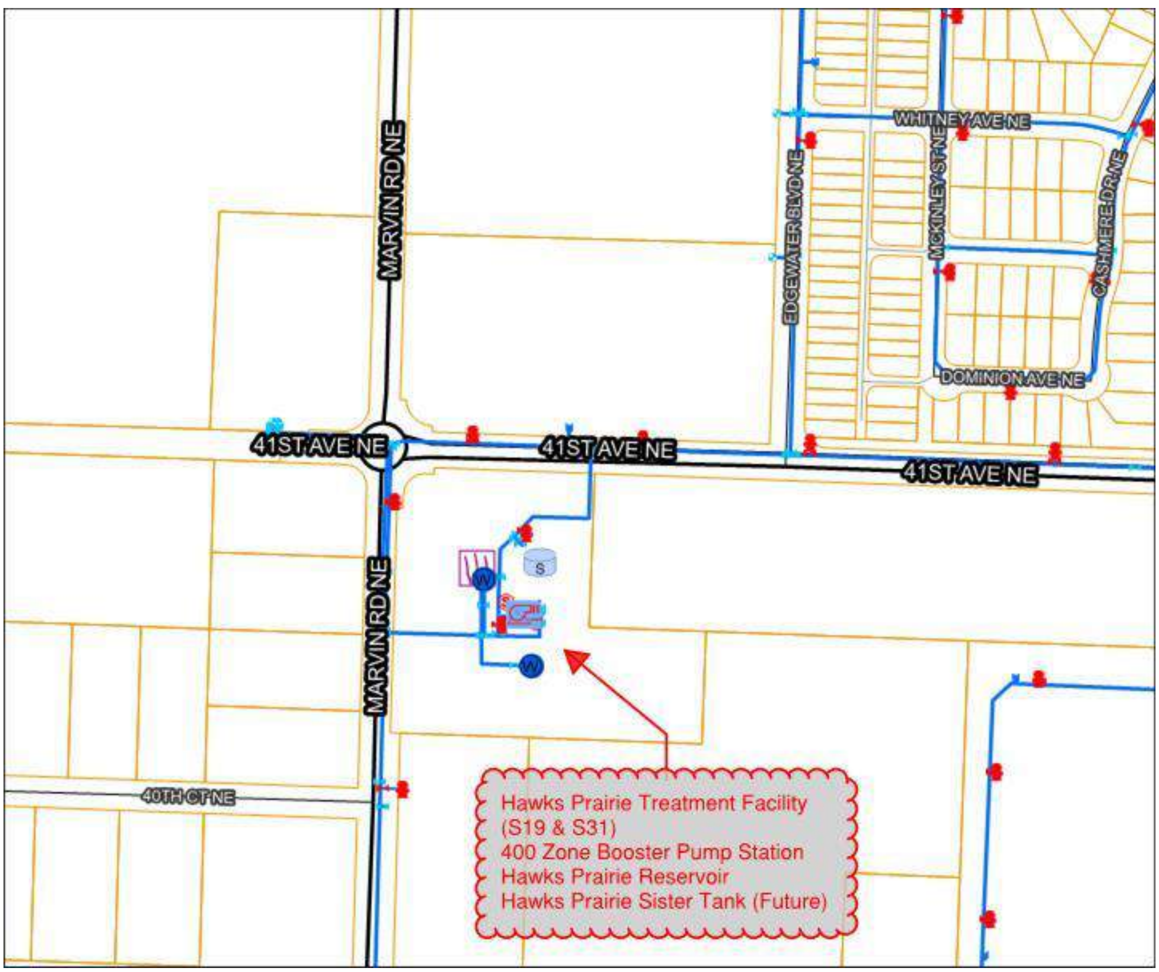


400 Zone Booster

Facility Information

Description	Pump #1	Pump #2	Pump #3	Pump #4
Address	4040 Marvin Rd. NE			
Year Constructed	2008			
Pressure Zone	400			
Floor Elevation	296.48			
Source	Hawks Prairie Reservoir			
Pump Type	Horizontal split case			
Pump Manufacturer	Peerless	Peerless	Peerless	Peerless
Pump Model	6AE11	6AE11	8AE15G	8AE15G
Pump Serial #	732492A	732492B	726611A	726611B
Control Valves	None	None	None	None
Settings	VFD set-point 45 psi	VFD set-point 45 psi	VFD set-point 45 psi	VFD set-point 45 psi
Pressure Relief	6" 50G-01BDKC CRL: 56 psi			
Motor Manufacturer	GE	GE	GE	GE
Motor Model	326T	326T	365T	365T
Horsepower (hp)	50	50	75	75
Speed (rpm)	1780 (VFD)	1780 (VFD)	1780 (VFD)	1780 (VFD)
Shutoff Head (ft)	122	122	125	125
Design Head (ft)	105	105	105	105
Design Flow (gpm)	850	850	2000	2000
Total Design Flow (gpm)	3700			
Meter	Reservoir Outlet: 10” magnetic Bypass: 6” magnetic			
Notes	Pumps directly from the Hawks Prairie Reservoir to the 400 Zone. Starts controlled by local pressure.			

400 Zone Booster

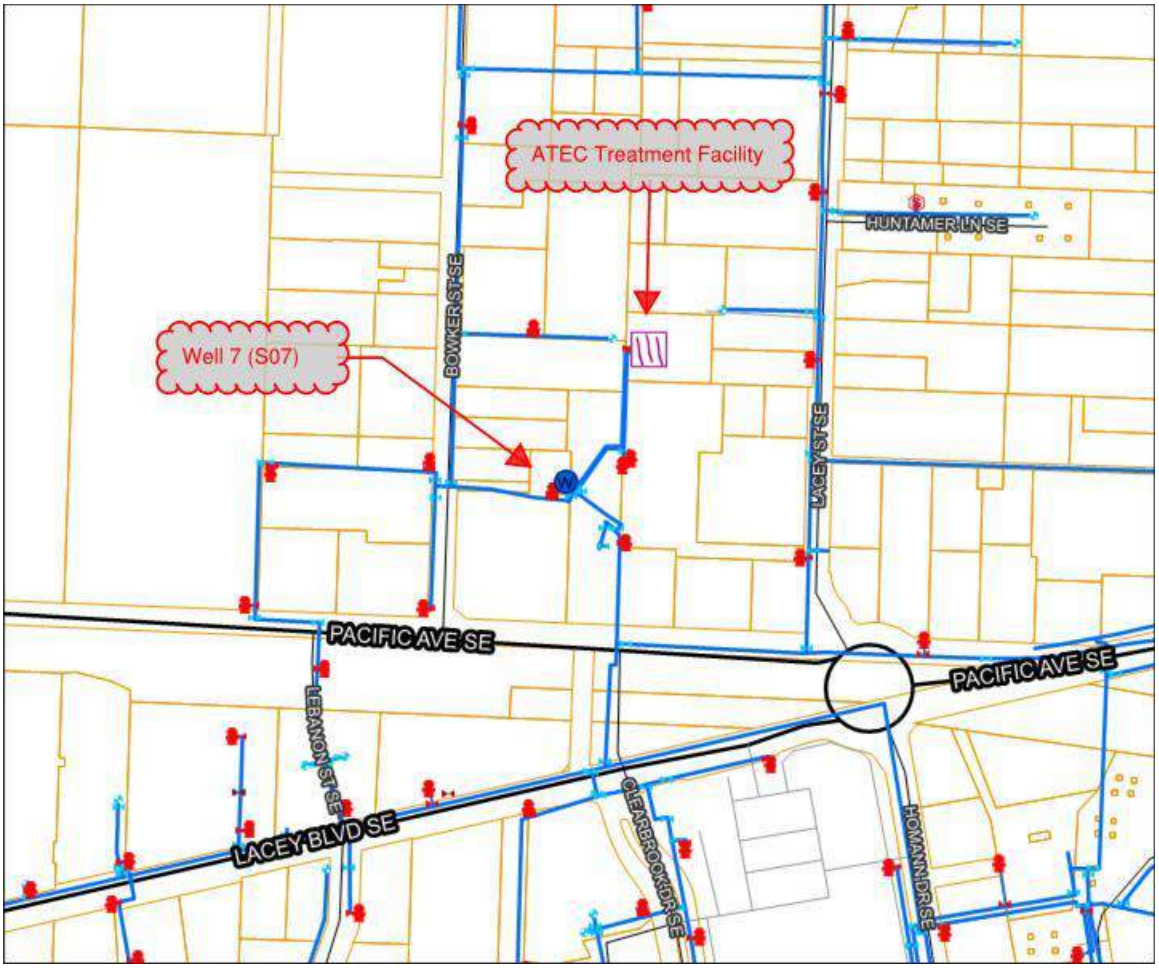


ATEC Water Treatment Facility

Facility Information

Description	Comments
Address	831 Lacey St. SE
Year On-Line	2002
Pressure Zone	337
Floor Elevation	181.80
Housing	Wood
Source Water	S07
Source Water Quality	Elevated Iron and Manganese
Oxidation	Potassium Permanganate injection at Well S07 Sodium Hypochlorite injection at ATEC facility
Filter Vessels	14 – ATEC skid mounted vessels 60” shell height (48” media depth)
Filter Media	20-40 mesh Pyrolusite (manganese dioxide)
Treatment Capacity (gpm)	1700
Chlorine Generator	Clortec 24lb/day Sodium Hypochlorite
Chlorine Feed Pump	Aldos KM25367
Sodium Hypochlorite Storage	500 gal
Chlorine Concentration	0.8%
Chlorine Analyzer	2 – Capital Controls Group series 1770
Backwash Disposal	Pumped to Sewer
Distribution Pumps	None
Pump Type	N/A
Pump Model	N/A
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	N/A
Pump Serial #	N/A
Pump Capacity (gpm)	N/A
Motor Model	N/A
Motor Serial #	N/A
Motor Speed (rpm)	N/A
Horsepower	N/A
Control Valves	N/A
PSV Setting	N/A
PRV Setting (psi)	N/A
Notes	

ATEC Water Treatment Facility



Hawks Prairie Water Treatment Facility

Facility Information

Description	Comments
Address	4040 Marvin Rd. NE
Year On-Line	2008
Pressure Zone	400
Floor Elevation	299.50
Housing	CMU
Source Water	S19 & S31
Source Water Quality	Elevated Iron, Manganese, Ammonia, Sulfide
Oxidation	Aeration Sodium Hypochlorite injection
Filter Vessels	2 – Loprest greensand vessels (144” x 80”) 2 – Loprest activated carbon vessels converted to greensand (144” x 90”)
Filter Media	0.60 – 0.80 mm anthracite 0.30 – 0.35 mm greensand (manganese dioxide)
Treatment Capacity (gpm)	2000
Chlorine Generator	US Filter B1-150 OSEC 125lb/day Sodium Hypochlorite
Chlorine Feed Pump	4 - Premia 75 mega
Sodium Hypochlorite Storage	3900 gal
Chlorine Concentration	0.8%
Chlorine Analyzer	5 – Prominent DMT series
Backwash Disposal	Concrete basin for recycle or discharge to sewer
Distribution Pumps	2
Pump Type	Turbine
Pump Model	Peerless M12LD – 2 stage
Pump Shaft Diameter (in)	1.00
Column Diameter/Length	8” column, 16’
Pump Serial #	N/A
Pump Capacity (gpm)	1100
Motor Model	GE L326TP #V3220
Motor Serial #	N/A
Motor Speed (rpm)	1775
Horsepower	50
Control Valves	10” 50G-01BDS
PSV Setting	70 psi @ 800 gpm
PRV Setting (psi)	None
Notes	Chlorine contact basin for Ammonia conversion.

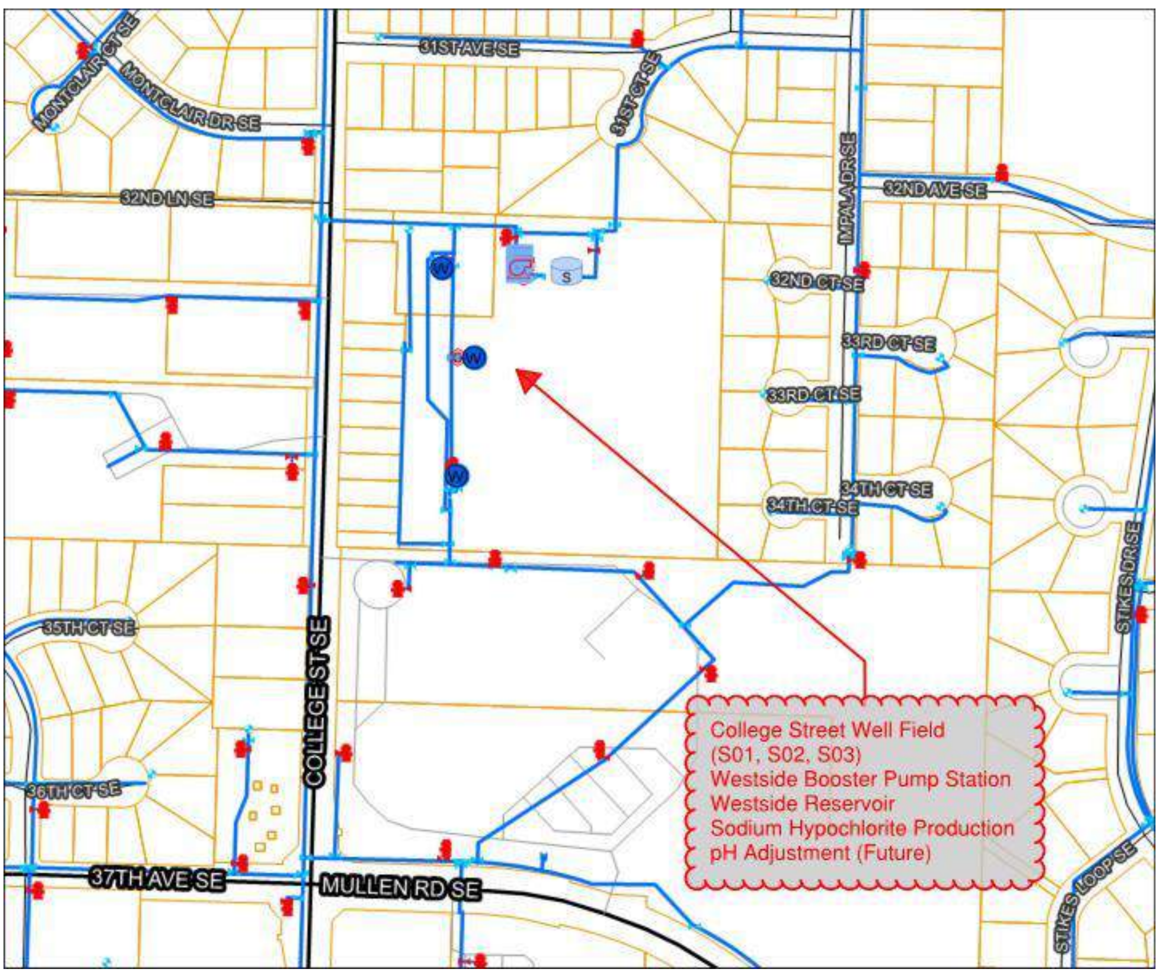
Hawks Prairie Water Treatment Facility

Westside Chlorine Generation Facility

Facility Information

Description	Comments
Address	3140 College St. SE
Year On-Line	2007
Pressure Zone	337
Floor Elevation	232.20
Housing	CMU
Chlorine Generator	US Filter B1-150 OSEC 180lb/day Sodium Hypochlorite
Brine Tank Storage	800 gal
Sodium Hypochlorite Storage	2850 gal
Chlorine Concentration	0.8%
Water Softener	Kinetico #CC208s
Brine Pump	Encore 700 series, 2” diaphragm, pulley drive 6.0 - 24 gph
Transfer Pump	Finish Thompson #DB11V-T-M219
Chlorine Analyzer	Prominent DC1 series
Chlorine Feed Pumps	1 – Prominent Sigma/1 #12035 PVT
Notes	

Westside Chlorine Generation Facility

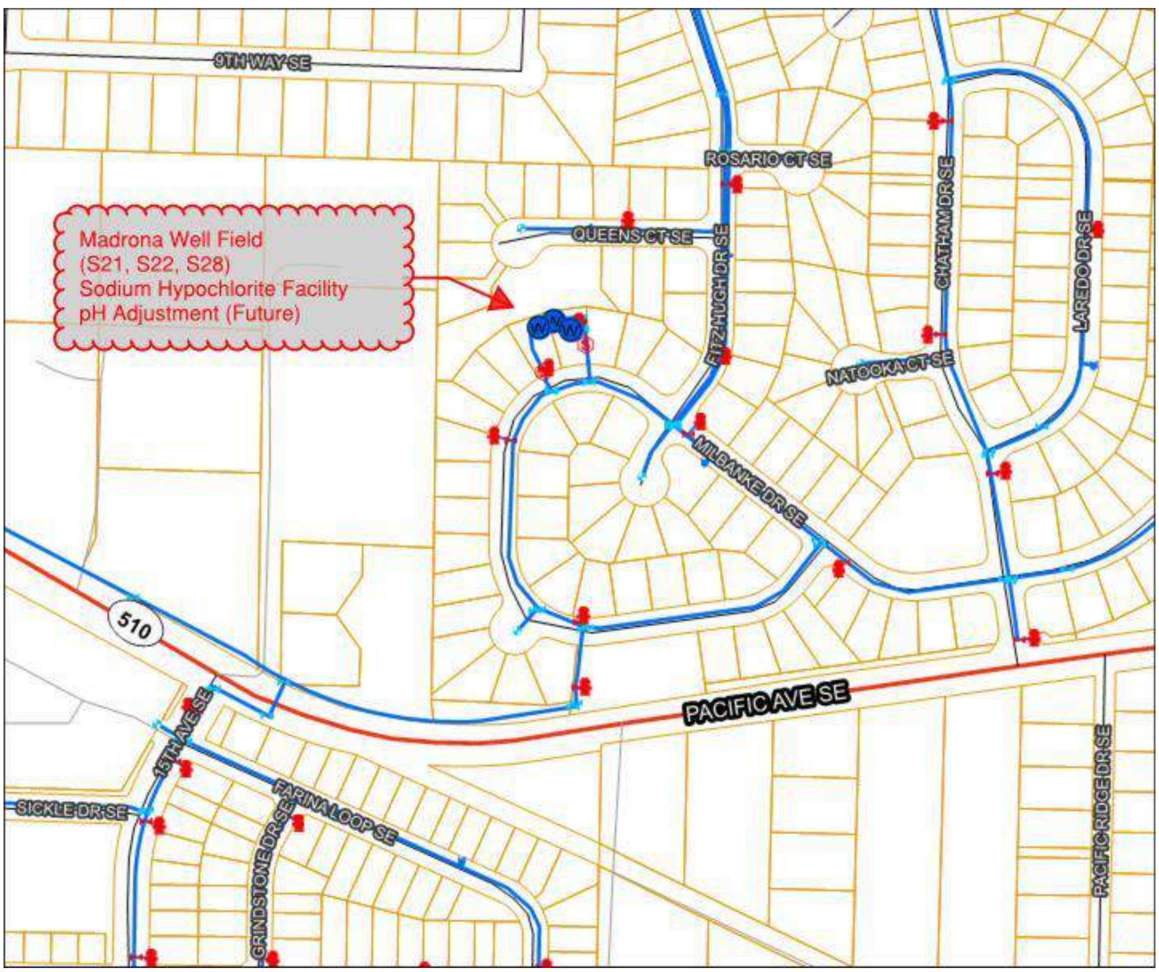


Madrona Chlorine Generation Facility

Facility Information

Description	Comments
Address	8824 Milbanke Dr. SE
Year On-Line	2007
Pressure Zone	400
Floor Elevation	259.00
Housing	CMU
Chlorine Generator	US Filter B1-150 OSEC 180lb/day Sodium Hypochlorite
Brine Tank Storage	800 gal
Sodium Hypochlorite Storage	2 - 2500 gal
Chlorine Concentration	0.8%
Water Softener	Kinetico #CC208s
Brine Pump	Encore 700 series, 2” diaphragm, pulley drive 6.0 - 24 gph
Transfer Pump	Finish Thompson #DB11V-T-M219
Chlorine Analyzer	Prominent DC1 series
Chlorine Feed Pumps	1 – Prominent Sigma/1 #12035 PVT 1 – Prominent Sigma/1 #07065 PVT
Notes	

Madrona Chlorine Generation Facility



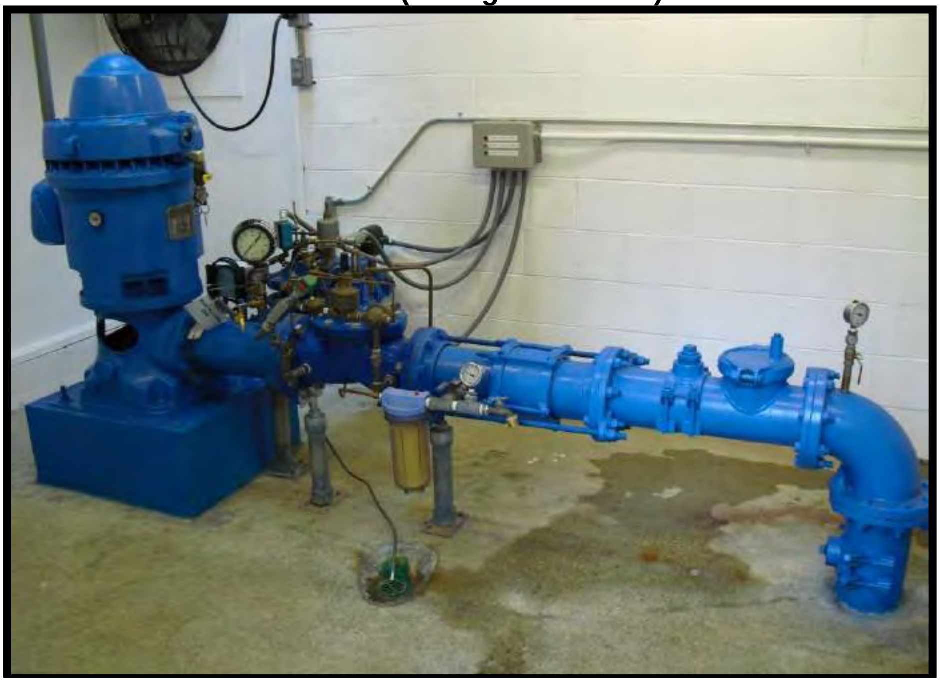
Well S01

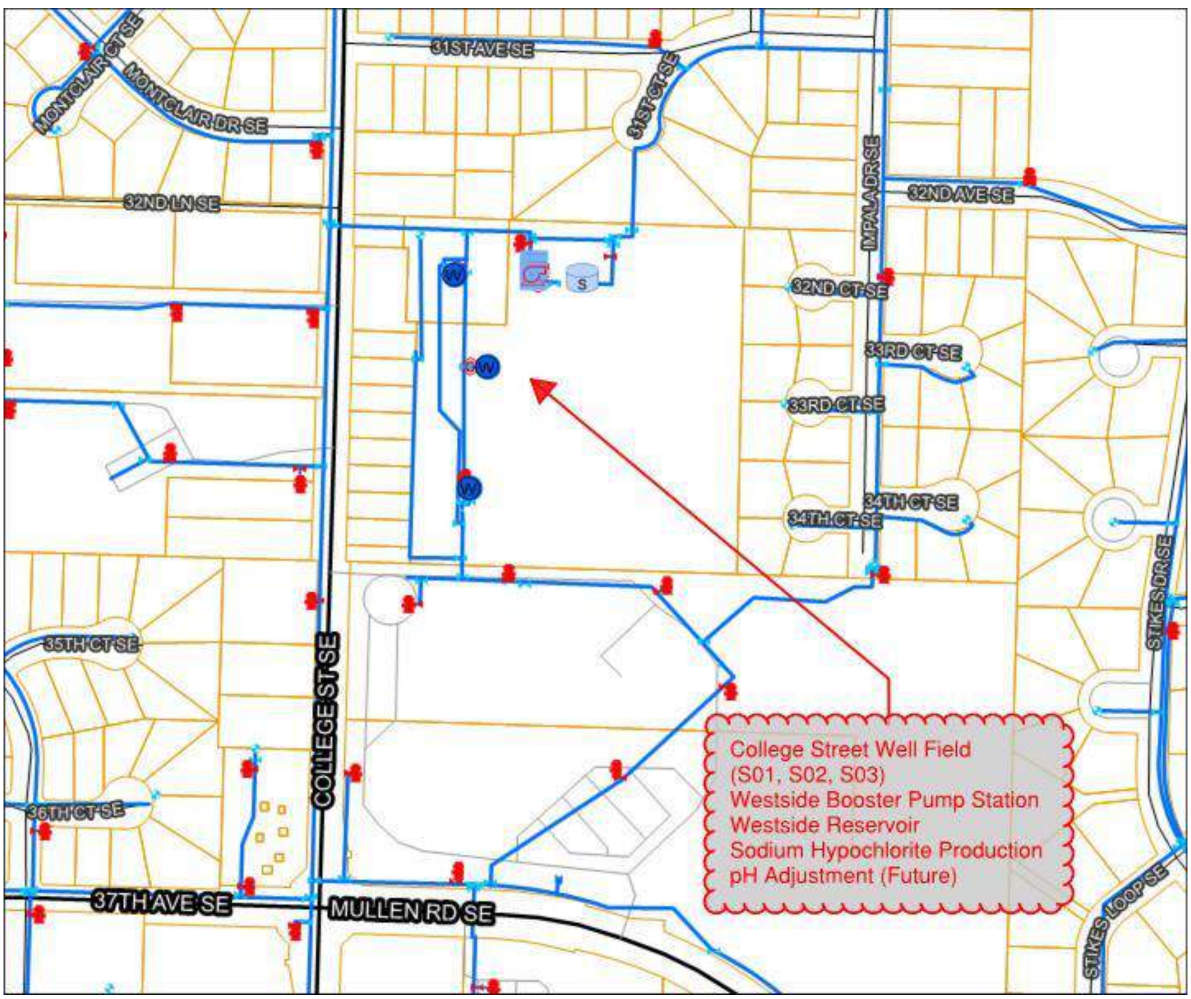
(College St. Well No. 1)

Facility Information

Description	Comments
Source #	S01
Address	3300 College St. SE
Year On-Line	1965
Pressure Zone	337
Floor Elevation	232.13
Housing	CMU
Pump Type	Turbine
Pump Model	Goulds 10RJMC (6.375” 7-stage)
Pump Shaft Diameter (in)	1.1875”
Column Diameter/Length	6" column, 90'
Pump Serial #	MG3465
Pump Depth (ft)	99
Pump Capacity (gpm)	665 GPM @ 227 FT TDH
Motor Model	US Electric HR1025460
Motor Serial #	HR1025460
Motor Speed (rpm)	1800
Horsepower	50
Casing Diameter (in)	10
Well Depth (ft)	122
Casing Depth (ft)	95
Screen	10-inch: 85-slot (100-122 ft)
Screen Capacity (gpm)	1100
Aquifer	Qva
Control Valves	3" 61-21ABX105 6" 692-07ABCDS-X101
PSV Setting	57psi @ 665 GPM
PRV Setting (psi)	54
Flow to Waste Setting	85psi @ 500gpm
Flow to Waste Duration (sec)	180
Well Capacity (gpm)	665
Chlorine Dose (mg/L)	0.82
Reliable Capacity (gpm)	665
Notes	Seasonal low aquifer levels during drought periods may require temporary reductions in pumping rates.

Well S01 (College St. Well 1)





STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
AND DEVELOPMENT Appli. #7746

WELL LOG

No. ..../........-........

Date Oct. 5, 1965

Record by Driller

Source Driller's Record

Location: State of WASHINGTON

County Thurston

Area 225' E and 175' S of

Map NE corner

NW ¼ SW¼ sec. 28 T. 18 N., R. 1 E.

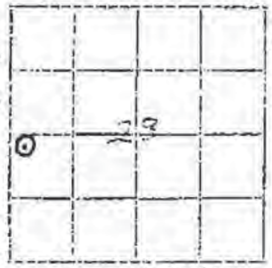


Diagram of Section

File number 18/1W-28H

Drilling Co. Kincy Hardware

Address 512 E. 4th, Olympia, Washington

Method of Drilling Cable Date Oct. 4, 1965

Owner Huntamer Water Service, Inc.

Address 4700 Lacey Blvd., Olympia, Washington

Land surface, datum .... ft. above / below

CORRELATION	MATERIAL	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Municipal use		
	DIMS: 10" x 122'		
	Clay and gravel	0	4
	Gravel and clay (compact)	4	10
	Clay and gravel	10	18
	Gravel, sand and clay	18	30
	Gravel and sand	50	53
	Clay and sand	53	66
	Sand and gravel	66	73
	Sand	73	80
	Clay, brown	80	80½
	Gravel, large, sand & clay	80½	86
	Gravel, large, gravel & sand	86	99
	Gravel and sandy	99	123
Turn up	Gravel and clay sand	123 / 125	125 / ?

Sheet .... of .... sheets

WELL LOG.—Continued No........./......-.......

CORRE-LATION	MATERIAL	THICKNESS (feet)	DEPTH (feet)
	Depth forward	———	
	Casing: 10" from 0-103'		
	Screen installed from 102 to 122'		
	SWL: 54'6" on Oct. 4. 1965.		
	Yield: 500 gpm with 14' DD after 4 hrs.		
	961 gpm with 20' DD after 10 min.		
	Pump: 40 h.p. Jacuzzi 600 gpm		
	5 stage 9½" bowl line-shaft turbine		

S. F. No. 7449—OS—6-61—2M.

HUNTAMER PROPERTY WELLS

Four wells have been drilled at this location.

Abandoned Well (18/1W - 28M1) - This well was abandoned sometime between 1969 and 1974.

Well No.1 (18/1W - 28M2) - Drilled by Kincy Hardware, October 1965.

Well Log:

Clay and gravel	0	4
Gravel and clay	4	10
Clay and gravel	10	18
Gravel, sand and clay	18	35
Gravel and sand	35	37
Gravel, sand and clay	37	50
Gravel and sand	50	53
Clay and sand	53	66
Sand and gravel	66	69
Sand	69	70
Sand and gravel	70	73
Sand	73	80
Brown clay	80	80 1/2
Cobbles, gravel, sand and clay	80 1/2	86
Gravel, sand	86	89
Gravel	89	90
Sand and gravel	90	92
Gravel and sand	92	99
Gravel and sand	99	119
Fine gravel and sand	119	122
Gravel, sand and some clay	122	123
Gravel and clay	123	125

Well constructed with 10-inch casing to about 103 feet below the surface. A 10-inch telescoping, stainless steel, wire wound, 85 slot screen placed between 100 and 122 feet.

Static water level was 55 1/2 feet when the well was drilled.

The well was originally test pumped at 500 gpm for 4 hours with 14 feet of drawdown. This results in a specific capacity of 35 gpm per foot of drawdown.

During the 1969 tests of Lacey Well No.2 and Well No.3, it was noted that the well had a pumping level of 78.5 feet with a reported yield of 600 gpm. When Well No.1 was turned off, the static level in Well No.2 dropped about 0.1 foot. The reason for this unexpected reversal is not clear but the event appears to demonstrate that there is a positive hydraulic seal between the upper aquifer of Well No.1 and the lower aquifer of Wells No.2 and No.3. The two zones should have no appreciable interference between them.

Well No.1 was test pumped in June 1974, utilizing the existing production equipment. The well was pumped at 710 gpm for two hours resulting in a draw-down to 81.6' (projected to 24 hours). Water level at the start of the test was 66.6 feet and still recovering. The tested specific capacity is 47 gpm per foot of drawdown. Water levels for the past year taken at various times of pumping and non-pumping show a range of 63 feet to 86 feet.

As compared to the 1965 construction records, the well's capacity has not decreased but the static water level has been lowered through withdrawal.

<u>Well No.2 (18/1W - 28M3)</u> - Well drilled by Kincy Hardware in October 1969.

Well Log:

Brown clay and gravel	0	3
Light brown clay and gravel	3	17
Brown clay with gravel streaks. Some water	17	35
Brown loose sand and gravel. No water	35	59
Brown sand and gravel. Water	59	69
Brown tight sand and gravel	69	73
Brown tight sand. Little water	73	75
Brown medium sand and gravel	75	76

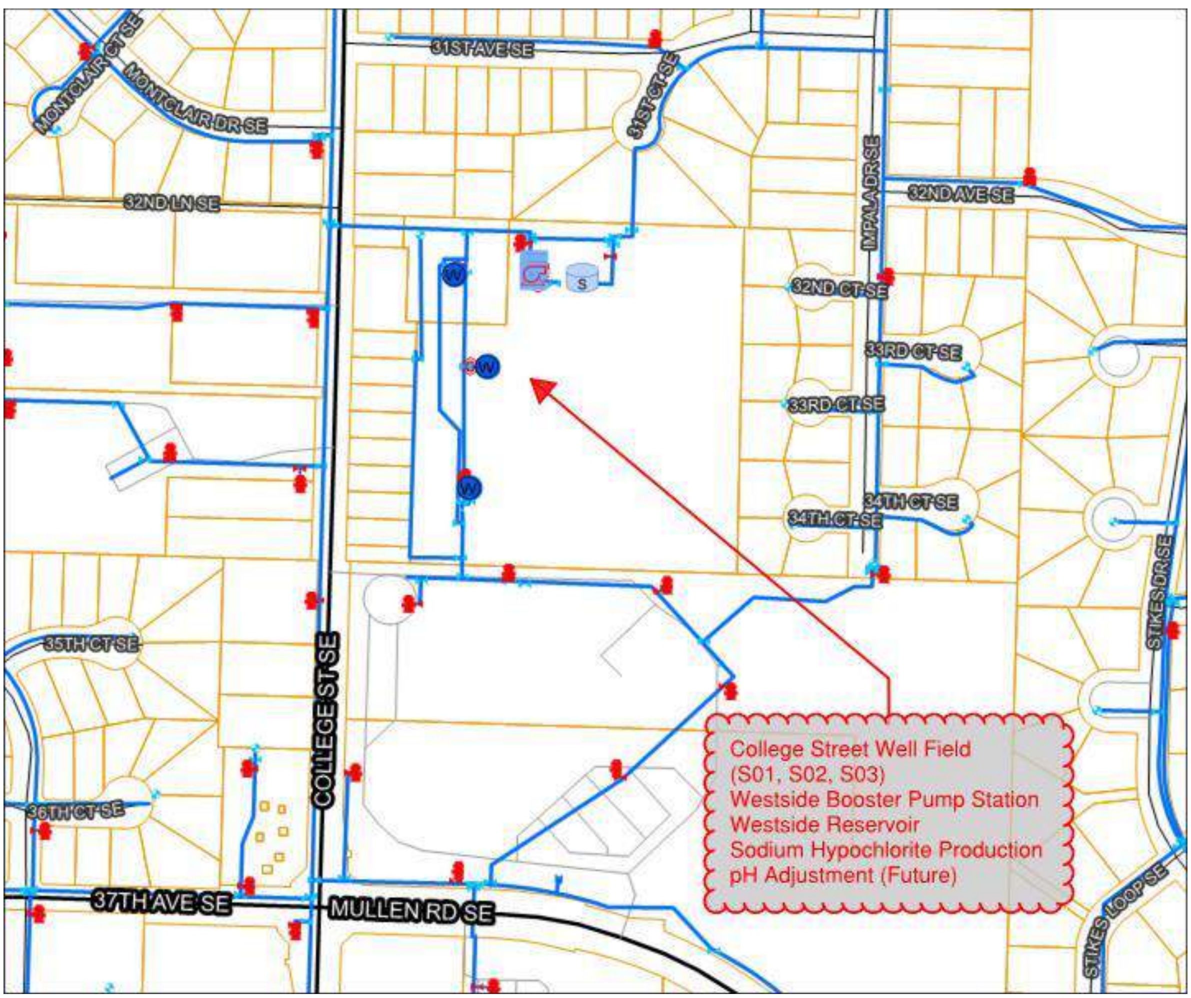
Well S02

(College St. Well No. 2)

Facility Information

Description	Comments
Source #	S02
Address	3300 College St. SE
Year On-Line	1969
Pressure Zone	337
Floor Elevation	233.26
Housing	CMU
Pump Type	Submersible
Pump Model	Hydroflo 12DC (9.29” 4-stage)
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	8" column, 160'
Pump Serial #	N/A
Pump Depth (ft)	180
Pump Capacity (gpm)	600 GPM @ 333 FT TDH
Motor Model	Tesla TR10
Motor Serial #	N/A
Motor Speed (rpm)	1775
Horsepower	75
Casing Diameter (in)	16
Well Depth (ft)	217
Casing Depth (ft)	189
Screen	16-inch: 35-slot (187-203 ft), 95-slot (203-217 ft)
Screen Capacity (gpm)	1550
Aquifer	Qpg
Control Valves	3" 61G-02 4" 92EG-07ABCDS
PSV Setting	52psi @ 550gpm
PRV Setting (psi)	66
Flow to Waste Setting	80psi @ 500gpm
Flow to Waste Duration (sec)	90
Well Capacity (gpm)	665
Chlorine Dose (mg/L)	0.79
Reliable Capacity (gpm)	600
Notes	

Well S02 (College St. Well 2)



Well #1

GWA-9994
GWP-9767

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

WELL LOG

Record by

Source

Location: State of WASHINGTON

County Thurston

Area

Map

NW ¼ SW ¼ sec. 28 T. 18 N., R. 1 E.

28
⊙ #1

Diagram of Section

File number 18/1E/W-28M

Drilling Co.

Address

Method of Drilling ... Date ..., 19...

Owner City of Lacey

Address

Land surface, datum 233 ft. above Sea Level

SWL: 66'5" Date June 6, 1969 Dims.: 16" X 188'

CORRELATION	MATERIAL (Municipal)	From (feet)	To (feet)
	(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)		
	Clay, Brown & Gravel	0	3
	Clay, Light Brown & Gravel	3	17
	Clay, Brown & Gravel, Streaks of Water	17	35
	Sand, Loose Brown & Gravel	35	59
	Sand, Brown & Gravel, Water	59	69
	Sand, Brown Tite, & Gravel	69	73
	Sand, Brown Tite & Little Water	73	75
	Sand, Brown Med. & Gravel	75	76
	Gravel, Brown Large & Sand	76	94
	Sand, Brown Med. & Gravel	94	102
	Clay, Brown & Gravel	102	109
	Sand, Brown Large & Gravel Water	109	111
	Continued		

Turn up

Sheet ... of ... sheets

WELL LOG.—Continued No......../.........

Correlation	Material	From (feet)	To (feet)
	Depth forward	———	
	Dirt, Brown, Sand, Med. & Gravel	111	119
	Dirt, Brown & Sand, Med.-Fine & Streaks of gravel	119	162
	Clay, Brown & Gravel	162	166
	Gravel, Brown Large & 0-8" Clay	166	174
	Gravel, Dark Brown, Med-Large	174	178
	Gravel, Dark Brown & Streaks of Clay	178	188
	Gravel, Dark Brown, Large Water	188	198
	Gravel, Dark Brown, Small-Med	198	202
	Sand, Brown Large, Gravel, Med	202	208
	Sand, Brown Large & Gravel	208	214
	Sand, Brown Large & Gravel	214	217
	Clay, Brown	217	
	Casing: 16" from 0 to 188'		
	Screens: Johnson. Everdure Stainless Diam. 16; Slot size 35 from 188' to 203 and Slot size 95 from 203' to 217'		
	Pump: Jacuzzi, Turbine 700 GPM, 75HP		
	Well Tests: 444 gpm, 23'DD, 1 Hr.		
	560 gpm, 39' DD, 2 Hr.		
	776 gpm, 100' DD, 5 Hr.		
	Recovery Data		
	5:28 – 120' 5:35 78'		
	5:30 – 87' 5:41 76.5		
	5:31 – 85 5:50 75.0		

S. F. No. 7449—OS—12-65.

Kincy Hardware and Well Drilling Co.

CONSTRUCTION RECORD

(#2 #2)

Date Oct 20 - 1964 408 #~~44~~ Total Depth 219' 5"

1. WELL OWNER
   Name City of Kincy
   Address
2. LOCATION
   R1W T18N Sec 28
   N.W Corner
   on Hanna Rd
3. TYPE OF WORK
   New Well X Deeping ____ Bailing ____
   Setting Screen ____ Developing ____
4. PROPOSED USE
   Domestic ____ Industrial ____ Municipal X
   Irrigation ____ Test Well ____ Other ____
5. CASING INSTALLED
   Above Ground 3' Below Ground 186' 9"
   Threaded ____ Welded X
   16" dia. from 0 ft. to 189' 9" ft. ga. 30
   ____ dia. from ____ ft. to ____ ft. ga. ____
   ____ dia. from ____ ft. to ____ ft. ga. ____
   ____ dia. from ____ ft. to ____ ft. ga. ____
6. PERFORATIONS
   Yes ____ No X
   From ____ to ____ size ____ x ____
   From ____ to ____ size ____ x ____
   From ____ to ____ size ____ x ____
7. SCREEN INSTALLED
   Yes X No ____
   Make Johnson Total Length 30' 4"
   Amount Exposed 27' 5" Fittings Welded
   Metal Stainless Ext. Piece NO
   Dia. 16" Slot Size 35 from ~~##~~ to 15.6
   Slot Size 95 from ____ to 14.4
   Slot Size ____ from ____ to ____
   Slot Size ____ from ____ to ____
   Slot Size ____ from ____ to ____
   6" Lead Packer
8. CONSTRUCTION
   Gravel Packed. Yes ____ No X
   Gravel Placed From ____ to ____ Size ____
9. WATER LEVELS
   State Water Level Mon June 9 1964 61½ ft
   Flowing NO Rate ____
10. PUMP TEST
    Yes X No ____ Bail Tested ____
    2 p.m. 700 Draw Down 150' 8"
    Hours Pumped 3 Bailed ____
11. PUMPS INSTALLED
    Make Jacuzzi
    Type Turbine
    Setting 160' GPM 700
    HP 25 Phase 3 Pipe Size 8"
12. CHEMICAL ANALYSIS
    Iron ____ ppm.
    P.H. ____ ppm.
    Hardness ____ gr.
    Odor - Yes ____ No ____
13. DRILLERS NOTES
14. DRILLER R. Kincy

(over)

Static water level was 55 1/2 feet when the well was drilled.

The well was originally test pumped at 500 gpm for 4 hours with 14 feet of drawdown. This results in a specific capacity of 35 gpm per foot of drawdown.

During the 1969 tests of Lacey Well No.2 and Well No.3, it was noted that the well had a pumping level of 78.5 feet with a reported yield of 600 gpm. When Well No.1 was turned off, the static level in Well No.2 dropped about 0.1 foot. The reason for this unexpected reversal is not clear but the event appears to demonstrate that there is a positive hydraulic seal between the upper aquifer of Well No.1 and the lower aquifer of Wells No.2 and No.3. The two zones should have no appreciable interference between them.

Well No.1 was test pumped in June 1974, utilizing the existing production equipment. The well was pumped at 710 gpm for two hours resulting in a drawdown to 81.6' (projected to 24 hours). Water level at the start of the test was 66.6 feet and still recovering. The tested specific capacity is 47 gpm per foot of drawdown. Water levels for the past year taken at various times of pumping and non-pumping show a range of 63 feet to 86 feet.

As compared to the 1965 construction records, the well's capacity has not decreased but the static water level has been lowered through withdrawal.

<u>Well No.2 (18/1W - 28M3)</u> - Well drilled by Kincy Hardware in October 1969.

Well Log:

Brown clay and gravel --------------	0	3
Light brown clay and gravel --------	3	17
Brown clay with gravel streaks. Some water -------------------	17	35
Brown loose sand and gravel. No water ---------------------	35	59
Brown sand and gravel. Water -----	59	69
Brown tight sand and gravel -------	69	73
Brown tight sand. Little water -----	73	75
Brown medium sand and gravel -----	75	76

Well Log (continued):

Brown large gravel, some sand ------	76	94
Brown medium sand, some gravel ----	94	102
Brown clay and gravel. No water ---	102	109
Brown large sand and gravel. Water --	109	111
Brown dirty medium sand and gravel --	111	119
Brown dirty medium to fine sand with streaks of gravel ----------------	119	162
Brown clay and gravel. No water ----	162	166
Brown large gravel 0" to 8" size. clay present --------------------	166	174
Dark brown medium to large gravel, very good ---------------------	174	178
Dark brown gravel with clay streaks. No water ----------------------	178	188
Dark brown large gravel. Water -----	188	198
Dark brown small to medium gravel, very good ---------------------	198	202
Brown large sand, medium gravel ----	202	208
Brown large sand, very little gravel --	208	214
Brown large sand and gravel .050" size	214	217
Brown clay ----------------------	217	

Well constructed with 16-inch casing to depth of 187 feet. Sixteen inch telescoping stainless-steel, wire wound screen, placed between 187 feet and 217 feet. The upper 15.6 feet of screen is 35 slot and the lower 14.7 feet is 95 slot.

Well was pump tested at time of construction by the driller at 750 and 700 gpm for 8 hours. The drawdown was 90 feet below a static water level of 61.5 feet, resulting in a specific capacity of 8.3 gpm per foot of drawdown.

A Robinson and Noble pumping test in 1969 showed similar results. The well was pumped at 740 gpm for 4 hours resulting in 85 feet of drawdown below a static water level of 64 feet. This results in an 8.7 gpm per foot of drawdown specific capacity.

Pump tested again by Robinson and Noble in June 1974, the water level was 70 feet below surface. The well was pumped at 760 gpm for 2 1/2 hours resulting in 62 feet of drawdown (projected to 24 hours). This results in a specific capacity of 12.2 gpm per foot of drawdown. Water level range, at various stages of pumping and non-pumping was 65' to 120' for the past year.

The well's capacity appears to be better than when drilled.

The static water level has possibly declined 5 feet or so since 1969.

Well No.3 (18/1W - 28M4) - Well drilled by Kincy Hardware during October 1969.

Well Log:

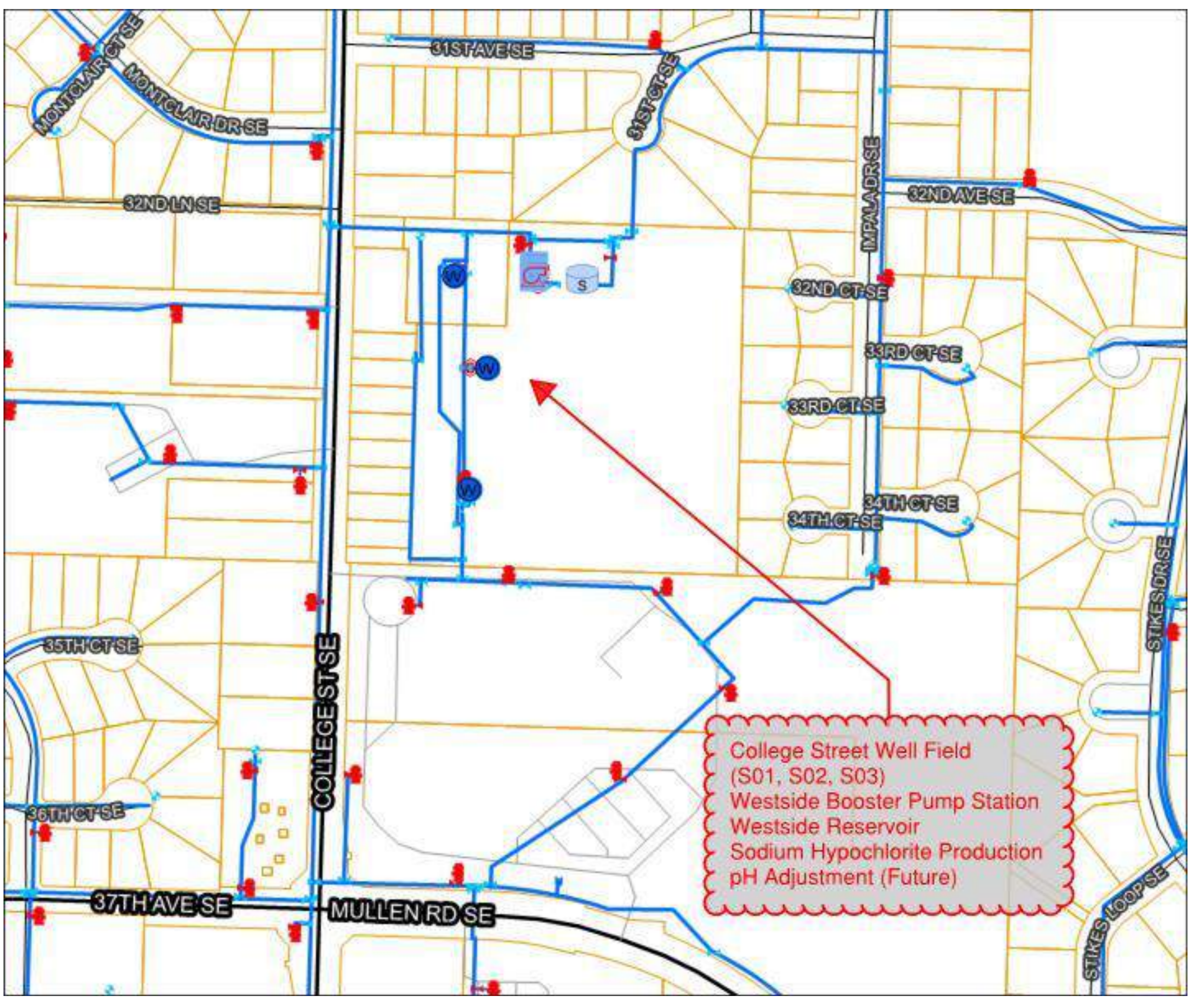
Top soil	0	2
Gray brown hardpan	2	29
Gray brown tight sand and gravel	29	60
Gray brown medium sand and gravel. Water	60	70
Gray brown fine to medium sand	70	76
Gray brown medium sand and gravel	76	80
Gray brown large gravel and sand 0" to 3" size. Good	80	84
Gray brown large to medium gravel, little sand	84	97
Brown clay and gravel. No water	97	103
Brown sand and small gravel. Water	103	116
Brown medium sand dirty with some gravel streaks	116	157
Brown medium sand and gravel	157	162
Brown large gravel and clay 0" to 6" size. No water	162	166
Brown clay and gravel. Had to drill up	166	191
Brown sand and gravel tight, some clay. Little water	191	193
Brown gravel and sand large 0" to 3" Good	193	226
Gray large sand and gravel, tight	226	227
Gray silts	227	238

Well S03
(College St. Well No. 3)

Facility Information

Description	Comments
Source #	S03
Address	3300 College St. SE
Year On-Line	1969
Pressure Zone	337
Floor Elevation	231.63
Housing	CMU
Pump Type	Turbine
Pump Model	Integrity 9IEL (7.7” 6-stage)
Pump Shaft Diameter (in)	1.005
Column Diameter/Length	6" column, 177'
Pump Serial #	IPM20149A
Pump Depth (ft)	185
Pump Capacity (gpm)	210 GPM @ 320 FT TDH
Motor Model	US Electric A326UP
Motor Serial #	HR177401269
Motor Speed (rpm)	1720
Horsepower	30
Casing Diameter (in)	16
Well Depth (ft)	225
Casing Depth (ft)	197
Screen	16-inch: 30-slot (194-202 ft), 40-slot (202-214 ft), 50-slot (214-222 ft)
Screen Capacity (gpm)	1100
Aquifer	Qpg
Control Valves	3" 61G-21B 6" 692G-07ABCDS
PSV Setting	62psi @ 230gpm
PRV Setting (psi)	54
Flow to Waste Setting	84psi @ 165gpm
Flow to Waste Duration (sec)	60
Well Capacity (gpm)	250
Chlorine Dose (mg/L)	0.69
Reliable Capacity (gpm)	210
Notes	

Well S03 (College St. Well 3)



GWA-9994
GWP-9757

STATE OF WASHINGTON
DEPARTMENT OF CONSERVATION
DIVISION OF WATER RESOURCES

WELL LOG

Record by: unk.
Source: Well Report

Location: State of WASHINGTON
County: Thurston
Area:
Map:
NW ¼ SW ¼ sec. 28 T. 18 N., R. 1 W.

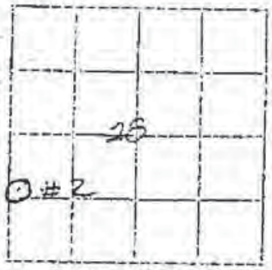


Diagram of Section

File number 18N/01W-28M

Drilling Co. Unknown
Address:
Method of Drilling: Date: , 19
Owner: City of Lacey
Address:
Land surface, datum 233 ft. above Sea Level
SWL: 61.5' Date June 6, 1969 Dims.: 16" X 227

(Transcribe driller's terminology literally but paraphrase as necessary, in parentheses. If material water-bearing, so state and record static level if reported. Give depths in feet below land-surface datum unless otherwise indicated. Correlate with stratigraphic column, if feasible. Following log of materials, list all casings, perforations, screens, etc.)

Correlation	Material	From (feet)	To (feet)
	Top Soil	0	2
	Hardpan, Gray Brown	2	29
	Sand, Brown Tite & Gravel	29	60
	Sand, Brown Med. & Gravel	60	70
	Water		
	Sand, Brown Fine to med.	70	76
	Sand, Brown, Med & Gravel	76	80
	Gravel, Brown 0 to 3 large	80	84
	& Sand, good		
	Gravel, Brown Large Med. &	84	97
	little Sand		
	Clay, Brown & Gravel	97	103
	Sand, Brown & Gravel, small	103	116
	Water		
	Sand, Brown, Med. (Dirty	116	157
	w/some gravel streaks		

Turn up

Sheet ...... of ...... sheets

WELL LOG.—Continued

No. ....

CORRELATION	MATERIAL	From (feet)	To (feet)
	Depth forward		
	Sand, Brown Med. & Gravel	157	162
	Gravel, Brown Large 0-6: size & Clay	162	166
	Clay, Brown & Gravel, Hard, Had to drill up	166	191
	Sand, Brown, Gravel, Tite Clay, Some Water	191	193
	Gravel, Brown, Sand, Large 0-6" good	193	226
	Sand, Gray, Large, Gravel Tite	226	227
	Silts, Gray, Drilled to 238	227	238
	Screens: Johnson, Stainless		
	Diam. 16 Size 30 from 197' to 207'		
	Size 40 from 207' to 219'		
	Size 50 from 219' to 227'		
	Pump: Jacuzzi, Turbine 200 GPM, 30 HP		
	Well Test: 350 GPM, 94'DD, 4 Hr.		

S. F. No. 7449—OS—12-65.

Kincy Hardware and Well Drilling Co. #3 (#3)

CONSTRUCTION RECORD

Date 10-20-69 409 #~~2~~ Total Depth 225' 5¼"

1. WELL OWNER
Name City of Lacy
Address

2. LOCATION
R1W T18N NW Corner
of Sec 28
on Herman Rd

3. TYPE OF WORK
New Well X Deeping ___ Bailing ___
Setting Screen ___ Developing ___

4. PROPOSED USE
Domestic ___ Industrial ___ Municipal X
Irrigation ___ Test Well ___ Other ___

5. CASING INSTALLED
Above Ground 2' 4" Below Ground 194
Threaded ___ Welded X
16" dia. from 0 ft. to 197 ft. ga. 30
___ dia. from ___ ft. to ___ ft. ga. ___
___ dia. from ___ ft. to ___ ft. ga. ___
___ dia. from ___ ft. to ___ ft. ga. ___

6. PERFORATIONS
Yes ___ No X
From ___ to ___ size ___ x ___
From ___ to ___ size ___ x ___
From ___ to ___ size ___ x ___

7. SCREEN INSTALLED
Yes X No ___
Make Johnson Total Length 30' 5¼
Amount Exposed 28' 5¼" Fittings Welded
Metal Stainless Ext. Piece NO
Dia. 16 Slot Size ___ from ___ to ___
Lead Top Slot Size — from 6⅜ to ___
Top Slot Size 30 from 10' to ___
Middle Slot Size 40 from 12' to ___
Bottom Slot Size 50 from 8' to ___

8. CONSTRUCTION
Gravel Packed. Yes ___ No X
Gravel Placed From ___ to ___ Size ___

9. WATER LEVELS
State Water Level 61' 6"
Flowing NO Rate ___

10. PUMP TEST
Yes X No ___ Bail Tested ___
2 p.m. 350 Draw Down 159
Hours Pumped 2 Bailed ___

11. PUMPS INSTALLED
Make Jacuzzi
Type Turbine
Setting 180 GPM 300
HP 30 Phase 3 Pipe Size 5"

12. CHEMICAL ANALYSIS
Iron ___ ppm.
P.H. ___ ppm.
Hardness ___ gr.
Odor - Yes ___ No ___

13. DRILLERS NOTES
~~[illegible]~~ Well was Tested
Between 60 To 97 ft And
And did 400 GPM

14. DRILLER R Kincy

(over)

Pump tested again by Robinson and Noble in June 1974, the water level was 70 feet below surface. The well was pumped at 760 gpm for 2 1/2 hours resulting in 62 feet of drawdown (projected to 24 hours). This results in a specific capacity of 12.2 gpm per foot of drawdown. Water level range, at various stages of pumping and non-pumping was 65' to 120' for the past year.

The well's capacity appears to be better than when drilled.

The static water level has possibly declined 5 feet or so since 1969.

<u>Well No.3 (18/1W - 28M4)</u> - Well drilled by Kincy Hardware during October 1969.

Well Log:

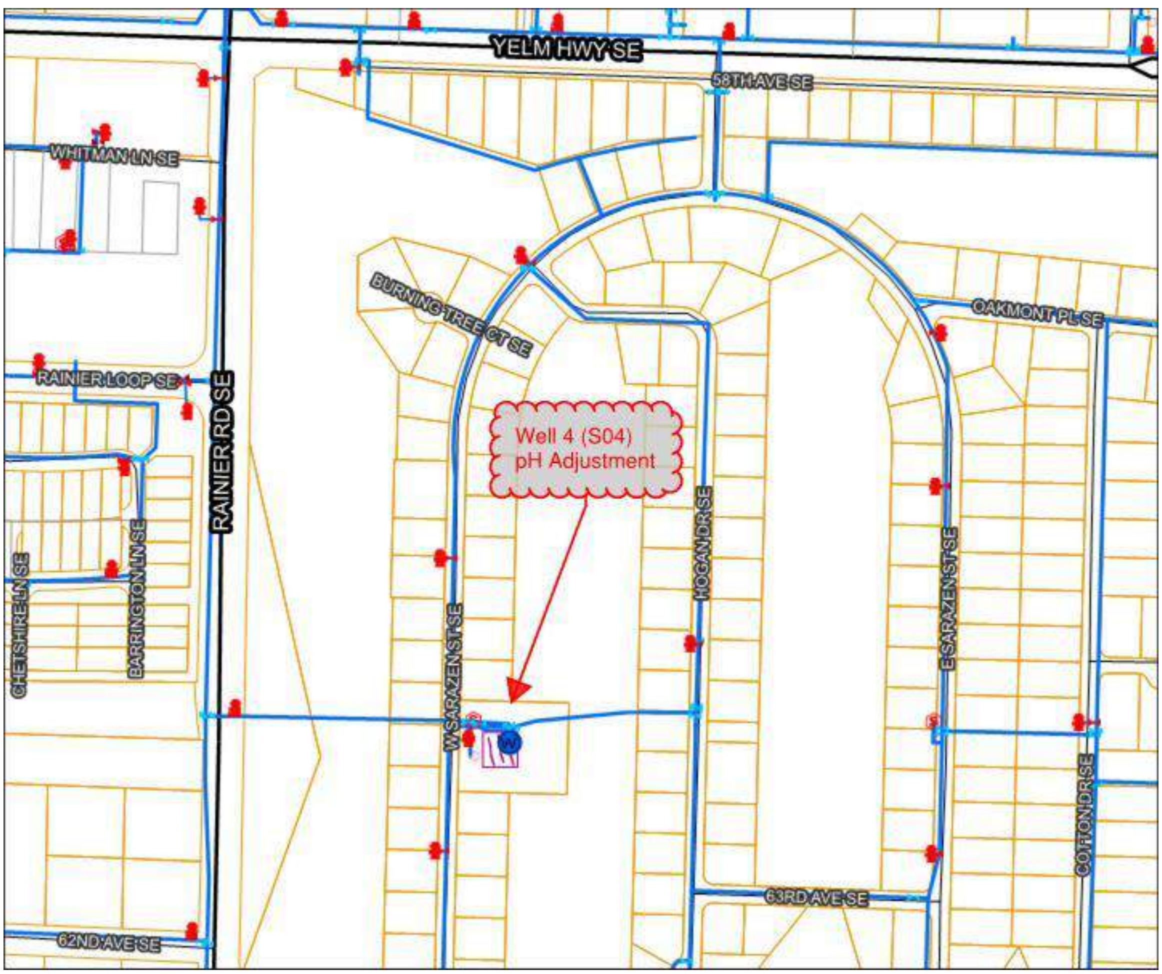
Top soil -------------------------	0	2
Gray brown hardpan ---------------	2	29
Gray brown tight sand and gravel ---	29	60
Gray brown medium sand and gravel. Water -----------------------	60	70
Gray brown fine to medium sand ----	70	76
Gray brown medium sand and gravel -	76	80
Gray brown large gravel and sand 0" to 3" size. Good -------------	80	84
Gray brown large to medium gravel, little sand ---------------------	84	97
Brown clay and gravel. No water ----	97	103
Brown sand and small gravel. Water -	103	116
Brown medium sand dirty with some gravel streaks -----------------	116	157
Brown medium sand and gravel -----	157	162
Brown large gravel and clay 0" to 6" size. No water ---------------	162	166
Brown clay and gravel. Had to drill up ------------------------	166	191
Brown sand and gravel tight, some clay. Little water ------------	191	193
Brown gravel and sand large 0" to 3" Good ----------------------	193	226
Gray large sand and gravel, tight --	226	227
Gray silts ------------------------	227	238

Well S04
(Golf Club Estates)

Facility Information

Description	Comments
Source #	S04
Address	6100 Sarazan SE
Year On-Line	1973
Pressure Zone	337
Floor Elevation	211.27
Housing	CMU
Pump Type	Submersible
Pump Model	Integrity 9IDML (7.025" 2-stage)
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	6" column, 64'
Pump Serial #	N/A
Pump Depth (ft)	66
Pump Capacity (gpm)	750 GPM @ 245 FT TDH
Motor Model	Hitachi
Motor Serial #	N/A
Motor Speed (rpm)	3600
Horsepower	60
Casing Diameter (in)	16
Well Depth (ft)	84
Casing Depth (ft)	65
Screen	14-inch: 80-slot (65-66 ft), 100-slot (66-67 ft), 150-slot (67-80 ft)
Screen Capacity (gpm)	1000
Aquifer	Qva
Control Valves	6" 61G-21B 10" 92G-01BCSD
PSV Setting	74psi @ 750gpm
PRV Setting (psi)	67
Flow to Waste Setting	95psi @ 700gpm
Flow to Waste Duration (sec)	300
Well Capacity (gpm)	1400
Chlorine Dose (mg/L)	0.62
Reliable Capacity (gpm)	750
Notes	Sand has been reported at flow rates above 850 gpm.

Well S04 (Golf Club Estates)



Well Inspection Video

Well Graphics

Well	Well 4	**Insp. no.**	5
		Insp. date	5/12/2008

Video		**Photos**	2
Video start	00:00:09	**Well depth [ft]**	84.00
Video end	00:38:03	**Inspection length [ft]**	82.90

Scale 1/ 764 **Graphics page** 1

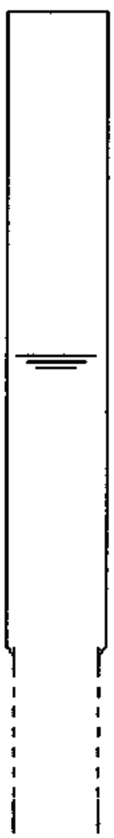
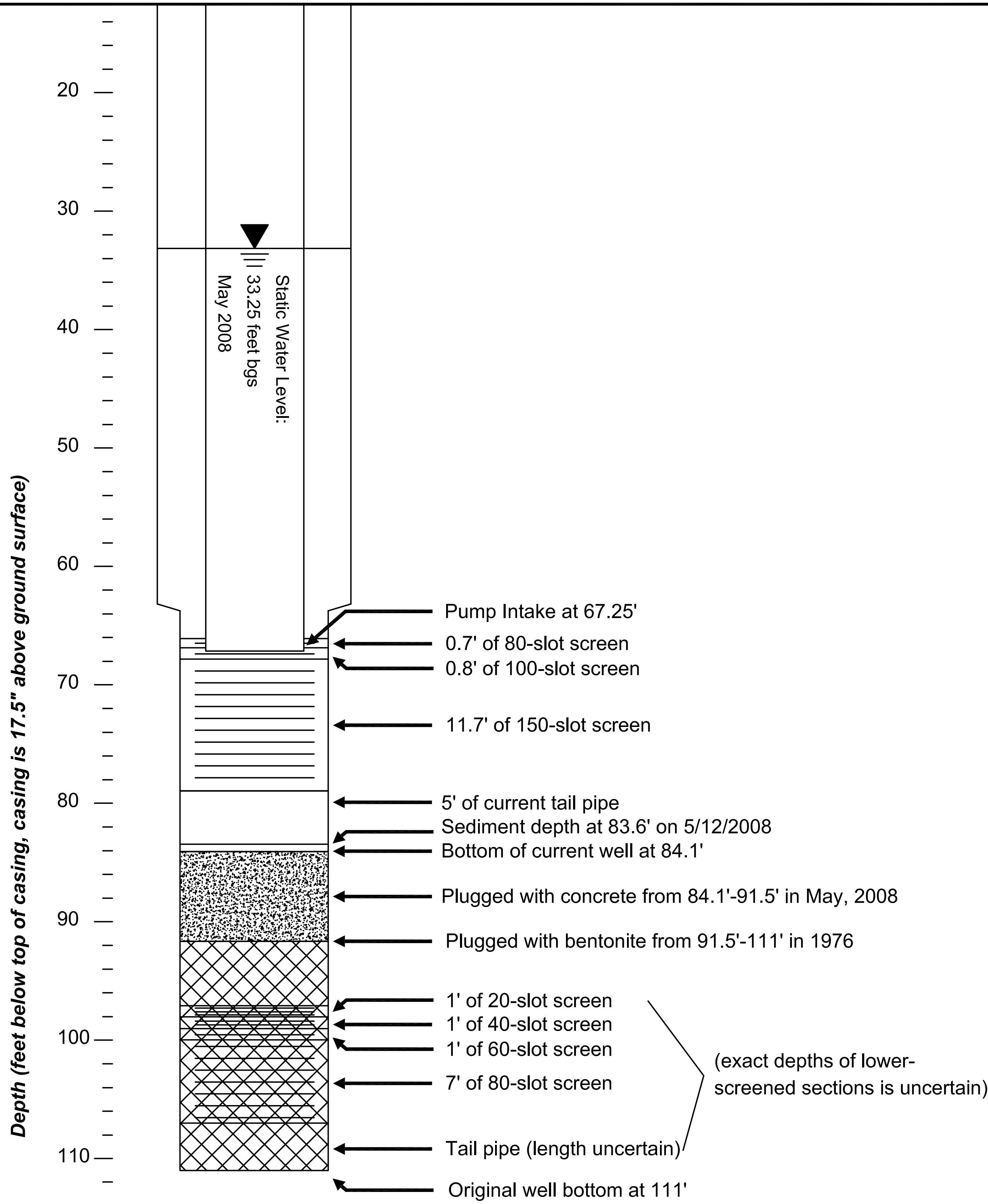


Photo	Video	Depth/ft	Condition	Description
	00:00:09	0.00	TOC	Top of Casing; 0ft
	00:02:10	8.90	CJ	Casing Joint; 8.9ft
	00:03:40	18.10	CJ	Casing Joint; 18.1ft
	00:05:19	27.60	CJ	Casing Joint; 27.6ft
	00:07:04	35.30	SWL	Static water level; 32.9ft
	00:14:16	64.00	CR	Casing reduction; 63.8ft
	00:16:31	64.30	RE	Remark; K-packer top
	00:22:36	66.20	TOS	Top of screen interval; 66.2ft; K-packer bottom
001	00:26:18	68.10	RE	Remark; Loose sand observed on screen opening 68.1
002	00:32:57	79.60	BOS	Bottom of screen interval; 79.6ft
	00:38:03	82.90	SFD	Sediment fill depth; 83.6ft



Notes

Screen type: 14-inch stainless steel
(13.125 - inch inner diameter)

Information compiled from multiple inspections/documents

Well 4 Screen Assembly Detail

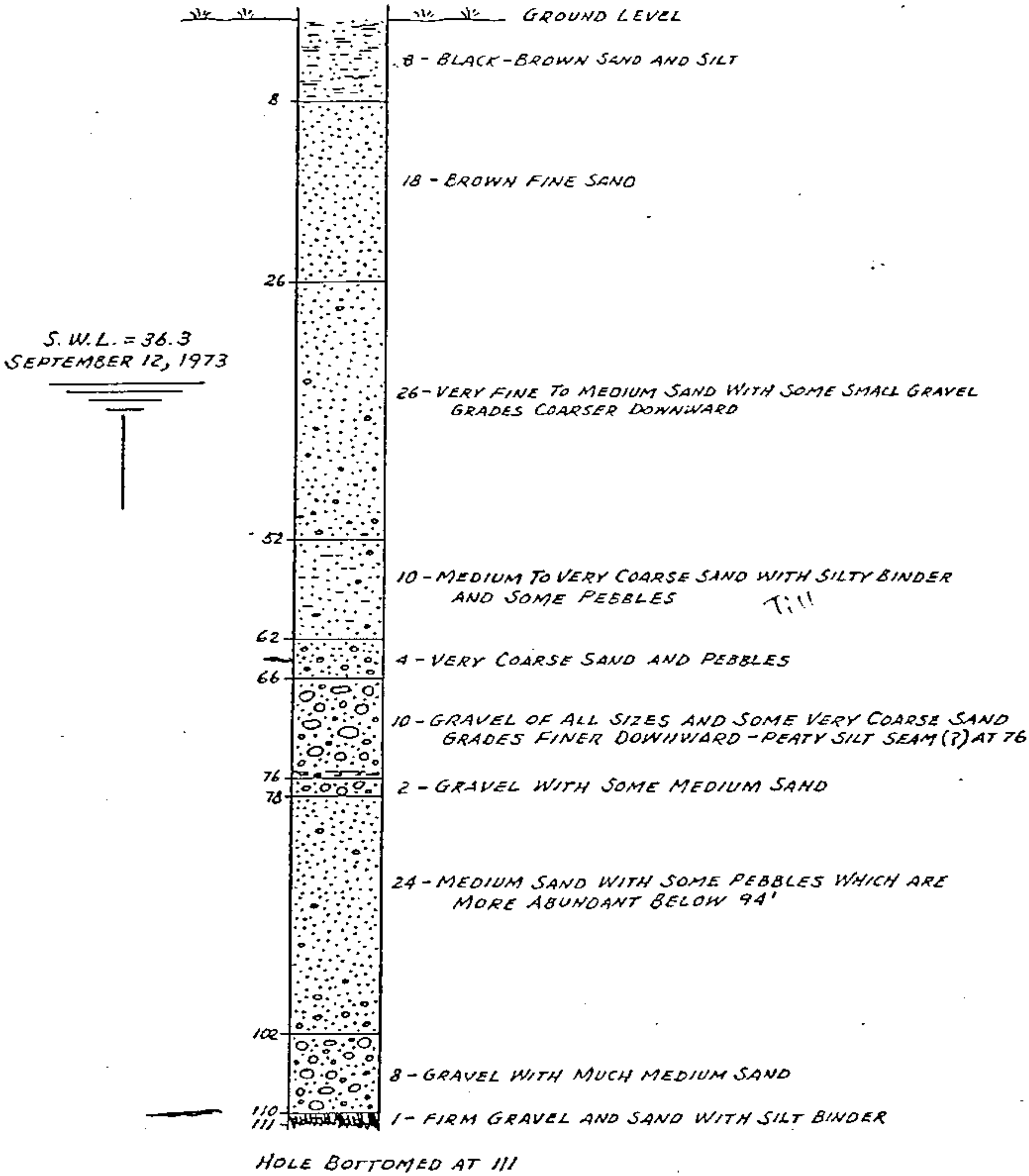
Well 4 Construction
City of Lacey, Washington

NORTHWEST Land & Water, INC.

D:\Projects\Lacey\2006 Test Well Program\Monitoring-WaterLevel&Flow\StepRate Tests\Well 4\Well4detail.dwg version 8/26/08

Western well

CITY OF LACEY GOLF COURSE WELL – 1973

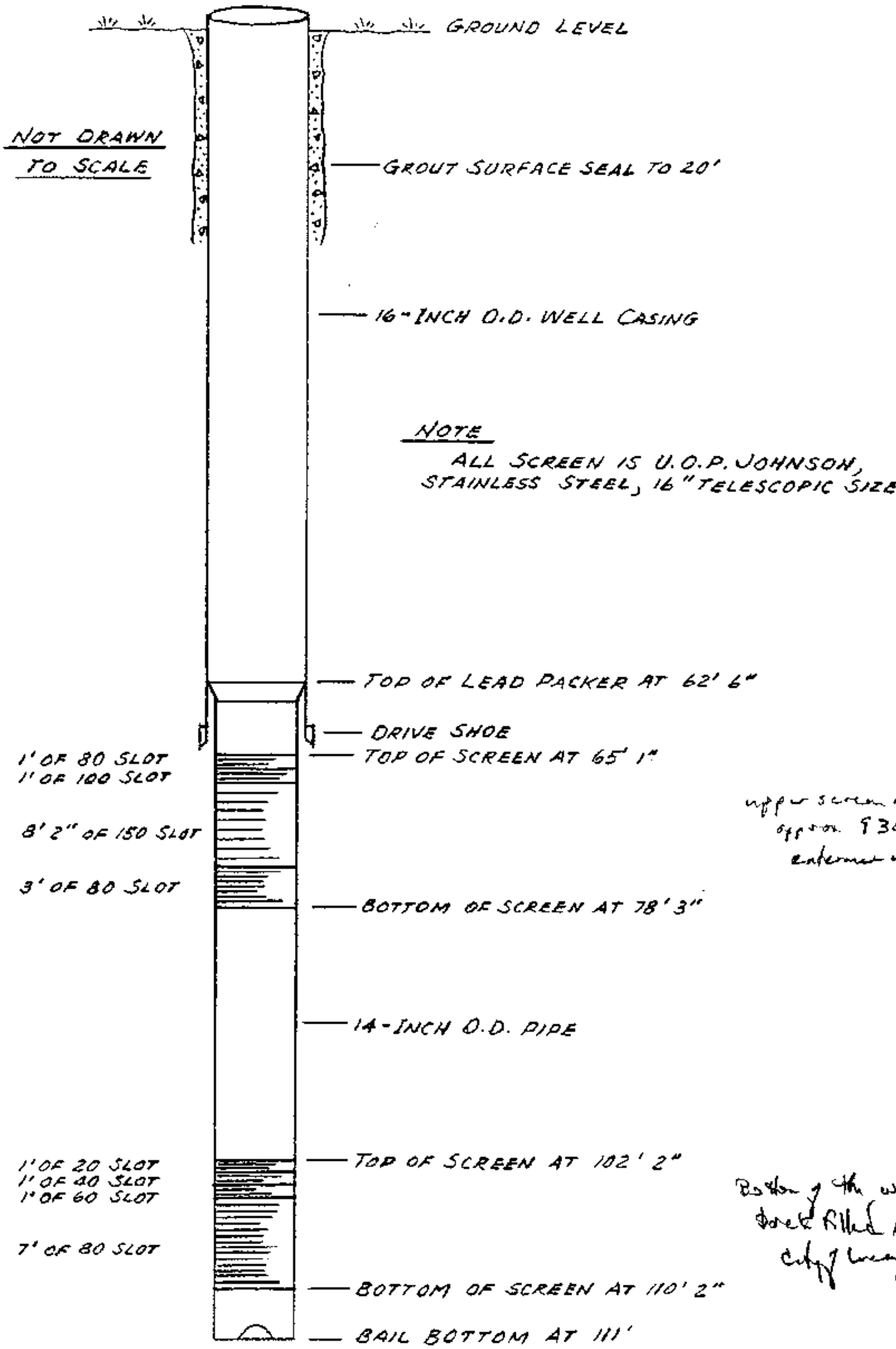


CITY OF LACEY WASHINGTON	ROBINSON AND NOBLE, INC. GROUND WATER GEOLOGISTS TACOMA, WASHINGTON	SEPT. 15, 1973 DRAWN BY H.N.

FIG. 2

GOLF COURSE WELL - 1973

CASING AND SCREEN DETAILS



upper screen rated for approx. 930 gpm for entrance vel = 0.1 ft/sec

Bottom of the well was: [illegible] filled per Cullen Wilder City of [illegible] (10-7-94)

CITY OF LACEY WASHINGTON	ROBINSON AND NOBLE, INC. GROUND WATER GEOLOGISTS TACOMA, WASHINGTON	SEPT. 15, 1973
		DRAWN BY H. N.

Well S06

(Judd Hill)

Facility Information

Description	Comments
Source #	S06
Address	2400 Judd St. SE
Year On-Line	1993
Pressure Zone	337
Floor Elevation	235.51
Housing	CMU
Pump Type	Submersible
Pump Model	Peerless 8LB - 3 Stage
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	6" column, 168'
Pump Serial #	9927004323-1
Pump Depth (ft)	168
Pump Capacity (gpm)	400 GPM @ 265 FT TDH
Motor Model	Hitachi
Motor Serial #	G2798805H
Motor Speed (rpm)	3470
Horsepower	75
Casing Diameter (in)	16
Well Depth (ft)	385
Casing Depth (ft)	190
Screen	10-inch: 40-slot (190-200, 223-238 ft), 60-slot (325-340, 352-367, 375-380 ft)
Screen Capacity (gpm)	1850
Aquifer	Qpg - TQu
Control Valves	4" 61G-21AB 8" 92G-02BD 2-1/2" 50G-01BD 8" 136EG-03ABCS
PSV Setting	330gpm
PRV Setting (psi)	60
Flow to Waste Setting	220gpm
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	550
Chlorine Dose (mg/L)	N/A
Reliable Capacity (gpm)	330
Notes	Declining specific capacity, requires frequent rehabilitation efforts to maintain specific capacity.

Well S06 (Judd Hill)

SC-014204

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [illegible]

Water Right Permit No. G2-27373 A

(1) OWNER: Name City of Lacey   Address

(2) LOCATION OF WELL: County Thurston   SW ¼ SW ¼ Sec 21 T. 18 N., R. 1 W.M.

(2a) STREET ADDDRESS OF WELL (or nearest address) Corner of Judd St. + 23rd Ave SE

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) Judd Hill 6 C - VW
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 403 feet. Depth of completed well 195 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from +2 ft. to 195 ft.
Welded ☒ ______" Diam. from ______ ft. to ______ ft.
Liner installed ☐
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type 304 Model No.
Diam. 10 Slot size 60 from 190 ft. to 200 ft.
Diam. 10 Slot size 60 from 223 ft. to 238 ft.

Gravel packed: Yes ☒ No ☐ Size of gravel Agua #1
Gravel placed from 400 ft. to 177 ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off

(7) PUMP: Manufacturer's Name
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 98 ft. below top of well Date
Artesian pressure ______ lbs. per square inch Date
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☐ No ☐ If yes, by whom?
Yield: 630 gal./min. with 57 ft. drawdown after 24 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date
Temperature of water ______ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Sand	0	5
Gray + brown sand + gravel	5	45
Gray to brown sand	45	95
Sand some gravel layers of silt water bearing	95	403
10" - 60 slot 325 - 340		
10" 60 slot 353 - 368		
10" 60 slot 375 - 380		

Work started 7-23-, 19 88 Completed 9-2, 19 88

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10621 Todd Rd E
(Signed) [signature] (WELL DRILLER) License No. 1099
Contractor's Registration No. HOLT D1 1360G Date 10-1, 19 88

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

Boring Log and Construction Data for Judd Hill Well 6C

Geologic Log

Depth in Feet

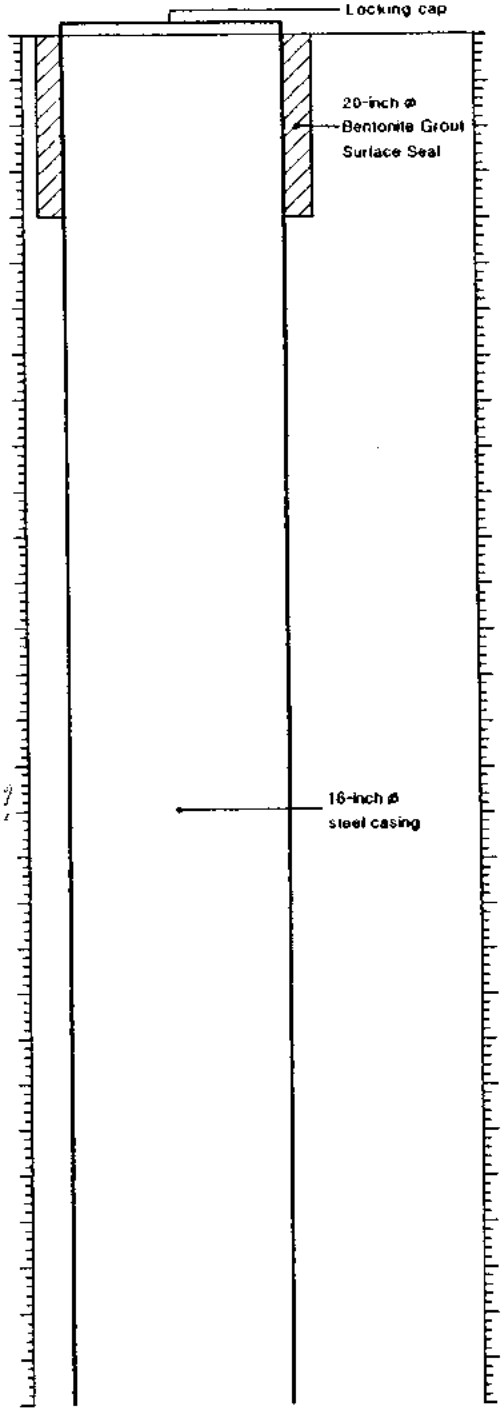
Ground Surface Elevation in Feet 234.6

Depth in Feet	Description	Sample	Lab
0	Brown, silty SAND (TOPSOIL).		
10	Gray to brown, gravelly SAND.		
30	Cobbles.		
50	Gray to brown, fine to medium SAND.		
60	Gray to brown, very gravelly SAND.		
70	Slightly gravelly, fine to medium SAND.		
80	Brown, slightly silty to silty, medium to fine SAND.	▽ 8/25/88	
	As above, saturated.		
	Brown, very gravelly, fine to medium SAND.		
110	Brown, very sandy GRAVEL with cobbles.		
130		B.T.=7.0 gpm/ft.	
	Gravel content decreases. Very gravelly SAND with cobbles.		
	Brown, gravelly SAND with interbedded SILT.		
150			

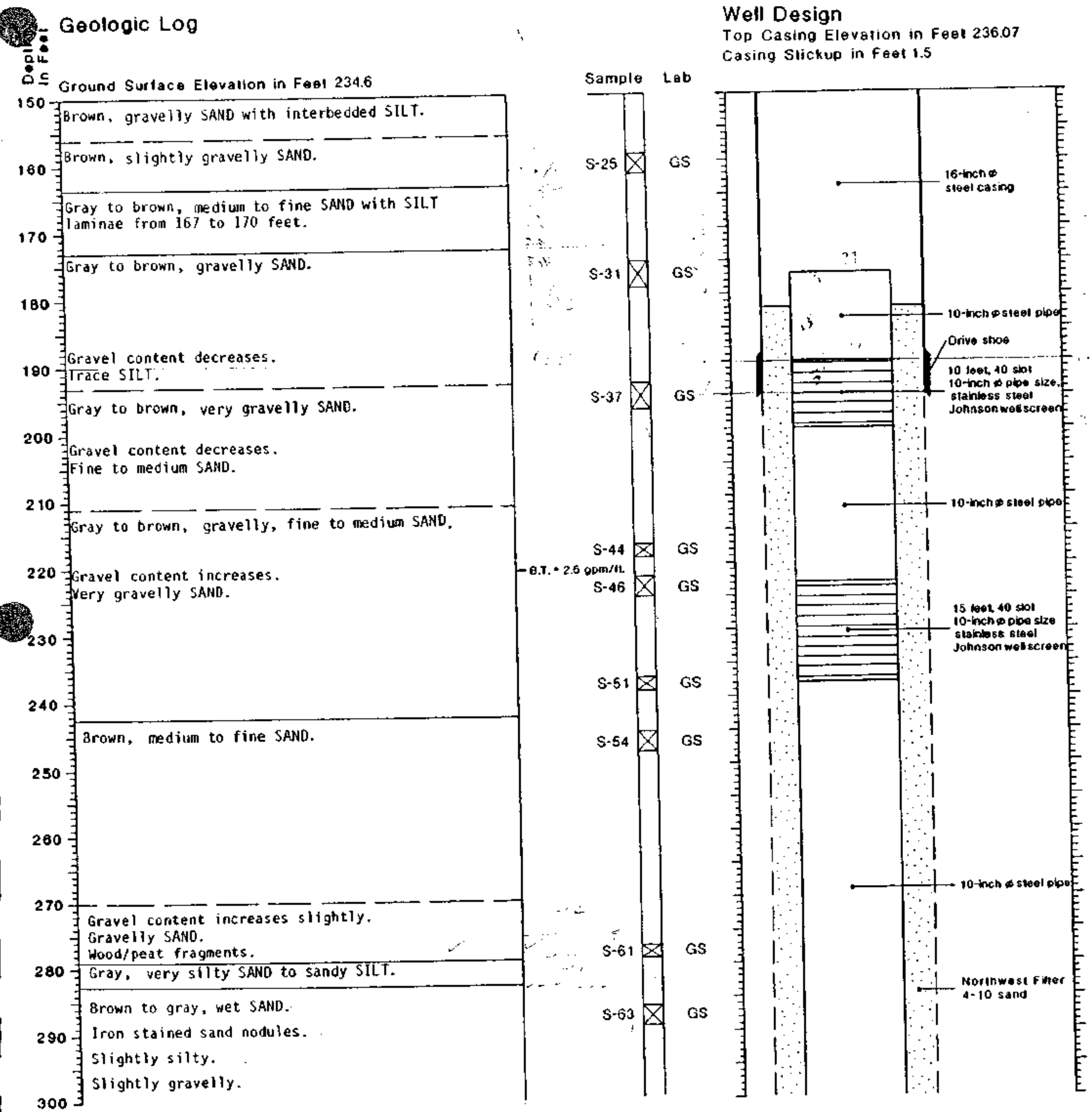
Well Design

Top Casing Elevation in Feet 236.07

Casing Stickup in Feet 1.5



Boring Log and Construction Data for Judd Hill Well 6C

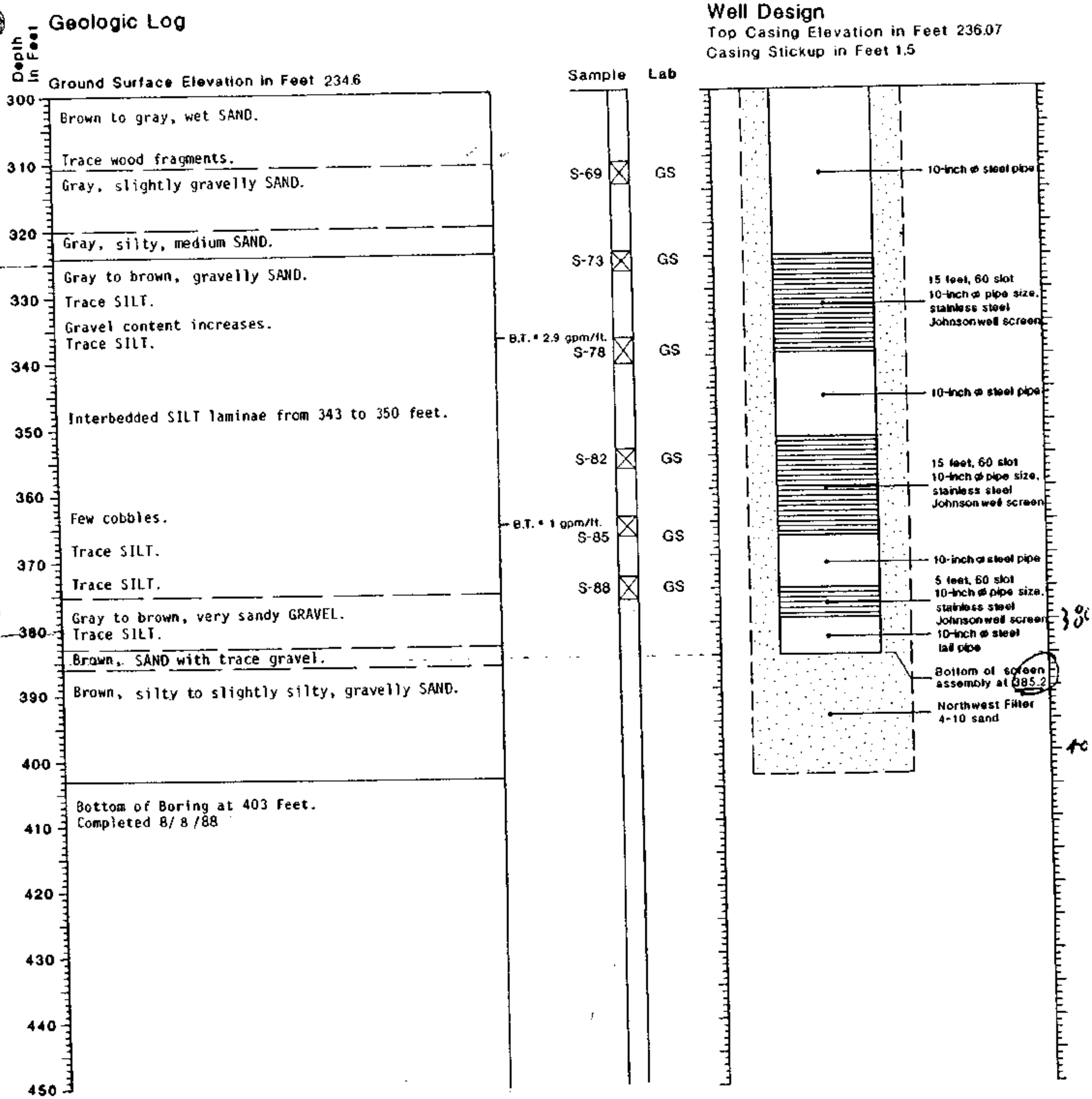


J-2111 August 1988

HART-CROWSER & associates, inc.

Sheet 2 of 3 Figure A-2

Boring Log and Construction Data for Judd Hill Well 6C



NOTES: 1. Soil description for samples collected between 0 and 128 feet and in a few cases, at other intervals, are based on samples obtained by Holt Drilling. Depths of changes in soil types represent our interpretation of the driller's log. At other depths soil descriptions were interpreted by our on-site field person from bail samples.
2. Water Level ▽ is for date indicated and may vary with time of year.
3. B.T. indicates Bail Test.
4. GS indicates a laboratory mechanical grain size analysis was performed on sample.

J-2111 August 1988
HART-CROWSER & associates, inc.
Sheet 3 of 3 Figure A-2

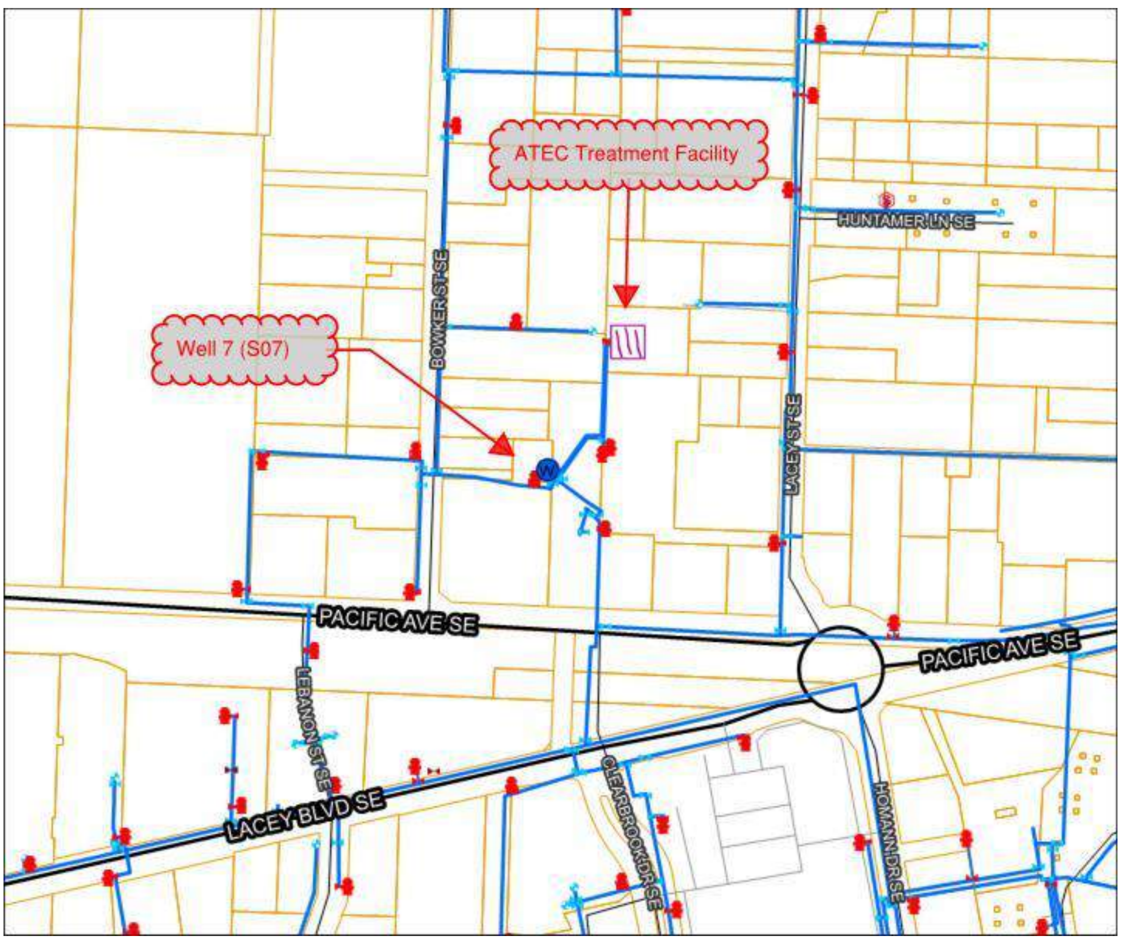
Well S07

(Fire Station)

Facility Information

Description	Comments
Source #	S07
Address	5606 Pacific Ave. SE
Year On-Line	1976
Pressure Zone	337
Floor Elevation	182.26
Housing	CMU
Pump Type	Turbine
Pump Model	Integrity 11IDHH (9.34" 7-stage)
Pump Shaft Diameter (in)	1.54
Column Diameter/Length	8" column, 245'
Pump Serial #	IPM20193A
Pump Depth (ft)	245
Pump Capacity (gpm)	1500 GPM @ 392 FT TDH
Motor Model	US Electric
Motor Serial #	C-2694-03-931
Motor Speed (rpm)	1775
Horsepower	200
Casing Diameter (in)	12
Well Depth (ft)	479
Casing Depth (ft)	430
Screen	8-inch: 80-slot (428-477 ft) with sand pack
Screen Capacity (gpm)	1950
Aquifer	TQu
Control Valves	6" 61G-21B 12" 692G-07ABCDS
PSV Setting	120 psi @ 1600 gpm
PRV Setting (psi)	85
Flow to Waste Setting	130psi
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	2150
Chlorine Dose (mg/L)	N/A
Reliable Capacity (gpm)	1800
Notes	Flows directly to ATEC treatment facility (iron/manganese). Sand production and water chemistry unknown at rates above 1800 gpm.

Well S07 (Fire Station)



File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G2-24351
Permit No.

(1) OWNER: Name City of Lacey Address

(2) LOCATION OF WELL: County Thurston NW ¼ NE ¼ Sec. 21 T. 18 N., R. 1 W.M.
Bearing and distance from section or subdivision corner 1500' WEST AND 700' SOUTH FROM NE COR. SEC. 21

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) Lots
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.
Drilled 488 ft. Depth of completed well 479 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 12" Diam. from 0 ft. to 430' ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No.
Diam. 8 Slot size 80 from 430 4/6 to 481 5/6
Diam. Slot size from ft. to ft.

Gravel packed: Yes ☒ No ☐ Size of gravel: Traction Sand
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 50' ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name Jacuzzi
Type: Turbine H.P. 200

(8) WATER LEVELS: Land-surface elevation above mean sea level.... ft.
Static level 52.5 ' 6" ft. below top of well Date 8-14-76
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Kincy
Yield: gal./min. with ft. drawdown after hrs.
1500 " To' 134'5" " 4 "
" " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	None				

Date of test
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Kincy Well Files City Lacey		
# 410	0	300
Brown Fine Silty Sand	300	325
Gray Fine To Medium Silty Sand	325	355
Gray Fine Silts	355	365
Gray Medium Sand	365	367
Gray Medium Dirty Sand	367	374
Gray Med. Fine Silty Sand Wood	374	380
Gray Med. Fine Sand Small Gravel	380	382
Gray Medium Sand	382	398
Gray Fine Med Sand Small Gravel	398	405
Gray Fine Med Silty Sand Wood	405	419
Gray Fine Med Sand Small Gravel	419	423
Gray Small Med. Gravel and Sand	423	437
Gray Corse Med Sand Some Gravel	437	461
Gray Med Small Gravel Large Sand	461	465
Gray Med Sand Gravel	465	467
Gray Fine Med Sand	467	469
Gray Medium Sand and Gravel	469	473
Gray Med Gravel Sand Very Good	473	476
Gray Fine Med Sand Gravel	476	481
Gray Fine Med Sand Little Gravel	481	483
Gray Fine Med Silty Sand	483	488

RECEIVED
OCT 28 1976
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 19 . Completed 19 .

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Kincy Hardware (Person, firm, or corporation) (Type or print)

Address 512 East 4th Ave Oly

[Signed] Reid Kincy (Well Driller)

License No. C-65 Date 8-14- , 1976

OK 1/10/77

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20

Started 2-3-76 #680

Kincy Hardware and Well Drilling Co.

CONSTRUCTION RECORD

Date 8-14-76

Well #7

Total Depth ~~4??~~ 479'

1. WELL OWNER
Name City Kacey
Address

2. LOCATION
Well in Back of fire Dept. T18N R1W NE Corner of Sec 21 Green with Strip Flag

3. TYPE OF WORK
New Well X Deeping ___ Bailing ___
Setting Screen ___ Developing ___

4. PROPOSED USE
Domestic ___ Industrial ___ Municipal X
Irrigation ___ Test Well ___ Other ___

5. CASING INSTALLED Total Casing 430' 4½
Above Ground 2' Below Ground 428' 4½"
Threaded ___ Welded X
12" dia. from 0 ft. to TC ft. ga. Sea 30
___ dia. from ___ ft. to ___ ft. ga. ___
___ dia. from ___ ft. to ___ ft. ga. ___
___ dia. from ___ ft. to ___ ft. ga. ___

6. PERFORATIONS
Yes ___ No X
From ___ to ___ size ___ x ___
From ___ to ___ size ___ x ___
From ___ to ___ size ___ x ___

7. SCREEN INSTALLED
Yes X No ___
Make Johnson Total Length 49' 1"
Amount Exposed 51' 1" Fittings Welded
Metal Stainless Ext. Piece 8" Pipe 31' 6⅞"
Dia. 8 Slot Size ___ from ___ to ___
Coupling Slot Size ___ from ___ to ___
Slot Size BLANK from 396 5/8 428
Slot Size 80 from 428 to 477
Slot Size BLANK from 477 to 479

8. CONSTRUCTION
Gravel Packed. Yes X No ___
Gravel Placed From ___ to ___ Size ___

9. WATER LEVELS
State Water Level 52' 6"
Flowing ___ Rate ___

10. PUMP TEST
Yes X No ___ Bail Tested ___
G.P.M. 2000 Draw Down To 134' 5"
Hours Pumped 4 Bailed ___

11. PUMPS INSTALLED
Make Jacuzzi
Type Turbine
Setting ___ GPM 2000
HP 200 Phase 3 Pipe Size ~~12~~" 10"

12. CHEMICAL ANALYSIS
Iron ___ ppm.
P.H. ___ ppm.
Hardness ___ gr.
Odor - Yes ___ No ___

13. DRILLERS NOTES
This was Grouted To 50' or More with Cement Grout.

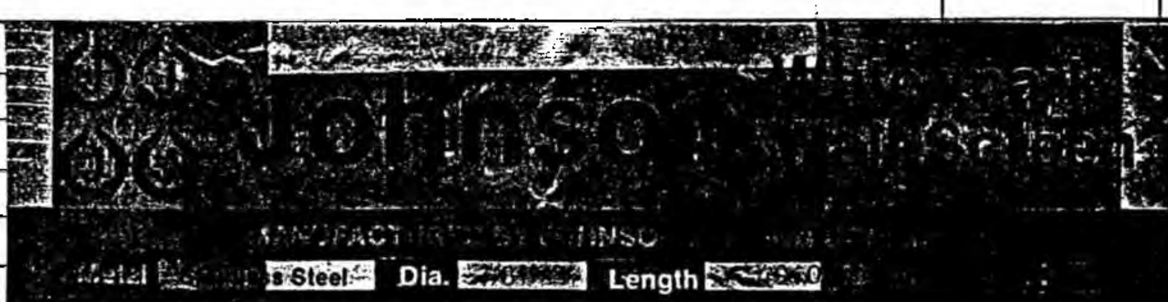
Screen capacity 49 ft x 153 in²/ft = 2324 gpm
0.31K

14. DRILLER Reid Kincy

(over)

15. FORMATIONS

Material	From	To
Formations are on Well File # 410	0	300
Brown Fine Silty Sand	300	325
Gray Fine To Medium Silty Sand	325	355
Gray Fine Silts	355	365
Gray Medium Sand	365	367
Gray Medium Dirty Sand	367	374
Gray Medium to Fine Silty Sand with wood	374	380
Gray Medium To Fine Sand with Some Small Gravel	380	382
Gray Medium Sand	382	398
Gray Fine To Medium Sand and Small Gravel	398	405
Gray Fine To Medium Silty Sand and wood	405	419
Gray Fine To Medium Sand Some Small Gravel	419	423
Gray Small To Medium Gravel and Sand	423	437
Gray Corse To Medium Sand and Some Gravel	437	461
Gray Medium To Small Gravel and Large Sand	461	465
Gray Medium Sand and Gravel	465	467
Gray Fine To Medium Sand	467	469
Gray Medium Sand and Gravel	469	473
Gray Medium Gravel and Sand very Good	473	476
Gray Fine To Medium Sand and Gravel	476	481
Gray Fine To Medium Sand Little Gravel	481	483
Gray Fine To Medium Silty Sand	483	488



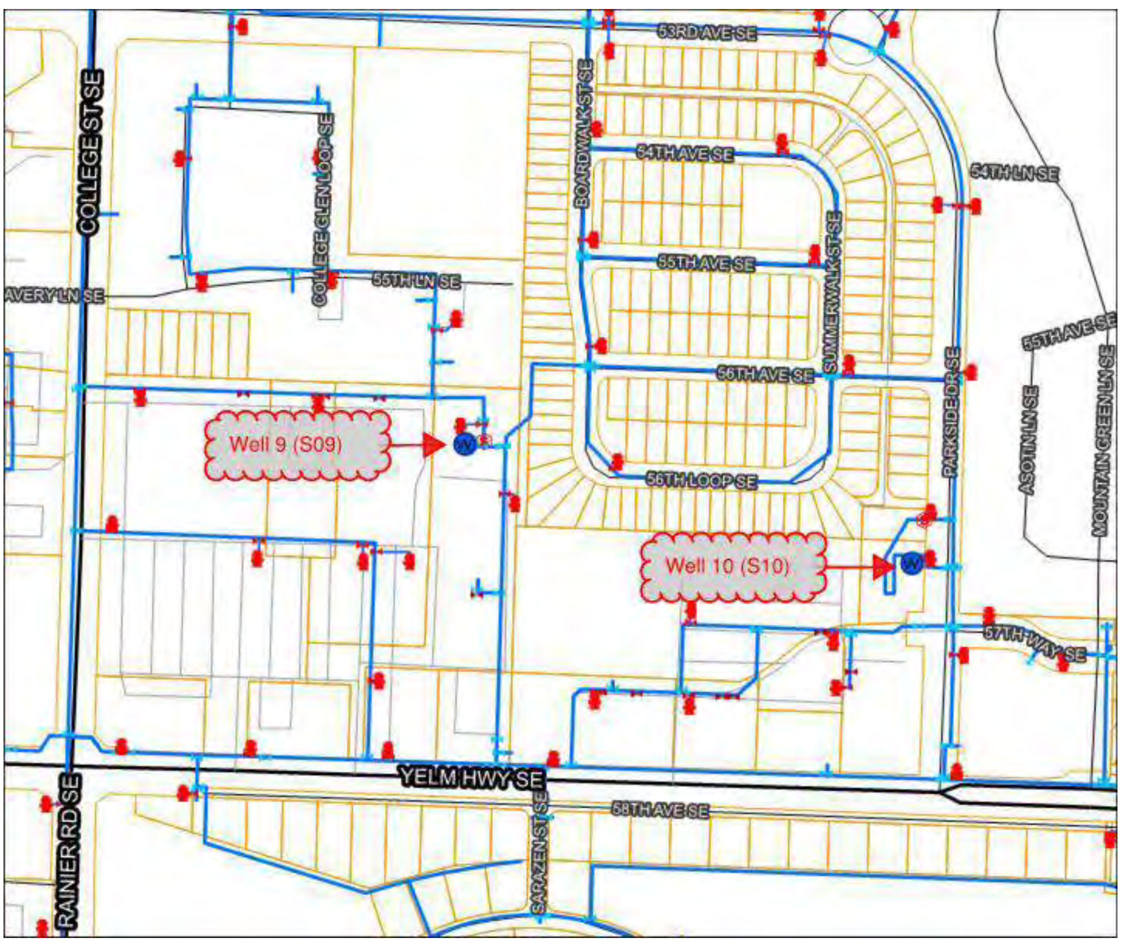
Well S09

(Little Prairie)

Facility Information

Description	Comments
Source #	S09
Address	4890 Yelm Hwy SE
Year On-Line	1981
Pressure Zone	337
Floor Elevation	192.19
Housing	CMU
Pump Type	Submersible
Pump Model	Grundfos 800 S1000-4-AA
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	6" column, 187'
Pump Serial #	B202500B4P119121001
Pump Depth (ft)	193
Pump Capacity (gpm)	800 GPM @ 310 FT TDH
Motor Model	Grundfos mms 8000 98979853 model B
Motor Serial #	P219060003
Motor Speed (rpm)	3450
Horsepower	100
Casing Diameter (in)	16
Well Depth (ft)	290
Casing Depth (ft)	218
Screen	8-inch: 30-slot (223-253 ft), 60-slot (254-284 ft) filter pack (aqua #8)
Screen Capacity (gpm)	2000
Aquifer	TQu
Control Valves	6" 61G-21 8" 692G-07ABCSDKC 2-1/2" 50A-01
PSV Setting	750 gpm
PRV Setting (psi)	74
Flow to Waste Setting	90 psi
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	1400
Chlorine Dose (mg/L)	1.49
Reliable Capacity (gpm)	750
Notes	Well 9 is used sparingly due to poor water quality, elevated iron and manganese have a history of contributing to local “brown water” occurrences. Distribution mains in the vicinity of well 9 are flushed annually to remove manganese deposits from the pipes. Well 9 has been known to produce sand at rates above 900 gpm.

Well S09 (Little Prairie)



File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name City of Lacey   Address P.O. Drawer "B", Lacey, WA.

(2) LOCATION OF WELL: County Thurston   SW ¼ SW ¼ Sec. 33 T. 18 N., R. 1 W.M.

Bearing and distance from section or subdivision corner 680 ft. North and 764.5 ft. East of the S.W. corner of Section 33.

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) No. 9
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 440 ft. Depth of completed well 285 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 222 ft.
Threaded ☐ ...." Diam. from .... ft. to .... ft.
Welded ☒ ...." Diam. from .... ft. to .... ft.

Perforations: Yes ☐ No ☒
Type of perforator used ....
SIZE of perforations .... in. by .... in.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.
.... perforations from .... ft. to .... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Telescoping Stainless Steel Model No. ....
Diam. 12 Slot size 30 from 223 ft. to 253 ft.
Diam. 12 Slot size 60 from 253 ft. to 283 ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ....
Gravel placed from .... ft. to .... ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Concrete Grout
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? .... Depth of strata ....
Method of sealing strata off ....

(7) PUMP: Manufacturer's Name ....
Type: .... H.P. ....

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 200 ft.
Static level 22 ft. below top of well Date 10/19/81
Artesian pressure .... lbs. per square inch Date ....
Artesian water is controlled by .... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Hart-Crowser
Yield: 1100 gal./min. with 136 ft. drawdown after 24 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
Transmissivity	estimated to be	29,700 gpd/ft			

Date of test 8/19/81
Bailer test .... gal./min. with .... ft. drawdown after .... hrs.
Artesian flow .... g.p.m. Date ....
Temperature of water .... Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand and gravel water bearing	0	50
Dirty sand some gravel	50	65
Dirty sand-water bearing	65	83
Brown sand and gravel	83	92
Dark gray gravel	92	122
Cemented gravel and boulder	122	168
Sand and gravel- waterbearing	168	196
Boulders and sand	196	200
Sand and gravel	200	203
Blue sticky clay	203	221
Dirty sand and gravel	221	249
Gravel with some sand	249	287
Fine sand	287	310
Sticky silty clay	310	314
Blue clay with layers of peat	314	336
Dirty sand and gravel	336	341
Sand and gravel	341	358
Brown claybound gravel	358	360
Brown silty clay	360	366
Gray silty sand and gravel	366	374
Blue clay	374	429
Dirty sand - water bearing	429	440

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DEC 31 1981
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 8/6/ 1981. Completed 10/21 1981

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Story and Dodge Drilling (Person, firm, or corporation) (Type or print)

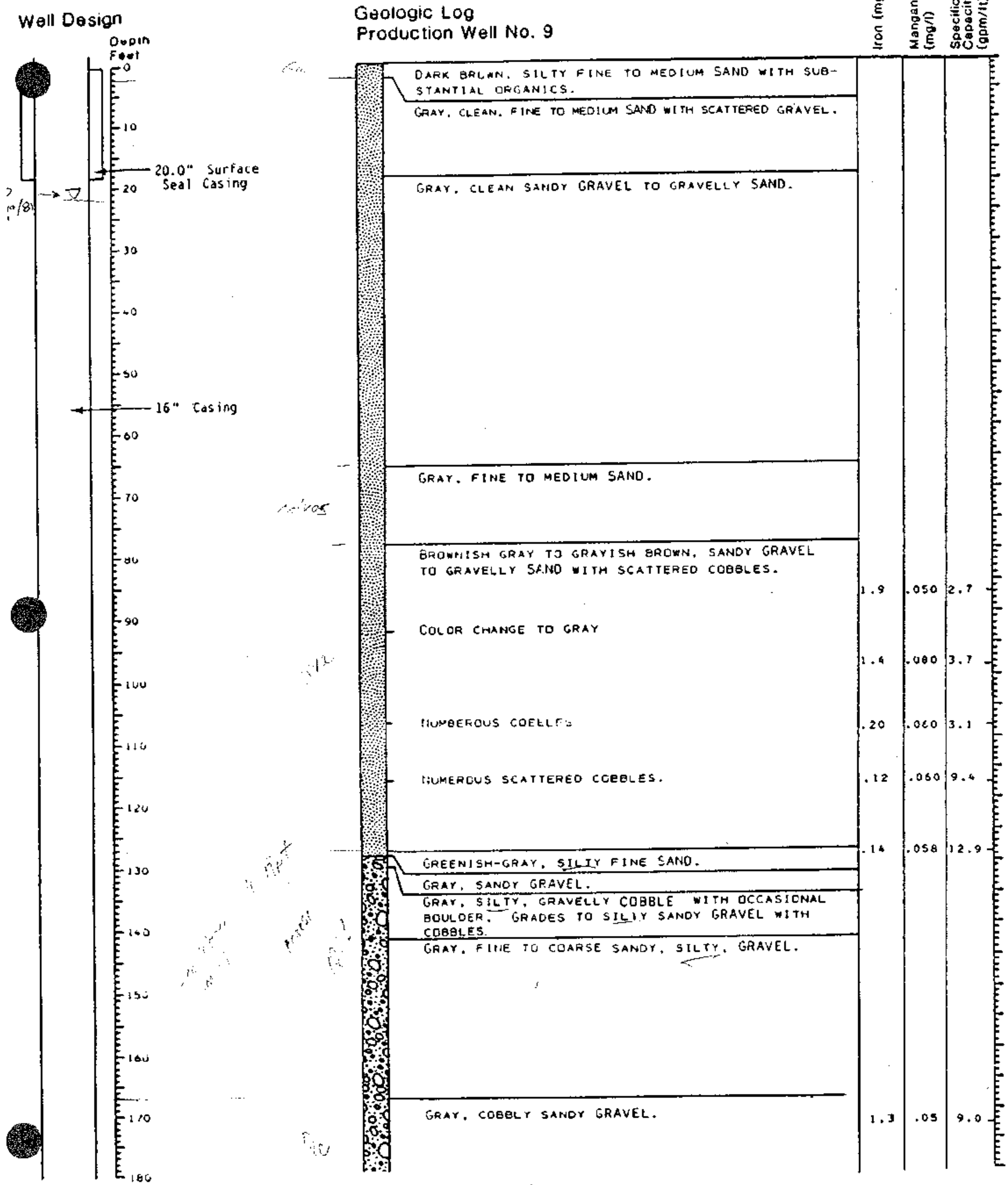
Address Graham, Washington

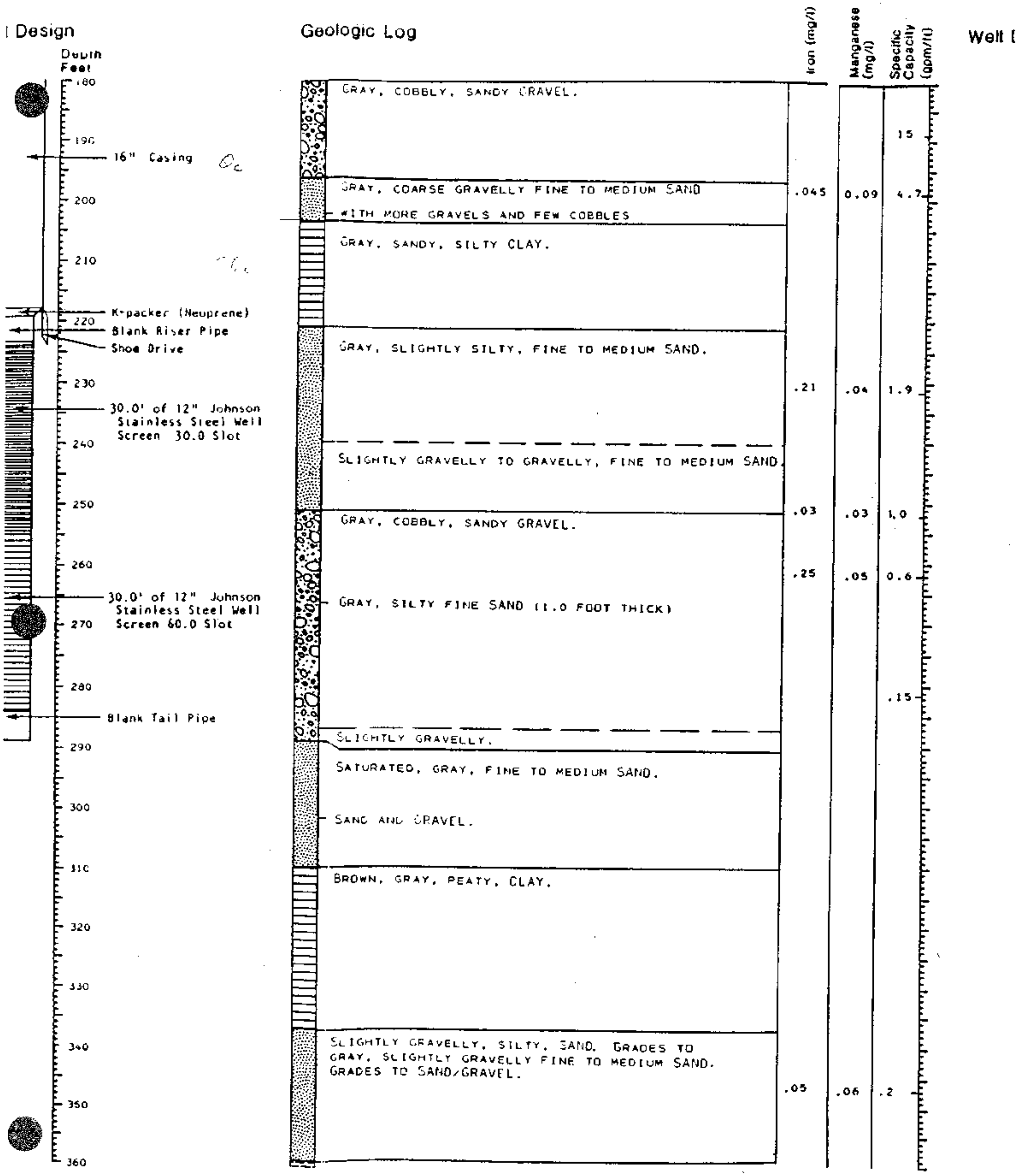
[Signed] Edgar D. Story (Well Driller)

License No. 0492 Date 12/22, 19 81

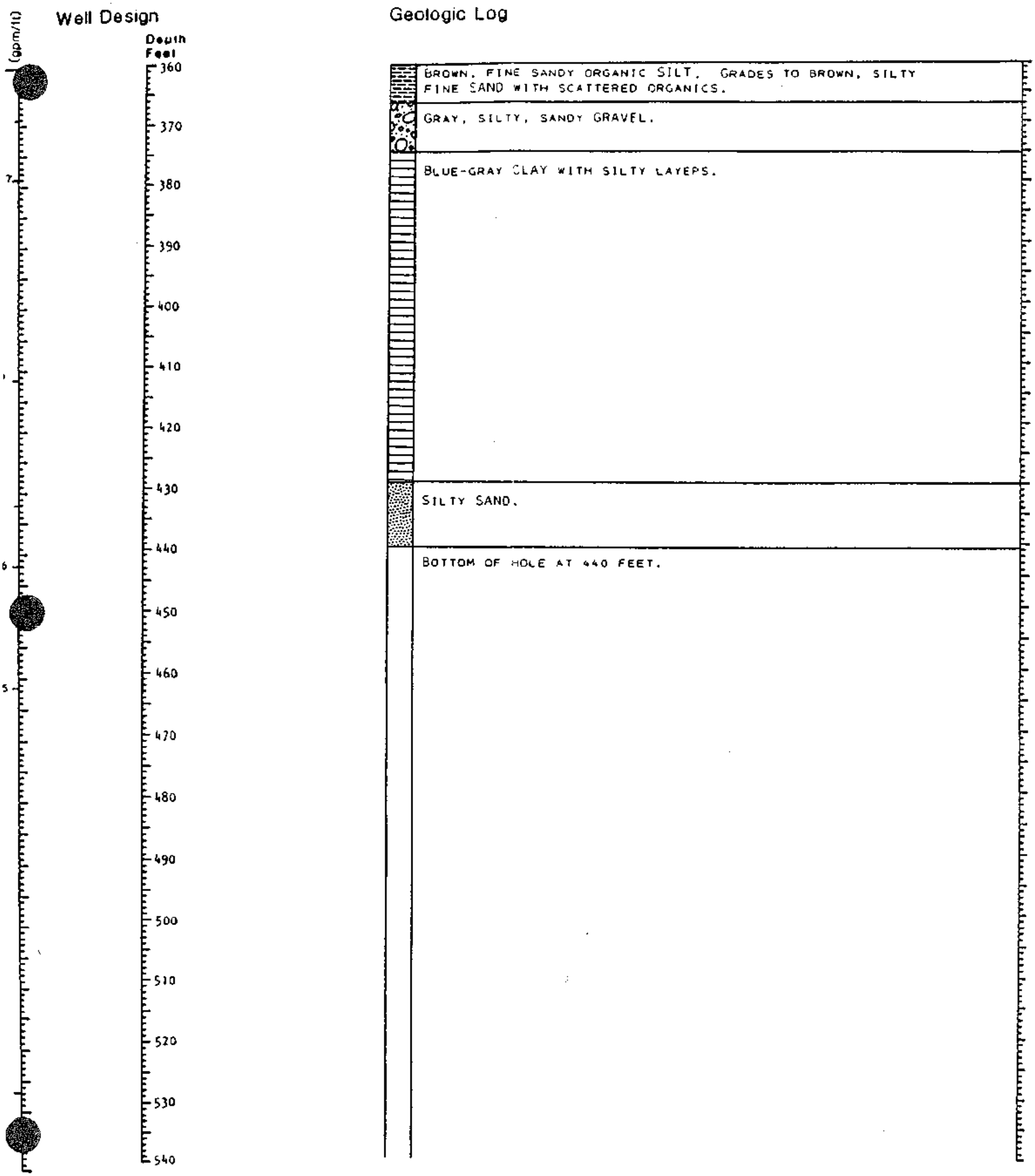
(USE ADDITIONAL SHEETS IF NECESSARY)

Well Boring and Construction Information





Design
Geologic Log
Iron (mg/l)
Manganese (mg/l)
Specific Capacity (gpm/ft)
Well I
Depth Feet
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
360
16" Casing
K-packer (Neuprene)
Blank Riser Pipe
Shoe Drive
30.0' of 12" Johnson Stainless Steel Well Screen 30.0 Slot
30.0' of 12" Johnson Stainless Steel Well Screen 60.0 Slot
Blank Tail Pipe
GRAY, COBBLY, SANDY GRAVEL.
GRAY, COARSE GRAVELLY FINE TO MEDIUM SAND WITH MORE GRAVELS AND FEW COBBLES
GRAY, SANDY, SILTY CLAY.
GRAY, SLIGHTLY SILTY, FINE TO MEDIUM SAND.
SLIGHTLY GRAVELLY TO GRAVELLY, FINE TO MEDIUM SAND.
GRAY, COBBLY, SANDY GRAVEL.
GRAY, SILTY FINE SAND (1.0 FOOT THICK)
SLIGHTLY GRAVELLY.
SATURATED, GRAY, FINE TO MEDIUM SAND.
SAND AND GRAVEL.
BROWN, GRAY, PEATY, CLAY.
SLIGHTLY GRAVELLY, SILTY, SAND. GRADES TO GRAY, SLIGHTLY GRAVELLY FINE TO MEDIUM SAND. GRADES TO SAND/GRAVEL.
15
.045
0.09
4.7
.21
.04
1.9
.03
.03
1.0
.25
.05
0.6
.15
.05
.06
.2



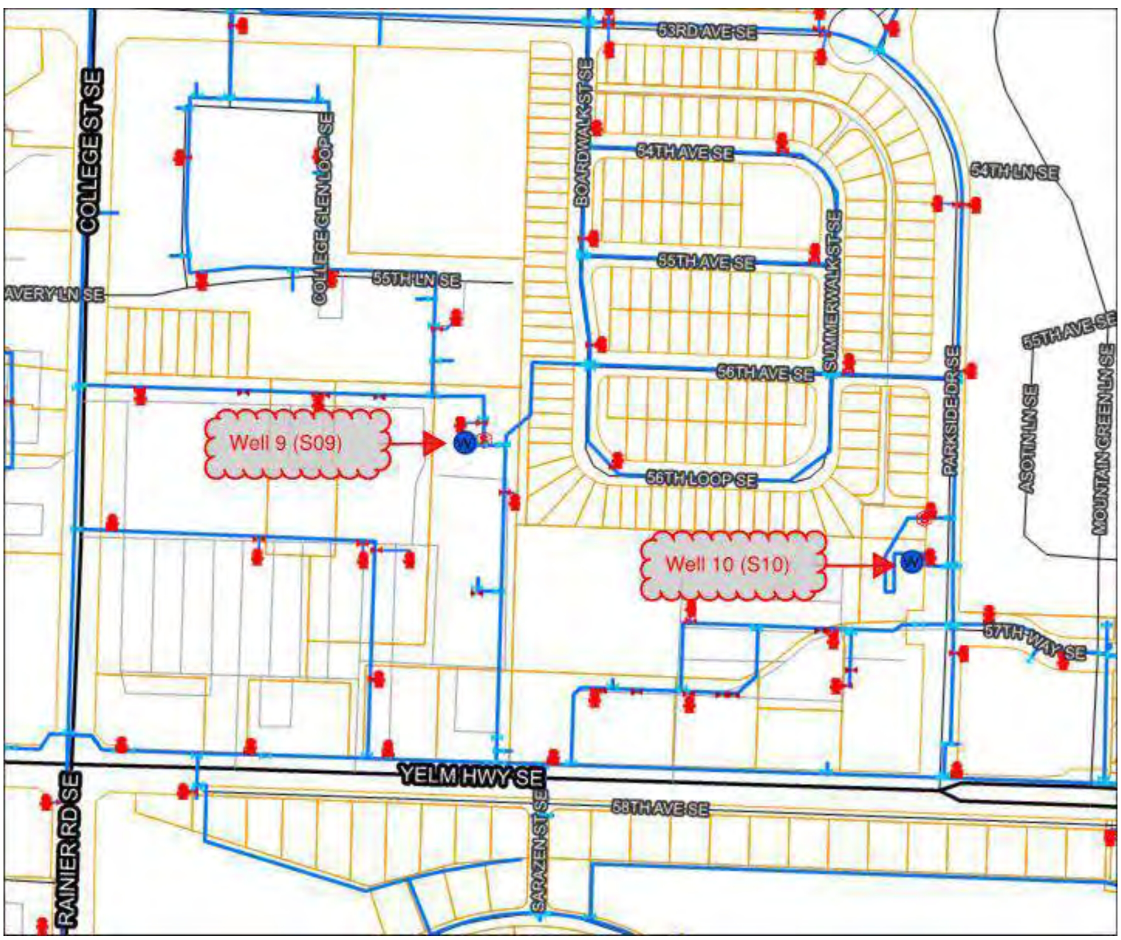
J-859-04 November 1981
HART-CROWSER & associates inc.
Figure 3

Well S10
(Mountain Greens)

Facility Information

Description	Comments
Source #	S10
Address	5138 Yelm Hwy SE
Year On-Line	1981
Pressure Zone	337
Floor Elevation	194.94
Housing	CMU
Pump Type	Turbine
Pump Model	Goulds 12CHC (8.31" 5-stage)
Pump Shaft Diameter (in)	1.6875
Column Diameter/Length	10" column, 115'
Pump Serial #	R1001346M
Pump Depth (ft)	122
Pump Capacity (gpm)	1200 GPM @ 335 FT TDH
Motor Model	US Electric 445TP WPI
Motor Serial #	R-6349-07-353
Motor Speed (rpm)	1770
Horsepower	200
Casing Diameter (in)	16
Well Depth (ft)	212
Casing Depth (ft)	170
Screen	16-inch: 80-slot (178-208 ft)
Screen Capacity (gpm)	2050
Aquifer	Qpg
Control Valves	6" 61G-21B 10" 692G-07ABCDS 3" 50A-01
PSV Setting	1200 gpm
PRV Setting (psi)	74
Flow to Waste Setting	106psi @ 900gpm
Flow to Waste Duration (sec)	180
Well Capacity (gpm)	1600
Chlorine Dose (mg/L)	0.68
Reliable Capacity (gpm)	1200
Notes	Well 10 is typically high in the call order due to its location and good water quality.

Well S10 (Mountain Greens)



The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ________
Permit No. G2-25778

(1) OWNER: Name City of Lacey Address P.O. Drawer "B" Lacey, WA

(2) LOCATION OF WELL: County Thurston SE ¼ SW ¼ Sec 33 T 18 N., R. 1 W.M.
Bearing and distance from section or subdivision corner 480'N & 1700'E of SW Corner of Sec 33

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) No. 10
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 216 ft. Depth of completed well ______ ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 16 " Diam. from 0 ft. to 178 ft.
Threaded ☐ ______ " Diam. from ______ ft. to ______ ft.
Welded ☒ ______ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Telescoping Stainless Steel Model No. ______
Diam. 16 Slot size 80 from 178 ft. to 208 ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal concrete grout
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level.... 195 ft.
Static level 17 ft. below top of well Date 7/23/81
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Hart-Crowser
Yield: 1400 gal./min. with 48 ft. drawdown after 6.6 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
Transmissivity	estimated to be	48,600 gpd/ft.			

Date of test 7/23/81
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Sand	6	10
Dirty Sand & Gravel	10	53
Blue Clay	53	72
Sand and Gravel with Cobbles	72	77
Silty Gravelly Sand	77	84
Sandy Gravel	89	91
Sandy Gravel with Silty Layers	91	124
Silty Sand and Gravel	124	140
Cemented Gravel	140	169
Dirty Sand and Gravel	169	180
Brown Sand and Gravel	180	211
Blue Clay	211	216

RECEIVED
NOV - 5 1981
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 5-13, 19 81. Completed 6/16, 19 81

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Story and Dodge Drilling (Person, firm, or corporation) (Type or print)

Address Graham , Washington

[Signed] Edgar T. Story (Well Driller)

License No. 0492 Date 11/3/, 19 81

OK (HI) 12-17-81

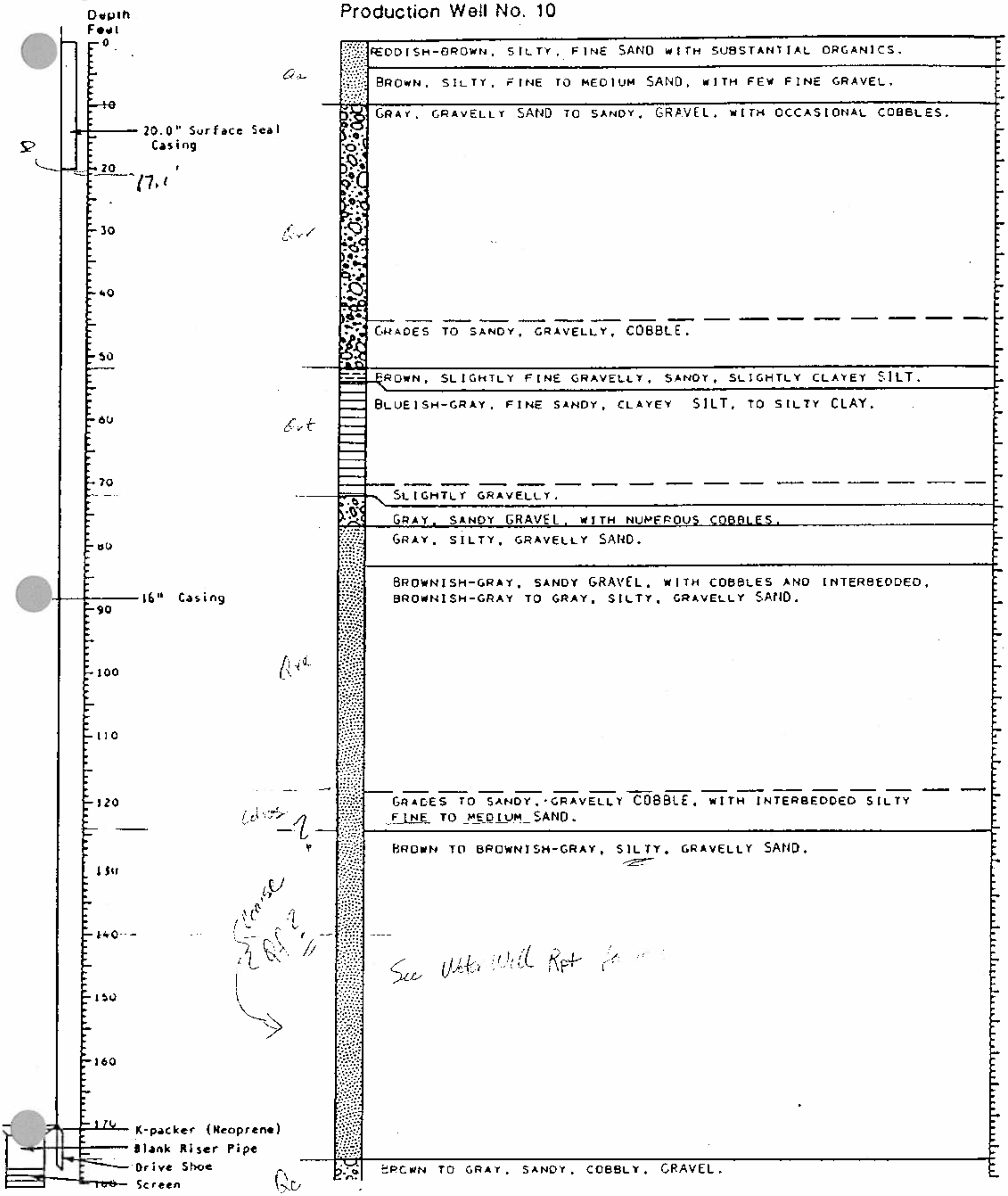
(USE ADDITIONAL SHEETS IF NECESSARY)

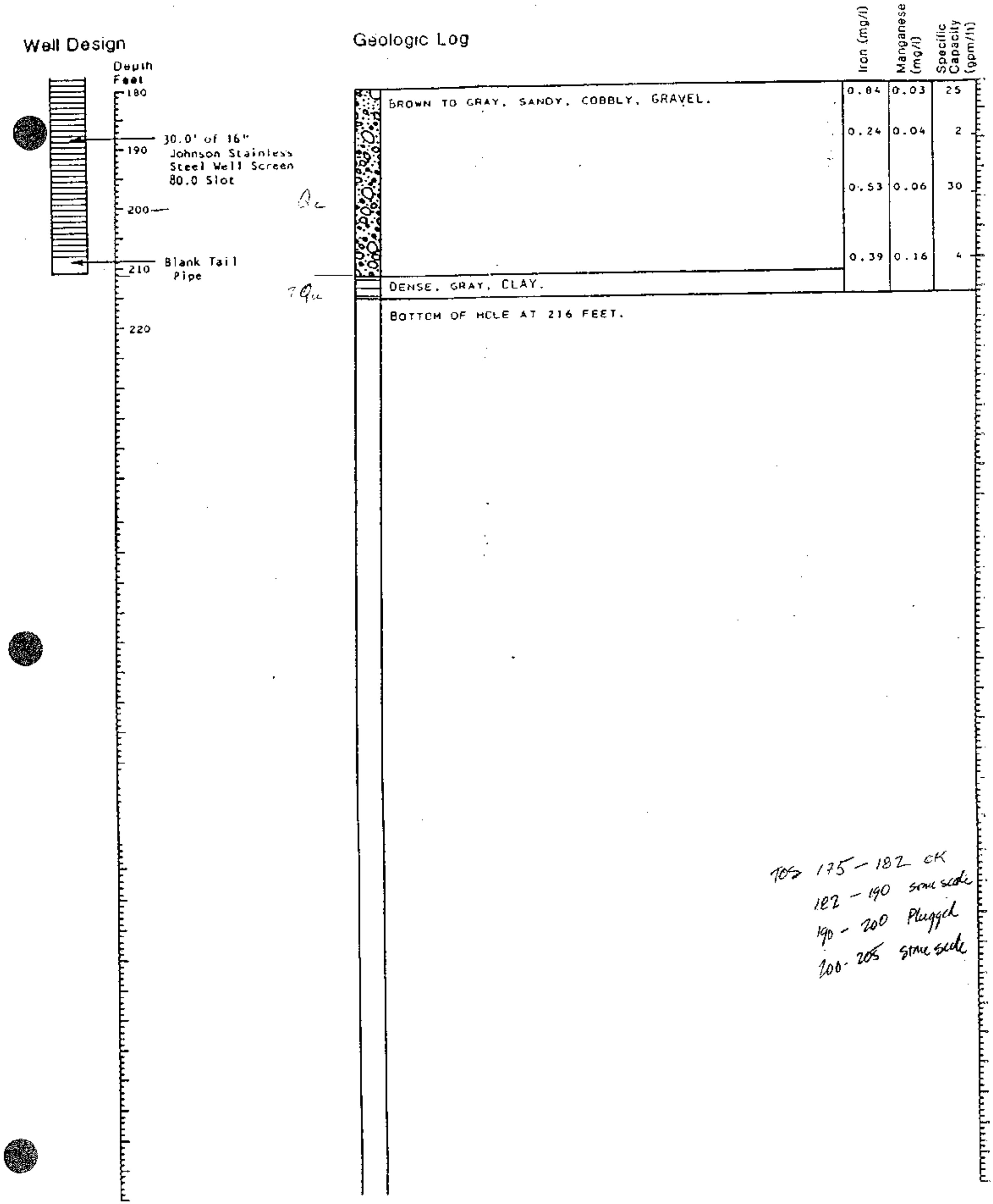
ECY 050-1-20

Vell Boring and Construction Information

ell Design

Geologic Log
Production Well No. 10





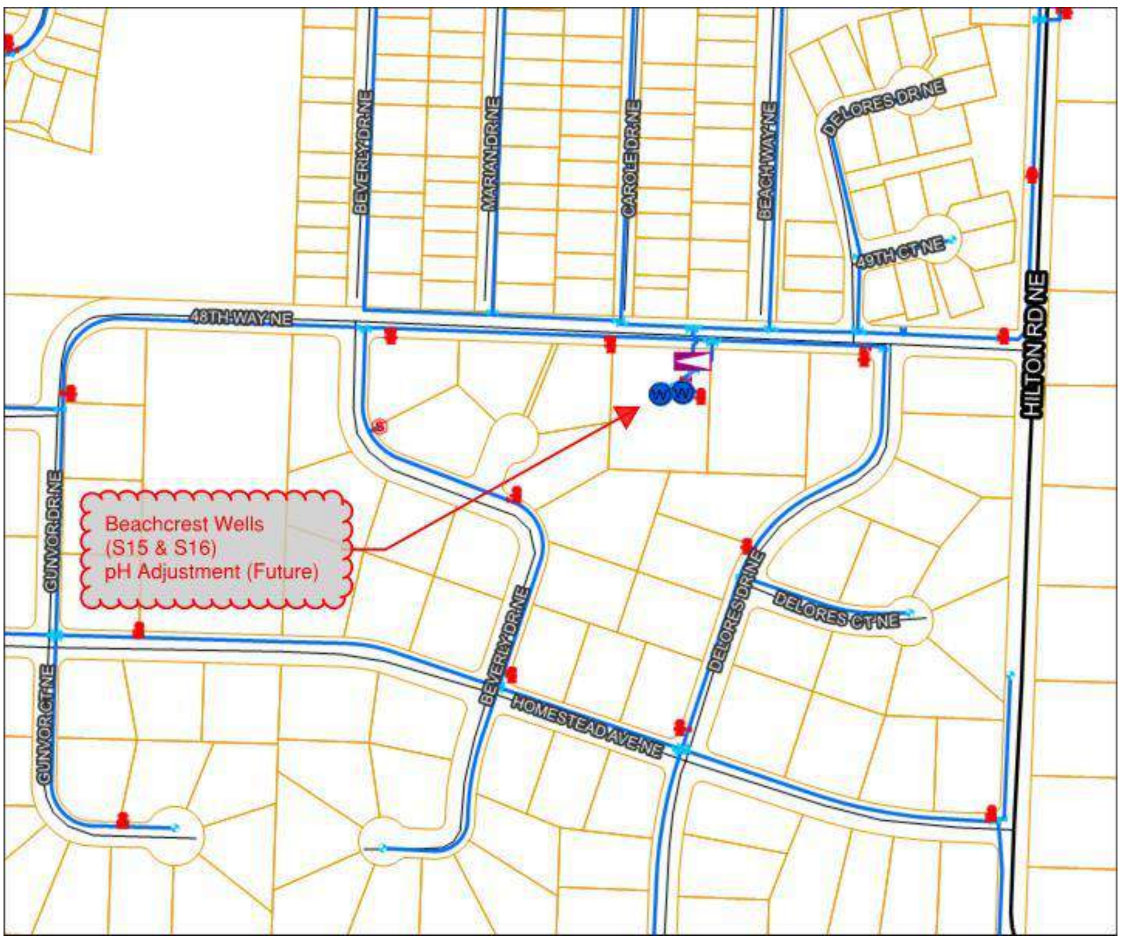
J-859-04 November 1981
HART-CROWSER & associates inc.
Figure 2

Well S15
(Beachcrest #1)

Facility Information

Description	Comments
Source #	S15
Address	8905 48th Way NE
Year On-Line	1976
Pressure Zone	400
Floor Elevation	230.21
Housing	Wood
Pump Type	Submersible
Pump Model	Peerless 6LB - 5 stage
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	4" column, 120'
Pump Serial #	4605262
Pump Depth (ft)	117
Pump Capacity (gpm)	180
Motor Model	Franklin Electric
Motor Serial #	2366158120
Motor Speed (rpm)	3450
Horsepower	25
Casing Diameter (in)	12
Well Depth (ft)	140
Casing Depth (ft)	115
Screen	12-inch: 25-slot (115-140 ft)
Screen Capacity (gpm)	N/A
Aquifer	Qva
Control Valves	3" 61G-02
PSV Setting	88psi @ 185gpm
PRV Setting (psi)	None
Flow to Waste Setting	None
Flow to Waste Duration (sec)	0
Well Capacity (gpm)	220
Chlorine Dose (mg/L)	0.68 (S15 and S16 combined)
Reliable Capacity (gpm)	180
Notes	Seasonal low aquifer levels.

Well S15 (Beachcrest #1)



: Original and First Copy with
Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ______
Permit No. ______

(1) OWNER: Name Hilton Sjoberg Address 336 PO Box

(2) LOCATION OF WELL: County ______ ¼ ______ ¼ Sec. 25 T. 19 N., R. 1 W.M.
Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) #1
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 12 inches.
Drilled 140 ft. Depth of completed well 140' 10" ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 12" Diam. from 0 ft. to 115'6" ft.
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.
Welded ☒ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Model No. ______
Diam. 12 Slot size 25 from 115'6" ft. to 140'10" ft.
Diam. ______ Slot size ______ from ______ ft. to ______ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: ______
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 18 ft.
Material used in seal Cement Grout
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 77 ft. below top of well Date 6-28-76
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? King
Yield: gal./min. with ft. drawdown after hrs.
250 112 4

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	None				

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG: Beachcrest #1 ?

Formation: *Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.*

MATERIAL	FROM	TO
Brown Clay Sand Gravel	0	6
Brown Hard Pan	6	48
Brown Sand Clay and Gravel	48	63
Brown Hard Pan	63	83
Brown Med Sand to 2" Gravel	83	94
Brown Fine Sand to 2" Gravel	94	97
Brown Med Sand to 2" Gravel	97	100
Brown Gravel and Sand	100	104
Red Med Sand to 2" Gravel	104	126
Brown Med Sand and Gravel	126	139
Brown Hard Clay	139	

Work started ______, 19___. Completed ______, 19___.

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME King Hardware (Person, firm, or corporation) (Type or print)

Address 512 East 4th Ave

[Signed] Ken Wilton (Well Driller)

License No. C-65 Date 6-28, 1976

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (Rev. 4-71)

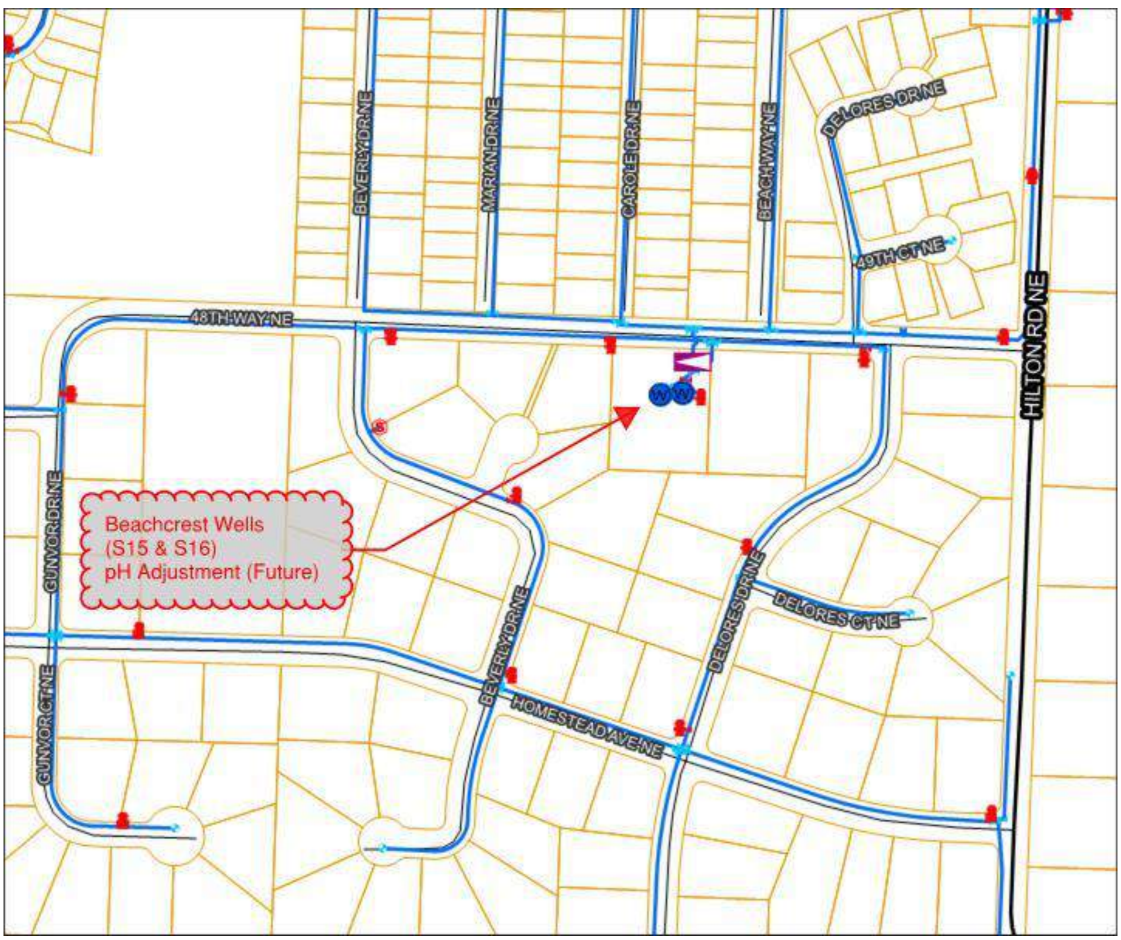
Well S16

(Beachcrest #2)

Facility Information

Description	Comments
Source #	S16
Address	8905 48th Way NE
Year On-Line	1979
Pressure Zone	400
Floor Elevation	232.82
Housing	Wood
Pump Type	Submersible
Pump Model	Peerless 6HXB - 6 stage
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	6" column, 109'
Pump Serial #	N/A
Pump Depth (ft)	112
Pump Capacity (gpm)	230
Motor Model	N/A
Motor Serial #	N/A
Motor Speed (rpm)	3450
Horsepower	30
Casing Diameter (in)	10
Well Depth (ft)	138
Casing Depth (ft)	113
Screen	10-inch: 40-slot (113-118, 133-138 ft), 50-slot (118-123 ft), 60-slot (123-133 ft)
Screen Capacity (gpm)	N/A
Aquifer	Qva
Control Valves	4" 65001BDS
PSV Setting	94psi @ 180gpm
PRV Setting (psi)	None
Flow to Waste Setting	None
Flow to Waste Duration (sec)	0
Well Capacity (gpm)	225
Chlorine Dose (mg/L)	0.68 (S15 and S16 combined)
Reliable Capacity (gpm)	180
Notes	Seasonal low aquifer levels.

Well S16 (Beachcrest #2)



File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Application No. G2-24547
Permit No. G2-24547-P

(1) **OWNER:** Name M. & R Cons. & Utilities Address P.O. Box 3772 Lacey, Wa. 98503

(2) **LOCATION OF WELL:** County Thurston SE ¼ SW ¼ Sec. 25 T. 19 N., R. 1W W.M.

Bearing and distance from section or subdivision corner 650' W + 1120' N. from the S¼ corner of Sec. 25

(3) **PROPOSED USE:** Domestic ☒ Industrial ☐ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐
Community

(4) **TYPE OF WORK:** Owner's number of well (if more than one) 2
New well ☒ Method: Dug ☐ Bored ☐
Deepened ☐ Cable ☒ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 10 inches.
Drilled 141 ft. Depth of completed well 138 ft.

(6) **CONSTRUCTION DETAILS:**

Casing installed: 10" Diam. from 0 ft. to 113 ft.
Threaded ☐ " Diam. from ft. to ft.
Welded ☒ " Diam. from ft. to ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations in. by in.
perforations from ft. to ft.
perforations from ft. to ft.
perforations from ft. to ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson Well
Type Stainless steel Model No.
Diam. 10 Slot size 40 from 113 ft. to 118 ft.
Diam. 10 Slot size 50 from 118 ft. to 123 ft.
10 60 123 133
10 40 133 138

Gravel packed: Yes ☐ No ☒ Size of gravel:
Gravel placed from ft. to ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? Depth of strata
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name Jacuzzi Bros.
Type: 20-ms-8a6 H.P. 20

(8) **WATER LEVELS:** Land-surface elevation above mean sea level ft.
Static level 84 ft. below top of well Date 4-23-79
Artesian pressure lbs. per square inch Date
Artesian water is controlled by (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Driller
Yield: 275 gal./min. with 31 ft. drawdown after 4 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test 4-23-79
Bailer test gal./min. with ft. drawdown after hrs.
Artesian flow g.p.m. Date
Temperature of water Was a chemical analysis made? Yes ☒ No ☐

(10) **WELL LOG:**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
Loose sand & gravel	0	5
Loose sand & gravel	5	9
Cemented sand & gravel	9	20
Cemented sand & gravel	20	40
Cemented sand & gravel	40	56
Dirty sand & gravel alittle seepage	56	61
Cemented sand & gravel	61	65
Hardpan	65	71
Cemented sand & gravel	71	73
Haddpan	73	80
Hardpan	80	96
Dirty sand & gravel some seepage	96	100
Dirty wet sand & gravel	100	107
Sand & gravel	107	124
Sand & gravel	124	141
Dark brown clay	141	

RECEIVED
AUG 23 1979
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 3-30, 19 79. Completed 4-23, 1979

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Richardson Well Drilling Co. (Person, firm, or corporation) (Type or print)

Address P.O. Box 44408 Tacoma, Wa. 98444

[Signed] (Well Driller)

License No. 223-02-6500 Date 8-21, 19 79

(USE ADDITIONAL SHEETS IF NECESSARY)

Well S19

(Hawks Prairie #1)

Facility Information

Description	Comments
Source #	S19
Address	4040 Marvin Rd. NE
Year On-Line	1994
Pressure Zone	400
Floor Elevation	299.50
Housing	CMU
Pump Type	Submersible
Pump Model	Integrity 7IMH (5.455" 7-stage)
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	8" column, 528'
Pump Serial #	N/A
Pump Depth (ft)	528
Pump Capacity (gpm)	500 GPM @ 590 FT TDH
Motor Model	N/A
Motor Serial #	N/A
Motor Speed (rpm)	3600
Horsepower	125
Casing Diameter (in)	12
Well Depth (ft)	646
Casing Depth (ft)	580
Screen	12-inch: 10-slot (585-592 ft), 12-slot (603-608 ft), 70-slot (623-632 ft), 30-slot (632-643 ft)
Screen Capacity (gpm)	970
Aquifer	TQu
Control Valves	4" 61G-21 8" 92G-01BCDS
PSV Setting	500 gpm
PRV Setting (psi)	N/A
Flow to Waste Setting	125psi @ 300 gpm
Flow to Waste Duration (sec)	400
Well Capacity (gpm)	800
Chlorine Dose (mg/L)	N/A
Reliable Capacity (gpm)	500
Notes	Poor water quality, elevated iron, manganese, ammonia, and sulfides. Flows directly to the Hawks Prairie Water Treatment Facility. Produces sand at flow rates above 750 gpm. Specific capacity reduces at flow rates above 600 gpm.

Well S19 (Hawks Prairie #1

014203

File Original and First Copy with Department of Ecology
Second Copy—Owner's Copy
Third Copy—Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. [illegible]

Water Right Permit No. ______

(1) OWNER: Name City of Lacey Address ______

(2) LOCATION OF WELL: County Thurston NW ¼ SW ¼ Sec 35 T 19 N., R 1W W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) Hawks Prairie Well

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
Abandoned ☐ New well ☒ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☒ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 x 12 inches.
Drilled 667 feet. Depth of completed well 646 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16" Diam. from 0 ft. to 406 ft.
Welded ☒ 12" Diam. from +2 ft. to 585 ft.
Liner installed ☐
Threaded ☐ ______" Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used ______
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type 10" 10 585 Model No. 592
Diam. ______ Slot size 12 from 603 ft. to 608 ft.
Diam. ______ Slot size 70 from 623 ft. to 633 ft.
Gravel packed: Yes ☐ No ☒ Size of gravel 30 633 643
Gravel placed from ______ ft. to ______ ft.

Surface seal: Yes ☒ No ☐ To what depth? 20 ft.
Material used in seal Cement
Did any strata contain unusable water? Yes ☐ No ☒
Type of water? ______ Depth of strata ______
Method of sealing strata off ______

(7) PUMP: Manufacturer's Name ______
Type: ______ H.P. ______

(8) WATER LEVELS: Land-surface elevation above mean sea level ______ ft.
Static level 261 ft. below top of well Date ______
Artesian pressure ______ lbs. per square inch Date ______
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Driller
Yield: 860 gal./min. with 145 ft. drawdown after 24 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ______
Bailer test ______ gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with stem set at ______ ft. for ______ hrs.
Artesian flow ______ g.p.m. Date ______
Temperature of water ______ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown sandy loam	0	3
Gray + brown silty sand + gravel	3	51
Dry loose sand + gravel	51	153
Sand + gravel making some water	153	202
Gray silt some gravel + peat	202	247
Gray silt	247	300
Fine sand + gravel silt binder water	300	313
Gray silt layered sand + gravel	313	333
Sand + gravel some silt water	333	355
Silt bound sand + gravel	355	359
Brown sand silt seams	359	401
Gray green brown silt	401	455
Silty sand some gravels heaving	455	477
Tight silty sand	477	482
Blue-gray silt	482	488
Black sand some gravels	488	525
Gray green silt sand layers	525	560
Gray sand some gravels	560	575
Clean sand some gravels	575	610
Tight sand layers silt	610	619
Sand + gravels	619	646
Clay fine sand some gravels	646	651
Silt bound sand + gravel	651	667

RECEIVED FEB 9 1989 [stamp]

Work started 9-21-88 19__. Completed 12-13-88 19__.

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10621 Todd Rd E
(Signed) [signature] (WELL DRILLER) License No. 1099
Contractor's Registration No. HO-LT*13606 Date 1-30, 1989

(USE ADDITIONAL SHEETS IF NECESSARY)

ECY 050-1-20 (10/87) -1329-

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

TOP CASING -
Well Casing 294.8 (1.6)

Boring Log and Construction Data for Hawks Prairie Test/Production Well

Geologic Log

Depth in Feet

Ground Surface Elevation in Feet 294.8

Sample

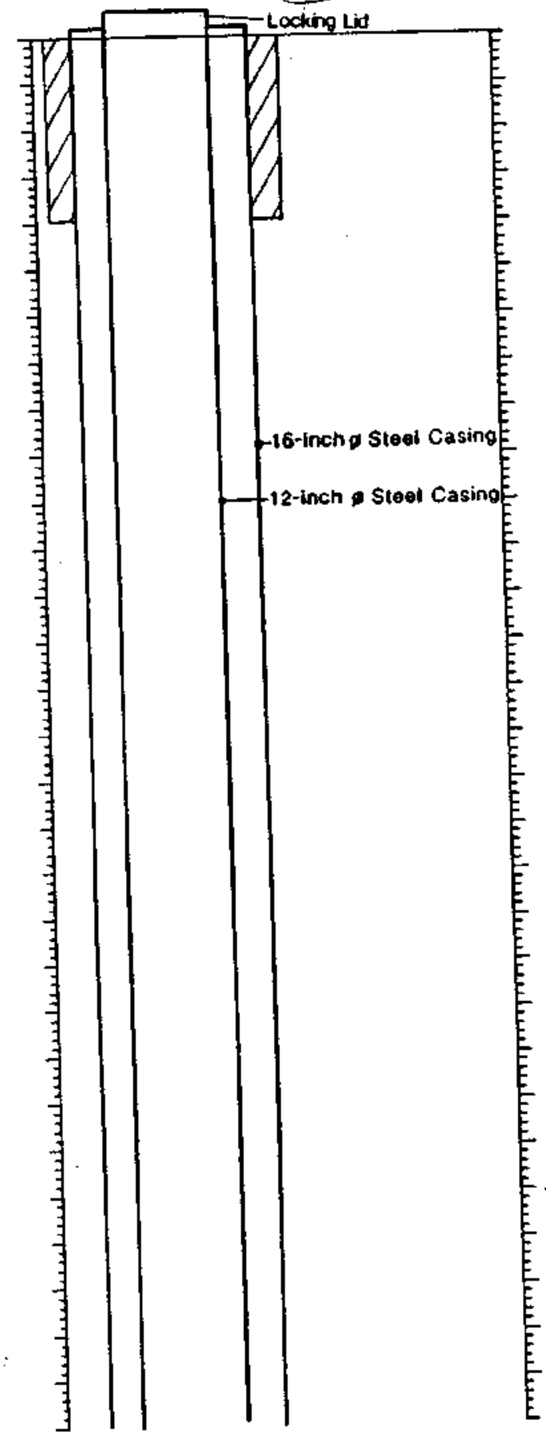
Depth in Feet	Description
0	Organic-rich, very sandy SILT.
	Brown, slightly gravelly, sandy SILT.
35	Gray-brown, gravelly SAND with cobbles and thin silt interbeds.

Depth scale: 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150

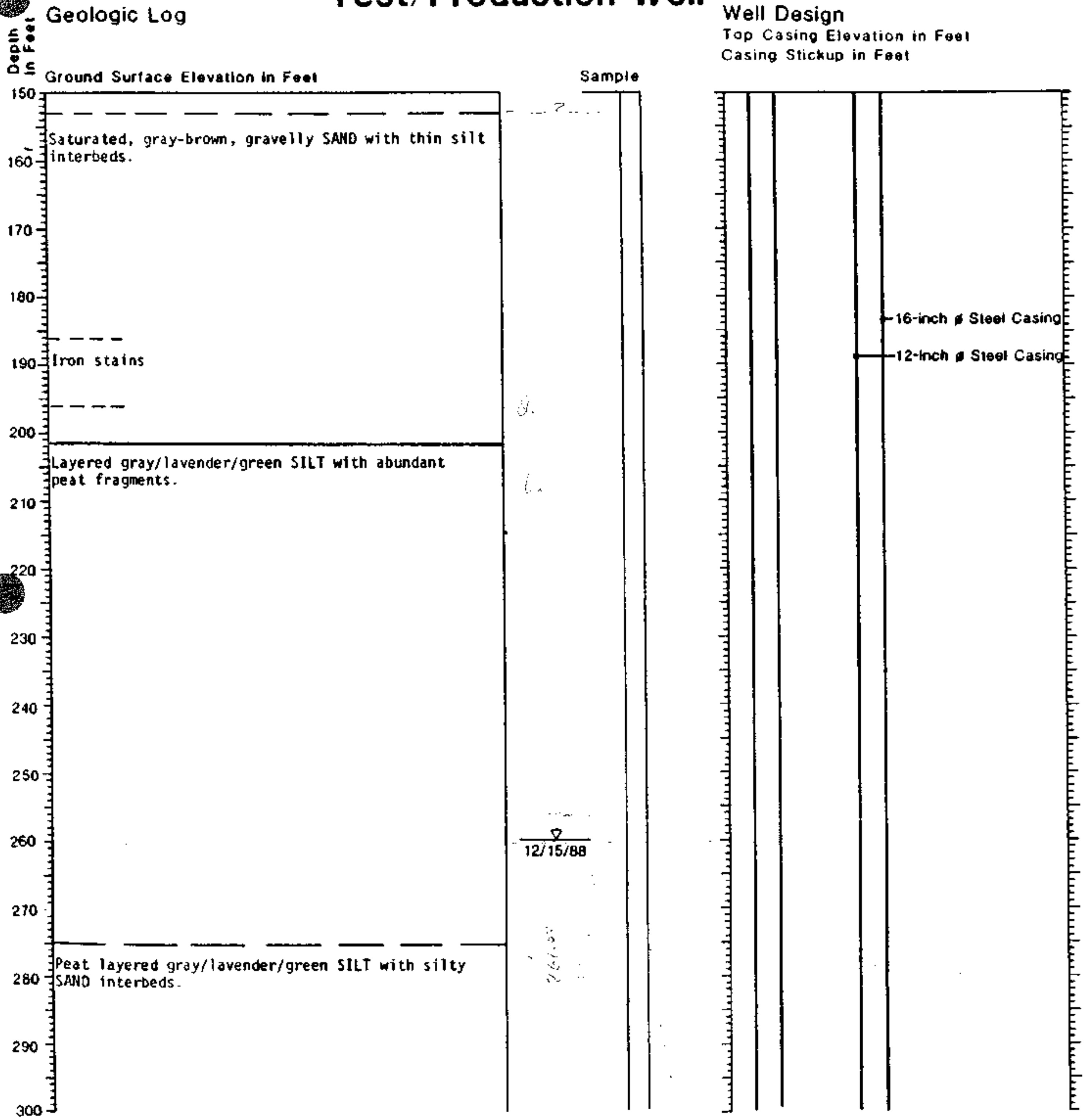
Well Design

Top Casing Elevation in Feet ~~328 ft~~ 296.4

Casing Stickup in Feet 1.7 ft



Boring Log and Construction Data for Hawks Prairie Test/Production Well

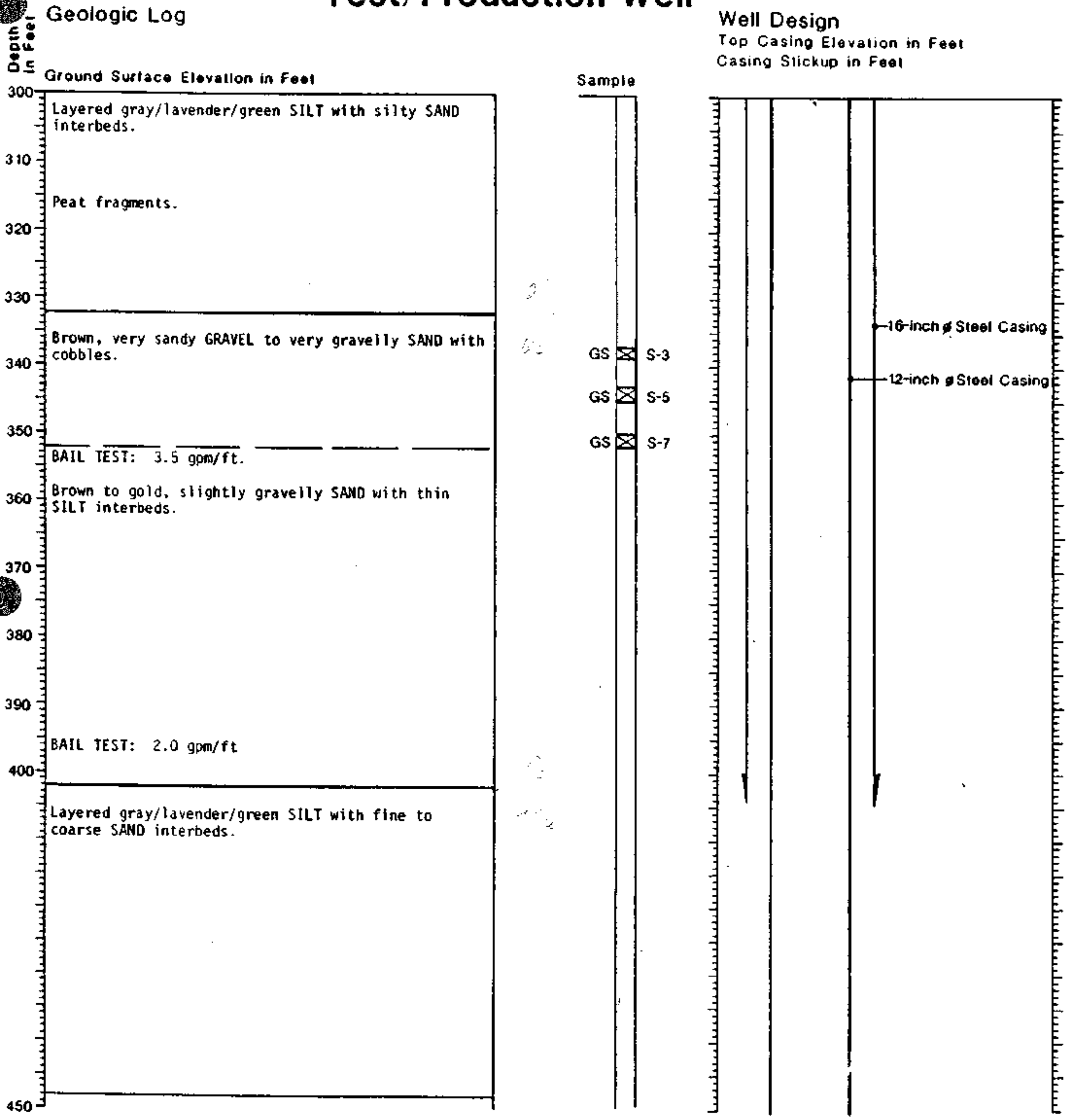


J-2111 October 1988

HART-CROWSER & associates inc.

Sheet 2 of 5 Figure A-2

Boring Log and Construction Data for Hawks Prairie Test/Production Well

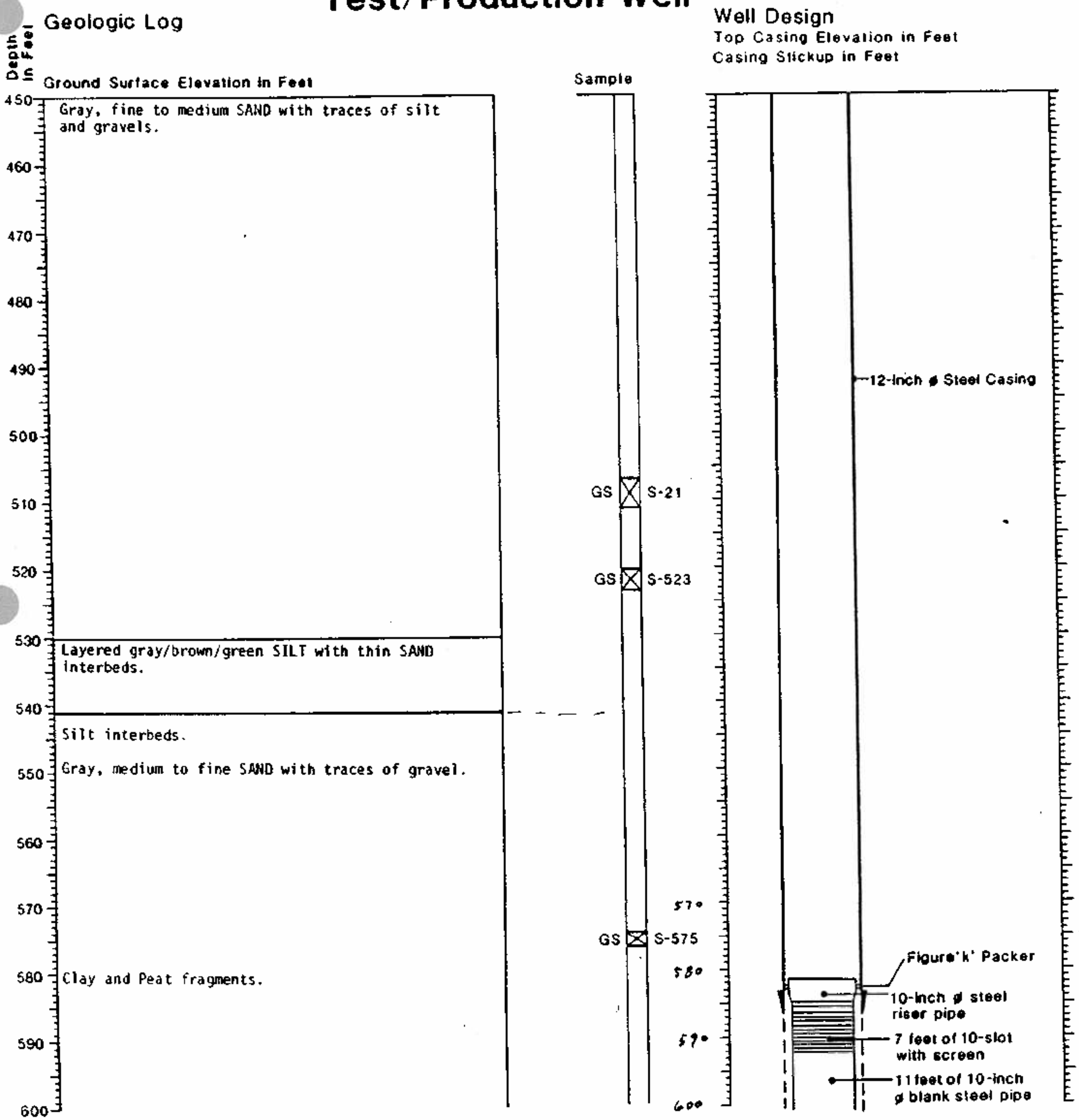


J-2111 October 1988

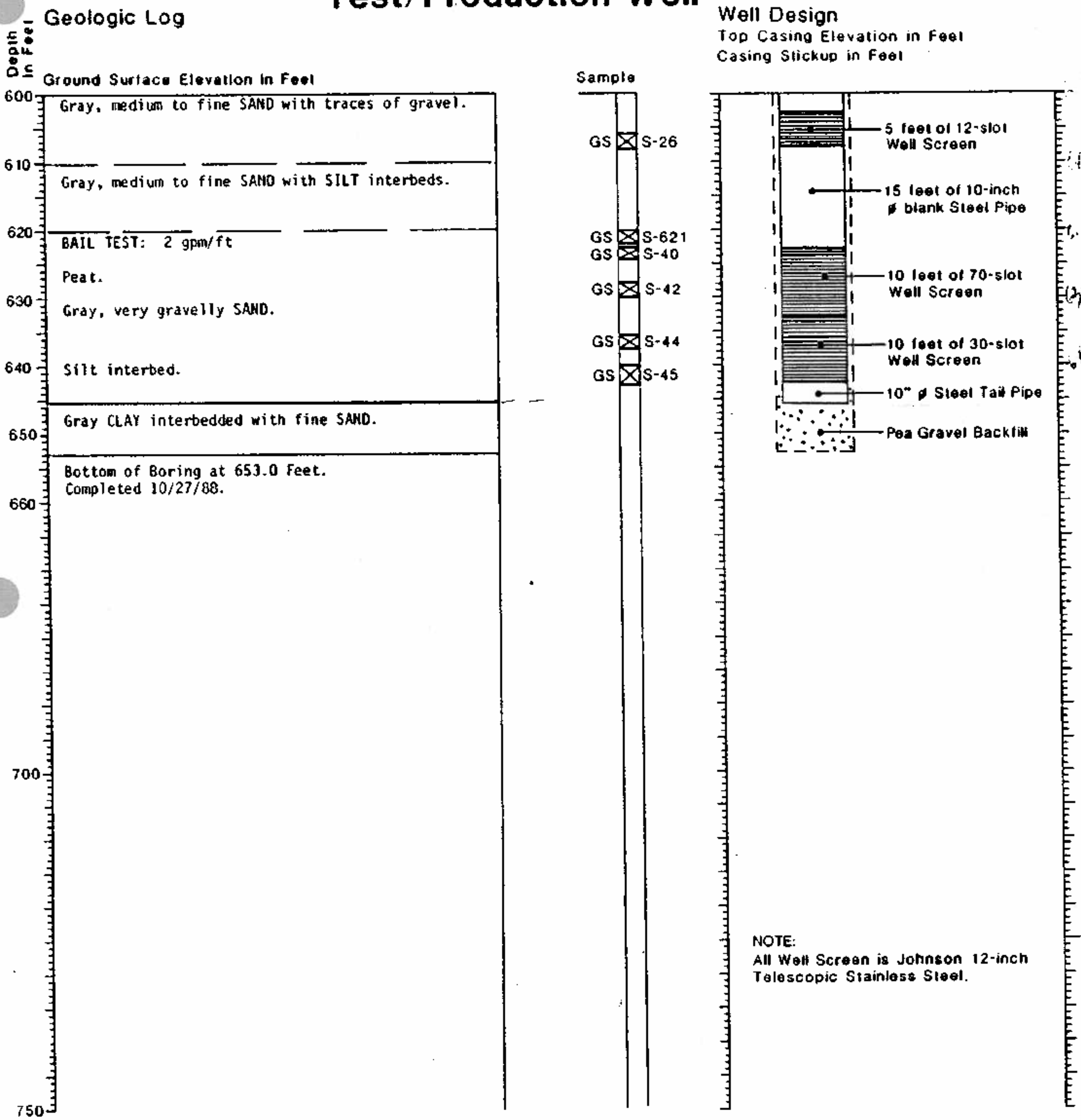
HART-CROWSER & associates inc.

Sheet 3 of 5 Figure A-2

Boring Log and Construction Data for Hawks Prairie Test/Production Well



Boring Log and Construction Data for Hawks Prairie Test/Production Well



NOTES: 1. Soil descriptions are often based on samples collected by the driller and our interpretation of the driller's log. Changes in material type are interpretive and actual changes may be gradual.
2. Water Level ∇ is for date indicated and may vary with time of year.
3. B.T. Indicates Bail Test.
4. GS Indicates a laboratory mechanical grain size analysis was performed on sample.

J-2111 October 1988
HART-CROWSER & associates inc.
Sheet 5 of 5 Figure A-2

Well S20
(McAllister Park)

Facility Information

Description	Comments
Source #	S20
Address	8500 19th Ave. SE
Year On-Line	1995
Pressure Zone	400
Floor Elevation	175.98
Housing	CMU
Pump Type	Submersible
Pump Model	Goulds 11CLC (8.125” 8-stage)
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	8" column, 165'
Pump Serial #	N/A
Pump Depth (ft)	165
Pump Capacity (gpm)	650 GPM @ 470 FT TDH
Motor Model	Hitachi
Motor Serial #	N/A
Motor Speed (rpm)	1800
Horsepower	125
Casing Diameter (in)	16
Well Depth (ft)	214
Casing Depth (ft)	180
Screen	14-inch: 150-slot (180-185 ft), 80-slot (193-198 ft), 100-slot (198-208 ft)
Screen Capacity (gpm)	1300
Aquifer	Qpg
Control Valves	4" 61G-21 10" 692G-01BD 2-1/2" 50G-01
PSV Setting	625 gpm
PRV Setting (psi)	110
Flow to Waste Setting	180psi @ 530gpm
Flow to Waste Duration (sec)	180
Well Capacity (gpm)	650
Chlorine Dose (mg/L)	0.54
Reliable Capacity (gpm)	600
Notes	Seasonal low aquifer levels, can occasionally require a reduction in pumping rate. Casing is out of alignment/plumb, which is hard on line shaft pumps.

Well S20 (McAllister Park)

The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W 16276
UNIQUE WELL I.D. #
Water Right Permit No. G2-29165

(1) **OWNER:** Name City of Lacey   Address P.O Box "B" Lacey, WA 98503-0987

(2) **LOCATION OF WELL:** County Thurston   NE 1/4 SW 1/4 Sec 24 T. 18 N., R 1W W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) ~2,600 ft east of Marvin Rd and ~1,500 ft South of Pacific Hwy SE

(3) **PROPOSED USE:** ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☑ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (If more than one) WELL B
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☑ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled 239 feet. Depth of completed well 213.5 ft.

(6) **CONSTRUCTION DETAILS:**
Casing installed: 16" Diam. from +2 ft. to 179.5 [redacted] ft.
Welded ☐ Liner installed ☐ Threaded ☐ " Diam. from ____ ft. to ____ ft.
" Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ☑
Type of perforator used
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name
Type 14-inch pipe size stainless steel Model No.
Diam. 14 Slot size 150 from 180 ft. to 185 ft.
Diam. 14 / 14 Slot size 80 / 100 from 193 / 198 ft. to 198 / 208 ft.

Gravel packed: Yes ☐ No ☐ Size of gravel
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☑ No ☐ To what depth? 87 ft.
Material used in seal Quik Grout
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ____ Depth of strata ____
Method of sealing strata off

(7) **PUMP:** Manufacturer's Name
Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 175 ft msl (approx) ft.
Static level 135.5 ft. below top of well 2.5 Date 3/1/95
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☑ No ☐ If yes, by whom? PGG / Holt
Yield: 908 gal./min. with 27.4 ft. drawdown after 31.5 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
	Transmissivity = 93,500 gpd/ft				
	Storage coeff = 0.00026				

Date of test
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ☑ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
silt-bound SAND : GRAVEL; thin zones of water start @ 12 ft	0 [redacted]	25 [redacted]
Gray, silty SAND, some gravel	25	28
Gray SAND : GRAVEL; water bearing	28	41
Gray-green, sandy SILT - silty SAND; dry 41-54 ft, some water 54-58	41	58
Gray-green, silty SAND : GRAVEL, water	58	66
Gray-green, sandy SILT	66	71
Gray-green, silty SAND - GRAVEL, some water	71	81
Gray-brown, sandy SILT; some gravel	81	91
Gray-brown to brown, sandy SILT + GRAVEL	91	111
Dark brown, SAND - SILT; minor gravel	111	124
Brown, silty SAND : GRAVEL	124	148
Light brown, silty SAND; minor gravel; small amount of water	148	157
Brown, silty SAND : GRAVEL; tight fm., some water	157	172
Brown, silt bound SAND : GRAVEL	172	180
Brown to gray, clean, sandy GRAVEL; water	180	185
Gray, m-c SAND, some silt-bnd zones; water	185	192
Brown to gray, sandy GRAVEL; some silt-bnd zones; water	192	202
	202	207
Gray, gravelly, m-c SAND, water	207	209
Brown to gray, silty, m-c SAND; water	209	217
Brown to gray, very silty, fine SAND; water	217	233
Brown-gray, sandy SILT	233	239
(Log Prepared by Pacific Groundwater Group)		

Work Started ____, 19__. Completed 3/2, 1995

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10621 Todd Rd. E. Puyallup
(Signed) Tony Fehtal (WELL DRILLER) License No. 1094
Contractor's Registration No. HOLTTI087OJ Date 4-2, 1995

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

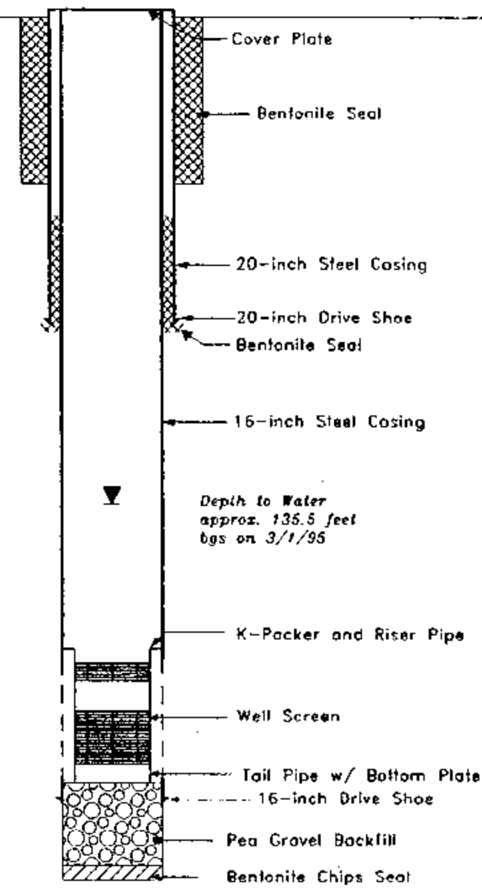
Geologic Log and Well Construction Details

McAllister Park (Well20)

Ground Surface Elevation: approx. 175 ft msl

DEPTH (ft)	GEOLOGIC LOG	Geologic Unit	Saturated Formation
0	Soil		
	Gray, silt-bound SAND and GRAVEL; thin zones of water start at 12 feet	Qvt	
25	Gray, silty SAND with some gravel		
	Gray SAND and GRAVEL; water bearing		
50	Gray-green sandy SILT and silty SAND; dry from 41 to 54 feet and some water 54 to 58 feet	Qva	
	Gray-green, silty SAND and GRAVEL; water		
	Gray-green, sandy SILT		
75	Gray-green, silty SAND and GRAVEL; some water		
	Gray-brown, sandy SILT; some GRAVEL		
100	Gray-brown to brown, sandy SILT and GRAVEL	Qk	
	Dark brown SAND and SILT; minor gravel		
125	Brown, silty SAND and GRAVEL		
150	Light brown, silty SAND; minor GRAVEL; seepage		
	Brown, silty SAND and GRAVEL; light formation; some water		
175	Brown, silt-bound SAND and GRAVEL		
	Brown to gray, clean, sandy GRAVEL; water	Qc	
	Gray, medium to coarse SAND; some silt-bound zones; water		
200	Brown to gray, sandy GRAVEL; some silt-bound zones; water		
	Brown to gray, sandy GRAVEL; water		
	Gray, gravelly, medium to coarse SAND; water		
	Brown to gray, silty, medium to coarse SAND; water		
225	Brown to gray, very silty, fine SAND; water		
	Brown-gray, sandy SILT	Qu	
	BOTTOM OF BORING		
250			
275			
300			
325			
350			
375			
400			

WELL CONSTRUCTION DETAILS



PROJECT NAME: Lacey Groundwater Devel. Program
WELL IDENTIFICATION NUMBER: WELL B
LOCATION: NE ¼ SW ¼ Sec. 24 T.18N, R.1W
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Jim Mathieu
DATUM: MSL

WATER LEVEL ELEVATION: 39.5 feet msl (approx.)
WATER LEVEL DATE: 3/1/95
START CARD NO.: W16276
UNIQUE WELL ID NO.: AAY 302
DRILLING METHOD: Cable Tool
FIRM: Holt Testing, Inc.

Well Screen As-Built

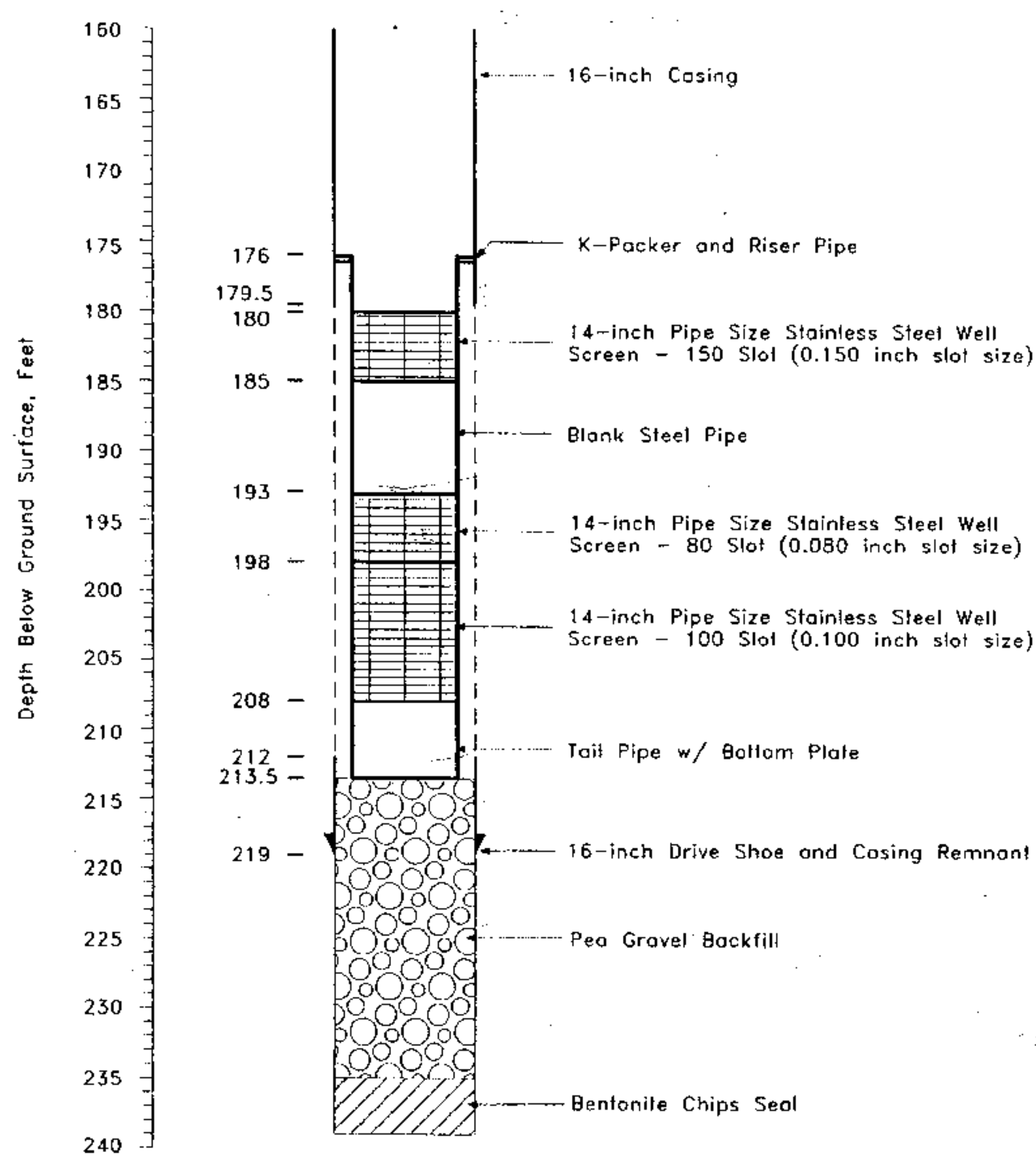


FIGURE 2
GEOLOGIC LOG AND WELL DESIGN FOR WELL B

Lacey Groundwater Development Program

Pacific Groundwater Group

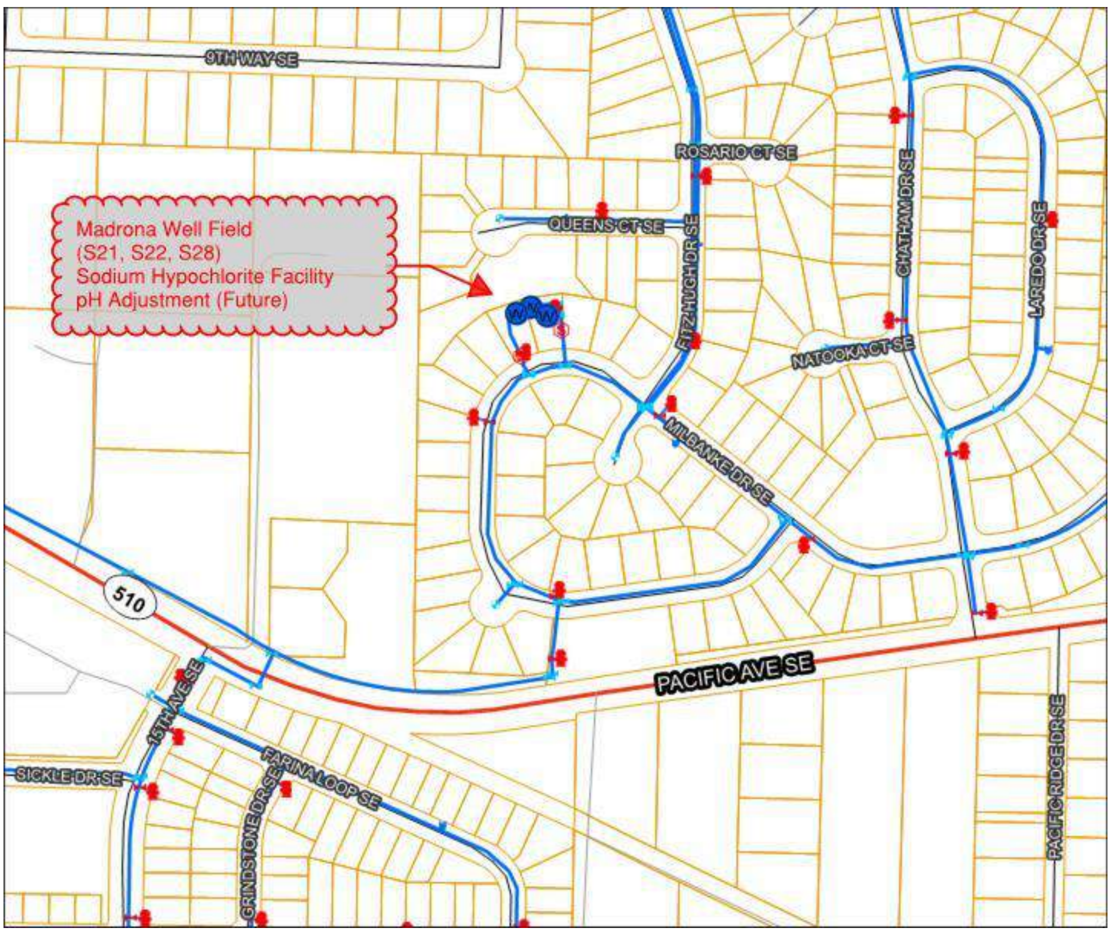
Well S21

(Madrona #1)

Facility Information

Description	Comments
Source #	S21
Address	8824 Milbanke Dr. SE
Year On-Line	1997
Pressure Zone	400
Floor Elevation	259.04
Housing	CMU
Pump Type	Turbine
Pump Model	Integrity 14ILH (10.895" 5-stage)
Pump Shaft Diameter (in)	1.93
Column Diameter/Length	10" column, 256'
Pump Serial #	N/A
Pump Depth (ft)	256
Pump Capacity (gpm)	1600
Motor Model	US Electric 445TPA
Motor Serial #	H06071/Z0721160905R-1
Motor Speed (rpm)	1770
Horsepower	250
Casing Diameter (in)	16
Well Depth (ft)	329
Casing Depth (ft)	263
Screen	14-inch: 100-slot (263-271 ft), 80-slot (280-287 ft), 150-slot (287-293 ft), 120-slot (313-319 ft), 30-slot (319-324 ft)
Screen Capacity (gpm)	1950
Aquifer	Qpg
Control Valves	6" 61G-21 10" 692EG-07BDS 2-1/2" 50G-01
PSV Setting	Solenoid Control 1600 gpm
PRV Setting (psi)	72
Flow to Waste Setting	150psi @ 400gpm
Flow to Waste Duration (sec)	180
Well Capacity (gpm)	1600
Chlorine Dose (mg/L)	0.58 (S21 and S22 combined)
Reliable Capacity (gpm)	1600
Notes	Local pressures limit simultaneous operation of wells S21, S22, and S28.

Well S21 (Madrona #1)



The Department of Ecology does NOT Warranty the Data and/or the Information on this Well Report.

File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. 16280
UNIQUE WELL I.D. # ABY 233
Water Right Permit No. G2-29165

(1) **OWNER:** Name City of Lacey Address P.O. Box "B", Lacey, WA 98503-0987

(2) **LOCATION OF WELL:** County Thurston NW 1/4 NW 1/4 Sec 24 T. 18 N., R. 1W W.M.

(2a) **STREET ADDRESS OF WELL** (or nearest address) 1200 ft east and 500 ft south of the NW corner of Section 24

(3) **PROPOSED USE:** ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☑ Other ☐

(4) **TYPE OF WORK:** Owner's number of well (If more than one) Well A
Abandoned ☐ New well ☑ Deepened ☐ Reconditioned ☐ Method: Dug ☐ Cable ☑ Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) **DIMENSIONS:** Diameter of well 16 inches.
Drilled 334 feet. Depth of completed well 329 ft.

(6) **CONSTRUCTION DETAILS:**
Casing Installed: 16" Diam. from +6 ft. to 263 ft.
Welded ☑ " Diam. from ____ ft. to ____ ft.
Liner installed ☐ " Diam. from ____ ft. to ____ ft.
Threaded ☐

Perforations: Yes ☐ No ☑
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ☑ No ☐
Manufacturer's Name Johnsons
Type 14" pipe size stainless steel Model No. ____
Diam. ____ Slot size (See details on right) ft. to ____ ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ☑ Size of gravel ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ☑ No ☐ To what depth? 125 ft.
Material used in seal Bentonite
Did any strata contain unusable water? Yes ☐ No ☑
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) **PUMP:** Manufacturer's Name ____
Type: ____ H.P. ____

(8) **WATER LEVELS:** Land-surface elevation above mean sea level 254 ft.
Static level 216.5 ft. below top of well Date 3/1/96
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) **WELL TESTS:** Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☑ No ☐ If yes, by whom? PGG
Yield: 1,050 gal./min. with 2.3 ft. drawdown after 9 hrs.
" Transmissivity ~ 2,000,000 gpd/ft "
" Storage coefficient ~ 3x10^{-6} "
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level

Date of test ____
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Airtest ____ gal./min. with stem set at ____ ft. for ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water 50°F Was a chemical analysis made? Yes ☑ No ☐

(10) **WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION**

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Tan, silt-bound Gravels	0	29
Brown & grey, silt-bound Gravels	29	50
Silty Gravels with sand	50	77
Brown, silty Sand & Gravel	77	85
Brown, silty Sand & Gravel, some water	85	95
Sand & Gravel, water	95	117
Blue and brown Clay	117	125
Tan, silt-bound Sand	125	145
Tan, slightly silty Sand with some gravel	145	188
Yellow-brown, silty to v. silty fine Sand	188	202
Yellowish-grey brown, siltbound, slightly sandy Gravel	202	217
Olive grey, silt-bound Sand & Gravel	217	229
Grey, silt-bound, slightly gravelly, coarse Sand	229	235
Yellow-brown, silty fine-med Sand	235	244
Yellow-brown, slightly silty Sand and Gravel w/ cobbles	244	265
Yellow-brown, Sand & Gravel w/ cobbles	265	270
Yellow-brown & olive grey, interbedded siltbound Gravel and gravelly fine Sand	270	283
Greyish-brown, very silty Sand and Gravel	283	291
Greyish-brown siltbound Sand & Gravel w/ cobbles	291	314
Olive grey, slightly silty Sand & Gravel	314	320
Yellow-brown, slightly silty fine Sand	320	327
Olive grey, silty fine Sand	327	334
(Log prepared by Pacific Groundwater Group)		

Screen details:

Dia	slot size	Top	Bottom
14"	100	263 ft	271 ft
14"	80	271.5	286.5
14"	150	286.5	292.5
14"	120	313	319
14"	80	319	324

Work Started 12/1/95, 19. Completed 3/4/96, 19

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Holt Drilling Inc (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 10621 Todd Rd E Puyallup
(Signed) Randy Holt (WELL DRILLER) License No. 1099
Contractor's Registration No. HOLTTIX0870J Date 3-27, 1996

(USE ADDITIONAL SHEETS IF NECESSARY)

ECL 050-1-20 (2/93)

Geologic Log and Well Construction Details

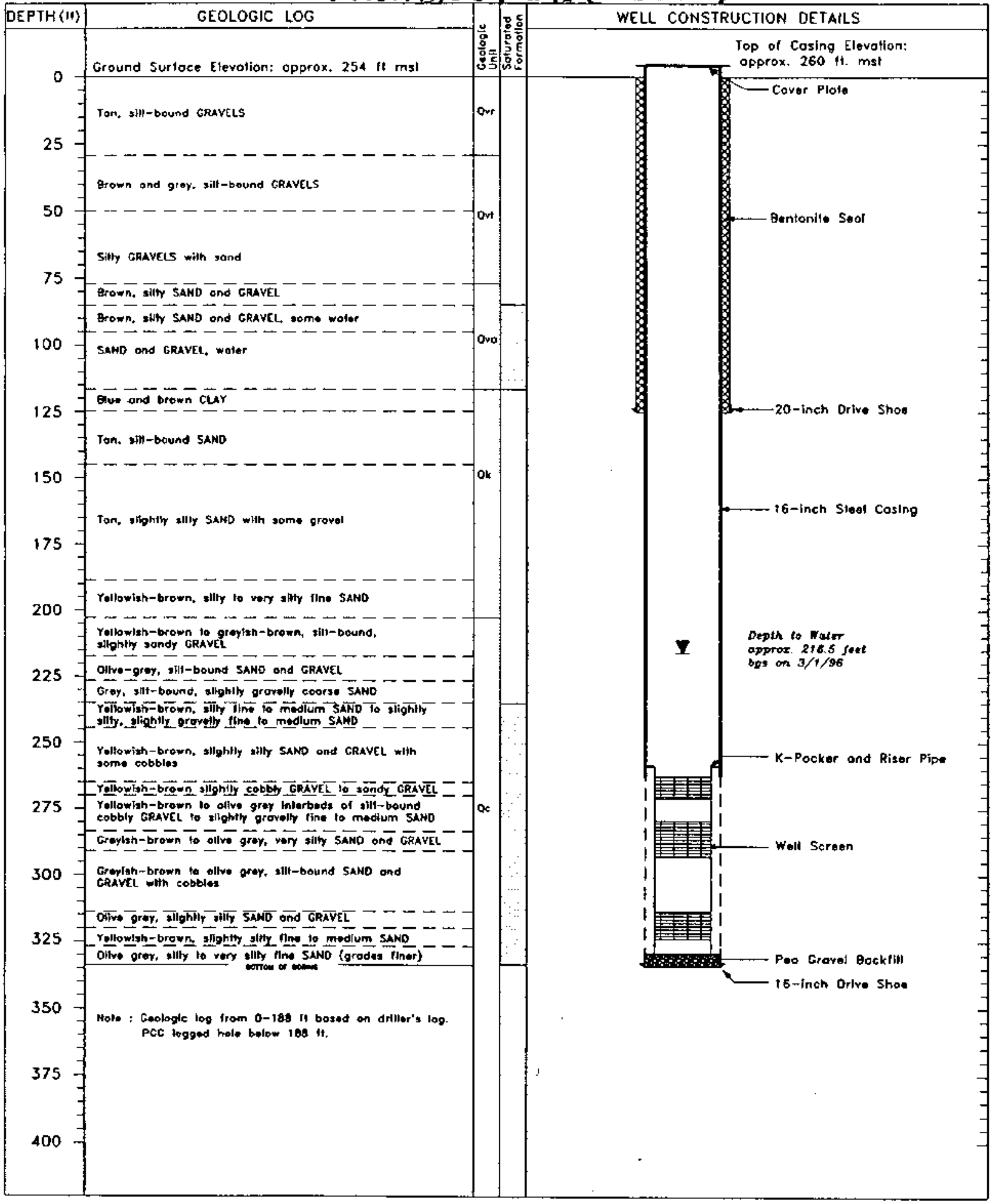
Madrona Park (Well 21)

Ground Surface Elevation: approx. 254 ft msl

GEOLOGIC LOG	Geologic Unit
Tan, silt-bound GRAVELS	Qvr
Brown and grey, silt-bound GRAVELS	Qvt
Silty GRAVELS with sand	
Brown, silty SAND and GRAVEL	Qva
Brown, silty SAND and GRAVEL, some water	
SAND and GRAVEL, water	
Blue and brown CLAY	Qk
Tan, silt-bound SAND	
Tan, slightly silty SAND with some gravel	
Yellowish-brown, silty to very silty fine SAND	
Yellowish-brown to greyish-brown, silt-bound, slightly sandy GRAVEL	Qc
Olive-grey, silt-bound SAND and GRAVEL	
Grey, silt-bound, slightly gravelly coarse SAND	
Yellowish-brown, silty fine to medium SAND to slightly silty, slightly gravelly fine to medium SAND	
Yellowish-brown, slightly silty SAND and GRAVEL with some cobbles	
Yellowish-brown slightly cobbly GRAVEL to sandy GRAVEL	
Yellowish-brown to olive grey interbeds of silt-bound cobbly GRAVEL to slightly gravelly fine to medium SAND	
Greyish-brown to olive grey, very silty SAND and GRAVEL	
Greyish-brown to olive grey, silt-bound SAND and GRAVEL with cobbles	
Olive grey, slightly silty SAND and GRAVEL	
Yellowish-brown, slightly silty fine to medium SAND	
Olive grey, silty to very silty fine SAND (grades finer)	

BOTTOM OF BORING

Note : Geologic log from 0-188 ft based on driller's log. PCC logged hole below 188 ft.



PROJECT NAME: Lacey Groundwater Devel. Program
WELL IDENTIFICATION NUMBER: WELL A
LOCATION: NW¼ NW¼ Sec. 24 T.18N, R.1W
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Jim Mathieu
DATUM: MSL

WATER LEVEL ELEVATION: 37.5 feet msl (approx.)
WATER LEVEL DATE: 3/1/96
START CARD NO.: 16280
UNIQUE WELL ID NO.: ABY233
DRILLING METHOD: Cable Tool
FIRM: Holt Testing, Inc.

Well Screen As-Built

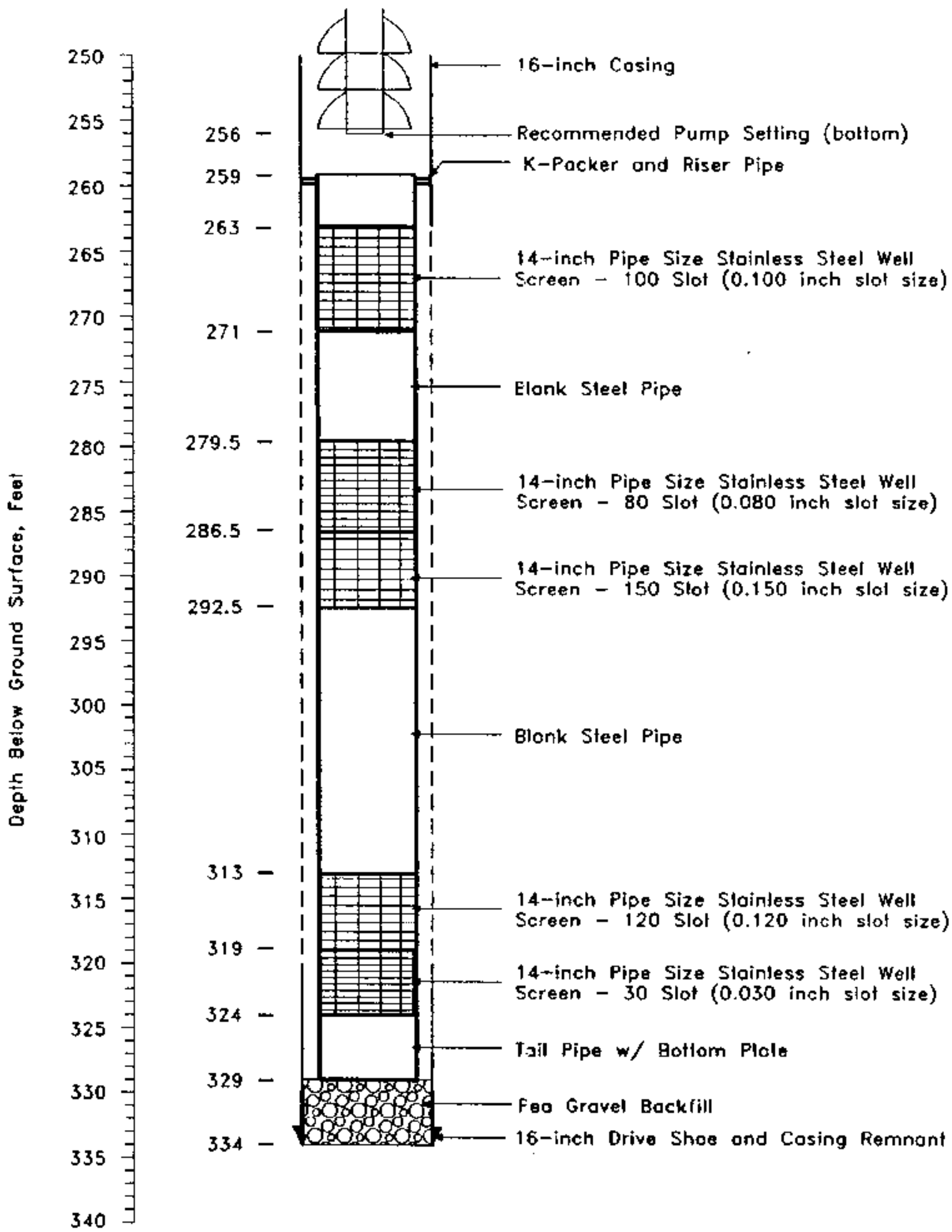


FIGURE 2
GEOLOGIC LOG AND WELL DESIGN FOR WELL A

Lacey Groundwater Development Program

Pacific Groundwater Group

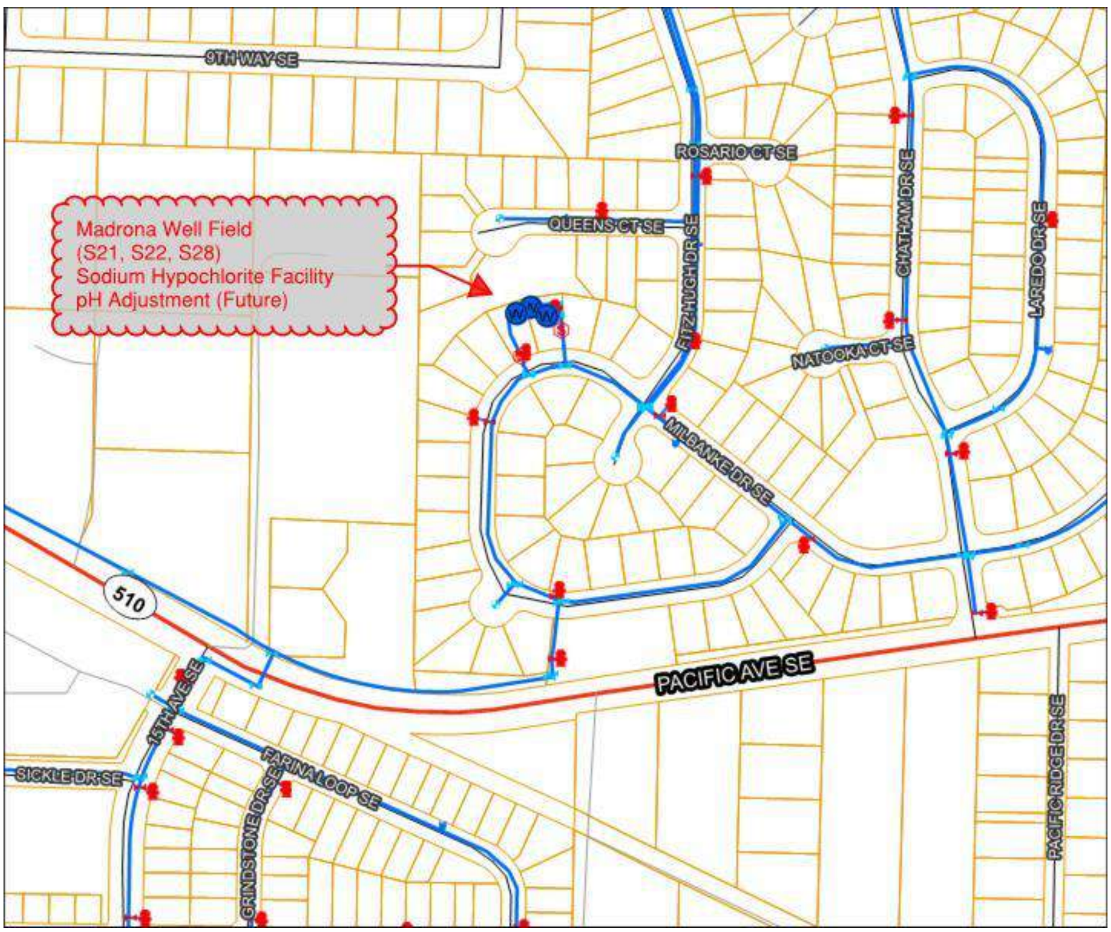
Well S22

(Madrona #2)

Facility Information

Description	Comments
Source #	S22
Address	8824 Milbanke Dr. SE
Year On-Line	1998
Pressure Zone	400
Floor Elevation	259.51
Housing	CMU
Pump Type	Turbine
Pump Model	Goulds VIT 14 RJMC-6 stage, 9.31 in
Pump Shaft Diameter (in)	1.93
Column Diameter/Length	10" column, 250'
Pump Serial #	458067
Pump Depth (ft)	256
Pump Capacity (gpm)	1600 GPM @ 460 FT TDH
Motor Model	US Electric 445TPA
Motor Serial #	B0597051101-001R-1
Motor Speed (rpm)	1770
Horsepower	250
Casing Diameter (in)	16
Well Depth (ft)	334
Casing Depth (ft)	265
Screen	14-inch: 150-slot (265-277, 294-306, 313-320 ft), 120-slot (277-282 ft), 100-slot (320-326)
Screen Capacity (gpm)	3220
Aquifer	Qpg
Control Valves	6" 61G-21 10" 692EG-07ABCDS 2-1/2" 50G-01
PSV Setting	108psi @ 1640gpm
PRV Setting (psi)	72
Flow to Waste Setting	150psi @ 1020gpm
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	1600
Chlorine Dose (mg/L)	0.58 (S21 and S22 combined)
Reliable Capacity (gpm)	1600
Notes	Local pressures limit simultaneous operation of wells S21, S22, and S28.

Well S22 (Madrona #2)



File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W11448
UNIQUE WELL I.D. # ACR 769
Water Right Permit No. Appl. → G2-29165 - Prelim Permit

(1) OWNER: Name CITY OF LACEY Address P.O.Box 3400, 420 College St. Lacey, WA 98509-3400

(2) LOCATION OF WELL: County Thurston - NW 1/4 NW 1/4 Sec 24 T. 18 N., R. 1W W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) MADRONA PARK SUBDIVISION

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater Industrial ☐ Test Well ☐ Municipal ☒ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) "C"
Abandoned ☐ New well XX Deepened ☐ Reconditioned ☐
Method: Dug ☐ Cable ☒XX Rotary ☐ Bored ☐ Driven ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 16 inches.
Drilled 334 feet. Depth of completed well 333 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 16 " Diam. from +2 ft. to 265 ft.
Welded ☒ " Diam. from ___ ft. to ___ ft.
Liner installed ☐ " Diam. from ___ ft. to ___ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ___
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Westco
Type Stainless steel Model No. ___
Diam. 14" Slot size 150/120 from 265 ft. to 282 ft.
Diam. 14" Slot size 150 from 294 ft. to 306 ft.
14" 150/100 313 326

Gravel packed: Yes ☐ No ☒ Size of gravel ___
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☒ No ☐ To what depth? 130 ft.
Material used in seal ~~XXXXXXXXXX~~ Quick Grout
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

(7) PUMP: Manufacturer's Name ___
Type: ___ H.P. ___

(8) WATER LEVELS: Land-surface elevation above mean sea level ___ ft.
Static level 219.53 ft. below top of well Date 6/4/97
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? Hokkaido
Yield: 1025 gal./min. with 2.01 ft. drawdown after 1 hrs.
" 1025 " 2.00 " 2 "
" 1025 " 2.21 " 4.23 "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	221.75	10m	219.77	120m	219.7
1 min.	219.69	30m	219.76		
5 min.	219.81	60m	219.70		

Date of test 6/4/97
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water ___ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown gray sandy till, hard	0'	10'
Gray brown sandy till w/cobbles	10'	69'
Dirty sand and gravel, moist	69'	76'
Brown gray till	76'	79'
Brown clay with gravel	79'	87'
Brown waterbearing sand & gravel	87'	121'
Brown silty sand with gravel	121'	123'
Blue gray clay	123'	133'
Brown silty sand, H_2O	133'	153'
Brown silty sand with clay and gravel, H_2O	153'	163'
Brown sandy silt with gravel, H_2O	163'	195'
Yellowish Sand & Gravel with binder, waterbearing	195'	306'
Brown Sand and gravel with clay lenses	306'	328'
Brown, fine to medium sand with gravel	328'	331'
Brown silty sand with binder	331'	334'
Bottom hole	334'	

RECEIVED '97 JUN 25 AM 10 18

Work Started March 21, 1997 Completed June 11, 1997

WELL CONSTRUCTOR CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME HOKKAIDO DRILLING & DEVELOPING CORP. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address P.O. BOX 100, GRAHAM, WA 98338-0100
(Signed) [signature] (WELL DRILLER) License No. 1146
Contractor's Registration No. HOKKADD178D3 Date JUNE 24, 1997

(USE ADDITIONAL SHEETS IF NECESSARY)

Ecology is an Equal Opportunity and Affirmative Action employer. For special accommodation needs, contact the Water Resources Program at (206) 407-6600. The TDD number is (206) 407-6006.

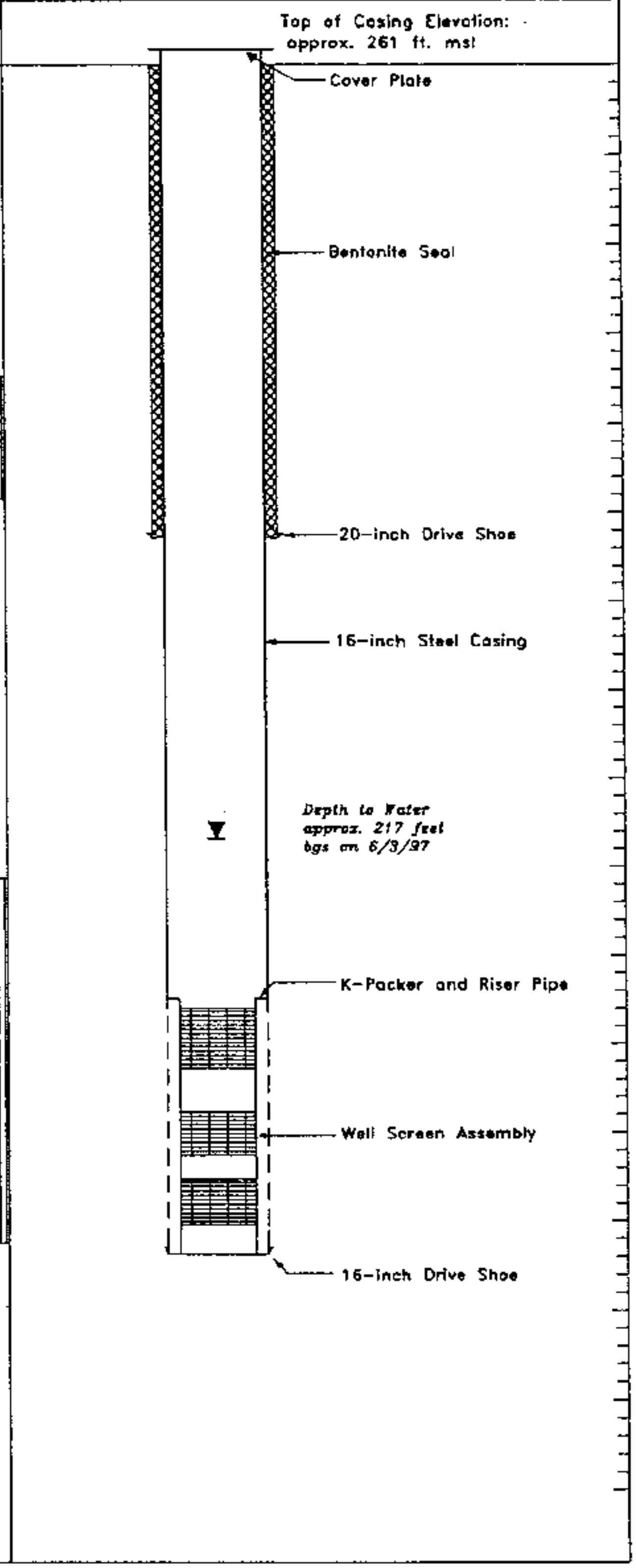
Geologic Log and Well Construction Details

Madrona Park (Well 22)

DEPTH (ft)	GEOLOGIC LOG	Geologic Unit	Saturated Formation
	Ground Surface Elevation: approx. 259 ft msl		
0	Brown gray sandy TILL (hard)	Qvt	
25–50	Gray brown sandy TILL with cobbles	Qvt	
75	Silty SAND and GRAVEL (moist)	Qvt	
	Brown gray TILL	Qvt	
	Brown CLAY with gravel (water at 80 ft)	Qva	
100	Brown SAND and GRAVEL (water bearing)	Qva	Saturated
125	Gray-blue sticky CLAY	Qk	
	Brown to gray-brown siltbound SAND and GRAVEL	Qk	
	Brown silty SAND	Qk	
150	Brown silty SAND with clay and gravel	Qk	
175	Brown sandy SILT with gravel	Qk	
200	Brown-gray siltbound and silty SAND and GRAVEL	Qc	
	Brown SILT and fine SAND	Qc	
	Gray-brown, slightly coarse sandy, slightly silty GRAVEL	Qc	
225	Brown siltbound SAND and GRAVEL	Qc	
	Olive-gray to brown, slightly silty and cobbly, medium to coarse sandy GRAVEL; water encountered at 228 ft	Qc	Saturated
	Brown, slightly silty, fine to medium SAND	Qc	Saturated
250	Brown to olive-gray, gravelly, fine to medium SAND	Qc	Saturated
	Brown to gray, poorly graded, fine to med. SAND & GRAVEL	Qc	Saturated
	Brown to olive-gray, well graded, coarse sandy GRAVEL	Qc	Saturated
275	Brown to olive-gray, well graded, slightly cobbly, fine to coarse sandy GRAVEL	Qc	Saturated
	Brown to olive-gray, medium to coarse sandy GRAVEL	Qc	Saturated
	Brown to olive-gray, poorly graded, f. to c. sandy GRAVEL	Qc	Saturated
300	Brown to olive gray, mod. well graded, slightly cobbly, sandy GRAVEL	Qc	Saturated
	Brown, claybound, fine to med. sandy GRAVEL and COBBLE	Qc	Saturated
325	Brown to olive-gray, well graded, slightly cobbly, medium to coarse sandy GRAVEL	Qc	Saturated
	Brown, slightly silty fine to medium SAND	Qc	Saturated
	Brown to gray-red SILT	Qc	
	BOTTOM OF BORING		
350			
375			
400			

Note : Geologic log from 0-210 ft based on driller's log. PGG logged hole below 210 ft.

WELL CONSTRUCTION DETAILS



PROJECT NAME: Lacey Groundwater Devel. Program
WELL IDENTIFICATION NUMBER: WELL C
LOCATION: NW¼ NW¼ Sec. 24 T.18N, R.1W
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Jim Mathieu
DATUM: MSL

WATER LEVEL ELEVATION: 42 feet msl (approx.)
WATER LEVEL DATE: 6/3/97
START CARD NO.: W11448
UNIQUE WELL ID NO.: ACR769
DRILLING METHOD: Cable Tool
FIRM: Hokkaido Drilling & Development Corp.

Well Screen As-Built

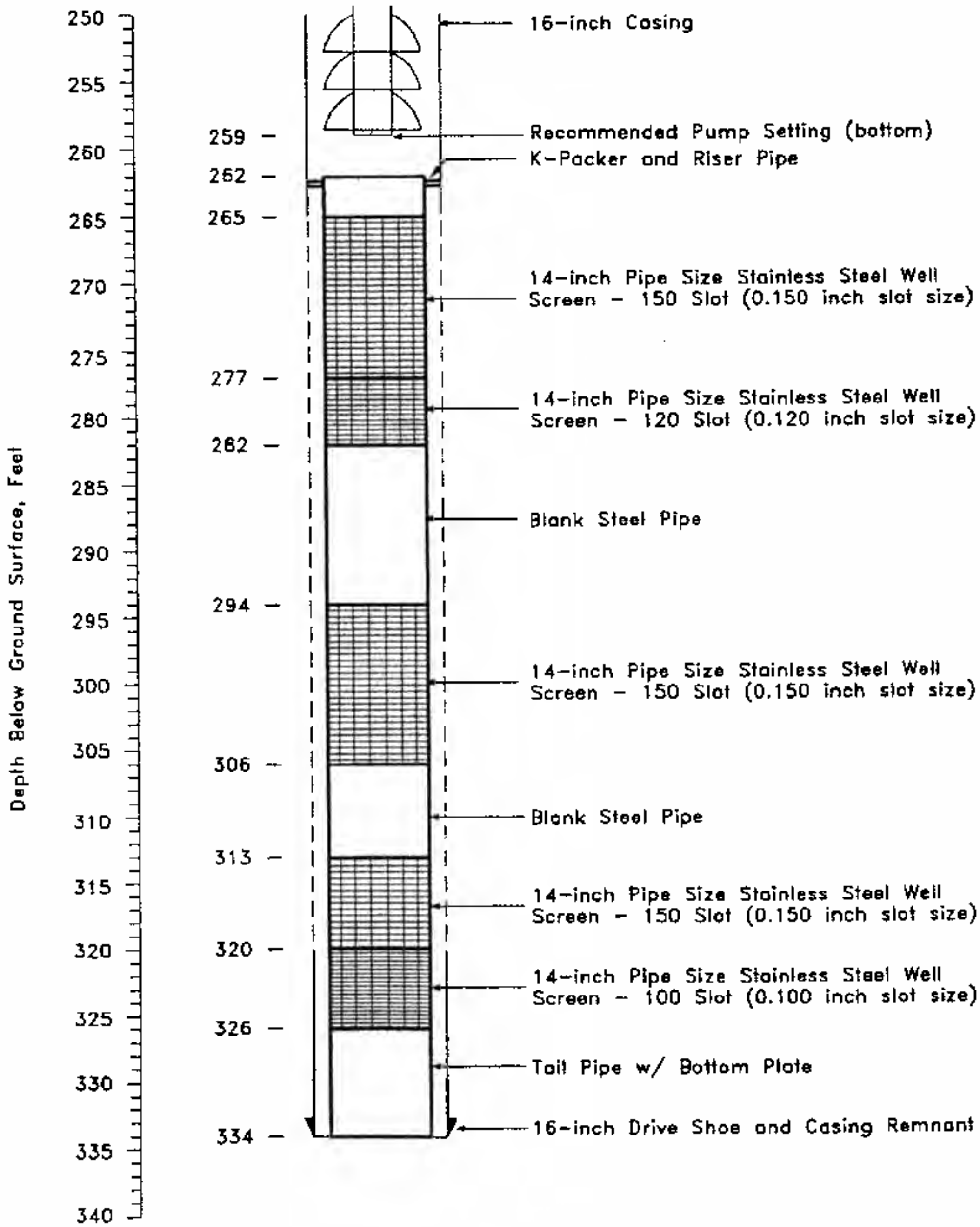


FIGURE 2
GEOLOGIC LOG AND WELL DESIGN FOR WELL C

Lacey Groundwater Development Program

Pacific Groundwater Group

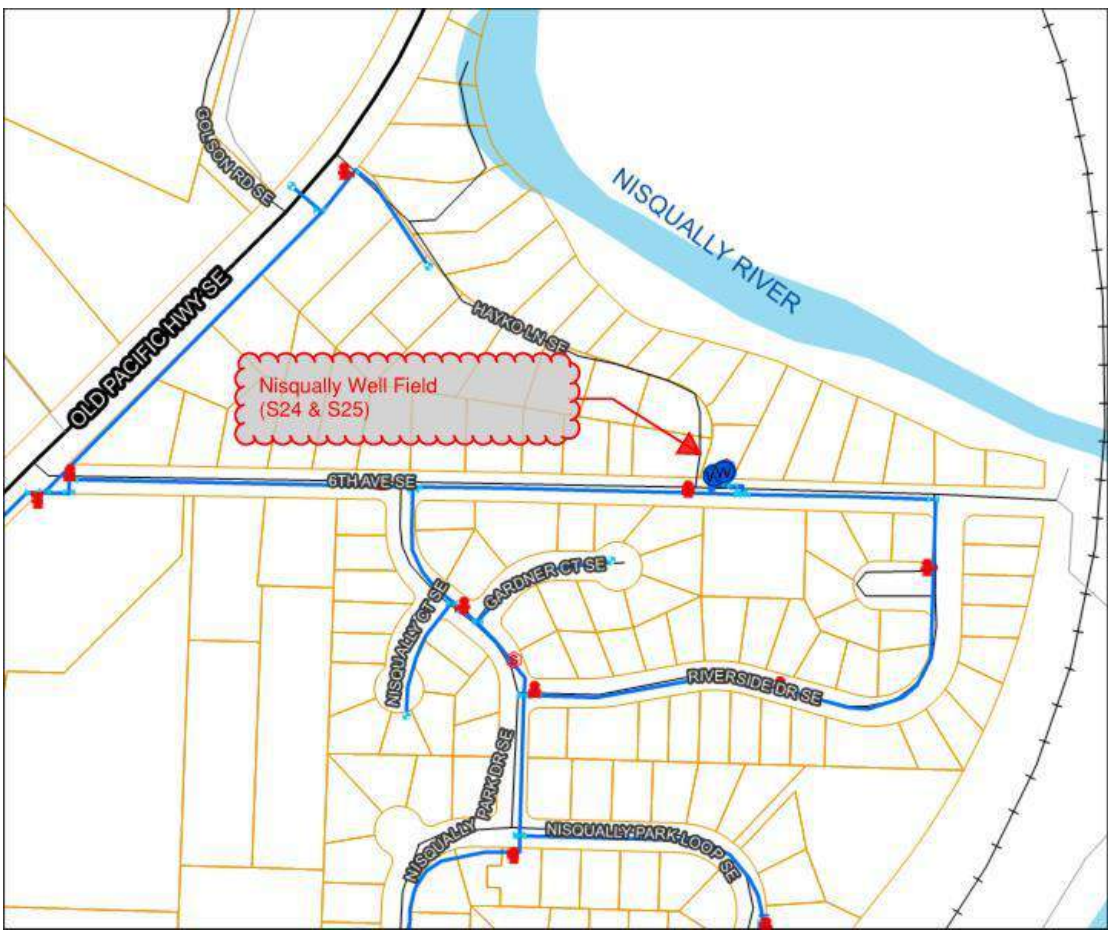
Well S24

(Nisqually 19A)

Facility Information

Description	Comments
Source #	S24
Address	11544 6th Ave. SE
Year On-Line	1986
Pressure Zone	188
Floor Elevation	25.00
Housing	CMU
Pump Type	Submersible
Pump Model	FNW-5LC00744C
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	2" column, 85'
Pump Serial #	2554755-A
Pump Depth (ft)	85
Pump Capacity (gpm)	70
Motor Model	Franklin 2343185202
Motor Serial #	00M1801-3515
Motor Speed (rpm)	3450
Horsepower	7.5
Casing Diameter (in)	6
Well Depth (ft)	107
Casing Depth (ft)	98
Screen	6-inch: 18-slot (98-107 ft)
Screen Capacity (gpm)	N/A
Aquifer	Qpg
Control Valves	None
PSV Setting	N/A
PRV Setting (psi)	N/A
Flow to Waste Setting	60 gpm
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	N/A
Chlorine Dose (mg/L)	0.57
Reliable Capacity (gpm)	70
Notes	

Well S24 (Nisqually 19A)



File Original and First Copy with Department of Ecology
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. ....
Permit No. ....

(1) OWNER: Name CITY OF LACEY Address 6TH AVE SE - NISQUALLY

(2) LOCATION OF WELL: County THURSTON — W½ SW ¼ Sec. 9 T. 18N N., R. 1E W.M.

Bearing and distance from section or subdivision corner

(3) PROPOSED USE: Domestic ☒ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) 2
New well ☐ Method: Dug ☐ Bored ☐
Deepened ☒ Cable ☐ Driven ☐
Reconditioned ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 6 inches.
Drilled 108 ft. Depth of completed well 107 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 6" Diam. from +1 ft. to 98 ft.
Threaded ☐ ....." Diam. from ..... ft. to ..... ft.
Welded ☒ ....." Diam. from ..... ft. to ..... ft.

Perforations: Yes ☐ No ☒
Type of perforator used.....
SIZE of perforations ..... in. by ..... in.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.
..... perforations from ..... ft. to ..... ft.

Screens: Yes ☒ No ☐
Manufacturer's Name JOHNSON
Type..... Model No.....
Diam. 6 Slot size 18 from 107 ft. to 98 ft.
Diam. ..... Slot size ..... from ..... ft. to ..... ft.

Gravel packed: Yes ☐ No ☒ Size of gravel: .....
Gravel placed from ..... ft. to ..... ft.

Surface seal: Yes ☐ No ☐ To what depth? ..... ft.
Material used in seal NO
Did any strata contain unusable water? Yes ☐ No ☐
Type of water?..... Depth of strata.....
Method of sealing strata off.....

(7) PUMP: Manufacturer's Name BERKLEY
Type: SUB H.P. 7½

(8) WATER LEVELS: Land-surface elevation above mean sea level.... +20 ft.
Static level 13'-6 ft. below top of well Date 5/20
Artesian pressure ..... lbs. per square inch Date.....
Artesian water is controlled by..... (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? TIM
Yield: 110 gal./min. with 20'1" ft. drawdown after 4 hrs.
" " " "
" " " "

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	33'-7"				
30 sec	17-9"	— TOO FAST FOR GOOD			
60 sec	14-1"	MEASUREMENTS			

Date of test .....
Bailer test..... gal./min. with..... ft. drawdown after..... hrs.
Artesian flow..... g.p.m. Date.....
Temperature of water..... Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
UNKNOWN	0	63
WB SAND - GRAVEL	63	68
SAND - GRAVEL - CLAY	68	88
CEMENTED SAND - GRAVEL	88	94
WB Sand	94	96
WB Sand - gravel	96	107
Purple Sand - WB	107	108

RECEIVED
JUN 12 1986
DEPARTMENT OF ECOLOGY
SW REGIONAL OFFICE

Work started 5, 1986 Completed 5, 1986

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME TIMS WELL DRILLING (Person, firm, or corporation) (Type or print)

Address 6246 LIBBY RD NE

[Signed] [signature] (Well Driller)

License No. 0832 Date 5/29, 1986

(USE ADDITIONAL SHEETS IF NECESSARY)

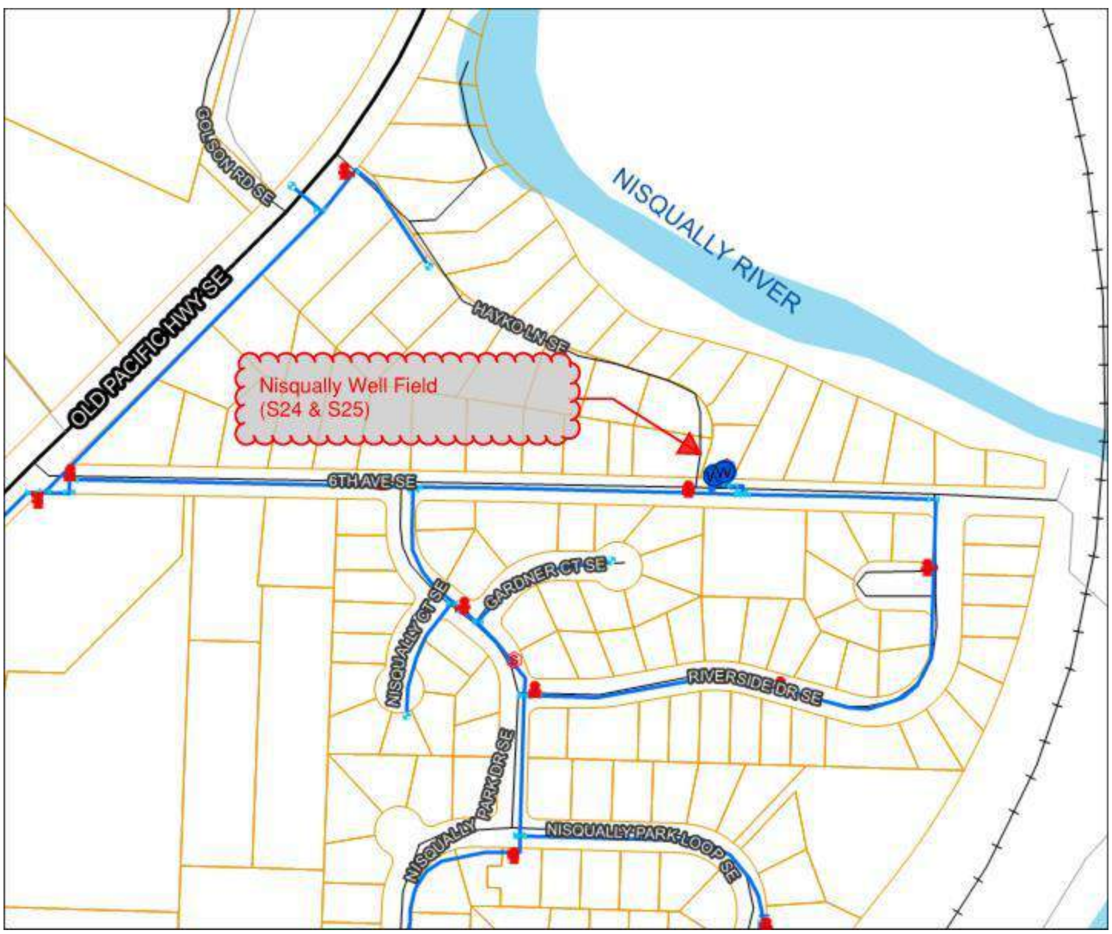
ECY 050-1-20

Well S25
(Nisqually 19C)

Facility Information

Description	Comments
Source #	S25
Address	11544 6th Ave. SE
Year On-Line	1972
Pressure Zone	188
Floor Elevation	24.46
Housing	CMU
Pump Type	Turbine
Pump Model	Integrity 7IMH (5.58” 10-stage)
Pump Shaft Diameter (in)	1.93
Column Diameter/Length	6" column, 75'
Pump Serial #	375864
Pump Depth (ft)	75
Pump Capacity (gpm)	200 GPM @ 275 FT TDH
Motor Model	US Electric 445TPA
Motor Serial #	H06071/Z0721160905R-1
Motor Speed (rpm)	1770
Horsepower	30
Casing Diameter (in)	10
Well Depth (ft)	79
Casing Depth (ft)	58
Screen	10-inch: 100-slot (58-73 ft)
Screen Capacity (gpm)	N/A
Aquifer	Qpg
Control Valves	3" 61G-02
PSV Setting	N/A
PRV Setting (psi)	N/A
Flow to Waste Setting	230 gpm
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	N/A
Chlorine Dose (mg/L)	0.81
Reliable Capacity (gpm)	250
Notes	

Well S25 (Nisqually 19C)



Well #90

File Original and First Copy with Division of Water Resources
Second Copy — Owner's Copy
Third Copy — Driller's Copy

WATER WELL REPORT
STATE OF WASHINGTON

Application No. G1220104
Permit No. G2-20104P

(1) OWNER: Name CITY OF LACEY — Address P.O. Drawer B, Lacey, Wn. 98503

(2) LOCATION OF WELL: County THURSTON — SW¼ SW¼ Sec. 9 T. 18 N., R. 1 E. W.M.

Bearing and distance from section or subdivision corner N45°E, 300 FT FROM S.W. 1/16 COR

(3) PROPOSED USE: Domestic ☐ Industrial ☐ Municipal ☒ Irrigation ☐ Test Well ☐ Other ☐

(4) TYPE OF WORK: Owner's number of well (if more than one) ____
New well ■ Deepened ☐ Reconditioned ☐
Method: Dug ☐ Bored ☐ Cable ■ Driven ☐ Rotary ☐ Jetted ☐

(5) DIMENSIONS: Diameter of well 10 inches.
Drilled 79 ft. Depth of completed well 73 ft.

(6) CONSTRUCTION DETAILS:

Casing installed: 10" Diam. from 0 ft. to 58 ft.
Threaded ☐ ____" Diam. from ____ ft. to ____ ft.
Welded ■ ____" Diam. from ____ ft. to ____ ft.

Perforations: Yes ☐ No ■
Type of perforator used ____
SIZE of perforations ____ in. by ____ in.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.
____ perforations from ____ ft. to ____ ft.

Screens: Yes ■ No ☐
Manufacturer's Name JOHNSON
Type ST. STEEL TELESCOPE Model No. ____
Diam. 10" Slot size .100 from 58 ft. to 73 ft.
Diam. ____ Slot size ____ from ____ ft. to ____ ft.

Gravel packed: Yes ☐ No ■ Size of gravel: ____
Gravel placed from ____ ft. to ____ ft.

Surface seal: Yes ■ No ☐ To what depth? 30 ft.
Material used in seal CONCRETE
Did any strata contain unusable water? Yes ☐ No ■
Type of water? ____ Depth of strata ____
Method of sealing strata off ____

(7) PUMP: Manufacturer's Name ____
Type: ____ H.P. ____

(8) WATER LEVELS: Land-surface elevation above mean sea level 20 ft.
Static level 15 ft. below top of well Date 7-12-72
Artesian pressure ____ lbs. per square inch Date ____
Artesian water is controlled by ____ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ■ No ☐ If yes, by whom? DRILLER
Yield: 450 gal./min. with 11.5 ft. drawdown after 4 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
:00	26.5				
:01	20.8				
:02	15.0				

Date of test 7-12-72
Bailer test ____ gal./min. with ____ ft. drawdown after ____ hrs.
Artesian flow ____ g.p.m. Date ____
Temperature of water ____ Was a chemical analysis made? Yes ■ No ☐

(10) WELL LOG:

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of formation.

MATERIAL	FROM	TO
SAND, SOME SILTY CLAY BINDER	0	19
SAND & GRAVEL	19	32
SAND & GRAVEL (TIGHT)	32	43
SAND & GRAVEL, (CEMENTED IN CLAY TILL)	43	49
SAND & GRAVEL (TIGHT & DIRTY)	49	55
SAND & GRAVEL LOOSE (WATER DRIVE & BAIL)	55	58
SAND & GRAVEL (WATER DRIVE & BAIL)	58	73
SAND & GRAVEL (TIGHT VERY DIRTY NO WATER)	73	75
SAND & GRAVEL (CEMENTED)	75	79

RECEIVED
OCT 4 1973
DEPARTMENT OF ECOLOGY
SOUTHWEST REGIONAL OFFICE

Work started 6-29 19 72 Completed 7-1 19 72

WELL DRILLER'S STATEMENT:

This well was drilled under my jurisdiction and this report is true to the best of my knowledge and belief.

NAME Stoney-Armstrong Drilling, Inc. (Person, firm, or corporation) (Type or print)
Address 514½ River Road
[Signed] John E. Armstrong (Well Driller)
License No. ____ Date 9-10- 1972

OK/WHPT 10-12-73

(USE ADDITIONAL SHEETS IF NECESSARY)

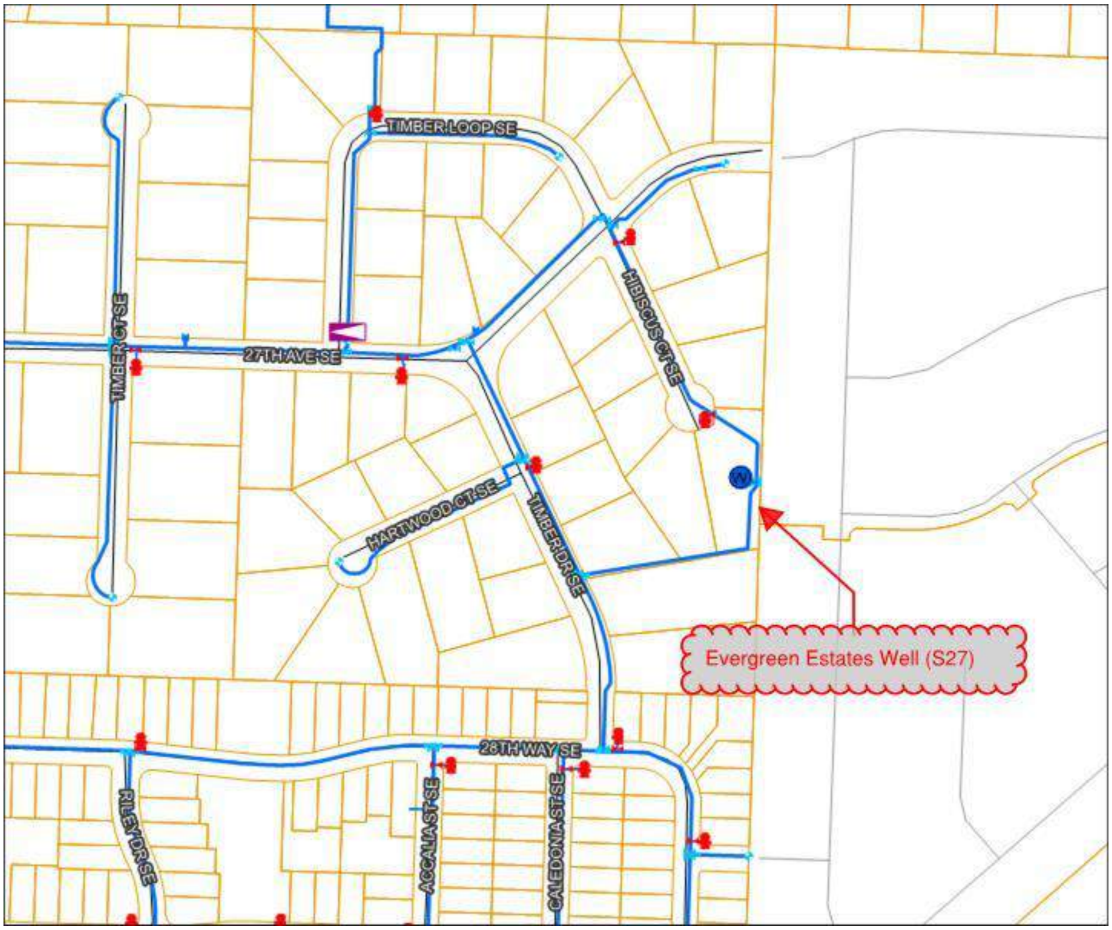
Well S27

(Evergreen Estates)

Facility Information

Description	Comments
Source #	S27
Address	2814 Hibiscus Ct. SE
Year On-Line	2003
Pressure Zone	400
Floor Elevation	256.57
Housing	CMU
Pump Type	Turbine
Pump Model	Byron Jackson 12 MQLX - 8 stages
Pump Shaft Diameter (in)	1.5
Column Diameter/Length	8" column, 240'
Pump Serial #	N/A
Pump Depth (ft)	252
Pump Capacity (gpm)	1100
Motor Model	US Motor VHS 444TP BF76
Motor Serial #	N/A
Motor Speed (rpm)	1785
Horsepower	150
Casing Diameter (in)	16
Well Depth (ft)	282
Casing Depth (ft)	256
Screen	14-inch: 150-slot (256-266 ft), 200-slot (266-276 ft)
Screen Capacity (gpm)	1750
Aquifer	Qpg
Control Valves	6" 61G-21ABKC 8" 692EG-07ABCSDKC 2-1/2" 50G-01
PSV Setting	147psi @ 770gpm
PRV Setting (psi)	80
Flow to Waste Setting	180psi @ 430gpm
Flow to Waste Duration (sec)	240
Well Capacity (gpm)	1100
Chlorine Dose (mg/L)	0.51
Reliable Capacity (gpm)	700
Notes	

Well S27 (Evergreen Estates)



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WATER WELL REPORT
STATE OF WASHINGTON

Notice of Intent W166611
UNIQUE WELL I.D. # AGP-478
Water Right Permit No. G2-20883C

(1) OWNER: Name City of Lacey Address PO BOX 3400, Lacey, WA 98509-3400

(2) LOCATION OF WELL: County Thurston NE 1/4 NW 1/4 Sec 25 T 18 N.R 1W WM
(2a) STREET ADDRESS OF WELL: (or nearest address) 2800 Hibiscus Court, Lacey, WA
TAX PARCEL NO. 46780004600

(3) PROPOSED USE: ☐ Domestic ☐ Industrial ☒ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK: Owner's number of well (if more than one) Well 24
Replacement well
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method ☐ Dug ☐ Bored ☐ Cable ☐ Driven ☐ Rotary ☐ Jetted

(5) DIMENSIONS: Diameter of well 16 inches
Drilled 290 feet. Depth of completed well 282 ft

(6) CONSTRUCTION DETAILS
Casing Installed:
☒ Welded 16" Diam from +2 ft to 256 ft
☐ Liner installed ___" Diam. from ___ ft. to ___ ft
☐ Threaded ___" Diam from ___ ft to ___ ft

Perforations: ☐ Yes ☒ No
Type of perforator used ___
SIZE of perforations ___ in by ___ in
___ perforations from ___ ft to ___ ft.

Screens: ☒ Yes ☐ No ☐ K-Pac Location 252 ft
Manufacturer's Name Johnsons
Type 304 Stainless Model No ___
Diam 14 PS Slot Size 150 from 256 ft. to 266 ft.
Diam 14 PS Slot Size 200 from 266 ft to 276 ft

Gravel/Filter packed: ☐ Yes ☒ No ☐ Size of gravel/sand ___
Material placed from ___ ft. to ___ ft

Surface seal: ☒ Yes ☐ No To what depth? 168 ft
Material used in seal Bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

(7) PUMP: Manufacturer's Name ___
Type: ___ H.P. ___

(8) WATER LEVELS: Land-surface elevation above mean sea level 258 ft
Static level 214.4 ft below top of well Date 11/26/02
Artesian pressure ___ lbs per square inch Date ___
Artesian water is controlled by ___ (Cap, valve, etc)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? PGG / Holt
Yield 900 gal./min with 11 ft drawdown after 2.5 hrs
Yield ___ gal./min with ___ ft drawdown after ___ hrs.
Yield ___ gal./min with ___ ft drawdown after ___ hrs
Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0	225.4	5	214.60	27	214.56
1	214.57	11	214.59	45	214.53
3	214.61	17	214.58	95	214.50

Date of test 11/26/02
Bailer test ___ gal./min. with ___ ft drawdown after ___ hrs
Airtest ___ gal./min with ___ ft. drawdown after ___ hrs.
Artesian flow ___ g.p.m Date ___
Temperature of water 50°F Was a chemical analysis made? ☒ Yes ☐ No

ECY 050-1-20 (11/98)
Transmissivity ~ 1,250,000 gpd/ft
Storage Coef ~ 0.2

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered

MATERIAL	FROM	TO
Brown Sand & Gravel	0	5
Brown silty, cobbly Sand & Gravel	5	27
Brown sand & Gravel	27	58
Brown silty Sand & Gravel	58	88
Reddish-brown, silty, sand Gravel	88	109
Reddish-brown, silty, sandy Gravel w/ tan silt layers	109	129
Brown, silty Sand w/ some gravel	129	152
Brown Sand & Gravel	152	158
Brown Silt	158	163
Brown, siltbound Sand & Gravel	163	192
brown, siltbound, cobbly, Sand & Gravel	192	203
Brown Sand & Gravel	203	210
Brown siltbound Sand & Gravel	210	225
Brown cobbly Sand & Gravel	225	235
Brown to olive brown, silty, cobbly Sand & Gravel	235	245
Brown cobbly sand & Gravel	245	248
Brown to olive-brown, silty, cobbly Sand & Gravel	248	257
Brown cobbly Sand & Gravel	257	278
grayish-brown silt and gray silty fine SAND	278	290

Work Started 9/5/02 Completed 12/12/02

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief

Type or Print Name Wade Iverson License No 597
(Licensed Driller/Engineer)
Trainee Name Mike Polly License No ___
Drilling Company Holt Drilling Inc
(Signed) [signature] License No ___
(Licensed Driller/Engineer)
Address PO Box 1890
Contractor's Registration No HOLTDI*136OG Date 12/5/02

(USE ADDITIONAL SHEETS IF NECESSARY)

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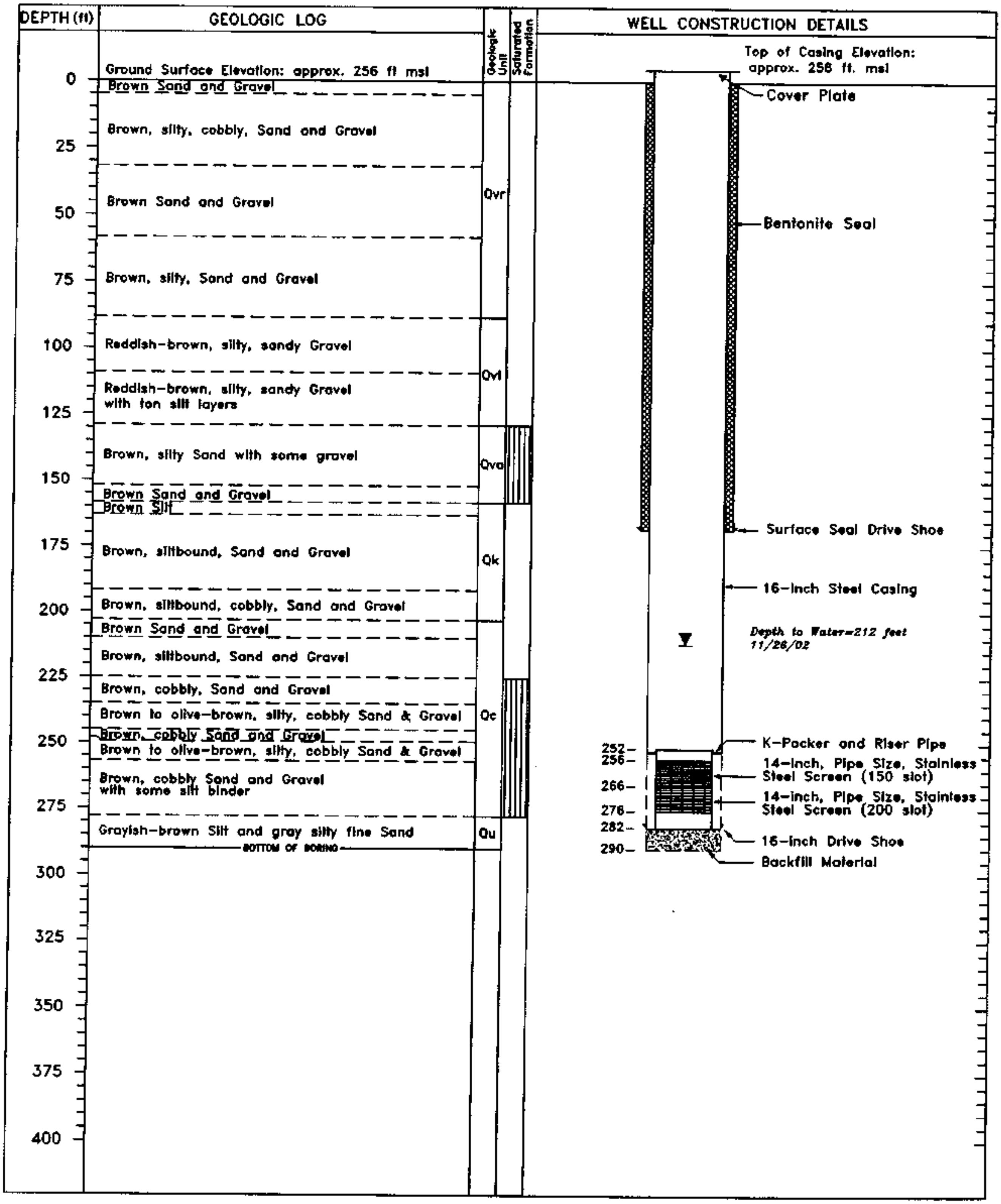
Figure 2 Well Log and Construction Details for Lacey Well 24



PROJECT NAME: Lacey Groundwater Devel. Program
WELL IDENTIFICATION NUMBER: Well 24
LOCATION: NE ¼ NW¼ Sec. 25 T.18N, R.1W
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Dan Matlock
DATUM: MSL

WATER LEVEL ELEVATION: 44 feet msl
WATER LEVEL DATE: 11/26/02
START CARD NO.: W166611
UNIQUE WELL ID NO.: AGP-478
DRILLING METHOD: Cable Tool
FIRM: Holt Drilling

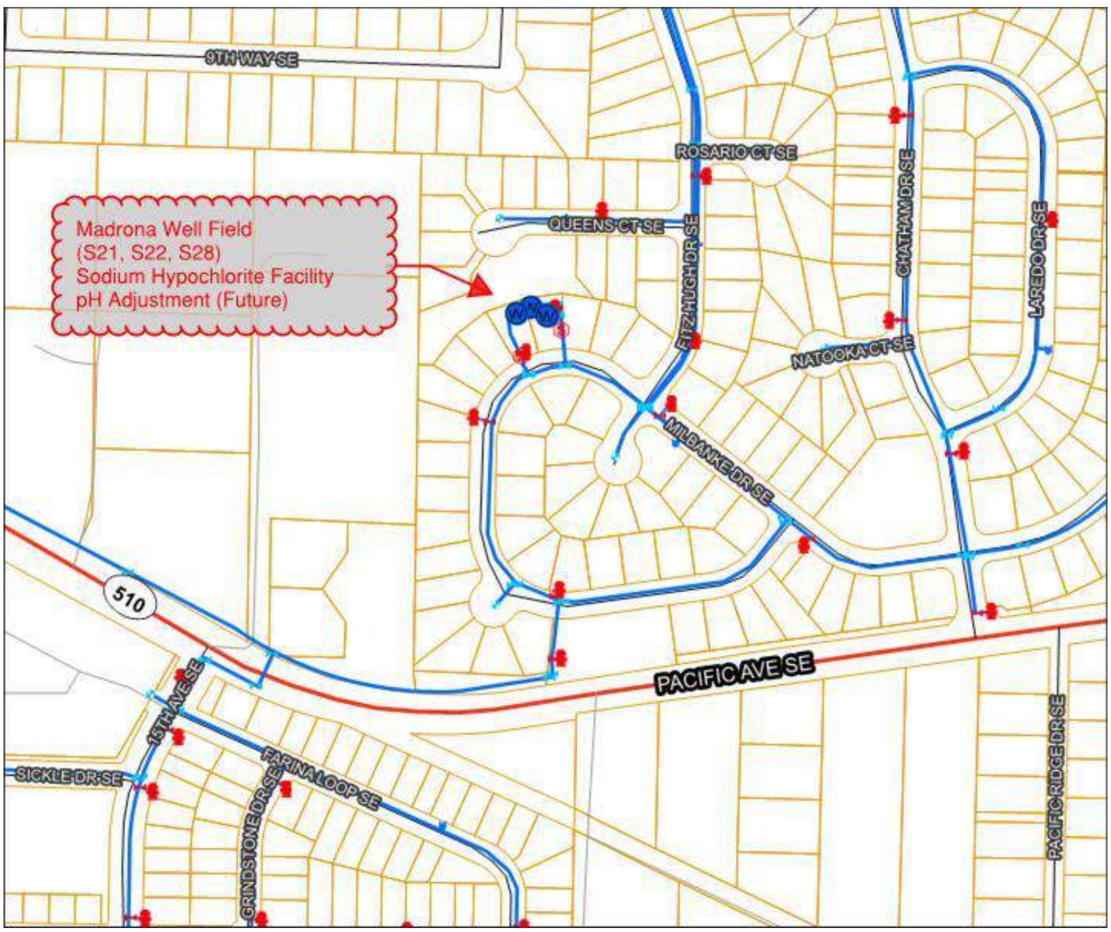
Pacific Groundwater Group

Well S28
(Madrona #3)

Facility Information

Description	Comments
Source #	S28
Address	8824 Milbanke Dr. SE
Year On-Line	2004
Pressure Zone	400
Floor Elevation	259.50
Housing	CMU
Pump Type	Turbine
Pump Model	Peerless 14MC - 7 stages
Pump Shaft Diameter (in)	1.9375
Column Diameter/Length	10" column, 249'
Pump Serial #	N/A
Pump Depth (ft)	256
Pump Capacity (gpm)	1600
Motor Model	US Motor H445TPA BF84
Motor Serial #	N/A
Motor Speed (rpm)	1780
Horsepower	250
Casing Diameter (in)	20
Well Depth (ft)	330
Casing Depth (ft)	262
Screen	18-inch: 120-slot (262-265, 272-277 ft), 80-slot (265-272, 286-292 ft), 150-slot (292-325 ft)
Screen Capacity (gpm)	4380
Aquifer	Qpg
Control Valves	6" 61G-21 10" 692EG-07ABCDS 2-1/2" 50G21
PSV Setting	112psi @ 1570gpm
PRV Setting (psi)	72
Flow to Waste Setting	150psi @ 960gpm
Flow to Waste Duration (sec)	120
Well Capacity (gpm)	3200
Chlorine Dose (mg/L)	0.67
Reliable Capacity (gpm)	1600
Notes	Local pressures limit simultaneous operation of wells S21, S22, and S28.

Well S28 (Madrona #3)



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WATER WELL REPORT

STATE OF WASHINGTON

Start Card No. W124732
UNIQUE WELL I.D. # AEC 883
Water Right Permit No. G2-29304

(1) OWNER: Name City of Lacey   Address P.O.Box "B" Lacey, WA 98503-0987

(2) LOCATION OF WELL: County Thurston   NW 1/4 NW 1/4 Sec 24 T. 18 N., R 1W W.M.

(2a) STREET ADDRESS OF WELL (or nearest address) 8824 Milbank Rd, Lacey, WA

(3) PROPOSED USE: ☐ Domestic ☐ Irrigation ☐ DeWater   Industrial ☐   Test Well ☐   Municipal ☒   Other ☐

(4) TYPE OF WORK: Owner's number of well (If more than one) Well 23
Abandoned ☐   New well ☒   Deepened ☐   Reconditioned ☐   Method: Dug ☐   Cable ☒   Rotary ☐   Bored ☐   Driven ☐   Jetted ☐

(5) DIMENSIONS: Diameter of well 20 inches.
Drilled 338 feet. Depth of completed well 330.5 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 20" Diam. from -2 ft. to 262.5 ft.
Welded ☐ ___" Diam. from ___ ft. to ___ ft.
Liner installed ☐ ___" Diam. from ___ ft. to ___ ft.
Threaded ☐

Perforations: Yes ☐ No ☒
Type of perforator used ___
SIZE of perforations ___ in. by ___ in.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.
___ perforations from ___ ft. to ___ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name Johnson
Type Stainless Steel   Model No. ___
Diam. ___ Slot size See below   from ___ ft. to ___ ft.
Diam. ___ Slot size ___ from ___ ft. to ___ ft.

Gravel packed: Yes ☐ No ☒ Size of gravel ___
Gravel placed from ___ ft. to ___ ft.

Surface seal: Yes ☒ No ☐ To what depth? 137 ft.
Material used in seal ___
Did any strata contain unusable water? Yes ☐ No ☐
Type of water? ___ Depth of strata ___
Method of sealing strata off ___

(7) PUMP: Manufacturer's Name ___
Type: ___ H.P. ___

(8) WATER LEVELS: Land-surface elevation above mean sea level ~~249.18~~ 259 ft.
Static level 220.8 ft. below top of well Date 6/5/00
Artesian pressure ___ lbs. per square inch Date ___
Artesian water is controlled by ___ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? Yes ☒ No ☐ If yes, by whom? PGG/Driller
Yield: 1680 gal./min. with 2.4 ft. drawdown after 4 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
0.0	223.2	6.0	221.16	50.0	221.06
2.0	221.19	10.0	221.13		
4.0	221.18	20.0	221.10		

Date of test ___
Bailer test ___ gal./min. with ___ ft. drawdown after ___ hrs.
Airtest ___ gal./min. with stem set at ___ ft. for ___ hrs.
Artesian flow ___ g.p.m. Date ___
Temperature of water ___ Was a chemical analysis made? Yes ☒ No ☐

(10) WELL LOG or ABANDONMENT PROCEDURE DESCRIPTION

Formation: Describe by color, character, size of material and structure, and show thickness of aquifers and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information.

MATERIAL	FROM	TO
Brown Till	0	35
Brown Siltbound Sand & Gravel	35	58
Brown Sandy Gravel	58	63
Brown siltbound, slightly sandy Gravel	63	83
Brown silty Sand & Gravel	83	97
Brown Sand & Gravel (water)	97	123
Gray-blue sticky clay	123	129
Brown-grayish brown, siltbound Sand and Gravel	129	137
Brown silty Sand	137	162
Brown silty Sand with clay	162	173
Brown silty Sand	173	197
Brown siltbound, slightly sandy Gravel	197	207
Tan silty clay and Gravel	207	215
Brown silty Sand & Gravel	215	229
Brown slightly silty Sand & Gravel	229	242
Brown slightly silty to silty f-m Sand and slightly silty to silty Sand & Gravel	242	257
Tan Clay	257	259
Brown, well graded, slightly cobbly, fine to coarse sandy Gravel	259	277
Brown f-m Sand and siltbound Sand & Gravel	277	281
Brown to olive gray, cobbly Sand & Gravel	281	293
Brown, siltbound, cobbly Sand & Gravel	293	295
Brown, well graded, coarse sandy, cobbly Gravel	295	316
Brown slightly silty gravelly, f-m Sand	316	333
	333	338

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Screen: 18-inch; 120 slot; 262.5 - 265.5'
18-inch; 80 slot; 265.5 - 272.5'
18-inch; 120 slot; 272.5 - 277.5
18-inch; 80 slot; 286.5 - 292.5
18-inch; 150 slot; 292.5 - 320.5

Work Started 2/22/2000 Completed 6/9/2000

WELL CONSTRUCTOR CERTIFICATION:

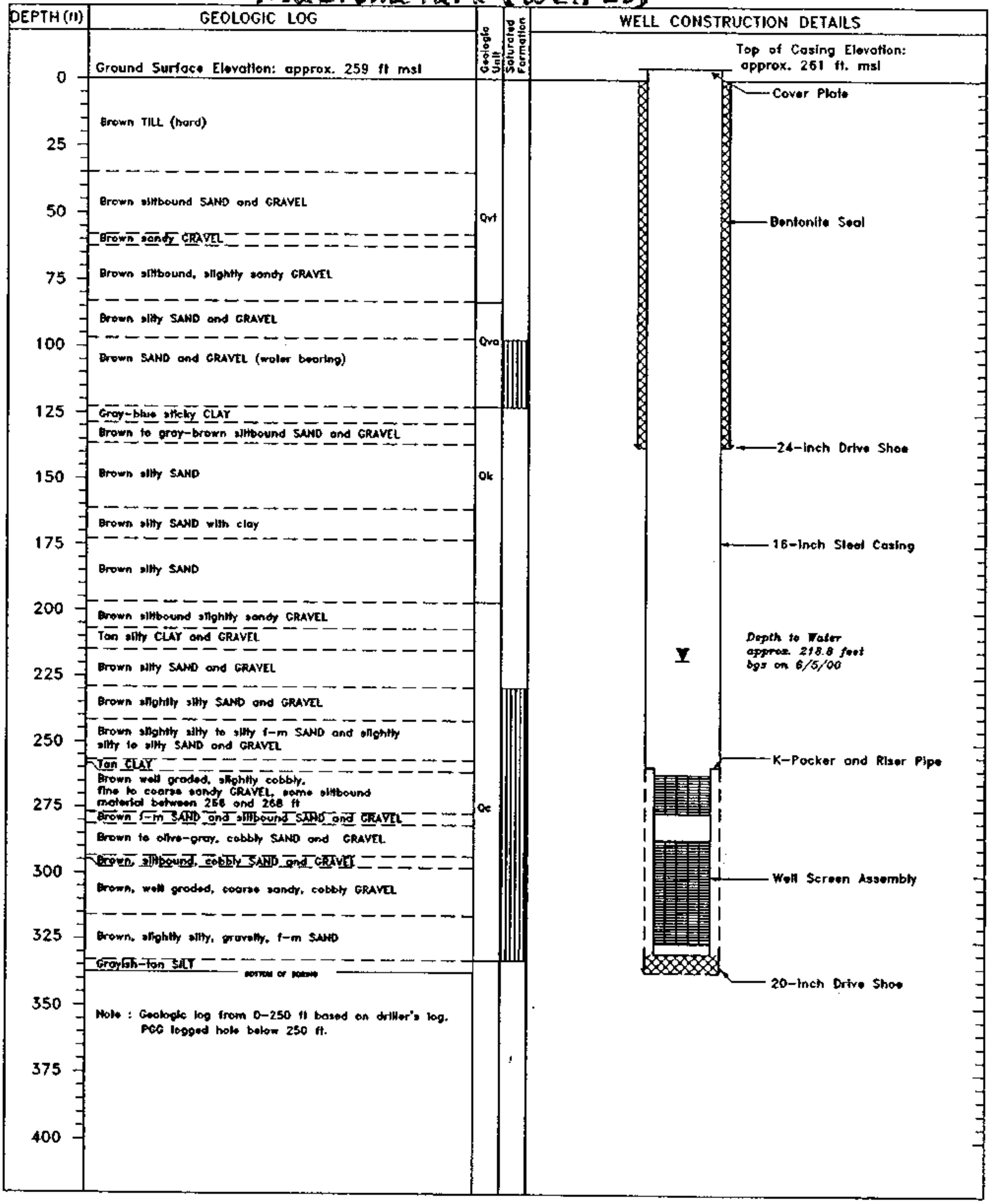
I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

NAME Arcadia Drilling Inc. (PERSON, FIRM, OR CORPORATION) (TYPE OR PRINT)
Address 170 SE Walker Park Rd Shelton, WA985
(Signed) Duane H Knapp (WELL DRILLER) License No. 1706
Contractor's Registration No. ARCADDI083I Date 7-13-00, 19___

(USE ADDITIONAL SHEETS IF NECESSARY)

Geologic Log and Well Construction Details

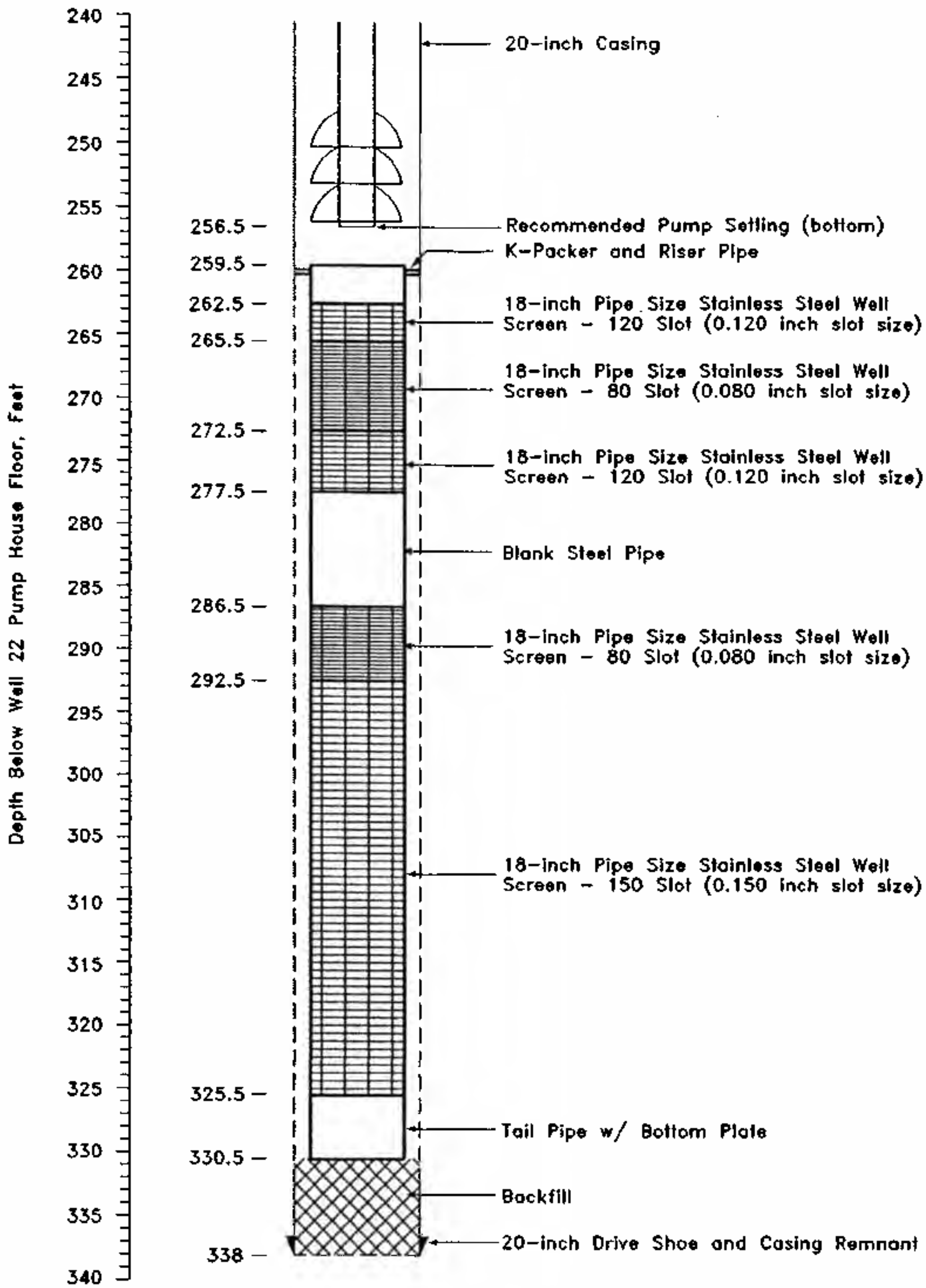
Madrona Park (Well 23)



PROJECT NAME: Lacey Groundwater Devel. Program
WELL IDENTIFICATION NUMBER: WELL 23
LOCATION: NW¼ NW¼ Sec. 24 T.18N, R.1W
CONSULTING FIRM: Pacific Groundwater Group
REPRESENTATIVE: Dan Matlock
DATUM: MSL

WATER LEVEL ELEVATION: 40.2 feet msl (approx.)
WATER LEVEL DATE: 6/5/00
START CARD NO.: W124732
UNIQUE WELL ID NO.: AEC-883
DRILLING METHOD: Cable Tool
FIRM: Arcadia Drilling

Well Screen As-Built



Note:
All screen assembly depths are referenced to the floor elevation of Well 22

FIGURE 3
GEOLOGIC LOG AND WELL DESIGN FOR MADRONA PARK WELL 23

Lacey Groundwater Development Program

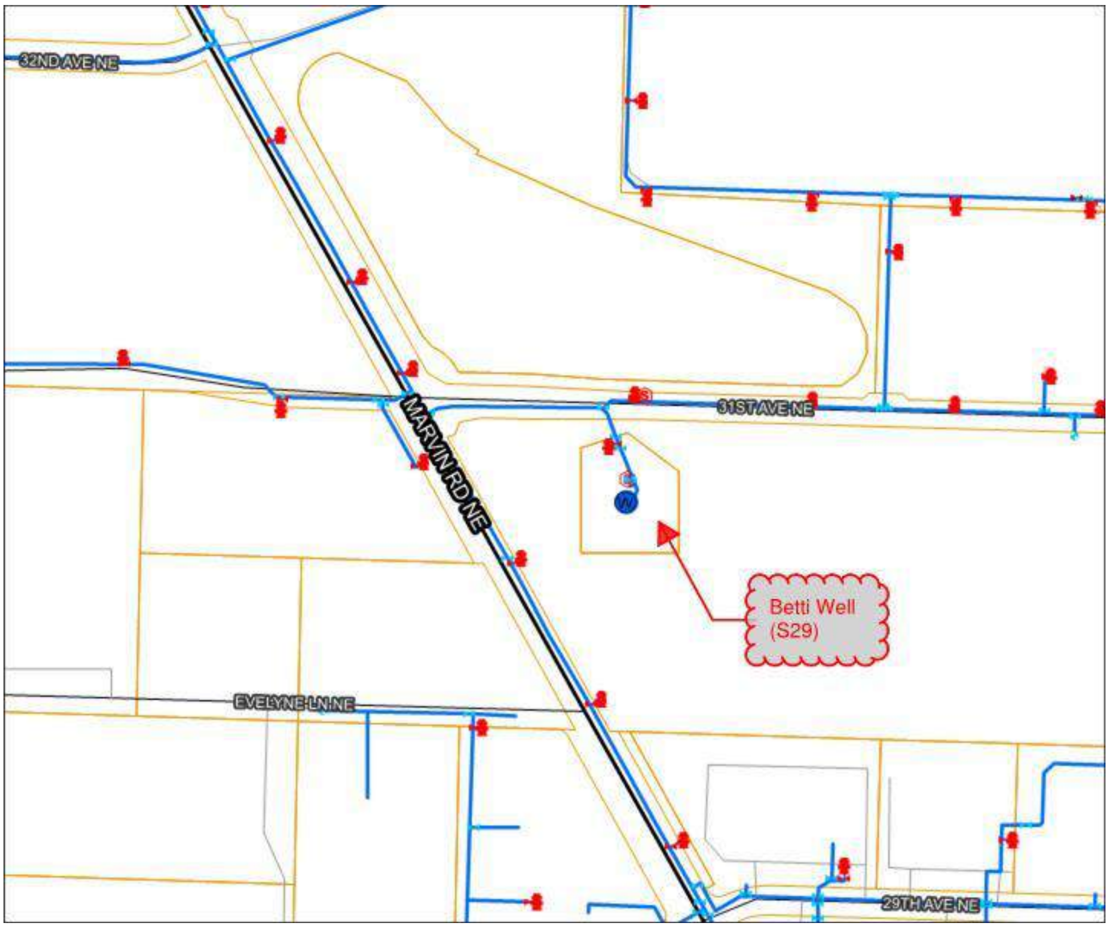
Pacific Groundwater Group

Well S29
(Betti)

Facility Information

Description	Comments
Source #	S29
Address	2950 Marvin Rd. NE
Year On-Line	2005
Pressure Zone	400
Floor Elevation	224.98
Housing	CMU
Pump Type	Turbine
Pump Model	Byron Jackson 11MQH - 10 stages
Pump Shaft Diameter (in)	1.5
Column Diameter/Length	8" column, 280'
Pump Serial #	N/A
Pump Depth (ft)	297
Pump Capacity (gpm)	1000
Motor Model	US Motor VHS 445TP
Motor Serial #	N/A
Motor Speed (rpm)	1770
Horsepower	200
Casing Diameter (in)	20
Well Depth (ft)	390
Casing Depth (ft)	300
Screen	12-inch: 35-slot (293-310, 332-348 ft), 20-slot (354-377 ft), 8x12 Colorado Silica sand
Screen Capacity (gpm)	1098
Aquifer	Qpg
Control Valves	6" 61G-21ABKC 8" 692EG-07ABCSDKC 2-1/2" 50G-01
PSV Setting	110psi @ 1000gpm
PRV Setting (psi)	86
Flow to Waste Setting	156psi @ 765gpm
Flow to Waste Duration (sec)	180
Well Capacity (gpm)	1000
Chlorine Dose (mg/L)	0.82
Reliable Capacity (gpm)	1000
Notes	

Well S29 (Betti)



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WATER WELL REPORT

STATE OF WASHINGTON

Notice of Intent W106926 (Revised)

UNIQUE WELL I.D. # AEC 941

Water Right Permit No. G2-27007

(1) OWNER: Name City of Lacey Address PO Box 3400 Lacey, WA 98509

(2) LOCATION OF WELL: County Thurston NE 1/4 SW 1/4 Sec 2 T 18 N.R. 1 W WM

(2a) STREET ADDRESS OF WELL: (or nearest address) Marvin Rd E. - Lacey

TAX PARCEL NO.:

(3) PROPOSED USE: ☐ Domestic ☐ Industrial ☒ Municipal ☐ Irrigation ☐ Test Well ☐ Other ☐ DeWater

(4) TYPE OF WORK: Owner's number of well (if more than one) ______
☒ New Well ☐ Deepened ☐ Reconditioned ☐ Decommission
Method: ☐ Dug ☐ Bored ☒ Cable ☐ Driven ☐ Rotary ☐ Jetted

(5) DIMENSIONS: Diameter of well 20" inches
Drilled 394 feet. Depth of completed well 392 ft.

(6) CONSTRUCTION DETAILS:
Casing installed: 20" Diam. from +2 ft. to 300 ft.
Welded ☒ 16" Diam. from 243.5 ft. to 293.6 ft.
Liner installed ☒
Threaded ☐ " Diam. from ______ ft. to ______ ft.

Perforations: Yes ☐ No ☒
Type of perforator used
SIZE of perforations ______ in. by ______ in.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.
______ perforations from ______ ft. to ______ ft.

Screens: Yes ☒ No ☐
Manufacturer's Name ALLOY
Type 304 SS Model No.
Diam. 12" Slot size 35 from 293.6 ft. to 309.25 ft.
Diam. 12" Slot size 35 / 30 from 332.2 / 354.9 ft. to 347.9 / 395 ft.
Gravel packed: Yes ☒ No ☐ Size of gravel
Gravel placed from 275 ft. to 392 ft.

Surface seal: ☒ Yes ☐ No To what depth? 80 ft.
Material used in seal bentonite
Did any strata contain unusable water? ☐ Yes ☒ No
Type of water? Depth of strata
Method of sealing strata off

(7) PUMP: Manufacturer's Name NA
Type: ______ H.P.

(8) WATER LEVELS: Land-surface elevation above mean sea level 233 ft.
Static level 170 ft. below top of well Date 3/18/05
Artesian pressure ______ lbs. per square inch Date
Artesian water is controlled by ______ (Cap, valve, etc.)

(9) WELL TESTS: Drawdown is amount water level is lowered below static level
Was a pump test made? ☒ Yes ☐ No If yes, by whom? DRILLER, Robinson Noble

step test
Yield: 400 gal./min. with 70 ft. drawdown after 1/2 hrs.
Yield: 800 gal./min. with 40 ft. drawdown after 1/2 hrs.
Yield: 1200 gal./min. with 60 ft. drawdown after 24 hrs.

Recovery data (time taken as zero when pump turned off) (water level measured from well top to water level)

Time	Water Level	Time	Water Level	Time	Water Level
10min	173.5	84min	170.7		
19min	172.5				
39min	171.6				

Date of test 3/18/05
Bailer test na gal./min. with ______ ft. drawdown after ______ hrs.
Airtest ______ gal./min. with ______ ft. drawdown after ______ hrs.
Artesian flow ______ g.p.m. Date
Temperature of water 49.9°F Was a chemical analysis made? ☒ Yes ☐ No

(10) WELL LOG or DECOMMISSIONING PROCEDURE DESCRIPTION
Formation: Describe by color, character, size of material and structure, and the kind and nature of the material in each stratum penetrated, with at least one entry for each change of information. Indicate all water encountered.

MATERIAL	FROM	TO
Topsoil	0	4
Gray Brown till	4	16
Dense gray clay/bound gravelly silty sand	16	190
Medium brown silty sand w/occasional gravel	190	306
Brown medium sand w/some gravel	306	312
Brown sandy silt	312	333
Brown medium sand w/silt layers and some gravel	333	357
Brown sand gravel	357	382
Brown silt + sand	382	394

12/15/04 - 3/22/05

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Work Started 12/15/04 Completed 3/22/05

WELL CONSTRUCTION CERTIFICATION:

I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Type or Print Name Dave Charon License No. 1190
(Licensed Driller/Engineer)
Trainee Name na License No. —
Drilling Company Charon Drilling, Inc.
(Signed) Dave Charon License No. 1190
(Licensed Driller/Engineer)
Address 12719-224 St E, Graham, WA 98338
Contractor's Registration No. CHARODI133NF Date 4/15/05

(USE ADDITIONAL SHEETS IF NECESSARY)

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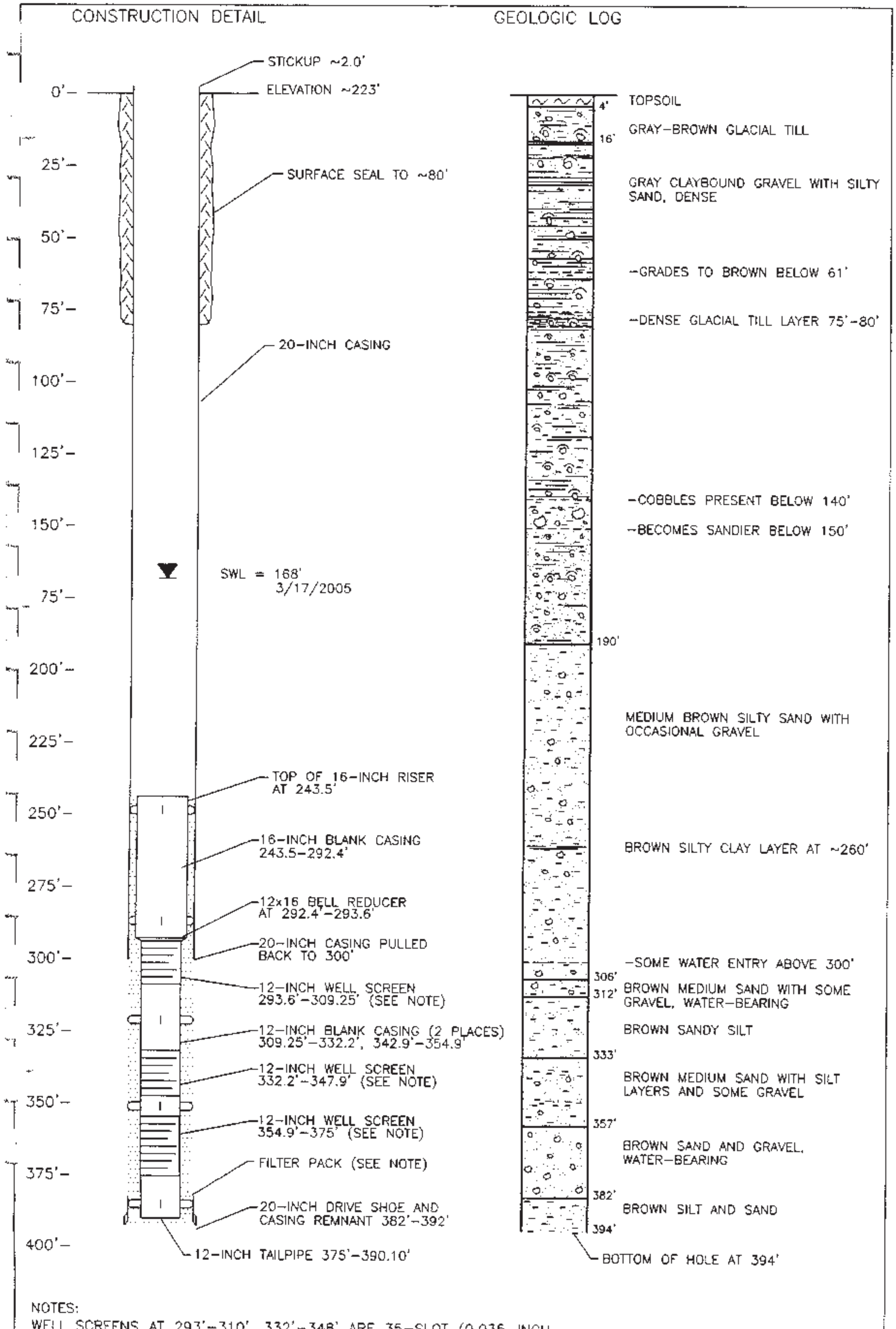
ECY 050-1-20 (11/98)



NOTES:
WELL SCREENS AT 293'-310', 332'-348' ARE 35-SLOT (0.035-INCH OPENING) WELL SCREEN AT 354'-377' IS 20-SLOT (0.020-INCH OPENING) ALL ARE 12-INCH PIPE SIZE, STANDARD STAINLESS STEEL, STRENGTH.

FILTER PACK IS 8X12 COLORADO SILICA SAND PRODUCT.

ROBINSON NOBLE SALTBUSH INC. GROUNDWATER & ENVIRONMENTAL SCIENTISTS	PM: CE T 18 N/R 1 W - 2 1518-006A May 2005	Figure 3 Construction Detail and Geologic Log for the Betti Production Well City of Lacey

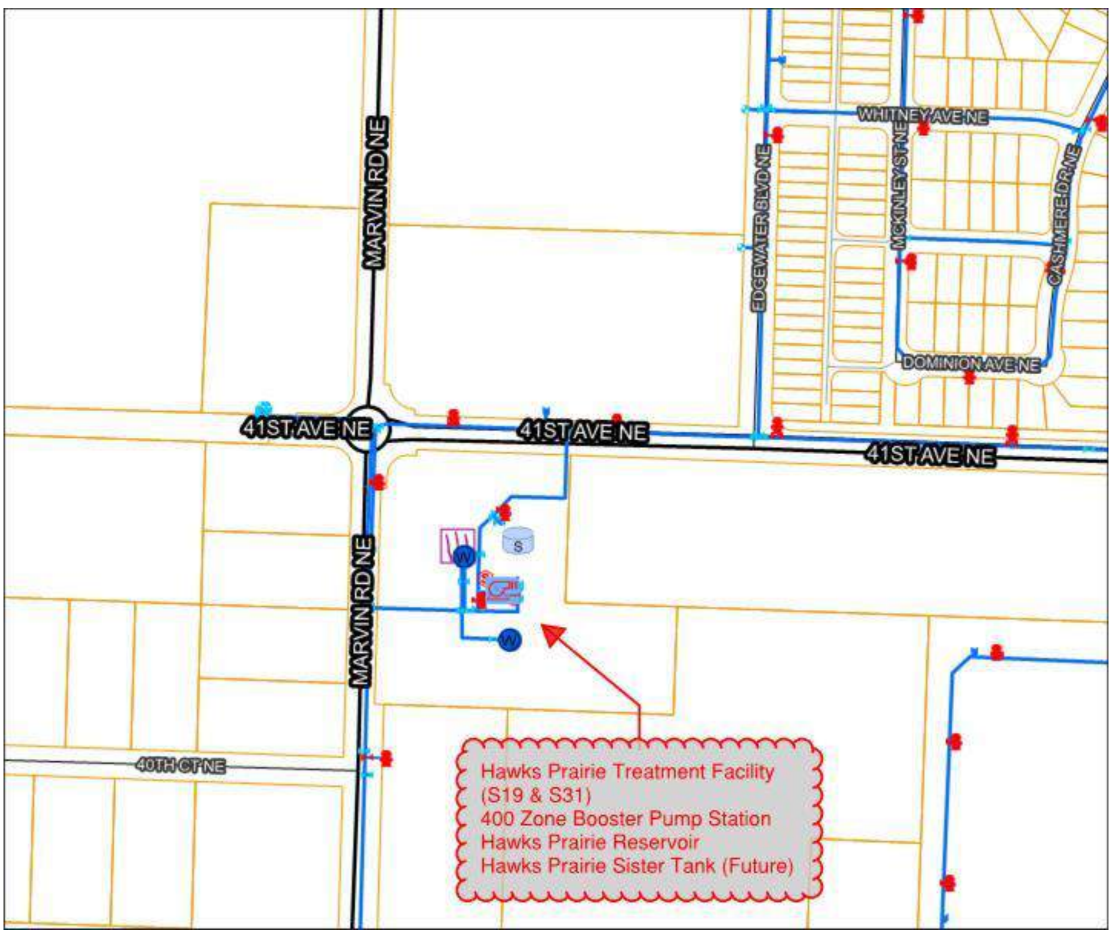
Well S31

(Hawks Prairie #2)

Facility Information

Description	Comments
Source #	S31
Address	4040 Marvin Rd. NE
Year On-Line	2013
Pressure Zone	400
Floor Elevation	298.63
Housing	CMU
Pump Type	Submersible
Pump Model	Peerless 12LD (7-stage)
Pump Shaft Diameter (in)	N/A
Column Diameter/Length	10" column, 470'
Pump Serial #	N/A
Pump Depth (ft)	480
Pump Capacity (gpm)	1000 GPM @ 505 FT TDH
Motor Model	Hitachi
Motor Serial #	N/A
Motor Speed (rpm)	1800
Horsepower	200
Casing Diameter (in)	20
Well Depth (ft)	656
Casing Depth (ft)	500
Screen	20-inch: 15-slot (498-518 ft), 12-slot (518-525 ft), 10-slot (573-598 ft), Blanked Off (629-648 ft)
Screen Capacity (gpm)	N/A
Aquifer	TQu
Control Valves	Solenoid Control in Treatment Plant
PSV Setting	Solenoid Control Valve 800 gpm
PRV Setting (psi)	N/A
Flow to Waste Setting	N/A
Flow to Waste Duration (sec)	400
Well Capacity (gpm)	900
Chlorine Dose (mg/L)	N/A
Reliable Capacity (gpm)	800
Notes	Poor water quality, elevated iron, manganese, ammonia, and sulfides. Flows directly to the Hawks Prairie Water Treatment Facility. Occasional episodes of sand production.

Well S31 (Hawks Prairie #2)

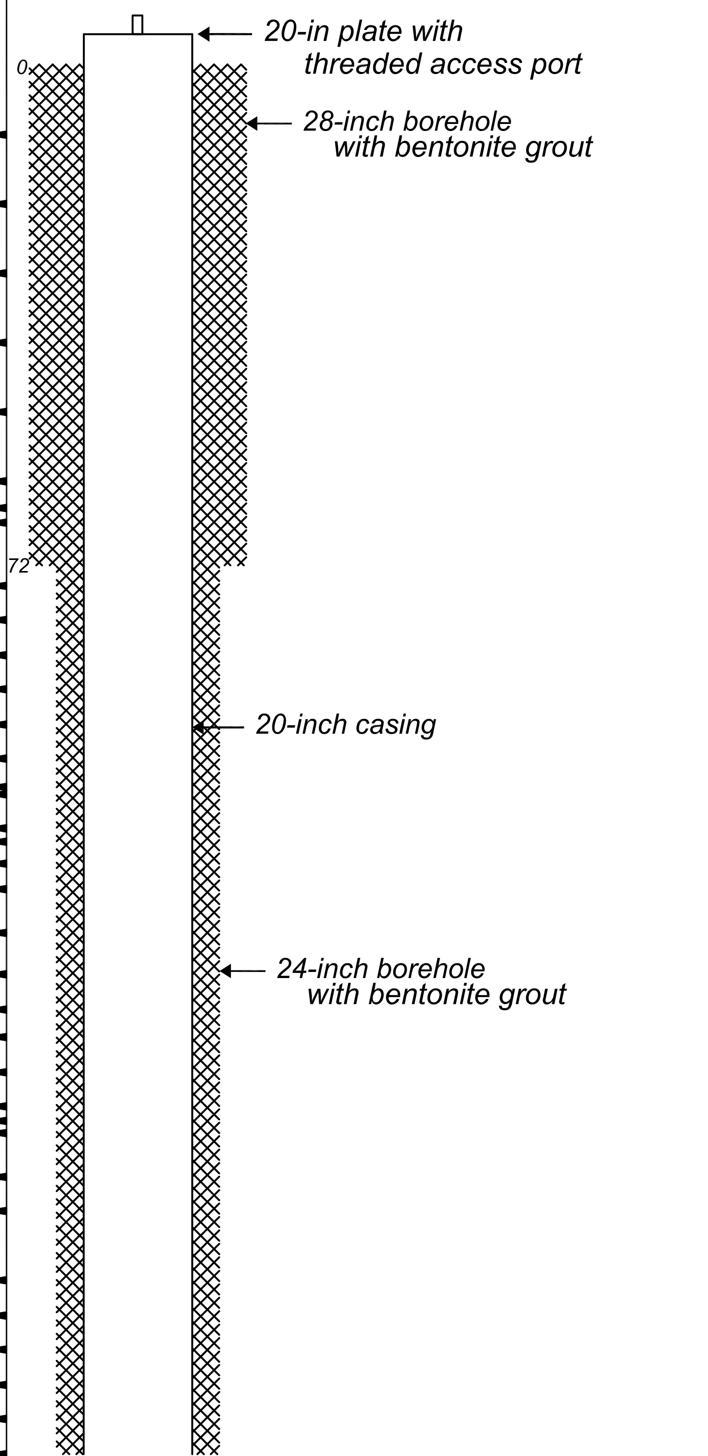


Depth Below Ground (feet)	GEOLOGIC LOG	HG unit or Zone
0	*Ground Elevation 295.5 feet msl*	
	Med loose, sli silty, f-m SAND & c SAND	*Soil*
	Loose, sli silty, m-c sndy; f-m GRVL	*Qvr*
25	*Olive gray, m-c SAND & GRVL*	*Qvr*
50	*Lt olive gary, silty, f-c sndy, f-m GRVL*	*Qvt*
75	*Multi colored (predom ol gry), loose,"clean", m-c SAND; local gravel*	*Qva*
	Olive gray, loose, sli silty & f sndy, m-c SAND; local gravel	*Qva*
	Olive gray, loose, sli silty, c sndy, f-m SAND	*Qva*
100	*Olive gray, loose, silty, f SAND*	*Qva*
	Olive gray, sli silty, sli c. sandy f-m SAND	*Qva*
	Olive gray, ls, sli f grvly, f-c SAND	*Qva*
125	*Olive gray, ls, sli silty & c sndy, f-m SAND*	*Qva*
	Olive gray, loose, f sandy, m-c SAND	*Qva*
150	*Olive gray, loose, f grvly, f-m SAND*	*Qva*
175	*Olive gray, loose, cobbly, c GRAVEL & f-mSAND*	*Qva*
	Multi-colored, (predom brown), loose, rnd, f-c SAND and f-c GRAVEL	*Qva*
	Mulit-colr (prdm gry), ls, f-c sndy, f-c GRVL	*Qva*
200	*Borehole log continues on next page*	*Qk*

f = fine, m = medium, c = coarse
sli = slightly, bnd = bound

Sample

WELL CONSTRUCTION DETAILS



version 7/31/20

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PROJECT NAME: City of Lacey, Potable Water Exploration
DRILLING METHOD: DR 28-in; Cable Tool 24-inch / 20-inch
DRILLER: Gordon Burton; Richard Miller
FIRM: Boart Longyear; Zone 3 modification by Holt Services
CONSULTING FIRM: Northwest Land & Water, Inc.
REPRESENTATIVE: Jim Mathieu
LOCATION: NW 1/4 SW 1/4 Sec 35, T19N, R1W
WELL NAME: HP2
WELL TAG ID: BAM406

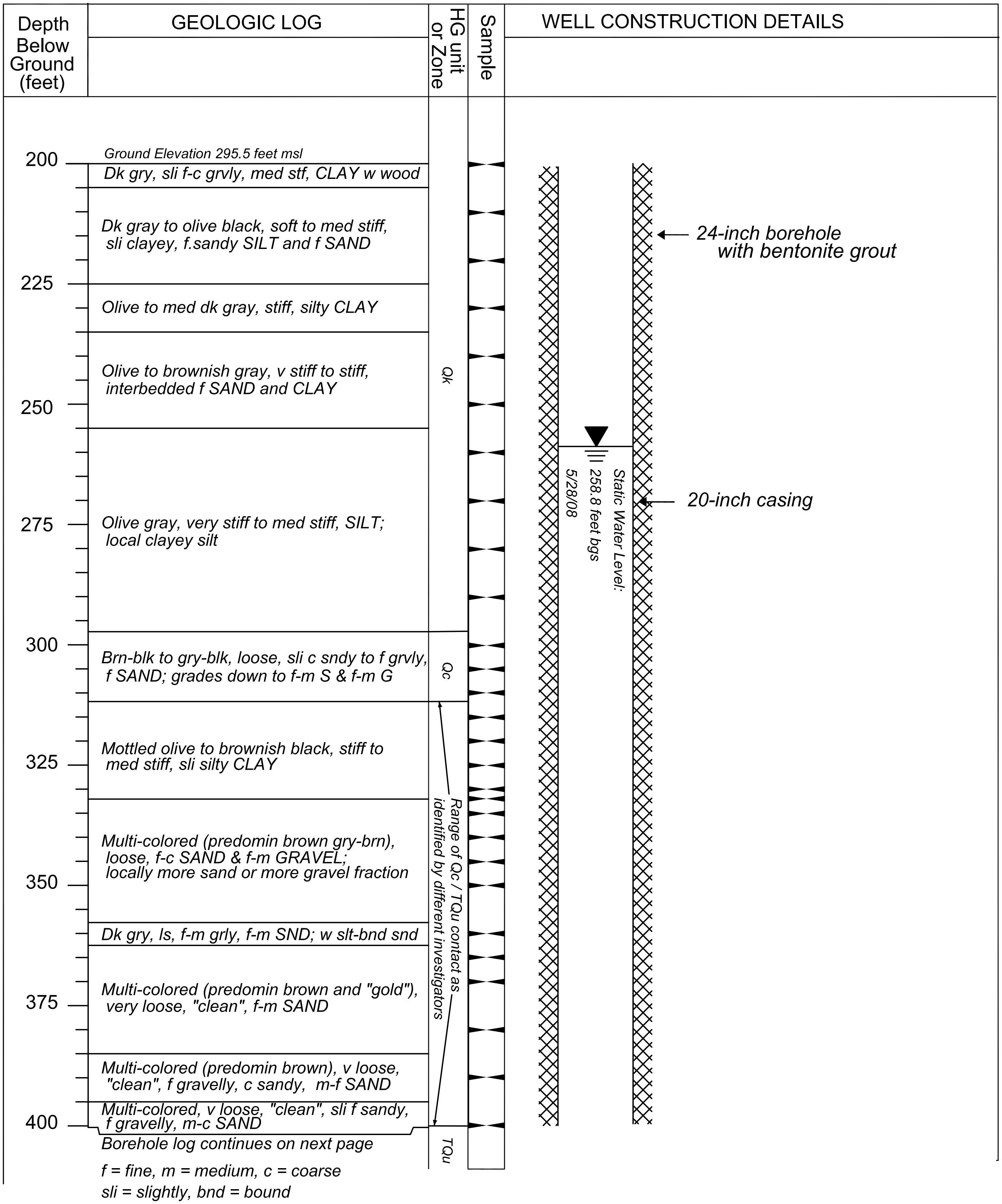
Figure 1 (page 1/4)

Well S31 Log and Packer Assembly*
Plugging Zone 3 (lower screen)

*assembly constructed in well 3/13/18

Potable Water Exploration
City of Lacey

NORTHWEST Land & Water, Inc.



version 7/31/20

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Figure 1 (page 2/4)

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Potable Water Exploration
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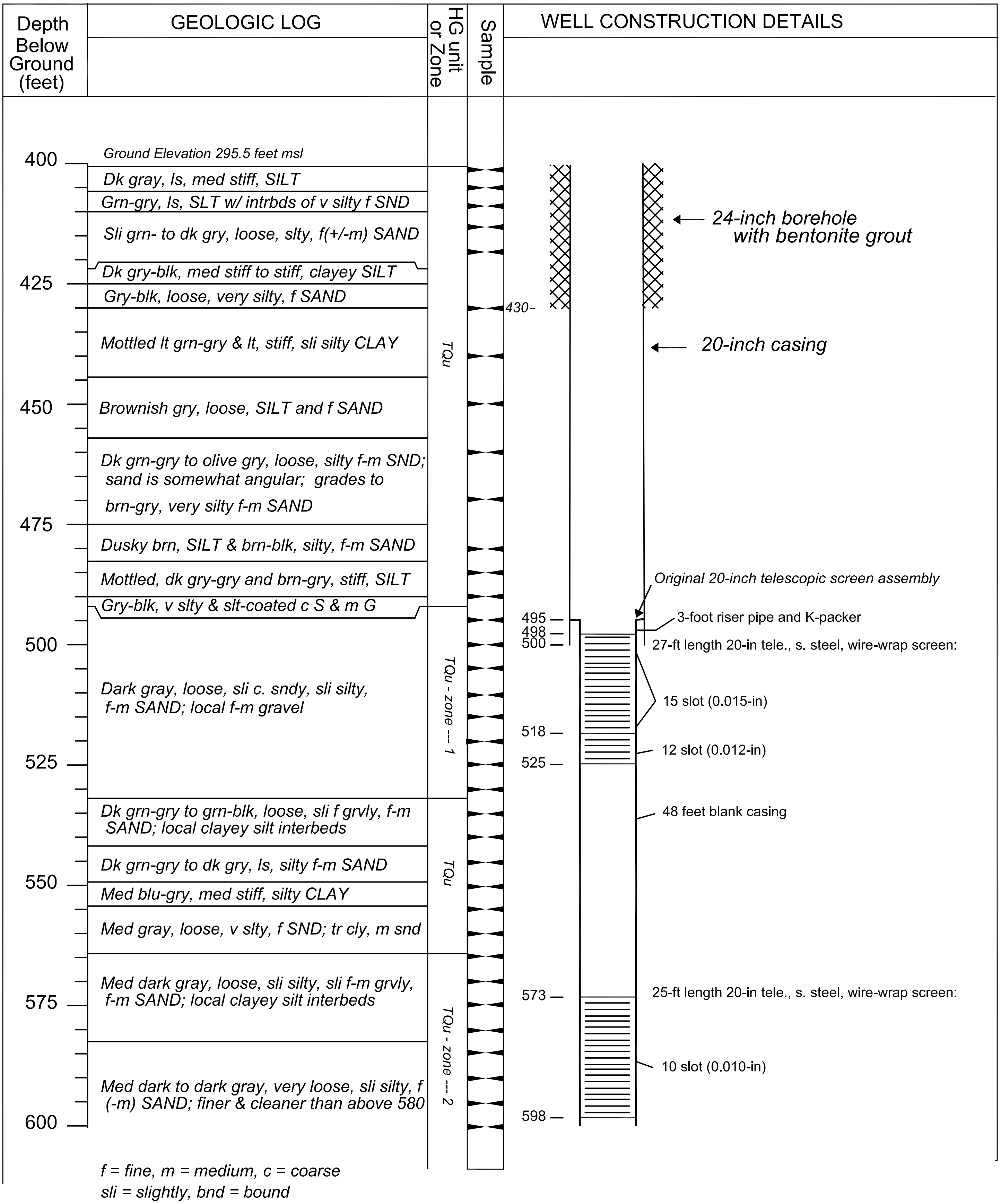

version 7/31/20

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Figure 1 (page 3/4)

Well S31 Log and Packer Assembly*
Plugging Zone 3 (lower screen)

*assembly constructed in well 3/13/18

Potable Water Exploration
City of Lacey

Northwest Land & Water, Inc.

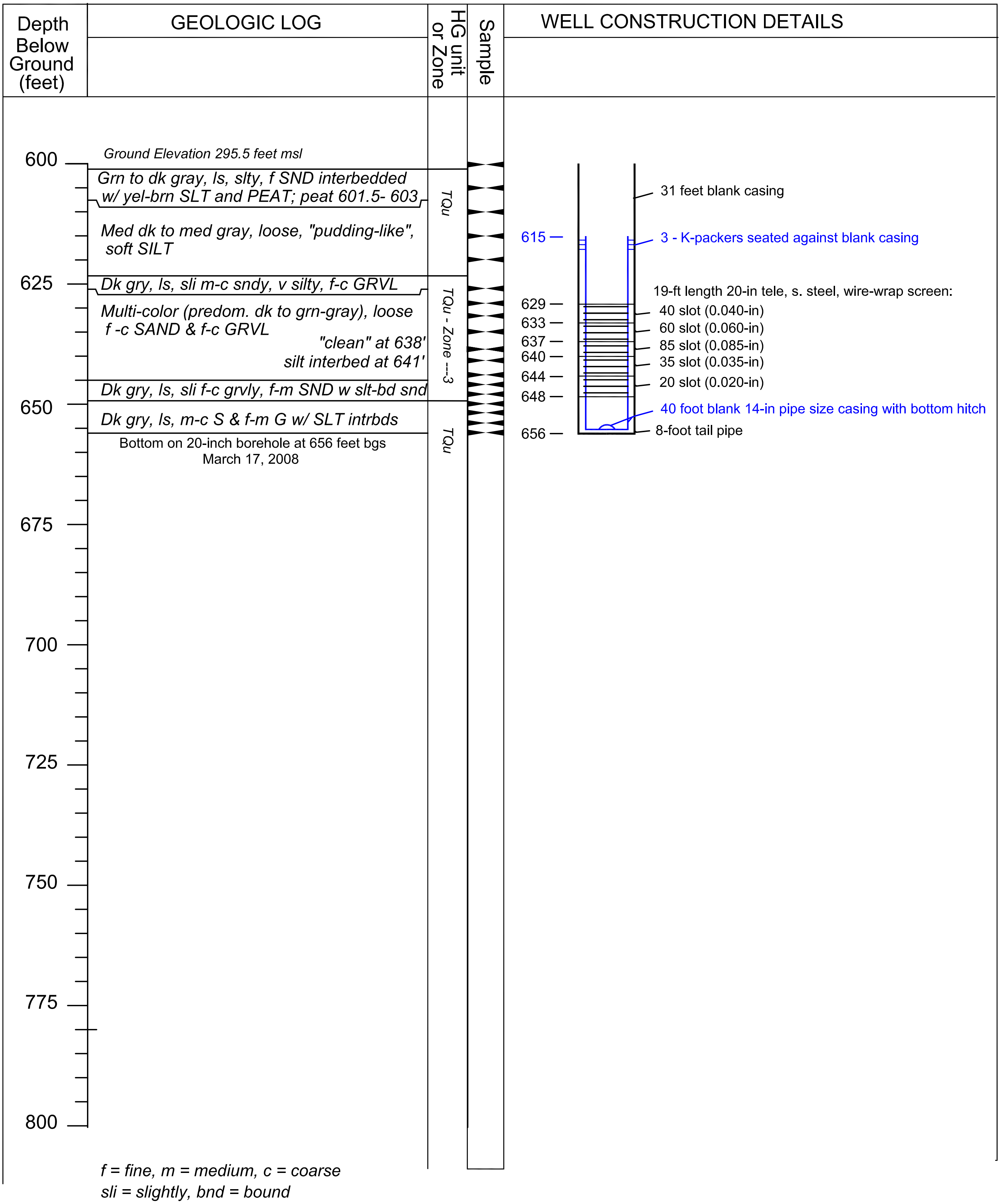

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Figure 1 (page 4/4)

Well S31 Log and Packer Assembly*
Plugging Zone 3 (lower screen)

*assembly constructed in well 3/13/18

Potable Water Exploration
City of Lacey

NORTHWEST Land & Water, INC.

version 7/31/20

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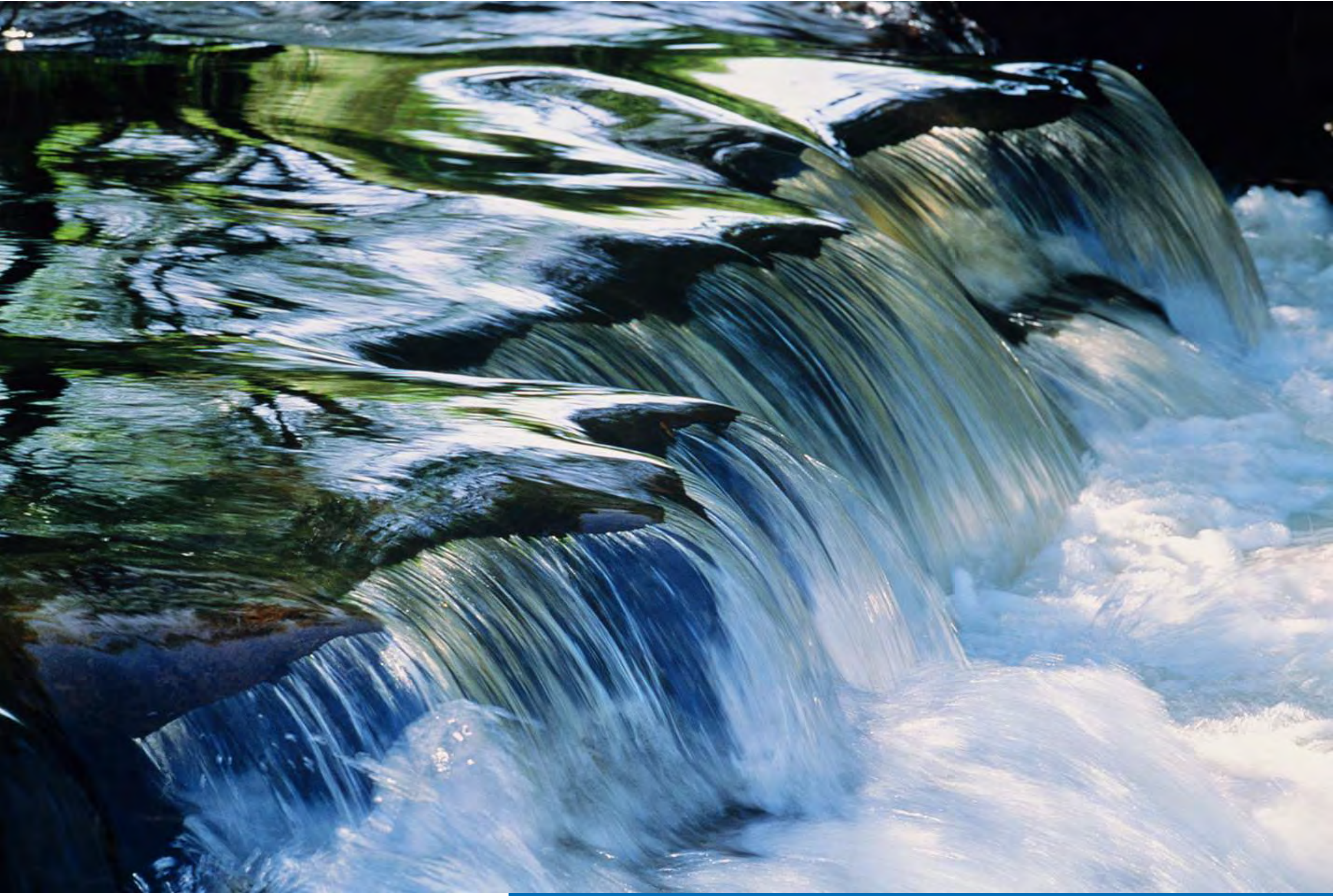
Appendix G

337 and 400 Zone Pressure and Storage Study Reports



City of Lacey
337 Pressure Zone Facilities and Pressure, and
400 Pressure Zone Storage Studies

Report 2
337 PRESSURE ZONE FACILITIES AND PRESSURE STUDY

FINAL | December 2018

City of Lacey
337 Pressure Zone Facilities and Pressure,
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Report 2
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DANIEL L. REISINGER
STATE OF WASHINGTON
53657
REGISTERED
PROFESSIONAL ENGINEER

Contents

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Tables

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Abbreviations

AACE	American Association of Cost Engineers
ADD	average day demand
AWWA	American Water Works Association
BPS	booster pump station
Carollo	Carollo Engineers, Inc.
CIP	Capital Improvement Plan
City	City of Lacey
Comp Plan	Water System Comprehensive Plan Update, February 2013
DOH	Washington State Department of Health
ENR	Engineering News Record
fps	feet per second
ft	feet
FTE	full time equivalent
gpm	gallons per minute
HGL	hydraulic-grade-line
hp	horsepower
HPWTF	Hawks Prairie Water Treatment Facility
kWh	kilowatt hour
LF	linear feet
MDD	maximum day demand
MG	million gallons
mgd	million gallons per day
O&M	operations and maintenance
PHD	peak hour demand
PRV	pressure reducing valve
psi	pounds per square inch
PSV	pressure sustain valve
PVC	polyvinyl chloride
PZ	Pressure Zone
ROW	right-of-ways
SCADA	supervisory control and data acquisition
sf	square feet
UDF	unidirectional flushing
VFD	variable frequency drive
WSDM	DOH Water System Design Manual, 2009
WTPO	Water Treatment Plant Operator

EXECUTIVE SUMMARY

ES.1 Introduction

The City of Lacey's (City) 337 Pressure Zone (PZ) is located in the western portion of the distribution system. It has numerous facilities, such as reservoirs, wells, pump stations, and receives flows from the 400 PZ. This pressure zone struggles with aging well sources, low pressures along the College Street Corridor, challenging water quality within the distribution system, transmission challenges from existing sources, and continued growth.

To mitigate these challenges, a study was conducted evaluating the existing infrastructures and low pressures experienced in the City's College Corridor. Additionally, the study selected supply projects to meet system-wide demands through 2028.

During this time, the following improvements are needed for the City to maintain a high level of service to its customers:

- New supply sources to meet demand growth.
- Water storage to improve operations and provide emergency storage.
- New infrastructure to improve water pressures for high elevation customers.

A study was conducted to explore alternatives that would allow the City to serve customers during peak demand and improve local pressures. This report summarizes the results of the study.

ES.2 Hydraulic Model Update

The City provided a calibrated hydraulic model that represented 2016 winter and summer conditions. Carollo Engineers, Inc. (Carollo) allocated future (4-year and 10-year) water demands to appropriate nodes in the hydraulic model. Carollo also added the nine planned pipeline improvement projects to the hydraulic model, listed below:

- College and 22nd Street.
- Capital City Golf Course Fire Flow Improvement.
- 2017 Waterline Replacement Project 2.
- Mullen Road Water Project.
- 48th Avenue and 50th Avenue NE (Beachcrest) Fire Flow Improvements.
- Impala Water Main Replacement.
- Oak Preserve Development.
- Gateway Development.
- Willamette Drive Velocity Improvements (long-term scenario).

ES.3 Supply Assumptions and Ability to Serve

To meet its current supply needs, the City uses groundwater wells. Additional supply sources are needed to meet demand growth throughout the entire system. A high-level "supply and ability to serve evaluation" was performed to compare available supply in the next 10 years (2028) to projected demands. The evaluation used existing supplies and five planned water supply improvement projects:

1. Pump improvements at S19 and S31 going back online to add 980 gallons per minute (gpm) (1.41 million gallons per day [mgd]) of supply.
2. S15/S16 upgrades in 2019 to add 110 gpm (0.16 mgd) of supply.
3. New Marvin Road Well with a pumping capacity of 1,000 gpm (1.44 mgd) in 2021. The increase in supply is 200 gpm (0.29 mgd) because the Hawks Prairie Water Treatment Facility (HPWTF) can only treat 1,800 gpm (2.59 mgd) of supply from S19, S31, and Marvin Road Well.
4. The replacement well for S01 will be in service in 2022 to add 665 gpm (0.96 mgd) of supply.
5. HPWTF expansion in 2028 will allow the full use of S19, S31, and Marvin Road Well water rights to add 800 gpm (1.15 mgd) of supply.

The evaluation found that in addition to the current and planned supplies, the City will need additional supply capacity by 2028. This finding underscores the importance of implementing the above planned system improvements, as well as developing new supplies. The City identified two new supply improvement projects to meet this deficit:

- 2022: Madrona Transmission Improvements to make full use of Madrona's full water rights.
- 2025: HPWTF expansion or Drill a new well next to S04.

Should the City not make the supply system improvements per the above schedule or demands vary from projections, the results will differ from those presented in this report.

ES.4 Preliminary System Analysis

This section summarizes the preliminary system analysis to understand the improvements to the distribution system to better meet level of service goals and criteria. The study evaluations used criteria consistent with the City's Water System Comprehensive Plan Update (Comp Plan) from February 2013 and Washington State's Department of Health (DOH) 2009 Water System Design Manual (WSDM).

ES.4.1 Storage Analysis

The Comp Plan identified a 337 PZ storage deficiency of 2.97 million gallons (MG) in 2029. This study sought to provide additional 337 PZ storage at the Intelco Loop reservoir site, while also improving distribution system pressures and operational flexibility. Future reservoir projects at other sites will be required to address the remaining 337 PZ storage deficiency.

ES.4.2 Customers with Low Pressures

High elevation customers in the Southwestern portion of the distribution system experience low pressures, identified as those below 40 pounds per square inch (psi). At these pressures plumbing fixtures and appliances may be negatively impacted, especially in upper stories of buildings. Additionally, some customers infrequently experience even further temporary pressure reductions to as low as 32 psi. While the City exceeds the State required pressure of 30 psi, low pressures are perceived negatively by customers. To increase service pressures the City would need to create a new higher pressure zone for these high elevation customers, referred to as rezoning or a rezone. The Intelco Loop reservoir site is ideally situated to serve both 337 PZ and the proposed rezone. Even without the rezone, the Intelco reservoir can mitigate the temporary pressure reductions in the area.

ES.5 Recommended Alternatives

Three alternatives were developed to provide 337 PZ storage and maintain pressures along the College Street Corridor under 2028 peak hour demand (PHD) and during fire flow events:

- <u>Alternative 1 – Rezone with At-Hydraulic-Grade Tank</u> involves rezoning customers that experience low pressures and adding storage along the College Street Corridor. The rezone boundary was developed to minimize the impact to existing distribution mains along College Avenue and was done with the City's input. An at-hydraulic-grade tank supplies the new zone through a new pump station, both located at the Intelco Loop site. The tank can also supply the 337 PZ without pumping.
- <u>Alternative 2 – Rezone with Below-Hydraulic-Grade Tank</u> is similar to Alternative 1. Like Alternative 1, Alternative 2 involves rezoning the customers in the College Corridor and adding storage volume at the Intelco property. However, for this alternative, new storage would be a below-hydraulic-grade reservoir, and requires a pump station to supply the both the 337 PZ and new PZ.
- <u>Alternative 3 – No Rezone and At-Hydraulic-Grade Tank</u> involves constructing an at-hydraulic-grade tank at the Intelco site. It does not rezone high elevation customers to increase pressures, but will mitigate the temporary pressure reductions in the area. This alternative also recommends adding a variable frequency drive (VFD) to Well 10 to improve operations of the new tank.

ES.6 Life-Cycle Costs and Capital Costs

The cost estimates developed in this report are American Association of Cost Engineers (AACE). Class 4 estimates, which are planning-level estimates only and should be refined during pre-design.

The resulting costs for the three alternatives are shown below in Table ES.1. Detailed cost estimates for each alternative can be found in the Appendix B. Ranking for each alternative is also shown as described in the next section.

Table ES.1 Summary Costs

Costs	337 PZ Alternative 1	337 PZ Alternative 2	337 PZ Alternative 3
Capital Costs(1)	$10,399,500	$9,043,300	$6,070,200
O&M(2) Costs(3)	$11,851,000	$13,529,900	$2,327,000
Total Capital and O&M(4)	**$22,250,500**	**$22,573,200**	**$8,397,200**
Ranking (Score)(5)	**2.90**	**3.20**	**3.90**

Notes:
(1) Capital costs are in 2022 dollars.
(2) O&M: operation and maintenance.
(3) O&M costs are inflated to the year in which the operation or maintenance is performed, over a 50-year period.
(4) Total costs rounded to the nearest $100.
(5) Weighted ranking from 1 (worst) to 5 (best) based on life cycle (capital plus O&M) cost, pressure, water quality, and O&M.

ES.7 Alternatives Ranking

Each Alternative was ranked by Carollo and City Staff based on life cycle (capital plus O&M) cost, pressure, water quality, and O&M. A weighted ranking was given for each criteria from 1 (worst) to 5 (best) and combined for a total Alternative ranking score. Receiving the highest score, Alternative 3 – No Rezone and At-Hydraulic-Grade Tank, was recommended for implementation. Alternative 3 had the lowest life cycle costs, reduces temporary pressure reductions in the area, and added the least operational complexity of the alternatives. Alternative 3 does not significantly increase low pressures in the College Corridor during normal operations, but is expected to prevent pressure sags.

It is recommended that a 0.75 MG elevated style at-hydraulic-grade be constructed to provide the benefits described above and provide a portion of the required storage in the 337 PZ.

Section 1

BACKGROUND

The City of Lacey's (City's) 337 Pressure Zone (PZ) is located in the western portion of the distribution system. It has numerous facilities, such as reservoirs, wells, pump stations, and pressure reducing valves (PRVs) from the 400 PZ. Figure 1 shows the study area for the report.

This pressure zone struggles with aging well sources, low pressures along the College Street Corridor, challenging water quality within the distribution system, transmission challenges from existing sources, and continued growth.

To mitigate these challenges, a study was conducted evaluating the existing infrastructures and low pressures experienced in the City's College Corridor. Additionally, the study selected supply projects to meet system-wide demands through planning year 2028.

This report summarizes the results of this study and provides information on the following:

- Evaluation criteria for the study.
- Supply project selection.
- Description of alternatives.
- Results of a hydraulic analysis of alternatives.
- Recommended alternative to serve customers.

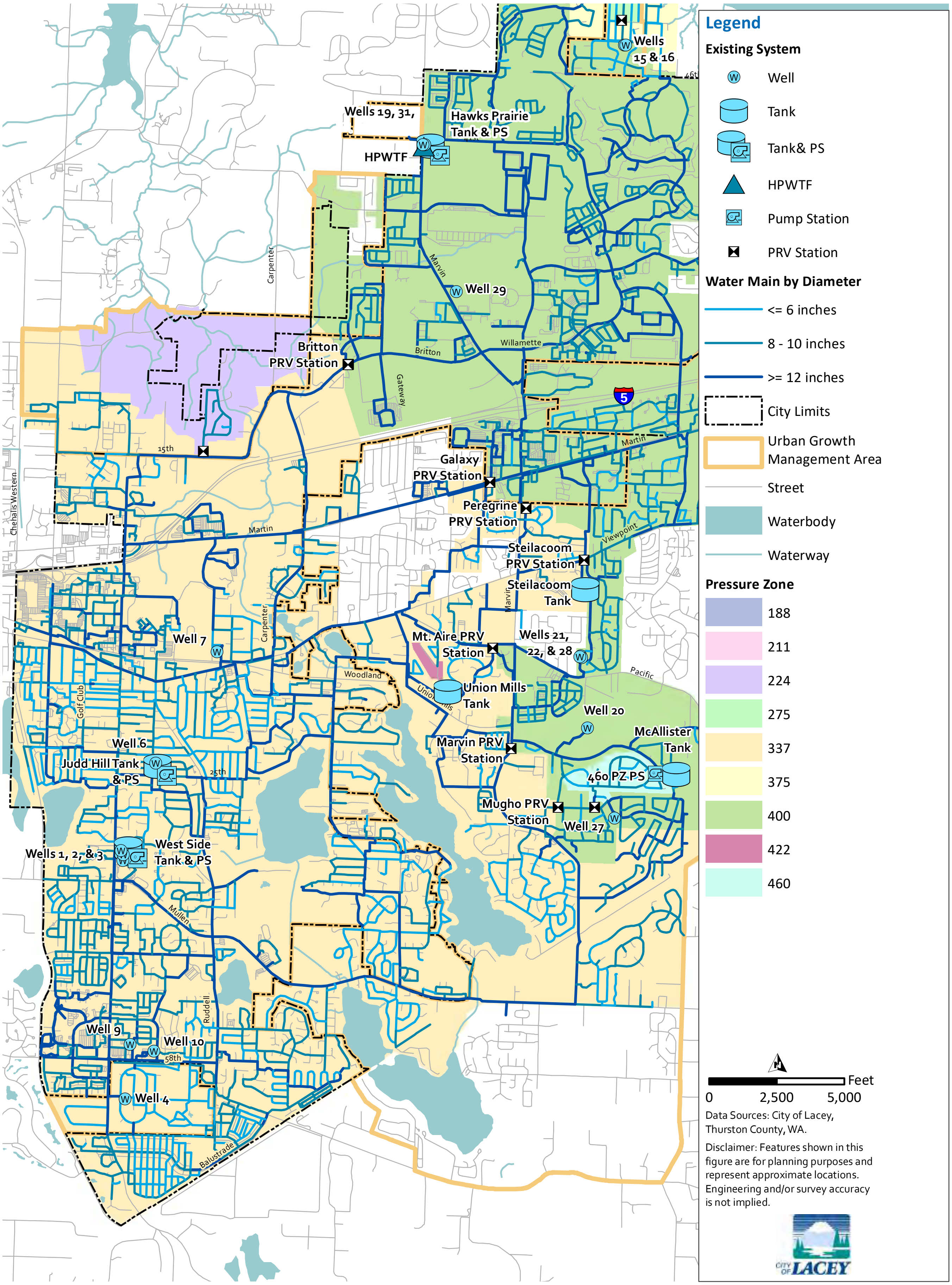


Figure 1 337 Pressure Zone Study Area

Section 2

SUPPLY ABILITY TO SERVE

A high-level "supply and ability to serve evaluation" was performed at the beginning of the project. The following sections describe the results from this evaluation and present recommended improvements to the infrastructure to mitigate future supply deficiencies.

2.1 Demands

System-wide demands were reviewed from the Water System Comprehensive Plan Update (Comp Plan). For this study, no new demand forecasts were completed. Figure 2 compares projected system-wide average day demand (ADD) with historical consumption data from 2009 through 2017. As shown, the rate of demand increased similarly.

However, historical demands were approximately 0.8 million gallons per day (mgd) below projected demands; the 2017 ADD was roughly equivalent to the projected 2012 ADD. As a result, the projected demands were "scaled down" to match historical consumption, as shown on Figure 2, effectively shifting demands five years into the future. For example, the Comp Plan's 2023 demands were considered the 2028 demands for this study.

Table 1 shows updated ADD and maximum day demand (MDD) for 2017, near-term (2022), and long-term (2028) planning periods. The MDD to ADD peaking factor of 2.2 and peak hour demand (PHD) to MDD peaking factor of 1.6 were both unchanged from the Comp Plan.

Carollo Engineers, Inc. (Carollo) recommends that the City update its demand projections during its upcoming Water System Plan Update. Although the study's scaled down demands are adequate for conceptual level hydraulic modeling in this study, they should not be used for water rights, supply timing, or storage facility sizing.

Table 1 Summary of Projected Demands

Year	ADD		MDD	
	(mgd)	(gpm)	(mgd)	(gpm)
2017	7.43	5,200	16.34	11,300
2022	8.25	5,700	18.15	12,600
2028	9.14	6,300	20.12	14,000

Note:
(1) gpm: gallons per minute.

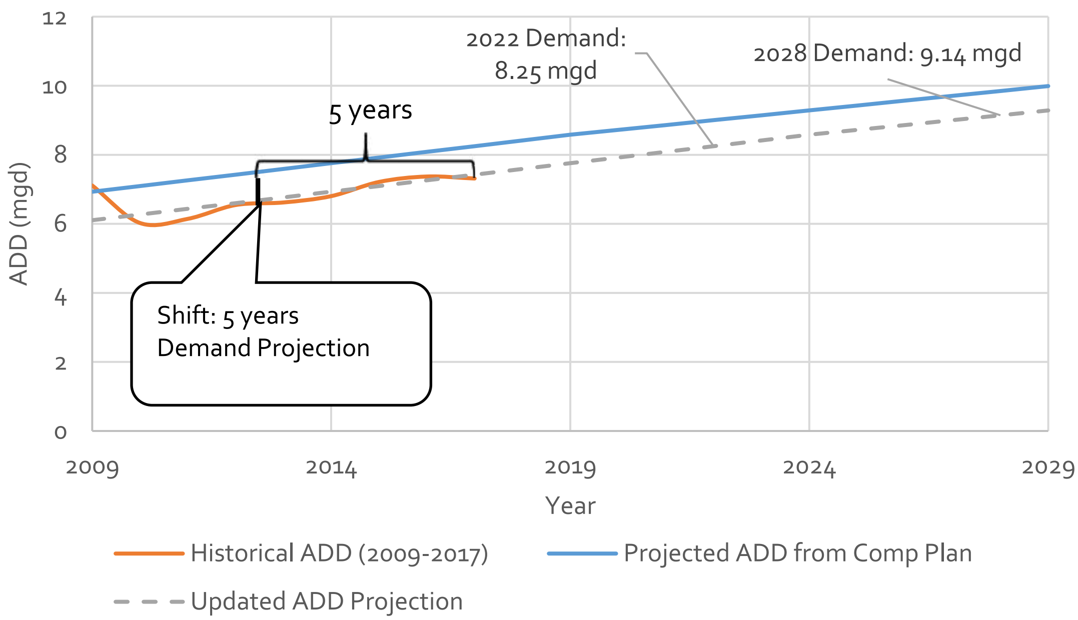


Figure 2 Adjusted Demand Projections

2.2 Ability to Serve Requirements

To meet its current supply needs, the City uses groundwater. The analysis described in this section evaluated the City's groundwater wells "ability to serve," a measurement commonly used for long-term planning.

"Ability to serve" is the maximum water a source can produce given the following limitations:

- Water Rights: The maximum water rights available.
- Pumping Capacity: Pumping capacity for each individual well, according to the City.
- Treatment Capacity: Total treatment capacity for each well.
- Operational/ Seasonal Limitations: Limitations on supply use due to seasonal variations in available supply or operational requirements.

Table 2 shows all of the City's groundwater wells "abilities to serve" taking into account the limitations described above.

Table 2 Wells Ability to Serve

Well No.	Pressure Zone	Ability to Serve (gpm)	Ability to Serve (mgd)
S01	337 PZ	0	0.00
S02	337 PZ	500	0.72
S03	337 PZ	206	0.30
S04	337 PZ	750	1.08
S06	337 PZ	290	0.42
S07	337 PZ	1,800	2.59
S09	337 PZ	730	1.05
S10	337 PZ	1030	1.48
S15	400 PZ	190	0.27

Table 2 Wells Ability to Serve (continued)

Well No.	Pressure Zone	Ability to Serve (gpm)	Ability to Serve (mgd)
S16	400 PZ	220	0.32
S19	400 PZ	620	0.89
S20	400 PZ	580	0.84
S21	400 PZ	1,350	1.94
S22	400 PZ	1,350	1.94
S24	188 PZ	80	0.12
S25	188 PZ	160	0.23
S27	400 PZ	1,000	1.44
S28	400 PZ	1,350	1.94
S29	400 PZ	1,000	1.44
S31	400 PZ	0	0.00

To estimate future supply needs and recommend supply improvements, the "ability to serve" was compared to the near-term and long-term MDD demands listed in Section 2.1. Carollo recommends updating this evaluation after the demand projections are updated in the upcoming Water System Plan Update.

2.3 "Ability to Serve" Analysis

For this analysis, criteria were developed that consider the firm supply capacity, or "redundancy." Firm capacity is the total supply sources with the largest source out of service, in this case Well S7.

Operational criteria were also used in the analysis to measure the system's capacity to provide water with a commonly out of service well in addition to the largest source out of service. In this case, the commonly out-of-service supply source is Well S19.

According to the analysis, the City can supply approximately 13,206 gpm (19.01 mgd). When the redundancy and operation criteria are applied to the analysis, however, the City's "ability to serve" was approximately 10,786 gpm (15.53 mgd).

2.3.1 Planned Supply Improvements

To meet future demands and provide additional redundancy and operational flexibility, the City planned for five water supply improvement projects in its Capital Improvement Plan (CIP):

1. Pump improvements at S19 and S31 going back online to add 980 gpm (1.41 mgd) of supply.
2. S15/S16 upgrades in 2019 to add 110 gpm (0.16 mgd) of supply.
3. New Marvin Road Well with a pumping capacity of 1,000 gpm (1.44 mgd) in 2021. The increase in supply is 200 gpm (0.29 mgd) because the Hawks Prairie Water Treatment Facility (HPWTF) can only treat 1,800 gpm (2.59 mgd) of supply from S19, S31, and Marvin Road Well.
4. The replacement well for S01 will be in service in 2022 to add 665 gpm (0.96 mgd) of supply.
5. HPWTF expansion in 2028 will allow the full use of S19, S31, and Marvin Road Well water rights to add 800 gpm (1.15 mgd) of supply.

Figure 3 shows the locations of these supply improvements.

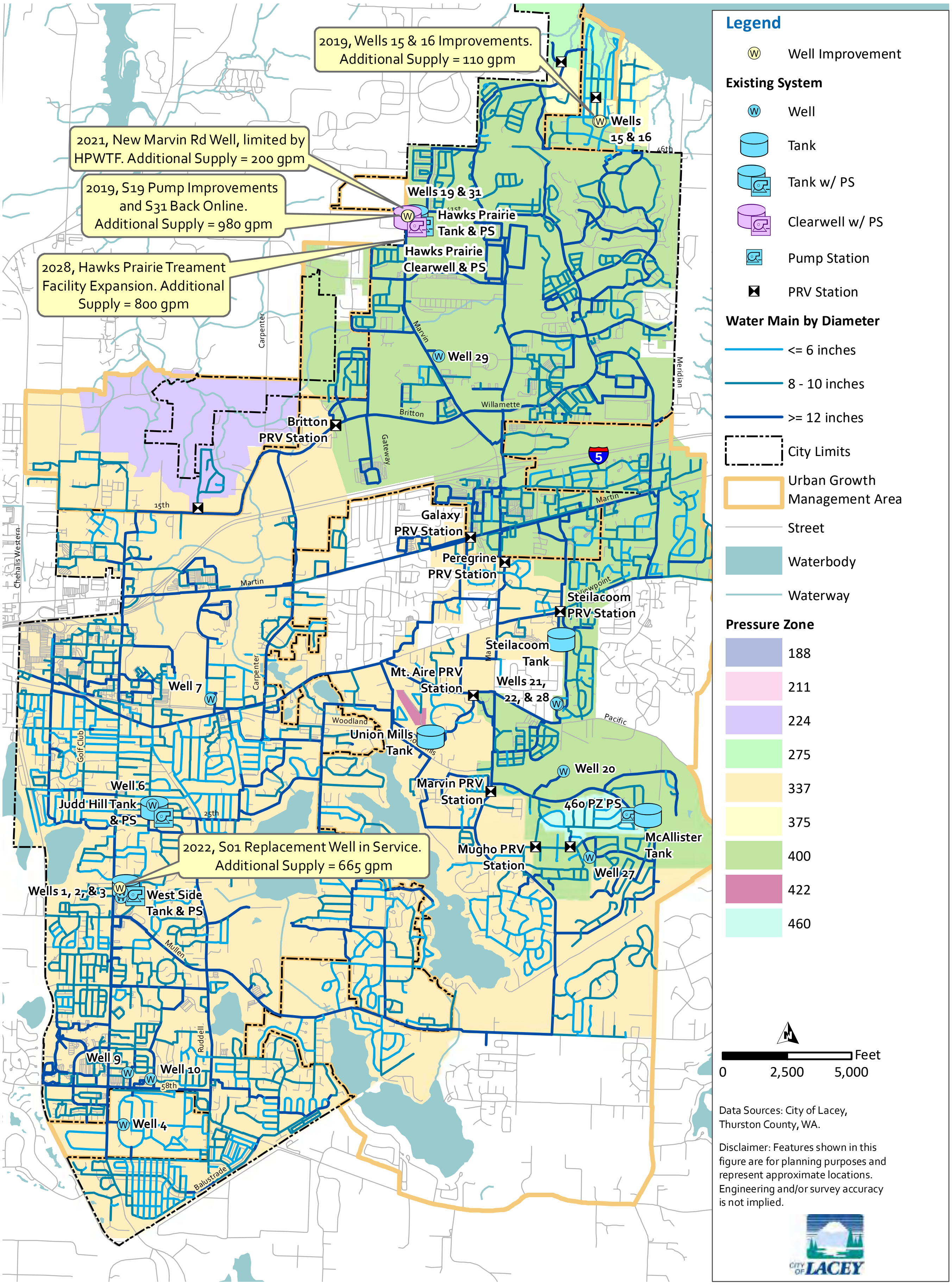


Figure 3 Planned Supply Improvements

2.3.2 "Ability to Serve" with Planned Projects Improvements

Figure 4 compares the City's "ability to serve" with the supply improvements already planned for the established criteria and MDD projections. If all planned improvements are implemented, the City will have sufficient supply in the near-term with all supplies online. To meet both redundancy and operational criteria by 2028, the City will need an additional 0.78 mgd (539 gpm) of supply capacity.

This finding underscores the importance of implementing planned supply improvements in Section 2.3.1, as well as developing new supplies. Note, should City not make the supply improvements or demands vary from projections, then results will differ from those presented in this report.

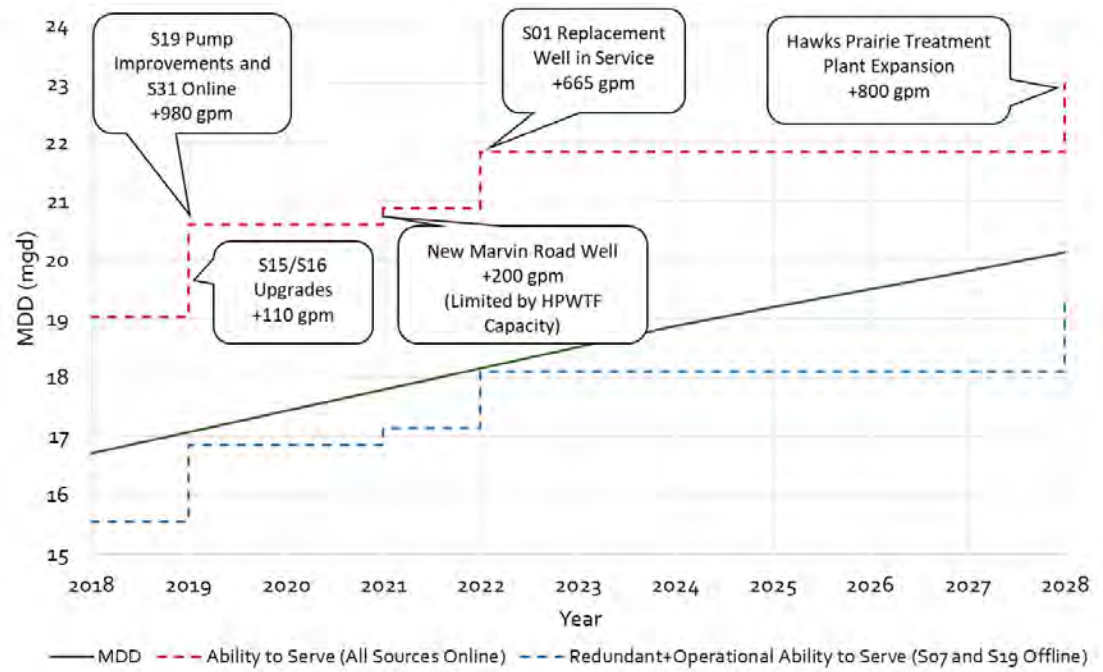


Figure 4 Ability to Serve with Planned Supply Improvements

2.3.3 Additional Supply Improvements to meet Demands

As the "ability to serve" analysis shows, the City will need more supply than just the already planned supply projects. The City identified the four supply improvement options that are presented below. Each project was qualitatively evaluated and ranked in a workshop setting with City staff based on available information. The hydraulic model was used to confirm the distribution system had sufficient capacity for the supply projects and to recommend necessary system improvements, and where improvements are recommended. Two of the supply projects presented below will be sufficient to meet the Redundant and Operational ability to serve deficiency through planning year 2028. The remaining supplies should be considered for long-term supplies after the study period:

1. **Make full use of Madrona's full water rights**. This option would make improvements to the distribution system to convey additional flow without upgrading pumps or treatment. This option would utilize the full water rights and increase supply from the

well field by 748 gpm. Hydraulic modeling indicates that the full use of Madrona can be achieved during both 2022 and 2028 MDD by upsizing 1,100 feet of distribution main. Note that, during lower demand conditions, the Madrona wells may not be able to produce their full water right because of limitations in overall distribution. City staff preferred this project, mainly because of cost and operational reasons.

2. **Drill a new well next to S04**. The new well is anticipated to have a yield of 1,350 gpm. The combined yield of the existing 750 gpm well and new well is anticipated to be 2,100 gpm. Existing treatment facilities can treat the additional yield without modification. The City is considering installing the new well after the area is sewered. City staff anticipates that septic-to-sewer conversions will occur within ten years; therefore, the additional well may not be available until the end of the planning period. Of the four improvements, City staff deemed this one their second best.
3. **Add treatment to S09**. By adding treatment for iron, manganese, and ammonia, a total of 1,300 gpm of supply will be available from S09, an increase of 570 gpm of supply from the existing 730 gpm ability to serve. This option is less preferred, since it would require adding a new treatment facility at a new site and acquiring land.
4. **Develop a new well near the Meridian Campus with a yield of 800 gpm**. The well will be drilled in the TQu aquifer and tests indicate the presence of iron, manganese, ammonia, and sulfides. The City proposes to drill the well in the Meridian Campus Park. This option is the least preferred because it will require treatment.

2.3.4 "Ability to Serve" Improvements and Timing

Timing for the supply projects are recommended to be:

- 2022: Madrona Transmission Improvements (1. Make full use of Madrona's full water rights).
- 2025: HPWTF expansion (Planned improvement 5 in Section 2.3.1) or Drill a new well next to S04.

The Madrona Transmission Improvements and HPWTF expansion by 2025 provide sufficient Redundant and Operational ability to serve, as shown on Figure 5. This would require the City to move up planned improvements from 2028 to 2025 to meet the Redundant and Operational ability to serve throughout the planning period.

If the City does not implement the HPWTF expansion in 2025, then it could consider drilling a new well next to S04 in 2025 to provide more than sufficient Redundant and Operational ability to serve through 2028, as shown on Figure 6. The HPWTF expansion could then be implemented as planned in 2028 or delayed for beyond 2028.

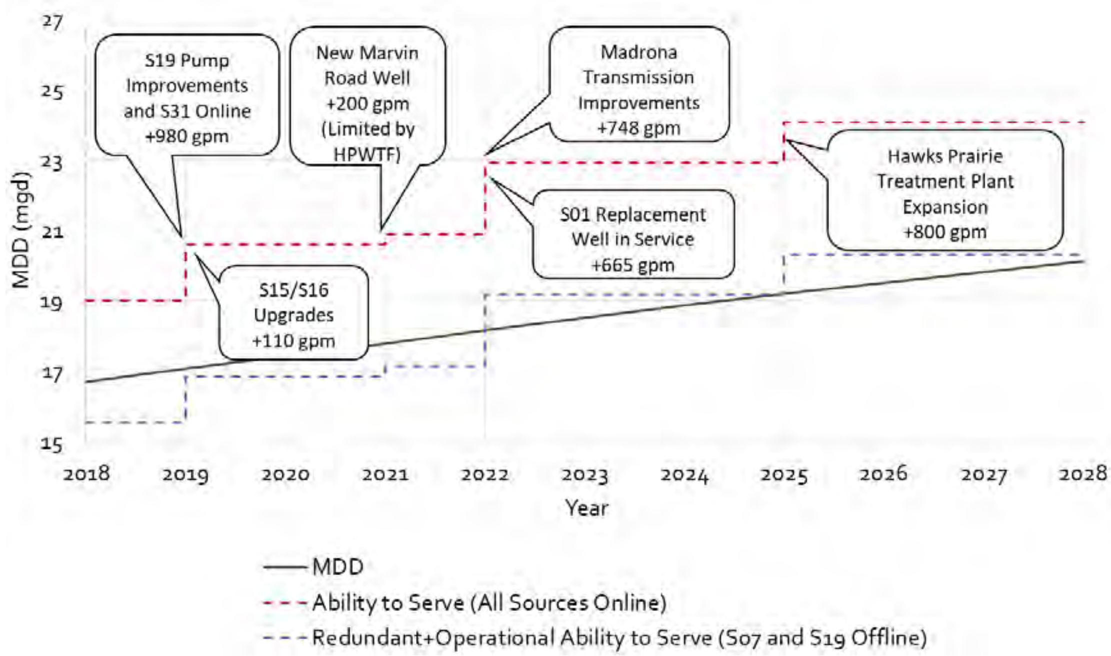


Figure 5 Ability to Serve with Planned Supply Improvements, Madrona Transmission Improvements and HPWTF Expansion

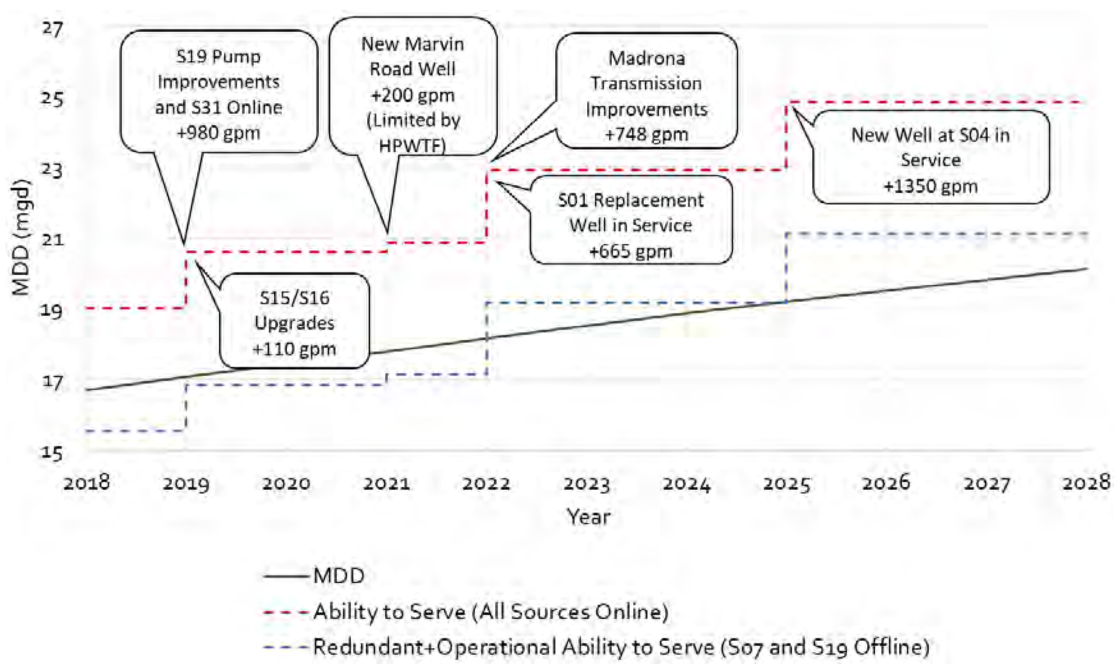


Figure 6 Ability to Serve with Planned Supply Improvements, Madrona Transmission Improvements, and a new well at S04

Section 3

HYDRAULIC MODEL UPDATE

The City gave Carollo the hydraulic model with 2017 facilities and 2016 demands. The demand were allocated in the model based on actual consumption data. Carollo updated the hydraulic model to include near-term (2022) and long-term (2028) demands, fire flows, planned distribution improvements, and future supply projects. Using the update, the following simulations of each alternative were modeled in the near- and long-term planning period (see Appendix C): MDD plus Fire Flows, Extended Period Simulation of PHD, and Extended Period Simulation of ADD. Select source trace results are included in Appendix C as well.

3.1 Demands

Future water demands were allocated to appropriate nodes in the hydraulic model. The City's existing summer 2016 model demands were then allocated to match the projected 2017 demands as described in Section 2.1 and shown in Table 1.

Additional projected ADDs were also allocated to the hydraulic model to match the demands shown in Table 1 for planning years 2022 and 2028. Future ADDs were developed using a combination of land use information, vacant land information, loading polygons, and planned development information. City-provided demands associated with planned developments were manually entered into the model based on the number of residential units planned.

The remaining demands were allocated to all vacant land and weighted based on area using loading polygons and vacant parcels. Future MDDs were developed by multiplying their respective years' ADD with the MDD/ADD peaking factor of 2.2. Future ADD and MDD diurnals used the summer 2016 diurnal patterns provided by the City.

3.2 Planned System Improvements

The City provided information on nine planned pipeline improvement projects. Eight of the projects are expected to be completed by 2022 and the ninth project is expected to be completed by 2028.The following projects were incorporated into the hydraulic model's near-term and long-term scenarios:

- College and 22nd Street.
- Capital City Golf Course Fire Flow Improvement.
- 2017 Waterline Replacement Project 2.
- Mullen Road Water Project.
- 48th Avenue and 50th Avenue NE (Beachcrest) Fire Flow Improvements.
- Impala Water Main Replacement.
- Oak Preserve Development.
- Gateway Development.
- Willamette Drive Velocity Improvements (long-term planning period).

3.3 Planned Supply Projects

The City planned water supply improvements to meet future demands and provide additional redundancy and operational flexibility. The hydraulic model was updated to include the planned supply improvements discussed in Section 2.3 and shown on Figure 5 and Figure 6. See Appendix A for information on how the planned supply improvements were operated in the hydraulic model.

3.4 PZ Operations

The 337 PZ alternatives require that facility operations be added and updated in the model. Model updates are described in the following sections. The following operational changes are applied to all 337 PZ alternatives:

- Wells 7 and 19 controls are disabled for baseline and all alternatives.
- Wells 1, 2, 3, 4, 6, 9, and 10 will continue to be operated by their existing control facilities. Controls related to proposed facilities were modified or added, as described in Appendix A.

3.5 400 PZ Proposed Facilities

For the 337 PZ modeling, a new 1 million gallon (MG) Hawks Prairie Sister Tank was assumed to be online for 2028 planning scenario. The existing Hawks Prairie Tank was assumed to be online for both 2022 and 2028 planning scenarios. Please refer to the 400 PZ Storage Study Report 1 (Carollo 2018) for information on the proposed Sister Tank.

Section 4

EVALUATION CRITERIA

This section presents the evaluation criteria used to evaluate the distribution system and to size future water system infrastructure. These criteria address storage capacity, acceptable service pressures, and the distribution's main performance. To help develop evaluation criteria, the City's Comp Plan and Washington State Department of Health (DOH) 2009 Water System Design Manual (WSDM) were used.

4.1 Water Storage Requirements

The City's storage reservoir volume requirements were divided into four separate categories as defined by DOH:

1. Operating Storage.
2. Equalizing Storage.
3. Fire Fighting Storage.
4. Standby (or emergency) Storage.

Reservoirs may include "dead storage," which is the volume in a reservoir not available to the system. This volume is usually the result of high elevations served by the reservoir and minimum pressures required for customers in the zone.

For this analysis, criteria and results from the Comp Plan were used and checked against adjusted demands from Section 3.1. A comprehensive storage analysis was not performed. However, criteria from the Comp Plan were used to determine storage volumes required in the 337 PZ.

Table 3 presents the volume of storage deficiencies based on the Comp Plan and adjusted demands. The 337 PZ has four storage tanks (Westside, Judd Hill, Union Mills, and Steilacoom) with a total storage volume of 7.71 MG and an available storage of 3.98 MG. The Comp Plan storage analysis identified the required storage based on City criteria. Of note, the standby criteria is a function of the demand and firm supply capacity. New supplies developed after year 2023 reduced the overall standby storage required by 2034. Based on this analysis, the Comp Plan recommended a 3.2 MG reservoir be constructed on the Intelco Loop property.

Table 3 337 PZ Storage Analysis Adapted from Comp Plan

Storage Surplus / (Deficit)	2019	2023	2034
Available Storage (MG)	3.98	3.98	3.98
Required Storage			
Operational Storage (MG)	0.24	0.24	0.24
Equalizing Storage (MG)	0.74	1.12	1.36
Max of Standby / Fire (MG)	3.56	5.87	5.36
Total Storage Required (MG)	**4.54**	**7.23**	**6.96**
Excess / Deficiency in 337 PZ	-0.55	-3.24	-2.97

The adjusted Comp Plan analysis was considered adequate for this study's planning purposes. It is recommended the Storage Analysis be updated as part of the upcoming Comp Plan update.

Similar to Table 3, the Comp Plan also showed a surplus of storage volume in the 400 PZ and deficiency in the 337 PZ. Surplus in the 400 PZ will further increase with the proposed Hawks Prairie Sister Tank. Since moving storage from the 400 PZ to the 337 PZ requires complex operations, with storage that must travel through miles of pipe and control valves, the City has sought additional storage in the 337 PZ for self-sufficiency within the 337 PZ.

The alternatives analysis use a goal of 1 MG of storage at the Intelco site. The 1 MG storage volume is typically cost-effective for both at-hydraulic-grade and below-hydraulic-grade reservoirs – allowing direct comparison. Below-hydraulic-grade reservoirs are typically more cost effective at higher volumes and at-hydraulic-grade are more cost effective at lower volumes. The proposed additional storage will only meet a portion of the 3.2 MG deficiency. To meet the entire 3.2 MG deficiency, the City will need to develop additional storage at separate sites.

4.2 Fire Flow Criteria

Fire flows stress a water system near a hydrant and can thus identify deficiencies, which are generally associated with pipe sizes (diameter) or age (roughness). Under high flow conditions, these deficiencies increase head losses and lower pressures.

Fire flow criteria measure a system's ability to deliver a high rate of water while maintaining a minimum pressure of 20 pounds per square inch (psi) in the distribution system. To evaluate the effect of fire flows throughout the distribution system, each model node was assigned a fire flow based on highest fire flow requirement considering the City's land-use based criteria. Where a node represents service to multiple land uses, the largest fire flow was chosen to be simulated in the model. The fire flow demands were used in conjunction with MDD conditions. By simulating MDD plus fire flows, the performance of supply sources, booster pumps, and storage tanks could be determined under those conditions.

The recommended fire flow criteria are summarized below by land use. City staff provided the following fire flow criteria:

- *Single-Family Residential:* 750 gpm for two hours.
- *Low Commercial:* 1,250 gpm for two hours (in 188 PZ) and 1,500 gpm for two hours (everywhere else).
- *Medium Commercial:* 2,500 gpm for three hours.
- *High Commercial:* 4,000 gpm for four hours.

4.3 Service Pressures

Pressures maintained in the distribution system vary with the system's operations and pressure zone topography. Thus, the water pressure in a consumer's residence or place of business cannot be too high nor too low. The City established an operational pressure criteria of:

- *Minimum Pressure:* Minimum pressure of 40 psi under typical PHD conditions.
- *Maximum Pressure:* Maximum pressure of 80 psi under all conditions.

The City staff found most customer pressure complaints occur at pressures near 40 psi; therefore it was used as a minimum pressure. According to building code, individual PRV must be installed for pressures above 80 psi; therefore, high pressures are also highlighted.

Note that DOH requires water systems to provide PHD at no less than 30 psi at all service connections in the distribution system, except during a fire suppression event. This means that the City's operational criteria are more stringent than state requirements.

4.4 Distribution Mains

Transmission mains are generally sized to carry PHD or MDD plus fire flow. Other criteria related to the distribution piping include the maximum and minimum velocities and the maximum allowable friction losses.

DOH recommends a "maximum velocity of no more than 8 feet per second (fps) under PHD conditions, unless the manufacture specifies otherwise" (WSDM, 2009). Normally, velocities of 10 fps (American Water Works Association [AWWA] M-32) or higher do not cause problems if they are brief.

For this alternatives analysis, maximum velocity criteria were developed for the following demand conditions to prevent pipe damages caused by high velocities:

- *PHD:* City pipes' maximum velocity not to exceed 8 fps under typical PHD conditions.
- *MDD + Fire Flow:* City pipes' maximum velocity not to exceed 10 fps during a MDD plus fire flow event.

4.5 Water Age

4.5.1 Water Age Modeling

This study incorporates water quality modeling of the distribution system. Water quality modeling can encompass a number of areas, including evaluating overall water age within the distribution system, principally driven by reservoir detention times, or evaluation of source, when customers receive different sources of supply with different water quality characteristics.

Water quality problems, such as loss of disinfectant residual, or disinfection by product formation potential are dependent on a number of factors, such as system infrastructure, type of materials and age of components, water chemistry, water age, and water temperature. Since water age can be modeled, the age of the water can provide a general indicator of the potential for water quality problems. Often, water age modeling is used as a substitute for chlorine or chloramines modeling.

Water age is used for screening purposes, to indicate reservoirs with higher potential for water quality problems. Water age by itself cannot identify if water quality problems will occur. The hydraulic model calculates average water age, assuming that reservoirs are completely mixed.

American Water Works Association M68 – Water Quality in Distribution Systems (2017) recommends water age not exceed five to seven days at average day demand conditions. To achieve this level, reservoir turnover is typically recommended to be between 3 to 5 days; allowing some aging in the distribution system. Water age can vary significantly within a system and is primarily controlled by system design, system usage, and maintenance. Areas with longer transmission mains and dead-ends can experience longer water age.

Factors contributing to increased water age include demand planning and the requirements for providing capacity to deal with events such as power outages and firefighting. Planning necessitates the installation of facilities that have excess capacity for water storage and distribution, preparing to meet demands that may occur 20 years into the future and more. Greater reliance on supply sources can reduce tank turnover, increasing water age in the reservoirs. Depending on system hydraulics, this can lead to customers served primarily from the reservoir being adversely impacted.

Potential health impacts that can occur due to older water age are disinfection by-product formation, biodegradation of disinfection byproducts, nitrification, and microbial regrowth. Corrosion control effectiveness can also be related to water age. With increased detention time there are impacts on the effectiveness of pH management in poorly-buffered waters. Since the City's water sources come from wells, most of the potential health impacts do not pertain. The main issues that could arise from older water age would be degradation of chlorine, accumulation of iron and manganese, and pH stability. A more in depth study of these issues can be found in the City's 2018 Evaluation and Mitigation of Discolored Water (Confluence Engineering Group LLC, in prep.).

Since water age is considered only a general indicator of potential water quality problems, Carollo recommends that the City take into account current water age and any problems that they experience. With the future water age information, the City can watch areas of concern and use their operational experience in prioritizing and implementing water quality improvements to improve reservoir turnover and reduce water age. The City has a flushing program in place to improve the system's water quality. Manganese and iron deposits are flushed from the system on a periodic basis. Areas of low chlorine are also flushed on an as-needed basis. In a few areas of low demand, the City has year round automatic flushing because flushing significantly reduces water age.

4.5.2 Water Age Results Discussion

Two main drivers for high water ages were: Water age was run for the distribution system under the baseline condition for both 2017 and 2028 ADD with none of the 400 PZ or 337 PZ Alternatives included. Since the model does not reflect all of the field operational changes made throughout the year, the figures were found to be misleading and, therefore, were not included in this report.

Modeling showed that while water age is slightly sensitive to demands; it is significantly impacted by distribution system operations.

Two main drivers for high water ages were:

- Tank turnover during lower demand periods.
- Distribution system oversizing and dead ends.

4.5.2.1 Limited Tank Turnover

For the 2017 ADD, both Wells 7 and 19 are online, however, Wells 1 and 31 are offline, based on 2017 field conditions. Modeling showed that under this operation strategy, Westside tank is sporadically providing water to the distribution system, elevating water age values around the West Side tank. Water age in the adjacent distribution system is directly correlated with water age in the West Side tank, and is aged more than 20 days.

For the 2028 ADD modeling, operation strategy considered existing operations with the addition of the following:

- Well 19 pump replacement project completed.
- Wells 15 and 16 upgrades completed.
- New Marvin Road Well constructed.
- Well 1 improvements completed.
- HPWTF expansion completed.
- Full use of Madrona's water rights.

Based on these supply projects, Wells 1, 7, 19, and 31 are online and supplying water.

The City has excess supply when considering all wells online and available to run. Based on these conditions, the tanks in the system are supplying the distribution system in a limited manner. For instance, 2028 ADD runs indicate a significant decrease in water age around the West Side tank, from more than 20 days in 2017 ADD to 2 to 5 days in 2028 ADD. Under 2028 ADD conditions, modeling showed that the West Side tank is not supplying the 337 PZ, as Well 1 is now running and Well 1 controls are preventing the West Side tank from operating. The City has more than sufficient supply to provide demands to the customers directly in 2028 ADD with all supplies online, therefore, significantly limiting the use of the storage facilities.

Though maximum water age in the 337 PZ distribution mains are significantly reduced, the age of the water in the tanks is significantly older. For instance, as soon as West Side tank starts regularly operating, the water age in the vicinity of West Side would be realistically closer to the 2017 ADD modeling results.

Similar results were found for the 400 PZ, with HPWTF and Wells 19, 31, and Marvin Road operating more frequently and providing the bulk of the supply to the customers' demands.

Because there is a significant relationship between water age and system operations, it is recommended that the City optimize its controls throughout the year and for different supply conditions to facilitate tank turnover to the extent practical. This should help maintain or lower water age in the distribution system. The City changes its operations seasonally, and based on wells water quality and conditions, which will change water age in the system significantly based on the facilities being operated. As stated previously, water age is considered only a general indicator of potential water quality problems, and Carollo recommends that the City take into account operational experience in prioritizing and implementing water quality improvements to improve reservoir turnover and reduce water age.

4.5.2.2 Distribution System Oversizing and Dead Ends

Water age can also increase within the distribution system where the volume of water in the pipe is substantially larger than the demand in the area. For example, the Britton Parkway distribution system has been sized for large fire flows; however, slower than anticipated development has resulted in relatively low demand in the area. Further, the Britton PRV (400 PZ to the 337 PZ) at the eastern boundary of the Parkway rarely operates in the winter and is effectively a dead end. Similar reductions in PRV operations create effective dead ends in the winter at several of the City's other large PRV stations, including the Galaxy PRV Station. It is recommended the City consider changes in operation to allow regular flow through its PRVs to limit these effective dead ends.

The City also has areas of the distribution system with limited looping, as well as short dead ends mains, which require periodic flushing to maintain chlorine residual. Areas of low chlorine are flushed on an as-needed basis. In a few areas of low demand, the City has year round automatic flushing because flushing significantly reduces water age. General water age improvements from operational changes at facilities discussed above may help lessen the frequency of flushing. Additional looping is also generally recommended to improve water age in dead end areas. However, due the complex nature of water quality issues, these changes may not resolve all water quality issues and periodic flushing may still be required.

4.6 Well 9 Supply Tracking

Well 9 (S09) water contains manganese and iron and is untreated. Consequently, use of this source can lead to customer complaints regarding taste, odor and "dirty" water. In addition, manganese in the water tends to accumulate in the distribution system, which the City currently manages with its unidirectional flushing (UDF) program. To minimize impacts to water customers, the well is primarily used to meet seasonal demands. The hydraulic model's source tracking feature was used to evaluate if the proposed Intelco Loop tank would change the distribution of S09 water. This information may be used to adjust the route and frequency of UDF to account for the S09 supply.

Supply tracking is a way to understand which area Well 9 serves under these specific conditions. Similar to water age, results may vary based on system operation. The figures discussed in this section can be found in Appendix C for reference. Supply tracking was performed using the hydraulic model for the following four scenarios:

- 2022 ADD – Baseline (Figure 25 of Appendix C). Assumed facilities would operate according to current operation. Wells 7 and 19 are online, however, Wells 1 and 31 are offline, based on 2017 field conditions.
- 2022 ADD with recommended alternatives (Sister Tank at Hawks Prairie, and Alternative 3 with a new at-hydraulic-grade tank from this report, Figure 26 of Appendix C). Assumed facilities would operate according to current operation. Wells 7 and 19 are online, however, Wells 1 and 31 are offline, based on 2017 field conditions.
- 2022 MDD – Baseline (Figure 27 of Appendix C). Assumed facilities would operate according to current operation. Wells 7 and 19 are online, however, Wells 1 and 31 are offline, based on 2017 field conditions.
- 2022 MDD with recommended alternatives (Sister Tank at Hawks Prairie, and Alternative 3 with a new at-hydraulic-grade tank from this report. Figure 28 of Appendix C). Assumed facilities would operate how they currently operate. Wells 7 and 19 are online, however, Wells 1 and 31 are offline, based on 2017 field conditions.

The figures show the average percentage of the supply contributed by S09 at each node in the hydraulic model. The S09 supply will vary throughout the day due to changes in S09 pumping and operation of nearby infrastructure.

Operations change in response to increased demand between ADD and MDD. As illustrated by Figures 25 and 27 in Appendix C, the change in operations has a large impact on the number and location of customers served by water from Well 9. Under 2022 ADD, S09 is operated sparingly and modeling showed that customers are served up to a maximum of 20 percent by water from Well 9. Under 2022 MDD, S09 is operated for most of the day and modeling shows a significantly larger area is served by that water with a percent contributing of up to 100 percent of the demand at several locations. Under 2022 MDD condition, modeling shows that water from Well 9 may flow to Balustrade Street, south of 58th, which appears to be consistent with City staff has noted in the field.

The hydraulic model was also used to understand the impact of the alternatives to the system. Comparing Figure 25 to Figure 26 shows that under ADD, the impact of adding the Sister Tank at Hawks Prairie and the new at-hydraulic-grade Tank at the Intelco site is minimal. Comparing Figure 27 to Figure 28, modeling results indicate there will be a larger difference between baseline and with recommended alternatives. Overall, Well 9 contributes to less of the supply at each node with additional tanks in the system, which is likely due to additional supply sources being called online. Additionally, water from Well 9 seems constrained to a specific area around 58th, east and west of Ruddell Avenue. This is believed to be due to Intelco Tank and its impact on system operations in the College Street Corridor.

Section 5

PRELIMINARY SYSTEM ANALYSIS

The preliminary system analysis was completed to understand pressures in the 337 PZ and the cause for low pressures operators experienced in the field. Results from the analysis were used to identify system deficiencies and develop alternatives to mitigate them.

5.1 Baseline Condition

A preliminary analysis was completed using the City's existing hydraulic model. The Baseline scenarios consist of all system infrastructure as of 2017. For the Baseline and 337 Alternatives, the City-provided operational schema in the model was used as received, except for the following operational changes:

- Wells 7 and 19 controls are disabled for all alternatives.
- Wells 1, 2, 3, 4, 6, 9, and 10 will continue to be operated by their existing control facilities. Controls related to proposed facilities were modified for specific Alternatives as described in the subsequent sections.

Because the 400 PZ operations effects the 337 PZ, it is also noted that for the Baseline and 337 Alternatives: the proposed 400 PZ Hawks Prairie Sister Tank is online in the 2028 model simulations, the Hawks Prairie Reservoir was online in all model simulations, the proposed piping upsize near Madrona Well Field is online in the 2022 and 2028 simulations, and the supply improvements are online per the recommended schedule in Section 2.3.

5.1.1 Static Pressures

Static pressures, or the highest possible service pressure, were assessed to understand the impact of customer elevations to pressures. Static pressures were calculated based on the difference of the hydraulic-grade-line (HGL) at 337 feet (ft) and customer elevations at the street level. The customers at the highest elevations in the vicinity of the College Corridor have a maximum pressure of 41 psi. This lower pressure area extends along a ridge roughly following College Street, as illustrated on Figure 7.

5.1.2 Minimum Pressures during PHD

Normal system pressures are less than static pressures due to head loss as water flows through pipes and other system operations (such as fluctuating reservoir levels). The model was run under initial 2016 summer conditions to understand the impact of operations to system pressures. As shown on Figure 8, pressures in the College Corridor dropped lower than 40 psi, down to 36 psi. The number of customers below 40 psi was smaller in the winter (due mostly to less demands and head loss). The pressures shown in the figures would be at the customer's service meter. Additional head losses occur through the customer's plumbing, especially in two-story houses. At Intelco, City staff stated that pressures as low as to 32 psi were experienced, which is likely due to temporary decreases in local supply availability (either from increased demand or supply sources being offline).

Modeling was used to understand the increases in future demand for pressures in the 337 PZ, where PHD pressures anticipated for 2022 are shown on Figure 9. Figure 10 shows the impacts of the projected demand increase between planning years 2022 and 2028, showing that a majority of locations drop in pressure due to increase in demands (less than 2 psi).

Using the hydraulic model, head loss and velocities were evaluated to identify transmission limitations in the distribution system. Areas with high head loss or velocity indicate a "bottleneck" in the system that would increase pressures if upsized. The 337 PZ had no moderate or high velocity pipes, as shown on Figure 11. The 400 PZ has several moderate velocity pipelines; however, upsizing the pipes in the 400 PZ are not expected to impact pressures in the 337 PZ.

5.1.3 Residual Pressures during MDD + Fire

With the current system, there is sufficient fire flow pressure availability for the 337 PZ customers through 2028. Figure 12 illustrates that the 2022 residual pressure is available, except several dead ends mains shown as red nodes (deficient) on the figure. Before improvements are made to dead-end mains, it is recommended the Fire Marshall review these areas to determine if there is sufficient fire flow for the existing uses. If improvements are needed, looping dead-end mains is generally recommended as it provides additional fire flow capacity and reduces water age.

5.1.4 Water Age

Water age was run for the 337 PZ under the baseline condition for 2028 ADD. Under the existing operational schema, water age is generally low to moderate, as it does not exceed ten days in most areas. High water ages are areas generally in dead end mains or influenced by long water ages in the Steilacoom and Union Mills reservoirs. As previously discussed, water age results are highly dependent on facility operations and results are subject to change with adjustments to facility controls.

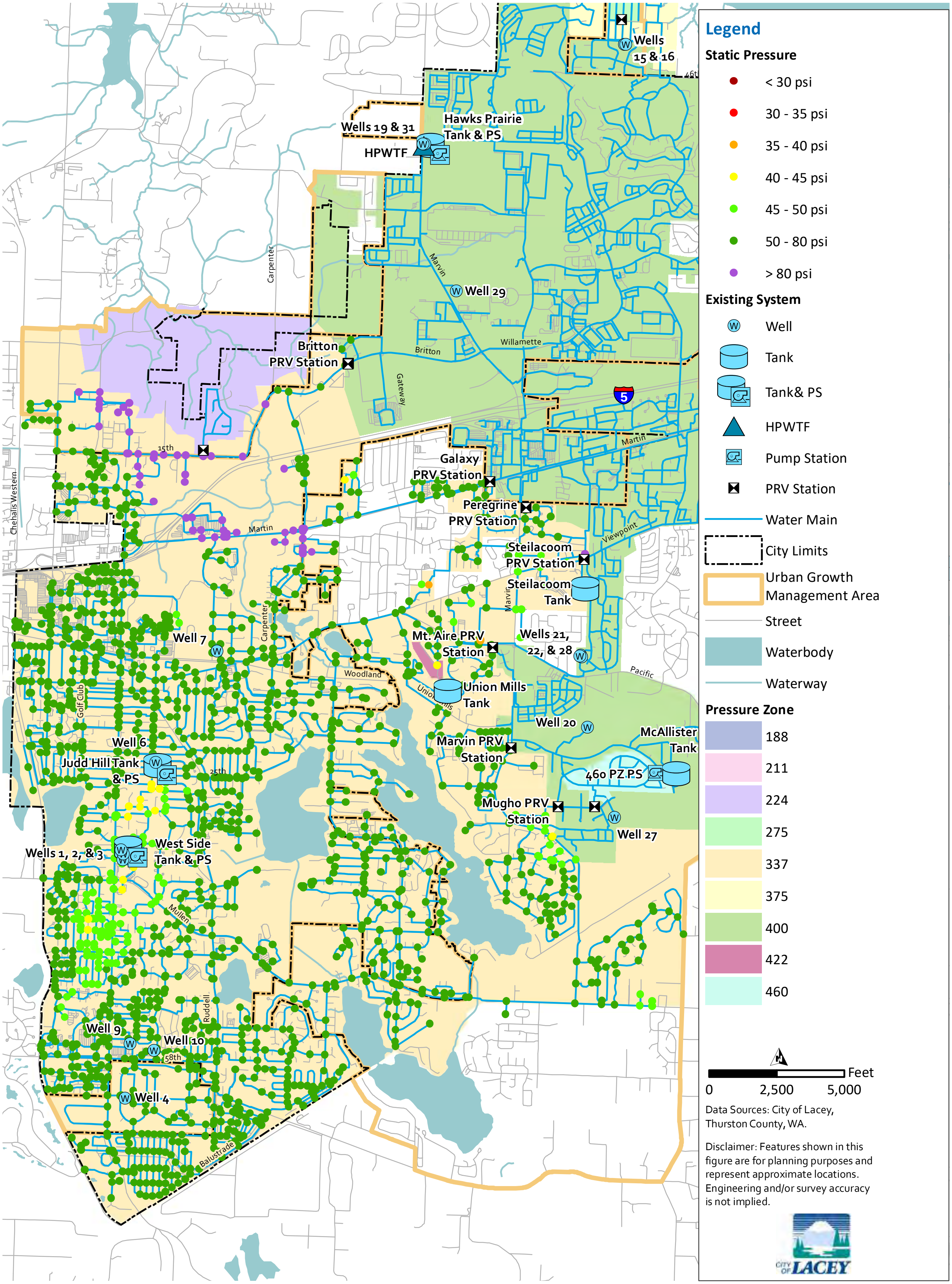


Figure 7 Static Pressures at 337 feet HGL 2016 - Baseline, All Sources Offline

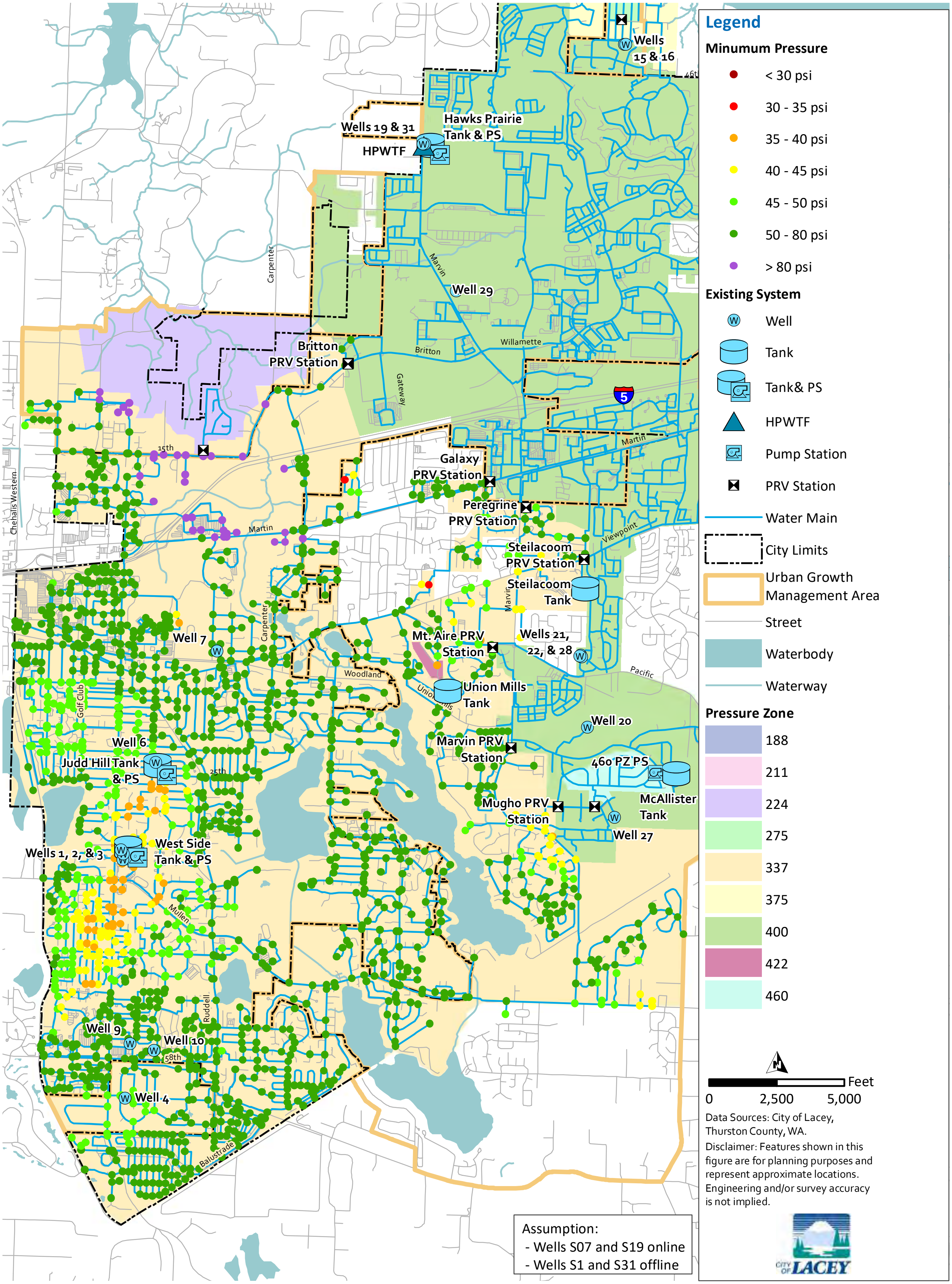
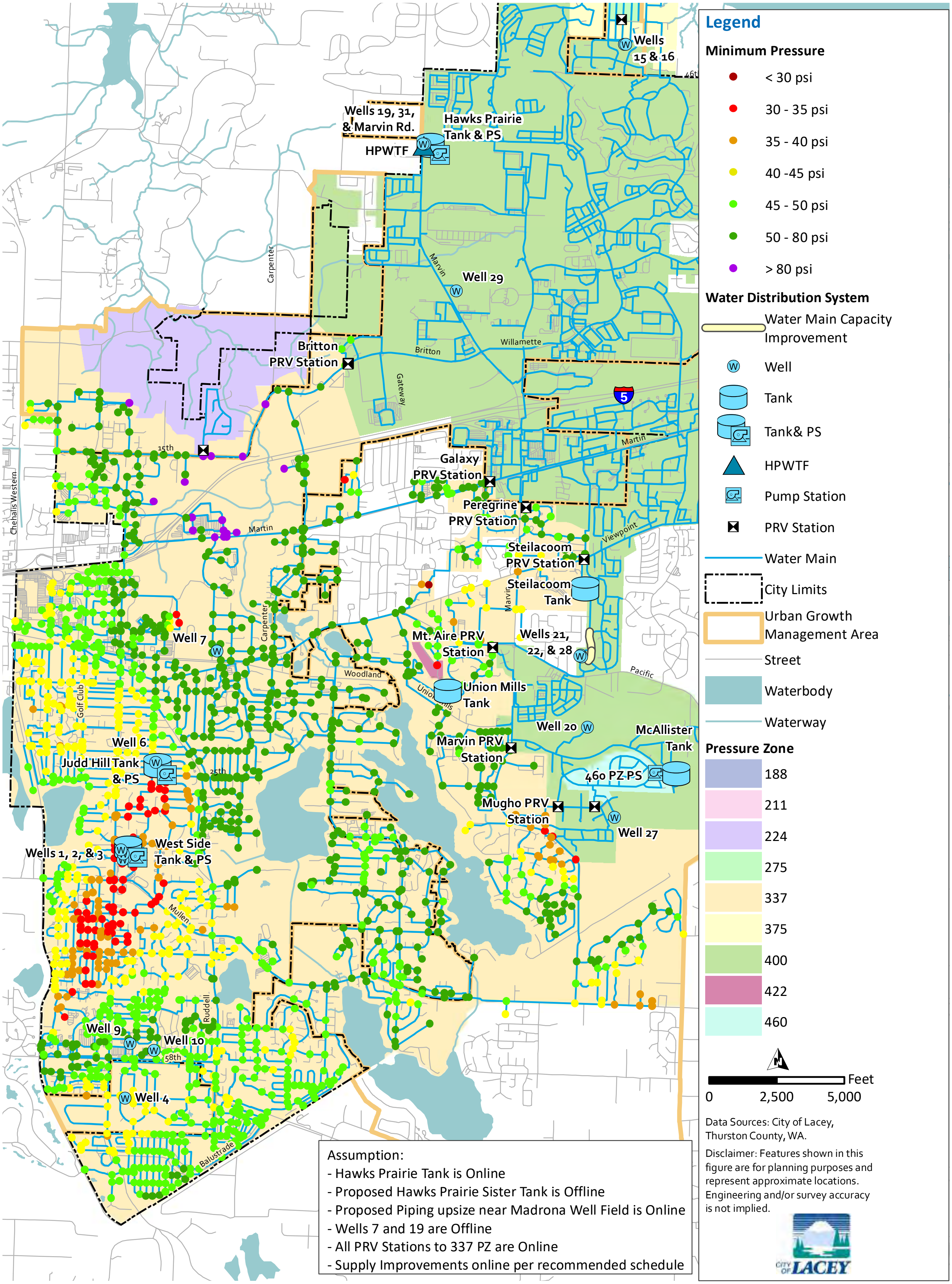


Figure 8 Minimum Pressures under 2016 Conditions – Baseline, S01 and S31 Offline



Assumption:
- Hawks Prairie Tank is Online
- Proposed Hawks Prairie Sister Tank is Offline
- Proposed Piping upsize near Madrona Well Field is Online
- Wells 7 and 19 are Offline
- All PRV Stations to 337 PZ are Online
- Supply Improvements online per recommended schedule

Data Sources: City of Lacey, Thurston County, WA.

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Figure 9 Minimum Pressures under 2022 PHD Conditions - Baseline, S07 and S19 Offline

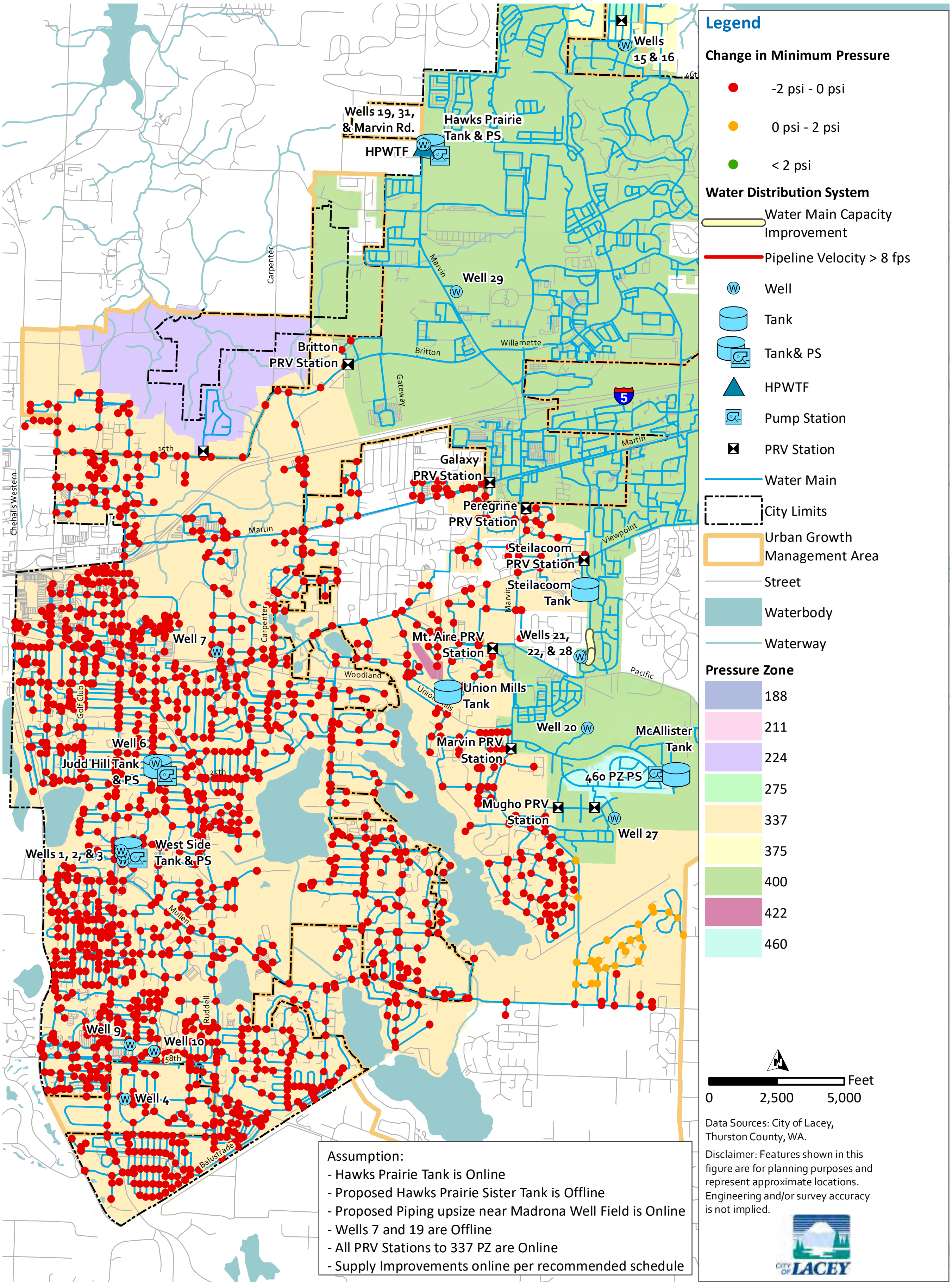


Figure 10 Change in Minimum Pressures from 2022 PHD Baseline to 2028 PHD Baseline Conditions, S07 and S19 Offline

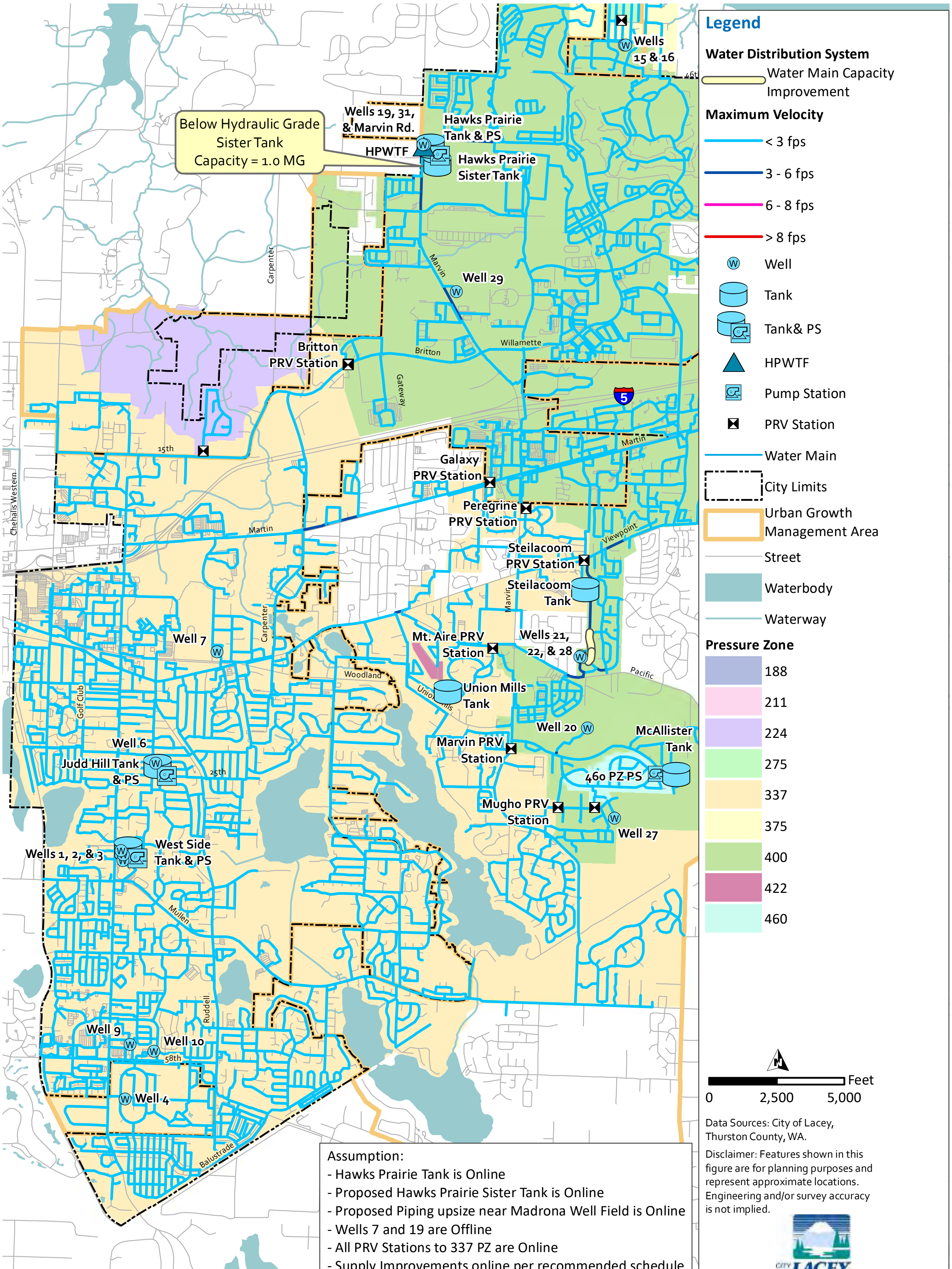


Figure 11 Maximum Velocity under 2028 PHD Conditions – Baseline, S07 and S19 Offline

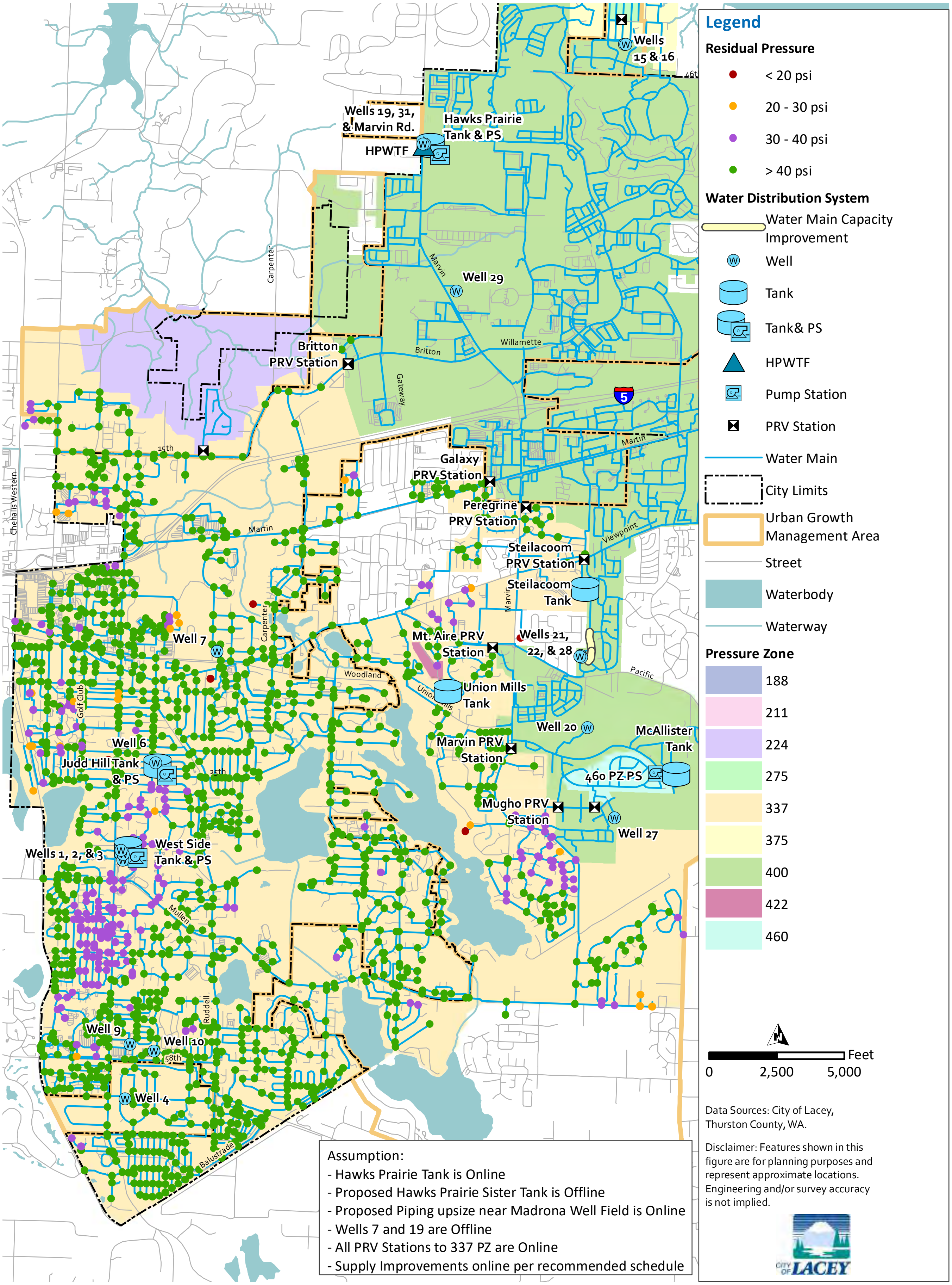


Figure 12 Residual Pressure under 2022 MDD plus Fire Flow Conditions - Baseline, S07 and S19 Offline

Section 6

RECOMMENDED ALTERNATIVES

As detailed in Section 5, the initial analysis showed that areas in the 337 PZ fell below 40 psi along the College Corridor under 2016 summer conditions. A pressure sag also occurs during low demand conditions. In this scenario, the wells are off and the HGL is set by water elevation in the tanks on the eastern side of the PZ. Furthermore, the City has experienced customer complaints for low pressures along 337 PZ's College corridor under high and low demand conditions.

In the College Corridor, elevations are higher than in the rest of the 337 PZ. Thus, alternatives were developed with the goal of improving the level of service along the College Corridor. In addition, each alternative provides additional storage to the 337 PZ. The following sections describe the facilities associated with the three 337 PZ recommended alternatives and present the results from the hydraulic analysis.

6.1 Alternative 1 – Rezone with At-Hydraulic-Grade Tank

6.1.1 Alternative 1 Infrastructure

Alternative 1 – Rezone with At-Hydraulic-Grade Tank involves rezoning customers that experience low pressures and adding storage along the College Street Corridor. The rezone boundary was developed to increase pressures, while minimizing the impact to existing distribution mains along College Street, using existing mains where feasible to reduce the construction of new water mains. The rezoning was done with the City's input. Minimum and maximum elevations in the new zone were considered and an optimal HGL of 380 PZ was chosen to maintain pressures between 50 and 80 psi.

The rezone boundary is shown on Figure 13. As shown, the new PZ will serve customers at a new HGL of 380 feet from a new 380 PZ pump station on the Intelco property site. The following facilities are recommended for Alternative 1:

- A new 620 gpm firm capacity 380 PZ pump station on the Intelco site. The 380 PZ pump station is sized to serve 2028 PHD only. The 380 PZ pump station includes approximately 500 feet of 12-inch diameter piping to connect the proposed pump station to the new 380 PZ.
- New check valves between 337 PZ and 380 PZ. The check valves allow the 380 PZ to be served by the 337 PZ during a fire event, which prevents the need for adding fire pumps to the new pump station, saving on construction cost. The zone boundaries were created in the model using up to 25 check valves. For the cost estimate, it was assumed that the actual number and location of valves would be reduced to 10 check valves during predesign.
- A surge or pressure reducing valve is recommended for the Rezone to prevent over pressurization in the event of a pump station control failure. The valve was assumed to be incorporated within the 380 PZ pump station and was not separately costed.

- Approximately 925 feet of 12-inch diameter pipe are recommended to connect the northern portion to the southern portion of the rezone.
- Transmission mains parallel to Business Park distribution mains to allow the Park to be served from the 380 PZ. Approximately 1,830 feet of 12-inch diameter transmission main and 1,200 feet of 16-inch diameter transmission main will be required.

In addition to the rezone, Alternative 1 involves constructing an at-hydraulic-grade tank at the Intelco site, as shown on Figure 13. The following are preliminary tank characteristics recommended per hydraulic modeling:

- Tank Type: At-hydraulic-grade.
- Storage Capacity = 0.75 MG.
- Tank overflow elevation: Modeled at 337 feet to match 337 PZ's HGL. Overflow elevation should be re-evaluated during predesign.
- Approximate bottom elevation = 220 ft.
- Approximately 120 ft of 16-inch diameter field piping is needed connect the Intelco tank to the 337 PZ mainline pipe in Intelco Loop SE.

An at-hydraulic-grade elevated style 0.75 MG reservoir was chosen to meet the City's operational criteria and therefore recommended as a cost-effective option. The 0.75 MG tank would provide 0.3 MG (40 percent) of operational/equalizing storage and 0.45 MG (60 percent) of Emergency/ Fire Suppression storage. The operational/equalizing storage was set to maintain pressures at high elevation customers, with the remaining volume assigned to Emergency/ Fire Suppression. A larger elevated style tank would increase these volumes proportionally (i.e. a 1 MG tank would have 0.4 MG of Operational/Equalizing storage). Note, this sizing requires the City to build additional storage in the future to meet its Comp Plan requirements.

Figure 13 shows the facilities associated with Alternative 1 improvements. If Alternative 1 is the selected alternative, operational changes are recommended to achieve proper tank cycling. With a new at-hydraulic-grade tank, nearby sources, Wells 1, 4, 9, and 10, will need to incorporate the Alternative 1 tank water levels to maintain adequate levels during operations. Additionally, a new PZ is recommended under this alternative, which will require new controls at the booster pump station (BPS) based on downstream pressures at customers in the 380 PZ. For specific facility controls, in the hydraulic model, see Appendix A.

6.1.2 Alternative 1 - Minimum Pressures during PHD

Alternative 1 was evaluated to understand its pressures improvements. Figure 14 shows minimum system pressures under 2028 PHD conditions. Alternative 1 shows an increase in pressures above the City's 40 psi operational criteria in the rezone area with minimal impacts on the adjacent zone. According to the modeling, the rezone provides a sufficient level of service for customers in the 380 PZ. PHD pressures within the rezone are generally increased by approximately 20 psi compared to the existing pressures.

However, the rezone boundary does not include customers directly along College Street and the at-hydraulic-grade tank does not significantly improve system pressures there above the Baseline (see Section 5.1). The rezone boundary was not expanded to include those customers as it would require extensive construction within College Street to avoid cutting off the large transmission lines conveying water north south along the zone. These customers from within the College Street area should be reviewed during pre-design, where more detailed site information may identify alternative approaches to connect them to the 380 PZ.

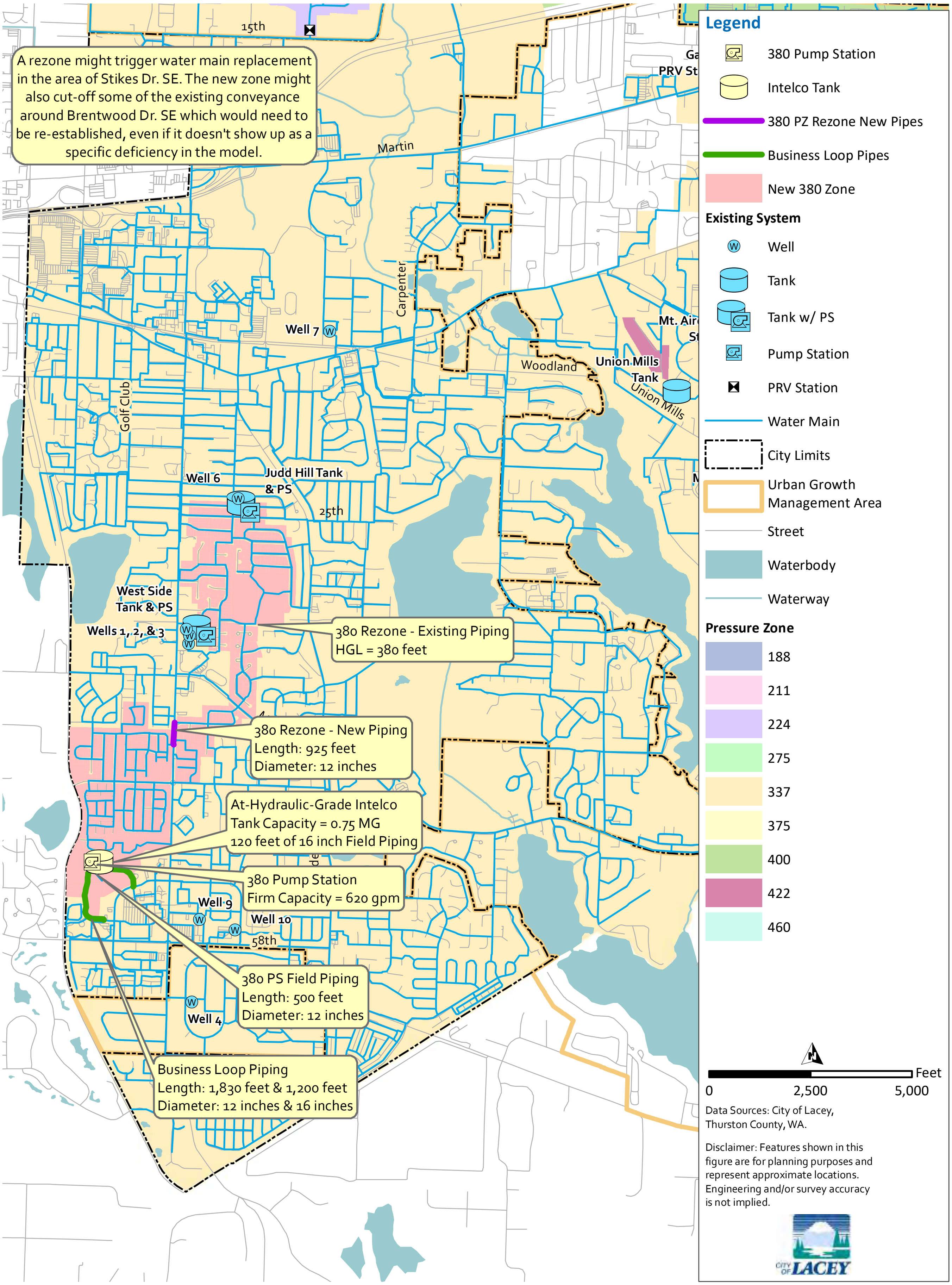


Figure 13 Alternative 1 Improvements

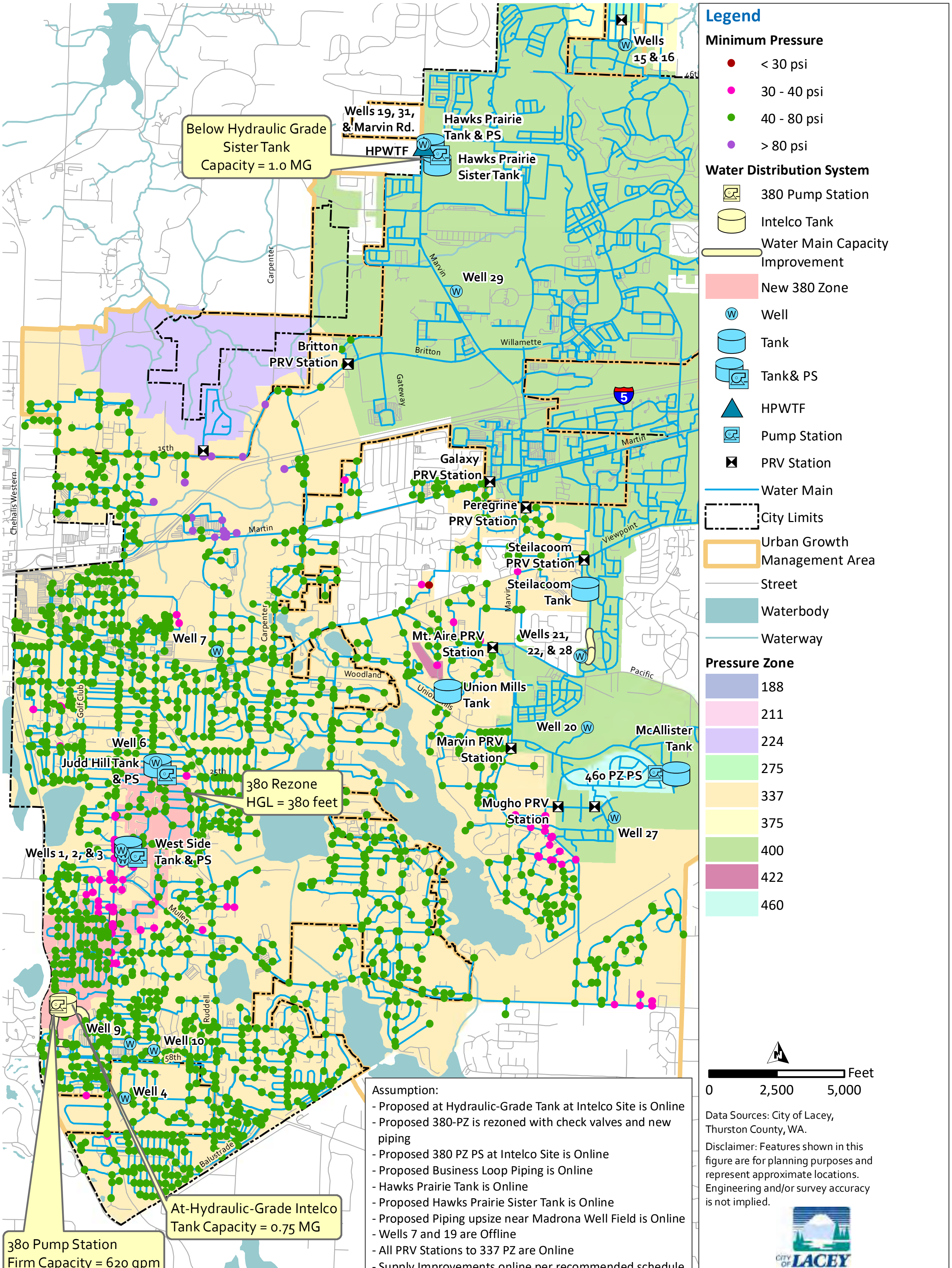


Figure 14 Minimum Pressure under 2028 PHD Conditions - 337 PZ Alternative 1, S07 and S19 Offline

Hydraulic modeling, also showed that minimum pressures, in the pressure-deficient areas identified above, fell below 40 psi when the at-hydraulic-grade tank water level was below 25 ft (326 ft HGL). The model indicates during 2028 PHD conditions tank levels may decrease to 20 ft (321 ft HGL) or 36 psi. During normal conditions, this pressure is less than 5 psi lower than existing pressures. However, the at-hydraulic-grade tank should limit temporary pressure decreases that are thought to create the lowest reported pressures in the area. Customer pressures still satisfy DOH's minimum pressure requirement of 30 psi.

If higher pressures are sought, the City should conduct a supply optimization study to determine if increasing supply can maintain higher tank volumes without adversely impacting other operations in the 337 PZ and 400 PZ.

Figure 15 shows that the at-hydraulic-grade tank can cycle appropriately under 2028 PHD conditions. With a new at-hydraulic-grade tank in the distribution system, nearby sources will need to operate based on the Alternative 1 tank water levels to maintain adequate levels during operations. The nearby sources include Wells 1, 4, 9, and 10. Additionally, a new PZ is recommended under this alternative, which will require new controls at the BPS based on 380 PZ customer pressures. For specific facility controls, in the hydraulic model, see Appendix A. Additional control optimization might maintain the minimum tank level to sustain pressures greater than 40 psi; however, this would likely increase water age and is therefore not recommended. For detailed facility control and operational changes made in the model, see Appendix A.

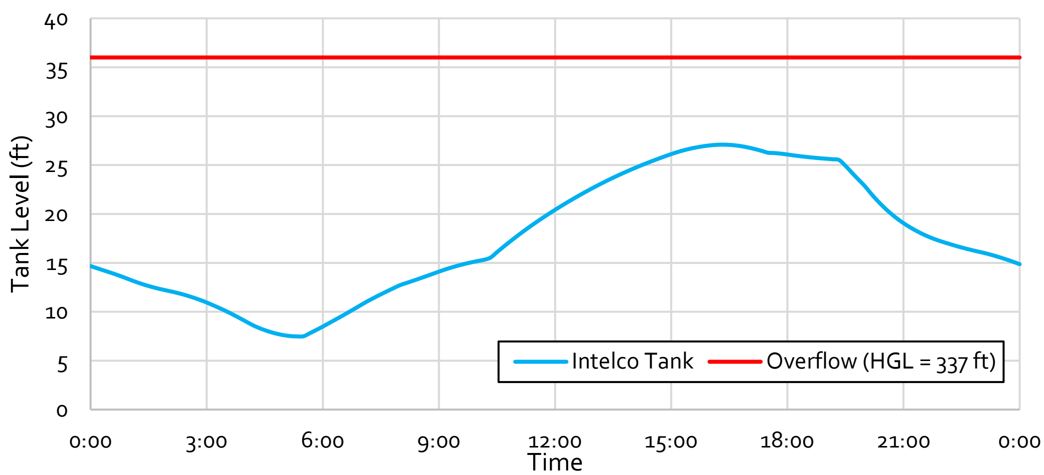


Figure 15 Intelco Tank Level under 2028 PHD Condition – 337 PZ Alternative 1

6.1.3 Alternative 1 - Residual Pressures during MDD + Fire Flow

The system can provide fire flow requirements during MDD plus fire flow conditions to the rezoned area through the check valves while maintaining 20 psi in the system under Alternative 1, as shown on Figure 16. Note that no new deficiencies were found in the 337 PZ with Alternative 1; however, the limited deficiencies identified under the Baseline condition presented in Section 5.1 remain. Under Alternative 1, the 380 PZ BPS does not provide fire flows; fire flows to the new PZ are conveyed through checked valves from the 337 PZ to provide similar as the existing. To be conservative, the BPS was modeled as offline during fire flow events.

6.1.4 Alternative 1 – Water Age

Water age was also considered for the infrastructure recommended with Alternative 1. According to the analysis, water age in the new 380 PZ was directly related to the age in the Intelco Tank and worsened compared to Baseline due to the additional storage and dead-end pipes created to form the new PZ. As previously discussed, water age results are highly dependent on facility operations; therefore, water age in the 380 PZ is anticipated to vary throughout the year. Water age outside of the new pressure zone in the 337 PZ remained similar, despite added storage volume in the pressure zone.

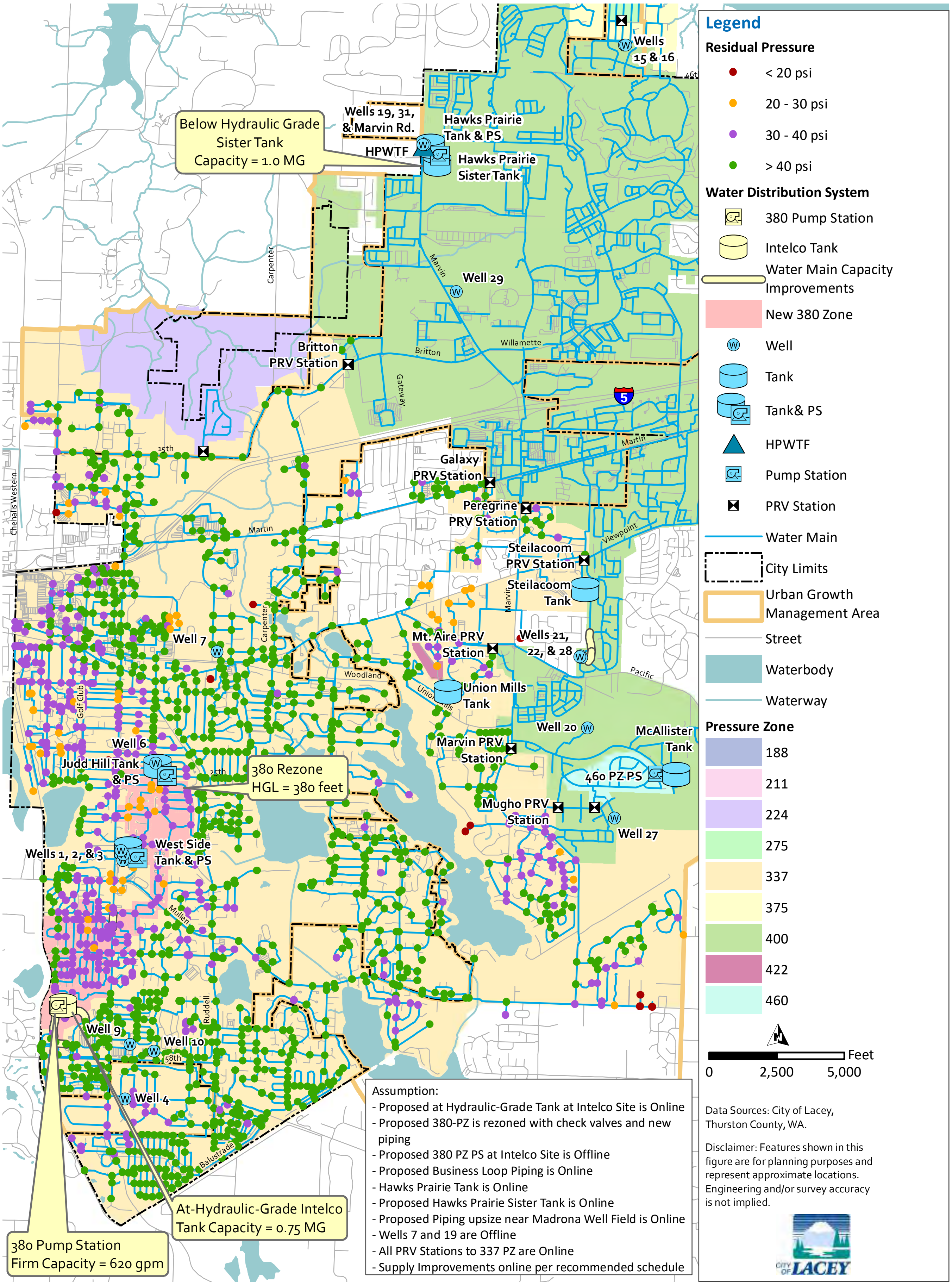


Figure 16 Residual Pressure under 2028 MDD plus Fire Flow Conditions - 337 PZ Alternative 1, S07 and S19 Offline

6.2 Alternative 2 – Rezone with Below-Hydraulic-Grade Tank

6.2.1 Alternative 2 Infrastructure

Alternative 2 is similar to Alternative 1. Like Alternative 1, Alternative 2 involves rezoning the customers in the College Corridor and adding storage volume at the Intelco property. However, for this alternative, new storage would be a below-hydraulic-grade reservoir, and a pump station. The following facilities are recommended for Alternative 2, and their locations are shown on Figure 17:

- A new pump station, approximately 620 gpm firm capacity, on the Intelco site to serve the new 380 PZ. The 380 PZ pump station would be sized to serve 2028 PHD only and would include approximately 500 feet of 12-inch diameter piping to connect the proposed pump station to the new 380 PZ.
- New check valves between 337 PZ and 380 PZ. With the check valves, the 380 PZ can be served by the 337 PZ during a fire event, preventing the need for fire pumps in the new 380 PZ pump station, saving on construction cost. The zone boundaries were created in the model using up to 25 check valves. For the cost estimate, it was assumed that the actual number and location of valves would be reduced to 10 check valves during predesign.
- A surge or pressure reducing valve is recommended for the Rezone to prevent over pressurization in the event of a pump station control failure. The valve was assumed to be incorporated within the 380 PZ pump station and was not separately costed.
- Approximately 925-feet of 12-inch diameter pipe for the rezone to connect the northern portion to the southern portion.
- Transmission mains parallel to Business Park distribution mains to allow the Park to be served from the 380 PZ. Approximately 1,830 feet of 12-inch diameter transmission main and 1,200 feet of 16-inch diameter transmission main will be required.

In addition to the rezone, Alternative 2 involves constructing a below-hydraulic-grade tank at the Intelco site, as shown on Figure 17. The below-hydraulic-grade tank will be a redundant tank that provides 337 PZ with pumped storage. The following preliminary tank characteristics are recommended:

- Tank Type: Ground.
- Storage Capacity = 1.5 MG.
- Alternative 2 storage allocation is anticipated to be similar to Alternative 1, where 0.3 MG (40 percent) will be used for operational/equalizing and the remaining 1.2 MG (60 percent) assigned to Emergency/Fire Suppression. Unlike an elevated style tank, the ground storage/ pump station configuration provides the City flexibility to increase the operational/equalizing portion beyond ~40 percent if needed.
- Tank Diameter: 80 ft.
- Tank Overflow Level: 40 ft (HGL = 260 ft).
- Approximately 120 ft of 16-inch diameter field piping is needed to connect the below-hydraulic-grade Intelco tank to the 337 PZ.

- New Pump Station: the approximately 1,000 gpm firm capacity pump station will pump water out of the new below-hydraulic-grade reservoir to the 337 PZ. The pump station was sized based on PHD demands in the southern area and based on modeling (approximately 1,000 gpm). The pump station includes approximately 100 ft of 12-inch diameter field piping. This pump station may be combined with the 380 PZ or separated depending on the City's operational and maintenance preferences.
- The tank will fill through an altitude valve. The valve will close when the new 337 PZ pump station is on, which is recommended to prevent pumping in a circle.

The below-hydraulic-grade tank was sized so the City can add additional storage. Alternative 2 is larger than Alternatives 1 and 3 because below-hydraulic-grade tanks are cheaper to construct. To ensure that the tank cycles properly, operational changes to the existing system are recommended. With a new below-hydraulic-grade in the distribution system, nearby sources, Wells 1, 4, 9, and 10, will need to look at the Alternative 2 tank water levels to maintain adequate levels during operations. For specific facility controls, in the hydraulic model, see Appendix A.

6.2.2 Alternative 2 – Minimum Pressures during PHD

Alternative 2 was evaluated to understand the new infrastructure's impact on pressures, fire flow, and water age.

Under 2028 PHD conditions, Alternative 2 provides a sufficient level of service in the new 380 PZ, as shown on Figure 18. The pump station maintains a minimum pressure of 42 psi at the highest elevation customer in the new PZ, while the lowest elevation customers have a minimum pressure of approximately 70 psi pressure. 337 PZ pressures were similar between Alternative 1 and Alternative 2, where changes were due to differing operations between the at-hydraulic-grade and below-hydraulic-grade tanks pump station.

Figure 19 shows the difference in pressure between Alternative 2 and the Baseline condition. Results show the increase in pressures within the new 380 PZ. Pressures in the 337 PZ remain similar, the system does not experience a decrease in level of service. Note, the operation of the new below-hydraulic-grade reservoir impacted operation of the Steilacoom PRV station and tank. This resulted in a slight decrease in pressure near those locations, highlighting the interrelatedness of the City's facility operations.

Minimum pressures at the customers located along College Street are below 40 psi. However, they satisfy DOH's minimum pressure requirement of 30 psi.

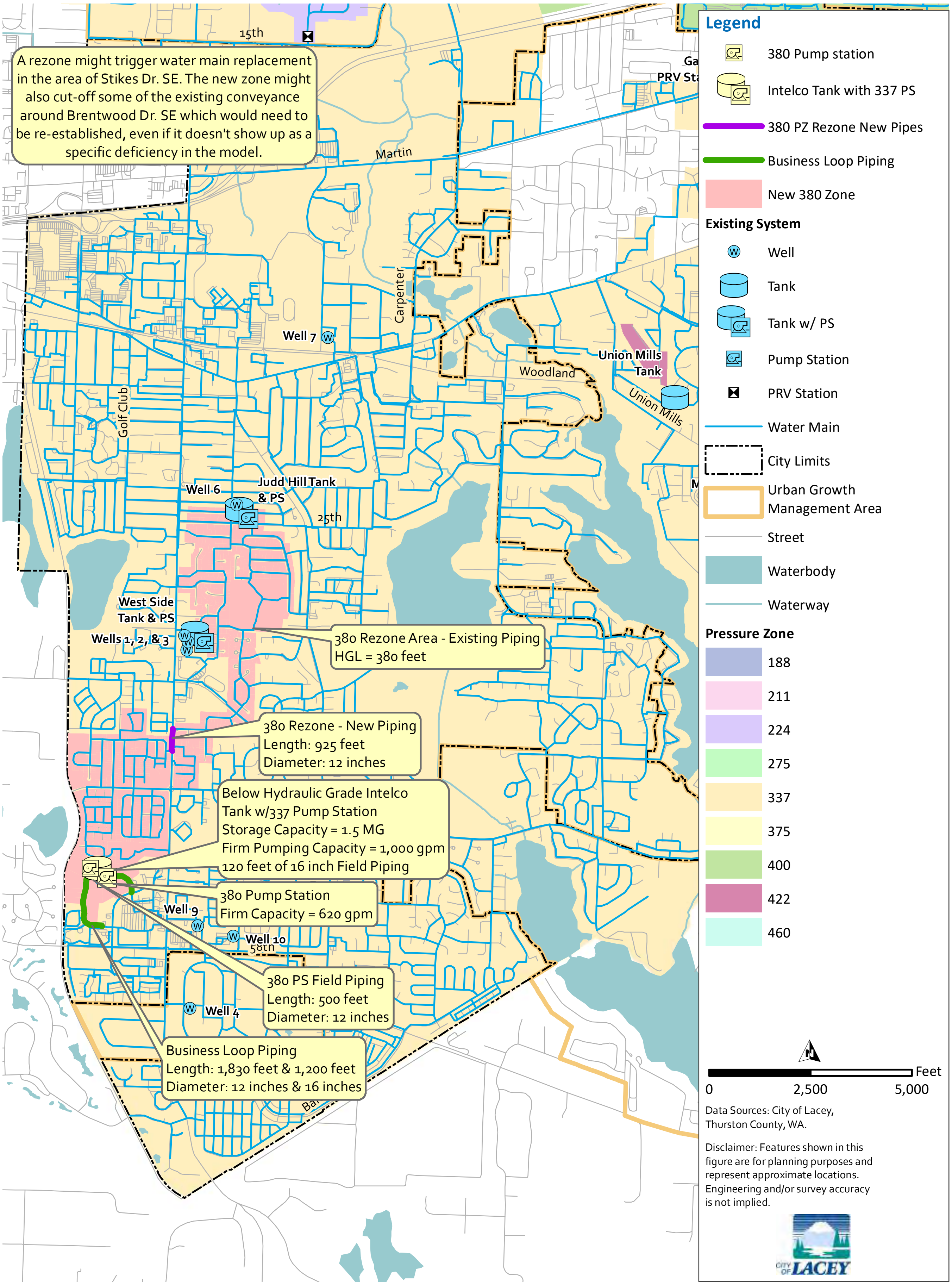


Figure 17 Alternative 2 Improvements

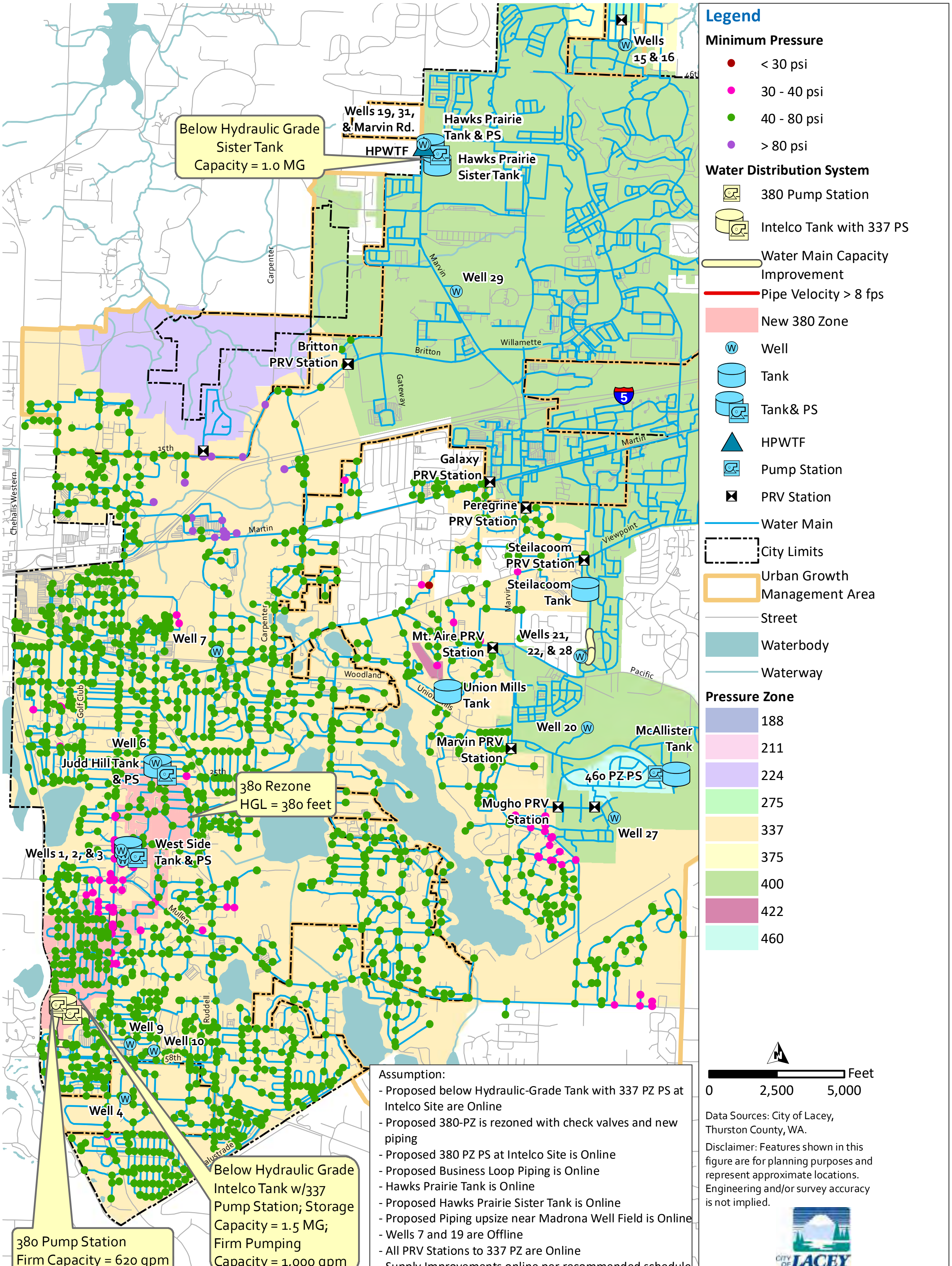


Figure 18 Minimum Pressures under 2028 PHD Conditions - Alternative 2, S07 and S19 Offline

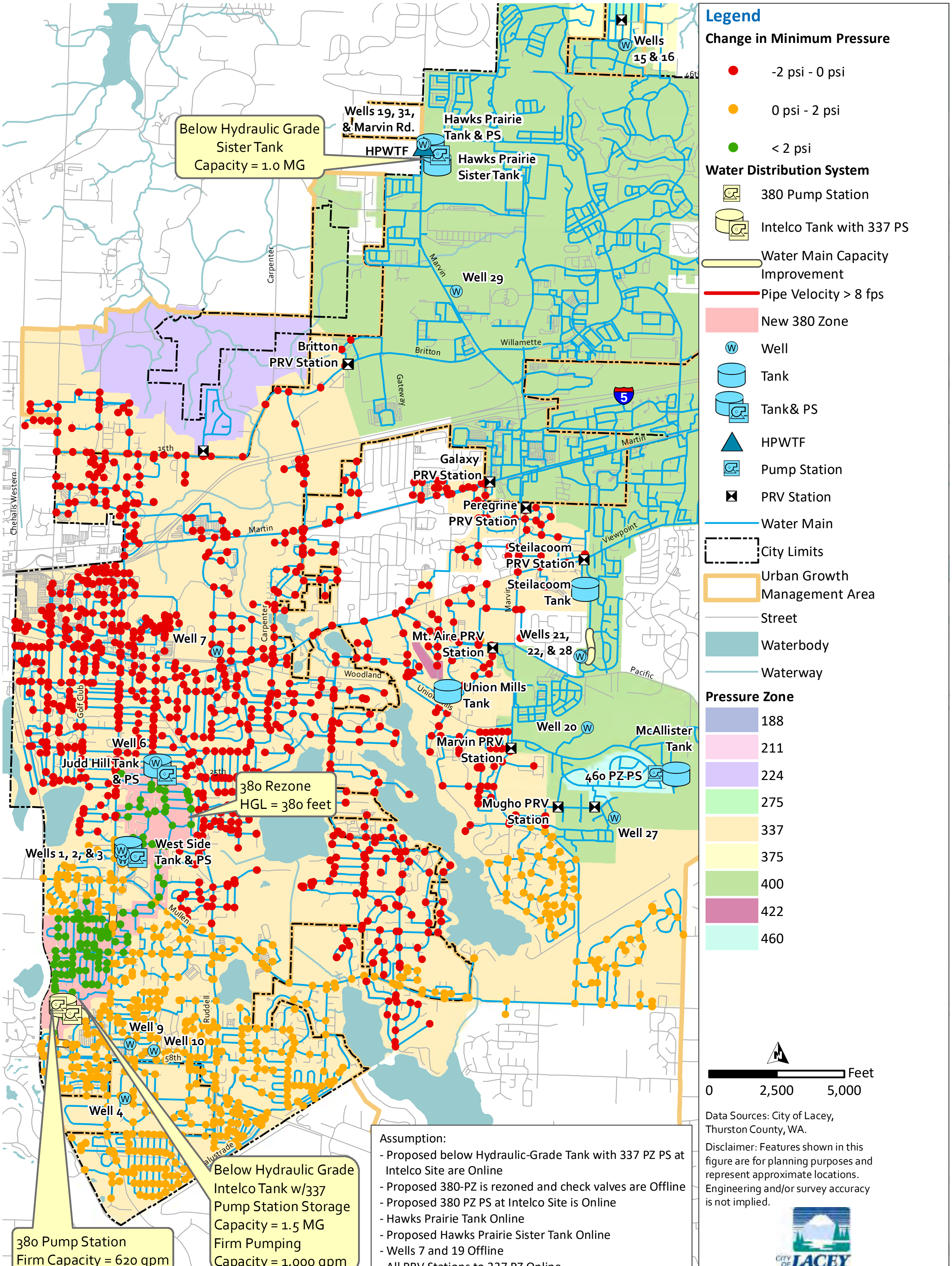


Figure 19 Change in Minimum Pressures from 2022 PHD Baseline to 2028 PHD Alternative 2 Conditions, S07 and S19 Offline

According to modeling, turning over the new below-hydraulic-grade reservoir appears problematic, as shown on Figure 20. Figure 20 shows the below-grade-reservoir tank level under 2028 PHD conditions with Alternative 2 infrastructure. In the model, a similar operational schema to the Westside reservoir was used. As shown, the control schema allows the below-hydraulic-grade tank to supply the 337 PZ during high demands and fill during low demands. However, the Alternative does not fully recover at the end of the day. Prolonged periods of high demands may cause reservoir levels to decrease into the Emergency/ Fire Suppression volume.

It is anticipated that the new below-hydraulic-grade tank in the distribution system will be fed by nearby sources. It is recommended that the tank have controls to limit inflows during lower pressures in the 337 PZ, such as a pressure sustain valve (PSV). A new 337 PZ pump station at the below-hydraulic-grade tank is needed to serve 337 PZ customers. The modeled 337 pump station is controlled off pressures in the 337 PZ and the below-hydraulic-grade tank levels. The 380 PZ pump station will run based on pressure controls in the 380 PZ to ensure customers get adequate pressures at all time. For detailed facility control and operational changes made in the model see Appendix A.

Modeling also showed that operating Alternative 2 appears more complicated and less stable than the other alternatives, since the system needs to balance operations of the Westside facilities, the new facilities, and the wells. If this alternative is selected, performing supply optimization is recommended to create daily recovery in the tanks.

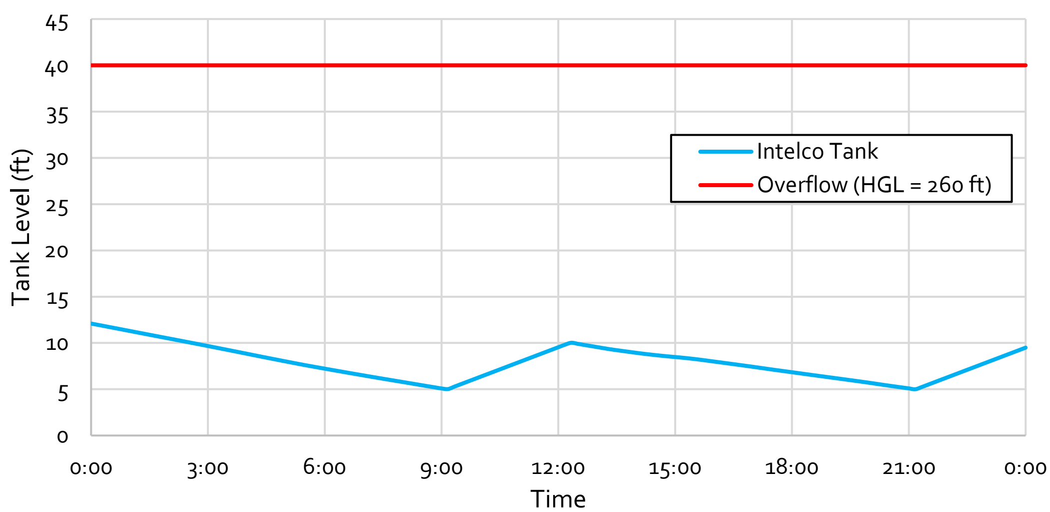


Figure 20 Intelco Tank Level under 2028 PHD Condition - Alternative 2

6.2.3 Alternative 2 – Residual Pressures during MDD + Fire Flow

The system can provide fire flow requirements during 2028 MDD plus fire flow condition to the rezoned area through the check valves maintaining 20 psi in the system under Alternative 2, as shown on Figure 21. Note that no new deficiencies were found in the 337 PZ with Alternative 2, the limited deficiencies identified under the baseline condition presented in Section 5.1 remain. Under Alternative 2, the 380 PZ BPS does not provide fire flows; fire flows to the new PZ are conveyed through checked valves from the 337 PZ to provide similar as the existing. To be conservative, the BPS was modeled as offline during fire flow events.

6.2.4 Alternative 2 – Water Age

Water age was also considered for the infrastructure recommended with Alternative 2. According to the analysis, water age in the new 380 PZ was directly related to the age in the Intelco Tank. As previously discussed, water age results are highly dependent on facility operations; therefore, water age in the 380 PZ is anticipated to vary throughout the year. Water age next to the new pressure zone in the 337 PZ remained similar, despite the added 1.5 MG storage volume in the pressure zone.

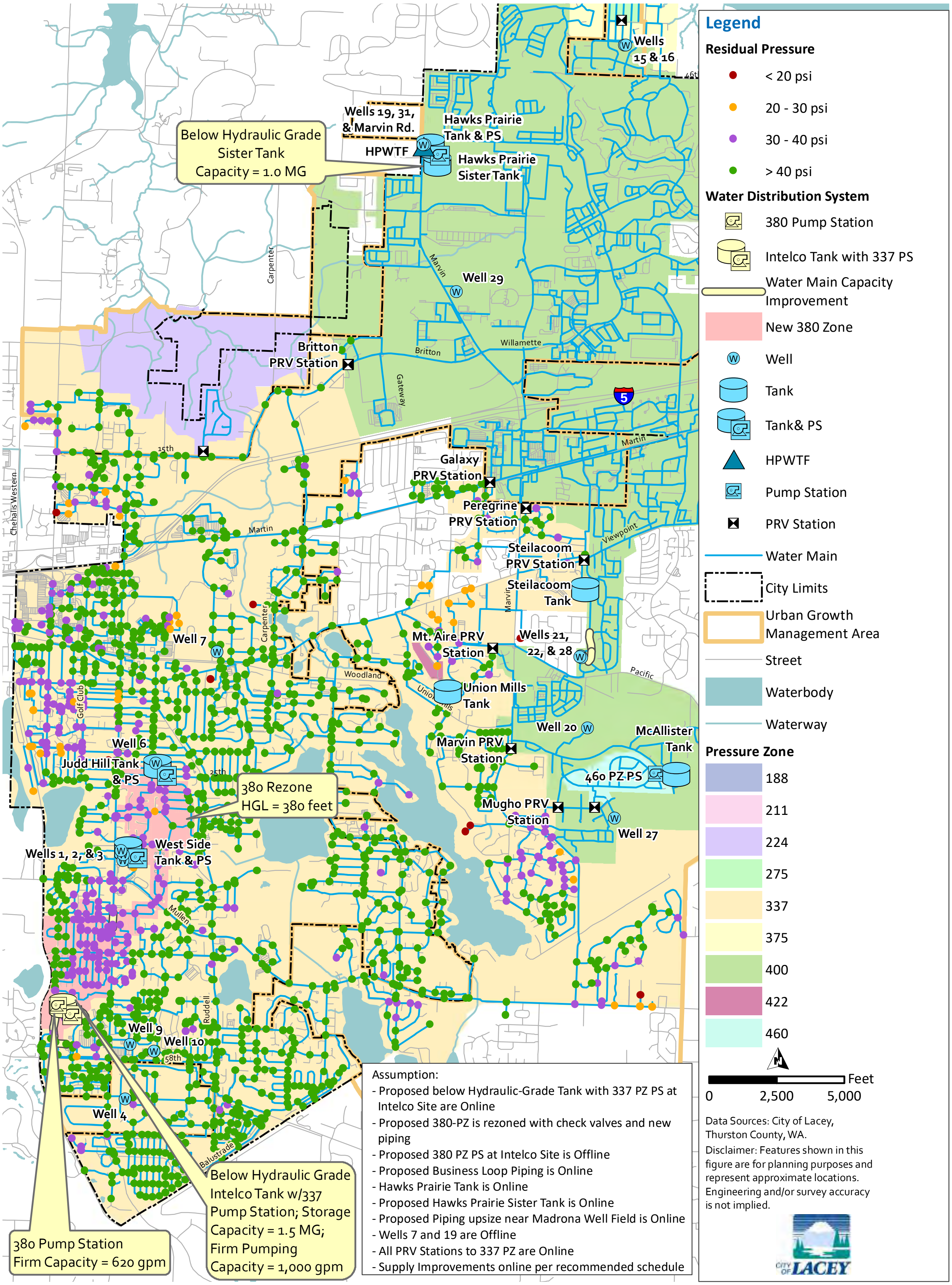


Figure 21 Residual Pressure under 2028 MDD plus Fire Flow Conditions - 337 PZ Alternative 2, S07 and S19 Offline

6.3 Alternative 3 – No Rezone and At-Hydraulic-Grade Tank

6.3.1 Alternative 3 Infrastructure

Alternative 3 involves constructing an at-hydraulic-grade tank at the Intelco site, as shown on Figure 22. The at-hydraulic-grade tank will provide gravity storage to the 337 PZ. The following preliminary tank characteristics are recommended:

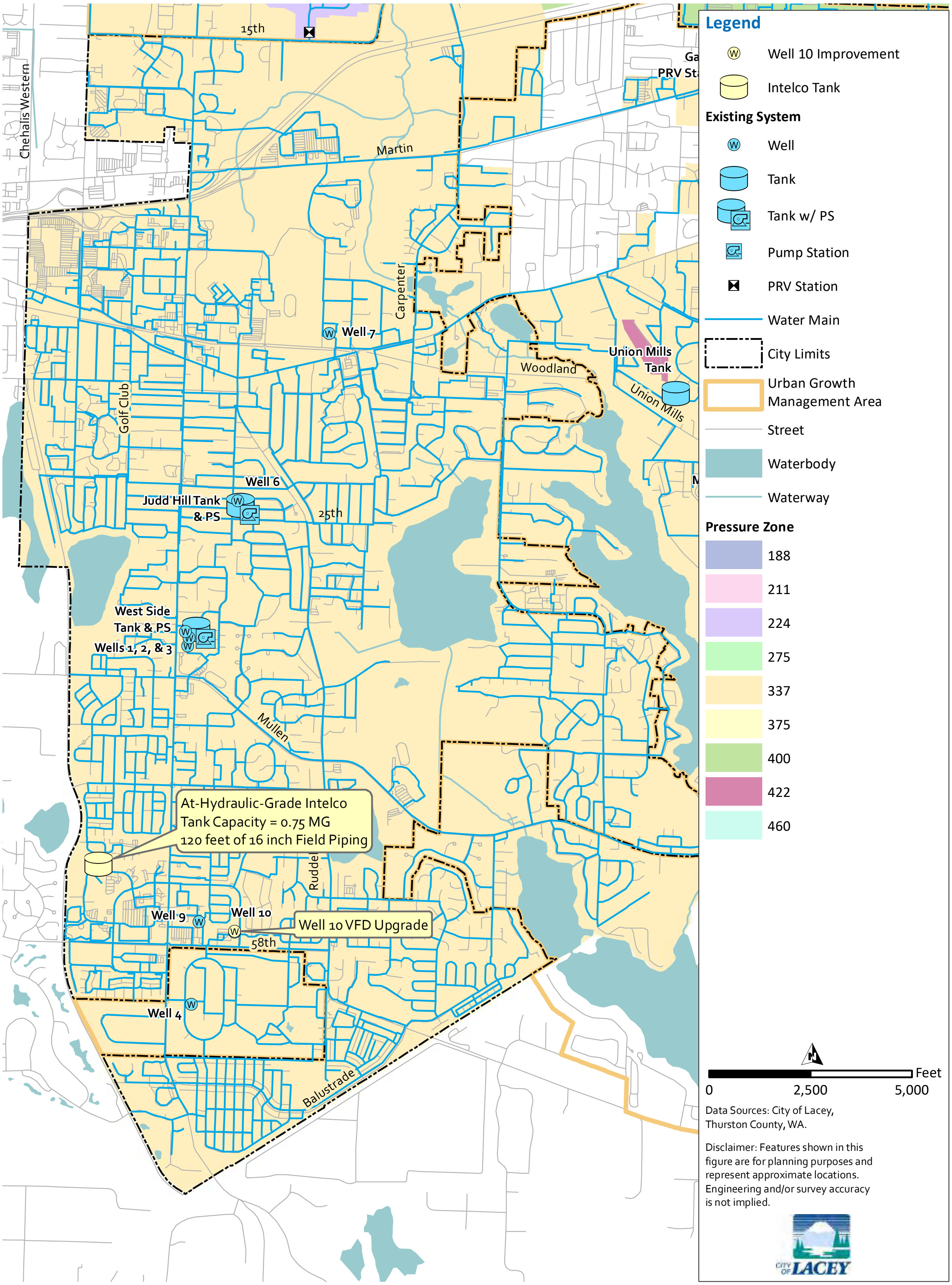
- Tank Type: at-hydraulic-grade.
- Storage Capacity = 0.75 MG.
- Tank overflow elevation: Modeled at 337 feet to match 337 PZ's HGL. Overflow elevation should be re-evaluated during predesign.
- Approximately 150 feet of 16-inch diameter field piping is needed connect the Intelco tank to the 337 PZ mainline pipe in Intelco Loop SE.

Three tank sizes were run in the hydraulic model (0.5, 0.75, and 1 MG). Based on the modeling, all three sizes provided adequate storage, and the proposed at-hydraulic-grade tank showed good turnover. A 0.75 MG was recommended since it provides similar performance as a 1 MG tank at a lower cost.

An at-hydraulic-grade elevated style 0.75 MG reservoir was chosen to meet the City's operational criteria and therefore recommended as a cost-effective option. The 0.75 MG tank would provide 0.3 MG (40 percent) of operational/equalizing storage and 0.45 MG (60 percent) of Emergency/ Fire Suppression storage. The operational/equalizing storage was set to maintain pressures at high elevation customers, with the remaining volume assigned to Emergency/ Fire Suppression. A larger elevated style tank would increase these volumes proportionally (i.e. a 1 MG tank would have 0.4 MG of Operational/Equalizing storage). This sizing requires the City to build additional storage in the future to meet its Comp Plan requirements.

If Alternative 3 is the selected alternative, operational changes are recommended to achieve proper tank cycling. With a new at-hydraulic-grade tank, nearby sources, Wells 1, 4, 9, and 10, will need to incorporate the Alternative 3 tank water levels to maintain adequate levels during operations. For specific facility controls, in the hydraulic model, see Appendix A.

Alternative 3 also involves adding variable frequency drives (VFDs) to Well 10 to increase operational flexibility. The model indicates a VFD on Well 10 improves the overall operation of the College Street corridor area, which is reflected in improved tank turnover. The VFD modulates pumping based on pressure and allows Well 10 to operate for longer periods of time; resulting in a "smoothing" of reservoir fluctuations. Therefore, while a VFD is not required, it is recommended for this Alternative.


Legend
Well 10 Improvement
Intelco Tank
Existing System
Well
Tank
Tank w/ PS
Pump Station
PRV Station
Water Main
City Limits
Urban Growth Management Area
Street
Waterbody
Waterway
Pressure Zone
188
211
224
275
337
375
400
422
460
Feet
0
2,500
5,000
Data Sources: City of Lacey, Thurston County, WA.
Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.
15th
Chehalis Western
Martin
Carpenter
Well 7
Union Mills Tank
Woodland
Union Mills
Golf Club
Well 6
Judd Hill Tank & PS
25th
West Side Tank & PS
Wells 1, 2, & 3
Mullen
At-Hydraulic-Grade Intelco
Tank Capacity = 0.75 MG
120 feet of 16 inch Field Piping
Rudder
Well 9
Well 10
Well 10 VFD Upgrade
58th
Well 4
Balustrade

6.3.2 Alternative 3 – Minimum Pressures during PHD

Alternative 3 was evaluated to understand the new infrastructure's impact on pressures, fire flow, and water age.

Figure 23 shows the minimum system pressures under 2028 PHD conditions. As discussed for Alternative 1 in Section 6.1.2, the system is unable to maintain minimum pressures of 40 psi under the PHD condition. Although the new at-hydraulic-grade reservoir acts as a buffer for pressure fluctuations, it cannot increase pressures to above 40 psi for the customers at the highest elevations.

The at-hydraulic-grade tank does not significantly improve system pressures along the College Corridor compared to the baseline scenario, as shown on Figure 24. Adding the new elevated tank in the 337 PZ showed minor benefits to customer pressures. The average increase in pressure, shown in the hydraulic model, was approximately 2 psi. The primary tank benefits are to provide additional storage in the 337 PZ and reduce temporary pressure sags. The new at-hydraulic-grade Intelco tank reservoir will meet College Street Corridor demand for short periods without pumping. This allows nearby infrastructure more flexibility in operation. Further, infrastructure in the College Street Corridor can be operated from the proposed Intelco Reservoir, rather than Steilacoom Reservoir. This should greatly reduce the temporary pressure sags that can occur with current operations.

According to Figure 25, the at-hydraulic-grade tank can cycle appropriately under 2028 PHD conditions. As previously discussed in Alternative 1, operating the tank at higher levels to maintain higher pressures is not recommended as it can result in poor water quality. For detailed facility control and operational changes made in the model, see Appendix A.

6.3.3 Alternative 3 – Residual Pressures during MDD + Fire Flow

The addition of the at-hydraulic-grade tank will improve fire suppression storage availability. Residual pressures under Alternative 3 are similar to the Baseline scenario performance, as shown on Figure 26.

6.3.4 Alternative 3 – Water Age

Water age was also run with the infrastructure recommended under Alternative 3. The water age analysis shows minimal difference in results from the baseline condition. Water age increases in the College corridor due mainly to the increase in storage volume in the area. Additionally, recommended transmission pipelines in Alternatives 1 and 2 for the rezone are not included in this alternative, which might limit flow from/to the new at-hydraulic-grade tank under this alternative. As previously discussed, water age results are highly dependent on facility operations; therefore, water age is anticipated to vary throughout the year.

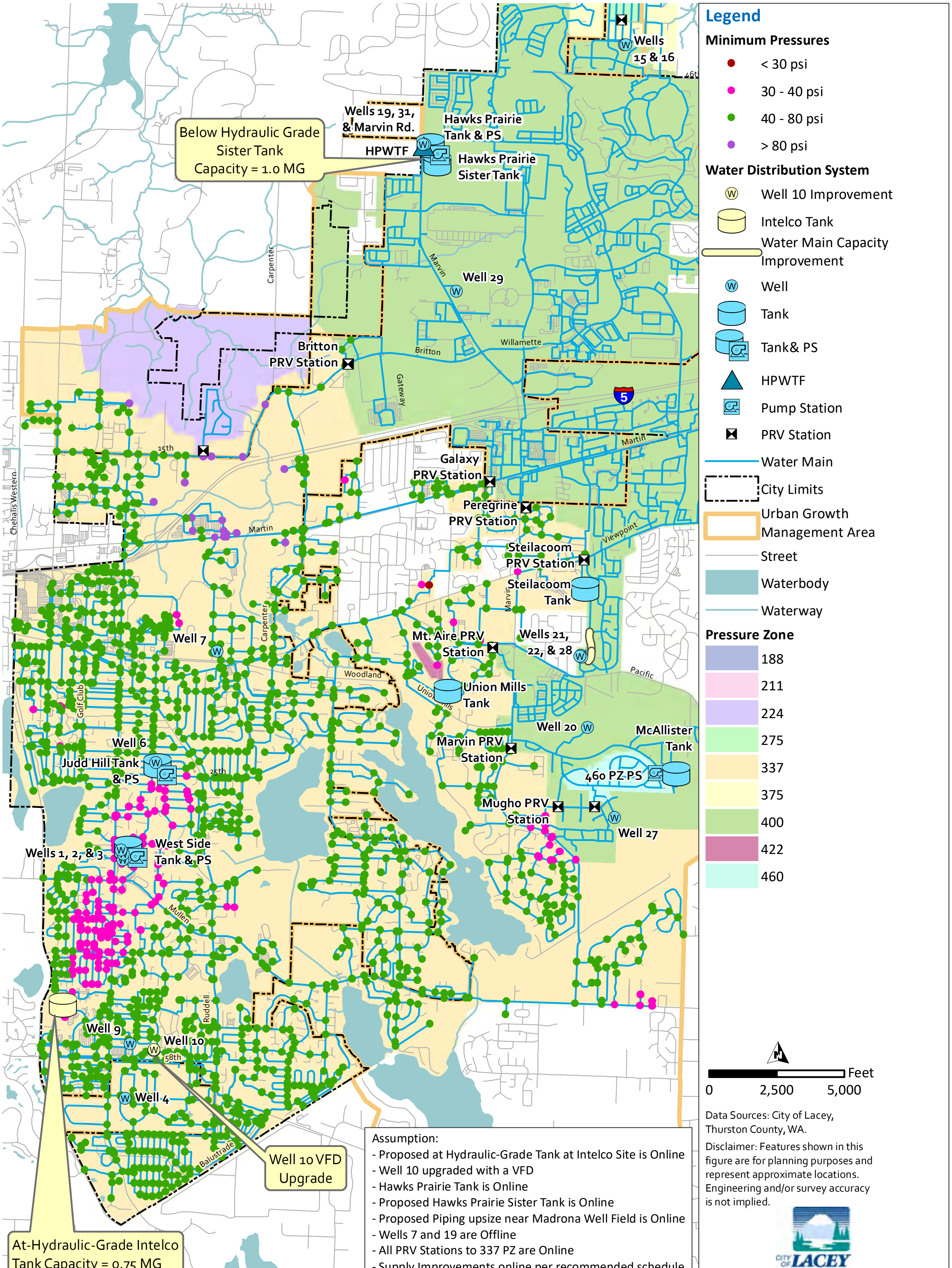
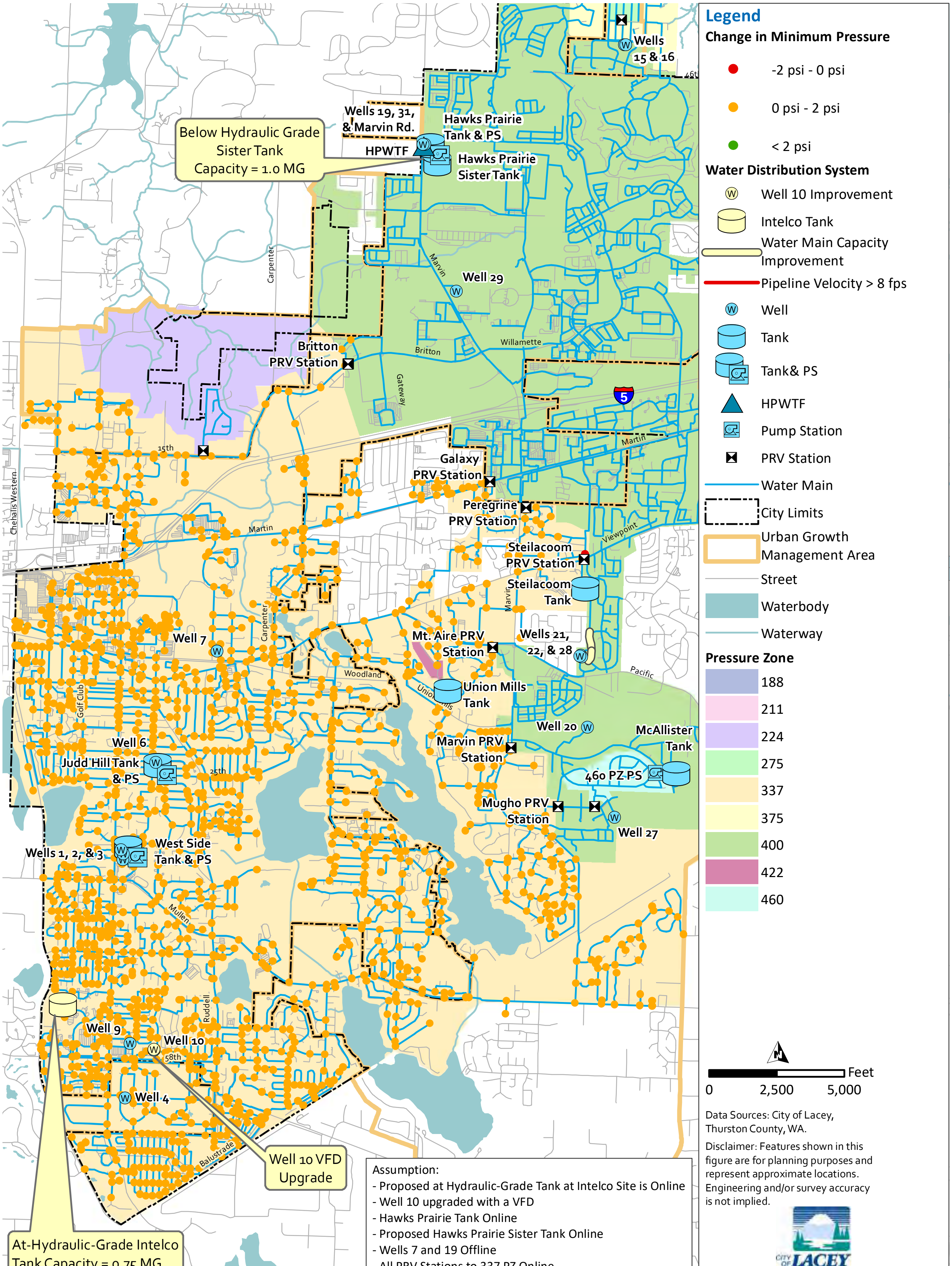


Figure 23 Minimum Pressures under 2028 PHD Conditions - Alternative 3, S07 and S19 Offline



carollo Figure 24 Change in Minimum Pressures from 2022 PHD Baseline to 2028 PHD Alternative 3 Conditions, S07 and S19 Offline

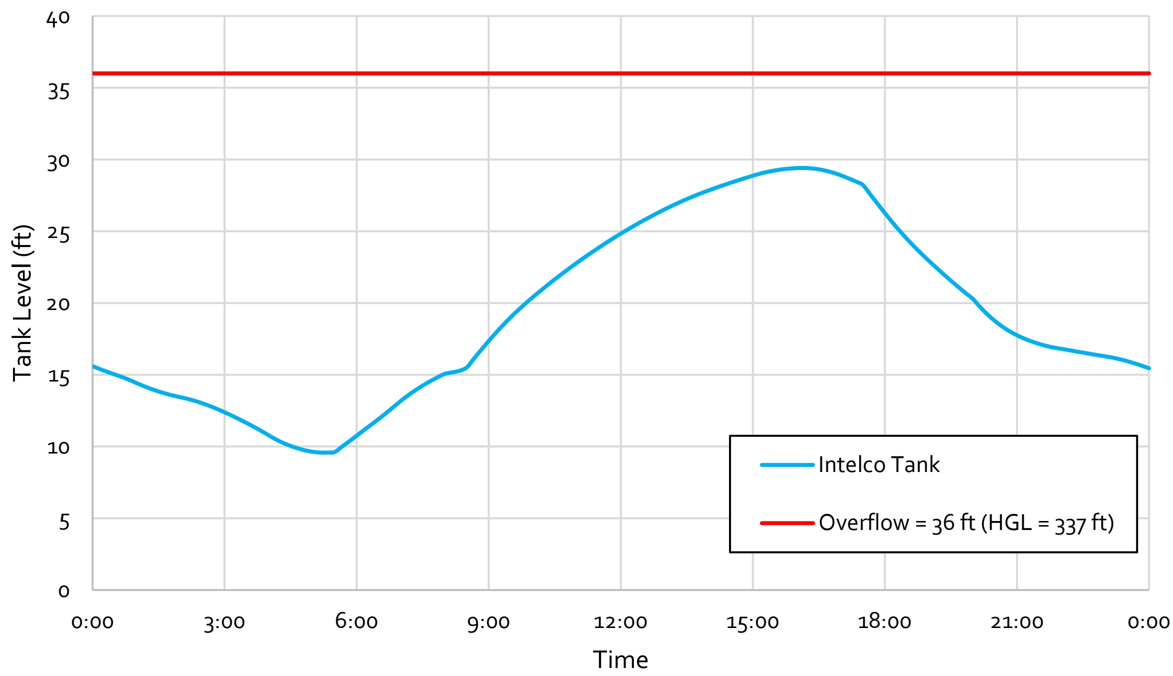


Figure 25 Intelco Tank Level under 2028 PHD Conditions - Alternative 3

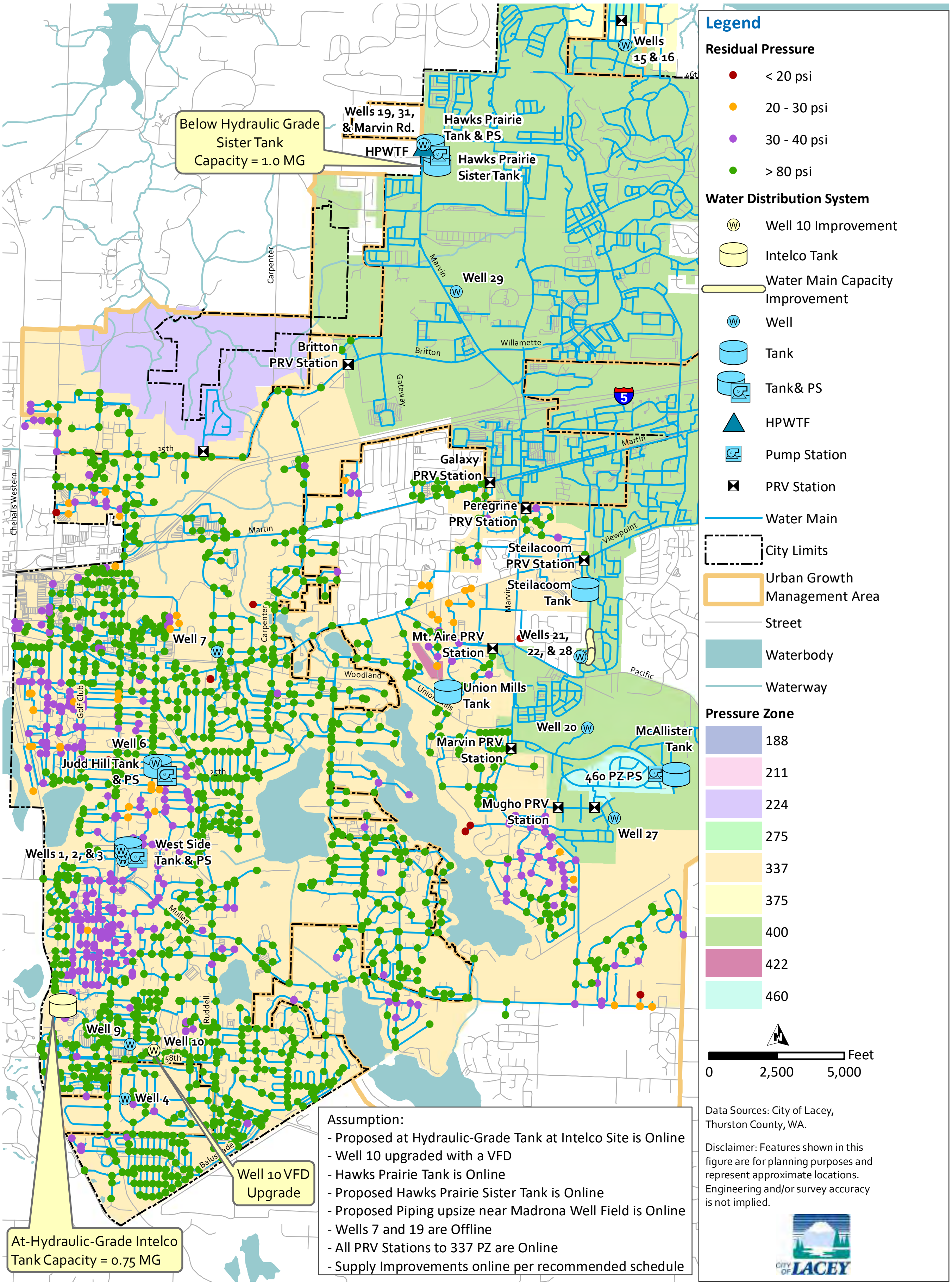


Figure 26 Residual Pressure under 2028 MDD plus Fire Flow Conditions - 337 PZ Alternative 3, S07 and S19 Offline

Section 7

LIFE-CYCLE COSTS AND CAPITAL COSTS

This section summarizes the cost assumptions used to develop costs for each alternative. These costs were used to compare the alternatives.

When possible, life-cycle costs are generated for new infrastructure to help select preferred improvements. Life-cycle costs include both capital costs and operations and maintenance (O&M) costs over a 50-year period. Capital costs are costs for new infrastructures, whereas O&M costs are for operating and maintaining new facilities.

The following capital costs assumptions are discussed in subsequent sections:

- Supply.
- Transmission.
- Treatment.
- Booster Pump Stations.
- Storage.
- Land acquisition.

The following items were collected and used to develop operations and maintenance costs:

- Energy.
- City staff effort.
- Pump station rehabilitation.
- Tank recoating.
- Valve maintenance.

7.1 Cost Estimating Methodology Assumptions

Cost estimates were developed for each alternative's supply, transmission, and treatment components. These costs are planning-level estimates only and should be refined during pre-design.

The cost estimates developed in this chapter are American Association of Cost Engineers (AACE) Class 4 estimates, which are budget-level estimates. Actual costs may vary from these estimates by -30 percent to +50 percent.

Project costs are also planning-level projections based on approximate average costs for similar projects.

All capital costs are in May 2018 dollars, inflated to the year the project is expected to be constructed in. The Engineering News Record's (ENR) US 20-City Construction Cost Index for May 2018 is 11013. O&M costs were inflated to the year the operation or maintenance will be performed.

The annual construction cost inflation rate of 3.0 percent is applied to the life-cycle costs.

7.2 Capital Cost Assumptions

The unit costs in this section were used to develop construction costs for each alternative. To develop the total project cost, construction costs were inflated using the cost factors shown in Table 4.

Table 4 Cost Factors

Cost Factor	Description	Factor
All Projects		
Contingency	Costs that may occur due to uncertainty in project scope and conditions.	30%
Water Main Replacement Projects		
City of Lacey staff, project and construction engineering finance codes	Costs for a project's in-house planning, design, and construction administration.	19%
Other	Costs for connection and permitting fees, easements, land acquisition, advertising, and finance administrative fee.	6%
Water Well Projects		
City and consultant, project and construction engineering finance codes	Costs for a project's studies, planning, design, and construction administration.	35%
Other	Costs for connection and permitting fees, easements, land acquisition, advertising, and finance administrative fee.	6%
Booster Pump Station & Reservoir Projects		
City and consultant, project and construction engineering finance codes	Costs for a project's studies, planning, design, and construction administration.	40%
Other	Costs for connection and permitting fees, easements, land acquisition, advertising, and finance administrative fee.	5%

7.2.1 Supply

The cost to add a VFD to the Source 10 well pump was assumed to be $50,000 using previous projects and engineer's estimates.

7.2.2 Transmission

Table 5 shows transmission main unit construction costs. These unit costs assume open-trench construction and include pavement cutting, excavation, hauling, shoring, pipe materials and installation, backfill material and installation, and a minimum pavement replacement of half the street. These costs also assume that main pipelines less than 12 inches in diameter are polyvinyl chloride (PVC) and mains 12 inches and greater are ductile iron. The unit costs are for "typical" field conditions with construction in stable soil at a depth ranging from three to five feet.

Acquisition, easements, and right-of-ways (ROWs) may be required for some of the recommended projects. For these cost estimates, pipeline corridors were assumed to be in a public ROW and do not require land acquisition.

Table 5 Transmission Costs

Element	Unit(1)	Unit Construction Cost ($/LF)(1)
8-inch Pipe	LF	$180
10-inch Pipe	LF	$200
12-inch Pipe	LF	$220
16-inch Pipe	LF	$240
18-inch Pipe	LF	$260
24-inch Pipe	LF	$310

Note:
(1) LF: linear feet.

7.2.3 Controls Valves

Check valves were recommended for isolating the Rezone in Alternatives 1 and 2. Construction costs of $75,000 per valve were used based on past experience. It was assumed a total of 10 valves would be required to isolate the Rezone area.

As previously stated, a surge or pressure reducing valve is recommended for the Rezone to prevent over pressurization in the event of a pump station control failure. The valve was assumed to be incorporated within the 380 PZ pump station and was not separately costed.

7.2.4 Treatment

No treatment project costs were included in the 337 PZ study.

7.2.5 Booster Pump Stations

BPS costs were included for ground reservoirs in some alternatives for both 337 PZ and 400 PZ. BPS construction costs were estimated using a unit construction cost based on each pump's number of pumps and horsepower (hp).

Table 6 lists the unit construction costs used. Unit construction costs include site work, pumps, a structure, all mechanical and electrical equipment, and a back-up generator. The cost to add a VFD was assumed to be $50,000 using previous projects and engineer's estimates.

Table 6 Pump Station Costs

Horsepower	Unit	Unit Construction Cost
0 to 199 hp	Per hp per Pump	$8,200
200 to 349 hp	Per hp per Pump	$3,300
350 to 649 hp	Per hp per Pump	$2,500
>650 hp	Per hp per Pump	$1,700

7.2.6 Storage

New storage reservoir project costs were developed based on typical costs from past projects and Carollo's experience. Conceptual costs for reservoirs vary based on the type of storage: ground, standpipe, and elevated.

These costs were estimated using reservoir volume in gallons, as presented in Table 7. Reservoir costs are sensitive to site-specific geotechnical and seismic considerations; as a result, Carollo recommends conducting a reservoir siting study to address these issues.

Table 7 Reservoir Costs

Reservoir Type	Cost per gallon ($/gallon)
Ground	$1.20
Standpipe	$2.00
Elevated	$4.00

Note:
(1) Reservoir unit costs are for construction only.

7.2.7 Land Acquisition

No alternatives required land acquisition.

7.3 Operation and Maintenance Costs

7.3.1 Energy

The City provided an estimate of energy costs at $0.11/ kilowatt hour (kWh), or $0.0002 per gallon pumped. The life cycle for the pump stations and tanks are assumed to be 50 years.

Each pump's conceptual hp was calculated based on the facility's hydraulics. Pumps were sized based on hydraulic modeling conducted during the MDD. The following pump efficiencies and treatment facility head loss characteristics were applied to size the pump's hp:

- Using the City's typical energy consumption, energy costs for Alternatives 1 and 2 were assumed to be $0.11 per kWh.
- Energy costs for all Alternatives assumes $100 per month for general electrical costs (instrumentation, supervisory control and data acquisition [SCADA], site lighting, etc.).
- Alternative 337-1 assumes one rezone pump at 75 hp motor is running 365 days per year.
- Alternative 337-2 assumes one rezone pump at 75 hp motor is running 365 days per year. Costs assume one 60 hp motor below-hydraulic-grade reservoir pump running 24 hours for 60 days/year.
- All energy costs assume a 3.0 percent general cost inflation per year, as noted in the City's 2013 Water Rate Study.

7.3.1.1 Booster Pump Stations

The booster pumps' energy use was calculated using its anticipated design flow rate and design head. Pump and motor efficiencies were assumed to be the following:

- Pump efficiency of 85 percent.
- Motor efficiency of 90 percent.

Horsepower requirements were identified for each BPS based on hydraulic modeling. Booster pumps will likely be operated to meet peak demands beyond the average MDD met by supplies. Peak demands were calculated using the City's summer diurnal curve, which was based on the 2016 consumption data shown on Figure 27. For each facility, the pump station's total usage was estimated using the hydraulic model. Conservatively, MDD booster station pumping was assumed to occur 60 days each year.

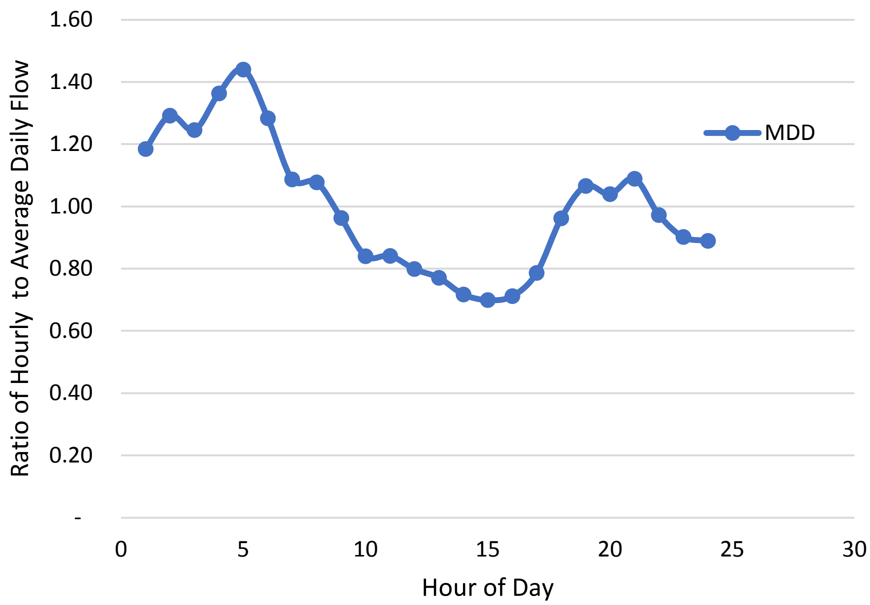


Figure 27 2016 Summer Diurnal Curve

7.3.1.2 Well Pumping

Well energy use was determined from existing City sources. The following sources represent the proposed supply projects and were thus used to size pumps:

- S02 – Well No. 2.
- S06 – Well No. 6.
- S07 – Well No. 7 + ATEC water treatment facility (Iron & Manganese Removal, disinfection).
- S21 – Madrona Well No. 1.
- S19 – Hawk's Prairie No. 1 + Hawks Prairie Treatment Facility (Iron & Manganese removal, Ammonia removal, Hydrogen Sulfide removal, disinfection).

Disinfection at other wells was assumed to have a negligible impact on well energy use.

The supply improvements are intended to meet MDD with redundant supplies and operational flexibility. Because the goal is more operational flexibility, the total amount of pumping throughout the year cannot be predicted. Furthermore, although pumping from new supplies may offset existing supplies, calculating this is beyond the scope of the project. As a result, energy costs were considered on a $/unit of pumping basis.

7.3.2 City Labor

City-provided staff to operate and maintain facilities was estimated for the generalized facilities described below.

7.3.2.1 Supply

- Well Supply, Disinfection Only (similar to S29): 204 hours, 0.10 full time equivalent (FTE), $18,478.32.
- Well Supply, Corrosion Control, Disinfection (similar to S04): 245 hours, 0.12 FTE, $22,192.10.
- Well Supply, Iron and Manganese Treatment, Disinfection (similar to Well 7 and ATEC system): 3,842 hours, 1.85 FTE, $348,008.36.
- Well Supply, Iron and Manganese Treatment, Ammonia treatment, Hydrogen Sulfide treatment, and disinfection (Similar to S19 and Hawks Prairie Treatment Facility): 3,655 hours, 1.76 FTE, $331,069.90.

7.3.2.2 Pumping

- Large BPS with backup generator (similar to Westside): 161 hours, 0.08 FTE, $14,583.38.
- Large BPS without backup generator (similar to Hawks Prairie booster): 36 hours, 0.02 FTE, $3,260.88.
- Small BPS without backup generator (similar to McAllister/460 BPS): 12 hours, 0.01 FTE, $1,086.96.
- BPS, PZ Transfer (limited use): although none is in the system, operations would run it at least once a month, so 12 hours, 0.01 FTE, $1,086.96 was assumed.

7.3.2.3 Reservoir

- Below-Hydraulic-Grade Storage (similar to Steilacoom Reservoir): 137 hours, 0.07 FTE, $12,409.46.
- At-Hydraulic-Grade (Elevated) Storage: assumed to have the same labor costs as the below-hydraulic-grade storage.

7.3.2.4 Valves

- Pressure Reducing Valve Station (similar to PRV15, with SCADA control): 16 hours, 0.01 FTE, $1,449.28.

It was assumed all control valves would require similar maintenance.

Note that isolation valves will likely be exercised through the City's existing valve program with negligible commitment needed from new staff.

Annual labor for new facilities was based on the existing facility that most closely matches the proposed facility. A Controls Technician/Water Treatment Plant Operator (WTPO) was assumed to perform the work, with a labor cost of $90.58/hour. This cost includes overhead, equipment, small tools, and vehicles.

A 3.0 percent labor cost inflation rate was applied to all labor costs per the 2013 Water Rate Study.

7.3.3 Pump Station Rehabilitation

To operate efficiently, pumps require regular preventative maintenance. Typically, this maintenance is performed by City staff. Even with preventative maintenance, however, pumps and motors require complete replacement every 30 years due to wear. Often, code revisions also require modernizing electrical equipment.

Pump station rehabilitation projects were assumed to cost 33 percent of the total pump station costs (Section 5.1.2.4) every 20 years. Per the City's 2013 Water Rate Study, a 3.0 percent general cost inflation was applied.

7.3.4 Tank Recoating

Steel water storage tanks typically require periodic recoating every 30 years. To compare alternatives, high-level conceptual costs for steel tank recoating were estimated. Unit costs are as follows:

- Tank Recoating: $7.59 / square feet (sf).
- Overspray Protection.
- Elevated Tank Surcharge.

These general costs include basic preparation, containment, coating material, installation, and restoration of tank appurtenances. Note that recoating material costs vary depending on the material and aesthetic specifications. Costs do not include the cost to repair corrosion or other surface damage and to replace damaged appurtenances. Complex surfaces, such as a multi-legged elevated tank, may incur additional costs due to the increased contractor effort.

Tank recoating costs should be refined during planning and predesign of any future reservoir. Per the City's 2013 Water Rate Study, a 3.0 percent general cost inflation was applied.

7.3.5 Valve Maintenance

The City contracts with GC Systems to rebuild its PRVs every five years, with an average cost of $2,000/valve. On average, proposed PRV and check valve stations are anticipated to require similar maintenance costs. It was assumed all control valves (check, surge, etc.) would require similar maintenance.

7.4 337-PZ Alternative Costs Summary

The resulting costs for the three alternatives are shown in Table 7. Capital costs are split into tank costs and rezone costs. Detailed costs for each alternative can be found in Appendix B.

Table 8 Summary Costs – 337-PZ Alternative

Costs	337 PZ Alternative 1	337 PZ Alternative 2	337 PZ Alternative 3
Capital Costs			
Tank Costs	$5,959,200	$3,595,600	$6,070,200
Rezone Costs	$4,440,300	$5,447,700	$0
Total Capital Costs	$10,399,500	$9,043,300	$6,070,200
O&M Costs	$11,851,000	$13,529,900	$2,327,000
Total Capital and O&M	**$22,250,500**	**$22,573,200**	**$8,397,200**

Notes:
(1) Capital costs are in 2022 dollars.
(2) O&M costs are inflated to the year in which the operation or maintenance is performed, over a 50 year period.
(3) Total costs rounded to the nearest $100.

Section 8

ALTERNATIVES RANKING AND SELECTION

8.1 Ranking Methodology and Criteria

To compare the alternatives and help with a recommendation, ranking criteria were developed. As shown in Table 9 below, the team scored each criterion between 1 and 5; a score of 1 was the worst, and a score of 5 was the best. To calculate a total score, the number was multiplied by the weight.

Lifecycle costs for each alternative were also evaluated, including capital costs and costs for additional operations FTE, power, maintenance, and replacement. The need to repair old mains during transition to higher HGL under Alternatives 1 and 2 was also considered but no cost was included.

The goal of this study was to increase pressure to customers along the College Corridor. Thus, as part of the study, pressure impact was evaluated for each alternative. The study evaluated the number of pressure improvements and constant pressure with minimum fluctuation.

Water quality was evaluated as well. The alternatives' effects on water quality, such as whether it would improve, worsen, or not affect quality, were assessed. The age of the water, chlorine demand, and oxidation of manganese in the reservoir and distribution system were also considered, as were changes to source water movement and mixing in the distribution system, pH, corrosion, tank turnover, temperature, and nitrates.

Lastly, the alternatives' O&M were evaluated, including whether the alternative improved or complicated operations, what impacts its O&M would have on the overall system, and how safe and easy it is to operate, maintain, and replace the new infrastructure.

Table 9 337 PZ Alternatives Ranking

Criteria	Weight	Alt 1	Alt 2	Alt 3
Life Cycle Costs	20%	2	3	5
Pressure	30%	5	5	3
Water Quality	30%	2	3	4
O&M	20%	2	1	4
Weighted Total	**100%**	**2.90**	**3.20**	**3.90**

8.2 Recommended Alternative

Based on the above ranking, the City selected Alternative 3 Elevated 337 PZ Tank for pre-design and implementation based on its superior ranking. The Alternative is described as follows:

- Tank Type: at-hydraulic-grade.
- Storage Capacity = 0.75 MG.
- Tank overflow elevation: 337 ft to match 337 PZ's HGL.
- Approximately 150 ft of 16-inch diameter field piping connect the Intelco tank to the 337 PZ.

The alternative has a capital cost of $6,070,200. O&M costs over 50 years are anticipated to be $2,327,000.

Alternative 3 provides additional storage, reduces current temporary pressure sags in the area, and will help simplify operational complexity of nearby infrastructure. The new at-hydraulic-grade Intelco tank reservoir will meet College Street Corridor demand for short periods without pumping. This allows nearby infrastructure more flexibility in operation. Further, Infrastructure in the College Street Corridor can be operated from the proposed Intelco Reservoir, rather than Steilacoom Reservoir. This should greatly reduce the temporary pressure sags that can occur with current operations. However, Alternative 3 does not significantly increase low pressures in the College Corridor.

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Appendix A

SYSTEM OPERATION AND MODEL UPDATE

City of Lacey

SYSTEM OPERATIONS AND MODEL UPDATE

Final | December 2018

Contents

Section 1 - System Controls

Appendix

Tables

Figures

Abbreviations

Carollo	Carollo Engineers, Inc.
City	City of Lacey
EPS	extended period simulation
ft	feet
gpm	gallons per minute
HGL	hydraulic grade line
HPWTF	Hawks Prairie Water Treatment Facility
MG	million gallons
mgd	million gallons per day
MSL	main sea level
PRV	pressure reducing valve
PS	pump station
psi	pounds per square inch
PSV	pressure sustaining valve
PZ	pressure zone
SCADA	supervisory control and data acquisition
VFD	variable frequency drive
WTP	water treatment plant

Section 1

SYSTEM CONTROLS

1.1 Background

The City of Lacey (City) provided Carollo Engineers, Inc. (Carollo) with a hydraulic model of their existing water distribution system. The model was updated with future demands and recent/upcoming projects, which are described in Section 1.4. The hydraulic model was then used to conduct a hydraulic analysis on the selected alternatives as part of the 337 Pressure Zone (PZ) Facilities and Pressure, and 400 PZ Storage Studies. This Report summarizes changes made to the model controls depending on the alternative.

1.2 Hydraulic Model Development

This section summarizes elements of a hydraulic model, how facilities are represented in a model and a review of the City's existing hydraulic model.

1.2.1 Elements of a Hydraulic Model

The following provides a brief overview of the various elements of the hydraulic model and the required input parameters associated with each:

- Junctions. Locations where pipe sizes change, where pipelines intersect, or where water demands are applied are represented by junctions in the hydraulic model. Required inputs for junctions include service elevation and water demands.
- Pipes. Water mains are represented as pipes in the hydraulic model. Input parameters for pipes include length, roughness (Manning's n factor), diameter, and whether or not the pipe is a check valve (i.e., does not allow reverse flow).
- Tanks. Cylindrical and Variable Area Tanks: Water tanks are included in the hydraulic model as either cylindrical tanks or variable area tanks, depending on the complexity of the tank geometry. Required input parameters for cylindrical tanks include bottom elevation, maximum level, initial level, and diameter. Required input parameters for variable area tanks include bottom elevation, maximum level, initial level, and a curve that varies the cross sectional area of the tank depending on the tank level (developed as appropriate based on As-built drawings).
- Fixed Head Reservoirs (water sources): For water distribution system modeling, fixed head reservoirs are used to represent a water source with a constant hydraulic grade line (HGL). Typically, fixed head reservoirs are used to represent water sources, such as wells or other sources.
- Pumps. Pumps are included in the hydraulic model as links. Input parameters for pumps include pump curves and operational controls.
- Valves. A number of different valves, such as pressure reducing valves (PRVs) and float valves, are represented as links in the hydraulic model. Required input parameters for valves include diameter, operational controls, and other settings or headloss curves depending on the type of valve.

- Demands. Water demands are applied at specific junctions in the hydraulic model. Up to ten different demands can be assigned at a particular junction.

1.2.2 Hydraulic Model Review

The City provided Carollo with a calibrated hydraulic model updated with 2016 demands and 2017 facilities to complete the alternatives analysis. A model review was conducted to understand the overall operations regarding production of various water supplies and system facilities prior to modeling alternatives.

Figure 1.1 shows the modeled water distribution system's pipeline alignments, as well as the locations of the tanks, wells, pump stations (PS), PRVs, interconnections, and pressure zones. The modeled water distribution system consists of over 324 miles of pipelines ranging from 0.5-inch to 18-inches in diameter. The following sections summarize the facilities characteristics and operational scheme. These sections include tables that summarize the facilities and lists simplified controls for the respective facilities. However, these tables do not fully represent the control logic within the hydraulic model. A copy of the detailed control logic is included in Appendix 1.

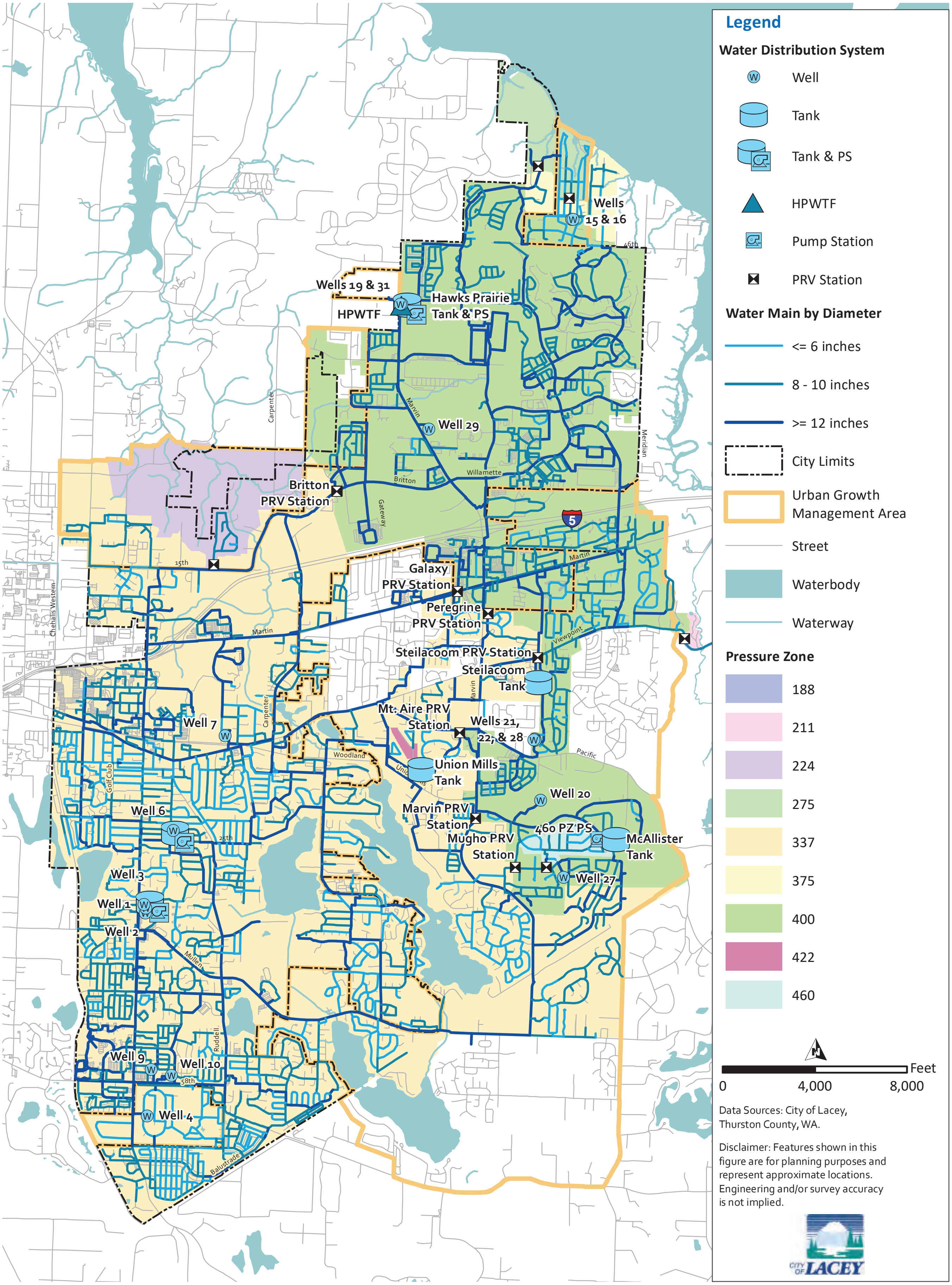
1.2.2.1 Pressure Zones

There are nine PZs within the City's distribution system designed to provide acceptable operating pressures throughout the system. Table 1.1 lists the maximum HGL of each pressure zone, which range from 188 feet (ft) to 460 ft above mean sea level (MSL). The City delineated pressure zones using closed valves and pipes.

Table 1.1 Pressure Zones

Pressure Zone(1)	Maximum HGL(1) (ft)	Lowest Customer Static Pressure(2) (psi)(6)	Highest Customer Static Pressure(3) (psi)
188 PZ	188	22(5)	73
211 PZ(4)	211	--	--
224 PZ	224	45	67
275 PZ	275	34	89
337 PZ	337	37	108
375 PZ	375	63	113
400 PZ	400	42	113
422 PZ(4)	422	--	--
460 PZ	460	67	101

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Lowest Customer Static Pressure = (PZ's Maximum HGL - highest PZ's elevation with demand)/2.31.
(3) Highest Customer Static Pressure = (PZ's Maximum HGL - lowest PZ's elevation with demand)/2.31.
(4) PZ was modeled as a single demand at a point within the PZ its source.
(5) This is a junction pressure in the model. It is not the pressure customers receive.
(6) psi: pounds per square inch.


Legend
Water Distribution System
Well
Tank
Tank & PS
HPWTF
Pump Station
PRV Station
Water Main by Diameter
<= 6 inches
8 - 10 inches
>= 12 inches
City Limits
Urban Growth Management Area
Street
Waterbody
Waterway
Pressure Zone
188
211
224
275
337
375
400
422
460
Feet
0
4,000
8,000
Data Sources: City of Lacey, Thurston County, WA.
Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.
Wells 15 & 16
Wells 19 & 31
Hawks Prairie Tank & PS
HPWTF
Well 29
Britton PRV Station
Galaxy PRV Station
Peregrine PRV Station
Steilacoom PRV Station
Steilacoom Tank
Mt. Aire PRV Station
Wells 21, 22, & 28
Union Mills Tank
Well 20
Marvin PRV Station
Mugho PRV Station
460 PZ PS
McAllister Tank
Well 27
Well 7
Well 6
Well 3
Well 1
Well 2
Well 9
Well 10
Well 4
Marvin
Carpenter
Britton
Willamette
Gateway
Meridian
Martin
Viewpoint
Pacific
Woodland
15th
Chehalis Western
Golf Club
25th
Mullen
Ruddell
58th
Balustrade
46th

1.2.2.2 Water Supply

Water is supplied from 20 groundwater wells and the Olympia Water System is used under emergency conditions. For the purpose of the hydraulic analysis, the Olympia Water System is assumed to be inactive. Many of the hydraulic model's wells were modeled as a fixed head reservoir with a pump and control valves. The control valves would dictate the wells production and discharge pressure. It is assumed that the wells are calibrated and reflect actual well performance. Wells operate using control logic based on tank levels and system pressures. Table 1.2 lists the City's well characteristics such as supply pumping capacity in gallons per minute (gpm) and simplified controls. The capacities shown in Table 1.2 were taken from the City's provided hydraulic model. These capacities were updated as part of the Ability to Serve analysis in Section 1.4.3. Detailed control logic is included in Appendix 1.

Table 1.2 Groundwater Wells

Well No.	Pressure Zone	Capacity[(1)] (gpm)
S01	337 PZ	510
S02	337 PZ	475
S03	337 PZ	200
S04	337 PZ	750
S06	337 PZ	265
S07	337 PZ	1,800
S09	337 PZ	700
S10	337 PZ	950
S15	400 PZ	170
S16	400 PZ	170
S19	400 PZ	670
S20	400 PZ	600
S21	400 PZ	1,600
S22	400 PZ	1,600
S24	188 PZ	70
S25	188 PZ	230
S27	400 PZ	750
S28	400 PZ	1,600
S29	400 PZ	975
S31	400 PZ	620

Note:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.

1.2.2.3 Storage Tanks

Water distribution systems rely on stored water to help equalize daily fluctuations between supply and demand, to supply sufficient water for firefighting, and to meet demands during an emergency or an unplanned outage of a major source of supply.

The City's hydraulic model includes seven storage tanks and one clear well with volumes ranging from 0.15 million gallons (MG) to 4 MG. Table 1.3 summarizes detailed information for each of the storage tanks.

Table 1.3 Storage Tanks

Tank	Pressure Zone	Storage Capacity (MG)	Grade	Bottom Elevation (ft)	Max. Water Level (ft)	Maximum HGL (ft)
Hawks Prairie	400 PZ	4.05	Below	295	85	380
Judd Hill	337 PZ	0.34	Below	236	50	286
McAllister	400 PZ	1.18	At	300	99	399
Nisqually	188 PZ	0.15	At	162	28	190
Steilacoom	337 PZ	2.94	At	267	71	338
Union Mills	337 PZ	2.12	At	272	63	334
West Side	337 PZ	1.86	Below	233	39	272

Notes:
(1) Source: City of Lacey Water System Comprehensive Plan.
(2) Source: City of Lacey Water Distribution System Hydraulic Model.

As shown in Table 1.3, the City's distribution system includes three tanks that are below the respective pressure zones HGL. For these tanks, water is stored via control valve to transfer water from the pressure zone to the tank without exceeding the allowable pressure. Water is supplied to the pressure zone via pump station transferring stored water.

A few notable controls in regards to the City's modeled storage tanks:

- Hawks Prairie Tank is modeled with a pressure sustaining valve (PSV) that opens when a set upstream pressure is met and closes when the 400 PZ PS is on.
- Judd Hill Tank is modeled with a PSV that opens when a set upstream pressure is met and closes when Judd Hill PS is on.
- McAllister Tank is modeled with a pressure breaker valve to force a specified pressure drop across the valve. Pressure breaker valves are not true physical devices but used to model a particular pressure drop when known.
- Union Mills Tank is modeled with a pressure breaker valve to force a specified pressure drop across the valve. Pressure breaker valves are not true physical devices but used to model a particular pressure drop when known.
- West Side Tank is modeled with a PSV to maintain a set upstream pressure and closes when the West Side PS is on.
- Note, Hawks Prairie contact basin is modeled to accurately represent water treatment plant (WTP) operations. It is not finished water storage.

1.2.2.4 Pump Stations

Water distribution systems rely on pump stations to move water from lower pressures to areas of higher pressures. The hydraulic model includes six pump stations. Pump stations are typically modeled as multiple point curves. For pumps with variable frequency drives (VFDs), the City's hydraulic model has pump setup such that a pressure reducing valve follows the pumps, essentially making them act like a VFD pump. The City inputted the hydraulic pump data into the model based on pump curves. It is assumed that the modeled pump stations are calibrated and reflect actual pump performance. Table 1.4 includes pump station characteristic and simplified controls. Detailed control logic is included in Appendix 1.

Table 1.4 Pump Stations

Pump Station(1)	From	To	Pumping Capacity(1) (gpm)
400 PZ	Hawks Prairie Tank	400 PZ	3,700
460 PZ	400 PZ	460 PZ(4)	500
Hawks Prairie	Hawks Prairie contact basin	400 PZ	2,000
Judd Hill	Judd Hill Tank	337 PZ	1,200
Skyridge(3)	400 PZ	422 PZ	110
West Side	West Side Tank	337 PZ	4,500

Notes:
(1) Source: City of Lacey Water System Comprehensive Plan.
(2) Source: City of Lacey Water Distribution System Hydraulic Model.
(3) Not included in the City's Water Distribution System Hydraulic Model.
(4) This study used the modeled 460 PZ, before field measurements put into question the pressure of the zone. The impact to this study is negligible.

1.2.2.5 Pressure Reducing Valves

PRVs allow distribution systems to transfer water from upper PZs to lower PZs without exceeding the allowable pressures in the lower zones or completely draining the pressure out of the higher zone. The water is transferred through a valve that reduces the pressure to a specified pressure setting. A PRV stations typically consist of several valves that are standby, or backup.

The City's distribution system includes 12 PRV stations, which convey and regulate water to lower zones. Five of these 12 have solenoids controlled by supervisory control and data acquisition (SCADA). The City's PRV station's typically included another valve that would open to move water at higher rates during a fire flow or an emergency situation. Table 1.5 lists the City's existing PRV stations. It is assumed that the PRV stations are calibrated and reflect actual PRV station performance. Some of the PRV stations have mechanical valves. These valves have controls based on tank levels and when the mechanical valve opens the PRVs close. See Appendix 1 for detailed control logic. The pressure ranges listed in Table 1.5 reflect the PRV pressure settings as HGL equivalent. Mechanical valves HGL equivalent is based on the lower HGL equivalent for control logic and PRV settings.

Table 1.5 Pressure Reducing Valve Stations

Station Name	From	To	Number of Valves	HGL Equiv. Range(1) (ft)
Britton Parkway	400 PZ	337 PZ	2	272 - 303(2)
Evergreen Heights	460 PZ	400 PZ	1	358
Galaxy	400 PZ	337 PZ	3	319 - 331(2)
Lower Beachcrest	375 PZ	275 PZ	2	261 - 272
Marvin Road	400 PZ	337 PZ	3	272 - 326(2)
Mt. Aire	400 PZ	337 PZ	3	310 - 327(2)
Mugho	400 PZ	337 PZ	1	326(2)
Nisqually	337 PZ	188 PZ	2	177 - 182
Peregrine	400 PZ	337 PZ	2	315 - 327
Steilacoom	400 PZ	337 PZ	1	327
Upper Beachcrest	400 PZ	375 PZ	2	363 - 375
Woodland Creek	337 PZ	224 PZ	2	212 - 224

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) See Appendix A for station's detailed control logic.

1.3 Current System Operations

The City's hydraulic model controls and logic was provided by the City and reflects how the City operates their system. These were identified by converting tank level or node pressure controls to an HGL equivalent control to determine the primary and secondary control facilities.

A primary control facility is the facility that dictates when a supply will open and close under static conditions. A secondary control facilities are facilities less stringent than primary controls under static conditions, or open under emergency conditions. Primary control facilities were used to determine the supply lead and lag order, while secondary controls were used to determine order incase primary control facilities equivalent HGL were the same.

Table 1.6 and Table 1.7 list the 400 PZ and 337 PZ supply order, respectively. The tables include pump stations that pump stored water and PRV Stations that moves water from higher pressures zones.

Table 1.6 400 PZ Supply Order

Supply Facility	Primary Control Facility(1)	Open HGL Equiv.(1) (ft)	Open Rank	Closed HGL Equiv.(1) (ft)	Closed Rank
S27	McAllister Tank	393	1	395	7
S20	McAllister Tank	392	2	397	8
S21	McAllister Tank	392	2	394	5
S22	McAllister Tank	392	2	394	5
S28	McAllister Tank	391	3	395	6
400 PZ PS	400 PZ	384	4	--	--
S19(2)	Hawks Prairie Tank	373	5	379	4
S15	Hawks Prairie Tank	373	5	377	3
S16	Hawks Prairie Tank	373	5	377	3
S29	Hawks Prairie Tank	372	6	375	2
S31(2)(3)	Hawks Prairie Tank	360	7	373	1

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Hawks Prairie Treatment Facility operates when Well 19 or Well 31 is operating.
(3) Existing Well 31 is offline due to well rehabilitation.

Table 1.7 337 PZ Supply Order

Supply Facility	Primary Control Facility(1)	Open HGL Equiv.(1) (ft)	Open Rank	Closed HGL Equiv.(1) (ft)	Closed Rank
S02	Steilacoom Tank	332	1	335	5
S04	Steilacoom Tank	332	1	333	3
S07	Steilacoom Tank	332	1	334	4
S03	Steilacoom Tank	331	2	334	4
S10	Steilacoom Tank	331	2	334	4
Galaxy PRV Station	Steilacoom Tank	331	2	--	--
S01(2)	Steilacoom Tank	330	3	332	2
S09	Steilacoom Tank	329	4	332	2
Mt. Aire PRV Station	Steilacoom Tank	327	5	--	--
Peregrine PRV Station	337 PZ	327	5	--	--
Steilacoom PRV Station	337 PZ	327	5	--	--
Marvin Rd. PRV Station	337 PZ	326	6	--	--
Mugho PRV Station	337 PZ	326	6	--	--
S06	Steilacoom Tank	325	7	330	1
West Side PS	337 PZ	324	8	--	--
Britton Parkway PRV Station	337 PZ	303	9	--	--
Judd Hill PS	337 PZ	299	10	--	--

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Existing Well 1 is offline.

1.4 Future Supply Projects

In order to serve future users, the City has planned projects to implement within the planning period of the study (through 2028). This section discusses those improvements and corresponding changes made to the model as a brief description of control changes. The facility and control changes apply to all alternatives unless stated otherwise.

1.4.1 Existing Supply Model Updates

The City provided updated supply capacity information that wasn't entirely reflected in the model. The City's existing supply capacity facility operations are updated in the model. These model updates reflect existing supply conditions and may change based on future 400 PZ and 337 PZ alternatives. Table 1.8 lists the initial modeled well capacities and the updated existing well capacities based on City's staff input. Note that during the hydraulic model runs, both S19 and S7 are offline for redundancy and operational criteria purposes.

Table 1.8 Existing Well Capacity Model Update

Well No.	Pressure Zone	Initial Model Capacity(1) (gpm)	Updated Model Capacity(2) (gpm)
S01	337 PZ	510	0
S02	337 PZ	475	500
S03	337 PZ	200	206
S04	337 PZ	750	750
S06	337 PZ	265	290
S07	337 PZ	1800	1800
S09	337 PZ	700	730
S10	337 PZ	950	1,030
S15	400 PZ	170	190
S16	400 PZ	170	220
S19	400 PZ	670	620
S20	400 PZ	600	580
S21	400 PZ	1,600	1,350
S22	400 PZ	1,600	1,350
S24	188 PZ	70	80
S25	188 PZ	230	160
S27	400 PZ	750	1,000
S28	400 PZ	1,600	1,350
S29	400 PZ	975	1,000
S31(3)	400 PZ	620	0

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Source: City of Lacey Staff input.
(3) S31 is offline in 2016 then modeled at 620 gpm instead of 800 gpm for 2022 and 2028.

1.4.2 Planned Supply Improvements

The City confirmed that they have five planned supply improvements. Figure 1.2 shows the location of the planned supply improvements.

The City's planned improvements require that facility operations be added or updated in the model. Planned supply improvement descriptions and model updates are listed below. It is assumed that operational changes listed below are applied to 400 PZ and 337 PZ alternatives unless stated otherwise:

- In 2019, pump improvements at S19 and S31 going back online to add 980 gpm (1.41 million gallons per day [mgd]) of supply.
- In 2019, S15/S16 upgrades in 2019 to add 110 gpm (0.16 mgd) of supply.
- New Marvin Road Well with a pumping capacity of 1,000 gpm (1.44 mgd) in 2021. The increase in supply is 200 gpm (0.29 mgd) because the Hawks Prairie Water Treatment Facility (HPWTF) can only treat 1,800 gpm (2.59 mgd) of supply from S19, S31, and Marvin Road Well.

- The replacement well for S01 will be in service in 2022 to add 665 gpm (0.96 mgd) of supply.
- HPWTF expansion in 2028 will allow the full use of S19, S31, and Marvin Road Well water rights to add 800 gpm (1.15 mgd) of supply.
- In order to meet redundancy criteria the largest well is taken out of service. For the hydraulic model analysis Well 7's (S07) controls were disabled.
- In order to meet operational criteria Well 19 (S19) is considered offline. For the hydraulic modeling analysis Well 19 controls were disabled.

1.4.3 Ability to Serve Supply Project Alternatives

During the ability to serve analysis it was determined that the City will need to add an additional 539 gpm to meet the redundancy and operational criteria by 2028. Four supply alternatives were discussed, however, for the purpose of the hydraulic model analysis only the preferred alternatives will be modeled for 400 PZ and 337 PZ alternatives analysis. The preferred alternative allows full use of the Madrona's water rights. This alternative does not require pump upgrades, additional treatment, or wells. However, distribution piping improvements may be needed to convey the additional flows. Table 1.9 shows the updated future well capacities incorporating planned supply improvements and the preferred alternative improvements.

Table 1.9 Planned Well Capacity

Well No.	Pressure Zone	Planned Capacity (gpm)(1)	Implementation Year
S01	337 PZ	665	2022
S15	400 PZ	255	2019
S16	400 PZ	255	2019
S19(2)	400 PZ	1,600	2019
S21	400 PZ	1,600	2028
S22	400 PZ	1,600	2028
S28	400 PZ	1,600	2028
Marvin Road		1,000	2021

Notes:
(1) Wells without improvements maintain the capacities shown in Table 1.8.
(2) Well 19 is offline during the hydraulic analysis because of the operational criteria.

The operational controls associated with the Madrona's full water rights alternative require that facility operations be updated in the model:

- Existing pipelines that show capacity deficiencies will be identified and upsized during the hydraulic model alternative analysis.
- Well 21 (S21), Well 22 (S22) and Well 28 (S28) are revised to supply an additional combined capacity of 748 gpm. This equals to approximately 1,600 gpm each.

1.4.4 Planned Pipeline Improvements

The City provided information on seven planned pipeline improvement projects. The model was updated with these improvement projects based on near-term. The following projects were incorporated in the hydraulic models near-term scenarios:

- College and 22nd Street.
- Capital City Golf Course Fire Flow Improvement.

- 2017 Waterline Replacement Project 2.
- Mullen Road Water Project.
- 48th Avenue and 50th Avenue Fire Flow Improvements.
- Oak Preserve Development.
- Impala Water Main Replacement.
- Gateway Development.

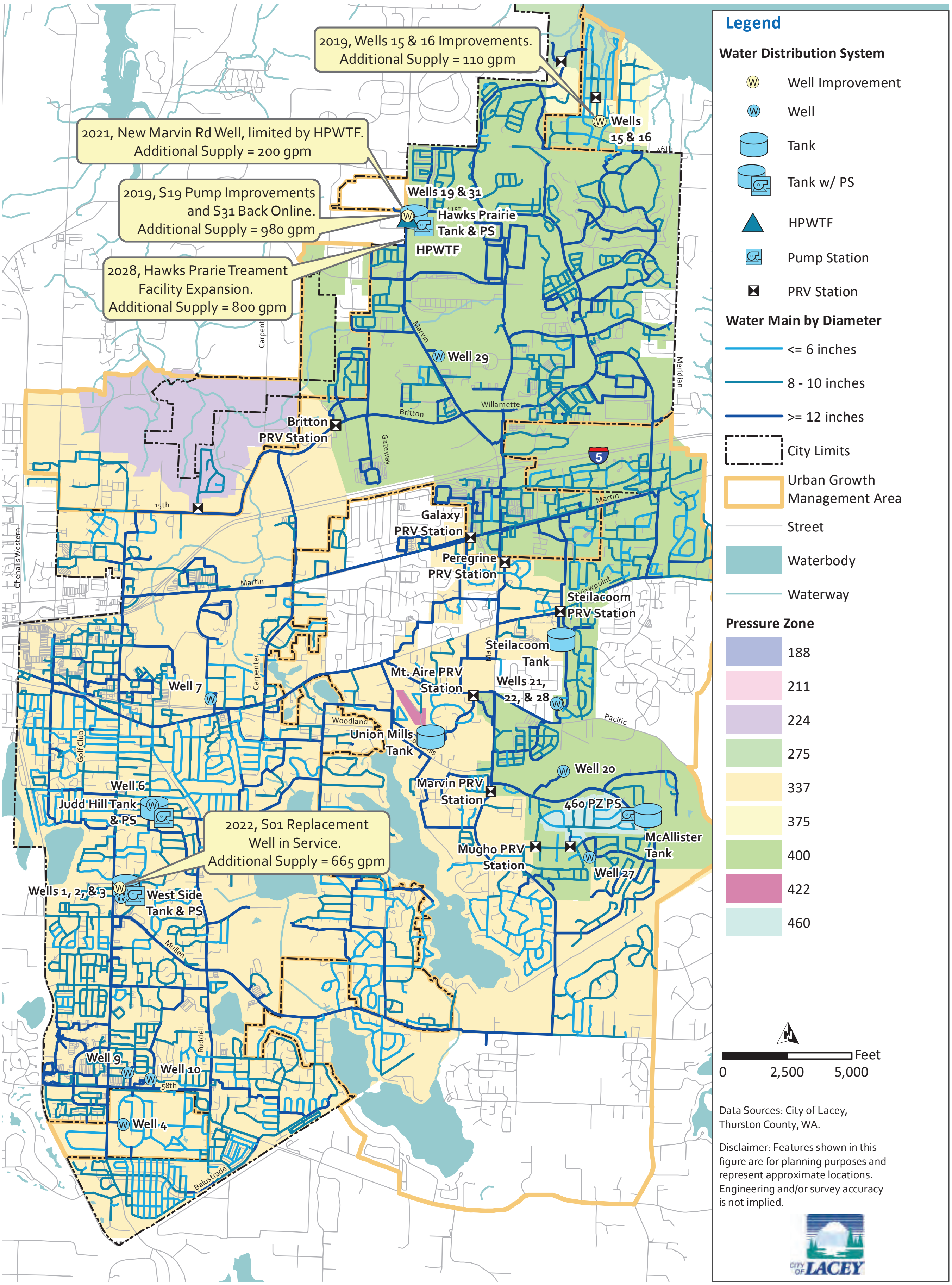


Figure 1.2 Planned Supply Improvements

1.5 400 PZ Storage Study

The City plans to take Hawks Prairie tank offline for six months during the 2022 summer for maintenance. The initial analysis showed 400 PZ north of the highway fell below 30 psi in some locations when Hawks Prairie tank is taken offline under peak hour demand conditions. The 400 PZ's northern and southern portions are connected via two pipelines that cross the highway. The hydraulic model indicated that the distribution system is unable to supply fire protection to its customers when Hawks Prairie tank is taken offline. The required fire suppression storage is 0.96 MG. Without Hawks Prairie Tank the City will only have 0.52 MG of fire suppression storage. Table 1.10 summarizes 400 PZ's fire suppression storage volume balance without Hawks Prairie Tank. Based on Table 1.10, the City's 400 PZ requires approximately 0.5 MG of additional fire suppression storage to meet its fire suppression storage volume requirements. Several, alternatives were explored and three were chosen to move forward for the 400 PZ Storage Study.

Table 1.10 400 PZ's Fire Suppression Storage Balance

Pressure Zone	Total Capacity (MG)	Available Fire Suppression Storage(1) (MG)	Required Fire Suppression Storage(2) (MG)	Fire Suppression Storage Balance (MG)
400 PZ w/ Hawks Prairie Tank online	5.23	4.09	0.96	3.13
400 PZ w/ Hawks Prairie Tank offline	1.18	0.52	0.96	-0.44

Notes:
(1) Source: City of Lacey Water System Comprehensive Plan.
(2) Required fire suppression storage = 4,000 gpm for 4 hours.

1.5.1 400 PZ Alternative Descriptions

The following is a brief description of the facilities associated with each 400 PZ alternative:

- 400 PZ Alternative 1 (400-1) consists of the following facilities:
  - Add VFDs to the Hawks Prairie Treatment Facility low lift pumps.
  - Construct a pump station at McAllister or Steilacoom tank site. The pump station is designed to access dead storage thus expanding the City's 400 PZ's fire suppression storage. Transmission mains will have to be upsized to enable additional flow from the southern to the northern portion of the 400 PZ. Tank will be isolated from the system when the pump station is running. There might be some reconfiguration to be done to allow this operation.
- 400 PZ Alternative 2 (400-2) consists of the following facilities:
  - Add VFDs to the Hawks Prairie Treatment Facility low lift pump station's pumps.
  - Construct an at-hydraulic-grade tank at the existing Marvin Road Well site, which is located next to the new school site. This facility will be referred to as School tank in these appendices. To meet the required fire suppression storage volume this tank must have minimum storage capacity of 0.44 MG. The School tank will be 1.0 MG to meet the minimum storage capacity and add some additional for equalization.

- 400 PZ Alternative 3 (400-3) consists of the following facilities:
  - Construct a below-hydraulic-grade sister tank at the Hawks Prairie Site. This facility will be referred to as Sister Tank. To meet the required fire suppression storage volume this tank must have minimum storage capacity of 0.44 MG. The Sister Tank will be 1.0 MG to meet the minimum fire suppression storage (0.44 MG) and add some additional for equalization storage (0.56 MG).

1.5.2 400 PZ Operation Changes

The 400 PZ alternatives require that facility operations be added or updated in the model while Hawks Prairie tank is taken offline. These facility and operational changes are listed below. The following operational changes are applied to all 400 PZ alternatives while the Hawks Prairie tank is offline:

- Wells 7 and 19 controls are disabled for all alternatives.
- Wells 21, 22, and 28 controls related to Hawks Prairie Tank level were modified. These wells will continue to be controlled by their primary control facility, McAllister Tank Level. Controls related to Hawks Prairie Tank were modified and described in the following sections.
- Planned Marvin Road Well will be modeled as a reservoir and a flow control valve.

The following sections describe operational changes applied to each alternative while Hawks Prairie tank is offline. It is assumed that facilities will operate according to their existing controls when Hawks Prairie tank is online. The facilities will be operated to ensures sufficient pressure and maintain the minimum required fire suppression storage while the Hawks Prairie Tank is offline.

1.5.2.1 Alternative 400-1

The following model updates are associated with Alternative 400-1 (while Hawks Prairie Reservoir is offline):

- Planned Marvin Road Well controls:
  - If J-965 pressure is below 45 psi then Marvin Road Well is open.
  - If J-965 pressure is above 50 psi then Marvin Road Well is closed.
- Modify Well 31 controls:
  - If J-965 pressure is below 35 psi then Well 31 is open.
  - If J-965 pressure is above 40 psi then Well 31 is closed.
- Modify Wells 15 and 16 controls:
  - If J-965 pressure is below 40 psi then Well 15 is open and Well 16 is open.
  - If J-965 pressure is above 45 psi then Well 15 is closed and Well 16 is closed.
- Modify Well 29 controls:
  - If J-965 pressure is below 30 psi then Well 29 is open.
  - If J-965 pressure is above 35 psi then Well 29 is closed.
- Modify Well 21 controls related to Hawks Prairie Tank:
  - If J-8311 pressure is below 25 psi then Well 21 is open.
  - If J-8311 pressure is above 30 psi then Well 21 is closed.
- Modify Well 22 controls related to Hawks Prairie Tank:
  - If J-8311 pressure is below 35 psi then Well 22 is open.
  - If J-8311 pressure is above 40 psi then Well 22 is closed.

- Modify Well 28 controls related to Hawks Prairie Tank:
  - If J-8311 pressure is below 30 psi then Well 28 is open.
  - If J-8311 pressure is above 35 psi then Well 28 is closed.
- McAllister PS controls:
  - If fire within 400 PZ then McAllister PS is open and a control valves are closed to isolate McAllister Tank from 400 PZ.
  - If no fire within 400 PZ then McAllister PS is closed and control valves are open that allows McAllister Tank to float within the 400 PZ.
- Britton and Galaxy PRV Stations are closed while Hawks Prairie Tank is offline.

The model has the proposed Marvin Road Well, S19, and S31 discharging to the contact basin. The model ensures the total flow rate of these wells does not exceed the HPWTF capacity.

1.5.2.2 Alternative 400-2

The following model operational updates are associated with Alternative 400-2 (while Hawks Prairie Reservoir is offline):

- Planned Marvin Road Well controls:
  - If School Tank level is below 32 ft then Marvin Road Well is open.
  - If School Tank level is above 35.5 ft then Marvin Road Well is closed.
- Modify Well 31 controls:
  - If School Tank level is below 32 ft then Well 31 is open.
  - If School Tank level is above 35.5 ft then Well 31 is closed.
- Modify Wells 15 and 16 controls:
  - If School Tank level is below 30 ft then Well 15 is open and Well 16 is open.
  - If School Tank level is above 34 ft then Well 15 is closed and Well 16 is closed.
- Modify Well 29 controls:
  - If School Tank level is below 28 ft then Well 29 is open.
  - If School Tank level is above 32 ft then Well 29 is closed.
- Modify Well 21 controls related to Hawks Prairie Tank:
  - If School Tank level is below 22 ft then Well 21 is open.
  - If School Tank level is above 27 ft then Well 21 is closed. Assuming other controls is satisfied.
- Modify Well 22 controls related to Hawks Prairie Tank:
  - If School Tank level is below 27 ft then Well 22 is open.
  - If School Tank level is above 32 ft then Well 22 is closed. Assuming other controls is satisfied.
- Modify Well 28 controls related to Hawks Prairie Tank:
  - If School Tank level is below 23 ft then Well 28 is open.
  - If School Tank level is above 28 ft then Well 28 is closed. Assuming other controls is satisfied.
- Britton and Galaxy PRV Stations are closed while Hawks Prairie Tank is offline.

1.5.2.3 Alternative 400-3(while Hawks Prairie Reservoir is offline):

The following model operational updates are associated with Alternative 400-3:

- Planned Marvin Road Well controls:
  - If Hawks Prairie Sister Tank level is below 78 ft then Marvin Road Well is open.

  - If Hawks Prairie Sister Tank level is above 84 ft then Marvin Road Well is closed.
- Modify Well 31 controls:
  - If Hawks Prairie Sister Tank level is below 78 ft then Well 31 is open.
  - If Hawks Prairie Sister Tank level is above 84 ft then Well 31 is closed.
- Wells 15, 16, 21, 22, 28, and 29 will be controlled by the Hawks Prairie sister tank using the same set points as the existing Hawks Prairie Tank.
- Britton and Galaxy PRV Stations are closed while Hawks Prairie Tank is offline.

1.6 337 PZ Facilities and Pressure Study

The City has a goal of improving its level of service beyond what is in the Water System Plan. The City's operational staff spends significant amount of time responding to pressure complaints. Typically low pressures are the result of a customer having a high service elevation. The City's staff found that customer complaints increase when 337 PZ's pressure falls below 45 psi, and set a goal for its minimum operational pressure of 40 psi during normal conditions. Note, the City is required to maintain 30 psi during peak hour demand conditions and 20 psi during the maximum day demand plus fire flow at the customer's meters. One purpose of the 337 PZ Facilities and Pressure Study is to perform an alternatives analysis in order to improve system pressures under near-term and future conditions. Figure 1.3 shows locations in 337 PZ where the pressure falls below 40 psi under static conditions.

An initial modeling analysis was completed using the City's existing model to determine where deficiencies occur and develop alternatives to mitigate deficiencies. First, static pressures were calculated using node elevations and the HGL set to 337 ft. The static pressures do not account for demands, headloss, and system operations. Customers near the College corridor experienced static pressures no more than 41 psi. An extended period simulation (EPS) under 2016 summer conditions was performed to understand the impact operations have on system pressures. The preliminary analysis found that pressures fell below 40 psi along the College corridor. The number of customers with pressures below 40 psi decreased during the winter conditions. Several alternatives were explored and three were chosen to move forward with in 337 PZ Facilities and Pressure Study.

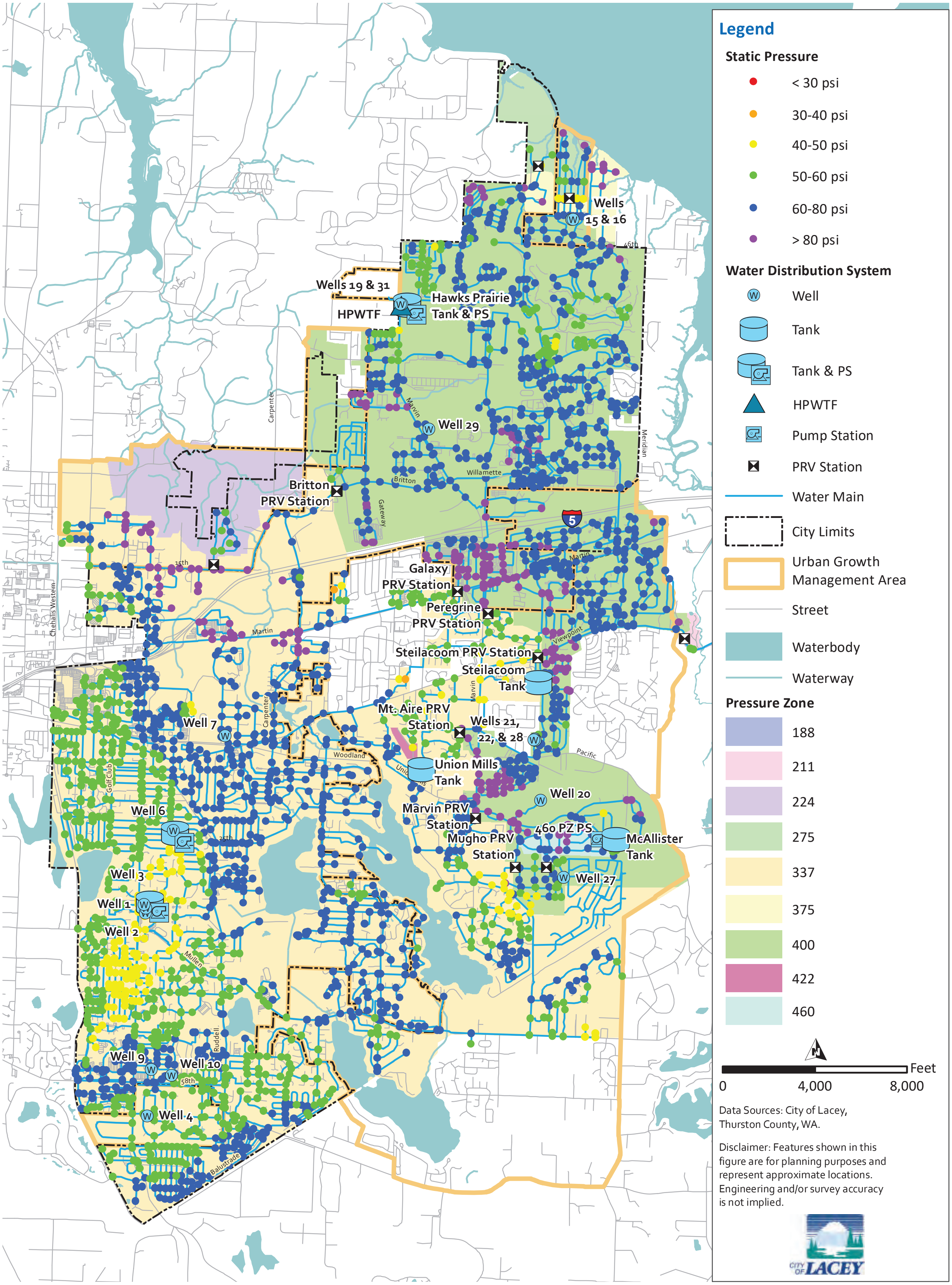


Figure 1.3 Static Pressures

1.6.1 337 PZ Alternative Descriptions

The following is a brief description of the facilities associated with each 337 PZ alternative:

- 337 PZ Alternative 1 (337-1) consists of the following facilities:
  - Rezone the College Corridor. The new pressure zone will be referred to as 380 PZ. Check valves will be installed to isolate 380 PZ from 337 PZ during normal operating conditions. The check valves will open in the event of low pressures in 380 PZ. The rezone boundaries will be developed to capture areas with low pressures. The actual boundaries will be developed later during hydraulic model alternative analysis.
  - Construct a 0.75 MG at-hydraulic-grade tank on the Intelco property site. The elevated tank at-hydraulic-grade with 337 PZ. This proposed elevated tank will be referred to as Intelco Elevated Tank.
  - Construct a pump station on the Intelco property site. This new facility will be referred to as 380 PZ PS. The proposed pump station will move water from 337 PZ to the new 380 PZ. The 380 PZ PS will be sized to supply domestic water demands within 380 PZ.
- 337 PZ Alternative 2 (337-2) consists of the following facilities:
  - Rezone the College Corridor. The new pressure zone is identical to Alternative 1's rezone.
  - Construct a 1.5 MG below-hydraulic-grade storage tank on the Intelco property site. This proposed tank will be referred to as Intelco below-hydraulic-grade Tank. Because the tank is below 337 PZ's HGL a pump station is required to supply the 337 PZ. The tank will be filled from 337 PZ using a control valve.
  - Construct a pump station with two sets of the pumps on the Intelco property site:
    - The first set will supply the rezoned 380 PZ and is referred to as the 380 PZ PS. The proposed pump station will move water from 337 PZ to the new 380 PZ. The 380 PZ PS will be sized to supply domestic water demands within 380 PZ.
    - The second set will be the 337 PZ PS. The purpose of this facility is to supply the 337 PZ with water stored in the Intelco below-hydraulic-grade Tank for both fire and domestic purposes.
- 337 PZ Alternative 3 (337-3) consists of the following facilities:
  - Construct a 0.75 MG at-hydraulic-grade tank on the Intelco property site. This proposed elevated tank will be referred to as Intelco Elevated Tank. The elevated tank will be at the 337 PZ grade.
  - Upgrade Well 10 (S10) with a VFD. The VFD will help stabilize pressures in the surrounding area.
  - This alternative is considered acceptable if pressures are maintained above 38 psi without large fluctuations during both winter and summer conditions.
- For all 337 PZ alternatives:
  - It is assumed that 400 PZ Alternative 3 facilities are implemented for planning year 2028 337 PZ hydraulic analysis.
  - It is assumed that the existing Hawks Prairie Reservoir will be online for 2022 and 2028 337 PZ hydraulic analysis.

1.6.2 337 PZ Operational Changes

The 337 PZ alternatives require that facility operations be added and updated in the model. Model updates are described in the following sections. The following operational changes are applied to all 337 PZ alternatives:

- Wells and 7 and 19 controls are disabled for all alternatives.
- Wells 1, 2, 3, 4, 6, 9, and 10 will continue to be operated by their existing control facilities. Controls related to proposed facilities were modified and described in the following sections.

1.6.2.1 Alternative 337-1

The following model updates are associated with Alternative 337-1:

- Modify Well 1 controls:
  - If Intelco Tank level is below 25 ft then Well 1 is open.
  - If Intelco Tank level is above 30 ft then Well 1 is closed.
- Modify Well 4 controls:
  - If Intelco Tank level is below 27 ft then Well 4 is open.
  - If Intelco Tank level is above 32 ft then Well 4 is closed.
- Modify Well 9 controls:
  - If Intelco Tank level is below 30 ft then Well 9 is open.
  - If Intelco Tank level is above 35 ft then Well 9 is closed.
- Modify Well 10 controls:
  - If Intelco Tank level is below 28 ft then Well 10 is open.
  - If Intelco Tank level is above 33 ft then Well 10 is closed.
- New 380 PZ boundary controls:
  - Some of the 380 PZ boundary pipes will become check valves that enable flow from 337 PZ to 380 PZ during emergency or fire events. A check valve is not an actuated valve and does not have controls or settings.
  - If the 380 PZ's HGL were to drop below the 337 ft, the check valves will open and revert back to 337 PZ HGL. This is expected to only occur during fire or emergency conditions.
  - The use of check valves is possible because the initial hydraulic model analysis did not show fire flow deficiencies within 337 PZ under existing conditions.
  - A PRV station will be constructed allowing flow from 380 PZ to 337 PZ to prevent over pressurization in 380 PZ.
- New 380 PZ PS controls:
  - This pump station will be setup as a VFD and is set to maintain a minimum pressure of 42 psi within 380 PZ.
  - The proposed 380 PZ PS to be sized for supplying domestic flows.

1.6.2.2 Alternative 337-2

The following model updates are associated with Alternative 337-2:

- Modify Well 1 controls:
  - If Intelco Tank level is below 30 ft then Well 1 is open.
  - If Intelco Tank level is above 36 ft then Well 1 is closed.

- Modify Well 4 controls:
  - If Intelco Tank level is below 27 ft then Well 4 is open.
  - If Intelco Tank level is above 32 ft then Well 4 is closed.
- Modify Well 9 controls:
  - If Intelco Tank level is below 34 ft then Well 9 is open.
  - If Intelco Tank level is above 39 ft then Well 9 is closed.
- Modify Well 10 controls:
  - If Intelco Tank level is below 32 ft then Well 10 is open.
  - If Intelco Tank level is above 36 ft then Well 10 is closed.
- New 380 PZ boundary controls:
  - Some of the 380 PZ boundary pipes will become check valves that enable flow from 337 PZ to 380 PZ during emergency or fire events. A check valve is not an actuated valve and does not have controls or settings.
  - If the 380 PZ's HGL were to drop below the 337 ft, the check valves will open and revert back to 337 PZ HGL. This is expected to only occur during fire or emergency conditions.
  - The use of check valves is possible because the initial hydraulic model analysis did not show fire flow deficiencies within 337 PZ under existing conditions.
  - A PRV station will be constructed allowing flow from 380 PZ to 337 PZ to prevent over pressurization in 380 PZ.
- New 380 PZ PS controls:
  - This pump station will be setup as a VFD and is set to maintain a minimum pressure of 42 psi within 380 PZ.
  - The proposed 380 PZ PS to be sized for supplying domestic flows.
- New 337 PZ PS Pump 1 controls:
  - If J-1711 pressure is below 45 psi and Intelco Tank level is above 10 ft then 337 PZ PS Pump 1 is open.
  - If J-1771 pressure is above 50 psi or Intelco Tank level is below 5 ft then 337 PZ PS Pump 1 is closed.
- New 337 PZ PS Pump 2 controls:
  - If J-1711 pressure is below 40 psi and Intelco Tank level is above 15 ft then 337 PZ PS Pump 2 is open.
  - If J-1771 pressure is above 45 psi or Intelco Tank level is below 10 ft then 337 PZ PS Pump 2 is closed.
- New Intelco Tank inlet control valve settings and controls to fill the tank:
  - The Intelco Tank inlet control valve will be modeled as a PSV to maintain a minimum upstream pressure of 42 psi within the 337 PZ.
  - If 337 PZ PS is closed and upstream pressure is above 42 psi then Intelco Tank inlet control valve is open.
  - If 337 PZ PS is open or upstream pressure is below 42 psi then Intelco Tank inlet control valve is closed.

1.6.2.3 Alternative 337-3

The following model updates are associated with Alternative 337-3:

- Modify Well 1 controls:
  - If Intelco Tank level is below 25 ft then Well 1 is open.

  - If Intelco Tank level is above 30 ft then Well 1 is closed.
- Modify Well 4 controls:
  - If Intelco Tank level is below 27 ft then Well 4 is open.
  - If Intelco Tank level is above 32 ft then Well 4 is closed.
- Modify Well 9 controls:
  - If Intelco Tank level is below 30 ft then Well 9 is open.
  - If Intelco Tank level is above 35 ft then Well 9 is closed.
- Modify Well 10 controls:
  - The well will be setup as a VFD.
  - If Intelco Tank level is below 33 ft then Well 10 is open.
  - If Intelco Tank level is above 35.75 ft then Well 10 is closed.

1.7 Conclusion

The hydraulic model received is assumed to be calibrated and ready for use to evaluate the different alternatives develop in both 337 PZ and 400 PZ. The model facility and operational update discussed in this report should be reviewed by the City. Operational updates in the model will likely differ when applied when operating their system. It should be noted that the system is very sensitive while the Hawks Prairie Tank is offline.

Appendix 1

MODEL CONTROLS

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
400 PZ PS #1 and #2 Lockout	If Hawks Prairie Tank level is below 10 feet. Then 400 PZ PS #1 is closed. And 400 PZ PS #2 is closed.
400 PZ PS #1 Off	If 400 PZ PS flow is below 300 gpm. And 400 PZ PS #2 is closed. And 400 PZ PS #1 is open. Then 400 PZ PS #1 is closed. And Hawks Prairie Tank Valve is open.
400 PZ PS # 1 On	If J-1280 pressure is below 36 psi. And Hawks Prairie Tank level is above 15 feet. Then 400 PZ PS #1 is open. And Hawks Prairie Tank Valve is closed.
400 PZ PS #2 Off	If 400 PZ PS flow is below 900 gpm. And 400 PZ PS #3 is closed. Then 400 PZ PS #2 is closed.
400 PZ PS #2 On	If J-1280 pressure is below 38 psi. And Hawks Prairie Tank level is above 15 feet. And 400 PZ PS #1 is open. Then 400 PZ PS #2 is open.
400 PZ PS #3 and #4 Lockout	If Hawks Prairie Tank level is below 20 feet. Then 400 PZ PS #3 is closed. And 400 PZ PS #4 is closed.
400 PZ PS #3 Off	If 400 PZ PS flow is below 1,800 gpm. And 400 PZ PS #4 is closed. Then 400 PZ PS #3 is closed.
400 PZ PS #3 On	If J-1280 pressure is below 38 psi. And Hawks Prairie Tank level is above 25 feet. And 400 PZ PS #2 is open. Then 400 PZ PS #3 is open.
400 PZ PS #4 Off	If 400 PZ PS flow is below 3,000 gpm. Then 400 PZ PS #4 is closed.
400 PZ PS #4 On	If J-1280 pressure is below 38 psi. And Hawks Prairie Tank level is above 25 feet. And 400 PZ PS #3 is open. Then 400 PZ PS #4 is open.
Judd Hill PS Lockout	If Judd Hill Tank level is below 10 feet. Then Judd Hill PS is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Judd Hill PS On	If Judd Hill Tank level is above 15 feet. And J-106 pressure is below 26 psi. Then Judd Hill PS is open.
Judd Hill PS Off	If time is 8:00 AM. Or time is 8:00 PM. Then Judd Hill PS is closed.
Judd Hill PS Timer	If time is 5:30 AM. Or time is 5:30 PM. And Judd Hill Tank level is above 15 feet.
Westside PS Jockey Off	If Westside PS flow is below 250 gpm. And Westside PS Jockey is open. Then Westside PS Jockey is closed. And Westside Tank Valve is open.
Westside PS Jockey On	If J-1256 pressure is below 38 psi. And Westside Tank level is above 20 feet. And Westside PS #1 is closed. And Westside PS Jockey is closed. Then Westside PS Jockey is open. And Westside Tank Valve is closed.
Westside PS Lockout	If Westside Tank level is below 10 feet. Then Westside PS Jockey is closed. And Westside PS #1 is closed. And Westside PS #2 is closed. And Westside PS #1 is closed.
Westside PS #1 Off	If Westside PS flow is below 900 gpm. And Westside PS #2 is closed. And Westside PS #1 is open. Then Westside PS #1 is closed. And Westside PS Jockey is open.
Westside PS #1 On	If J-1256 pressure is below 36 psi. And Westside Tank level is above 20 feet. And Westside PS Jockey is open. Then Westside PS #1 is open. And Westside PS Jockey is closed.
Westside PS #2 Off	If Westside PS flow is below 1,900 gpm. And Westside PS #3 is closed. Then Westside PS #2 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Westside PS #2 On	If J-1256 pressure is below 32 psi. And Westside Tank level is above 20 feet. And Westside PS #1 is open. Then Westside PS #2 is open.
Westside PS #3 Off	If Westside PS flow is below 3,000 gpm. Then Westside PS #3 is closed.
Westside PS #3 On	If J-1256 pressure is below 32 psi. And Westside Tank level is above 20 feet. And Westside PS #2 is open. Then Westside PS #3 is open.
Hawks Prairie Treatment Facility Low Lift Pump #1 Off	If Well 19 is open. And Hawks Prairie Clearwell level is below 11 feet. Then Hawks Prairie Treatment Facility Pump 1 is closed.
Hawks Prairie Treatment Facility Low Lift Pump #1 On	If Well 19 is open. And Hawks Prairie Clearwell level is above 12 feet. Then Hawks Prairie Treatment Facility Pump 1 is open.
Hawks Prairie Treatment Facility Low Lift Pump #2 Off	If Well 31 is open. And Hawks Prairie Clearwell level is below 11 feet. Then Hawks Prairie Treatment Facility Pump 2 is closed.
Hawks Prairie Treatment Facility Low Lift Pump #2 On	If Well 31 is open. And Hawks Prairie Clearwell level is above 12 feet. Then Hawks Prairie Treatment Facility Pump 2 is open.
Britton Parkway PRV Station Controls	If Steilacoom Tank level is below 0 feet. Or Union Mills Tank level is below 0 feet. Then Britton Parkway Valve is open. And Britton Parkway PRV Large is closed. Else Britton Parkway PRV Large is open. And Britton Parkway Valve is closed.
Galaxy PRV Station Controls	If Steilacoom Tank level is below 63.5 feet. Or Union Mills Tank level is below 53 feet. Then Galaxy FCV is open. And Galaxy PRV is closed. Else Galaxy PRV is open. And Galaxy FCV is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Marvin Road PRV Station Controls	If Steilacoom Tank level is below 0 feet. Or Union Mills Tank level is below 0 feet. Then Marvin Road FCV is open. And Marvin Road PRV is closed. Else Marvin Road PRV is open. And Marvin Road FCV is closed.
Mt. Aire PRV Station Controls	If Steilacoom Tank level is below 60 feet. Or Union Mills Tank level is below 50 feet. Then Mt. Aire FCV is open. And Mt. Aire PRV is closed. Else Mt. Aire PRV is open. And Mt. Aire FCV is closed.
Mugho PRV Station Controls	If Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 58 feet. Then Mugho FCV is open. And Mugho PRV is closed. Else Mugho PRV is open. And Mugho FCV is closed.
Westside Tank Lockout	If Westside PS Jockey is closed. And Westside PS #3 is closed. And Westside PS #2 is closed. And Westside PS #1 is closed. Then Westide Tank control valve is open. Else Westide Tank control valve is closed.
Well 1 Off	If Steilacoom Tank level is above 65 feet. And Union Mills Tank level is above 60 feet. Then Well 1 is closed.
Well 1 On	If Steilacoom Tank level is below 63 feet. Or Union Mills Tank level is below 56 feet. Or J-5456 pressure is below 60 psi. Then Well 1 is open.
Well 10 Off	If Steilacoom Tank level is above 66.5 feet. And Union Mills Tank level is above 58 feet. And Westside Tank level is above 36 feet. Then Well 10 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 10 On	If Steilacoom Tank level is below 64 feet. Or Union Mills Tank level is below 56 feet. Or Westside Tank level is below 30 feet. Then Well 10 is open.
Well 15 Off	If Hawks Prairie Tank level is above 82 feet. Then Well 15 is closed.
Well 15 On	If Hawks Prairie Tank level is below 78 feet. Then Well 15 is open.
Well 16 Off	If Hawks Prairie Tank level is above 82 feet. Then Well 16 is closed.
Well 16 On	If Hawks Prairie Tank level is below 78 feet. Then Well 16 is open.
Well 19 Off	If Hawks Prairie Tank level is above 84 feet. Then Well 19 is closed. And Hawks Prairie Treatment Facility Pump 1 is closed.
Well 19 On	If Hawks Prairie Tank level is below 78 feet. Then Well 19 is open.
Well 2 Off	If Steilacoom Tank level is above 67.5 feet. And Union Mills Tank level is above 60 feet. And Westside Tank level is above 39 feet. Then Well 2 is closed.
Well 2 On	If Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 58 feet. Or Westside Tank level is below 35 feet. Or J-5456 pressure is below 62 psi. Then Well 2 is open.
Well 20 Off	If McAllister Tank level is above 96.5 feet. Then Well 20 is closed.
Well 20 On	If McAllister Tank level is below 92 feet. Then Well 20 is open.
Well 21 Off	If Hawks Prairie Tank level is above 74 feet. And McAllister Tank level is above 94 feet. And Steilacoom Tank level is above 1 feet. And Union Mills Tank level is above 1 feet. Then Well 21 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 21 On	If Hawks Prairie Tank level is below 70 feet. Or McAllister Tank level is below 92 feet. Or Steilacoom Tank level is below 0 feet. Or Union Mills Tank level is below 0 feet. Then Well 21 is open.
Well 22 Off	If Hawks Prairie Tank level is above 74 feet. And McAllister Tank level is above 94 feet. And Steilacoom Tank level is above 62 feet. And Union Mills Tank level is above 52 feet. Then Well 22 is closed.
Well 22 On	If Hawks Prairie Tank level is below 70 feet. Or McAllister Tank level is below 92 feet. Or Steilacoom Tank level is below 60 feet. Or Union Mills Tank level is below 50 feet. Then Well 22 is open.
Well 24 Off	If Nisqually Tank level is above 26 feet. Then Well 24 is closed.
Well 24 On	If Nisqually Tank level is below 24 feet. Then Well 24 is open.
Well 25 Off	If Nisqually Tank level is above 26 feet. Then Well 25 is closed.
Well 25 On	If Nisqually Tank level is below 24 feet. Then Well 25 is open.
Well 27 Off	If McAllister Tank level is above 95 feet. And Steilacoom Tank level is above 66 feet. And Union Mills Tank level is above 60 feet. Then Well 27 is closed.
Well 27 On	If McAllister Tank level is below 93 feet. Or Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 58 feet. Then Well 27 is open.
Well 28 Off	If Hawks Prairie Tank level is above 50 feet. And McAllister Tank level is above 95 feet. And Steilacoom Tank level is above 63.5 feet. And Union Mills Tank level is above 56 feet. Then Well 28 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 28 On	If Hawks Prairie Tank level is below 40 feet. Or McAllister Tank level is below 91 feet. Or Steilacoom Tank level is below 61.5 feet. Or Union Mills Tank level is below 53 feet. Then Well 28 is open.
Well 29 Off	If Hawks Prairie Tank level is above 80 feet. Then Well 29 is closed.
Well 29 On	If Hawks Prairie Tank level is below 77 feet. Then Well 29 is open.
Well 3 Off	If Steilacoom Tank level is above 67 feet. And Union Mills Tank level is above 60.5 feet. And Westside Tank level is above 38 feet. Then Well 3 is closed.
Well 3 On	If Steilacoom Tank level is below 64 feet. Or Union Mills Tank level is below 57 feet. Or Westside Tank level is below 34 feet. Or J-5456 pressure is below 68 psi. Then Well 3 is open.
Well 31 Off	If Hawks Prairie Tank level is above 78 feet. Then Well 31 is closed. And Hawks Prairie Treatment Facility Pump 2 is closed.
Well 31 On	If Hawks Prairie Tank level is below 65 feet. Then Well 31 is open.
Well 4 Off	If Steilacoom Tank level is above 66 feet. And Union Mills Tank level is above 59 feet. And Westside Tank level is above 38 feet. Then Well 4 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 4 On	If Steilacoom Tank level is below 65 feet. Or Union Mills Tank level is below 53 feet. Or Westside Tank level is below 20 feet. Then Well 4 is open.
Well 6 Off	If Steilacoom Tank level is above 63 feet. And Union Mills Tank level is above 55 feet. And Judd Hill Tank level is above 50 feet. Then Well 6 is closed.
Well 6 On	If Steilacoom Tank level is below 58 feet. Or Union Mills Tank level is below 52 feet. Or Judd Hill Tank level is below 47 feet. Then Well 6 is open.
Well 6 Valve Controls	If Steilacoom Tank level is below 58 feet. Or Union Mills Tank level is below 52 feet. Then Well 6 is open. Else Well 6 is closed.
Well 7 Off	If Steilacoom Tank level is above 66.5 feet. And Union Mills Tank level is above 59 feet. Then Well 7 is closed.
Well 7 On	If Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 56 feet. Then Well 7 is open.
Well 9 Off	If Steilacoom Tank level is above 65 feet. And Union Mills Tank level is above 56 feet. And time is 9:30 AM. Then Well 9 is closed.
Well 9 On	If Steilacoom Tank level is below 61.5 feet. Or Union Mills Tank level is below 53 feet. Or time is 7:30 AM. Then Well 9 is open.

Appendix B
DETAILED COST ESTIMATE

City of Lacey
337 PZ Pressure and Storage Study
Cost Estimate for Alternatives
Assumptions

All preliminary Capital costs are in 2018 dollars. Cost estimate made in: 2018

To update Capital Costs to future value, enter inflation rate: 3.00%

Capital Costs

Transmission Costs

Element	Unit	Unit Construction Cost ($/LF)
16-inch Pipe	LF	$240
20-inch Pipe	LF	$277
24-inch Pipe	LF	$310

Pump Station Costs

Horsepower	Unit	Unit Construction Cost
0 to 199 HP	Per HP per Pump	$8,200

Hawks Prarie Facility Improvement

Cost	Unit
$250,000	each

Storage Costs

Reservoir Type	Cost per gallon ($/gallon)
Standpipe	$2.00
Elevated	$4

APPENDIX B
337 PZ Pressure and Storage Study
Life Cycle Cost Assumptions

Lacey 337 PZ - Life Cycle Costs	**Annual**		**2018**	**Yearly**	**50-Yr (2022-2072)**
	Quantity	**Unit**	**$/Unit**	**% Escalation**	**Total**
Energy Costs					
Energy Costs - Alt 337-1	472,545	kWh	$0.11	3.00%	$6,797,027
Energy Costs - Alt 337-2	533,208	kWh	$0.11	3.00%	$7,669,596
Energy Costs - Alt 337-3	10,920	kWh	$0.11	3.00%	$157,072
					50-Yr
City Staff Effort					**Total**
Large Booster Pump Station, with backup generator	0.080	FTE	$182,292	3.00%	$1,906,959
Below Hydraulic Grade Storage	0.070	FTE	$177,278	3.00%	$1,622,692
Elevated Storage	0.070	FTE	$177,278	3.00%	$1,622,692
					2052
Tank Recoating (Every 30 Years)	26,399	SF	$7.59	3.00%	$547,207
Pump Station Rehab					**2052**
0 to 199 HP - Steilacoom PS	110	LF	$2,706	3.00%	$813,179

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 337-1
Project Name: 337 PZ Alternative 1

Project Description:
- Rezone the College Corridor. The new pressure zone will be referred to as 380 PZ. Check valves will be installed to isolate 380 PZ from 337 PZ during normal operating conditions. The check valves will open in the event of low pressures in 380 PZ. The rezone boundaries will be developed to capture areas with low pressures. The actual boundaries will be developed later during hydraulic model alternative analysis.
- Construct an elevated tank on the Intelco property site. This proposed elevated tank will be referred to as Intelco Elevated Tank. The elevated tank at-hydraulic-grade in 337 PZ.
- Construct a pump station on the Intelco property site. This new facility will be referred to as 380 PZ Pump Station. The proposed pump station will move water from 337 PZ to the new 380 PZ. The 380 PZ Pump Station will be sized to supply domestic water demands within 380 PZ.

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 337-1
Project Name: 337 PZ Alternative 1

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
Water Main Replacement Contingencies-->						19%		6%	
380 Booster Pump Station	75	Per HP per Pump	$ 8,200	Capital	$ 615,000	$ 246,000	$ 184,500	$ 30,750	$ 1,076,250
BPS Field Piping - 12-inch	500	LF	$ 220	Capital	$ 110,000	$ 20,900	$ 33,000	$ 6,600	$ 170,500
Intelco Elevated Tank	750,000	gallon	$ 4.00	Capital	$ 3,000,000	$ 1,200,000	$ 900,000	$ 150,000	$ 5,250,000
Tank Field Piping - 16-inch	120	LF	$ 240	Capital	$ 28,800	$ 5,472	$ 8,640	$ 1,728	$ 44,640
Business Park Piping Upsize - 16-inch	1,200	LF	$ 240	Capital	$ 288,000	$ 54,720	$ 86,400	$ 17,280	$ 446,400
Business Park Piping Upsize - 12-inch	1,830	LF	$ 220	Capital	$ 402,600	$ 76,494	$ 120,780	$ 24,156	$ 624,030
Rezone Connection Piping - 12-inch	925	LF	$ 220	Capital	$ 203,500	$ 38,665	$ 61,050	$ 12,210	$ 315,425
Check Valve - 8-inch	10	EA	$ 75,000	Capital	$ 750,000	$ 300,000	$ 225,000	$ 37,500	$ 1,312,500
BPS Energy Costs - 50 years	1	LS	$ 6,797,027	O&M	$ 6,797,027	$ -	$ -	$ -	$ 6,797,027
Tank Energy Costs - 50 years	1	LS	$ 163,976	O&M	$ 163,976	$ -	$ -	$ -	$ 163,976
City Staff Effort (BPS) - 50 Years	1	LS	$ 1,906,959	O&M	$ 1,906,959	$ -	$ -	$ -	$ 1,906,959
City Staff Effort (Tank) - 50 Years	1	LS	$ 1,622,692	O&M	$ 1,622,692	$ -	$ -	$ -	$ 1,622,692
PS Rehab - 30 Years	1	LS	$ 813,179	O&M	$ 813,179	$ -	$ -	$ -	$ 813,179
Tank Recoating - 30 Years	1	LS	$ 547,207	O&M	$ 547,207	$ -	$ -	$ -	$ 547,207
Total Project Cost									$ 21,090,786

Notes on Cost Estimation:

See Assumptions tab for details. See Life Cycle costs Tab for O&M costs. Pipe Upsizing uses contingencies for Water Main Replacements as shown in Assumptions tab.

Go to Assumptions Tab

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 337-1
Project Name: 337 PZ Alternative 1

Project Timing:

Project Element		Timing	Cost
380 Booster Pump Station	Capital	2022	$ 1,211,329
BPS Field Piping - 12-inch	Capital	2022	$ 191,899
Intelco Elevated Tank	Capital	2022	$ 5,908,921
Tank Field Piping - 16-inch	Capital	2022	$ 50,243
Business Park Piping Upsize -	Capital	2022	$ 502,427
Business Park Piping Upsize -	Capital	2022	$ 702,351
Rezone Connection Piping - 1	Capital	2022	$ 355,014
Check Valve - 8-inch	Capital	2022	$ 1,477,230
0			$ -
BPS Energy Costs - 50 years	O&M	Varies	$ 6,797,027
Tank Energy Costs - 50 years	O&M	Varies	$ 163,976
City Staff Effort (BPS) - 50 Yea	O&M	Varies	$ 1,906,959
City Staff Effort (Tank) - 50 Ye	O&M	Varies	$ 1,622,692
PS Rehab - 30 Years	O&M	Varies	$ 813,179
Tank Recoating - 30 Years	O&M	Varies	$ 547,207

Total Project Cost			$ 22,250,455

City of Lacey
337 PZ Facilities & Pressure Study

Project ID:	337-2
Project Name:	337 PZ Alternative 2

Project Description:

- Rezone the College Corridor. The new pressure zone is expected to be identical to Alternative 1.
- Construct a below-hydraulic-grade storage tank on the Intelco property site. This proposed tank will be referred to as Intelco below-hydraulic-grade Tank. Because the tank is below-hydraulic-grade; therefore, a pump station is required to supply the 337 PZ. The tank will be filled from 337 PZ using a control valve.

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 337-2
Project Name: 337 PZ Alternative 2

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
Water Main Replacement Contingencies-->						19%		6%	
380 Booster Pump Station	75	Per HP per Pump	$ 8,200	Capital	$ 615,000	$ 246,000	$ 184,500	$ 30,750	$ 1,076,250
380 BPS Field Piping - 12-inch	500	LF	$ 220	Capital	$ 110,000	$ 20,900	$ 33,000	$ 6,600	$ 170,500
Intelco Below Hydraulic-Grade Tank	1,500,000	gallon	$ 1.20	Capital	$ 1,800,000	$ 720,000	$ 540,000	$ 90,000	$ 3,150,000
Tank Field Piping - 16-inch	120	LF	$ 240	Capital	$ 28,800	$ 5,472	$ 8,640	$ 1,728	$ 44,640
337 PZ Booster Pump Station	60	Per HP per Pump	$ 8,200	Capital	$ 492,000	$ 196,800	$ 147,600	$ 24,600	$ 861,000
337 BPS Field Piping - 12-inch	100	LF	$ 220	Capital	$ 22,000	$ 4,180	$ 6,600	$ 1,320	$ 34,100
Business Park Piping Upsize - 16-inch	1,200	LF	$ 240	Capital	$ 288,000	$ 54,720	$ 86,400	$ 17,280	$ 446,400
Business Park Piping Upsize - 12-inch	1,830	LF	$ 220	Capital	$ 402,600	$ 76,494	$ 120,780	$ 24,156	$ 624,030
Rezone Connection Piping - 12-inch	925	LF	$ 220	Capital	$ 203,500	$ 38,665	$ 61,050	$ 12,210	$ 315,425
Check Valve - 8-inch	10	EA	$ 75,000	Capital	$ 750,000	$ 300,000	$ 225,000	$ 37,500	$ 1,312,500
					$ -	$ -	$ -	$ -	$ -
BPS Energy Costs - 50 years	1	LS	$ 7,669,596	O&M	$ 7,669,596	$ -	$ -	$ -	$ 7,669,596
Tank Energy Costs - 50 years	1	LS	$ 157,072	O&M	$ 157,072	$ -	$ -	$ -	$ 157,072
City Staff Effort (BPS) - 50 Years	1	LS	$ 1,906,959	O&M	$ 1,906,959	$ -	$ -	$ -	$ 1,906,959
City Staff Effort (Tank) - 50 Years	1	LS	$ 1,622,692	O&M	$ 1,622,692	$ -	$ -	$ -	$ 1,622,692
PS Rehab - 30 Years	2	LS	$ 813,179	O&M	$ 1,626,358	$ -	$ -	$ -	$ 1,626,358
Tank Recoating - 30 Years	1	LS	$ 547,207	O&M	$ 547,207	$ -	$ -	$ -	$ 547,207

Total Project Cost	$ 21,564,729

Notes on Cost Estimation:

See Assumptions tab for details. See Life Cycle costs Tab for O&M costs. Pipe Upsizing uses contingencies for Water Main Replacements as shown in Assumptions tab.

Go to Assumptions Tab

City of Lacey
337 PZ Facilities & Pressure Study

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Project ID: 337-2
Project Name: 337 PZ Alternative 2

Project Timing:

Project Element		Timing	Cost
380 Booster Pump Station	Capital	2022	$ 1,211,329
380 BPS Field Piping - 12-inch	Capital	2022	$ 191,899
Intelco Below Hydraulic-Grad	Capital	2022	$ 3,545,353
Tank Field Piping - 16-inch	Capital	2022	$ 50,243
337 PZ Booster Pump Station	Capital	2022	$ 969,063
337 BPS Field Piping - 12-inch	Capital	2022	$ 38,380
Business Park Piping Upsize -	Capital	2022	$ 502,427
Business Park Piping Upsize -	Capital	2022	$ 702,351
Rezone Connection Piping - 1	Capital	2022	$ 355,014
Check Valve - 8-inch	Capital	2022	$ 1,477,230
			$ -
BPS Energy Costs - 50 years	O&M	Varies	$ 7,669,596
Tank Energy Costs - 50 years	O&M	Varies	$ 157,072
City Staff Effort (BPS) - 50 Yea	O&M	Varies	$ 1,906,959
City Staff Effort (Tank) - 50 Ye	O&M	Varies	$ 1,622,692
PS Rehab - 30 Years	O&M	Varies	$ 1,626,358
Tank Recoating - 30 Years	O&M	Varies	$ 547,207

Total Project Cost		$ 22,573,173

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 337-3
Project Name: 337 PZ Alternative 3

Project Description:
- Construct an elevated tank on the Intelco property site. This proposed elevated tank will be referred to as Intelco Elevated Tank. The elevated tank will be at the 337 PZ grade.
- Upgrade Well 10 (S10) with a VFD. The VFD will help stabilize pressures in the surrounding area.

City of Lacey
337 PZ Facilities & Pressure Study

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Project ID: 337-3
Project Name: 337 PZ Alternative 3

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
Water Main Replacement Contingencies-->						19%		6%	
Intelco Above Hydraulic Grade Tank	750,000	gallon	$ 4.00	Capital	$ 3,000,000	$ 1,200,000	$ 900,000	$ 150,000	$ 5,250,000
Tank Field Piping - 16-inch	150	LF	$ 240	Capital	$ 36,000	$ 6,840	$ 10,800	$ 2,160	$ 55,800
Well 10 Upgrade - VFD	1	LS	$ 50,000	Capital	$ 50,000	$ 20,000	$ 15,000	$ 2,500	$ 87,500
Energy Costs - 50 years	1	LS	$ 157,072	O&M	$ 157,072	$ -	$ -	$ -	$ 157,072
City Staff Effort (Tank) - 50 Years	1	LS	$ 1,622,692	O&M	$ 1,622,692	$ -	$ -	$ -	$ 1,622,692
Tank Recoating - 30 Years	1	LS	$ 547,207	O&M	$ 547,207	$ -	$ -	$ -	$ 547,207

Total Project Cost	$ 7,720,271

Notes on Cost Estimation:

See Assumptions tab for details. See Life Cycle costs Tab for O&M costs. Pipe Upsizing uses contingencies for Water Main Replacements as shown in Assumptions tab.

Go to Assumptions Tab

Project Timing:

Project Element		Timing	Cost
Intelco Above Hydraulic Grad	Capital	2022	$ 5,908,921
Tank Field Piping - 16-inch	Capital	2022	$ 62,803
Well 10 Upgrade - VFD	Capital	2022	$ 98,482
			$ -
Energy Costs - 50 years	O&M	Varies	$ 157,072
City Staff Effort (Tank) - 50 Ye	O&M	Varies	$ 1,622,692
Tank Recoating - 30 Years	O&M	Varies	$ 547,207
Total Project Cost			$ 8,397,178

Appendix C

DETAILED MODELING RESULTS FIGURES

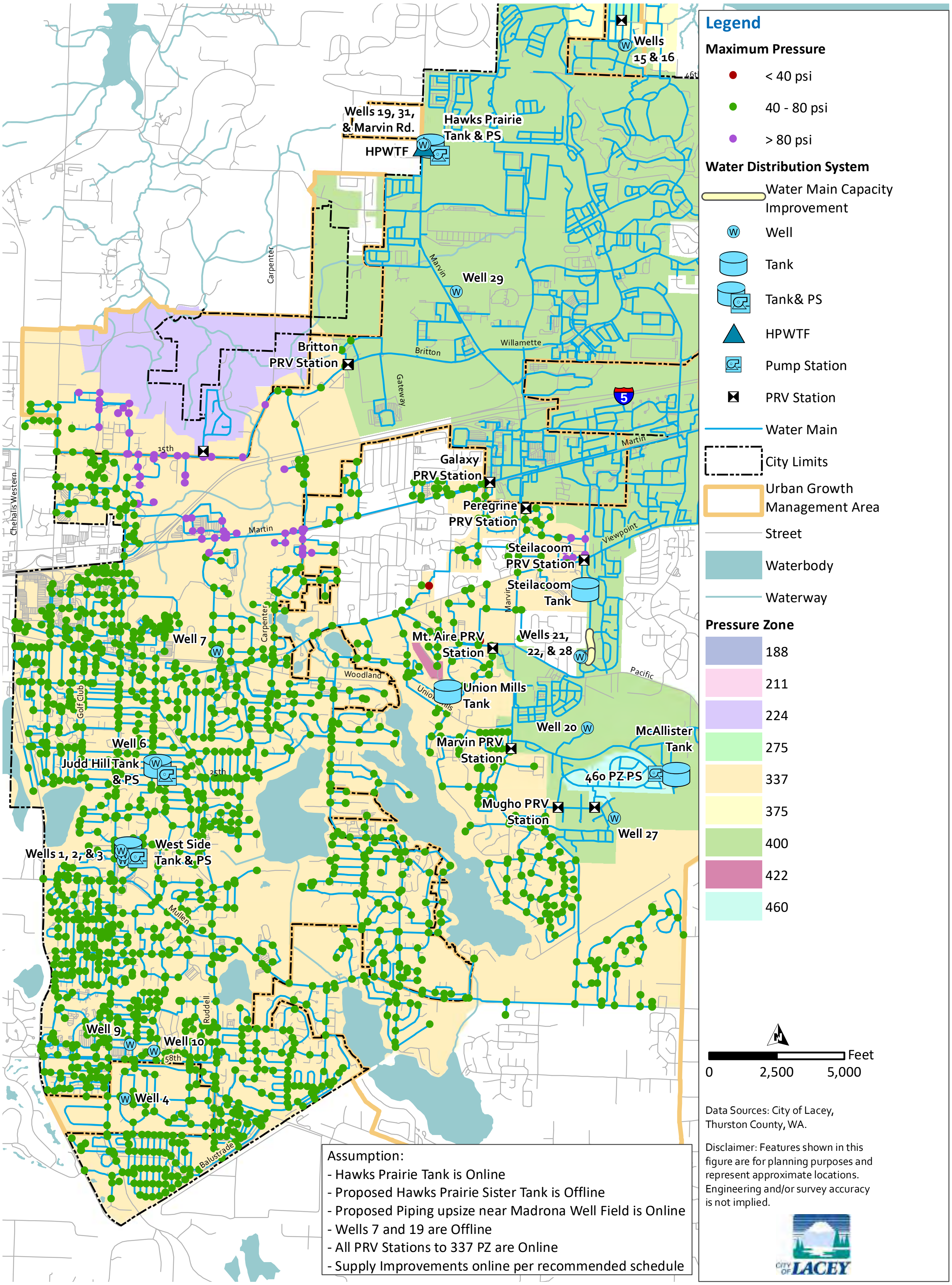
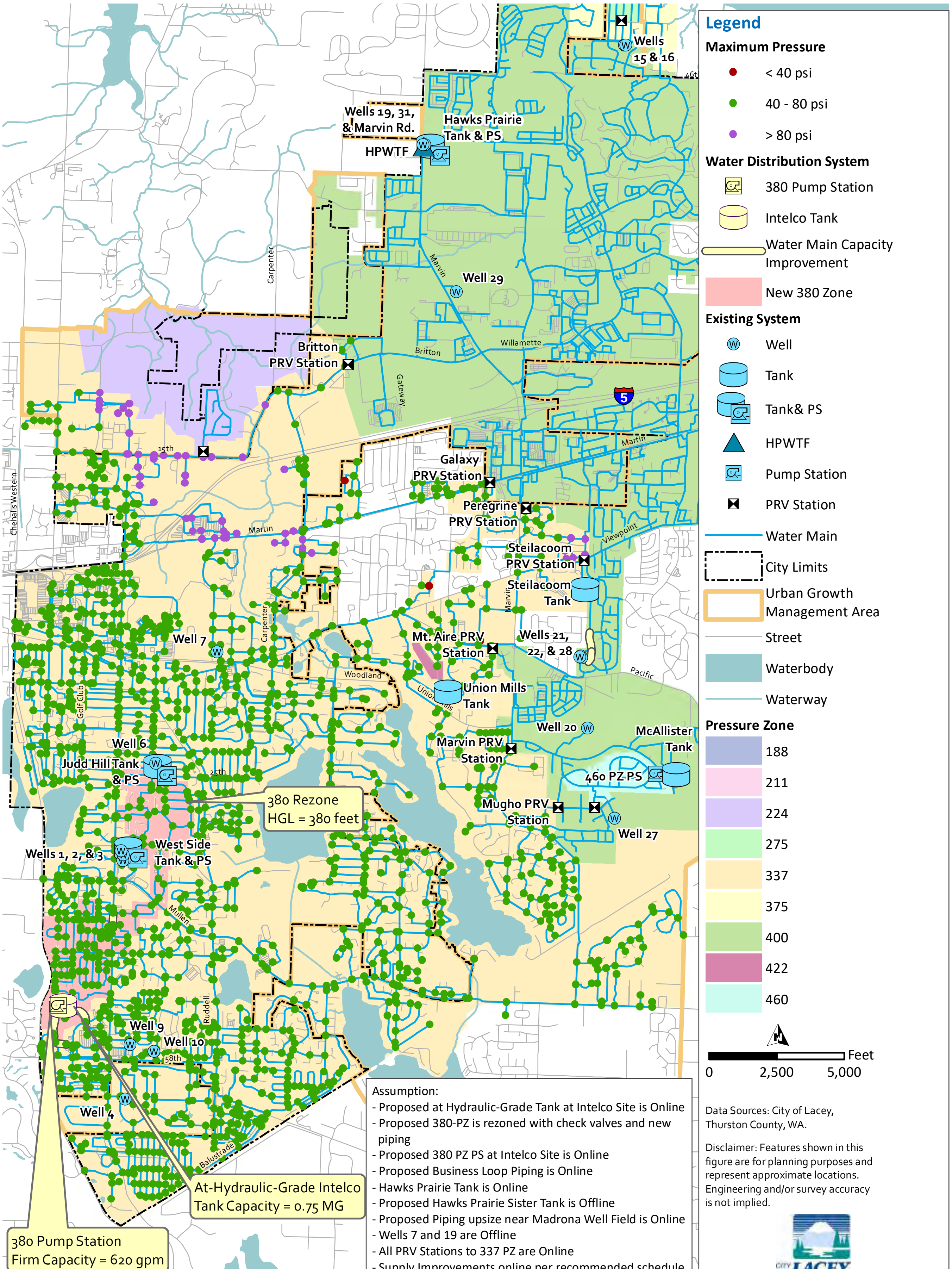


Figure 1 Maximum Pressures under 2022 ADD Conditions - Baseline



Assumption:
- Proposed at Hydraulic-Grade Tank at Intelco Site is Online
- Proposed 380-PZ is rezoned with check valves and new piping
- Proposed 380 PZ PS at Intelco Site is Online
- Proposed Business Loop Piping is Online
- Hawks Prairie Tank is Online
- Proposed Hawks Prairie Sister Tank is Offline
- Proposed Piping upsize near Madrona Well Field is Online
- Wells 7 and 19 are Offline
- All PRV Stations to 337 PZ are Online
- Supply Improvements online per recommended schedule

Data Sources: City of Lacey, Thurston County, WA.

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Figure 2 Maximum Pressure under 2022 ADD Conditions - 337 PZ Alternative 1

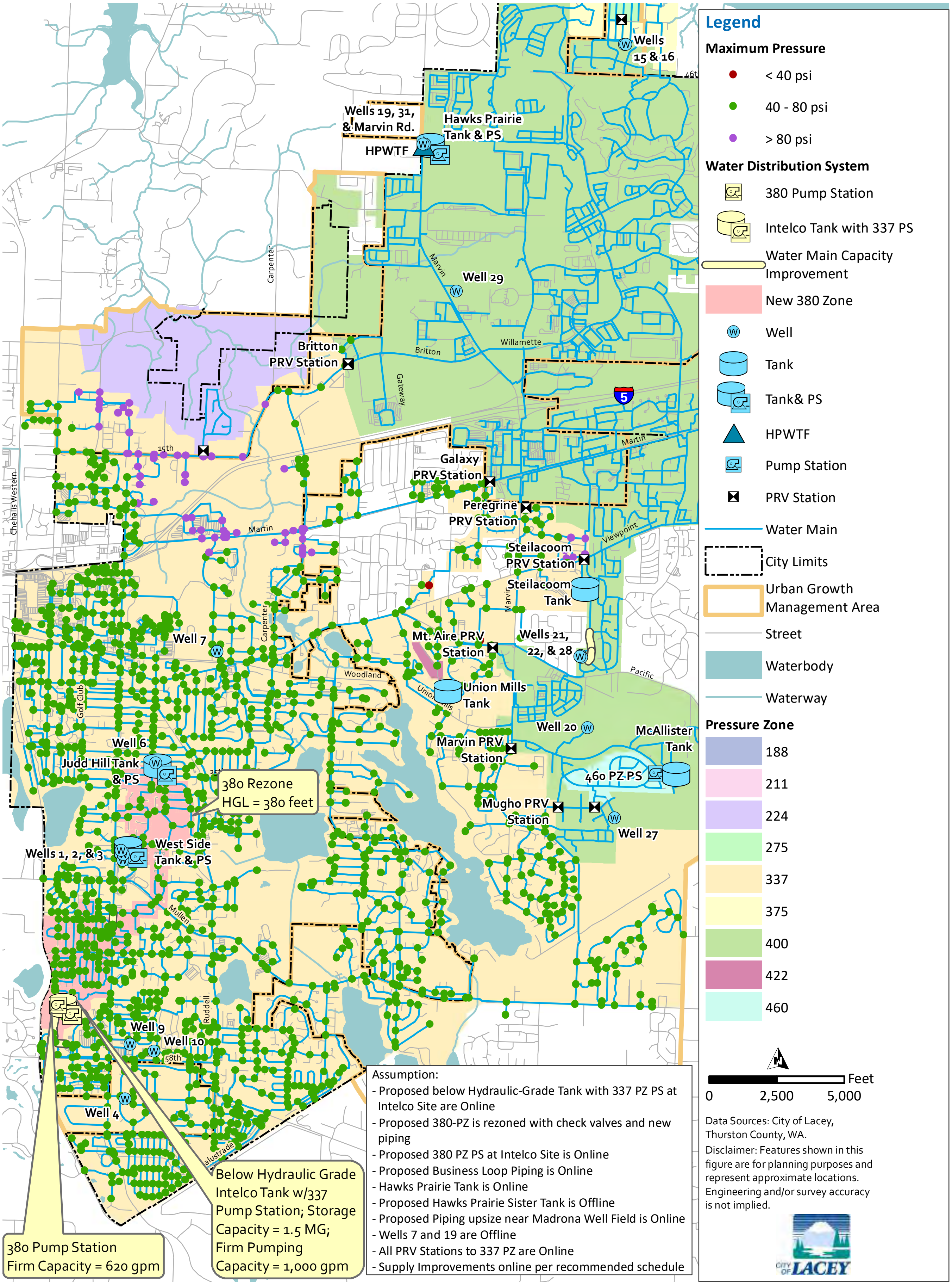


Figure 3 Maximum Pressure under 2022 ADD Conditions - 337 PZ Alternative 2

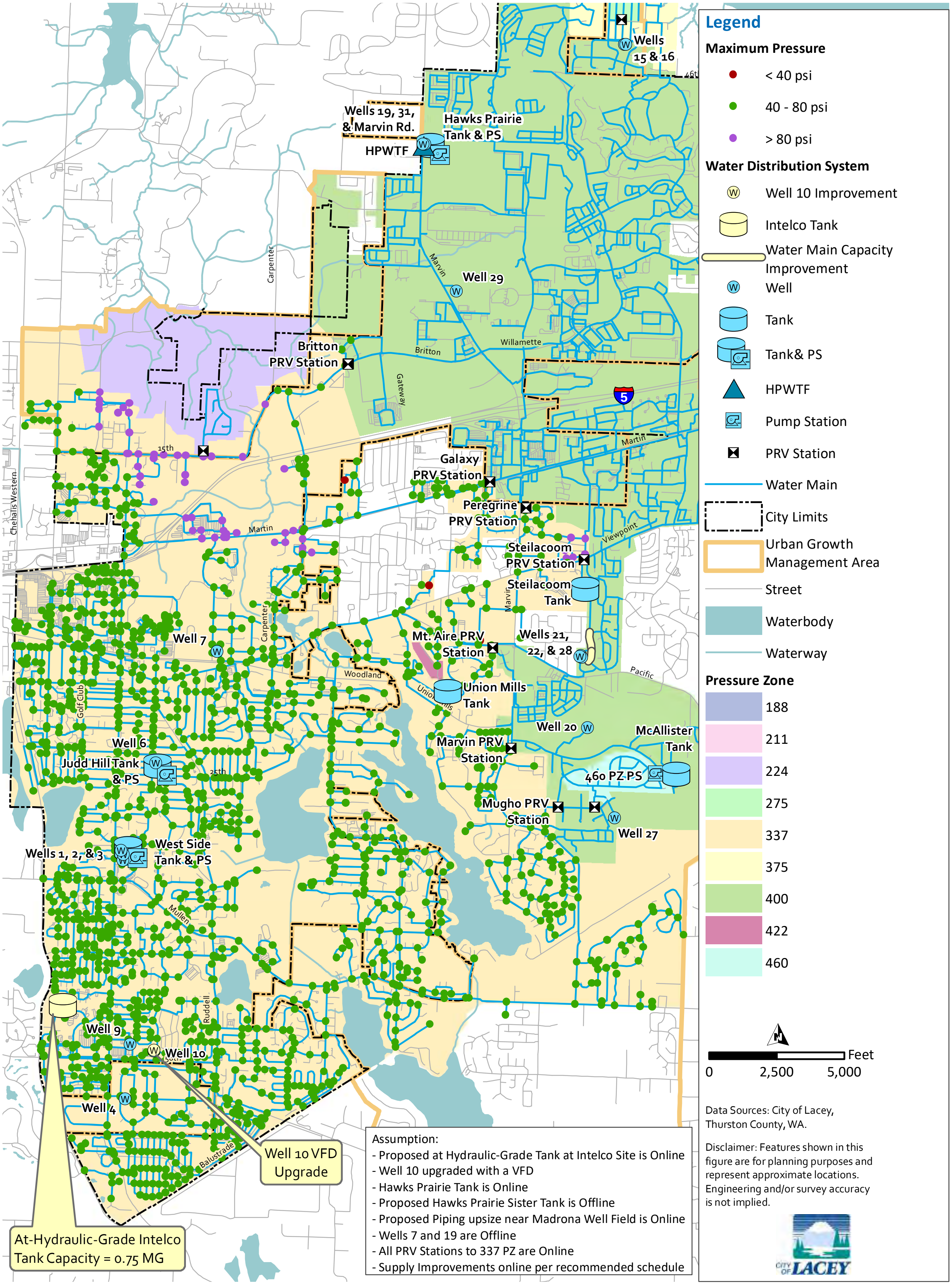


Figure 4 Maximum Pressure under 2022 ADD Conditions - 337 PZ Alternative 3

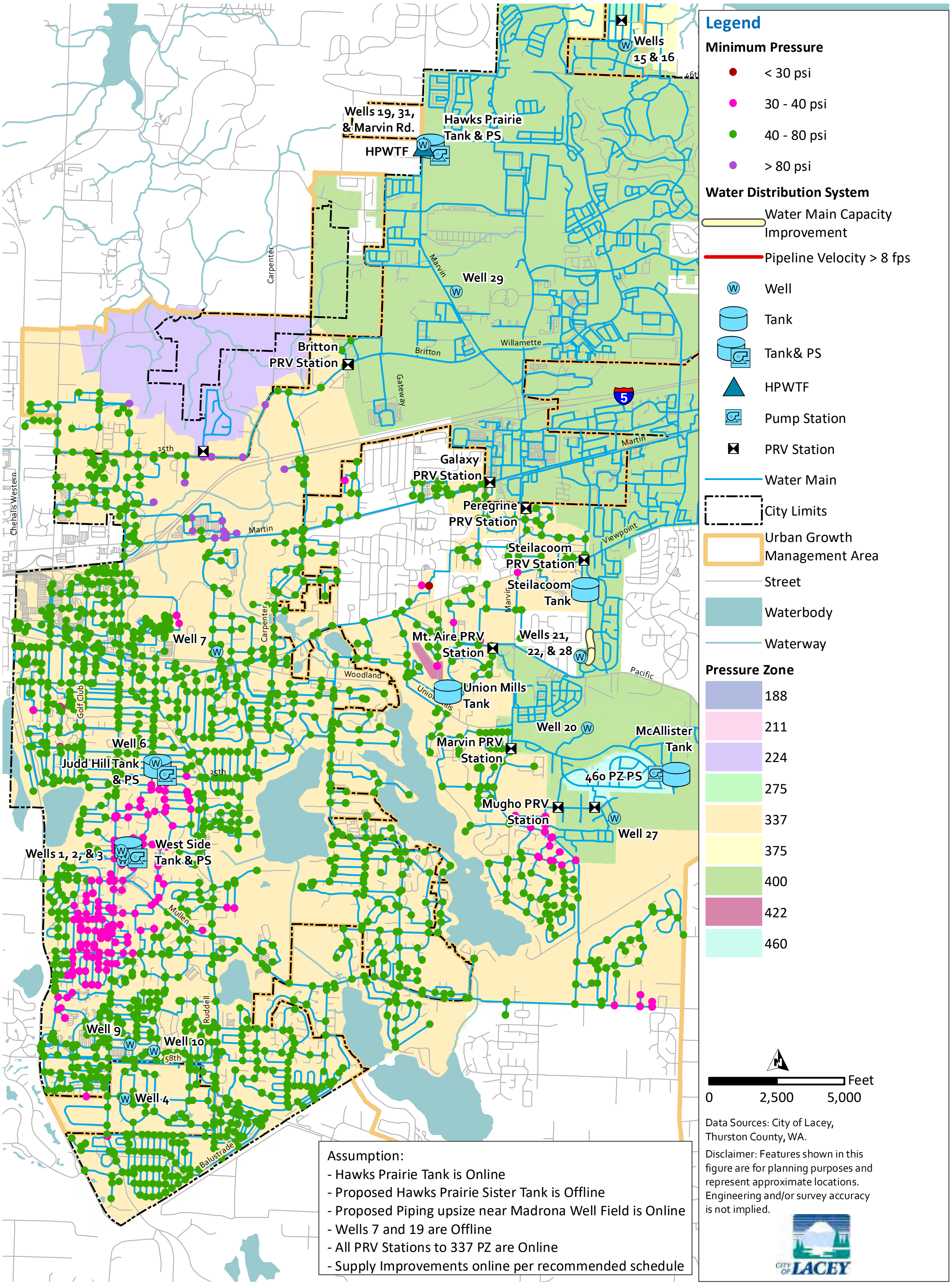


Figure 5 Minimum Pressure and Maximum Velocity under 2022 PHD Conditions - Baseline

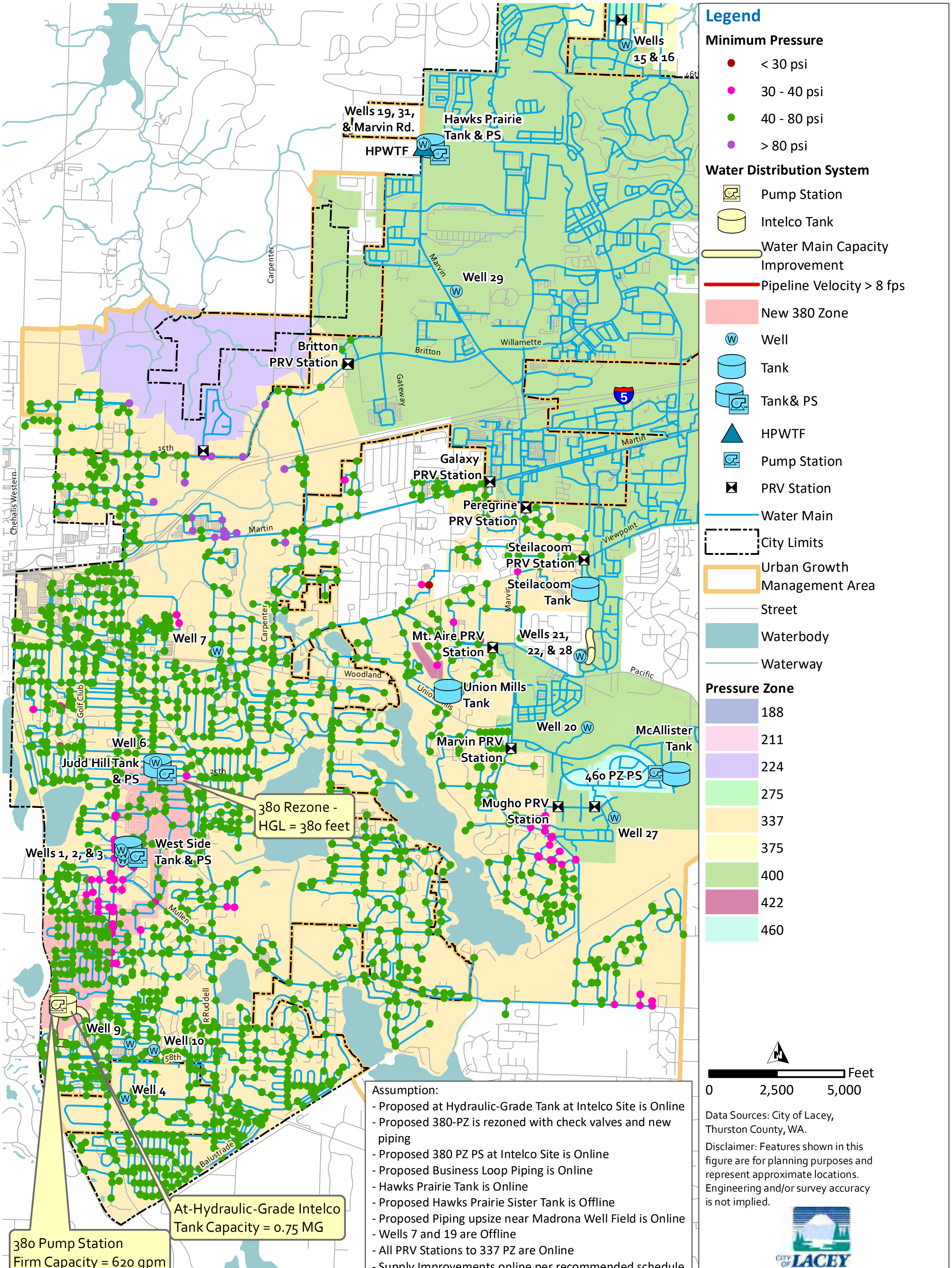


Figure 6 Minimum Pressure and Maximum Velocity under 2022 PHD Conditions - 337 PS Alternative 1

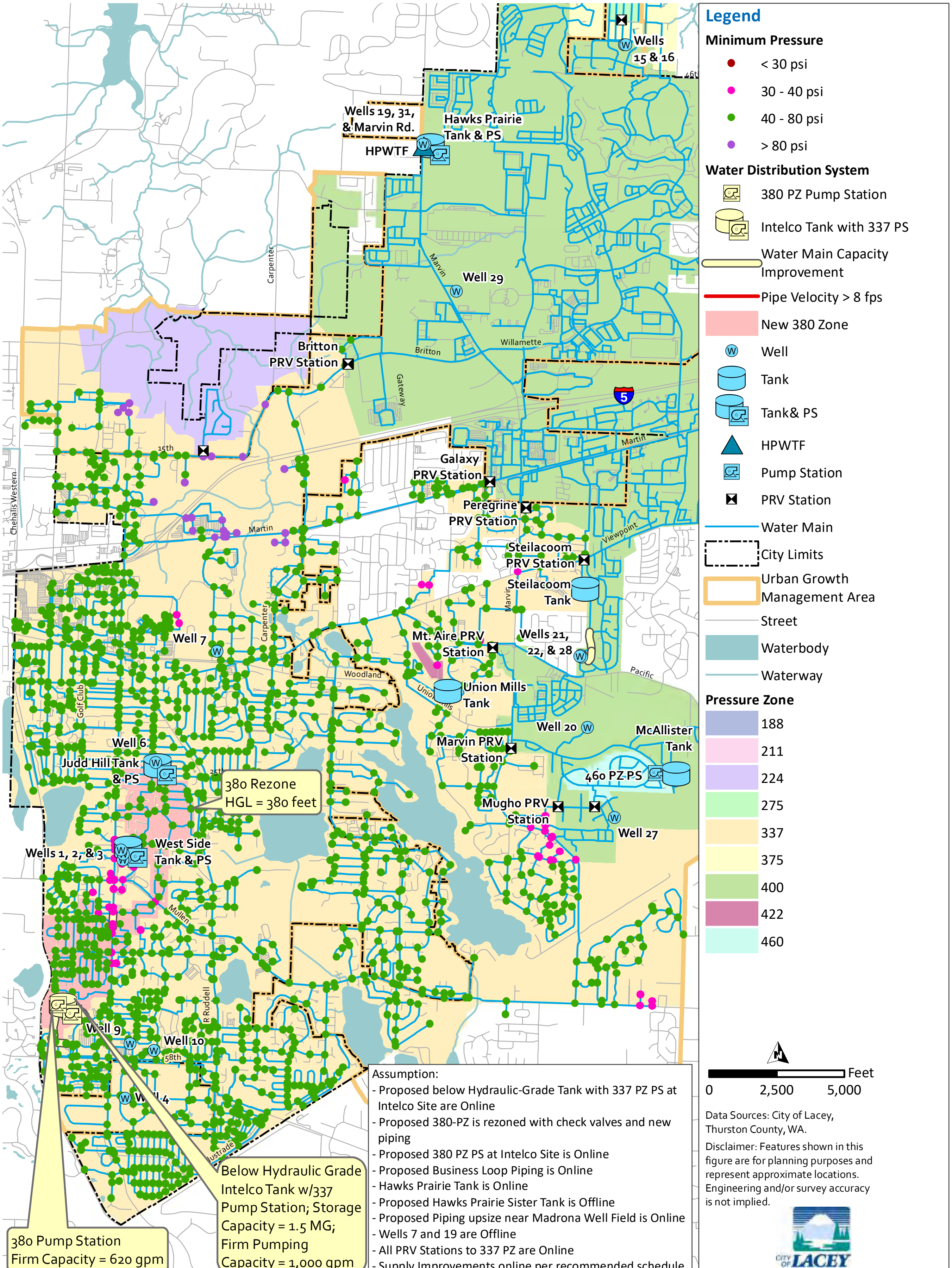


Figure 7 Minimum Pressure and Maximum Velocity under 2022 PHD Conditions - 337 PS Alternative 2

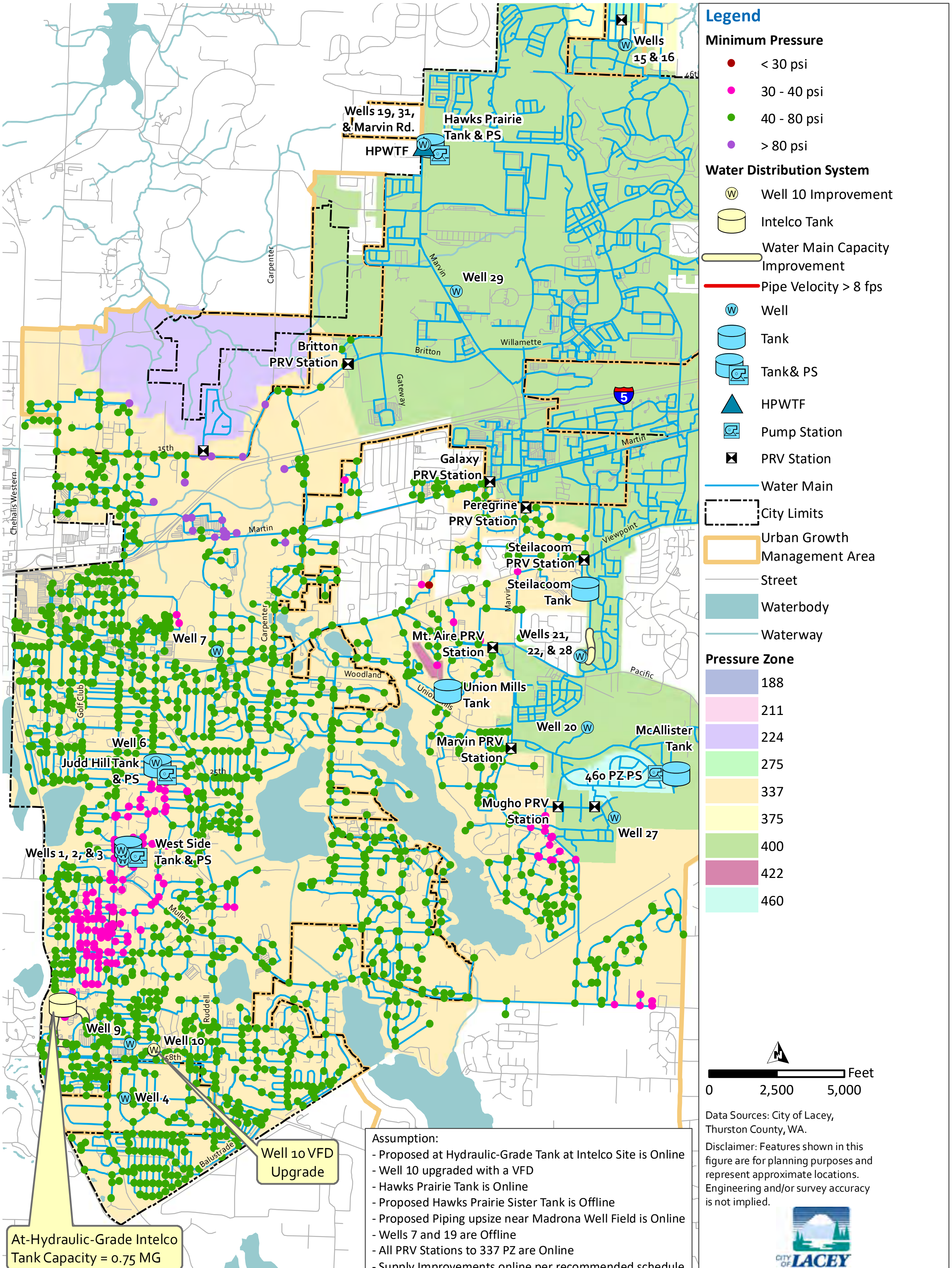


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Figure 8 Minimum Pressure and Maximum Velocity under 2022 PHD Conditions - 337 PS Alternative 3

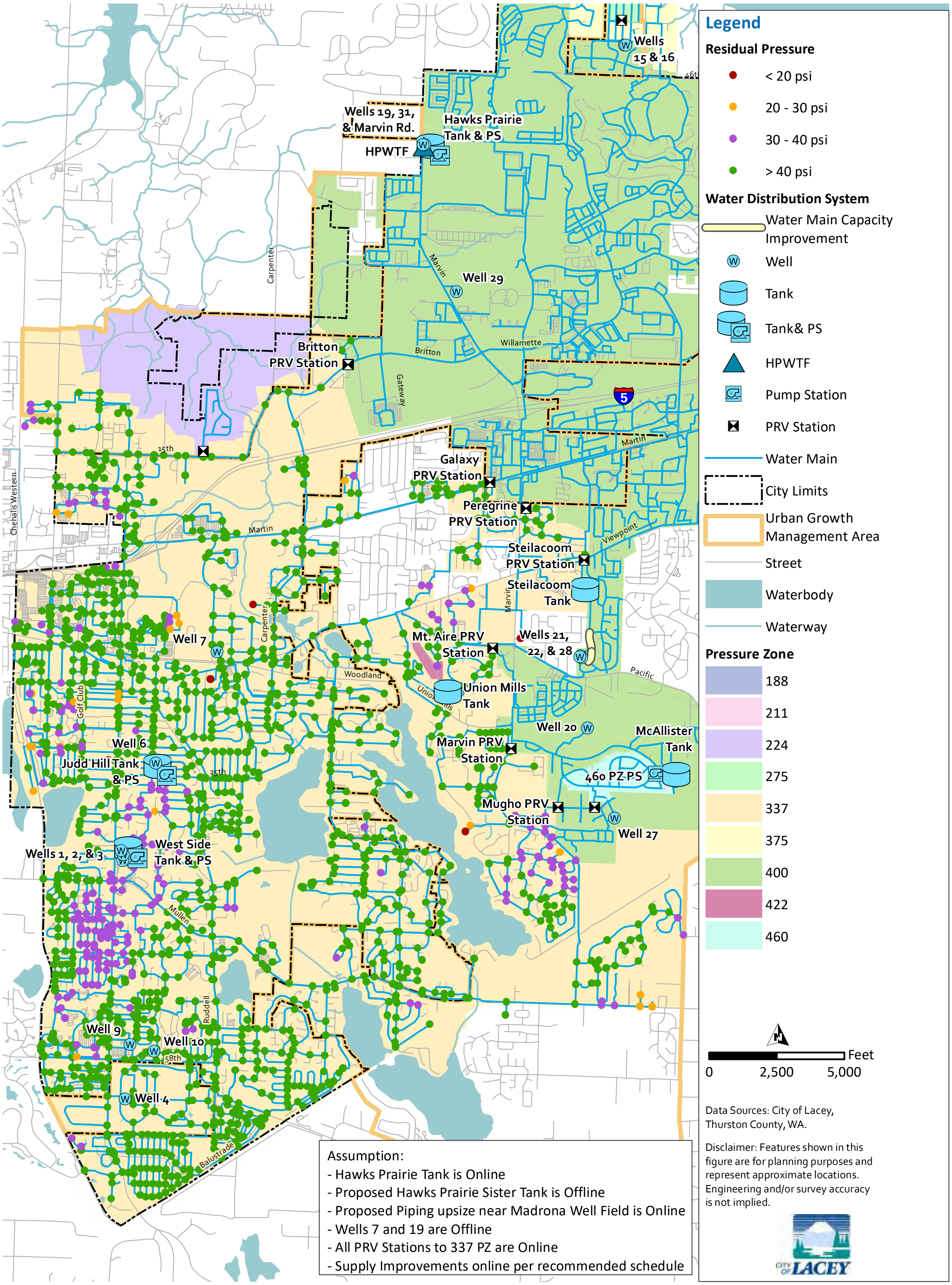


Figure 9 Residual Pressure under 2022 MDD plus Fire Flow Conditions - Baseline

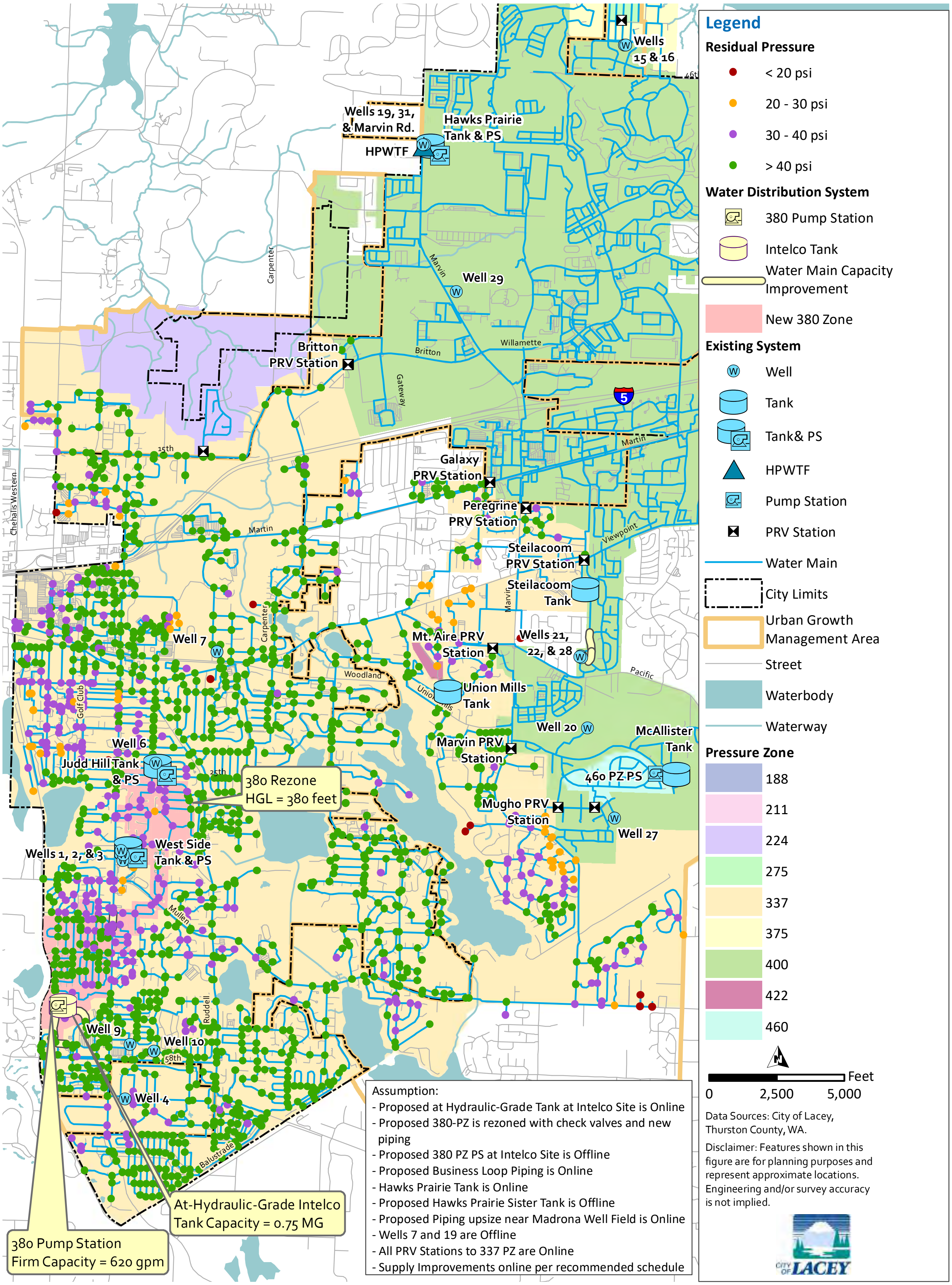
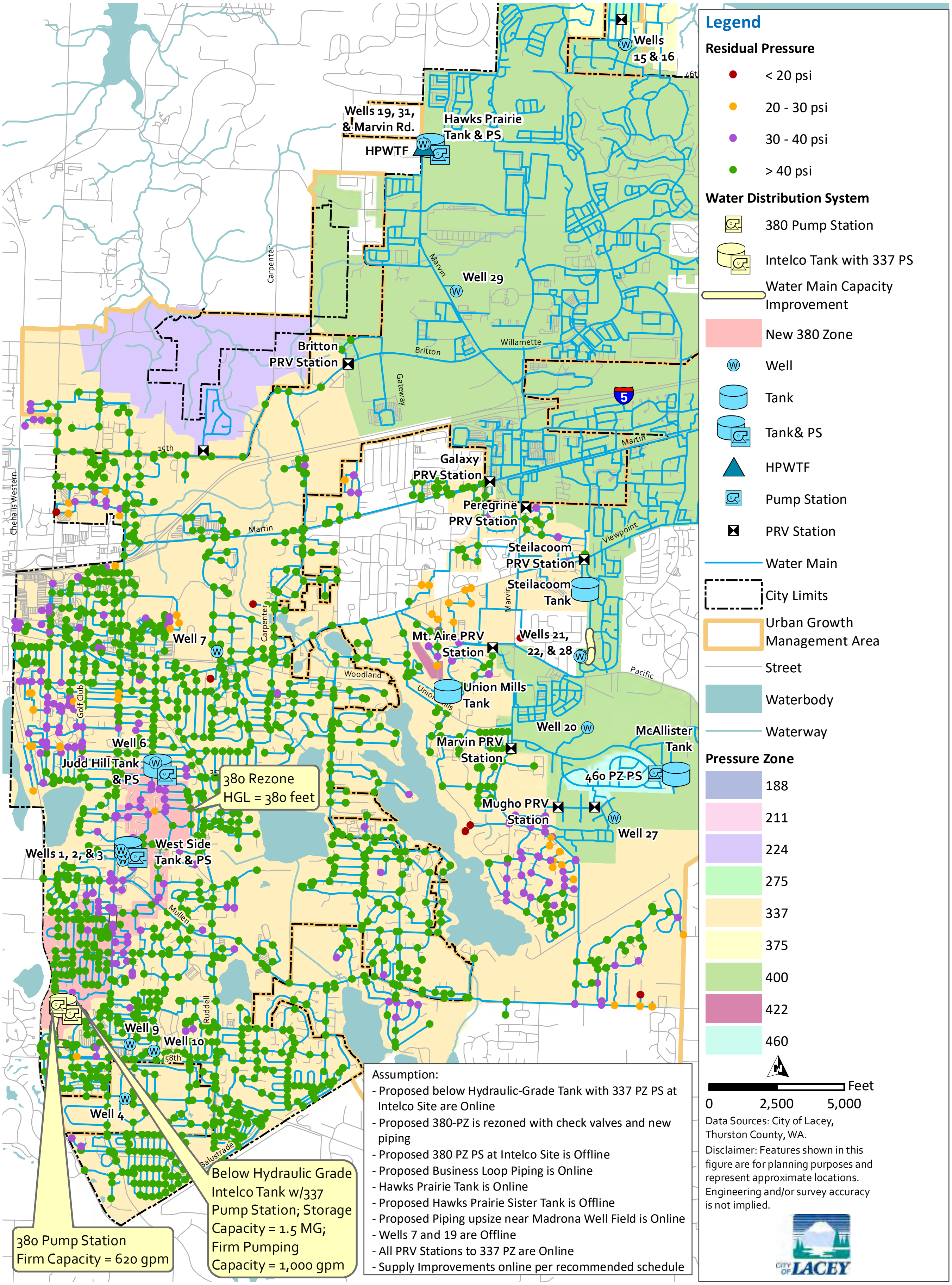


Figure 10 Residual Pressure under 2022 MDD plus Fire Flow Conditions - 337 PZ Alternative 1



Assumption:
- Proposed below Hydraulic-Grade Tank with 337 PZ PS at Intelco Site are Online
- Proposed 380-PZ is rezoned with check valves and new piping
- Proposed 380 PZ PS at Intelco Site is Offline
- Proposed Business Loop Piping is Online
- Hawks Prairie Tank is Online
- Proposed Hawks Prairie Sister Tank is Offline
- Proposed Piping upsize near Madrona Well Field is Online
- Wells 7 and 19 are Offline
- All PRV Stations to 337 PZ are Online
- Supply Improvements online per recommended schedule

Data Sources: City of Lacey, Thurston County, WA.

Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.

Figure 11 Residual Pressure under 2022 MDD plus Fire Flow Conditions - 337 PZ Alternative 2

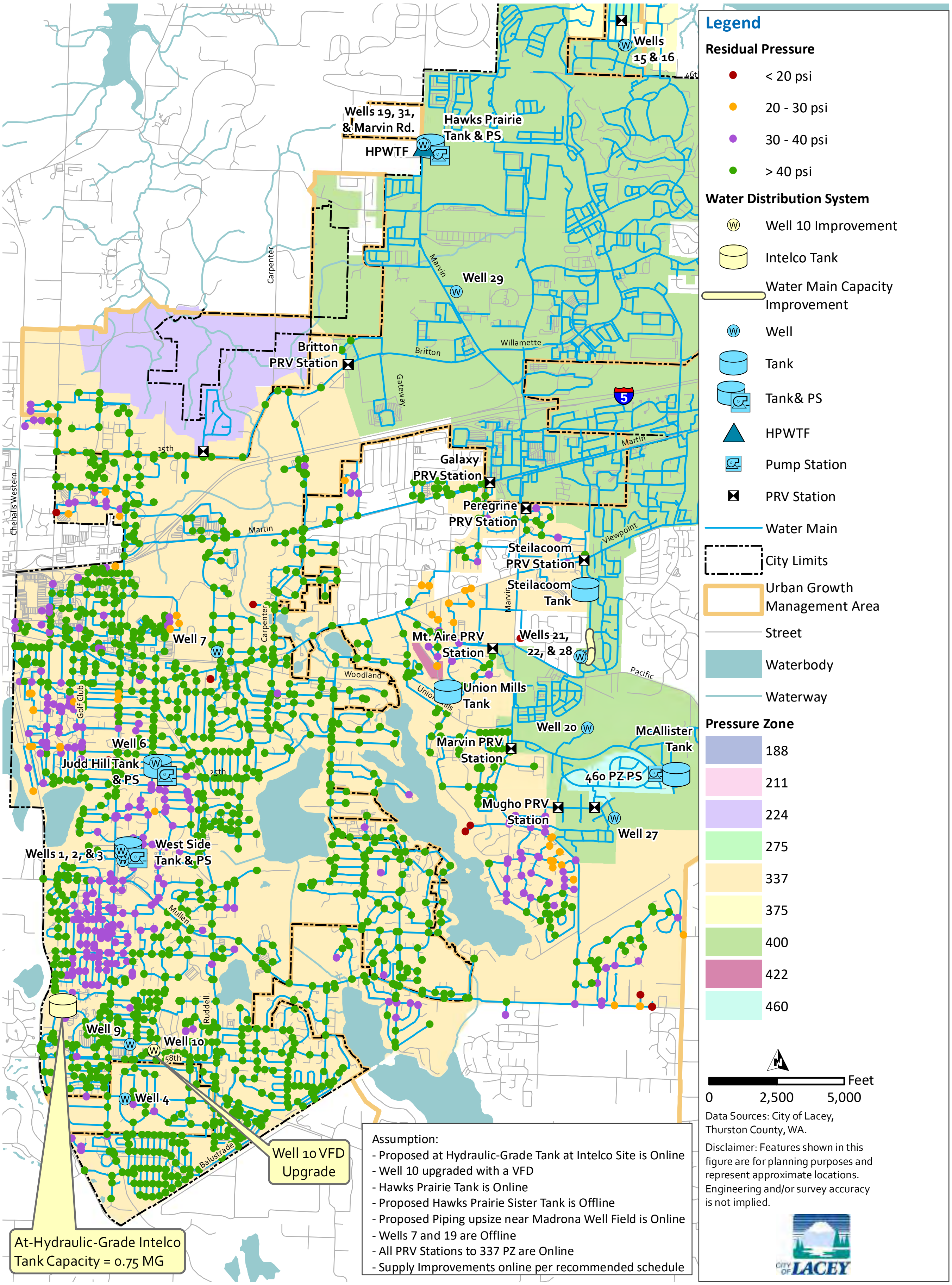


Figure 12 Residual Pressure under 2022 MDD plus Fire Flow Conditions - 337 PZ Alternative 3

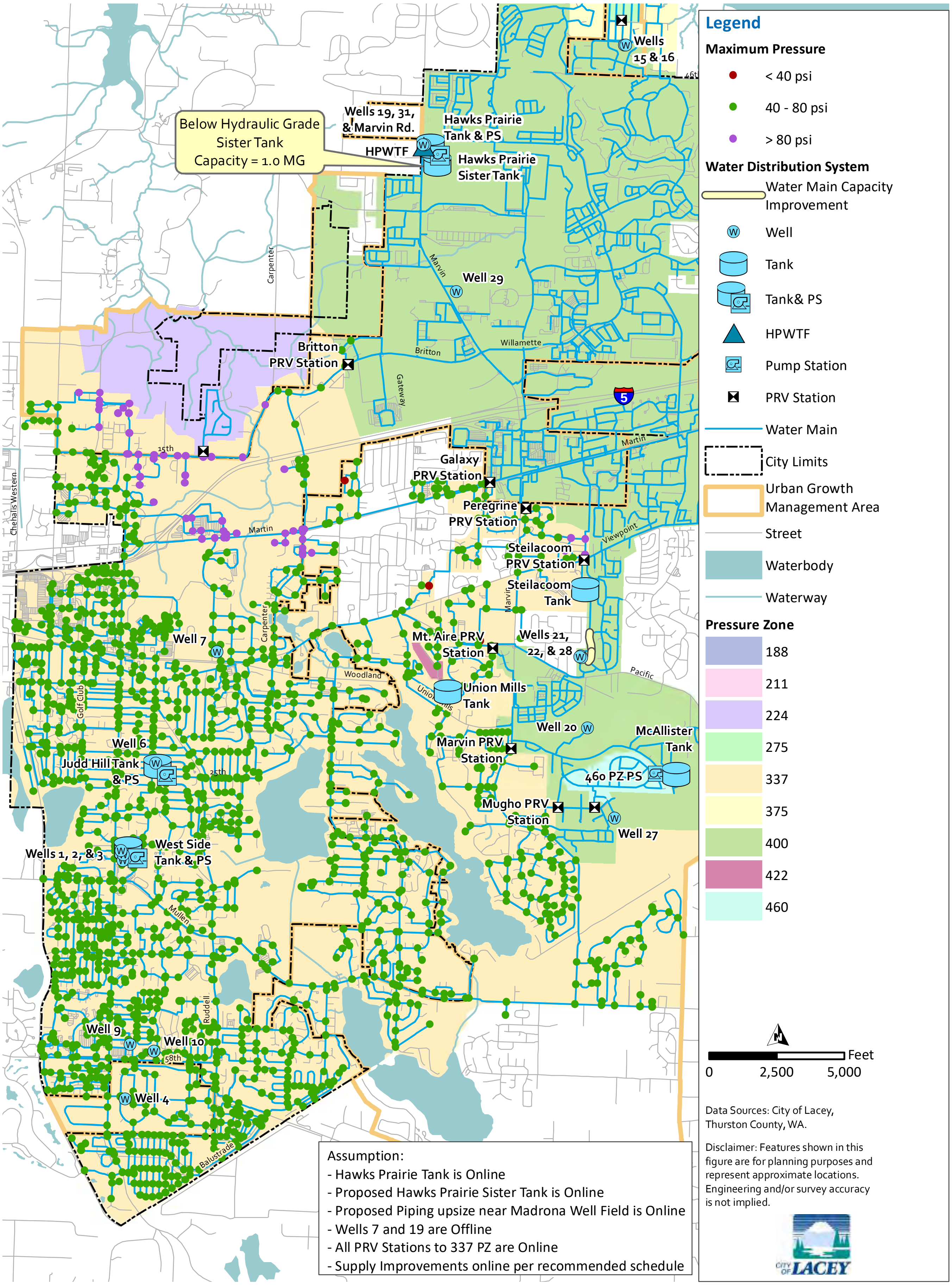


Figure 13 Maximum Pressures under 2028 ADD Conditions - Baseline

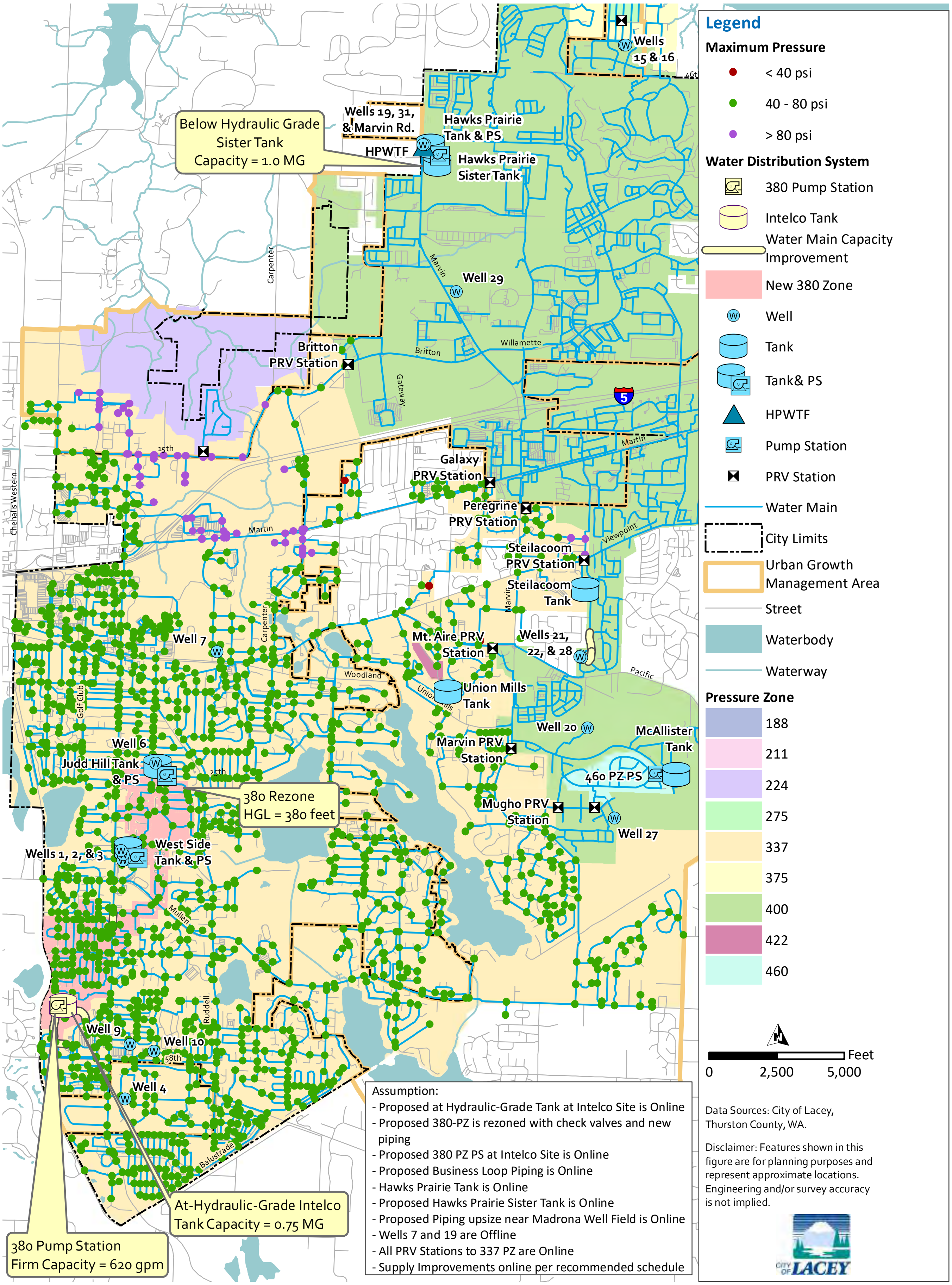


Figure 14 Maximum Pressure under 2028 ADD Conditions - 337 PZ Alt. 1

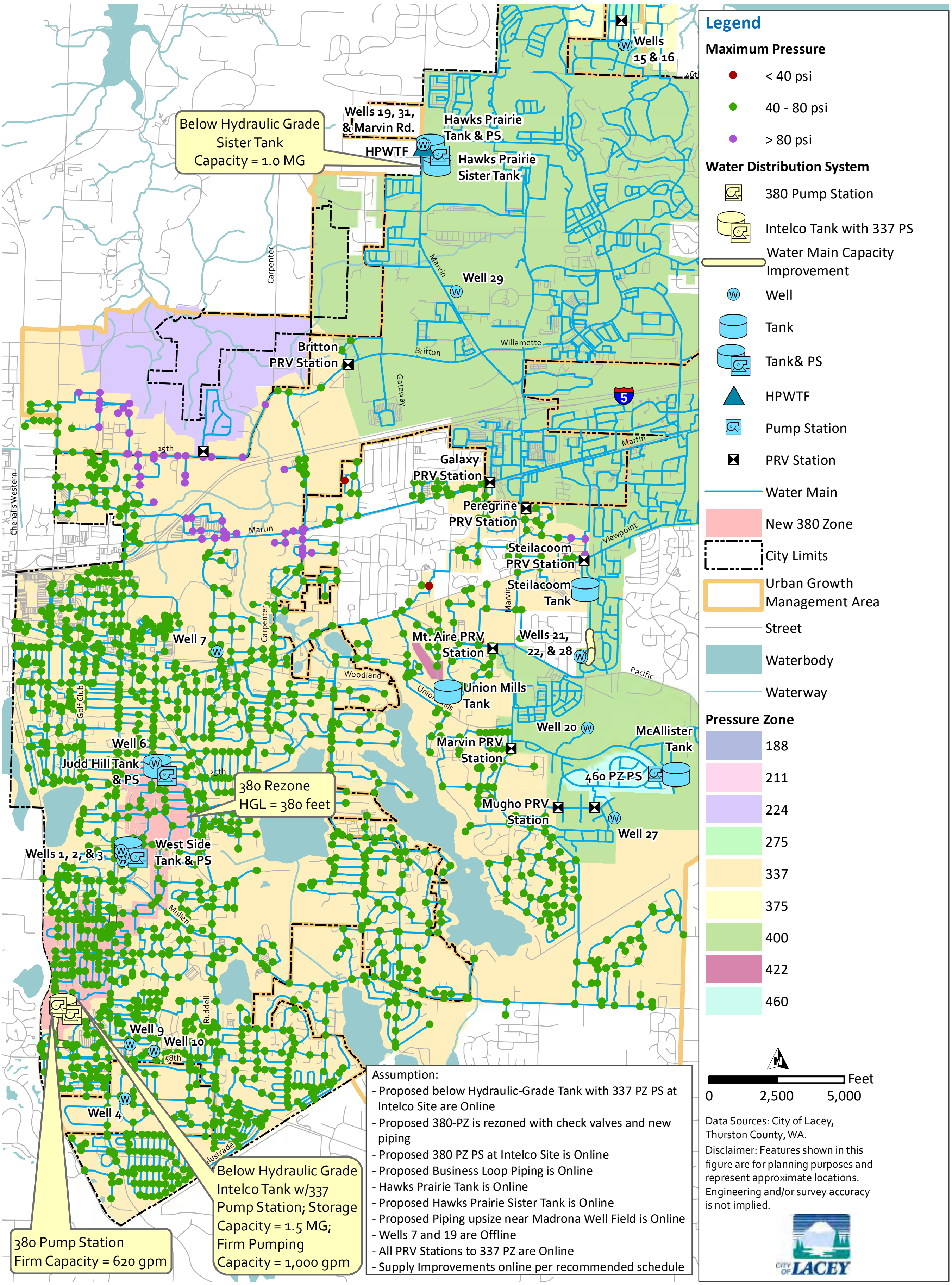


Figure 15 Maximum Pressure under 2028 ADD Conditions - 337 PZ Alternative 2

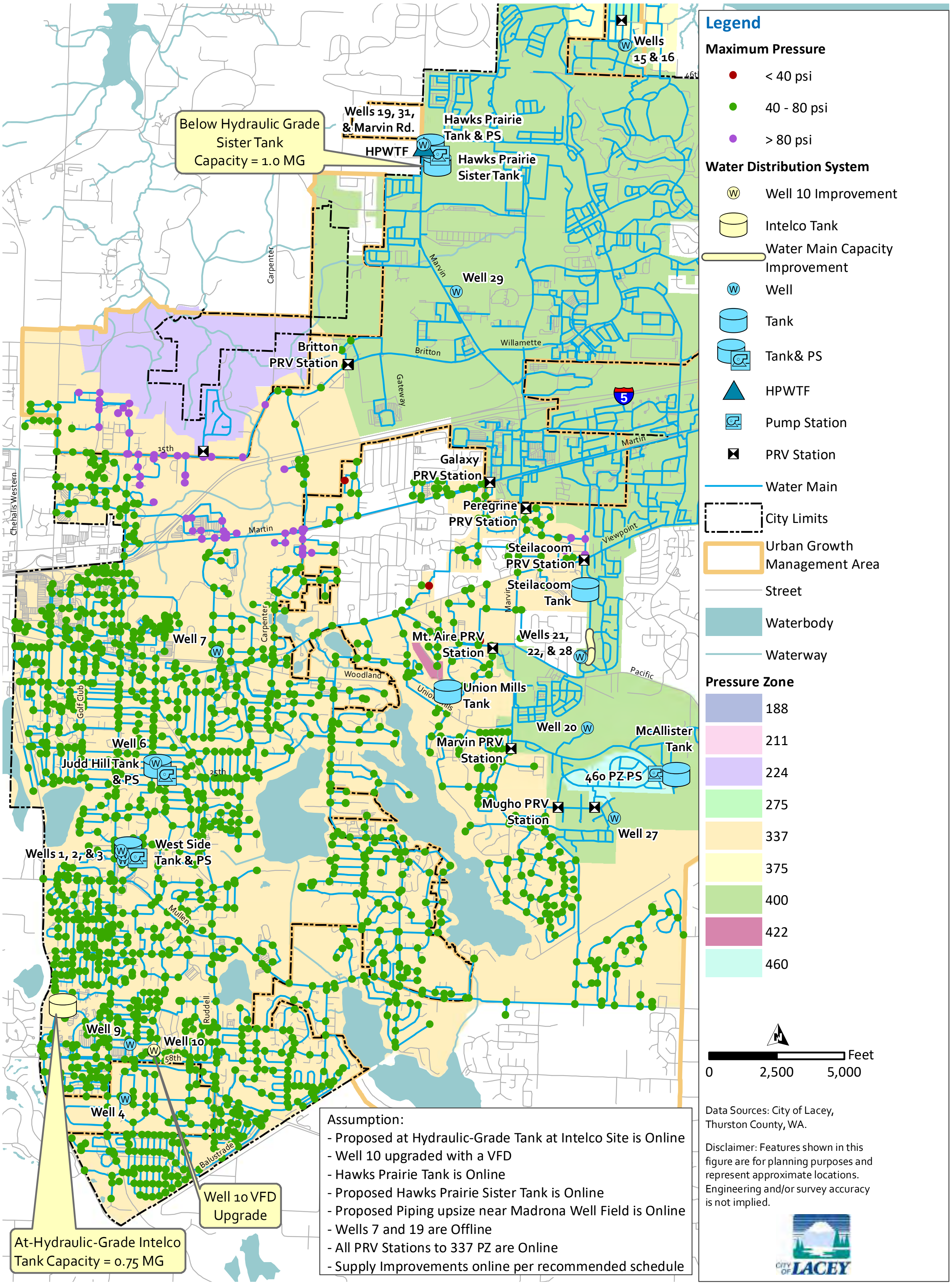


Figure 16 Maximum Pressure under 2028 ADD Conditions - 337 PZ Alternative 3

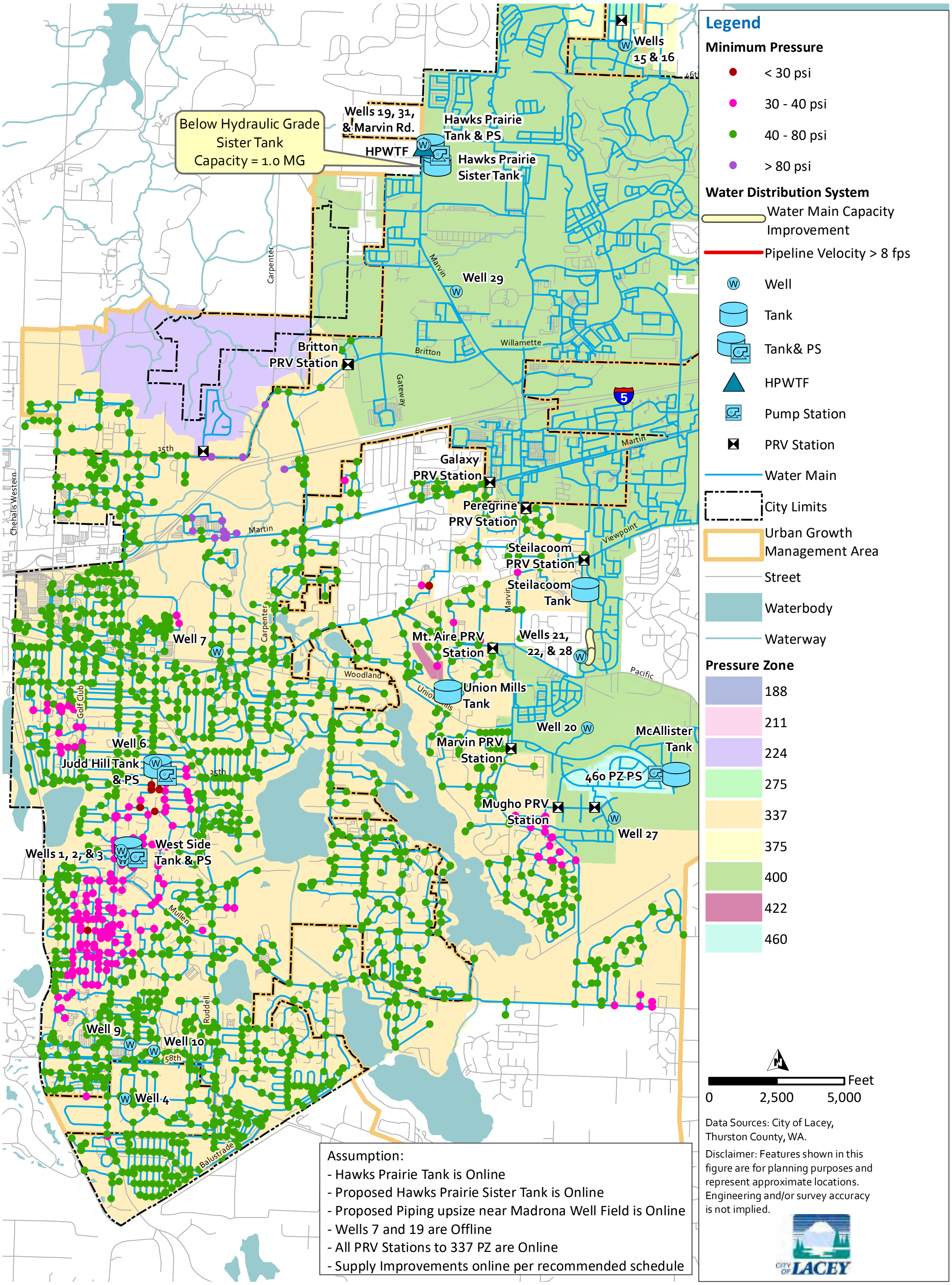


Figure 17 Minimum Pressure and Maximum Velocity under 2028 PHD Conditions - Baseline

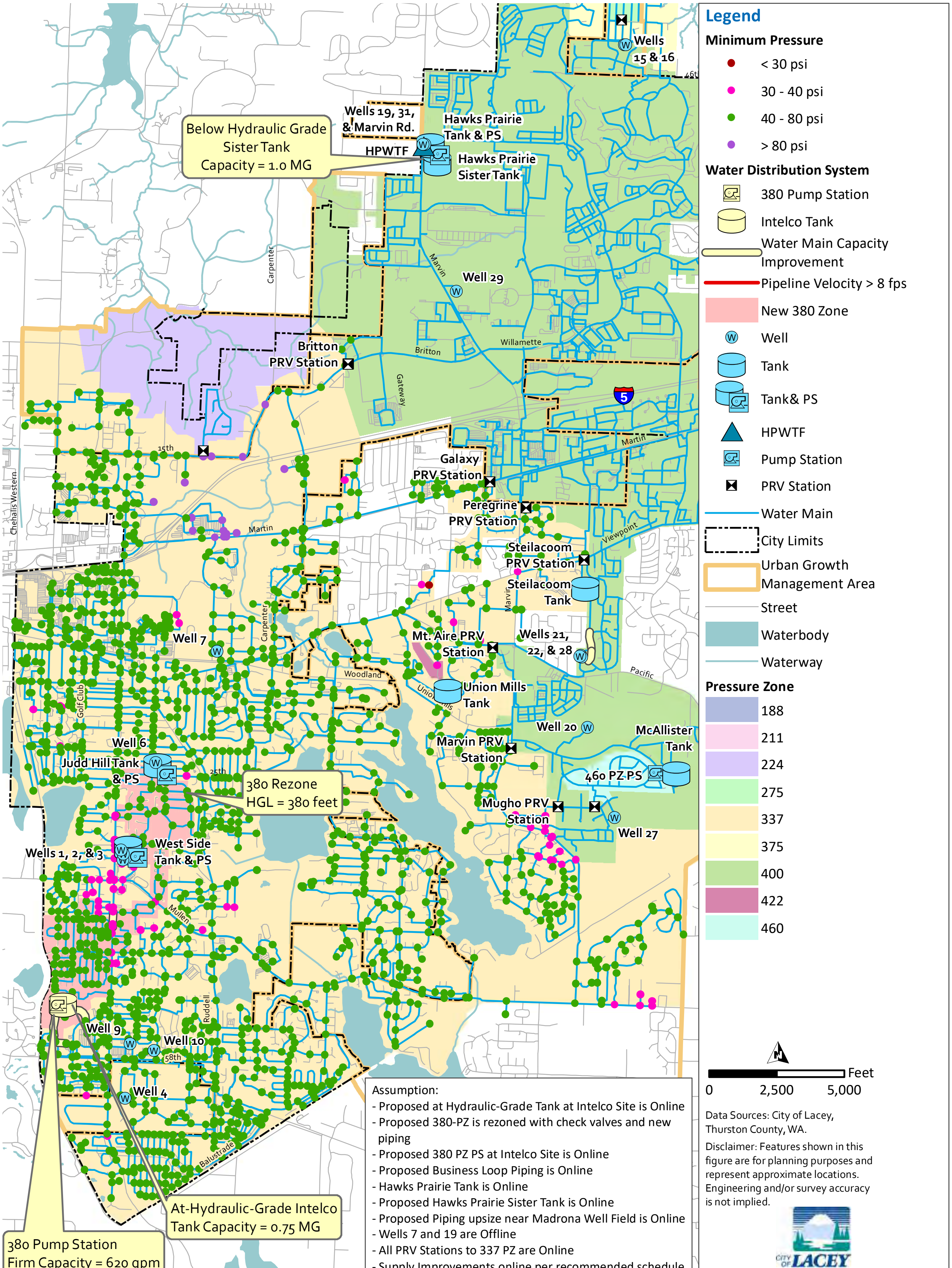


Figure 18 Minimum Pressure and Maximum Velocity under 2028 PHD Conditions - 337 PS Alternative 1

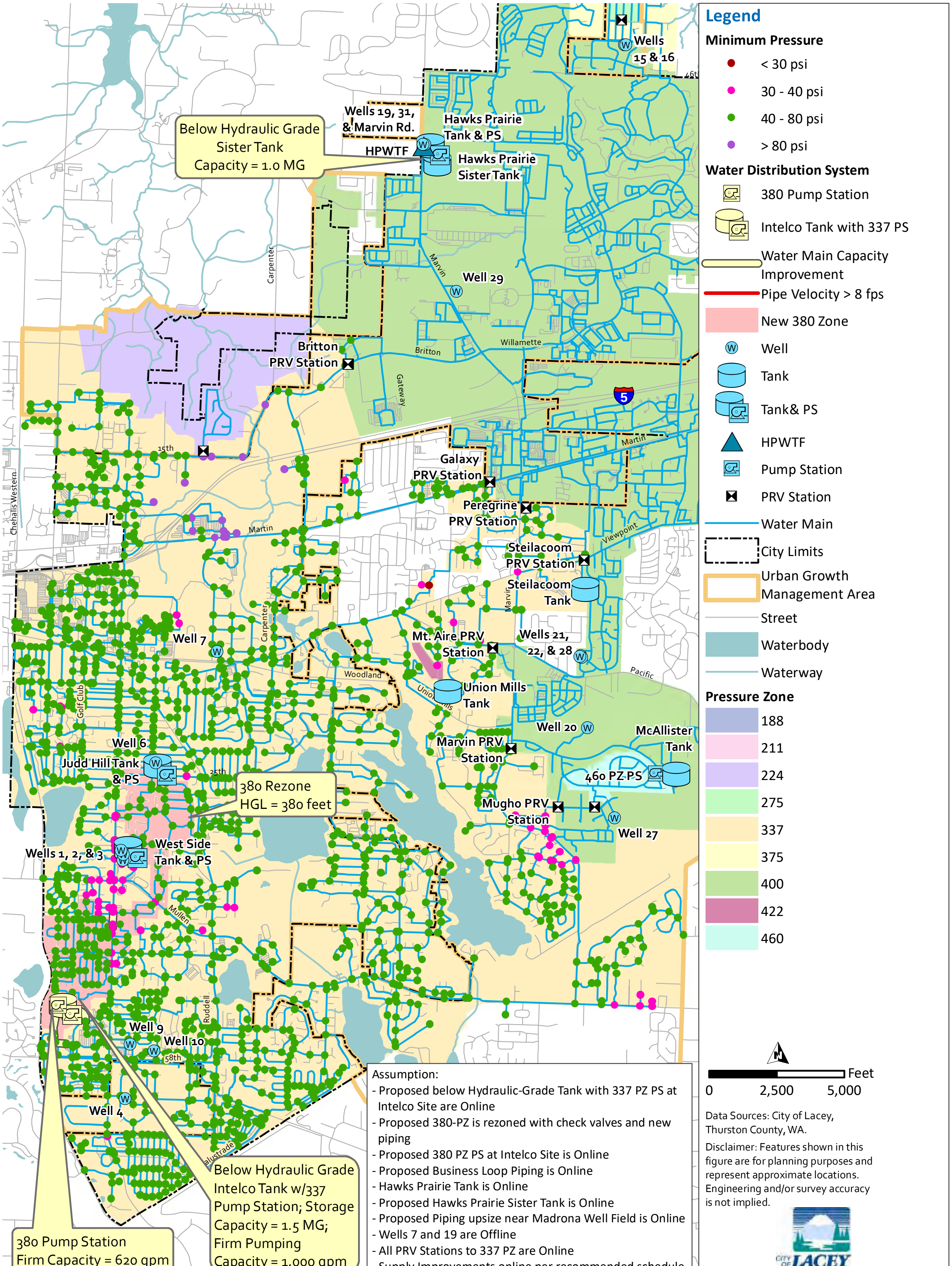


Figure 19 Minimum Pressure and Maximum Velocity under 2028 PHD Conditions - 337 PS Alternative 2

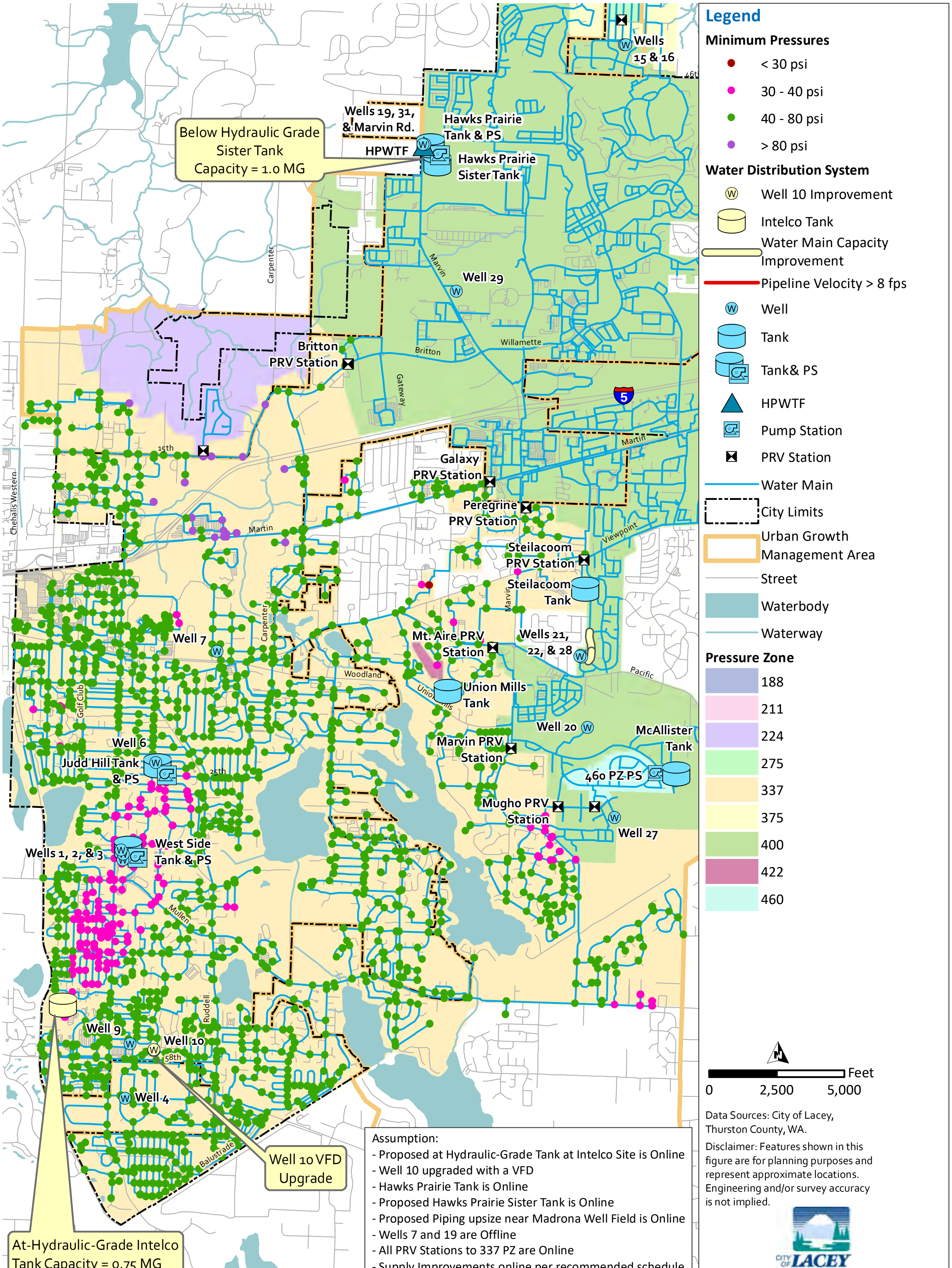


Figure 20 Minimum Pressure and Maximum Velocity under 2028 PHD Conditions - 337 PS Alternative 3

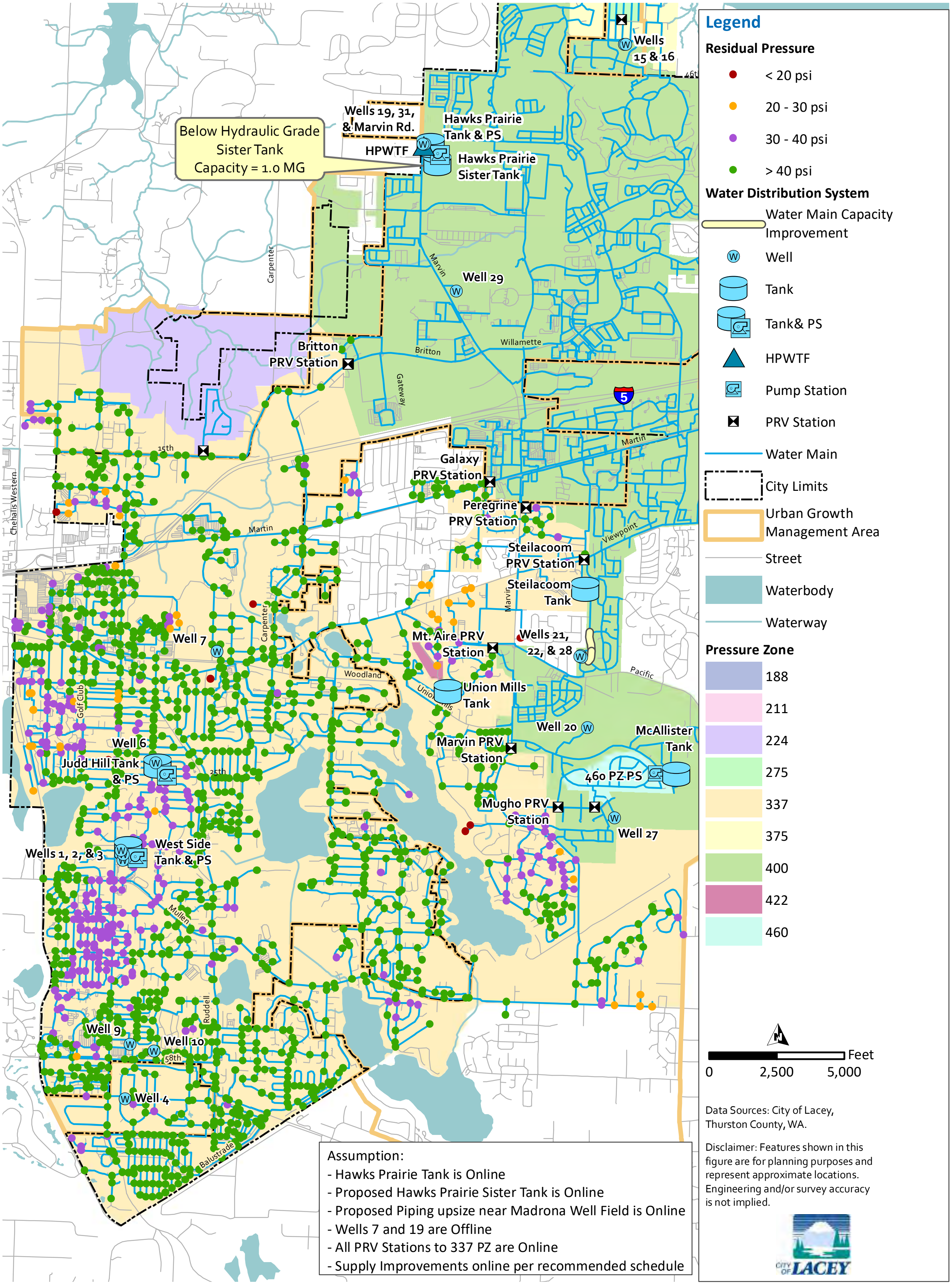


Figure 21 Residual Pressure under 2028 MDD plus Fire Flow Conditions - Baseline

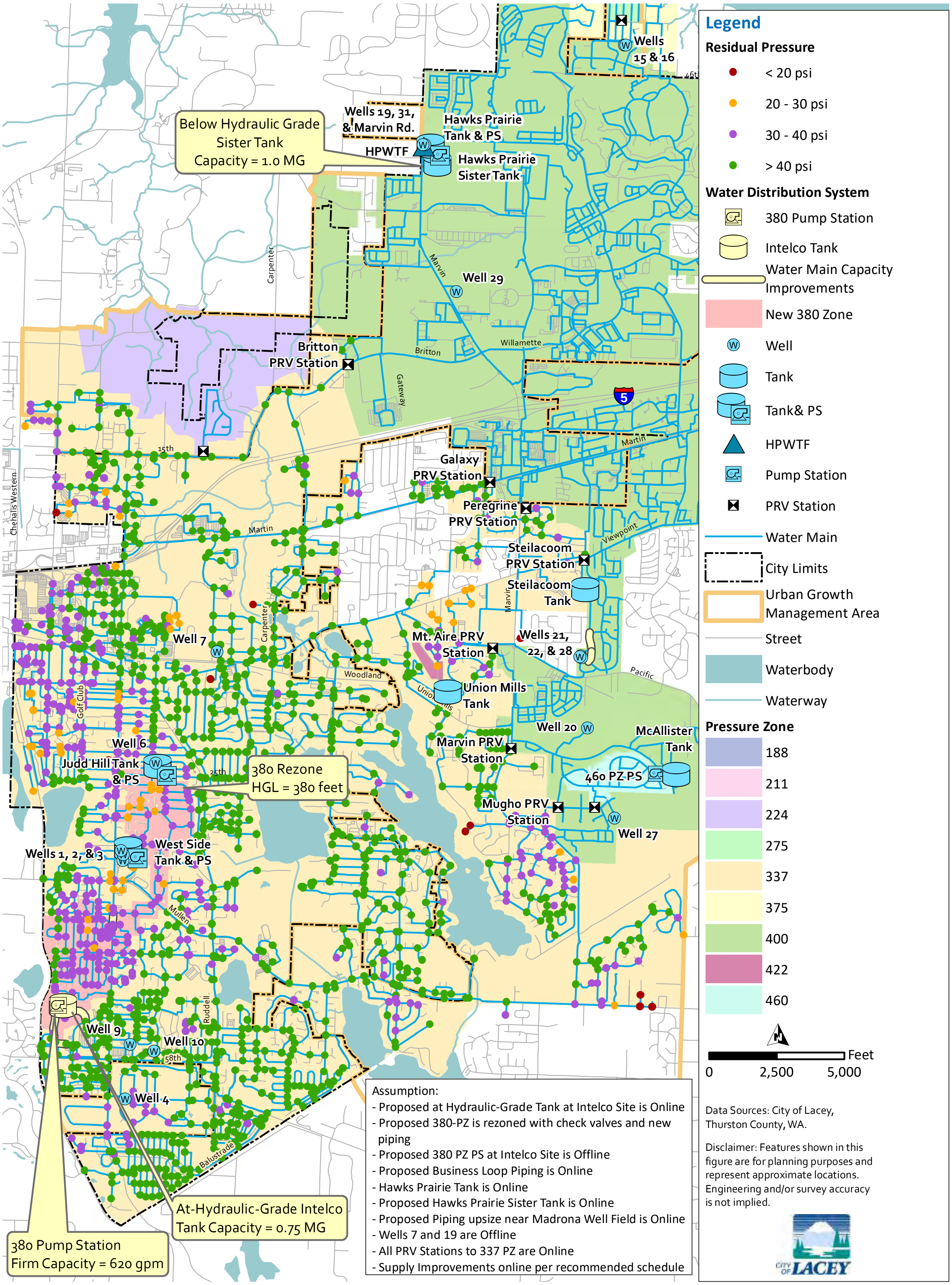


Figure 22 Residual Pressure under 2028 MDD plus Fire Flow Conditions - 337 PZ Alt. 1

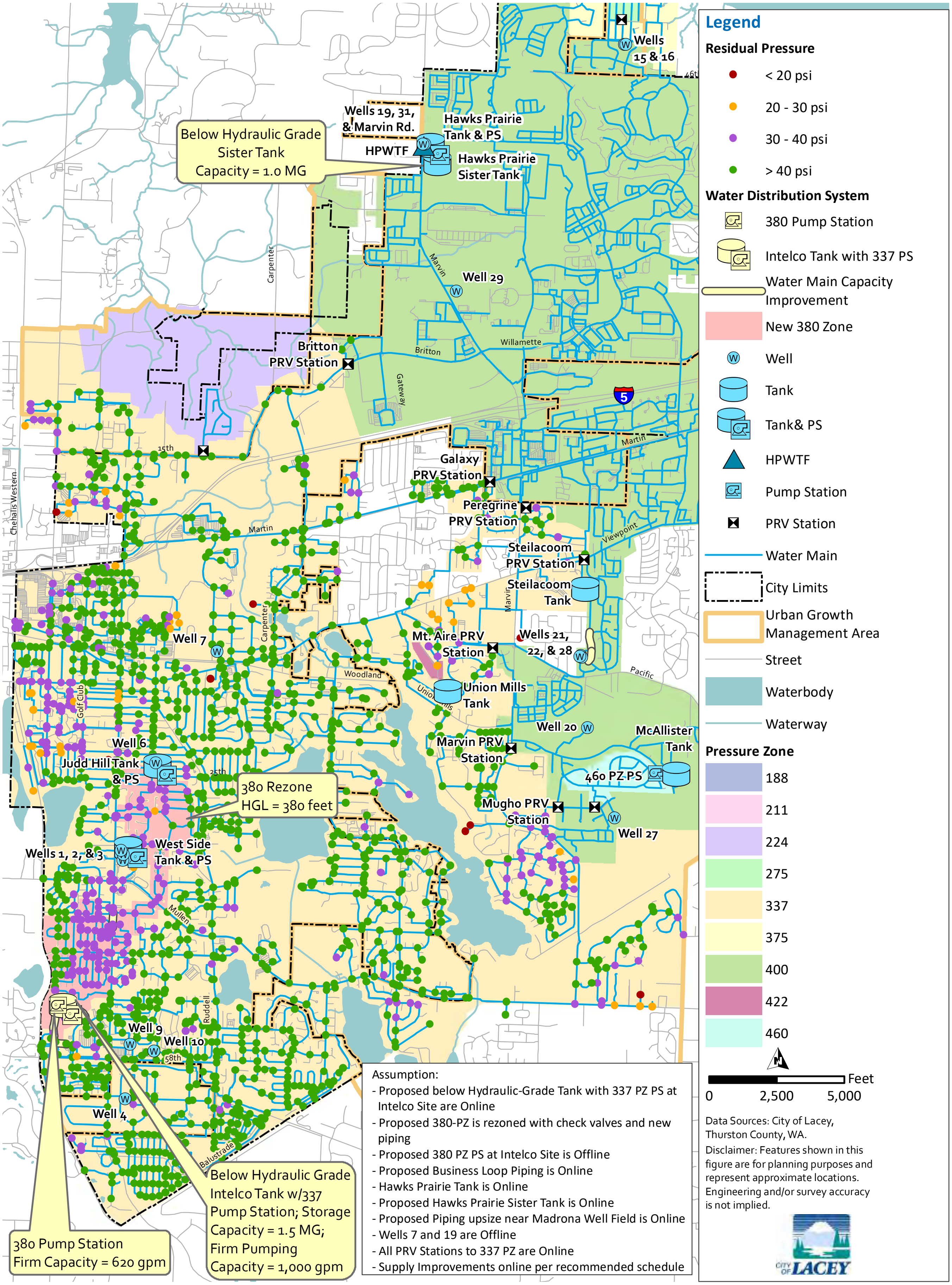


Figure 23 Residual Pressure under 2028 MDD plus Fire Flow Conditions - 337 PZ Alt. 2

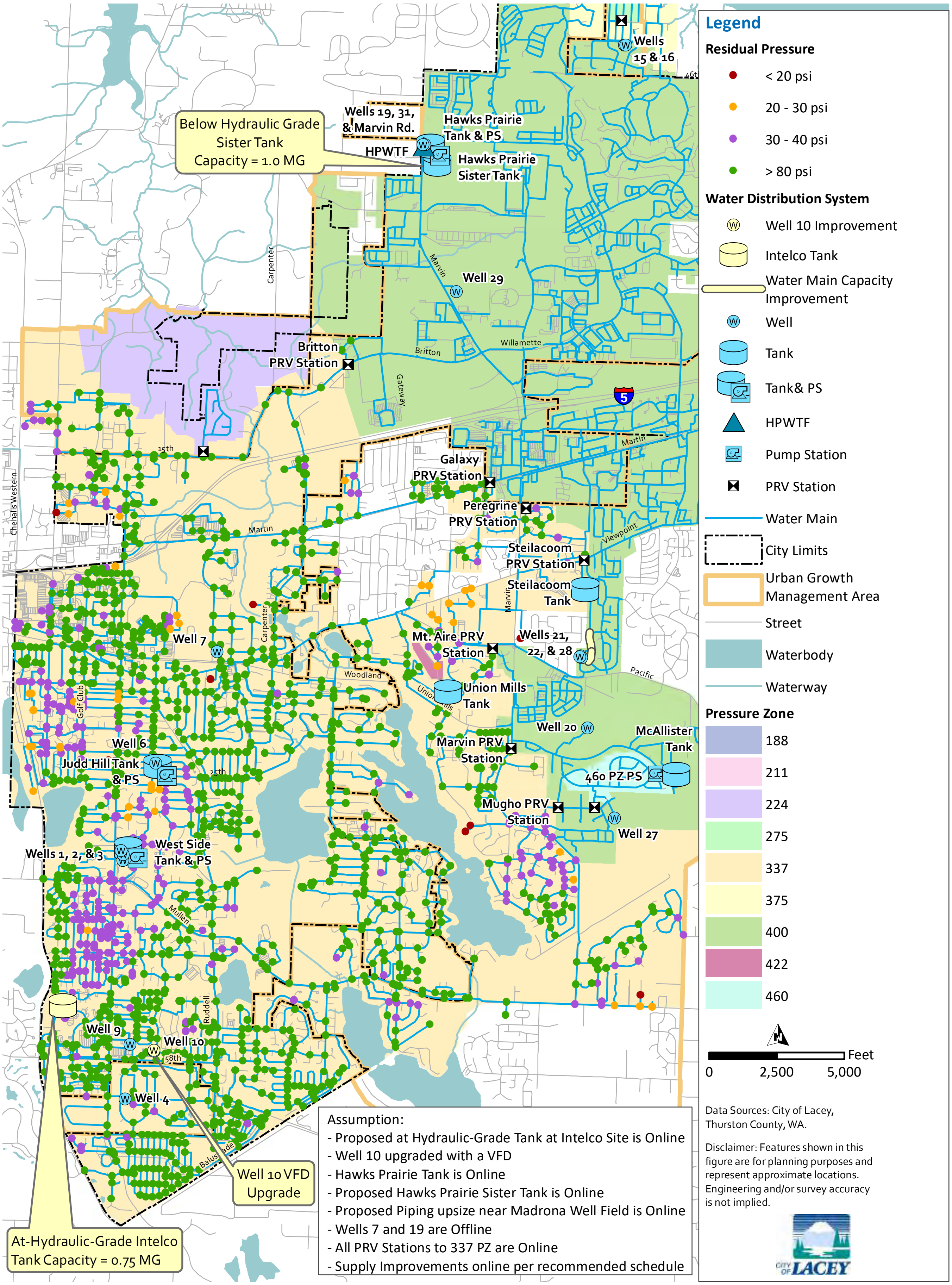


Figure 24 Residual Pressure under 2028 MDD plus Fire Flow Conditions - 337 PZ Alternative 3

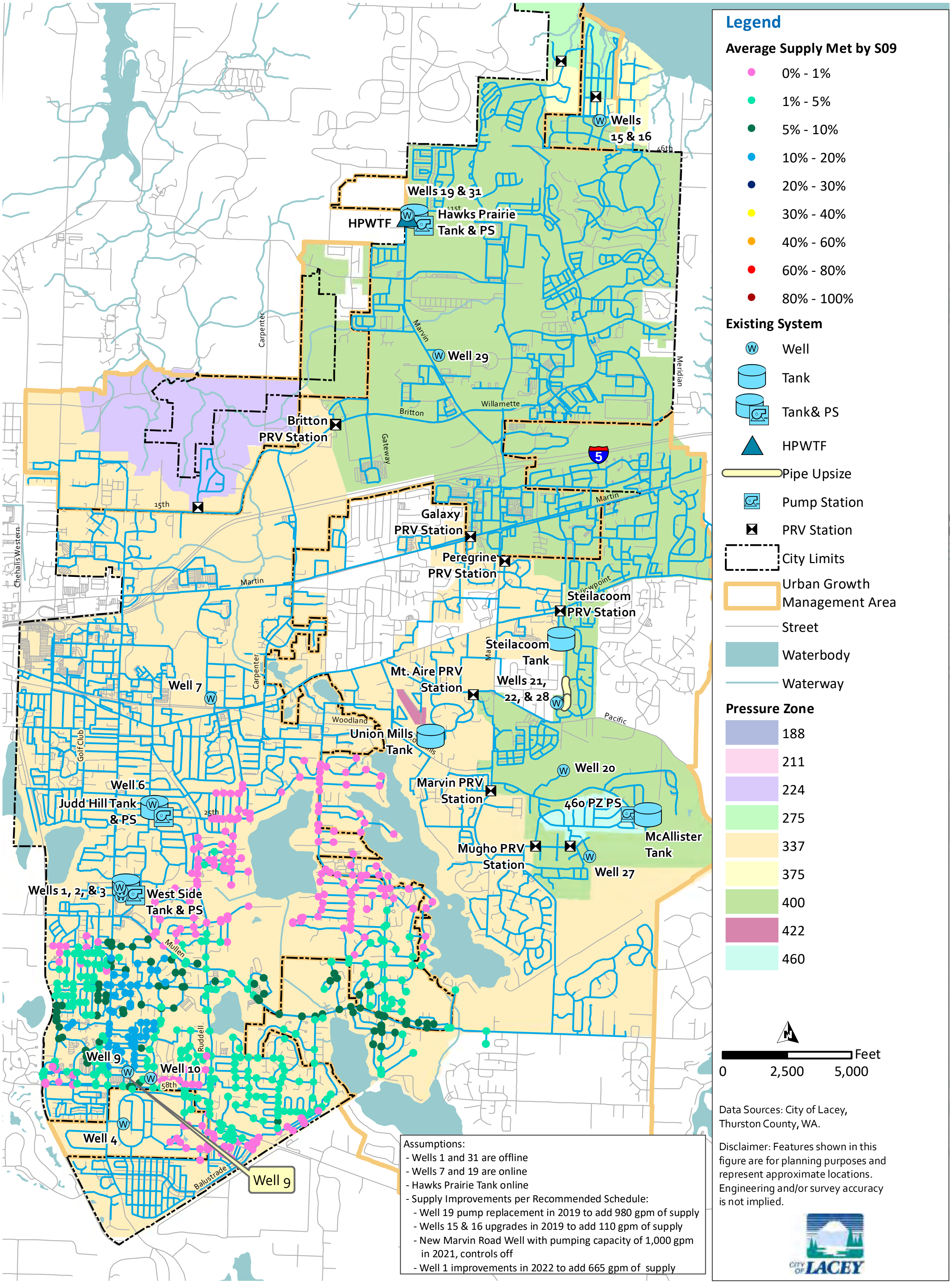


Figure 25 Average Supply Met by Well 9 under 2022 ADD Conditions - Baseline

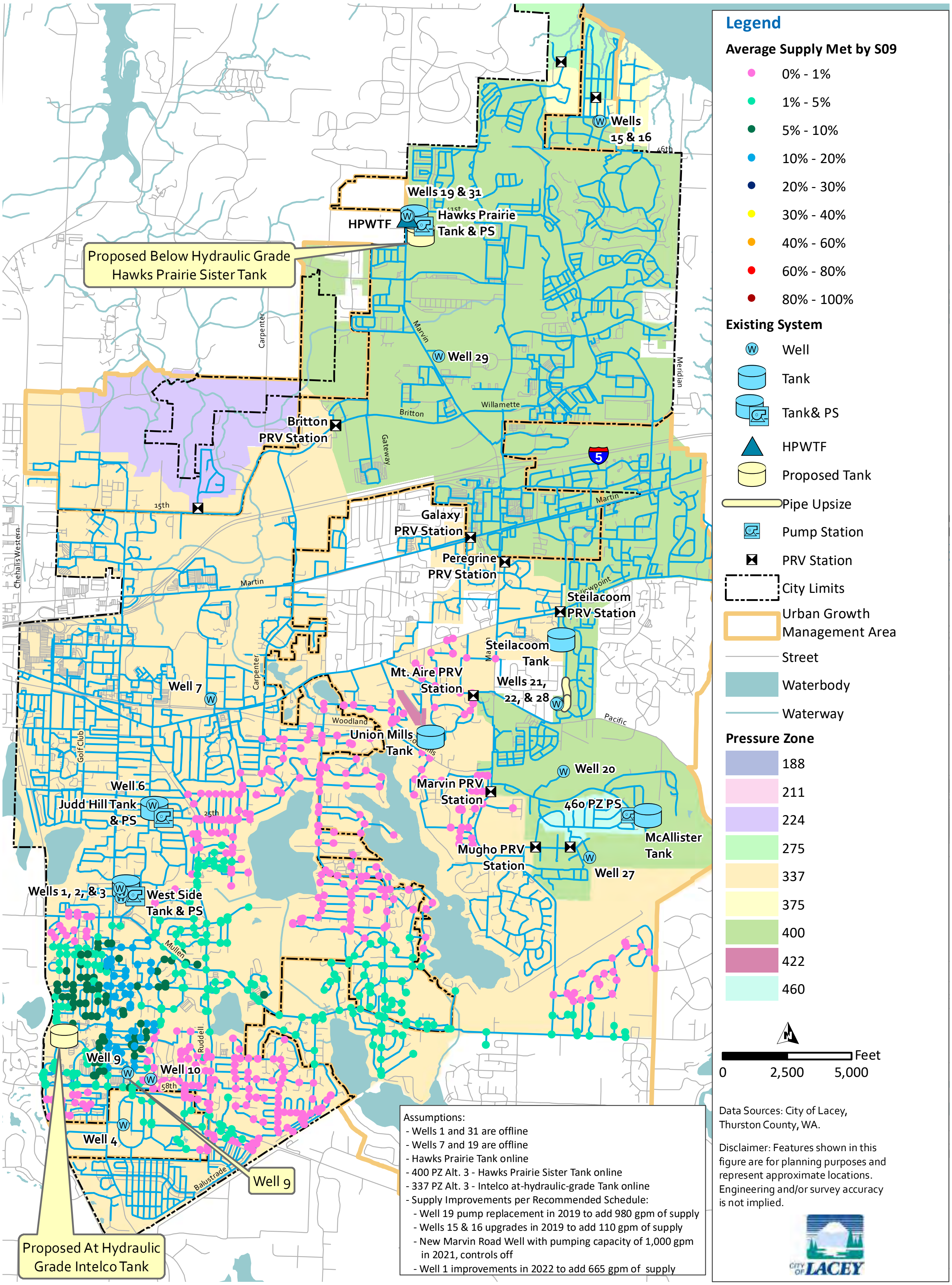
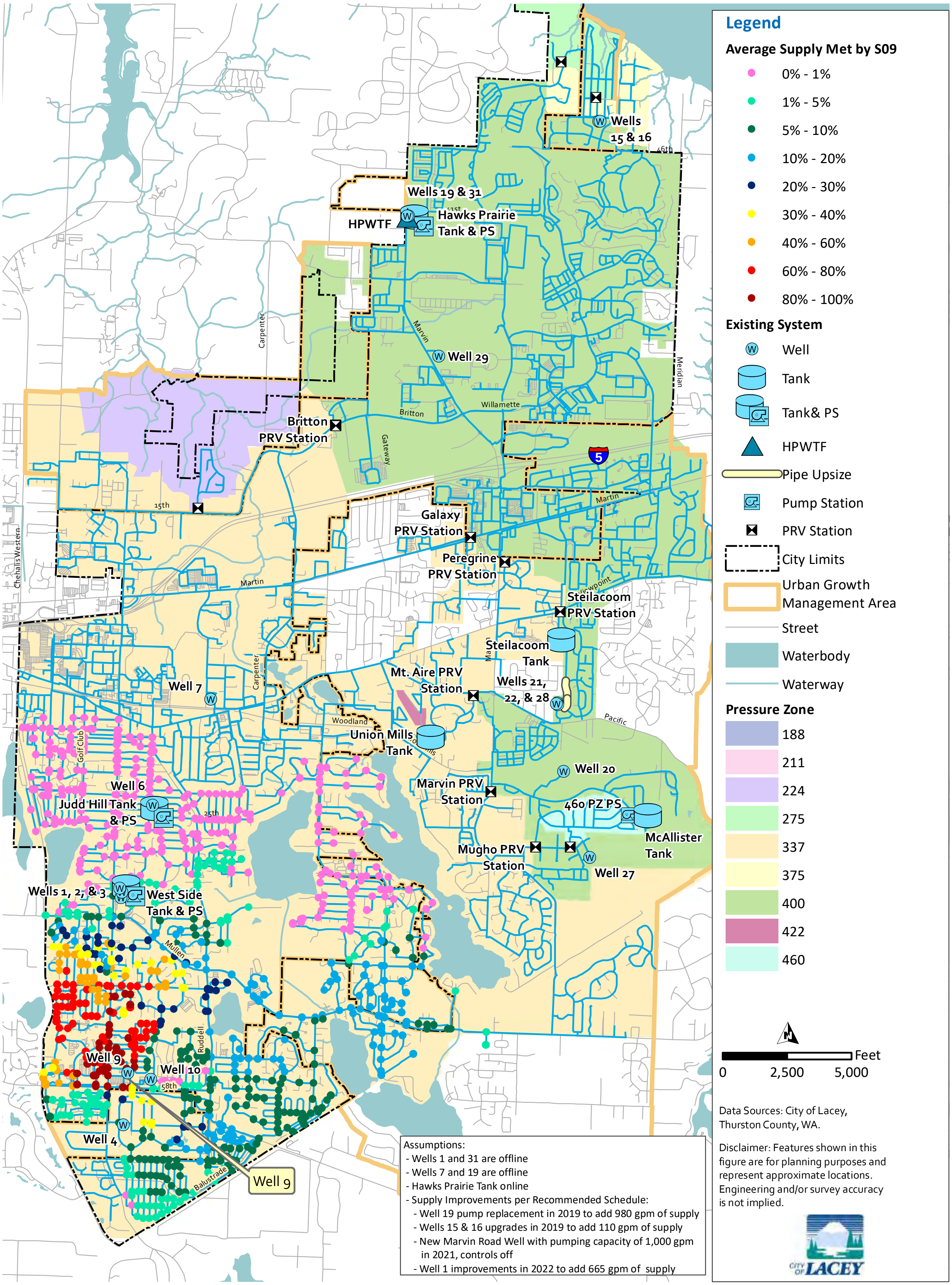


Figure 26 Average Supply Met by Well 9 under 2022 ADD Conditions - with HP Sister and Intelco Tanks



carollo

Figure 27 Average Supply Met by Well 9 under 2022 MDD Conditions - Baseline

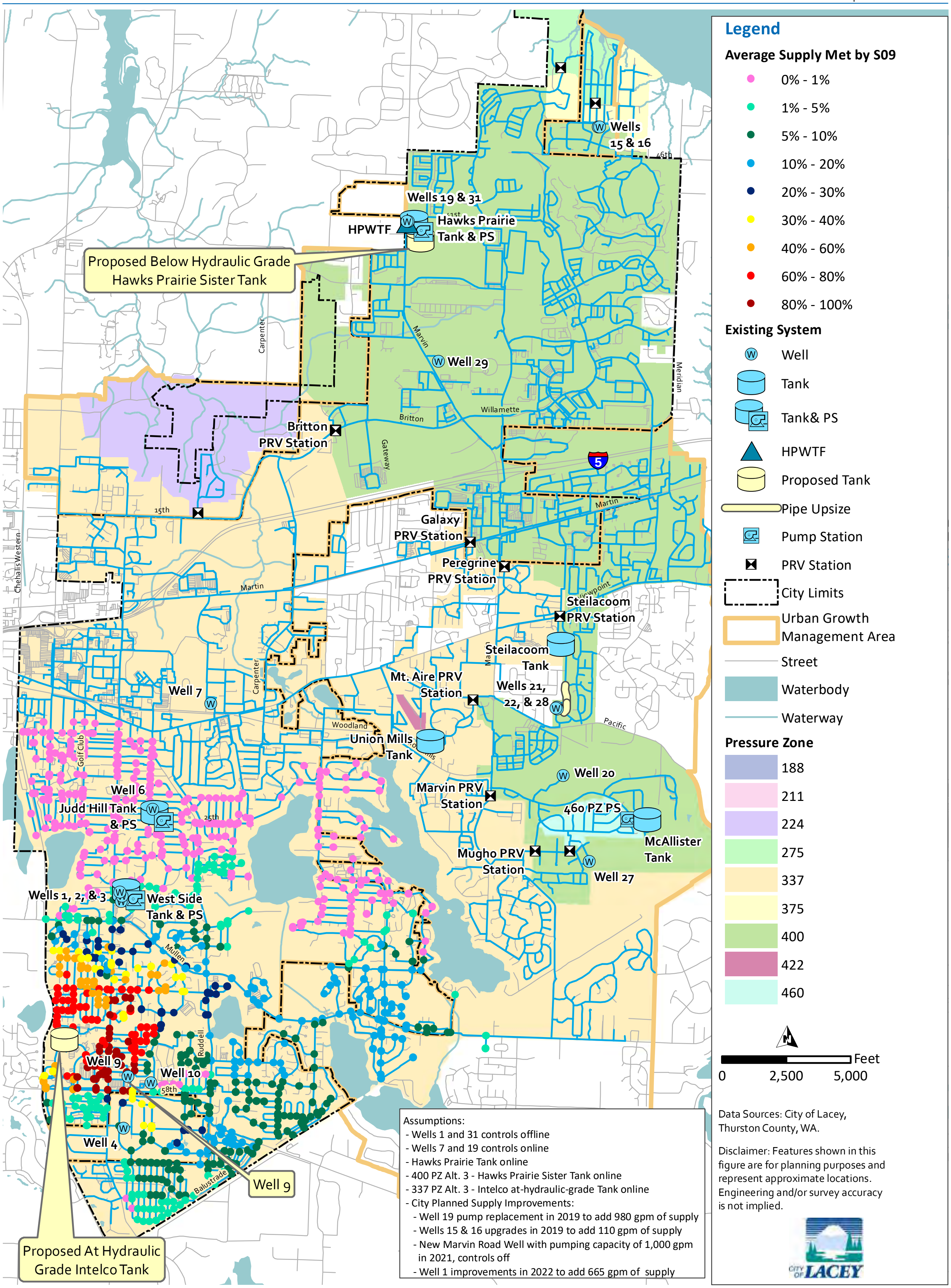
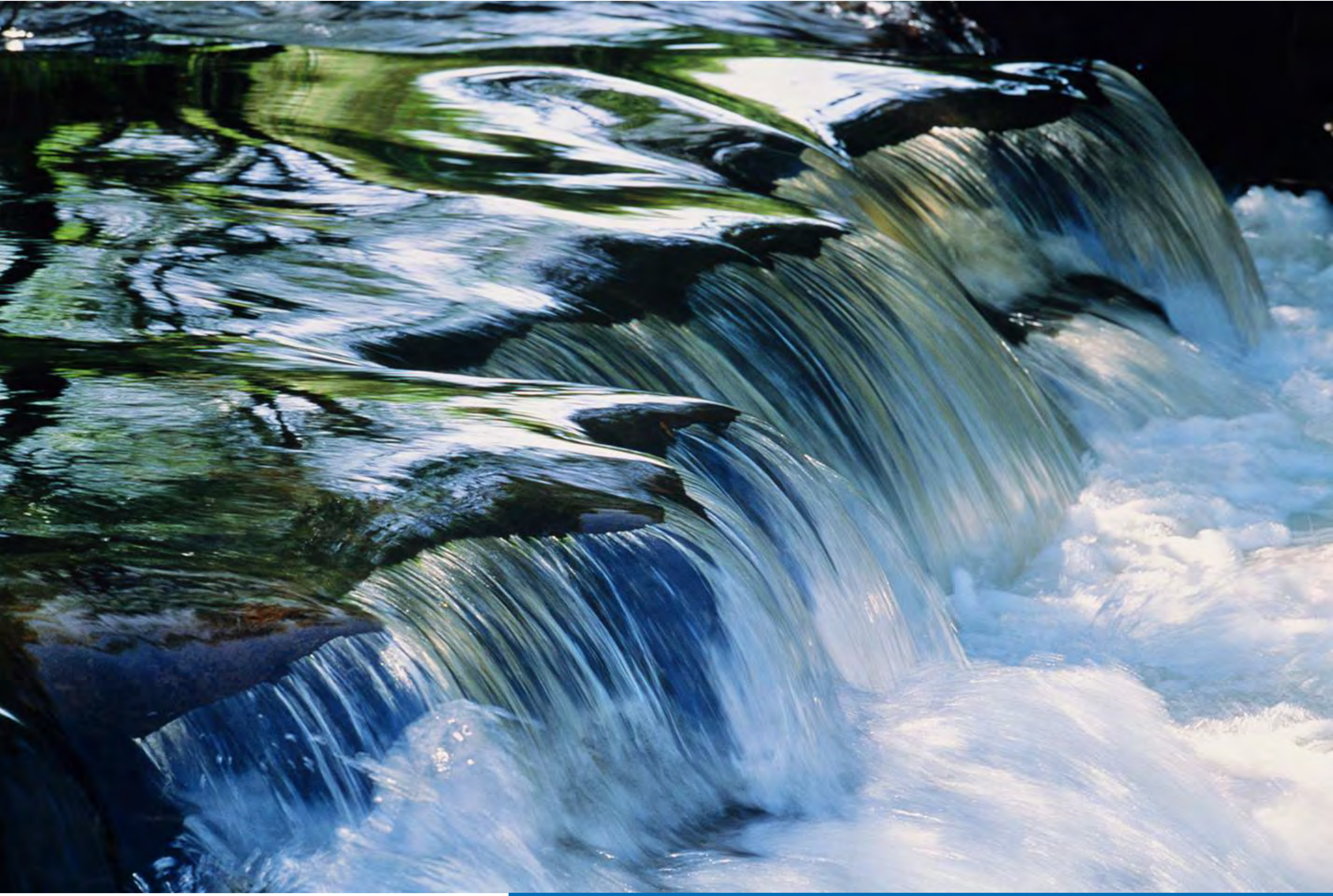


Figure 28 Average Supply Met by Well 9 under 2022 MDD Conditions - with HP Sister and Intelco Tanks

Appendix D

LACEY WATER MODEL



City of Lacey
337 Pressure Zone Facilities and Pressure, and 400 Pressure Zone Storage Studies

Report 1
400 PRESSURE ZONE STORAGE STUDY

FINAL | October 2018

CITY OF LACEY

City of Lacey
337 Pressure Zone Facilities and Pressure,
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REGISTERED
PROFESSIONAL ENGINEER

10/22/2018

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Abbreviations

AACE	American Academy of Cost Engineers
ADD	average day demand
AWWA	American Water Works Association
BPS	Booster pump station
Carollo	Carollo Engineers, Inc.
CIP	Capital Improvement Plan
City	City of Lacey
Comp Plan	Water System Comprehensive Plan Update, Feb 2013 from City
DOH	Washington State Department of Health
fps	feet per second
FTE	full time equivalent
gpm	gallons per minute
HGL	hydraulic-grade-line
hp	horsepower
HP Tank	Hawks Prairie Tank
HPWTF	Hawks Prairie Water Treatment Facility
I-5	Interstate 5
kWh	Kilowatt-hour
LF	Linear Feet
MDD	maximum day demand
MG	Million gallon
mgd	million gallons per day
O&M	operation and maintenance
PHD	peak hour demand
PRV	Pressure Reducing Valve
psi	pounds per square inch
PVC	Polyvinyl chloride
PZ	Pressure Zone
ROW	right-of-ways
SCADA	Supervisory Control And Data Acquisition
sf	square feet
TM	Technical Memorandum
VFD	variable frequency drive
WSDM	2009 Water System Design Manual
WTPO	Water Treatment Plant Operator

EXECUTIVE SUMMARY

ES.1 Introduction

The City of Lacey's (City) Hawks Prairie Tank (HP Tank) is located in the north end of the 400 pressure zone (PZ). The four million gallon (MG) Tank stores water for the entire distribution system, which shares water among the 400 and 337 PZs. The Tank is scheduled to be taken offline for maintenance and repair within the next 5 years for approximately six months in the summer season. During this time, the following improvements are needed for the City to maintain the minimum level of service to its customers:

- New supply sources to meet demand growth.
- Water storage to maintain required fire protection ability in the 400 PZ.
- Infrastructure improvements to maintain water pressures in the 400 PZ.

A study was conducted to explore alternatives that would allow the City to serve customers during peak demand and provide fire protection. This report summarizes the results of the study.

ES.2 Hydraulic Model Update

The City provided a calibrated hydraulic model that represented 2016 winter and summer conditions. Carollo Engineers, Inc. (Carollo) allocated future (4-year and 10-year) water demands to appropriate nodes in the hydraulic model. Carollo also added the nine planned pipeline improvement projects to the hydraulic model, listed below:

- College and 22nd Street.
- Capital City Golf Course Fire Flow Improvement.
- 2017 Waterline Replacement Project 2.
- Mullen Road Water Project.
- 48th Avenue and 50th Avenue NE (Beachcrest) Fire Flow Improvements.
- Impala Water Main Replacement.
- Oak Preserve Development.
- Gateway Development.
- Willamette Drive Velocity Improvements (long-term scenario).

ES.3 Supply Assumptions and Ability to Serve

To meet its current supply needs, the City uses groundwater wells. Additional supply sources for 400 PZ are needed to meet demand growth throughout the entire system. A high-level "supply and ability to serve evaluation" was performed to compare available supply in the next 10 years (2028) to projected demands. The evaluation used existing supplies and five planned water supply improvement projects:

1. Pump improvements at S19 and S31 going back online to add 980 gallons per minute (gpm) (1.41 million gallons per day [mgd]) of supply.

2. S15 / S16 upgrades in 2019 to add 110 gpm (0.16 mgd) of supply.
3. New Marvin Road Well with a pumping capacity of 1,000 gpm (1.44 mgd) in 2021. The increase in supply is 200 gpm (0.29 mgd) because the Hawks Prairie Water Treatment Facility (HPWTF) can only treat 1,800 gpm (2.59 mgd) of supply from S19, S31, and Marvin Road Well.
4. The replacement well for S01 will be in service in 2022 to add 665 gpm (0.96 mgd) of supply.
5. HPWTF expansion in 2028 will allow the full use of S19, S31, and Marvin Road Well water rights to add 800 gpm (1.15 mgd) of supply.

The evaluation found that in addition to the current and planned supplies, the City will need additional supply capacity by 2028. This finding underscores the importance of implementing the above planned system improvements, as well as developing new supplies. The City identified two new supply improvement projects to meet this deficit:

- 2022: Madrona Transmission Improvements to make full use of Madrona's full water rights.
- 2025: HPWTF expansion or Drill a new well next to S04.

Should the City not make the supply system improvements per the above schedule or demands vary from projections, the results will differ from those presented in this report.

ES.4 Preliminary System Analysis

This section summarizes the preliminary system analysis to understand the impact of taking Hawks Prairie offline from the distribution system and the level of service goals and criteria. The study evaluations used criteria consistent with the City's Water System Comprehensive Plan Update (Comp Plan) from February 2013 and Washington State's Department of Health (DOH) 2009 Water System Design Manual (WSDM).

ES.4.1 Storage Analysis

The 400 PZ has two storage tanks:

- HP Tank – available storage volume is 3.57 MG.
- McAllister Tank – available storage volume is 0.52 MG.

While the HP Tank is offline, the 400 PZ available storage will be reduced to 0.52 MG (McAllister Tank), which is not sufficient to meet the largest fire requirement in the PZ (0.96 MG). As a result, all alternatives developed increase available storage by approximately 1.0 MG to provide sufficient fire protection capacity and additional operational storage.

ES.4.2 Impact of Hawks Prairie Offline on Customers Pressures

The existing infrastructure cannot serve the customers without HP Tank online. The initial analysis showed that some locations in the northern area of the 400 PZ fell below 30 pounds per square inch (psi), the minimum level of service, when HP Tank was taken offline under summer 2016 conditions. This is due to a combination of lack of storage in the PZ and lack of transmission piping.

ES.5 Recommended Alternatives

Three alternatives were developed by Carollo to meet fire suppression storage and maintain minimum service pressures under 2022 peak hour demand (PHD), when the HP Tank is offline:

- Alternative 1 – Access existing storage volume through either a new pump station at the Steilacoom Tank or the McAllister Tank. Over 37,000 linear feet (LF) of transmission pipe upsize would be required to maintain pressure above 40 psi when Hawks Prairie is offline. In addition to this significant capital need, modeling showed that the system remains sensitive to changes in operation (wells turn off for instance) and would be difficult to operate. This alternative was not recommended.
- Alternative 2 – Construct a new 1 MG at-hydraulic-grade tank (elevated type) at existing Marvin Road well site, which is located next to the new school site. This alternative provides sufficient level of service to the customers when the HP Tank is offline and provides the 400 PZ with gravity storage (no pump) during emergencies.
- Alternative 3 – Construct a new 1 MG Sister Tank adjacent to the HP Tank on the existing site. The Sister Tank would have similar hydraulic characteristics as the existing HP Tank and would use the existing HP Tank pump station. Of all three alternatives, the Sister Tank option provides the highest level of service while the HP Tank is offline.

ES.6 Life-Cycle Costs and Capital Costs

The cost estimates developed in this report are American Academy of Cost Engineers (AACE). Class 4 estimates, which are planning-level estimates only and should be refined during pre-design.

The resulting costs for the three alternatives are shown below in Table 1. Detailed cost estimates for each alternative can be found in the Appendix B. Ranking for each alternative is also shown as described in the next section.

Table 1 Summary Costs

Costs	400 PZ Alternative 1	400 PZ Alternative 2	400 PZ Alternative 3
Capital Costs(1)	$21,164,900	$9,105,200	$6,444,600(6)
O&M(2) Costs(3)	$2,884,100	$2,300,800	$2,183,000
Total Capital and O&M(4)	**$24,049,000**	**$11,406,000**	**$8,627,600**
Ranking (Score)(5)	**1.2**	**3.0**	**4.4**

Notes:
(1) Capital costs are in 2022 dollars.
(2) O&M: operation and maintenance.
(3) O&M costs are inflated to the year in which the operation or maintenance is performed, over a 50-year period.
(4) Total costs rounded to the nearest $100.
(5) Weighted ranking from 1 (worst) to 5 (best) based on capital cost, water quality, timeline, and O&M.
(6) Costs based on 1.5 MG below-hydraulic-grade sister tank consistent with the Study's final recommendation.

ES.7 Alternatives Ranking

Each Alternative was ranked by Carollo and City Staff, for the period leading up to and during the HP Tank outage, based on capital cost, water quality, time line, and O&M. A weighted ranking was given for each criteria from 1 (worst) to 5 (best) and combined for a total Alternative ranking score. Receiving the highest score, Alternative 3 – Sister Tank, was recommended for implementation. The Sister Tank had the lowest cost and provided the highest level of service when the HP Tank is offline. Further, it was ranked highest among the alternatives for the period after the HP Tank outage, based on life cycle costs, water quality, and O&M.

To provide full fire suppression volume (0.96 MG) and operational volume, it is recommended that the Sister Tank be upsized to 1.5 MG.

Section 1
BACKGROUND

The City HP Tank is located in the north end of the 400 PZ. The four MG tank stores water for the entire distribution system, which shares water among the 400 and 337 PZ's. Figure 1 shows the study area for the report.

The HP Tank is scheduled to be taken offline for maintenance and upgrades in the near-term for approximately six months in the summer. While this occurs, the City has to be able to maintain the minimum level of service to its customers.

Hydraulic modeling was performed on the distribution system. According to this modeling, the distribution system will not be able to serve the customers in the north end of the 400 PZ during peak demand or provide fire protection while the HP Tank is offline.

To ensure the City can meet its service goals, a PZ study was conducted to explore alternatives that would allow the City to serve customers during peak demand and provide fire protection. This report summarizes the results of this study and provides information on the following:

- Evaluation criteria for the study.
- Description of alternatives.
- Results of a hydraulic analysis of alternatives.
- Recommended alternative to serve customers.

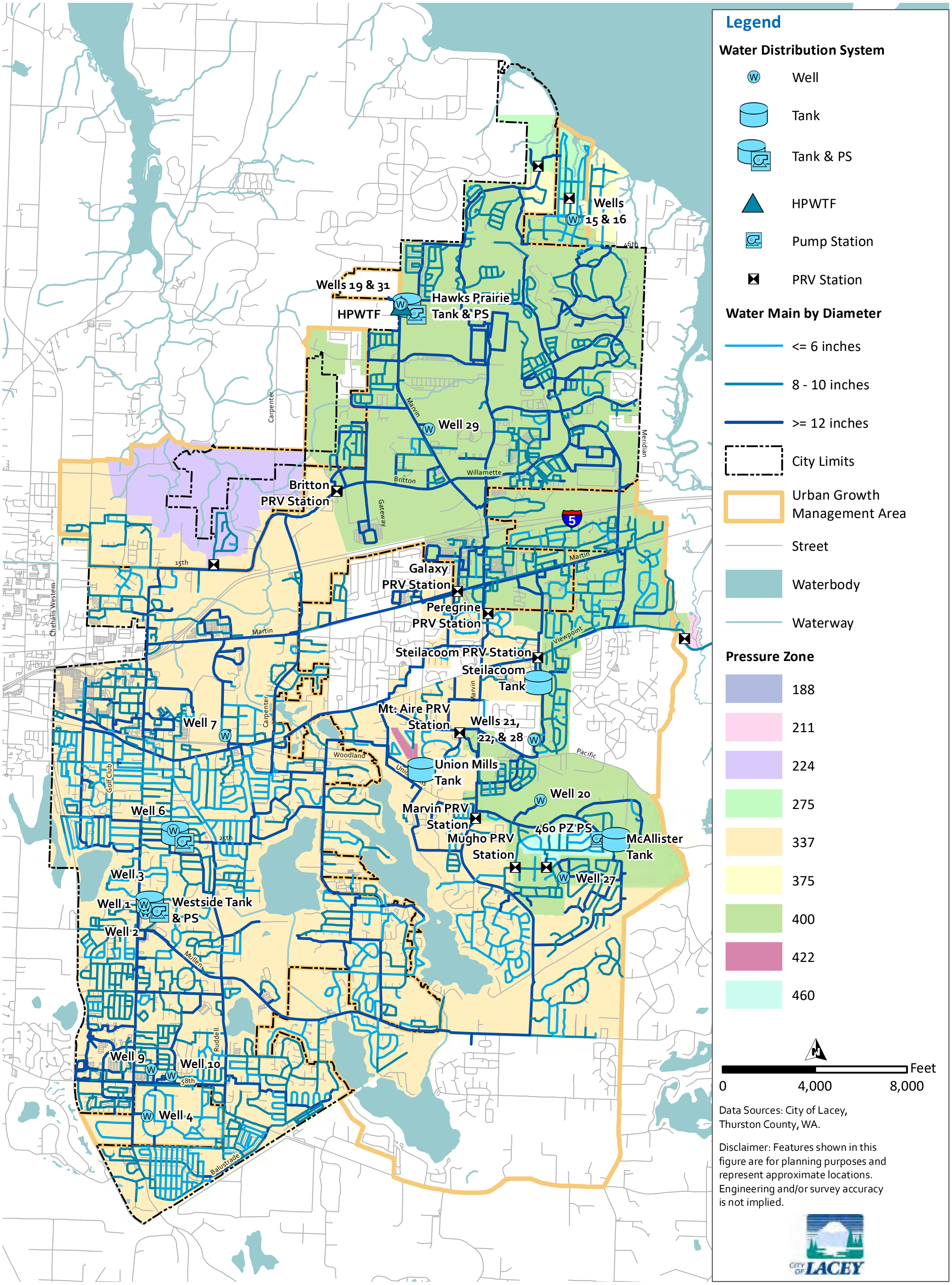

Figure 1 Study Area

Section 2

SUPPLY ASSUMPTIONS AND ABILITY TO SERVE

A high-level "supply and ability to serve evaluation" was performed at the beginning of the project. The following sections describe the results from this evaluation and present recommended improvements to the infrastructure to mitigate future supply deficiencies.

2.1 Demands

System-wide demands were reviewed from the Comp Plan. For this study, no new demand forecasts were completed. Figure 2 compares projected system-wide average day demand (ADD) with historical consumption data from 2009 through 2017. As shown, the rate of demand increased similarly.

However, historical demands were approximately 0.8 mgd below projected demands; the 2017 ADD was roughly equivalent to the projected 2012 ADD. As a result, the projected demands were "scaled down" to match historical consumption, as shown in Figure 2, effectively shifting demands five years into the future. For example, the Comp Plan's 2023 demands were considered the 2028 demands for this Study.

Table 2 shows updated ADD and maximum day demand (MDD) for 2017, near-term (2022), and long-term (2028) planning periods. The MDD to ADD peaking factor of 2.2 and PHD to MDD peaking factor of 1.6 were both unchanged from the Comp Plan.

Carollo recommends that the City update its demand projections during its upcoming Water System Plan Update. Although the Study's scaled down demands are adequate for conceptual level hydraulic modeling in this study, they should not be used for water rights, supply timing, or storage facility sizing.

Table 2 Summary of Projected Demands

Year	ADD		MDD	
	(mgd)	(gpm)	(mgd)	(gpm)
2017	7.43	5,200	16.34	11,300
2022	8.25	5,700	18.15	12,600
2028	9.14	6,300	20.12	14,000

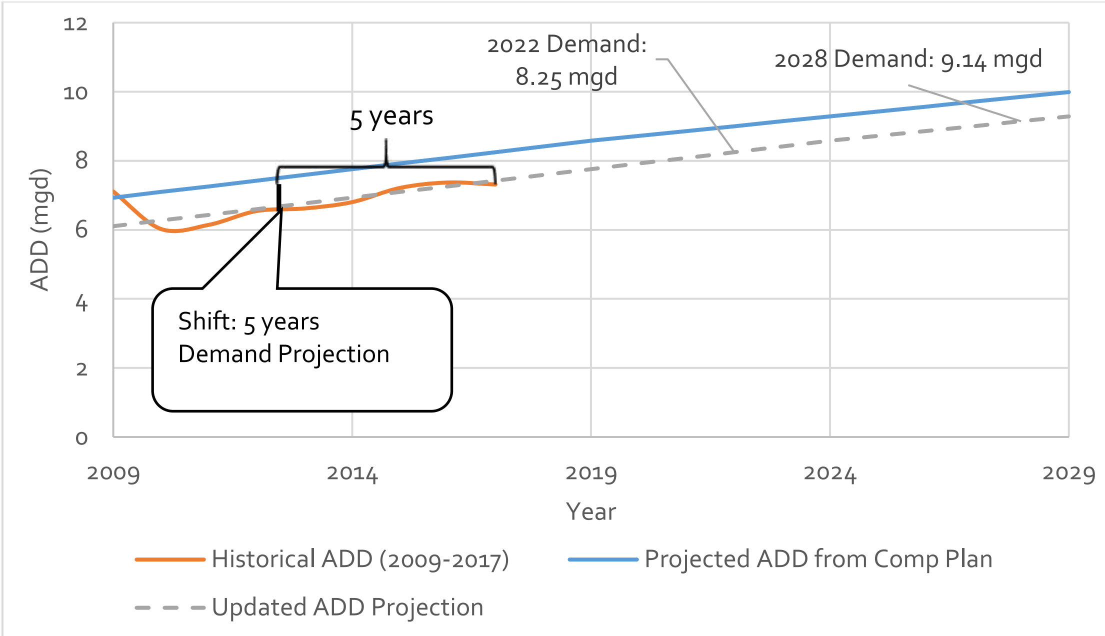

Figure 2 Adjusted Demand Projections

2.2 Ability to Serve Requirements

To meet its current supply needs, the City uses groundwater. The analysis described in this section evaluated the City's groundwater wells "ability to serve," a measurement commonly used for long-term planning.

"Ability to serve" is the maximum water a source can produce given the following limitations:

- Water Rights: The maximum water rights available.
- Pumping Capacity: Pumping capacity for each individual well, according to the City.
- Treatment Capacity: Total treatment capacity for each well.
- Operational/ Seasonal Limitations: Limitations on supply use due to seasonal variations in available supply or operational requirements.

Table 3 shows all of the City's groundwater wells "abilities to serve" taking into account the limitations described above.

Table 3 Wells Ability to Serve

Well No.	Pressure Zone	Ability to Serve (gpm)	Ability to Serve (mgd)
S01	337 PZ	0	0.00
S02	337 PZ	500	0.72
S03	337 PZ	206	0.30
S04	337 PZ	750	1.08
S06	337 PZ	290	0.42
S07	337 PZ	1,800	2.59
S09	337 PZ	730	1.05
S10	337 PZ	1030	1.48
S15	400 PZ	190	0.27

Table 4 Wells Ability to Serve

Well No.	Pressure Zone	Ability to Serve (gpm)	Ability to Serve (mgd)
S16	400 PZ	220	0.32
S19	400 PZ	620	0.89
S20	400 PZ	580	0.84
S21	400 PZ	1,350	1.94
S22	400 PZ	1,350	1.94
S24	188 PZ	80	0.12
S25	188 PZ	160	0.23
S27	400 PZ	1,000	1.44
S28	400 PZ	1,350	1.94
S29	400 PZ	1,000	1.44
S31	400 PZ	0	0.00

To estimate future supply needs and recommend supply improvements, the "ability to serve" was compared to the near-term and long-term MDD demands listed in Section 2.2. Carollo recommends updating this evaluation after the demand projections are updated in the new Water System Plan Update.

2.3 "Ability to Serve" Analysis

For this analysis, criteria were developed that consider the firm supply capacity, or "redundancy." Firm capacity is the MDD with the largest source out of service, in this case Well S7.

Operational criteria were also used in the analysis to measure the system's capacity to provide water with a commonly out of service well in addition to the largest source out of service. In this case, the commonly out-of-service supply source is Well S19.

According to the analysis, the City can supply approximately 13,206 gpm (19.01 mgd). When the redundancy and operation criteria were applied to the analysis, however, the City's "ability to serve" was approximately 10,786 gpm (15.53 mgd).

2.3.1 Planned Supply Improvements

To meet future demands and provide additional redundancy and operational flexibility, the City planned for five water supply improvement projects in its Capital Improvement Plan (CIP):

1. Pump improvements at S19 and S31 going back online to add 980 gpm (1.41 mgd) of supply.
2. S15/S16 upgrades in 2019 to add 110 gpm (0.16 mgd) of supply.
3. New Marvin Road Well with a pumping capacity of 1,000 gpm (1.44 mgd) in 2021. The increase in supply is 200 gpm (0.29 mgd) because the HPWTF can only treat 1,800 gpm (2.59 mgd) of supply from S19, S31, and Marvin Road Well.
4. The replacement well for S01 will be in service in 2022 to add 665 gpm (0.96 mgd) of supply.
5. HPWTF expansion in 2028 will allow the full use of S19, S31, and Marvin Road Well water rights to add 800 gpm (1.15 mgd) of supply.

Figure 3 shows the locations of these supply improvements.

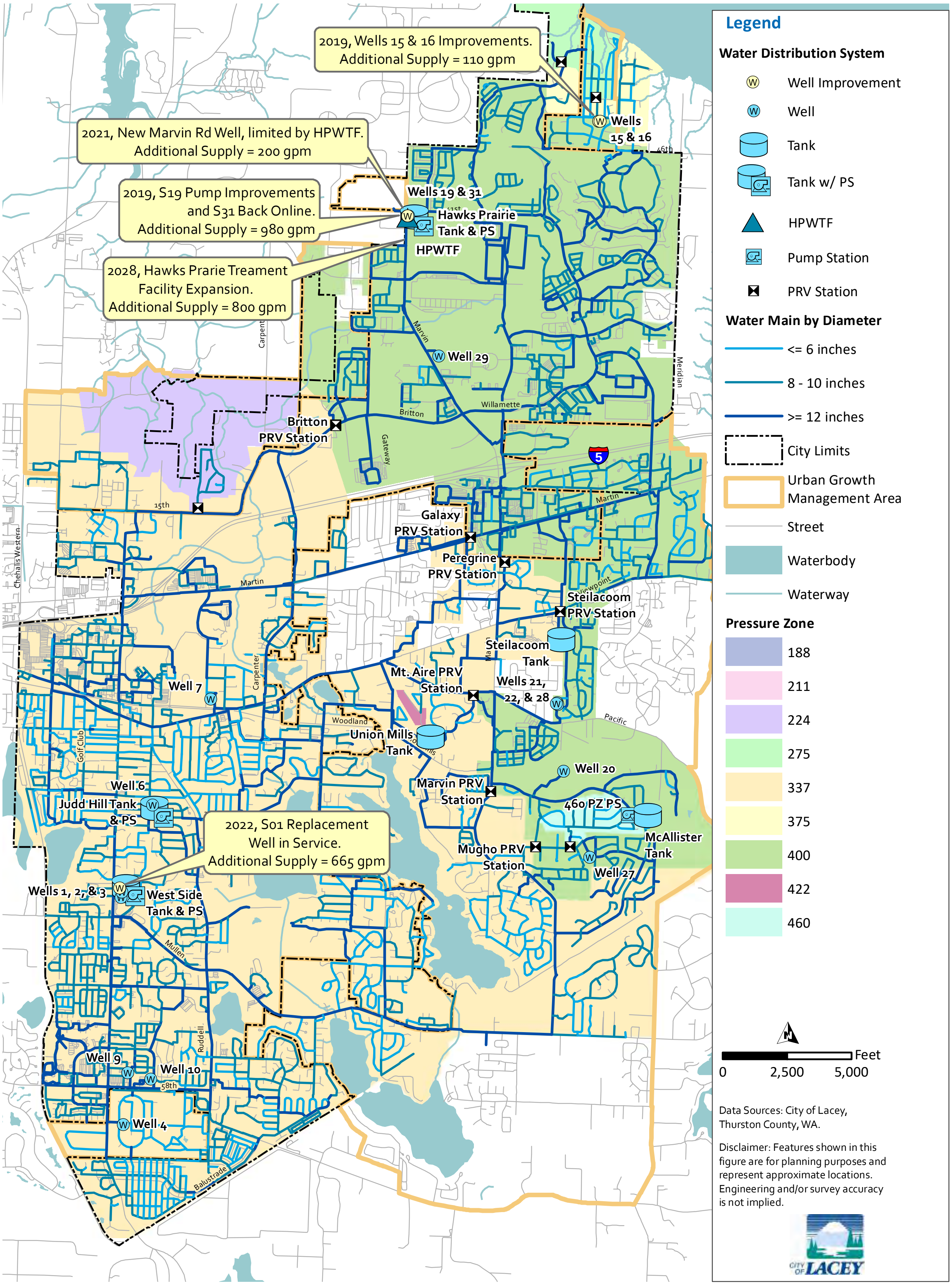

Figure 3 Planned Supply Improvements

2.3.2 "Ability to Serve" with Planned Projects Improvements

Figure 4 compares the City's "ability to serve" with the supply improvements already planned for the established criteria and MDD projections. If all planned improvements are implemented, the City will have sufficient supply in the near-term with all supplies online. To meet both redundancy and operational criteria by 2028, the City will need an additional 0.78 mgd (539 gpm) of supply capacity.

This finding underscores the importance of implementing planned supply improvements in Section 2.3.1, as well as developing new supplies. Note, should City not make the supply improvements or demands vary from projections, then results will differ from those presented in this report.

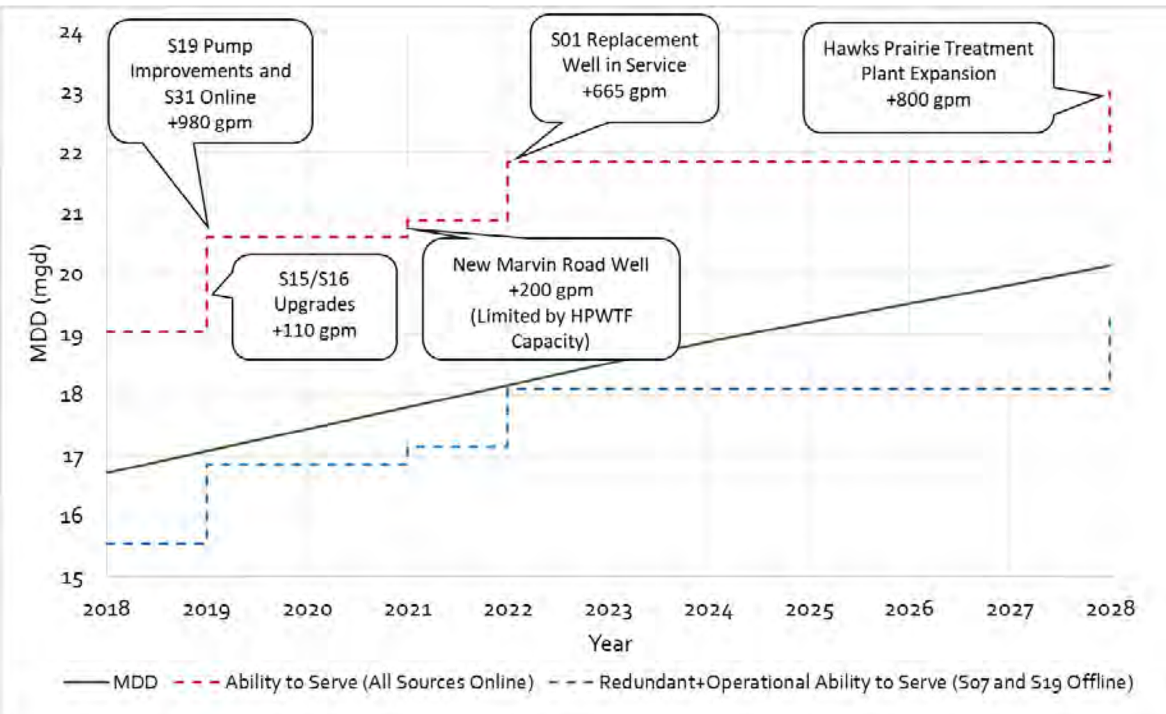

Figure 4 Ability to Serve with Planned Supply Improvements

2.3.3 Additional Supply Improvements to meet Demands

As the "ability to serve" analysis shows, the City will need more supply than just the already planned supply projects. The City identified the four (4) supply improvement options that are presented below. Each project was qualitatively evaluated and ranked in a workshop setting with City staff based on available information. The hydraulic modeling was used to confirm the distribution system had sufficient capacity for the supply projects and where necessary improvements are recommended. Two supply projects will be sufficient to meet the Redundant and Operational ability to serve deficiency through 2028. The remaining supplies should be considered for long-term supplies after the study period:

1. **Make full use of Madrona's full water rights**. This option would make improvements to the distribution system to convey additional flow without upgrading pumps or treatment. This option would utilize the full water rights and increase supply from the well field by 748 gpm. Hydraulic modeling indicates that the full use of Madrona can be achieved during both 2022 and 2028 MDD by upsizing 1,100 feet of distribution main. Note that, during lower demand conditions, the Madrona wells may not be able to produce their full water right because of limitations in overall distribution. City staff preferred this project, mainly because of cost and operational reasons**.**
2. **Drill a new well next to S04**. Drill a new well next to S04. The new well is anticipated to have a yield of 1,350 gpm. The combined yield of the existing 750 gpm well and new well is anticipated to be 2,100 gpm. Existing treatment facilities can treat the additional yield without modification. The City is considering installing the new well after the area is sewered. City staff anticipates that septic-to-sewer conversions will occur within ten years; therefore, the additional well may not available until the end of the planning period. Of the four improvements, City staff deemed this one their second best.
3. **Add treatment to S09**. By adding treatment for iron, manganese, and ammonia, a total of 1,300 gpm of supply will be available from S09, an increase of 570 gpm of supply from the existing 730 gpm ability to serve. This option is less preferred, since it would require adding a new treatment facility at a new site and acquiring land.
4. **Develop a new well near the Meridian Campus with a yield of 800 gpm**. The well will be drilled in the TQu aquifer and tests indicate the presence of iron, manganese, ammonia, and sulfides. The City proposes to drill the well in the Meridian Campus Park. This option is the least preferred because it will require treatment.

2.3.4 "Ability to Serve" Improvements and Timing

Timing for the supply projects are recommended to be:

- 2022: Madrona Transmission Improvements (1. Make full use of Madrona's full water rights).
- 2025: HPWTF expansion (Planned improvement 5 in Section 2.3.1) or Drill a new well next to S04.

The Madrona Transmission Improvements and HPWTF expansion in 2025 provides sufficient Redundant and Operational ability to serve, as shown in Figure 5. This would require the City to move up planned improvements from 2028 to 2025 to meet the Redundant and Operational ability to serve throughout the planning period.

If the City does not implement the HPWTF expansion in 2025, then it could consider drilling a new well next to S04 in 2025 to provide more than sufficient Redundant and Operational ability to serve through 2028, as shown in Figure 6. The HPWTF expansion could then be implemented as planned in 2028 or delayed for beyond 2028.

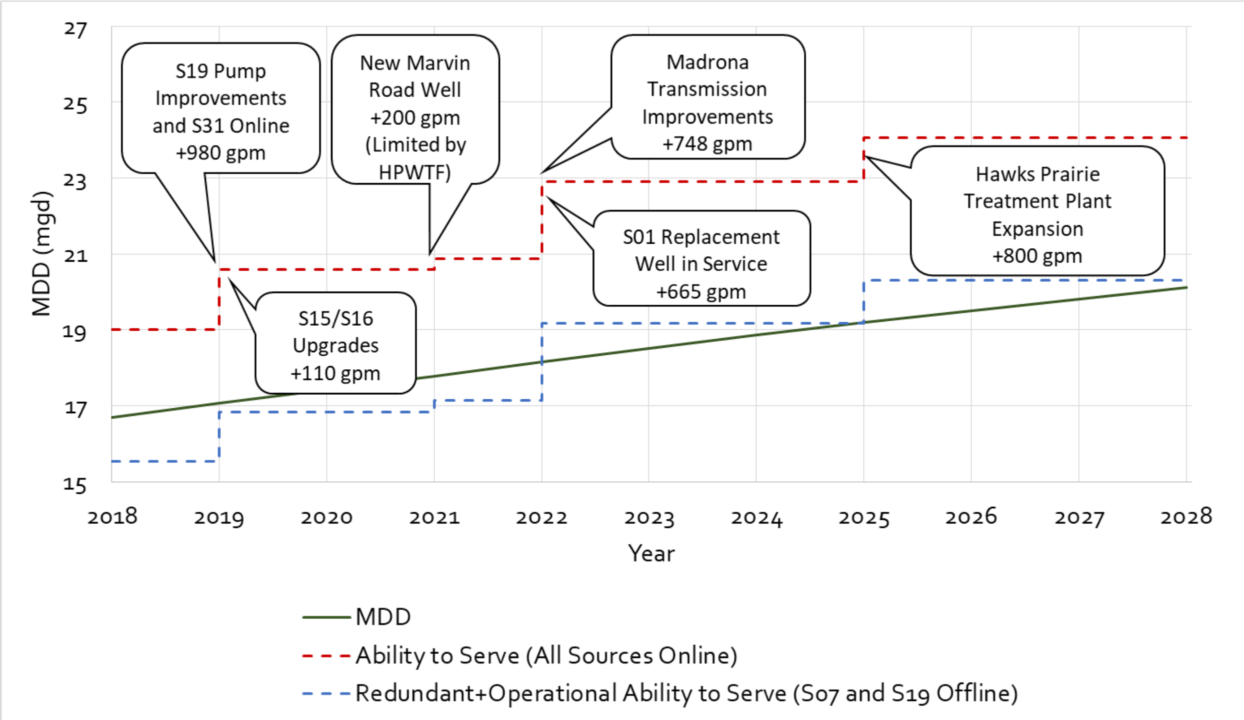

Figure 5 Ability to Serve with Planned Supply Improvements, Madrona Transmission Improvements and HPWTF Expansion

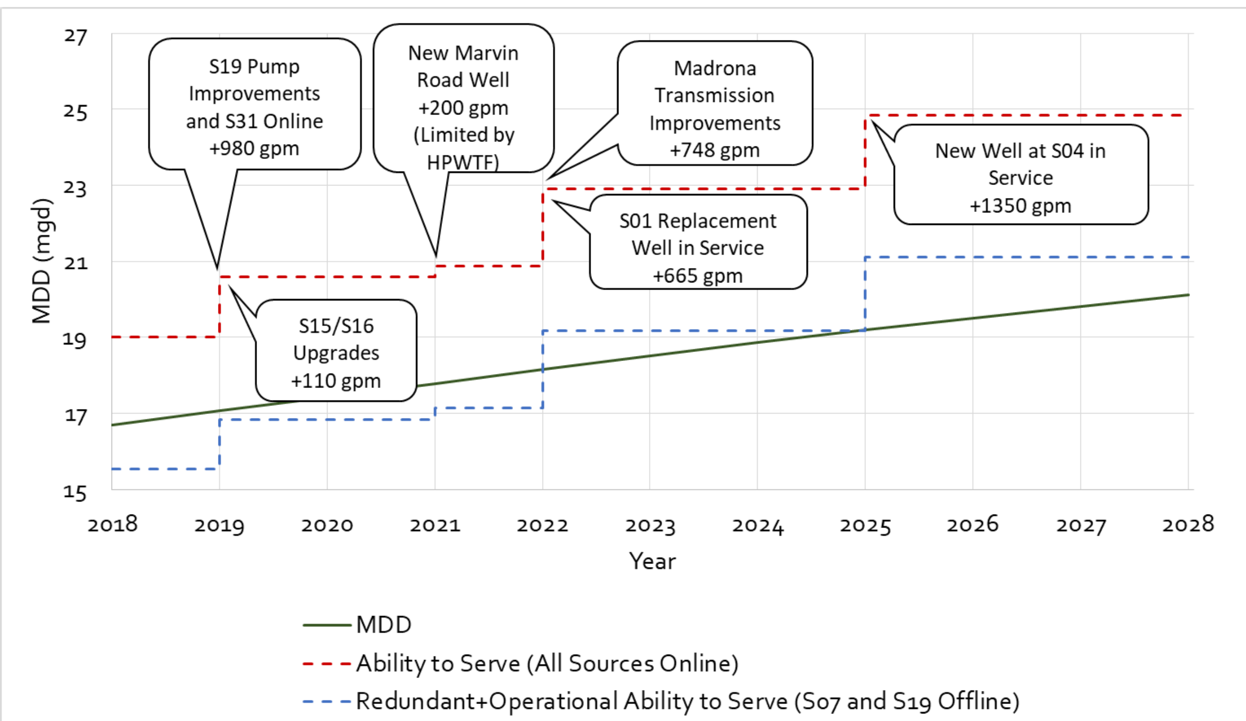

Figure 6 Ability to Serve with Planned Supply Improvements, Madrona Transmission Improvements, and a new well at S04

Section 3

HYDRAULIC MODEL UPDATE

The hydraulic model was updated to include near-term (2022) and long-term (2028) demands, fire flows, planned distribution improvements, and future supply projects.

3.1 Demands

Future water demands were allocated to appropriate nodes in the hydraulic model. The City's existing summer 2016 model demands correspond to the average summer demands based on customer's data, as initially provided by the City. MDD demand corresponds to the highest day in the year, and is therefore higher than the summer 2016. Summer 2016 demands are between ADD and MDD.

Additional projected ADDs were also allocated to the hydraulic model to match the demands shown in Table 2 for planning years 2022 and 2028. The existing 2017 ADD, shown in Table 2, were allocated using a combination of land use information, vacant land information, loading polygons, and planned development information. City-provided demands associated with planned developments were manually entered into the model based on the number of residential units planned.

The remaining demands were allocated using loading polygons and vacant parcels and were allocated to all vacant land and weighted based on area. Future MDDs were developed by scaling their respective years' ADD with the MDD/ADD peaking factor of 2.2. Future ADD and MDD diurnals used the existing summer 2016 diurnal patterns used to perform extended period simulations in the hydraulic model.

3.2 Planned System Improvements

The City provided information on planned pipeline improvement projects. The model was updated with these improvement projects based on near- and long-term timing. The following projects were incorporated into the hydraulic model's near-term scenarios:

- College and 22nd Street.
- Capital City Golf Course Fire Flow Improvement.
- 2017 Waterline Replacement Project 2.
- Mullen Road Water Project.
- 48th Avenue and 50th Avenue NE (Beachcrest) Fire Flow Improvements.
- Impala Water Main Replacement.
- Oak Preserve Development.
- Gateway Development.
- Willamette Drive Velocity Improvements (long-term scenario).

3.3 Planned Supply Projects

The City planned water supply improvements to meet future demands and provide additional redundancy and operational flexibility. The hydraulic model was updated to include the planned supply improvements discussed in Section 2.3 and shown on Figure 3. See Appendix A for information on how the planned supply improvements were operated in the hydraulic model.

Section 4

EVALUATION CRITERIA

This section presents the evaluation criteria used to evaluate the distribution system and to size future water system infrastructure. The developed criteria address storage capacity, acceptable service pressures, and the distribution system performance. The Comp Plan and DOH WSDM were used to help develop evaluation criteria.

4.1 Model Simulations

Using the update, the following simulations of each alternative were modeled in the near- and long-term planning period (a total of 18 model simulations, see Appendix C):

1. MDD plus Fire Flows.
2. Extended Period Simulation of PHD.
3. Extended Period Simulation of ADD.

4.2 Water Storage Requirements

The City's storage tank volume requirements are divided into four separate categories:

1. Operating Storage.
2. Equalizing Storage.
3. Fire Fighting Storage.
4. Standby Storage.

Tanks may include a "dead storage", which is the volume in a tank not available to the system. This volume is usually caused by high elevations served by the tank and required minimum pressures to provide to the customers in the zone.

For this analysis, criteria and results from the Comp Plan were used and checked against adjusted demands from Section 3.1. A comprehensive storage analysis was not performed. However, criteria from the Comp Plan were used to determine storage volumes required in the 400 PZ.

4.3 Fire Flow Criteria

Fire flows stress a water system near a fire. Because of this stress, these flows can identify deficiencies, which are generally associated with pipe sizes (diameter) or age (roughness) that increases headlosses and lowers pressures under high flow conditions.

Fire flow criteria measure a system’s ability to deliver a high rate of water while maintaining a minimum pressure of 20 psi in the distribution system. To evaluate the effect of fire flows throughout the distribution system, each model node was assigned a fire flow based on highest fire flow requirement considering the City's land-use based criteria. Where a node represents service to multiple land uses, the largest fire flow was chosen to be simulated in the model. The fire flow demands were during MDD conditions. By simulating MDD plus fire flows, the performance of supply sources, booster pumps, and storage tanks could be determined under those conditions.

The recommended fire flow criteria are summarized below by land use. These fire flow criteria were developed based on input from City staff:

- *Single-Family Residential:* 750 gpm for two hours.
- *Low Commercial:* 1,250 gpm for two hours (in 188 PZ) and 1,500 gpm for two hours (everywhere else).
- *Medium Commercial:* 2,500 gpm for three hours.
- *High Commercial:* 4,000 gpm for four hours.

4.4 Service Pressures

Pressures maintained in the distribution system vary depending on its operations and topography. Thus, the water pressure in a consumer's residence or place of business must be neither too high nor too low. Generally, pressures below 40 psi can cause noticeable flow reductions when more than one appliance using water is used, as well as impact lawn irrigation. High pressures may cause faucets to leak and valve seats to wear out quickly and can lead to wasted water and high water utility bills. Building code requires the installation of individual pressure reducing valve (PRV) for pressures above 80 psi to limit pressures in buildings. Acceptable water pressures in the distribution system can vary based design standards; however, pressures exceeding 120 psi are generally considered high.

The DOH requires water systems to provide PHD at no less than 30 psi at all service connections in the distribution system. A water system does not have to maintain a minimum pressure of 30 psi during a fire suppression event. In that case, DOH requires water systems to provide 20 psi of minimum pressure at ground level at all points in the distribution system.

PHD tank levels were set within the normal operating range and allowed to vary based on demands and supply operation in an extended period simulation. Fire flow scenarios are modeled under static conditions (single point in time), where the tank's water levels are set at the bottom of the fire pool (typically the lowest water level of the tank).

For this alternative analysis, however, service pressures criteria were developed for various demand conditions, as summarized below:

- *Peak Hour Demand:* To provide adequate service pressures, the City goal is to provide service pressure of at least 40 psi at the customer meter during a typical PHD condition.

- *Maximum Day Demand + Fire Flow:* This pressure criterion relates to fire flows and was devised to ensure adequate positive pressures during a fire. A minimum acceptable residual pressure of 20 psi is required per DOH criteria at the connecting hydrant under MDD plus fire flow while equalization and fire flow storage are depleted.

4.5 Distribution Mains

Transmission mains are generally sized to carry PHD or MDD plus fire flow. Other criteria related to the distribution piping include the maximum and minimum velocities, and the maximum allowable friction losses.

The DOH recommends a maximum velocity of no more than 8 feet per second (fps) under PHD conditions, unless the manufacture specifies otherwise (WSDM, 2009). Generally, velocities of 10 fps (American Water Works Association [AWWA] M-32) or higher do not cause problems if they occur briefly. For this alternatives analysis, maximum velocity criteria were developed for the following demand conditions to prevent pipe damages caused by high velocities:

- *Peak Hour Demand:* City pipes' maximum velocity not to exceed 8 fps under typical PHD conditions.
- *Maximum Day Demand + Fire Flow:* Maximum velocity not to exceed 10 fps during a MDD plus fire flow event.

Section 5

PRELIMINARY SYSTEM ANALYSIS

The preliminary system analysis was completed to understand how taking the HP Tank offline compares to current operations. Results from the analysis were used to identify system deficiencies and develop alternatives to mitigate them.

5.1 Storage Analysis

The 400 PZ has two storage tanks:

- HP Tank – available storage volume is 3.57 MG (4 MG total).
- McAllister Tank – available storage volume is 0.52 MG (1 MG total).

Note that these available storage volumes and total volumes are from the Comp Plan. The City anticipates taking the HP Tank offline for six months during the 2022 summer for maintenance and repair. While the HP Tank is offline, the 400 PZ available storage will be reduced to 0.52 MG, which is not sufficient to meet the largest fire requirement in the PZ (4,000 gpm for 4 hours = 0.96 MG). The City is required to hold sufficient fire flow storage for the largest fire at all times.

The Comp Plan storage analysis found the 400 PZ did not require equalizing storage (used to meet peak demands) based the City's storage criteria. Additionally, the 400 PZ Emergency (also known as Standby) storage is combined with fire flow storage, therefore, no additional emergency storage is required beyond the above fire flow storage, of 0.96 MG, per City criteria. Therefore, all alternatives developed below provide a minimum available storage of 1 MG to provide operational and sufficient PZ fire flow storage. Further detail on sizing will be provided in Section 6 for the different alternatives developed in this study.

The HP Tank is currently effectively supplying operational storage to the 337 PZ. With the HP Tank offline, the City will likely be required to change well and pump station set points throughout the system to mitigate the reduced storage volume. These changes will likely require substantial effort by City Staff and may require new programming to provide the needed controls in supervisory control and data acquisition (SCADA). Additional storage may be sought beyond the 1 MG to lessen changes to system operations.

Note, the City's storage criteria does not consider sharing between PZs, where the 337 PZ has sufficient storage for operation, equalizing, and fire suppression storage. Therefore, there is no change in the 337 PZ storage deficit with the HP Tank offline.

5.2 Baseline Condition

A preliminary analysis was completed using the City's existing hydraulic model. The modeling did not include improvements identified in the 337 PZ Pressure and Storage Study that was completed in parallel with this analysis.

5.2.1 Minimum Pressures during PHD

During PHD, the City's goal is to maintain a minimum pressure of 40 psi at every customer in the system. With S07 and S19 offline, HP Tank online, and the current system configuration, the infrastructure appears to be able to serve the 400 PZ through 2028 in terms of pressures, as illustrated in Figure 7. No model node falls below 40 psi under the 2028 PHD condition. Both 2022 and 2028 PHD conditions were run in the model, this report only shows 2028 PHD, as this condition has the highest demands and would trigger the minimum pressures. However, Appendix C details modeling results for all conditions for additional detail. Figure 8 shows the impact of the projected demand increase between planning years 2022 and 2028. Figure 8 shows that the increase in demands between 2022 and 2028 did not significantly impact the minimum pressures in the 400 PZ and that all nodes varied between -5 psi and +2 psi between planning years 2022 and 2028.

5.2.2 Residual Pressures during MDD + Fire

During a fire flow condition, the City's goal is to maintain 20 psi everywhere in the system assuming the fire event occurs during a MDD condition. The hydraulic model was run for both 2022 and 2028 MDD + Fire condition. Results show that the 400 PZ is able to provide the required fire flows while maintaining 20 psi everywhere in the system. Figure 9 illustrates the residual pressures in the 400 PZ under 2028 MDD + FF condition, which is anticipated to be the worst case scenario because of increased demands from 2022. Both planning years did meet the City's criteria and Appendix C includes all modeling results for further details.

5.3 Impact of Hawks Prairie Offline

The hydraulic model was run under the 2016 summer demand condition with well S09 and S17 offline to understand the impact of taking Hawks Prairie offline in the distribution system's pressures and service goals. As illustrated on Figure 10, when the HP Tank is offline, the pressure in the northern portion of the 400 PZ cannot hold the hydraulic-grade-line (HGL) under 2016 summer conditions. As a result, the infrastructure cannot serve the customers under these conditions. This is due to a combination of lack of storage in the PZ and lack of transmission piping.

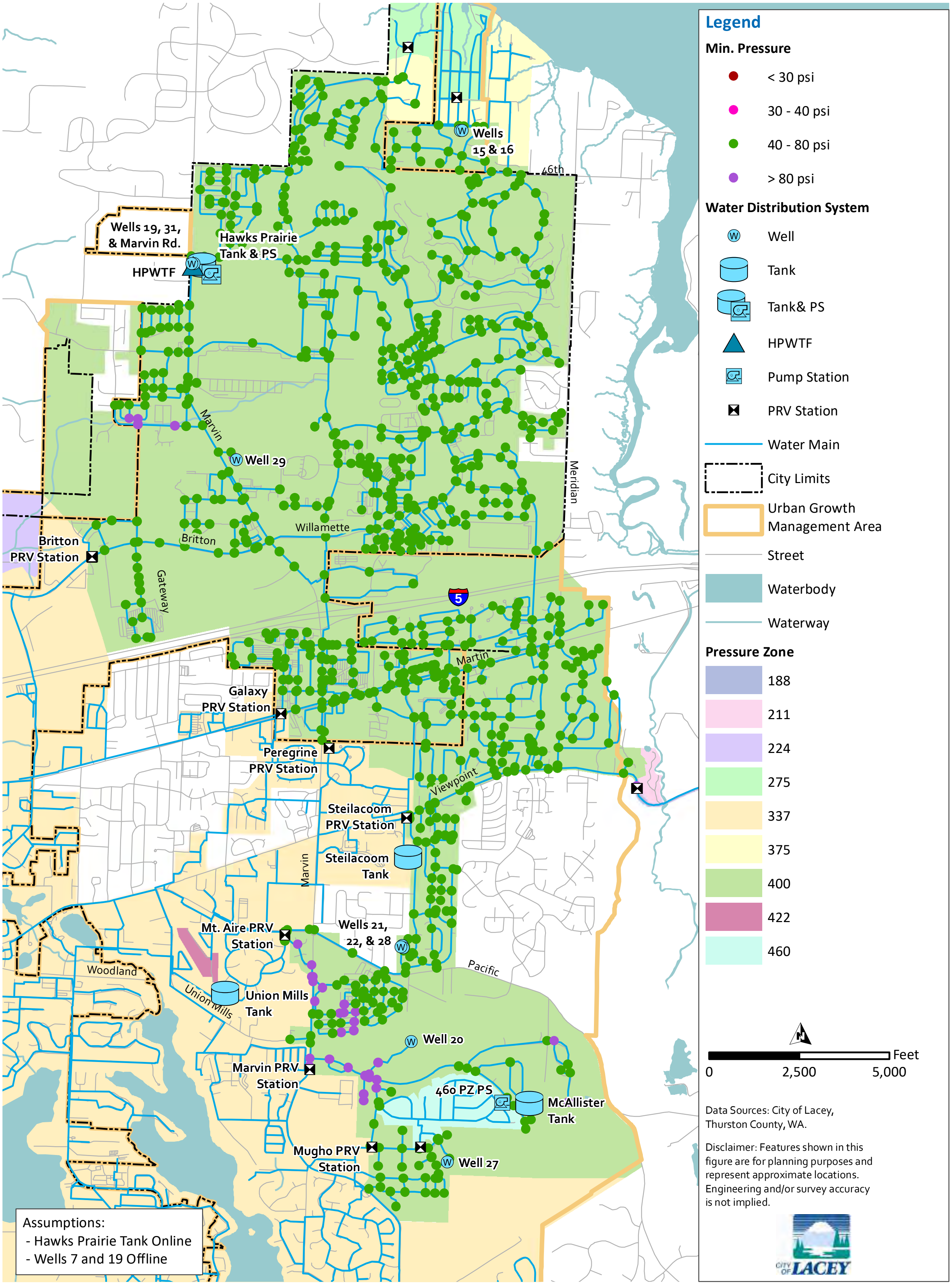

Figure 7 Minimum Pressures under 2028 PHD Conditions - Baseline

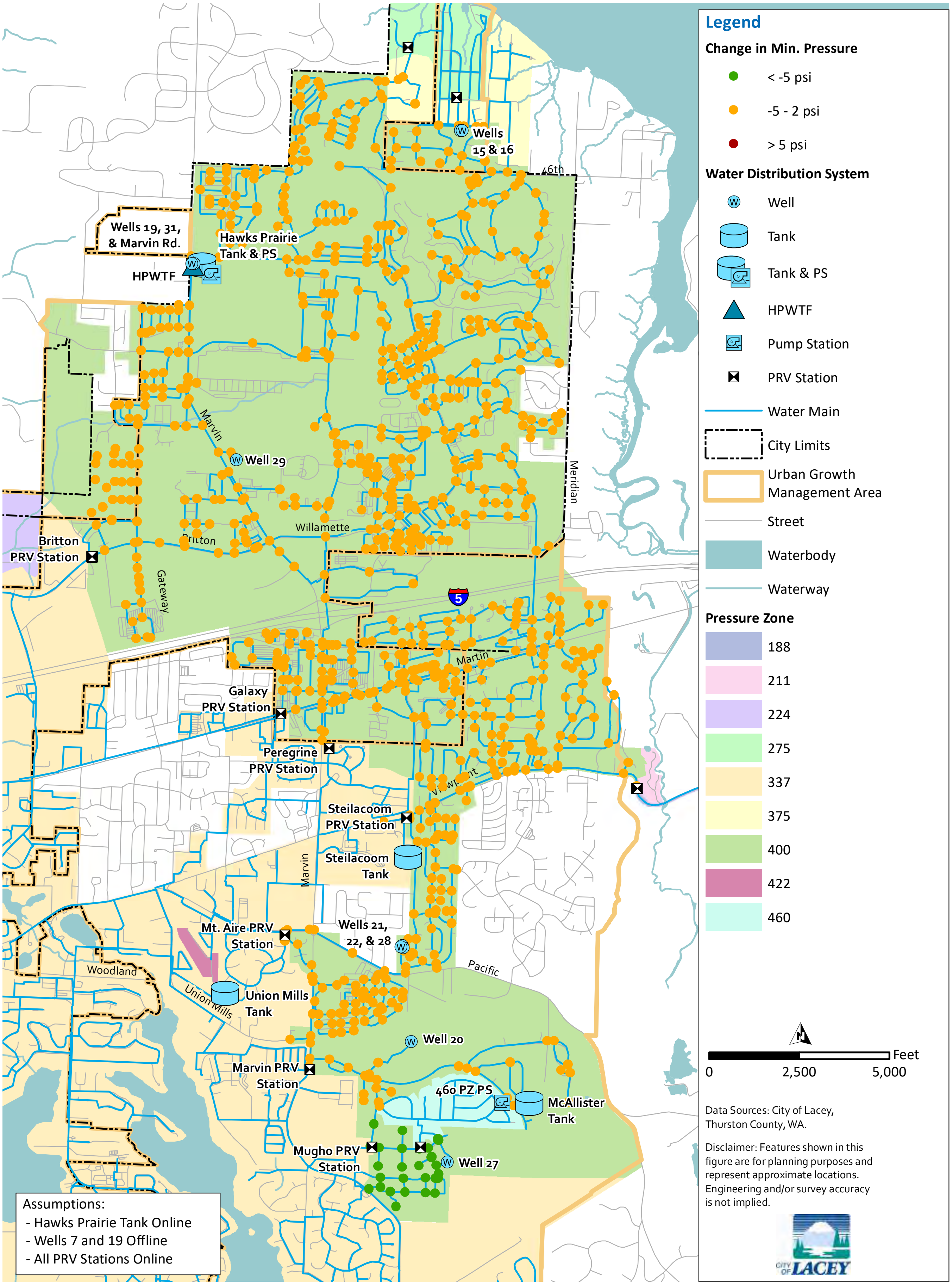

Figure 8 Change in Min. Pressures under 2022 and 2028 PHD Conditions - Baseline

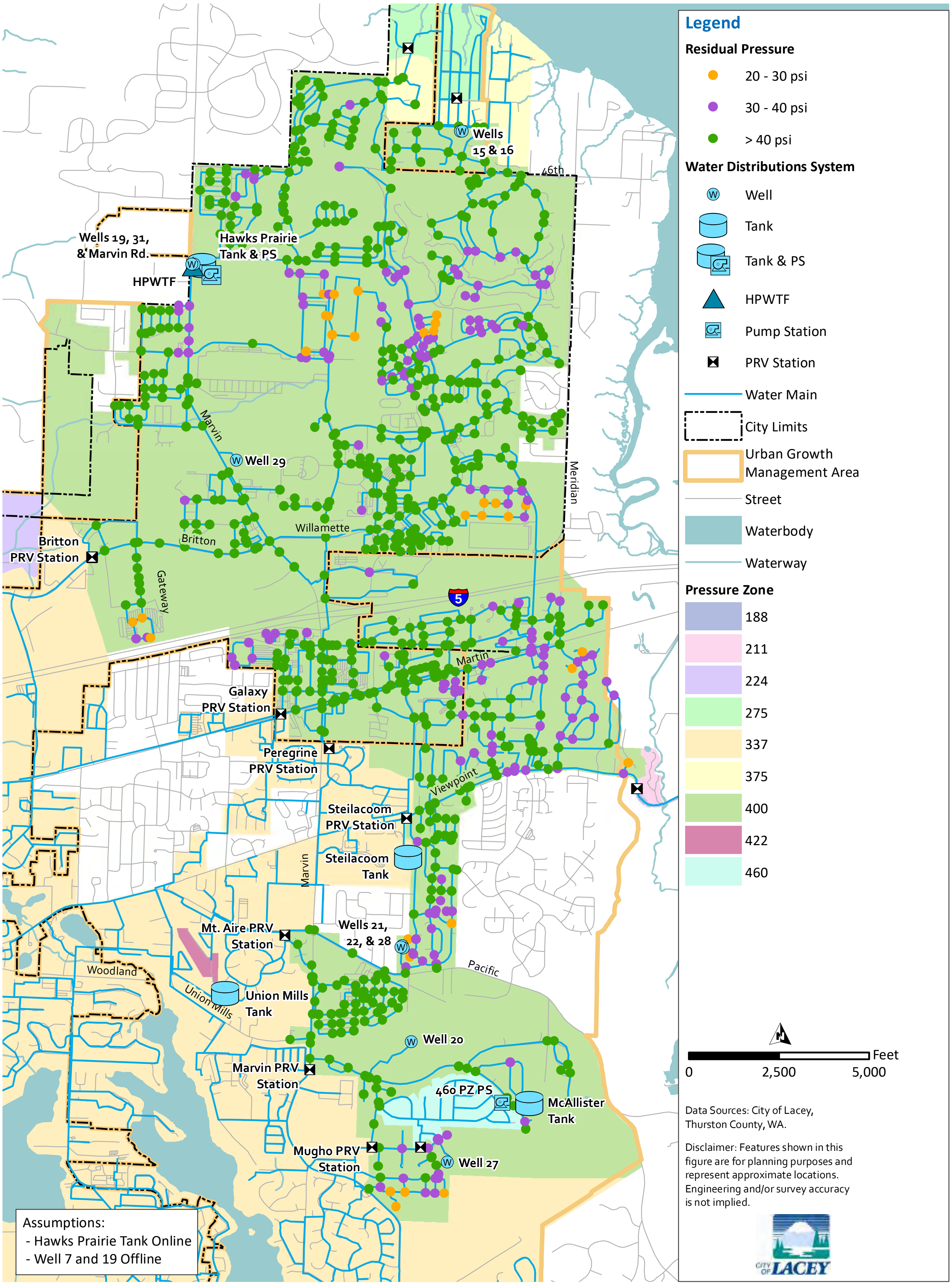

Figure 9 Residual Pressures under 2028 MDD plus Fire Flow Conditions for Baseline

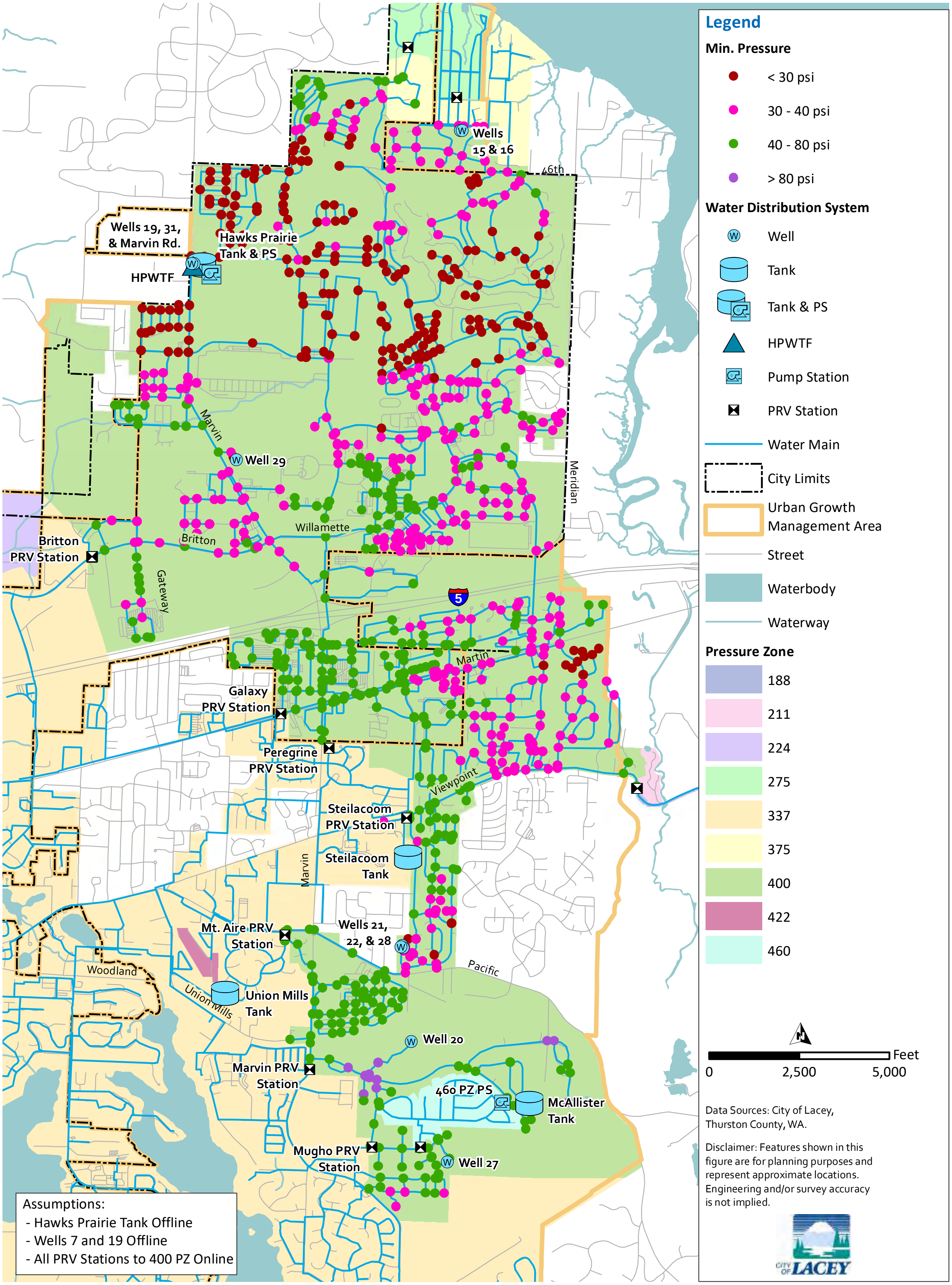

Figure 10 Minimum Pressures under Summer 2016 Conditions - Hawks Prairie Tank Offline

Section 6

RECOMMENDED ALTERNATIVES

As detailed in Section 5, the initial analysis showed that the northern area of the 400 PZ of Interstate 5 (I-5) fell below 30 psi in some locations when the HP Tank was taken offline under 2016 PHD conditions.

The 400 PZ's northern and southern portions are connected via several pipelines that cross I-5. Very minor restrictions were identified in the hydraulic model in the pipes crossing I-5 during normal conditions. Maximum velocity results are found in Appendix C. These were not included in the main report, as these results did not trigger deficiencies in the 400 PZ and alternatives.

The storage analysis also indicated that the 400 PZ cannot meet the fire suppression storage requirement of 0.96 MG with the HP Tank offline. Without the HP Tank, the City's 400 PZ has 0.52 MG of fire suppression storage.

Storage alternatives were developed to meet fire suppression storage and maintain minimum service pressures under 2022 PHD conditions when the HP Tank will be taken offline for maintenance and repair. The following sections describe the facilities associated with each 400 PZ recommended alternatives and present the results from the hydraulic analysis. Note, Wells S07 and S19 are offline for all alternatives to match the operational and redundant supply scenarios.

6.1 Alternative 1

Alternative 1 avoids constructing a new tank in the distribution system. With this alternative, storage volume not accessible under the existing configuration is used.

Alternative 1 initially considered two sub-alternatives:

- A: Access existing storage in 337 PZ at Steilacoom Tank via a new pump station. Note that the 337 PZ does not have supply to spare during high demand. Approximately 1,160 feet of 16-inch diameter pipe is required to connect the new pump station to the 400 PZ. This Alternative was unstable in the hydraulic model and was abandoned. Alternative 1B below is used for modeling and results in this section.
- B: Access dead storage in the McAllister Tank via a new pump station. This would allow the full 1 MG tank to be used during a Fire or other emergency. This alternative is referred to as Alternative 1 in this Technical Memorandum (TM).

Note, that the McAllister Tank will need to be reconfigured so it can be isolated from the system while the pump station is running. Doing so would keep pressures in the 400 PZ from dropping below acceptable pressures.

In addition to the proposed pump station, Alternative 1 would carry out the following system improvements:

- Adding variable frequency drives (VFDs) to pumps in the HPWTF low lift pumps. This helps the pumps match demands when HP Tank is offline.

- Making full use of Madrona Well Field's full water rights by increasing the transmission capacity.
- Completing main improvements (37,300 LF) to help move water from the southern portion of 400 PZ to the northern portion, especially with increased supply from Madrona. The transmission main alignments and sizing are shown in Figure 11 for Alternative 1.
- Completing operational changes while the HP Tank is offline.

6.1.1 2022 Hawks Prairie Tank Offline

Alternative 1A was operationally challenging and unstable in the model, so it was not selected for further evaluation, and no modeling results were reported. This is because most of the City's supplies are controlled by the Steilacoom Tank. This alternative would therefore require significant changes in the SCADA system and operations.

Alternative 1B (Alternative 1) was run in the hydraulic model. Results indicated that the alternative does not maintain pressures above 40 psi throughout the PZ under PHD conditions in 2022, as shown in Figure 12. Several locations slightly drop down to 38 to 39 psi due to slightly higher ground elevations in the area. Note, Alternative 1 does meet DOH's minimum pressure requirement of 30 psi.

Figure 13 shows that Alternative 1 can give the City its desired level of service during a MDD plus fire flow event condition with the current piping infrastructure. However, to achieve this level of service, extensive distribution main improvement would be required. Modeling showed that at least 37,300 LF of pipes would need to be constructed for this alternative to meet level of service goals.

Normal changes in supply or operation appear to cause large drops in pressures in the northern portion of the system when the HP Tank is offline. To better maintain minimum pressures, PRV stations were taken offline while the HP Tank is offline to limit the movement water from the 400 PZ to 337 PZ. Table 4 summarizes inactive PRVs for each Alternative. The City has flexibility to setting and operating its PRVs; therefore, valve operation was divided by normal conditions (2022 PHD) and during fire flows (2022 MDD + FF). To reduce the complexity of this dual approach, the City could elect to apply the more stringent fire flow requirements to all conditions. However, this will likely require adjustments to 337 PZ operations to reduce flow from the 400 PZ. Detailed facility controls and operational changes made in the model for Alternative 1 are documented in Appendix A.

Table 5 Temporarily Offline PRV Stations during Hawks Prairie Reservoir Offline

PRV Station	PRV Station Status while Hawks Prairie Tank is Offline					
	2022 PHD			2022 MDD + FF		
	Alt. 1	Alt.2	Alt. 3	Alt. 1	Alt.2	Alt. 3
Britton	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Galaxy	Inactive	Inactive	Inactive	Inactive	Inactive	Inactive
Pergrine	Active	Active	Active	Inactive	Inactive	Active
Steilacoom	Active	Active	Active	Inactive	Inactive	Active
Mt. Aire	Active	Active	Active	Inactive	Inactive	Active
Mugho	Active	Active	Active	Inactive	Inactive	Active
Marvin	Active	Active	Active	Active	Active	Active

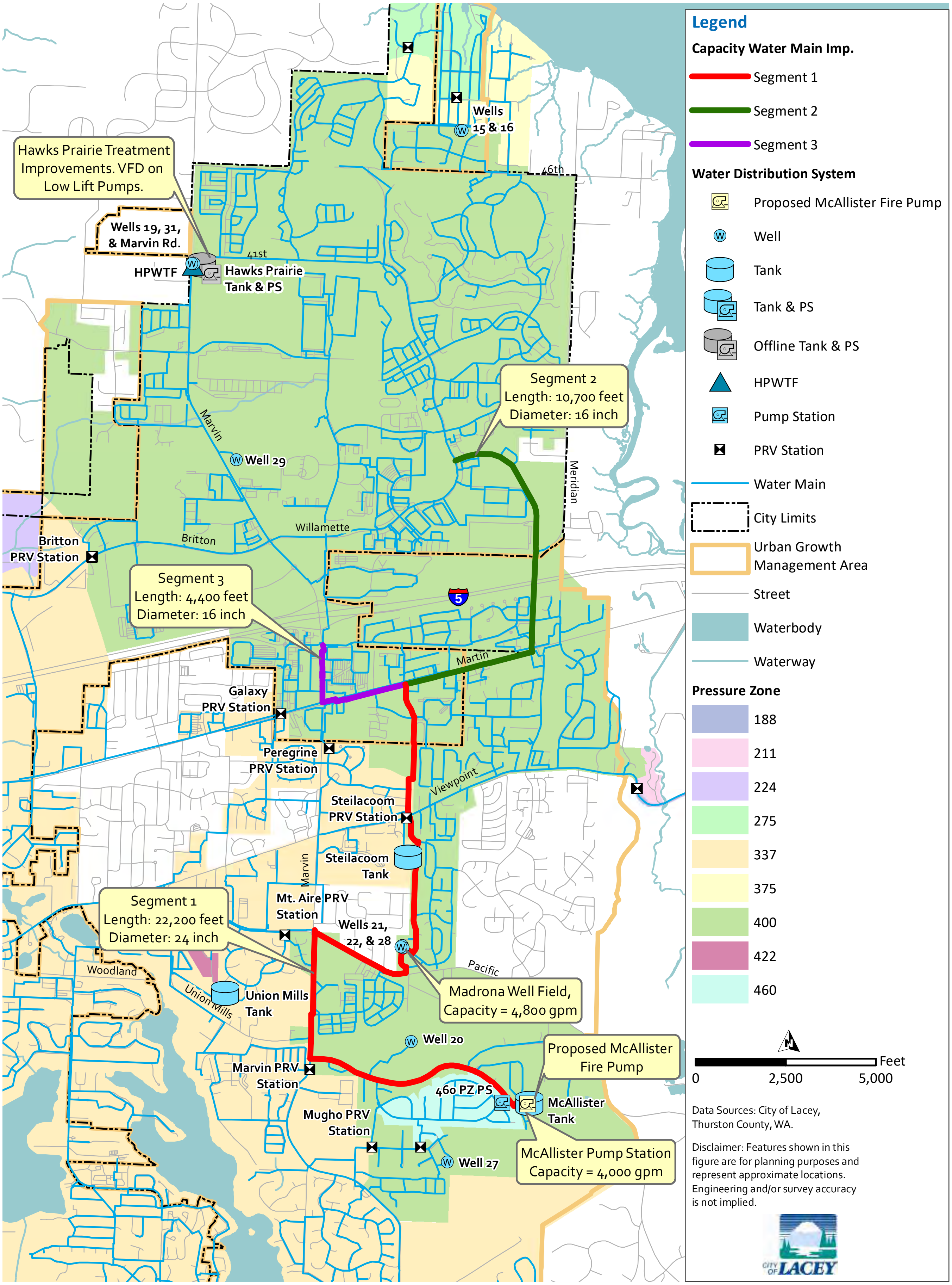

Figure 11 Alternative 1 Improvements

6.1.2 2028 Hawks Prairie Tank Online

Alternative 1 was evaluated to understand operations with the new infrastructure after the HP Tank is back online. City staff raised concerns over the potential increase in water age from the larger distribution mains.

In order to significantly decrease headloss in the system to allow to serve the customers in the north-end of the 400 PZ when Hawks Prairie is out of service, more than 33,000 LF of pipe upsize is recommended. However, when HP Tank goes back online, these pipes will not be needed as much, and will flow a lower amount of water to the north. In return, water age is expected to increase; these pipes become oversized when both McAllister and HP Tank are online, and water quality challenges outweighed this benefit.

Based on the recommended infrastructure needed for this alternative, the need to cross both railroad and I-5, and the alternative's operational instability, it was eliminated from further consideration. Further information on ranking can be found in Section 8.

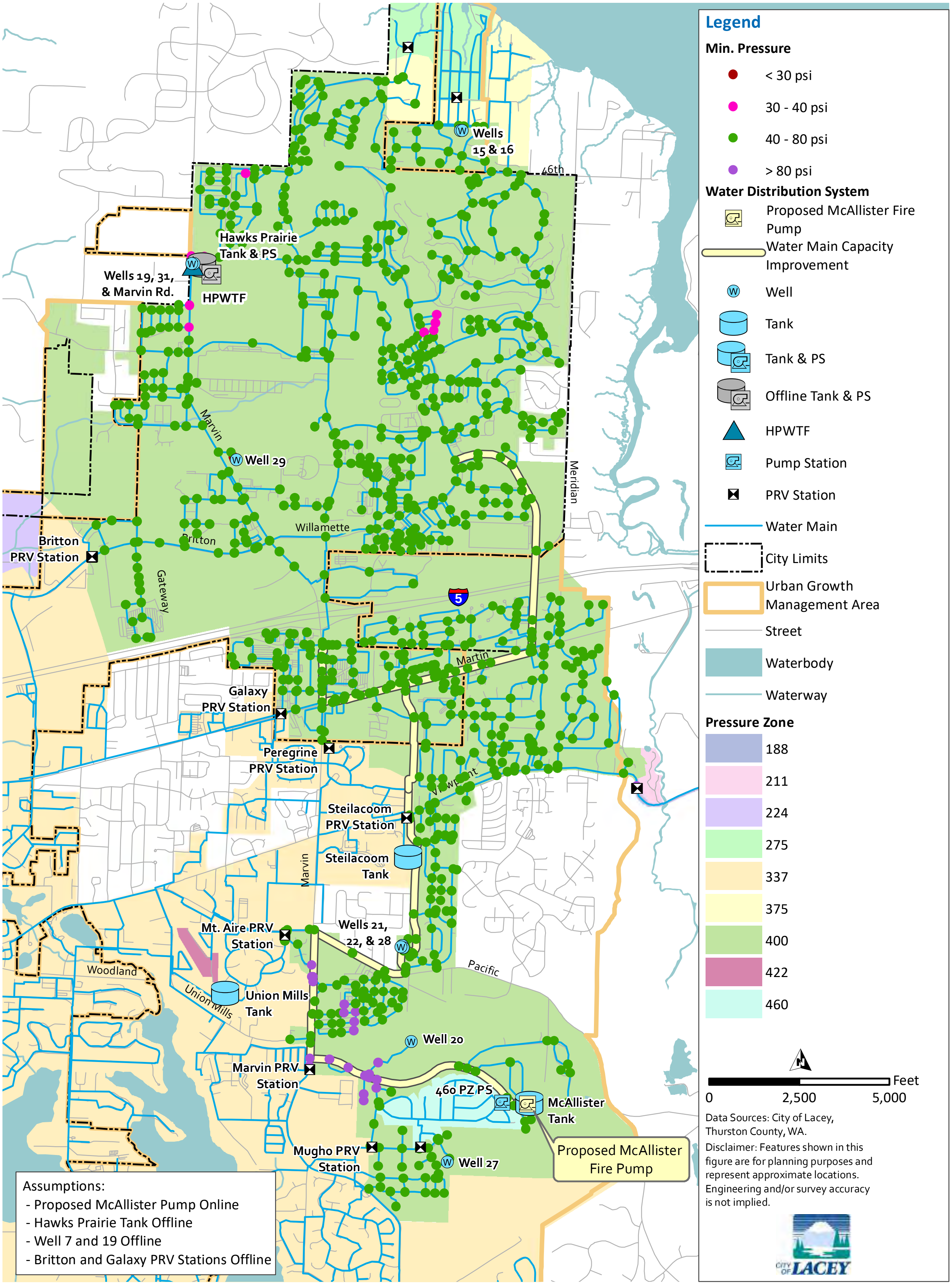

Figure 12 Min. Pressures under 2022 PHD Conditions - Alt. 1, Hawks Prairie Tank Offline

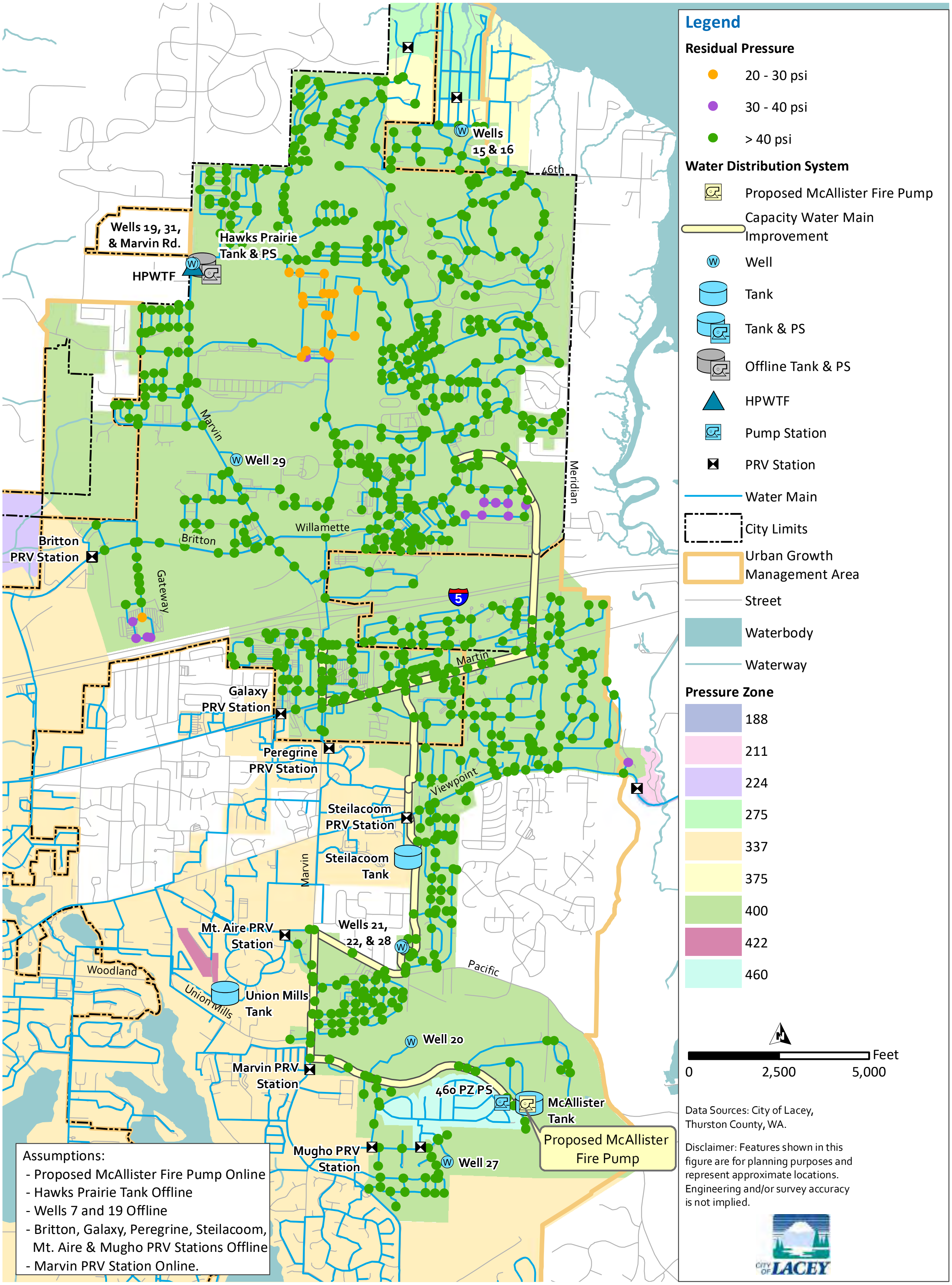

Figure 13 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Alt. 1, Hawks Prairie Tank Offline

6.2 Alternative 2

Alternative 2 involves constructing an at-hydraulic-grade tank at the existing Marvin Well site, which is located next to the new school site, as shown on Figure 14. The at-hydraulic-grade tank will be a redundant tank that provides 400 PZ with gravity storage. The following preliminary tank characteristics were modeled:

- Tank Type = At-hydraulic-grade elevated tank.
- Storage Capacity = 1.0 MG.
- Approximate Height = 36 feet.
- Approximate Diameter (at constant slope) = 75.6 feet.
- Tank overflow elevation: 400 feet to match 400 PZ's HGL.
- Approximately 570 feet of 16-inch diameter transmission main to connect the tank to the distribution system.

In addition to the at-hydraulic-grade tank, Alternative 2 would carry out the following improvements:

- Adding VFDs to pumps in the HPTWF’s low lift pump station to match demands.
- Upsizing approximately 1,100 feet of 12-inch diameter distribution main to 16-inch diameter distribution main for Madrona Well Improvements.

Figure 14 shows facilities associated with Alternative 2 improvements. The new at-hydraulic-grade tank was sized so it allows the City to meet minimum fire suppression storage and add additional equalization storage.

To maintain tank levels and turnover, it is recommended that the controls at Madrona Well Field look at the water level in the new above hydraulic grade tank. The hydraulic model was used to determine general operational schema with the new infrastructure and make sure that the new tank could be operated in the operational band of storage. However, if this alternative moves forward, it is recommended that the City optimizes operation of the wells with Hawks Prairie and the new at hydraulic grade tank during the pre-design process.

6.2.1 2022 Hawks Prairie Tank Offline

Figure 15 shows the minimum system pressures under 2022 PHD conditions with the HP Tank offline. The at-hydraulic-grade tank provides a sufficient level of service while the HP Tank is offline, except for two isolated areas.

According to the hydraulic model, minimum pressures in pressure-deficient areas fall just below 40 psi for a relatively short time. Regardless, the pressure deficiencies still satisfy DOH's minimum pressure requirement of 30 psi. The system deficiencies can be mitigated with system operation optimization.

Two locations slightly drop below the 40 psi pressure goal in the northern area of the 400 PZ, as illustrated in red in Figure 15. These locations drop down to 37 to 38 psi due to slightly higher ground elevations in the area. The City considered these minor pressure deficiencies to be acceptable.

Figure 16 shows that the system can provide fire flow requirements during MDD plus fire flow condition while maintaining 20 psi in the system under Alternative 2.

To meet the minimum pressure criteria, closing Galaxy and Britton Parkway PRV stations is recommended while the HP Tank is offline, and closing all PRVs, except Marvin Road, is recommended during a fire event condition, as summarized in Table 4 Detailed facility control and operational changes in the hydraulic model can be found in Appendix A.

6.2.2 2028 Hawks Prairie Tank Online

Adding an at-hydraulic-grade tank requires change in supply and pumping setpoints during normal operations to turnover both the new tank and existing HP Tank. It is recommended that the controls at Madrona Well Field look at the water level in the new above hydraulic grade tank. The hydraulic model was used to determine general operational schema with the new infrastructure and make sure that the new tank could be operated in the operational band of storage. However, if this alternative moves forward, it is recommended that the City optimizes operation of the wells with Hawks Prairie and the new at hydraulic grade tank online simultaneously during the pre-design process. After operational controls are optimized, the tank turnover can be expected to be similar to Alternative 3 (Section 6.3).

While the level of service in the 400 PZ is expected to slightly decrease when the HP Tank is offline compared to current level of service with the HP Tank online, the level of service with both tanks online is anticipated to be consistent with the baseline existing system. The system meets minimum pressure criteria and shows little to no change from the baseline condition shown in Appendix C.

2028 MDD scenario was run in the hydraulic model and assumed Hawks Prairie online in all alternatives scenarios. Residual pressures during the 2028 MDD plus fire flow event were sufficient and greater than baseline at some locations because of increased available pressure where the new at-hydraulic-grade tank can provide fire flow at higher pressures then the HP Tank. Results are provided in Appendix C.

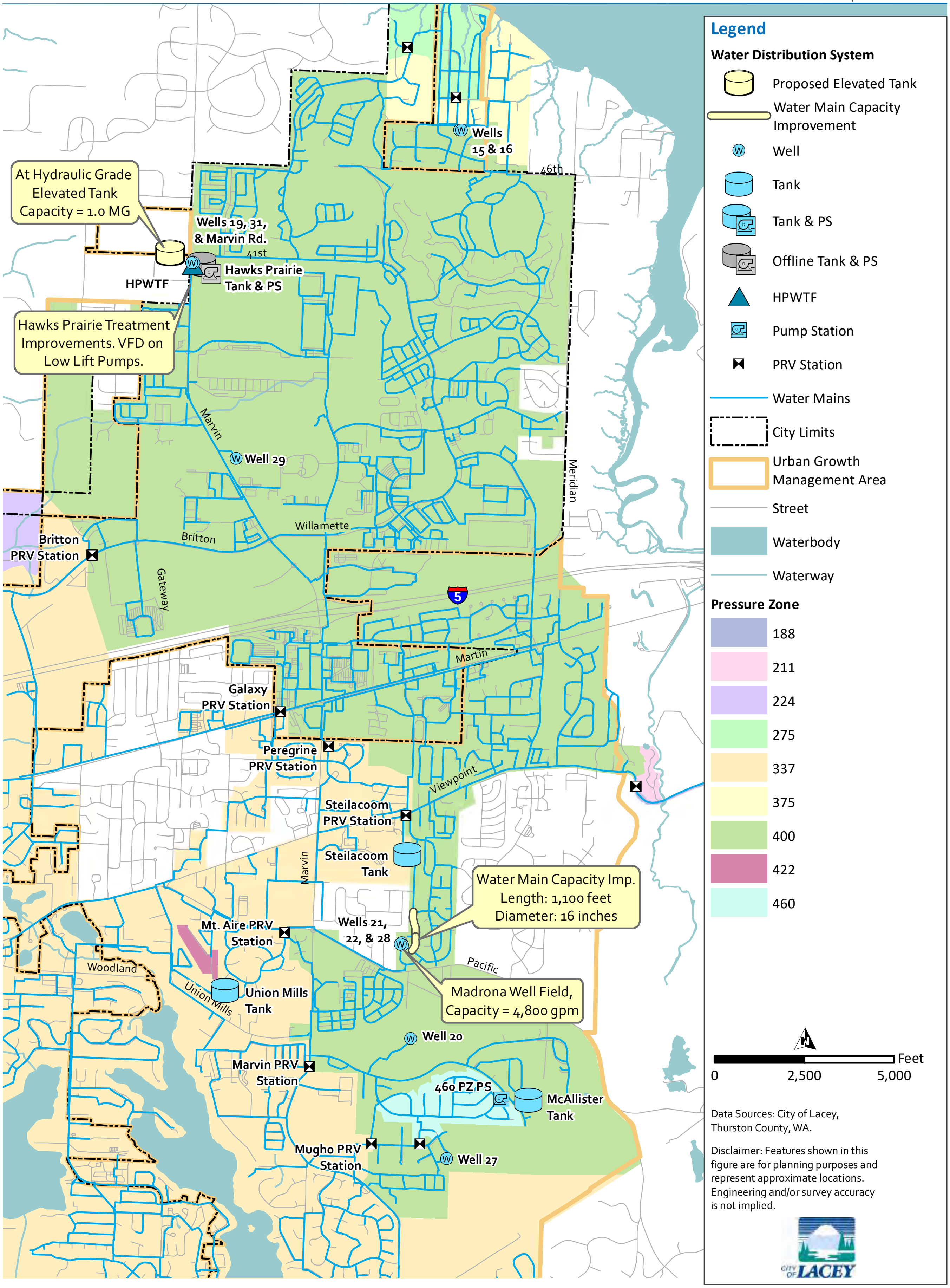

Figure 14 Alternative 2 Improvements

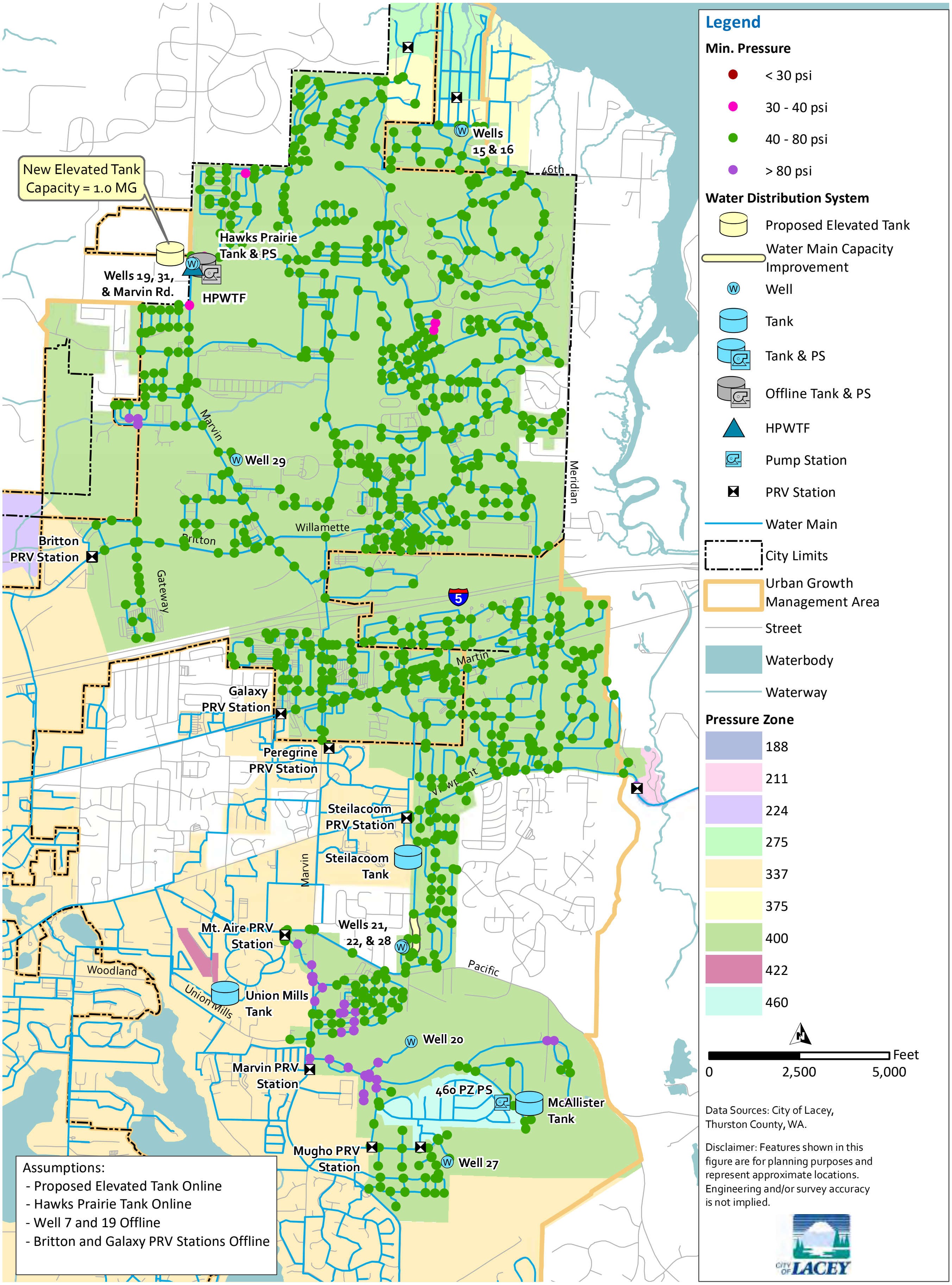

Figure 15 Minimum Pressures under 2022 PHD Conditions - Alt. 2, Hawks Prairie Tank Offline

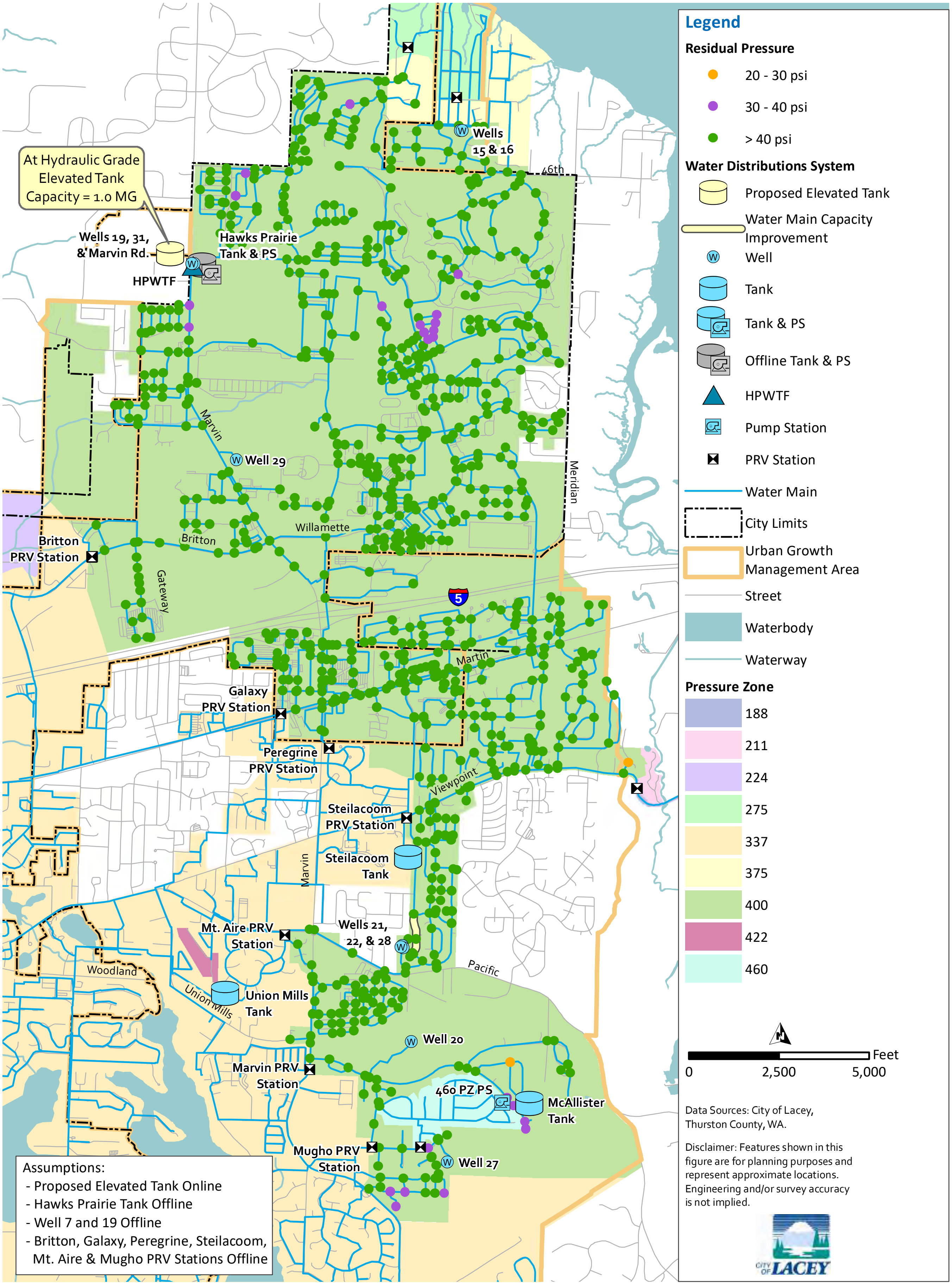

Figure 16 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Alt. 2, Hawks Prairie Tank Offline

6.3 Alternative 3

Alternative 3 involves constructing a below-hydraulic-grade tank (Sister Tank) on the HP Tank site. The Sister Tank would have similar hydraulic characteristics as the existing HP Tank and would use the existing Hawks Prairie Pump Station. The modeled Sister Tank characteristics are as follows:

- Tank Type - Stand Pipe.
- Storage Capacity = 1 MG.
- Overflow Elevation = 380 feet to match the existing HP Tank.
- Approximate Height = 85 feet.
- Approximate Diameter = 45 feet.
- Field piping to allow the existing 4 MG and new 1 MG to be connected during normal operation and isolated from each other for maintenance.

If the City selects this alternative, these characteristics will need to be evaluated in further detail and refined under the pre-design effort.

In addition to the new Sister Tank, the following system improvements are required under Alternative 3:

- Upsizing approximately 1,100 feet of 12-inch diameter distribution main to 16-inch diameter distribution main, as shown in Figure 17.

6.3.1 2022 Hawks Prairie Tank Offline

Of all three alternatives, the Sister Tank option provides the highest level of service while the HP Tank is offline. Figure 18 shows these results are very similar to the baseline condition, as Alternative 3 can maintain system pressures above 40 psi under 2022 PHD conditions without major changes to system operation with the 1 MG Sister Tank and existing pump station.

Some operational changes might be required to ensure that the system maintains the minimum level of service goals and sufficient fire flow storage when the HP Tank is offline. The SCADA data and wells will need to be reprogrammed to be controlled from the Sister Tank water level. With the HP Tank offline and the smaller volume at the Sister Tank, storage volume at the Hawks Prairie site is decreased and therefore new call set points on the wells will be required to ensure the water level in the Sister Tank remains above the equalizing band at all time.

Similar to the other two alternatives, both Britton and Galaxy PRV Stations are recommended to be closed while the HP Tank is offline during peak demand days to maintain sufficient volumes of water in the Sister Tank. If these PRVs remain online, it is anticipated that too much water would be transferred from the 400 PZ to the 337 PZ, lowering water levels in the Sister Tank, there will be insufficient water supply for the 400 PZ. Closing Britton and Galaxy PRV Stations will reduce the pressures in the 337 PZ by 2 to 3 psi. Sufficient supply is provided to the 337 PZ through the other PRVs. Tank operation shows sufficient level and good turnover, as show in Figure 19. For detailed facility control and operational changes made in the model see Appendix A.

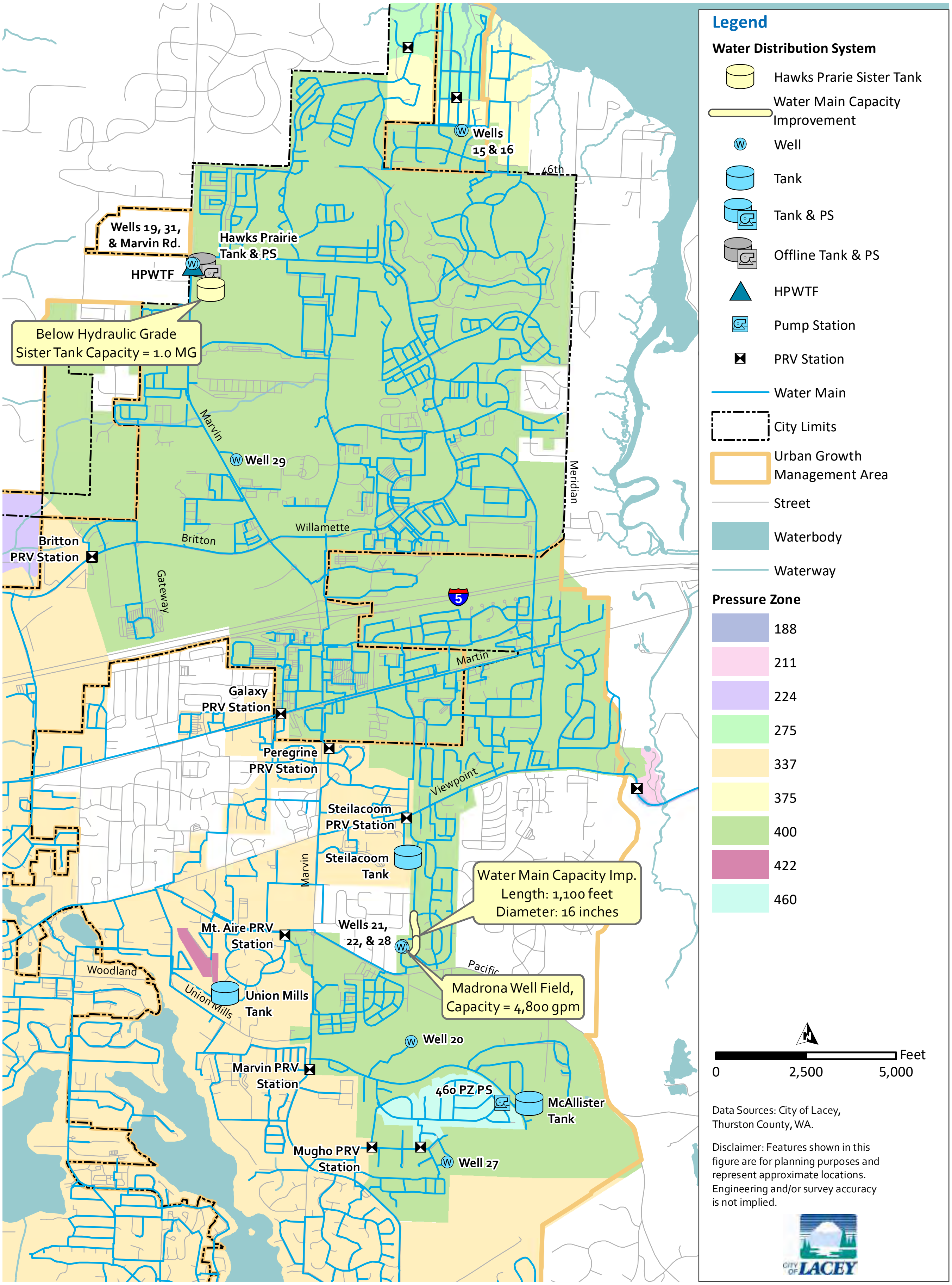

Figure 17 Alternative 3 Improvements

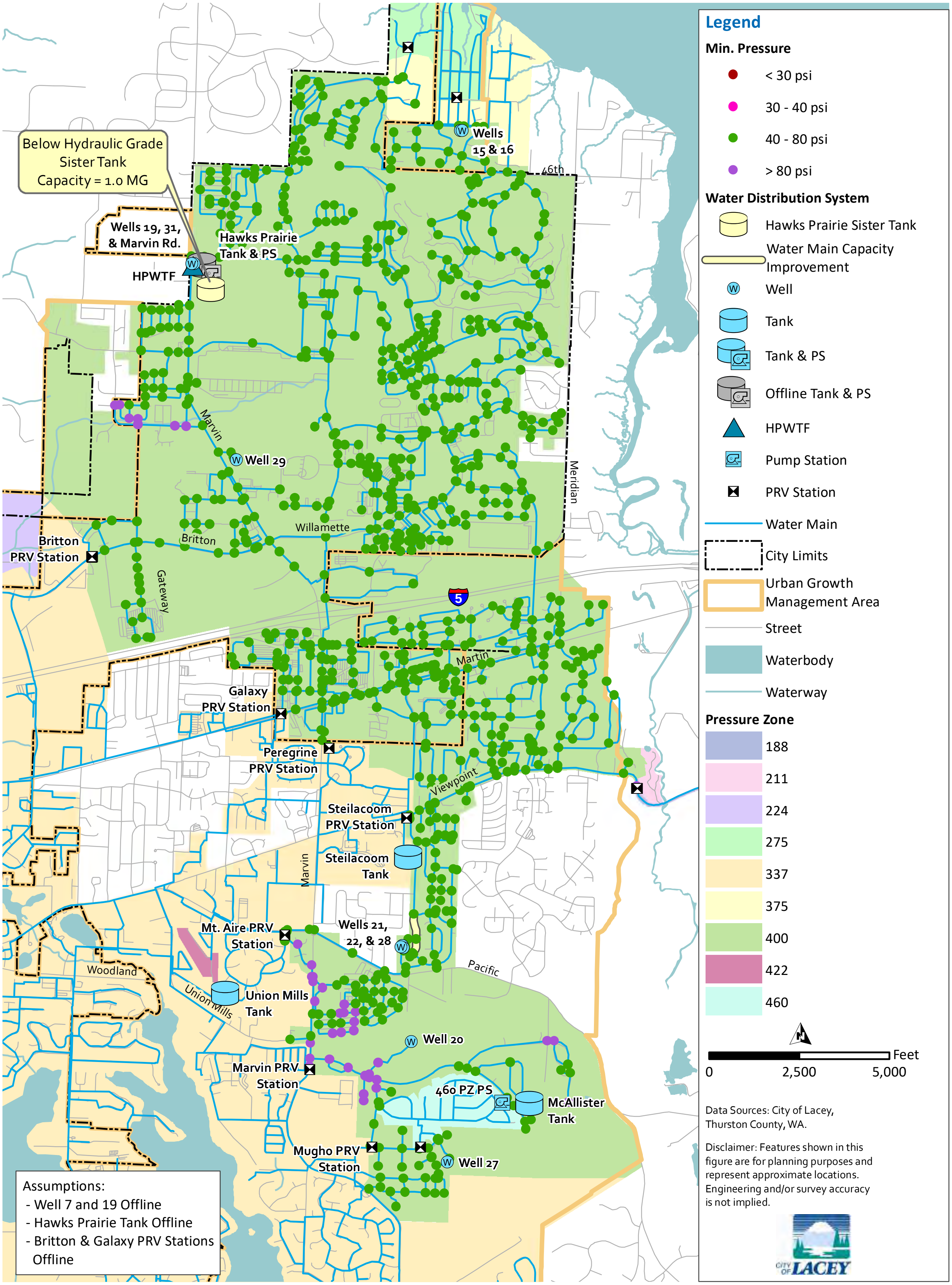

Figure 18 Minimum Pressures under 2022 PHD Conditions - Alt. 3
Hawks Prairie Tank Offline

The model results indicate that the Sister Tank should be a minimum of 1.0 MG. Subsequently, the figures in this study are based on a 1.0 MG tank, such as Figure 19, which shows the water level of the 1.0 MG tank when the HP Tank is offline. However, the City requested a 1.5 MG tank. The larger tank will provide more operational storage to the 337 PZ, which is currently dependent on the 400 PZ storage, more operational flexibility, and will allow for future growth in demand beyond the 4 to 10 year projections of this study. As a result, Carollo has provided a cost estimate and tank characteristics for a 1.5 MG tank in this report. Tank characteristics are presented in Table 5 below. Note, that the Hawks Prairie Booster Pump Station (BPS) is unable to pump to a depth below 6 feet when its fire flow pumps are being operated, which is considered unusable.

Table 6 Recommended 1.5 MG Sister Tank Characteristics

Parameter	1.5 MG Sister Tank
Height	85 feet
Diameter	55 feet
Volume per Foot of Storage	0.0178 MG/feet
Available Storage Volumes	79 feet (1.41 MG)
Unusable during Fire Flow	6 feet (0.11 MG)

The Sister Tank sizing should be reevaluated during tank pre-design when demand and operational schemes will be better known.

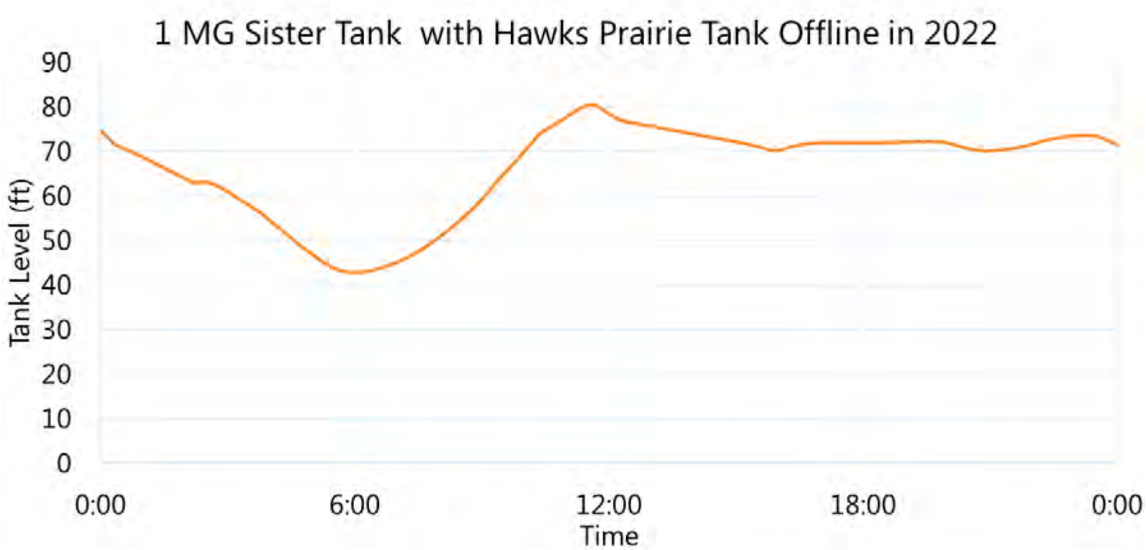

Figure 19 Sister Tank Water Level under 2022 MDD Condition

Figure 20 shows that the system can maintain residual pressure requirements during 2022 MDD plus fire flow event for Alternative 3.

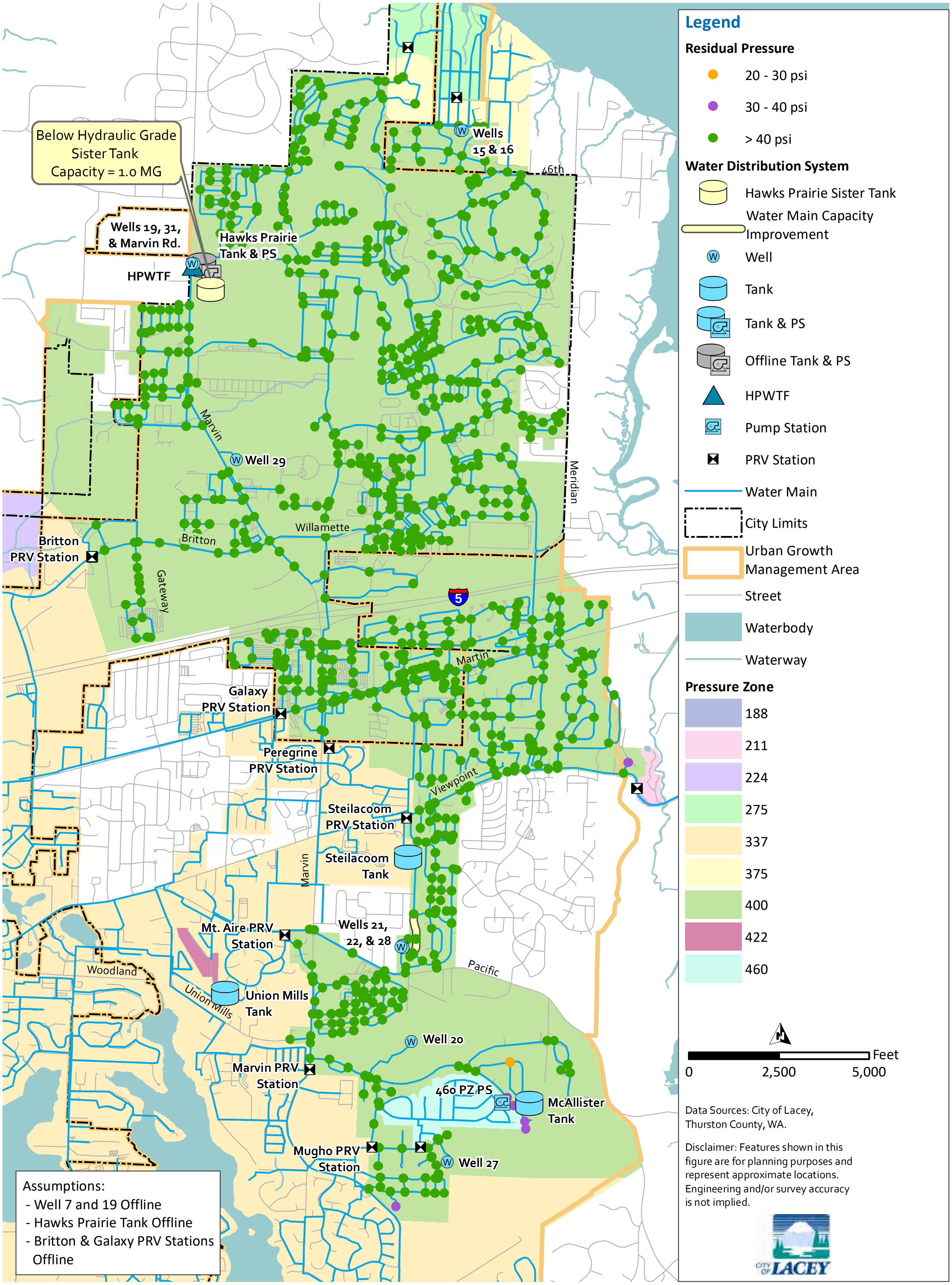

Figure 20 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Alt. 3, Hawks Prairie Tank Offline

6.3.2 2028 Hawks Prairie Tank Online

Because the HP Tank and Sister Tank are near each other, both are anticipated to act as a single tank during normal operations. Figure 21 shows that, under 2028 PHD conditions, both tank levels are virtually identical during normal operations and are nearly identical to the 2028 baseline HP Tank level. During normal operations, changes to supply controls are required to allow good turnover within the HP Tank sites. Additional operational changes might also be required during lower demand periods to optimize water age in the tanks from added storage volume.

With both tanks online at the Hawks Prairie site, SCADA and especially wells will need to be reprogrammed to account for both tanks operations. Ideally, it is recommended that both tanks be hydraulically connected and "float" on the same HGL. However, based on site condition, it is recommended that the operation of both tanks in conjunction be confirmed.

With the HP Tank online, modeling showed very limited change compared to the Baseline Scenario (see Section 5.2) for the 2028 PHD. The minimum pressure criteria are met during both 2028 PHD and 2028 MDD plus fire flow conditions. Detailed results are shown in Appendix C.

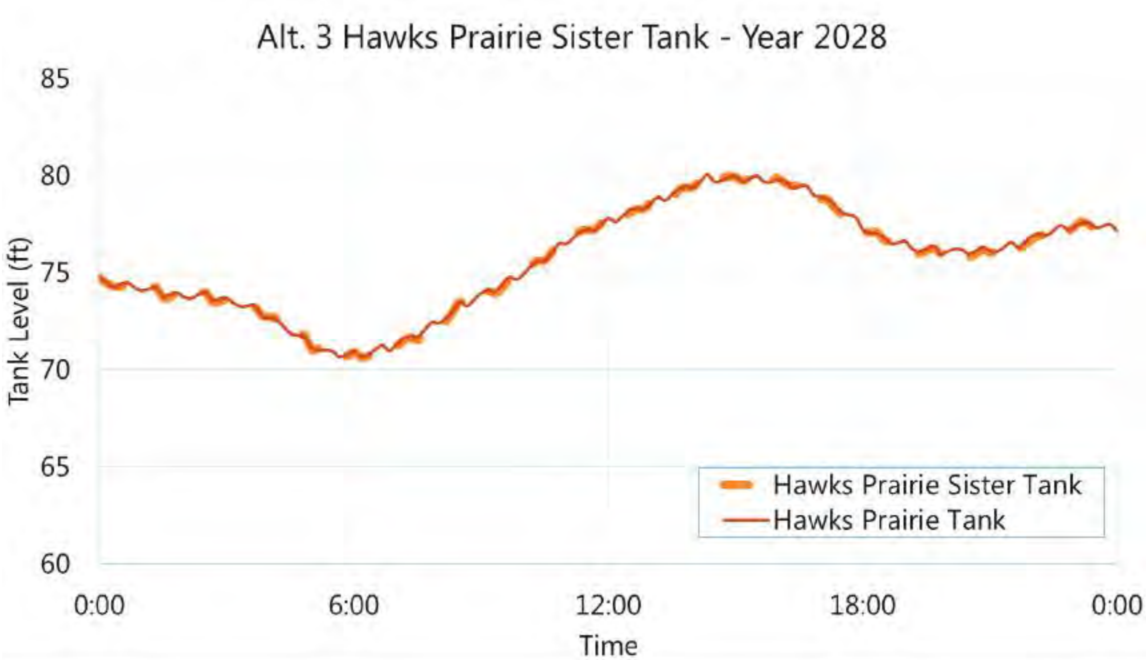

Figure 21 Change in Tank Water Levels during 2028 PHD between Alternative 3 and Baseline

Section 7

LIFE-CYCLE COSTS AND CAPITAL COSTS

This section summarizes the cost assumptions used to develop costs for each alternative that will be used to compare alternatives.

When possible, life-cycle costs are generated for new infrastructure to help select preferred improvements. Life-cycle costs include both capital costs and O&M costs over a 50-year period.

Capital costs relate to the construction of new infrastructures, whereas O&M costs relate to operations and maintenance of new facilities.

The following capital costs assumptions are discussed below:

- Supply.
- Transmission.
- Treatment.
- Booster Pump Stations.
- Storage.
- Land acquisition.

The following items were collected and used to develop operations and maintenance costs:

- Energy.
- City staff effort.
- Pump station rehabilitation.
- Tank recoating.
- Valve maintenance.

7.1 Cost Estimating Methodology Assumptions

Cost estimates were developed for each alternative's supply, transmission, and treatment components. These costs are planning-level estimates only and should be refined during pre-design.

The cost estimates developed in this chapter are AACE Class 4 estimates. Class 4 estimates are budget level estimates. Actual costs may vary from these estimates by -30 percent to +50 percent.

Project costs are also planning-level projections based on approximate average costs for similar projects.

All capital costs are in May 2018 dollars inflated to the year the project is expected to be constructed in. The Engineering News-Record's US 20-City Construction Cost Index for May, 2018 is 11013. O&M costs were inflated to the year the operation or maintenance will be performed.

The annual construction cost inflation rate of 3.0 percent is applied to the life-cycle costs.

7.2 Capital Cost Assumptions

The unit costs in this section were used to develop construction costs for each alternative. To develop the total project cost, construction costs were inflated using the cost factors shown in Table 6.

Table 7 Cost Factors

Cost Factor	Description	Factor
All Projects		
Contingency	Costs that may occur due to uncertainty in project scope and conditions.	30%
Water Main Replacement Projects		
City of Lacey staff, project and construction engineering finance codes	Costs for a project's in-house planning, design, and construction administration.	19%
Other	Costs for connection and permitting fees, easements, land acquisition, advertising, and finance administrative fee.	6%
Water Well Projects		
City and consultant, project and construction engineering finance codes	Costs for a project's studies, planning, design, and construction administration.	35%
Other	Costs for connection and permitting fees, easements, land acquisition, advertising, and finance administrative fee.	6%
Booster Pump Station & Tank Projects		
City and consultant, project and construction engineering finance codes	Costs for a project's studies, planning, design, and construction administration.	40%
Other	Costs for connection and permitting fees, easements, land acquisition, advertising, and finance administrative fee.	5%

7.2.1 Supply

No supply projects costs were included in the 400 PZ.

7.2.2 Transmission

Table 7 shows transmission main unit construction costs. These unit costs assume open-trench construction and include pavement cutting, excavation, hauling, shoring, pipe materials and installation, backfill material and installation, and a minimum pavement replacement of half the street. These costs also assume that main pipelines less than 12 inches in diameter are polyvinyl chloride (PVC) and mains 12 inches and greater are ductile iron. The unit costs are for "typical" field conditions with construction in stable soil at a depth ranging from three to five feet.

Acquisition, easements, and right-of-ways (ROWs) may be required for some of the recommended projects. For these cost estimates, pipeline corridors were assumed to be in a public ROW and do not require land acquisition.

Table 8 Transmission Costs

Element	Unit	Unit Construction Cost ($/LF)
8-inch Pipe	LF	$180
10-inch Pipe	LF	$200
12-inch Pipe	LF	$220
16-inch Pipe	LF	$240
18-inch Pipe	LF	$260
24-inch Pipe	LF	$310

7.2.3 Treatment

The Hawks Prairie Treatment Facility improvements will add VFDs to the low-lift pumps. A lump sum cost of $250,000 was used based on past projects and previous cost estimates.

7.2.4 Booster Pump Stations

BPS costs were included for ground tanks in some alternatives for both 337 and 400 PZs. BPS construction costs were estimated using a unit construction cost based on the number of pumps and horsepower (hp) of each pump.

Table 8 lists the unit construction costs used. Unit construction costs include site work, pumps, a structure, all mechanical and electrical equipment, and a back-up generator. The cost to add a VFD was assumed to be $50,000 using previous projects and engineer's estimates.

Table 9 Pump Station Costs

Horsepower	Unit	Unit Construction Cost
0 to 199 hp	Per hp per Pump	$8,200
200 to 349 hp	Per hp per Pump	$3,300
350 to 649 hp	Per hp per Pump	$2,500
>650 hp	Per hp per Pump	$1,700

7.2.5 Storage

New storage tank project costs were developed based on typical costs from past projects and Carollo's experience. Conceptual costs for tanks vary based on the type of storage: ground, standpipe, and elevated.

These costs were estimated using tank volume in gallons, as presented in Table 9. Tank costs are sensitive to site-specific geotechnical and seismic considerations; as a result, Carollo recommends conducting a tank siting study whenever a new tank project starts to address these issues.

Table 10 Tank Costs

Tank Type	Cost per gallon ($/gallon)
Ground	$1.20
Standpipe	$2.00
Elevated	$4.00

Note:
(1) Tank unit costs are for construction only.

7.2.6 Land Acquisition

Land acquisition was estimated at $500,000 per acre of land. None of the alternatives required land acquisition.

7.3 Operation and Maintenance Costs

7.3.1 Energy

The City provided an estimate of energy costs at $0.11/ kilowatt-hour (kWh).

Each pump's conceptual hp was calculated based on the facility's hydraulics. Pumps were sized based on hydraulic modeling conducted during the MDD.

The following pump efficiencies and treatment facility headloss characteristics were applied to size the pump's hp:

- Using the City's typical energy consumption, energy costs for Alternatives 1A and 1B were assumed to be $0.11 per kWh.
- Energy costs for Alternative 3 assumes $1,000 per month (accounting for lighting and pumping required under Alternative 3) for general electrical costs (instrumentation, SCADA, site lighting, etc.).
- Alternatives 1 and 2 assume $100 per month (accounting for general lighting at site).
- All energy costs assume a 3.0 percent general cost inflation per year, as noted in the City's 2013 Water Rate Study.

The resulting energy costs over 50 years are provided as a lump sum in the cost estimates presented in Appendix B.

7.3.1.1 Booster Pump Stations

The booster pumps' energy use was calculated using its anticipated design flow rate and design head. Pump and motor efficiencies were assumed to be the following:

- Pump efficiency of 85 percent.
- Motor efficiency of 90 percent.

Booster pumps will likely be operated to meet peak demands beyond the average MDD met by supplies. Peak demands were calculated using the City's summer diurnal curve, which was based on the 2016 consumption data shown in Figure 23. For each facility, the pump station's total usage was estimated using the hydraulic model. Conservatively, MDD booster station pumping was assumed to occur 60 days each year.

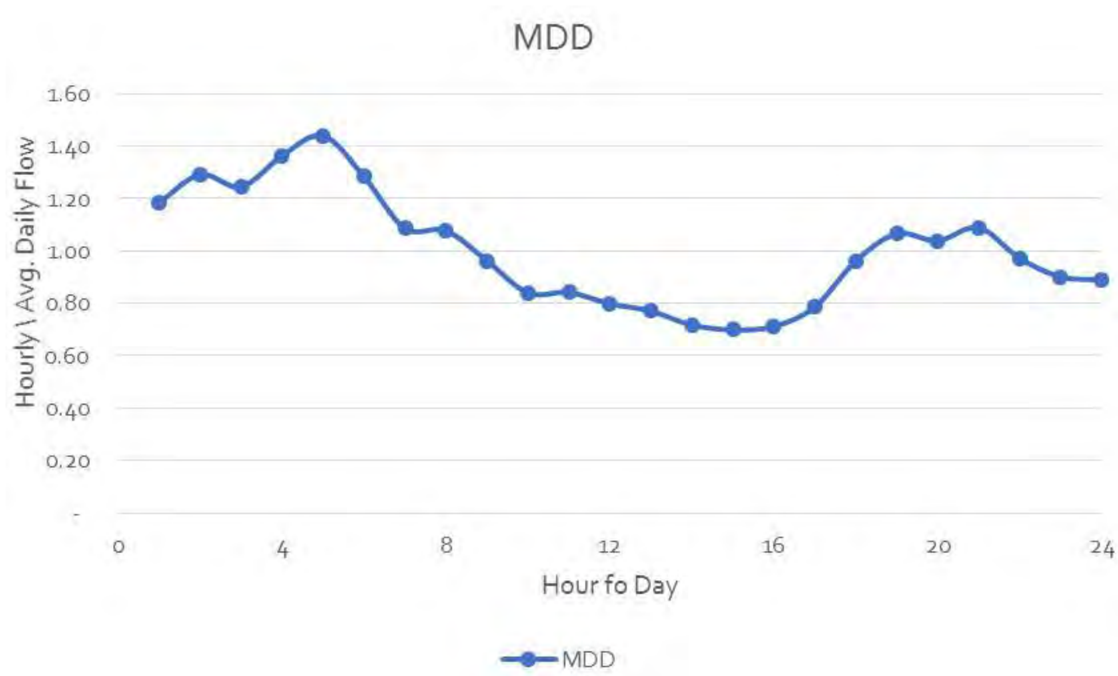

Figure 22 2016 Summer Diurnal Curve

7.3.1.2 Well Pumping

Well energy use was determined from existing City sources. The following sources represent the proposed supply projects and were thus used to size pumps:

- S02 – Well No. 2.
- S06 – Well No. 6.
- S07 – Well No. 7 + ATEC water treatment facility (Iron & Manganese Removal, disinfection).
- S21 – Madrona Well No. 1.
- S19 – Hawk's Prairie No. 1 + Hawks Prairie Treatment Facility (Iron & Manganese removal, Ammonia removal, Hydrogen Sulfide removal, disinfection).

Disinfection at other wells was assumed to have a negligible impact on well energy use.

The supply improvements are intended to meet MDD with redundant supplies and operational flexibility. Because the goal is more operational flexibility, the total amount of pumping throughout the year cannot be predicted. Furthermore, although pumping from new supplies may offset existing supplies, calculating this is beyond the scope of the project. As a result, energy costs were considered on a $/unit of pumping basis.

7.3.2 City Labor

City-provided staff to operate and maintain facilities was estimated for the generalized facilities described below.

7.3.2.1 Supply

- Well Supply, Disinfection Only (similar to S29): 204 hours, 0.10 full time equivalent (FTE), $18,478.32.

- Well Supply, Corrosion Control, Disinfection (similar to S04): 245 hours, 0.12 FTE, $22,192.10.
- Well Supply, Iron and Manganese Treatment, Disinfection (similar to Well 7 and ATEC system): 3,842 hours, 1.85 FTE, $348,008.36.
- Well Supply, Iron and Manganese Treatment, Ammonia treatment, Hydrogen Sulfide treatment, and disinfection (Similar to S19 and Hawks Prairie Treatment Facility): 3,655 hours, 1.76 FTE, $331,069.90.

7.3.2.2 Pumping

- Large Booster Pump Station with backup generator (similar to Westside): 161 hours, 0.08 FTE, $14,583.38.
- Large Booster Pump Station without backup generator (similar to hp booster): 36 hours, 0.02 FTE, $3,260.88.
- Small Booster Pump Station without backup generator (similar to McAllister/460 BPS): 12 hours, 0.01 FTE, $1,086.96.
- Booster Pump Station, PZ Transfer (limited use): although none is in the system, operations would run it at least once a month, so 12 hours, 0.01 FTE, $1,086.96 was assumed.

7.3.2.3 Tank

- Below Hydraulic Grade Storage (similar to Steilacoom Tank): 137 hours, 0.07 FTE, $12,409.46.
- At Hydraulic - Grade (Elevated) Storage: assumed to have the same labor costs as the below hydraulic grade storage.

7.3.2.4 Valves

- Pressure Reducing Valve Station (similar to PRV15, with SCADA control): 16 hours, 0.01 FTE, $1,449.28.

Note that isolation valves will likely be exercised through the City's existing valve program with negligible commitment needed from new staff.

Annual labor for new facilities was based on the existing facility that most closely matches the proposed facility. A Controls Technician/Water Treatment Plant Operator (WTPO) was assumed to perform the work, with a labor cost of $90.58/hour. This cost includes overhead, equipment, small tools, and vehicles.

A 3.0 percent labor cost inflation rate was applied to all labor costs per the 2013 Water Rate Study.

7.3.3 Pump Station Rehabilitation

Pumps require regular preventative maintenance to operate efficiently. Typically, this maintenance is performed by City Staff. Even with preventative maintenance, however, pumps and motors require complete replacement every 20 years or so due to wear. Often, code revisions also require modernizing replacement electrical equipment.

Pump station rehabilitation projects were assumed to cost 33 percent of the total pump station costs every 20 years. A 3.0 percent general cost inflation was applied per the City's 2013 Water Rate Study.

7.3.4 Tank Recoating

Steel water storage tanks typically require periodic recoating every 30 years. To compare alternatives, high-level conceptual costs for steel tank recoating were estimated. Unit costs are as follows:

- Tank Recoating: $7.59 / square feet (sf).
- Overspray Protection.
- Elevated Tank Surcharge.

These general costs include basic preparation, containment, coating material, installation, and restoration of tank appurtenances. Note that recoating material costs vary depending on the material and aesthetic specifications. Costs do not include the cost to repair corrosion or other surface damage and to replace damaged appurtenances. Complex surfaces, such as a multi-legged elevated tank, may incur additional costs due to the increased contractor effort.

Tank recoating costs should be refined during planning and predesign of any future tank. A 3.0 percent general cost inflation was applied per the City's 2013 Water Rate Study.

7.3.5 Valve Maintenance

The City contracts with GC Systems to rebuild its PRVs every five years, with an average cost of $2,000/valve. Proposed PRV and check valve stations are anticipated to require similar maintenance costs, on average.

7.4 400-PZ Alternative Costs Summary

The resulting costs for the four alternatives are shown in Table 10. Detailed costs for each alternative can be found in Appendix B.

Table 11 Summary Costs

Costs	400 PZ Alternative 1	400 PZ Alternative 2	400 PZ Alternative 3
Capital Costs(1)	$21,164,900	$9,105,200	$6,444,600(5)
O&M Costs(2)	$2,884,100	$2,300,800	$2,183,000
Total Capital and O&M(3)	**$24,049,000**	**$11,406,000**	**$8,627,600**
Ranking (Score)(4)	**1.2**	**3.0**	**4.4**

Notes:
(1) Capital costs are in 2022 dollars.
(2) O&M costs are inflated to the year in which the operation or maintenance is performed, over a 50-year period.
(3) Total costs rounded to the nearest $100.
(4) Weighted ranking from 1 (worst) to 5 (best) based on capital cost, water quality, timeline, and O&M.
(5) Costs based on 1.5 MG below-hydraulic-grade sister tank consistent with the Study's final recommendation.

Section 8

ALTERNATIVES RANKING

8.1 Ranking Methodology and Criteria

To compare the alternatives and help with a recommendation, ranking criteria were developed. As shown in Tables 11 and 12 below, the team scored each criterion between 1 and 5; a score of 1 was the worst, and a score of 5 was the best. To calculate a total score, the number was multiplied by the weight.

Costs for each alternative were evaluated, including costs before and during repairs, such as construction costs for new infrastructure and improvements to transmission mains. Costs after repair, such as life-cycle costs, were also evaluated, including capital costs and costs for additional operations FTE, power, maintenance, and replacement.

Water quality was evaluated by the team based on field observations and experience, since modeling results were not available at the time of the ranking. The alternatives' effects on water quality, such as whether it would improve, worsen, or not affect quality, were assessed. Items to consider when discussing water quality include the age of the water, chlorine demand, oxidation of manganese in the tank and distribution system, changes to source water movement and mixing in the distribution system, pH, corrosion, tank turnover, temperature, and nitrates. Water Quality was weighted differently for each time period. For modeling results of water age and source, refer to the 337 PZ Pressure and Storage Study.

In addition to water quality, the time it will take to construct an alternative was assessed. The quicker an alternative can be completed, the sooner the tank could be repaired. Thus, alternatives that could be constructed faster were ranked higher. This criteria was considered only for the period leading up to the HP Tank outage.

Lastly, the alternatives' O&M were evaluated, including whether the alternative improved or complicated operations, what impacts its O&M would have on the overall system, and how safe and easy it is to operate, maintain, and replace the new infrastructure. Note that additional O&M costs were not counted here, and that the criteria were weighted differently for each time period.

Table 12 Ranking Leading up to and During Hawks Prairie Tank Outage

Criteria	Weight	Alternative 1	Alternative 2	Alternative 3
Capital Cost	30%	1	3	5
Water Quality	10%	3	3	3
Time Line	40%	1	3	5
O&M	20%	1	3	3
Total	**100%**	**1.20**	**3.00**	**4.40**

Table 13 Ranking after Hawks Prairie Tank Outage

Criteria	Weight	Alternative 1	Alternative 2	Alternative 3
Life Cycle Cost	30%	1	3	4
Water Quality	40%	3	2	2
O&M	30%	1	3	5
Total	**100%**	**1.80**	**2.60**	**3.50**

8.2 Recommended Alternative

Based on the above ranking, Alternative 3 was recommended to move forward to pre-design and implementation.

Appendix A

SYSTEM OPERATION AND MODEL UPDATE

City of Lacey

SYSTEM OPERATIONS AND MODEL UPDATE

Final | October 2018

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STATE OF WASHINGTON
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REGISTERED
PROFESSIONAL ENGINEER

10/22/2018

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Abbreviations

Carollo	Carollo Engineers, Inc.
City	City of Lacey
EPS	extended period simulation
ft	feet
gpm	gallons per minute
HGL	hydraulic grade line
HPWTF	Hawks Prairie Water Treatment Facility
MG	million gallons
mgd	million gallons per day
MSL	main sea level
PRV	pressure reducing valves
psi	pounds per square inch
PSV	pressure sustaining valve
PZ	pressure zones
SCADA	supervisory control and data acquisition
VFD	variable frequency drive
WTP	water treatment plant

Section 1

SYSTEM CONTROLS

1.1 Background

The City of Lacey (City) provided Carollo Engineers, Inc. (Carollo) with a hydraulic model of their existing water distribution system. The model was updated with future demands and recent/upcoming projects, which are described in Section 1.4. The hydraulic model was then used to conduct a hydraulic analysis on the selected alternatives as part of the 337 Pressure Zone (PZ) Facilities and Pressure, and 400 PZ Storage Studies. This Report summarizes changes made to the model controls depending on the alternative.

1.2 Hydraulic Model Development

This section summarizes elements of a hydraulic model, how facilities are represented in a model and a review of the City's existing hydraulic model.

1.2.1 Elements of a Hydraulic Model

The following provides a brief overview of the various elements of the hydraulic model and the required input parameters associated with each:

- Junctions. Locations where pipe sizes change, where pipelines intersect, or where water demands are applied are represented by junctions in the hydraulic model. Required inputs for junctions include service elevation and water demands.
- Pipes. Water mains are represented as pipes in the hydraulic model. Input parameters for pipes include length, roughness (Manning's n factor), diameter, and whether or not the pipe is a check valve (i.e., does not allow reverse flow).
- Tanks. Cylindrical and Variable Area Tanks: Water tanks are included in the hydraulic model as either cylindrical tanks or variable area tanks, depending on the complexity of the tank geometry. Required input parameters for cylindrical tanks include bottom elevation, maximum level, initial level, and diameter. Required input parameters for variable area tanks include bottom elevation, maximum level, initial level, and a curve that varies the cross sectional area of the tank depending on the tank level (developed as appropriate based on As-built drawings).
- Fixed Head Reservoirs (water sources): For water distribution system modeling, fixed head reservoirs are used to represent a water source with a constant hydraulic grade line (HGL). Typically, fixed head reservoirs are used to represent water sources, such as wells or other sources.
- Pumps. Pumps are included in the hydraulic model as links. Input parameters for pumps include pump curves and operational controls.
- Valves. A number of different valves, such as pressure reducing valves (PRVs) and float valves, are represented as links in the hydraulic model. Required input parameters for valves include diameter, operational controls, and other settings or headloss curves depending on the type of valve.

- Demands. Water demands are applied at specific junctions in the hydraulic model. Up to ten different demands can be assigned at a particular junction.

1.2.2 Hydraulic Model Review

The City provided Carollo with a calibrated hydraulic model updated with 2016 demands and 2017 facilities to complete the alternatives analysis. A model review was conducted to understand the overall operations regarding production of various water supplies and system facilities prior to modeling alternatives.

Figure 1.1 shows the modeled water distribution system's pipeline alignments, as well as the locations of the tanks, wells, pump stations, PRVs, interconnections, and pressure zones. The modeled water distribution system consists of over 324 miles of pipelines ranging from 0.5-inch to 18-inches in diameter. The following sections summarize the facilities characteristics and operational scheme. These sections include tables that summarize the facilities and lists simplified controls for the respective facilities. However, these tables do not fully represent the control logic within the hydraulic model. A copy of the detailed control logic is included in Appendix 1.

1.2.2.1 Pressure Zones

There are nine (9) PZs within the City's distribution system designed to provide acceptable operating pressures throughout the system. Table 1.1 lists the maximum HGL of each pressure zone, which range from 188 feet (ft) to 460 ft above mean sea level (MSL). The City delineated pressure zones using closed valves and pipes.

Table 1.1 Pressure Zones

Pressure Zone(1)	Maximum HGL(1) (ft)	Lowest Customer Static Pressure(2) (psi)(6)	Highest Customer Static Pressure(3) (psi)
188 PZ	188	22(5)	73
211 PZ(4)	211	--	--
224 PZ	224	45	67
275 PZ	275	34	89
337 PZ	337	37	108
375 PZ	375	63	113
400 PZ	400	42	113
422 PZ(4)	422	--	--
460 PZ	460	67	101

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Lowest Customer Static Pressure = (PZ's Maximum HGL - highest PZ's elevation with demand)/2.31.
(3) Highest Customer Static Pressure = (PZ's Maximum HGL - lowest PZ's elevation with demand)/2.31.
(4) PZ was modeled as a single demand at a point within the PZ its source.
(5) This is a junction pressure in the model. It is not the pressure customers receive.
(6) psi: pounds per square inch.

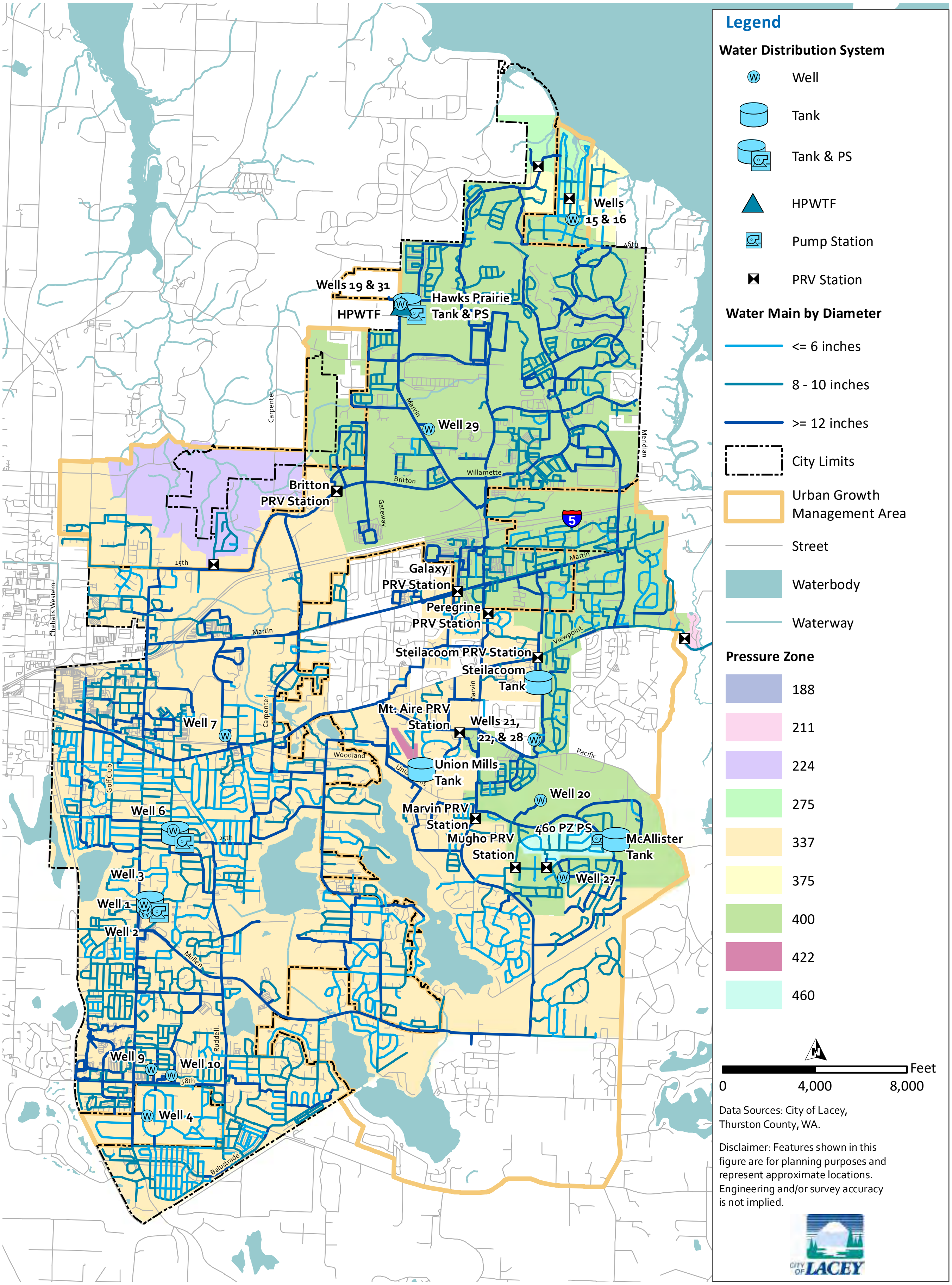


Figure 1.1 Existing Modeled Water Distribution System

1.2.2.2 Water Supply

Water is supplied from 20 groundwater wells and the Olympia Water System is used under emergency conditions. For the purpose of the hydraulic analysis, the Olympia Water System is assumed to be inactive. Many of the hydraulic model's wells were modeled as a fixed head reservoir with a pump and control valves. The control valves would dictate the wells production and discharge pressure. It is assumed that the wells are calibrated and reflect actual well performance. Wells operate using control logic based on tank levels and system pressures. Table 1.2 lists the City's well characteristics such as supply pumping capacity in gallons per minute (gpm) and simplified controls. The capacities shown in Table 1.2 were taken from the City’s provided hydraulic model. These capacities were updated as part of the Ability to Serve analysis in Section 1.4.3. Detailed control logic is included in Appendix 1.

Table 1.2 Groundwater Wells

Well No.	Pressure Zone	Capacity[1] (gpm)
S01	337 PZ	510
S02	337 PZ	475
S03	337 PZ	200
S04	337 PZ	750
S06	337 PZ	265
S07	337 PZ	1,800
S09	337 PZ	700
S10	337 PZ	950
S15	400 PZ	170
S16	400 PZ	170
S19	400 PZ	670
S20	400 PZ	600
S21	400 PZ	1,600
S22	400 PZ	1,600
S24	188 PZ	70
S25	188 PZ	230
S27	400 PZ	750
S28	400 PZ	1,600
S29	400 PZ	975
S31	400 PZ	620

Note:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.

1.2.2.3 Storage Tanks

Water distribution systems rely on stored water to help equalize daily fluctuations between supply and demand, to supply sufficient water for firefighting, and to meet demands during an emergency or an unplanned outage of a major source of supply.

The City's hydraulic model includes seven storage tanks and one clear well with volumes ranging from 0.15 million gallons (MG) to 4 MG. Table 1.3 summarizes detailed information for each of the storage tanks.

Table 1.3 Storage Tanks

Tank	Pressure Zone	Storage Capacity (MG)	Grade	Bottom Elevation (ft)	Max. Water Level (ft)	Maximum HGL (ft)
Hawks Prairie	400 PZ	4.05	Below	295	85	380
Judd Hill	337 PZ	0.34	Below	236	50	286
McAllister	400 PZ	1.18	At	300	99	399
Nisqually	188 PZ	0.15	At	162	28	190
Steilacoom	337 PZ	2.94	At	267	71	338
Union Mills	337 PZ	2.12	At	272	63	334
West Side	337 PZ	1.86	Below	233	39	272

Notes:
(1) Source: City of Lacey Water System Comprehensive Plan.
(2) Source: City of Lacey Water Distribution System Hydraulic Model.

As shown in Table 1.3, the City's distribution system includes three (3) tanks that are below the respective pressure zones HGL. For these tanks, water is stored via control valve to transfer water from the pressure zone to the tank without exceeding the allowable pressure. Water is supplied to the pressure zone via pump station transferring stored water.

A few notable controls in regards to the City's modeled storage tanks:

- Hawks Prairie Tank is modeled with a pressure sustaining valve that opens when a set upstream pressure is met and closes when the 400 PZ Pump Station is on.
- Judd Hill Tank is modeled with a pressure sustaining valve that opens when a set upstream pressure is met and closes when Judd Hill Pump Station is on.
- McAllister Tank is modeled with a pressure breaker valve to force a specified pressure drop across the valve. Pressure breaker valves are not true physical devices but used to model a particular pressure drop when known.
- Union Mills Tank is modeled with a pressure breaker valve to force a specified pressure drop across the valve. Pressure breaker valves are not true physical devices but used to model a particular pressure drop when known.
- West Side Tank is modeled with a pressure sustaining valve to maintain a set upstream pressure and closes when the West Side Pump Station is on.
- Note, Hawks Prairie contact basin is modeled to accurately represent water treatment plant (WTP) operations. It is not finished water storage.

1.2.2.4 Pump Stations

Water distribution systems rely on pump stations to move water from lower pressures to areas of higher pressures. The hydraulic model includes six pump stations. Pump stations are typically modeled as multiple point curves. For pumps with variable frequency drives (VFDs), the City’s hydraulic model has pump setup such that a pressure reducing valve follows the pumps, essentially making them act like a VFD pump. The City inputted the hydraulic pump data into the model based on pump curves. It is assumed that the modeled pump stations are calibrated and reflect actual pump performance. Table 1.4 includes pump station characteristic and simplified controls. Detailed control logic is included in Appendix 1.

Table 1.4 Pump Stations

Pump Station(1)	From	To	Pumping Capacity(1) (gpm)
400 PZ	Hawks Prairie Tank	400 PZ	3,700
460 PZ	400 PZ	460 PZ(4)	500
Hawks Prairie	Hawks Prairie contact basin	400 PZ	2,000
Judd Hill	Judd Hill Tank	337 PZ	1,200
Skyridge(3)	400 PZ	422 PZ	110
West Side	West Side Tank	337 PZ	4,500

Notes:
(1) Source: City of Lacey Water System Comprehensive Plan.
(2) Source: City of Lacey Water Distribution System Hydraulic Model.
(3) Not included in the City's Water Distribution System Hydraulic Model.
(4) This study used the modeled 460 PZ, before field measurements put into question the pressure of the zone. The impact to this study is negligible.

1.2.2.5 Pressure Reducing Valves

PRVs allow distribution systems to transfer water from upper PZs to lower PZs without exceeding the allowable pressures in the lower zones or completely draining the pressure out of the higher zone. The water is transferred through a valve that reduces the pressure to a specified pressure setting. A PRV stations typically consist of several valves that are standby, or backup.

The City's distribution system includes 12 PRV stations, which convey and regulate water to lower zones. Five (5) of these twelve (12) have solenoids controlled by supervisory control and data acquisition (SCADA). The City's PRV station's typically included another valve that would open to move water at higher rates during a fire flow or an emergency situation. Table 1.5 lists the City's existing PRV stations. It is assumed that the PRV stations are calibrated and reflect actual PRV station performance. Some of the PRV stations have mechanical valves. These valves have controls based on tank levels and when the mechanical valve opens the PRVs close. See Appendix 1 for detailed control logic. The pressure ranges listed in Table 1.5 reflect the PRV pressure settings as HGL equivalent. Mechanical valves HGL equivalent is based on the lower HGL equivalent for control logic and PRV settings.

Table 1.5 Pressure Reducing Valve Stations

Station Name	From	To	Number of Valves	HGL Equiv. Range(1) (ft)
Britton Parkway	400 PZ	337 PZ	2	272 - 303(2)
Evergreen Heights	460 PZ	400 PZ	1	358
Galaxy	400 PZ	337 PZ	3	319 - 331(2)
Lower Beachcrest	375 PZ	275 PZ	2	261 - 272
Marvin Road	400 PZ	337 PZ	3	272 - 326(2)
Mt. Aire	400 PZ	337 PZ	3	310 - 327(2)
Mugho	400 PZ	337 PZ	1	326(2)
Nisqually	337 PZ	188 PZ	2	177 - 182
Peregrine	400 PZ	337 PZ	2	315 - 327
Steilacoom	400 PZ	337 PZ	1	327
Upper Beachcrest	400 PZ	375 PZ	2	363 - 375
Woodland Creek	337 PZ	224 PZ	2	212 - 224

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) See Appendix A for station's detailed control logic.

1.3 Current System Operations

The City's hydraulic model controls and logic was provided by the City and reflects how the City operates their system. These were identified by converting tank level or node pressure controls to an HGL equivalent control to determine the primary and secondary control facilities.

A primary control facility is the facility that dictates when a supply will open and close under static conditions. A secondary control facilities are facilities less stringent than primary controls under static conditions, or open under emergency conditions. Primary control facilities were used to determine the supply lead and lag order, while secondary controls were used to determine order incase primary control facilities equivalent HGL were the same.

Table 1.6 and Table 1.7 list the 400 PZ and 337 PZ supply order, respectively. The tables include pump stations that pump stored water and PRV Stations that moves water from higher pressures zones.

Table 1.6 400 PZ Supply Order

Supply Facility	Primary Control Facility[1]	Open HGL Equiv.[1] (ft)	Open Rank	Closed HGL Equiv.[1] (ft)	Closed Rank
S27	McAllister Tank	393	1	395	7
S20	McAllister Tank	392	2	397	8
S21	McAllister Tank	392	2	394	5
S22	McAllister Tank	392	2	394	5
S28	McAllister Tank	391	3	395	6
400 PZ Pump Station	400 PZ	384	4	--	--
S19[2]	Hawks Prairie Tank	373	5	379	4
S15	Hawks Prairie Tank	373	5	377	3
S16	Hawks Prairie Tank	373	5	377	3
S29	Hawks Prairie Tank	372	6	375	2
S31[2][3]	Hawks Prairie Tank	360	7	373	1

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Hawks Prairie Treatment Facility operates when Well 19 or Well 31 is operating.
(3) Existing Well 31 is offline due to well rehabilitation.

Table 1.7 337 PZ Supply Order

Supply Facility	Primary Control Facility[1]	Open HGL Equiv.[1] (ft)	Open Rank	Closed HGL Equiv.[1] (ft)	Closed Rank
S02	Steilacoom Tank	332	1	335	5
S04	Steilacoom Tank	332	1	333	3
S07	Steilacoom Tank	332	1	334	4
S03	Steilacoom Tank	331	2	334	4
S10	Steilacoom Tank	331	2	334	4
Galaxy PRV Station	Steilacoom Tank	331	2	--	--
S01[2]	Steilacoom Tank	330	3	332	2
S09	Steilacoom Tank	329	4	332	2
Mt. Aire PRV Station	Steilacoom Tank	327	5	--	--
Peregrine PRV Station	337 PZ	327	5	--	--
Steilacoom PRV Station	337 PZ	327	5	--	--
Marvin Rd. PRV Station	337 PZ	326	6	--	--
Mugho PRV Station	337 PZ	326	6	--	--
S06	Steilacoom Tank	325	7	330	1
West Side Pump Station	337 PZ	324	8	--	--
Britton Parkway PRV Station	337 PZ	303	9	--	--
Judd Hill Pump Station	337 PZ	299	10	--	--

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Existing Well 1 is offline.

1.4 Future Supply Projects

In order to serve future users, the City has planned projects to implement within the planning period of the study (through 2028). This section discusses those improvements and corresponding changes made to the model as a brief description of control changes. The facility and control changes apply to all alternatives unless stated otherwise.

1.4.1 Existing Supply Model Updates

The City provided updated supply capacity information that wasn't entirely reflected in the model. The City's existing supply capacity facility operations are updated in the model. These model updates reflect existing supply conditions and may change based on future 400 PZ and 337 PZ alternatives. Table 1.8 lists the initial modeled well capacities and the updated existing well capacities based on City's staff input. Note that during the hydraulic model runs, both S19 and S7 are offline for redundancy and operational criteria purposes.

Table 1.8 Existing Well Capacity Model Update

Well No.	Pressure Zone	Initial Model Capacity(1) (gpm)	Updated Model Capacity(2) (gpm)
S01	337 PZ	510	0
S02	337 PZ	475	500
S03	337 PZ	200	206
S04	337 PZ	750	750
S06	337 PZ	265	290
S07	337 PZ	1800	1800
S09	337 PZ	700	730
S10	337 PZ	950	1,030
S15	400 PZ	170	190
S16	400 PZ	170	220
S19	400 PZ	670	620
S20	400 PZ	600	580
S21	400 PZ	1,600	1,350
S22	400 PZ	1,600	1,350
S24	188 PZ	70	80
S25	188 PZ	230	160
S27	400 PZ	750	1,000
S28	400 PZ	1,600	1,350
S29	400 PZ	975	1,000
S31(3)	400 PZ	620	0

Notes:
(1) Source: City of Lacey Water Distribution System Hydraulic Model.
(2) Source: City of Lacey Staff input.
(3) S31 is offline in 2016 then modeled at 620 gpm instead of 800 gpm for 2022 and 2028.

1.4.2 Planned Supply Improvements

The City confirmed that they have five (5) planned supply improvements. Figure 1.2 shows the location of the planned supply improvements.

The City's planned improvements require that facility operations be added or updated in the model. Planned supply improvement descriptions and model updates are listed below. It is assumed that operational changes listed below are applied to 400 PZ and 337 PZ alternatives unless stated otherwise.

- In 2019, pump improvements at S19 and S31 going back online to add 980 gpm (1.41 million gallons per day [mgd]) of supply.
- In 2019, S15/S16 upgrades in 2019 to add 110 gpm (0.16 mgd) of supply.
- New Marvin Road Well with a pumping capacity of 1,000 gpm (1.44 mgd) in 2021. The increase in supply is 200 gpm (0.29 mgd) because the Hawks Prairie Water Treatment Facility (HPWTF) can only treat 1,800 gpm (2.59 mgd) of supply from S19, S31, and Marvin Road Well.
- The replacement well for S01 will be in service in 2022 to add 665 gpm (0.96 mgd) of supply.
- HPWTF expansion in 2028 will allow the full use of S19, S31, and Marvin Road Well water rights to add 800 gpm (1.15 mgd) of supply.
- In order to meet redundancy criteria the largest well is taken out of service. For the hydraulic model analysis Well 7's (S07) controls were disabled.
- In order to meet operational criteria Well 19 (S19) is considered offline. For the hydraulic modeling analysis Well 19 controls were disabled.

1.4.3 Ability to Serve Supply Project Alternatives

During the ability to serve analysis it was determined that the City will need to add an additional 539 gpm to meet the redundancy and operational criteria by 2028. Four (4) supply alternatives were discussed, however, for the purpose of the hydraulic model analysis only the preferred alternatives will be modeled for 400 PZ and 337 PZ alternatives analysis. The preferred alternative allows full use of the Madrona's water rights. This alternative does not require pump upgrades, additional treatment, or wells. However, distribution piping improvements may be needed to convey the additional flows. Table 1.9 shows the updated future well capacities incorporating planned supply improvements and the preferred alternative improvements.

Table 1.9 Planned Well Capacity

Well No.	Pressure Zone	Planned Capacity (gpm)[1]	Implementation Year
S01	337 PZ	665	2022
S15	400 PZ	255	2019
S16	400 PZ	255	2019
S19[(2)]	400 PZ	1,600	2019
S21	400 PZ	1,600	2028
S22	400 PZ	1,600	2028
S28	400 PZ	1,600	2028
Marvin Road		1,000	2021

Notes:
(1) Wells without improvements maintain the capacities shown in Table 1.8.
(2) Well 19 is offline during the hydraulic analysis because of the operational criteria.

The operational controls associated with the Madrona's full water rights alternative require that facility operations be updated in the model.

- Existing pipelines that show capacity deficiencies will be identified and upsized during the hydraulic model alternative analysis.
- Well 21 (S21), Well 22 (S22) and Well 28 (S28) are revised to supply an additional combined capacity of 748 gpm. This equals to approximately 1,600 gpm each.

1.4.4 Planned Pipeline Improvements

The City provided information on seven (7) planned pipeline improvement projects. The model was updated with these improvement projects based on near-term. The following projects were incorporated in the hydraulic models near-term scenarios:

- College and 22nd Street.
- Capital City Golf Course Fire Flow Improvement.
- 2017 Waterline Replacement Project 2.
- Mullen Road Water Project.
- 48th Avenue and 50th Avenue Fire Flow Improvements.
- Oak Preserve Development.
- Impala Water Main Replacement.
- Gateway Development.

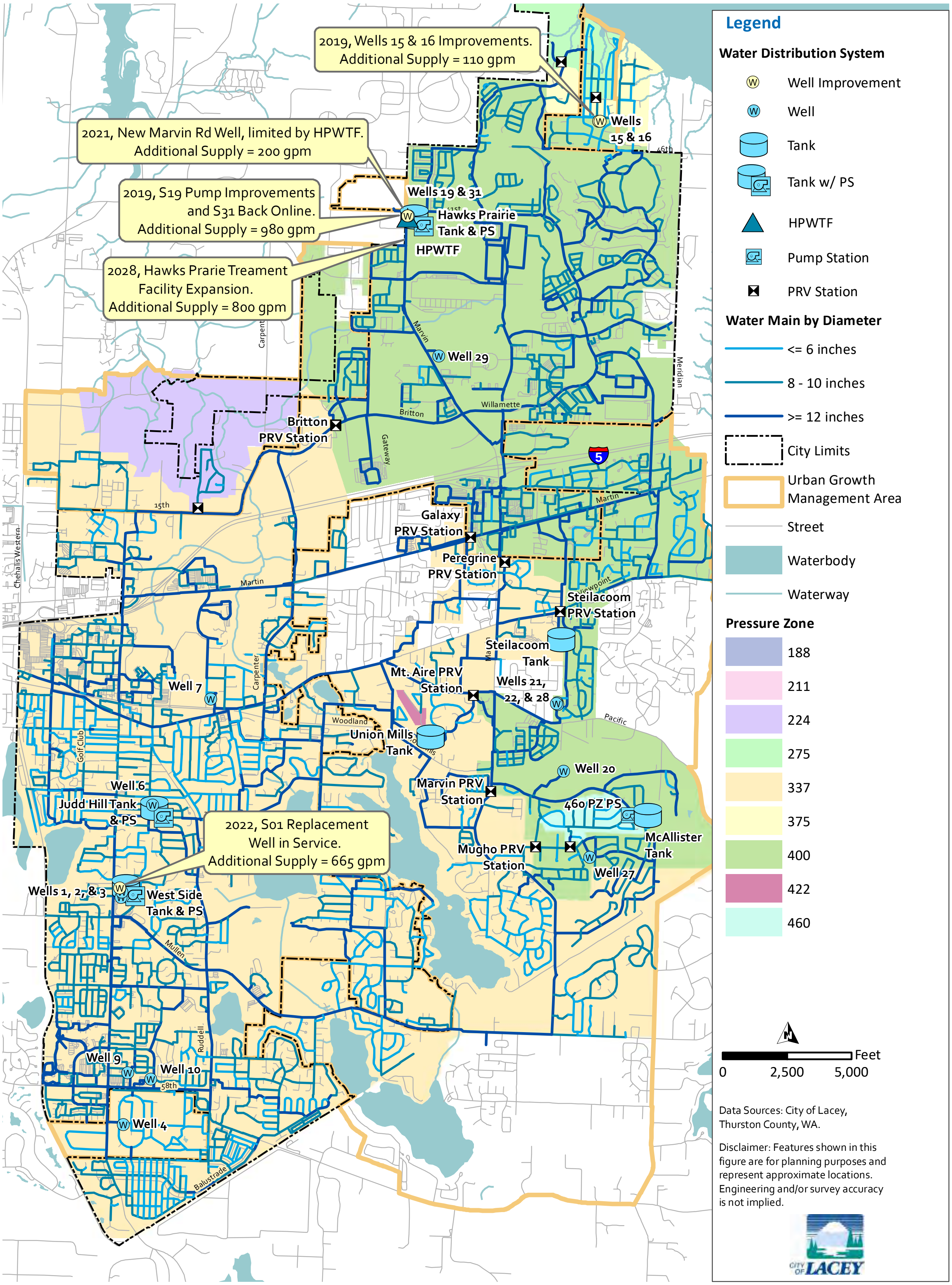


Figure 1.2 Planned Supply Improvements

1.5 400 PZ Storage Study

The City plans to take Hawks Prairie tank offline for six (6) months during the 2022 summer for maintenance. The initial analysis showed 400 PZ north of the highway fell below 30 psi in some locations when Hawks Prairie tank is taken offline under peak hour demand conditions. The 400 PZ's northern and southern portions are connected via two (2) pipelines that cross the highway. The hydraulic model indicated that the distribution system is unable to supply fire protection to its customers when Hawks Prairie tank is taken offline. The required fire suppression storage is 0.96 MG. Without Hawks Prairie Tank the City will only have 0.52 MG of fire suppression storage. Table 1.10 summarizes 400 PZ's fire suppression storage volume balance without Hawks Prairie Tank. Based on Table 1.10, the City's 400 PZ requires approximately 0.5 MG of additional fire suppression storage to meet its fire suppression storage volume requirements. Several, alternatives were explored and three were chosen to move forward for the 400 PZ Storage Study.

Table 1.10 400 PZ's Fire Suppression Storage Balance

Pressure Zone	Total Capacity (MG)	Available Fire Suppression Storage(1) (MG)	Required Fire Suppression Storage(2) (MG)	Fire Suppression Storage Balance (MG)
400 PZ w/ Hawks Prairie Tank online	5.23	4.09	0.96	3.13
400 PZ w/ Hawks Prairie Tank offline	1.18	0.52	0.96	-0.44

Notes:
(1) Source: City of Lacey Water System Comprehensive Plan.
(2) Required fire suppression storage = 4,000 gpm for 4 hours.

1.5.1 400 PZ Alternative Descriptions

The following is a brief description of the facilities associated with each 400 PZ alternative:

- 400 PZ Alternative 1 (400-1) consists of the following facilities:
  - Add VFDs to the Hawks Prairie Treatment Facility low lift pumps.
  - Construct a pump station at McAllister or Steilacoom tank site. The pump station is designed to access dead storage thus expanding the City's 400 PZ's fire suppression storage. Transmission mains will have to be upsized to enable additional flow from the southern to the northern portion of the 400 PZ. Tank will be isolated from the system when the pump station is running. There might be some reconfiguration to be done to allow this operation.
- 400 PZ Alternative 2 (400-2) consists of the following facilities:
  - Add VFDs to the Hawks Prairie Treatment Facility low lift pump station's pumps.
  - Construct an at-hydraulic-grade tank at the existing Marvin Road Well site, which is located next to the new school site. This facility will be referred to as School tank in these appendices. To meet the required fire suppression storage volume this tank must have minimum storage capacity of 0.44 MG. The School tank will be 1.0 MG to meet the minimum storage capacity and add some additional for equalization.

- 400 PZ Alternative 3 (400-3) consists of the following facilities:
  - Construct a below-hydraulic-grade sister tank at the Hawks Prairie Site. This facility will be referred to as Sister Tank. To meet the required fire suppression storage volume this tank must have minimum storage capacity of 0.44 MG. The Sister Tank will be 1.0 MG to meet the minimum fire suppression storage (0.44 MG) and add some additional for equalization storage (0.56 MG).

1.5.2 400 PZ Operation Changes

The 400 PZ alternatives require that facility operations be added or updated in the model while Hawks Prairie tank is taken offline. These facility and operational changes are listed below. The following operational changes are applied to all 400 PZ alternatives while the Hawks Prairie tank is offline:

- Wells 7 and 19 controls are disabled for all alternatives.
- Wells 21, 22, and 28 controls related to Hawks Prairie Tank level were modified. These wells will continue to be controlled by their primary control facility, McAllister Tank Level. Controls related to Hawks Prairie Tank were modified and described in the following sections.
- Planned Marvin Road Well will be modeled as a reservoir and a flow control valve.

The following sections describe operational changes applied to each alternative while Hawks Prairie tank is offline. It is assumed that facilities will operate according to their existing controls when Hawks Prairie tank is online. The facilities will be operated to ensures sufficient pressure and maintain the minimum required fire suppression storage while the Hawks Prairie Tank is offline.

1.5.2.1 Alternative 400-1

The following model updates are associated with Alternative 400-1 (while Hawks Prairie Reservoir is offline):

- Planned Marvin Road Well controls:
  - If J-965 pressure is below 45 psi then Marvin Road Well is open.
  - If J-965 pressure is above 50 psi then Marvin Road Well is closed.
- Modify Well 31 controls:
  - If J-965 pressure is below 35 psi then Well 31 is open.
  - If J-965 pressure is above 40 psi then Well 31 is closed.
- Modify Wells 15 and 16 controls:
  - If J-965 pressure is below 40 psi then Well 15 is open and Well 16 is open.
  - If J-965 pressure is above 45 psi then Well 15 is closed and Well 16 is closed.
- Modify Well 29 controls:
  - If J-965 pressure is below 30 psi then Well 29 is open.
  - If J-965 pressure is above 35 psi then Well 29 is closed.
- Modify Well 21 controls related to Hawks Prairie Tank:
  - If J-8311 pressure is below 25 psi then Well 21 is open.
  - If J-8311 pressure is above 30 psi then Well 21 is closed.
- Modify Well 22 controls related to Hawks Prairie Tank:
  - If J-8311 pressure is below 35 psi then Well 22 is open.
  - If J-8311 pressure is above 40 psi then Well 22 is closed.

- Modify Well 28 controls related to Hawks Prairie Tank:
  - If J-8311 pressure is below 30 psi then Well 28 is open.
  - If J-8311 pressure is above 35 psi then Well 28 is closed.
- McAllister Pump Station controls:
  - If fire within 400 PZ then McAllister Pump Station is open and a control valves are closed to isolate McAllister Tank from 400 PZ.
  - If no fire within 400 PZ then McAllister Pump Station is closed and control valves are open that allows McAllister Tank to float within the 400 PZ.
- Britton and Galaxy PRV Stations are closed while Hawks Prairie Tank is offline.

The model has the proposed Marvin Road Well, S19, and S31 discharging to the contact basin. The model ensures the total flow rate of these wells does not exceed the HPWTF capacity.

1.5.2.2 Alternative 400-2

The following model operational updates are associated with Alternative 400-2 (while Hawks Prairie Reservoir is offline):

- Planned Marvin Road Well controls:
  - If School Tank level is below 32 ft then Marvin Road Well is open.
  - If School Tank level is above 35.5 ft then Marvin Road Well is closed.
- Modify Well 31 controls:
  - If School Tank level is below 32 ft then Well 31 is open.
  - If School Tank level is above 35.5 ft then Well 31 is closed.
- Modify Wells 15 and 16 controls:
  - If School Tank level is below 30 ft then Well 15 is open and Well 16 is open.
  - If School Tank level is above 34 ft then Well 15 is closed and Well 16 is closed.
- Modify Well 29 controls:
  - If School Tank level is below 28 ft then Well 29 is open.
  - If School Tank level is above 32 ft then Well 29 is closed.
- Modify Well 21 controls related to Hawks Prairie Tank:
  - If School Tank level is below 22 ft then Well 21 is open.
  - If School Tank level is above 27 ft then Well 21 is closed. Assuming other controls is satisfied.
- Modify Well 22 controls related to Hawks Prairie Tank:
  - If School Tank level is below 27 ft then Well 22 is open.
  - If School Tank level is above 32 ft then Well 22 is closed. Assuming other controls is satisfied.
- Modify Well 28 controls related to Hawks Prairie Tank:
  - If School Tank level is below 23 ft then Well 28 is open.
  - If School Tank level is above 28 ft then Well 28 is closed. Assuming other controls is satisfied.
- Britton and Galaxy PRV Stations are closed while Hawks Prairie Tank is offline.

1.5.2.3 Alternative 400-3(while Hawks Prairie Reservoir is offline):

The following model operational updates are associated with Alternative 400-3:

- Planned Marvin Road Well controls:
  - If Hawks Prairie Sister Tank level is below 78 ft then Marvin Road Well is open.

  - If Hawks Prairie Sister Tank level is above 84 ft then Marvin Road Well is closed.
- Modify Well 31 controls:
  - If Hawks Prairie Sister Tank level is below 78 ft then Well 31 is open.
  - If Hawks Prairie Sister Tank level is above 84 ft then Well 31 is closed.
- Wells 15, 16, 21, 22, 28, and 29 will be controlled by the Hawks Prairie sister tank using the same set points as the existing Hawks Prairie Tank.
- Britton and Galaxy PRV Stations are closed while Hawks Prairie Tank is offline.

1.6 337 PZ Facilities and Pressure Study

The City has a goal of improving its level of service beyond what is in the Water System Plan. The City's operational staff spends significant amount of time responding to pressure complaints. Typically low pressures are the result of a customer having a high service elevation. The City's staff found that customer complaints increase when 337 PZ's pressure falls below 45 psi, and set a goal for its minimum operational pressure of 40 psi during normal conditions. Note, the City requires 30 psi during peak hour demand conditions and 20 psi during the maximum day demand plus fire flow. The purpose of the 337 PZ Facilities and Pressure Study is to perform an alternatives analysis in order to improve system pressures under near-term and future conditions. Figure 1.3 shows locations in 337 PZ where the pressure falls below 40 psi under static conditions.

An initial modeling analysis was completed using the City's existing model to determine where deficiencies occur and develop alternatives to mitigate deficiencies. First, static pressures were calculated using node elevations and the HGL set to 337 ft. The static pressures do not account for demands, headloss, and system operations. Customers near the College corridor experienced static pressures no more than 41 psi. An extended period simulation (EPS) under 2016 summer conditions was performed to understand the impact operations have on system pressures. The preliminary analysis found that pressures fell below 40 psi along the College corridor. The number of customers with pressures below 40 psi slightly decreased during the winter conditions. Several alternatives were explored and three were chosen to move forward with in 337 PZ Facilities and Pressure Study.

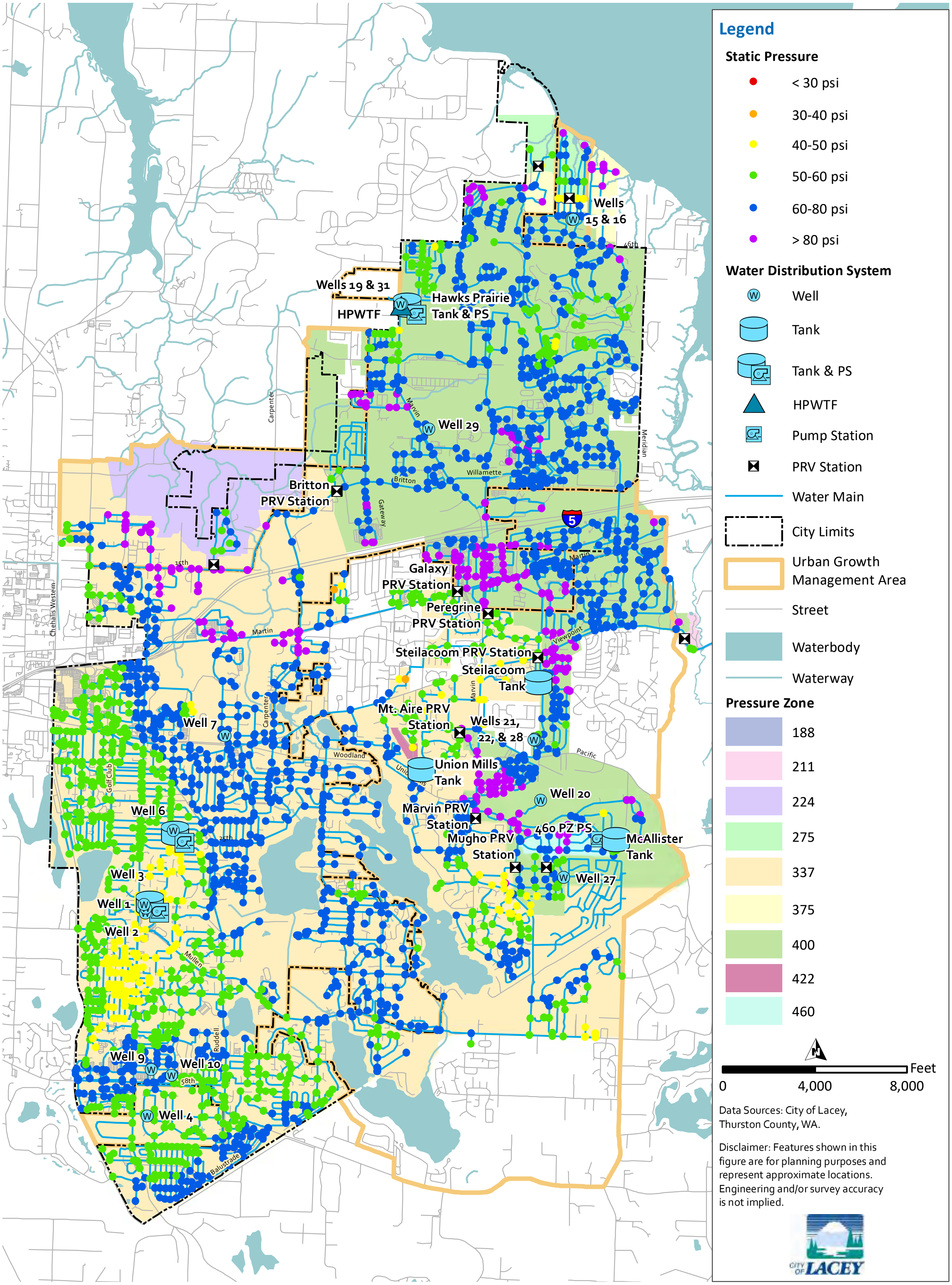


Figure 1.3 Static Pressures

1.6.1 337 PZ Alternative Descriptions

The following is a brief description of the facilities associated with each 337 PZ alternative:

- 337 PZ Alternative 1 (337-1) consists of the following facilities:
  - Rezone the College Corridor. The new pressure zone will be referred to as 380 PZ. Check valves will be installed to isolate 380 PZ from 337 PZ during normal operating conditions. The check valves will open in the event of low pressures in 380 PZ. The rezone boundaries will be developed to capture areas with low pressures. The actual boundaries will be developed later during hydraulic model alternative analysis.
  - Construct a 0.75 MG at-hydraulic-grade tank on the Intelco property site. The elevated tank at grade with 337 PZ. This proposed elevated tank will be referred to as Intelco Elevated Tank.
  - Construct a pump station on the Intelco property site. This new facility will be referred to as 380 PZ Pump Station. The proposed pump station will move water from 337 PZ to the new 380 PZ. The 380 PZ Pump Station will be sized to supply domestic water demands within 380 PZ.
- 337 PZ Alternative 2 (337-2) consists of the following facilities:
  - Rezone the College Corridor. The new pressure zone is identical to Alternative 1's rezone.
  - Construct a 1.5 MG below-hydraulic-grade storage tank on the Intelco property site. This proposed tank will be referred to as Intelco Below Grade Tank. Because the tank is below 337 PZ's HGL a pump station is required to supply the 337 PZ. The tank will be filled from 337 PZ using a control valve.
  - Construct a pump station with two sets of the pumps on the Intelco property site:
    - The first set will supply the rezoned 380 PZ and is referred to as the 380 PZ Pump Station. The proposed pump station will move water from 337 PZ to the new 380 PZ. The 380 PZ Pump Station will be sized to supply domestic water demands within 380 PZ.
    - The second set will be the 337 PZ Pump Station. The purpose of this facility is to supply the 337 PZ with water stored in the Intelco below Grade Tank for both fire and domestic purposes.
- 337 PZ Alternative 3 (337-3) consists of the following facilities:
  - Construct a 0.75 MG at-hydraulic-grade tank on the Intelco property site. This proposed elevated tank will be referred to as Intelco Elevated Tank. The elevated tank will be at the 337 PZ grade.
  - Upgrade Well 10 (S10) with a VFD. The VFD will help stabilize pressures in the surrounding area.
  - This alternative is considered acceptable if pressures are maintained above 38 psi without large fluctuations during both winter and summer conditions.
- For all 337 PZ alternatives:
  - It is assumed that 400 PZ Alternative 3 facilities are implemented for 337 PZ hydraulic analysis.

1.6.2 337 PZ Operational Changes

The 337 PZ alternatives require that facility operations be added and updated in the model. Model updates are described in the following sections. The following operational changes are applied to all 337 PZ alternatives:

- Wells and 7 and 19 controls are disabled for all alternatives.
- Wells 1, 2, 3, 4, 6, 9, and 10 will continue to be operated by their existing control facilities. Controls related to proposed facilities were modified and described in the following sections.

1.6.2.1 Alternative 337-1

The following model updates are associated with Alternative 337-1:

- Modify Well 1 controls:
  - If Intelco Tank level is below 25 ft then Well 1 is open.
  - If Intelco Tank level is above 30 ft then Well 1 is closed.
- Modify Well 4 controls:
  - If Intelco Tank level is below 27 ft then Well 4 is open.
  - If Intelco Tank level is above 32 ft then Well 4 is closed.
- Modify Well 9 controls:
  - If Intelco Tank level is below 30 ft then Well 9 is open.
  - If Intelco Tank level is above 35 ft then Well 9 is closed.
- Modify Well 10 controls:
  - If Intelco Tank level is below 28 ft then Well 10 is open.
  - If Intelco Tank level is above 33 ft then Well 10 is closed.
- New 380 PZ boundary controls:
  - Some of the 380 PZ boundary pipes will become check valves that enables flow from 337 PZ to 380 PZ during emergency or fire events. A check valve is not an actuated valve and does not have controls or settings.
  - If the 380 PZ's HGL were to drop below the 337 ft, the check valves will open and revert back to 337 PZ HGL. This is expected to only occur during fire or emergency conditions.
  - The use of check valves is possible because the initial hydraulic model analysis did not show fire flow deficiencies within 337 PZ under existing conditions.
  - A PRV station will be constructed allowing flow from 380 PZ to 337 PZ to prevent over pressurization in 380 PZ.
- New 380 PZ Pump Station controls:
  - This pump station will be setup as a VFD and is set to maintain a minimum pressure of 42 psi within 380 PZ.
  - The proposed 380 PZ Pump Station to be sized for supplying domestic flows.

1.6.2.2 Alternative 337-2

The following model updates are associated with Alternative 337-2:

- Modify Well 1 controls:
  - If Intelco Tank level is below 30 ft then Well 1 is open.
  - If Intelco Tank level is above 36 ft then Well 1 is closed.

- Modify Well 4 controls:
  - If Intelco Tank level is below 27 ft then Well 4 is open.
  - If Intelco Tank level is above 32 ft then Well 4 is closed.
- Modify Well 9 controls:
  - If Intelco Tank level is below 34 ft then Well 9 is open.
  - If Intelco Tank level is above 39 ft then Well 9 is closed.
- Modify Well 10 controls:
  - If Intelco Tank level is below 32 ft then Well 10 is open.
  - If Intelco Tank level is above 36 ft then Well 10 is closed.
- New 380 PZ boundary controls:
  - Some of the 380 PZ boundary pipes will become check valves that enables flow from 337 PZ to 380 PZ during emergency or fire events. A check valve is not an actuated valve and does not have controls or settings.
  - If the 380 PZ's HGL were to drop below the 337 ft, the check valves will open and revert back to 337 PZ HGL. This is expected to only occur during fire or emergency conditions.
  - The use of check valves is possible because the initial hydraulic model analysis did not show fire flow deficiencies within 337 PZ under existing conditions.
  - A PRV station will be constructed allowing flow from 380 PZ to 337 PZ to prevent over pressurization in 380 PZ.
- New 380 PZ Pump Station controls:
  - This pump station will be setup as a VFD and is set to maintain a minimum pressure of 42 psi within 380 PZ.
  - The proposed 380 PZ Pump Station to be sized for supplying domestic flows.
- New 337 PZ Pump Station Pump 1 controls:
  - If J-1711 pressure is below 45 psi and Intelco Tank level is above 10 ft then 337 PZ PS Pump 1 is open.
  - If J-1771 pressure is above 50 psi or Intelco Tank level is below 5 ft then 337 PZ PS Pump 1 is closed.
- New 337 PZ Pump Station Pump 2 controls:
  - If J-1711 pressure is below 40 psi and Intelco Tank level is above 15 ft then 337 PZ PS Pump 2 is open.
  - If J-1771 pressure is above 45 psi or Intelco Tank level is below 10 ft then 337 PZ PS Pump 2 is closed.
- New Intelco Tank control valve settings and controls:
  - The Intelco Tank control valve will be modeled as a pressure sustaining valve (PSV) to maintain a minimum upstream pressure of 42 psi.
  - If 337 PZ Pump Station is closed and upstream pressure is above 42 psi then Intelco Tank control valve is open.
  - If 337 PZ Pump Station is open or upstream pressure is below 42 psi then Intelco Tank control valve is closed.

1.6.2.3 Alternative 337-3

The following model updates are associated with Alternative 337-3:

- Modify Well 1 controls:
  - If Intelco Tank level is below 25 ft then Well 1 is open.

  - If Intelco Tank level is above 30 ft then Well 1 is closed.
- Modify Well 4 controls:
  - If Intelco Tank level is below 27 ft then Well 4 is open.
  - If Intelco Tank level is above 32 ft then Well 4 is closed.
- Modify Well 9 controls:
  - If Intelco Tank level is below 30 ft then Well 9 is open.
  - If Intelco Tank level is above 35 ft then Well 9 is closed.
- Modify Well 10 controls:
  - The well will be setup as a VFD and set to maintain a minimum pressure of 38 psi within 337 PZ.
  - If Intelco Tank level is below 33 ft then Well 10 is open.
  - If Intelco Tank level is above 35.75 ft then Well 10 is closed.

1.7 Conclusion

The hydraulic model received is assumed to be calibrated and ready for use to evaluate the different alternatives develop in both 337 PZ and 400 PZ. The model facility and operational update discussed in this report should be reviewed by the City. Operational updates in the model will likely differ when applied when operating their system. It should be noted that the system is very sensitive while the Hawks Prairie Tank is offline.

Appendix 1

MODEL CONTROLS

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
400 PZ PS #1 and #2 Lockout	If Hawks Prairie Tank level is below 10 feet. Then 400 PZ PS #1 is closed. And 400 PZ PS #2 is closed.
400 PZ PS #1 Off	If 400 PZ PS flow is below 300 gpm. And 400 PZ PS #2 is closed. And 400 PZ PS #1 is open. Then 400 PZ PS #1 is closed. And Hawks Prairie Tank Valve is open.
400 PZ PS # 1 On	If J-1280 pressure is below 36 psi. And Hawks Prairie Tank level is above 15 feet. Then 400 PZ PS #1 is open. And Hawks Prairie Tank Valve is closed.
400 PZ PS #2 Off	If 400 PZ PS flow is below 900 gpm. And 400 PZ PS #3 is closed. Then 400 PZ PS #2 is closed.
400 PZ PS #2 On	If J-1280 pressure is below 38 psi. And Hawks Prairie Tank level is above 15 feet. And 400 PZ PS #1 is open. Then 400 PZ PS #2 is open.
400 PZ PS #3 and #4 Lockout	If Hawks Prairie Tank level is below 20 feet. Then 400 PZ PS #3 is closed. And 400 PZ PS #4 is closed.
400 PZ PS #3 Off	If 400 PZ PS flow is below 1,800 gpm. And 400 PZ PS #4 is closed. Then 400 PZ PS #3 is closed.
400 PZ PS #3 On	If J-1280 pressure is below 38 psi. And Hawks Prairie Tank level is above 25 feet. And 400 PZ PS #2 is open. Then 400 PZ PS #3 is open.
400 PZ PS #4 Off	If 400 PZ PS flow is below 3,000 gpm. Then 400 PZ PS #4 is closed.
400 PZ PS #4 On	If J-1280 pressure is below 38 psi. And Hawks Prairie Tank level is above 25 feet. And 400 PZ PS #3 is open. Then 400 PZ PS #4 is open.
Judd Hill PS Lockout	If Judd Hill Tank level is below 10 feet. Then Judd Hill PS is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Judd Hill PS On	If Judd Hill Tank level is above 15 feet. And J-106 pressure is below 26 psi. Then Judd Hill PS is open.
Judd Hill PS Off	If time is 8:00 AM. Or time is 8:00 PM. Then Judd Hill PS is closed.
Judd Hill PS Timer	If time is 5:30 AM. Or time is 5:30 PM. And Judd Hill Tank level is above 15 feet.
Westside PS Jockey Off	If Westside PS flow is below 250 gpm. And Westside PS Jockey is open. Then Westside PS Jockey is closed. And Westside Tank Valve is open.
Westside PS Jockey On	If J-1256 pressure is below 38 psi. And Westside Tank level is above 20 feet. And Westside PS #1 is closed. And Westside PS Jockey is closed. Then Westside PS Jockey is open. And Westside Tank Valve is closed.
Westside PS Lockout	If Westside Tank level is below 10 feet. Then Westside PS Jockey is closed. And Westside PS #1 is closed. And Westside PS #2 is closed. And Westside PS #1 is closed.
Westside PS #1 Off	If Westside PS flow is below 900 gpm. And Westside PS #2 is closed. And Westside PS #1 is open. Then Westside PS #1 is closed. And Westside PS Jockey is open.
Westside PS #1 On	If J-1256 pressure is below 36 psi. And Westside Tank level is above 20 feet. And Westside PS Jockey is open. Then Westside PS #1 is open. And Westside PS Jockey is closed.
Westside PS #2 Off	If Westside PS flow is below 1,900 gpm. And Westside PS #3 is closed. Then Westside PS #2 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Westside PS #2 On	If J-1256 pressure is below 32 psi. And Westside Tank level is above 20 feet. And Westside PS #1 is open. Then Westside PS #2 is open.
Westside PS #3 Off	If Westside PS flow is below 3,000 gpm. Then Westside PS #3 is closed.
Westside PS #3 On	If J-1256 pressure is below 32 psi. And Westside Tank level is above 20 feet. And Westside PS #2 is open. Then Westside PS #3 is open.
Hawks Prairie Treatment Facility Low Lift Pump #1 Off	If Well 19 is open. And Hawks Prairie Clearwell level is below 11 feet. Then Hawks Prairie Treatment Facility Pump 1 is closed.
Hawks Prairie Treatment Facility Low Lift Pump #1 On	If Well 19 is open. And Hawks Prairie Clearwell level is above 12 feet. Then Hawks Prairie Treatment Facility Pump 1 is open.
Hawks Prairie Treatment Facility Low Lift Pump #2 Off	If Well 31 is open. And Hawks Prairie Clearwell level is below 11 feet. Then Hawks Prairie Treatment Facility Pump 2 is closed.
Hawks Prairie Treatment Facility Low Lift Pump #2 On	If Well 31 is open. And Hawks Prairie Clearwell level is above 12 feet. Then Hawks Prairie Treatment Facility Pump 2 is open.
Britton Parkway PRV Station Controls	If Steilacoom Tank level is below 0 feet. Or Union Mills Tank level is below 0 feet. Then Britton Parkway Valve is open. And Britton Parkway PRV Large is closed. Else Britton Parkway PRV Large is open. And Britton Parkway Valve is closed.
Galaxy PRV Station Controls	If Steilacoom Tank level is below 63.5 feet. Or Union Mills Tank level is below 53 feet. Then Galaxy FCV is open. And Galaxy PRV is closed. Else Galaxy PRV is open. And Galaxy FCV is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Marvin Road PRV Station Controls	If Steilacoom Tank level is below 0 feet. Or Union Mills Tank level is below 0 feet. Then Marvin Road FCV is open. And Marvin Road PRV is closed. Else Marvin Road PRV is open. And Marvin Road FCV is closed.
Mt. Aire PRV Station Controls	If Steilacoom Tank level is below 60 feet. Or Union Mills Tank level is below 50 feet. Then Mt. Aire FCV is open. And Mt. Aire PRV is closed. Else Mt. Aire PRV is open. And Mt. Aire FCV is closed.
Mugho PRV Station Controls	If Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 58 feet. Then Mugho FCV is open. And Mugho PRV is closed. Else Mugho PRV is open. And Mugho FCV is closed.
Westside Tank Lockout	If Westside PS Jockey is closed. And Westside PS #3 is closed. And Westside PS #2 is closed. And Westside PS #1 is closed. Then Westide Tank control valve is open. Else Westide Tank control valve is closed.
Well 1 Off	If Steilacoom Tank level is above 65 feet. And Union Mills Tank level is above 60 feet. Then Well 1 is closed.
Well 1 On	If Steilacoom Tank level is below 63 feet. Or Union Mills Tank level is below 56 feet. Or J-5456 pressure is below 60 psi. Then Well 1 is open.
Well 10 Off	If Steilacoom Tank level is above 66.5 feet. And Union Mills Tank level is above 58 feet. And Westside Tank level is above 36 feet. Then Well 10 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 10 On	If Steilacoom Tank level is below 64 feet. Or Union Mills Tank level is below 56 feet. Or Westside Tank level is below 30 feet. Then Well 10 is open.
Well 15 Off	If Hawks Prairie Tank level is above 82 feet. Then Well 15 is closed.
Well 15 On	If Hawks Prairie Tank level is below 78 feet. Then Well 15 is open.
Well 16 Off	If Hawks Prairie Tank level is above 82 feet. Then Well 16 is closed.
Well 16 On	If Hawks Prairie Tank level is below 78 feet. Then Well 16 is open.
Well 19 Off	If Hawks Prairie Tank level is above 84 feet. Then Well 19 is closed. And Hawks Prairie Treatment Facility Pump 1 is closed.
Well 19 On	If Hawks Prairie Tank level is below 78 feet. Then Well 19 is open.
Well 2 Off	If Steilacoom Tank level is above 67.5 feet. And Union Mills Tank level is above 60 feet. And Westside Tank level is above 39 feet. Then Well 2 is closed.
Well 2 On	If Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 58 feet. Or Westside Tank level is below 35 feet. Or J-5456 pressure is below 62 psi. Then Well 2 is open.
Well 20 Off	If McAllister Tank level is above 96.5 feet. Then Well 20 is closed.
Well 20 On	If McAllister Tank level is below 92 feet. Then Well 20 is open.
Well 21 Off	If Hawks Prairie Tank level is above 74 feet. And McAllister Tank level is above 94 feet. And Steilacoom Tank level is above 1 feet. And Union Mills Tank level is above 1 feet. Then Well 21 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 21 On	If Hawks Prairie Tank level is below 70 feet. Or McAllister Tank level is below 92 feet. Or Steilacoom Tank level is below 0 feet. Or Union Mills Tank level is below 0 feet. Then Well 21 is open.
Well 22 Off	If Hawks Prairie Tank level is above 74 feet. And McAllister Tank level is above 94 feet. And Steilacoom Tank level is above 62 feet. And Union Mills Tank level is above 52 feet. Then Well 22 is closed.
Well 22 On	If Hawks Prairie Tank level is below 70 feet. Or McAllister Tank level is below 92 feet. Or Steilacoom Tank level is below 60 feet. Or Union Mills Tank level is below 50 feet. Then Well 22 is open.
Well 24 Off	If Nisqually Tank level is above 26 feet. Then Well 24 is closed.
Well 24 On	If Nisqually Tank level is below 24 feet. Then Well 24 is open.
Well 25 Off	If Nisqually Tank level is above 26 feet. Then Well 25 is closed.
Well 25 On	If Nisqually Tank level is below 24 feet. Then Well 25 is open.
Well 27 Off	If McAllister Tank level is above 95 feet. And Steilacoom Tank level is above 66 feet. And Union Mills Tank level is above 60 feet. Then Well 27 is closed.
Well 27 On	If McAllister Tank level is below 93 feet. Or Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 58 feet. Then Well 27 is open.
Well 28 Off	If Hawks Prairie Tank level is above 50 feet. And McAllister Tank level is above 95 feet. And Steilacoom Tank level is above 63.5 feet. And Union Mills Tank level is above 56 feet. Then Well 28 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 28 On	If Hawks Prairie Tank level is below 40 feet. Or McAllister Tank level is below 91 feet. Or Steilacoom Tank level is below 61.5 feet. Or Union Mills Tank level is below 53 feet. Then Well 28 is open.
Well 29 Off	If Hawks Prairie Tank level is above 80 feet. Then Well 29 is closed.
Well 29 On	If Hawks Prairie Tank level is below 77 feet. Then Well 29 is open.
Well 3 Off	If Steilacoom Tank level is above 67 feet. And Union Mills Tank level is above 60.5 feet. And Westside Tank level is above 38 feet. Then Well 3 is closed.
Well 3 On	If Steilacoom Tank level is below 64 feet. Or Union Mills Tank level is below 57 feet. Or Westside Tank level is below 34 feet. Or J-5456 pressure is below 68 psi. Then Well 3 is open.
Well 31 Off	If Hawks Prairie Tank level is above 78 feet. Then Well 31 is closed. And Hawks Prairie Treatment Facility Pump 2 is closed.
Well 31 On	If Hawks Prairie Tank level is below 65 feet. Then Well 31 is open.
Well 4 Off	If Steilacoom Tank level is above 66 feet. And Union Mills Tank level is above 59 feet. And Westside Tank level is above 38 feet. Then Well 4 is closed.

Table 1 Existing Model Control and Logic Summary

Control Name	Control Rules/Logic
Well 4 On	If Steilacoom Tank level is below 65 feet. Or Union Mills Tank level is below 53 feet. Or Westside Tank level is below 20 feet. Then Well 4 is open.
Well 6 Off	If Steilacoom Tank level is above 63 feet. And Union Mills Tank level is above 55 feet. And Judd Hill Tank level is above 50 feet. Then Well 6 is closed.
Well 6 On	If Steilacoom Tank level is below 58 feet. Or Union Mills Tank level is below 52 feet. Or Judd Hill Tank level is below 47 feet. Then Well 6 is open.
Well 6 Valve Controls	If Steilacoom Tank level is below 58 feet. Or Union Mills Tank level is below 52 feet. Then Well 6 is open. Else Well 6 is closed.
Well 7 Off	If Steilacoom Tank level is above 66.5 feet. And Union Mills Tank level is above 59 feet. Then Well 7 is closed.
Well 7 On	If Steilacoom Tank level is below 64.5 feet. Or Union Mills Tank level is below 56 feet. Then Well 7 is open.
Well 9 Off	If Steilacoom Tank level is above 65 feet. And Union Mills Tank level is above 56 feet. And time is 9:30 AM. Then Well 9 is closed.
Well 9 On	If Steilacoom Tank level is below 61.5 feet. Or Union Mills Tank level is below 53 feet. Or time is 7:30 AM. Then Well 9 is open.

Appendix B

DETAILED COST ESTIMATE

City of Lacey
400 PZ Storage Studies
Cost Estimate for Alternatives
Assumptions

All preliminary Capital costs are in 2018 dollars. Cost estimate made in: 2018

To update Capital Costs to future value, enter inflation rate: 3.00%

Capital Costs

Transmission Costs

Element	Unit	Unit Construction Cost ($/LF)
16-inch Pipe	LF	$240
20-inch Pipe	LF	$277
24-inch Pipe	LF	$310

Pump Station Costs

Horsepower	Unit	Unit Construction Cost
0 to 199 HP	Per HP per Pump	$8,200

Hawks Prarie Facility Improvement

Cost	Unit
$250,000	each

Storage Costs

Reservoir Type	Cost per gallon ($/gallon)
Standpipe	$2.00
Elevated	$4

APPENDIX B
400 PRESSURE ZONE STORAGE STUDY
Life Cycle Cost Assumptions

Lacey 400 PZ - Life Cycle Costs	Annual Quantity	Unit	2018 $/Unit	Yearly % Escalation	50-Yr (2022-2072) Total
Energy Costs					
Energy Costs - Alt 400-1	11,400	kWh	$0.11	3.00%	$163,976
Energy Costs - Alt 400-2	9,100	kWh	$0.11	3.00%	$130,893
Energy Costs - Alt 400-3	910	kWh	$0.11	3.00%	$13,089
					50-Yr
City Staff Effort					**Total**
Large Booster Pump Station, with backup generator	0.080	FTE	$182,292	3.00%	$1,906,959
Below Hydraulic Grade Storage	0.070	FTE	$177,278	3.00%	$1,622,692
Elevated Storage	0.070	FTE	$177,278	3.00%	$1,622,692
					2052
Tank Recoating (Every 30 Years) - Alt 2	26,399	SF	$0.00	3.00%	$547,207
Pump Station Rehab					**2052**
0 to 199 HP - Steilacoom PS	110	LF	$2,706	3.00%	$813,179

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-1A
Project Name: 400 PZ Alternative 1A

Project Description:

- Add variable frequency drives (VFDs) to the Hawks Prairie Treatment Facility low lift pump station's pumps.
- Construct a pump station at Steilacoom tank site. The BPS is designed to access dead storage thus expanding the City's 400 PZ's fire suppression storage.

-The two freeway crossing pipes will most likely have to be upsized to enable additional flow from the southern to the northern portion of the 400 PZ Tank. The tank will be isolated from the system when the pump station is running. There might be some reconfiguration to be done to allow this operation.

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-1A
Project Name: 400 PZ Alternative 1A

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
Water Main Replacement Contingencies-->						19%		6%	
VFDs on the HPWTF low-lift pumps	1	LS	$ 250,000	Capital	$ 250,000	$ 100,000	$ 75,000	$ 12,500	$ 437,500
Booster Pump Station	150	Per HP per Pump	$ 8,200	Capital	$ 1,230,000	$ 492,000	$ 369,000	$ 61,500	$ 2,152,500
Field Piping - 16-inch	1,160	LF	$ 240	Capital	$ 278,400	$ 111,360	$ 83,520	$ 13,920	$ 487,200
Pipe Upsizing - 16-inch	1,110	LF	$ 240	Capital	$ 266,400	$ 50,616	$ 79,920	$ 15,984	$ 412,920
Segment 1 Piping Upsize - 20-inch	22,210	LF	$ 277	Capital	$ 6,152,170	$ 1,168,912	$ 1,845,651	$ 369,130	$ 9,535,864
Segment 2 Piping Upsize - 16-inch	10,300	LF	$ 240	Capital	$ 2,472,000	$ 469,680	$ 741,600	$ 148,320	$ 3,831,600
Segment 3 Piping Upsize - 16-inch	4,410	LF	$ 240	Capital	$ 1,058,400	$ 201,096	$ 317,520	$ 63,504	$ 1,640,520
Energy Costs - 50 years	1	LS	$ 163,976	O&M	$ 163,976	$ -	$ -	$ -	$ 163,976
City Staff Effort - 50 Years	1	LS	$ 1,906,959	O&M	$ 1,906,959	$ -	$ -	$ -	$ 1,906,959
PS Rehab - 30 Years	1	LS	$ 813,179	O&M	$ 813,179	$ -	$ -	$ -	$ 813,179
					$ -	$ -	$ -	$ -	$ -
Total Project Cost									$ 21,382,218

Notes on Cost Estimation:
See Assumptions tab for details. O&M costs are in future dollars of what year they would be performed. See Life Cycle costs Tab for detail. Pipe Upsizing uses contingencies for Water Main Replacements as shown in Assumptions tab.

Go to Assumptions Tab

Project Timing:

Project Element		Timing	Project Cost (Future $)
VFDs on the HPWTF low-lift pum	Capital	2022	$ 492,410
Booster Pump Station	Capital	2022	$ 2,422,658
Field Piping - 16-inch	Capital	2022	$ 548,348
Pipe Upsizing - 16-inch	Capital	2022	$ 464,745
Segment 1 Piping Upsize - 20-inc	Capital	2022	$ 10,732,698
Segment 2 Piping Upsize - 16-inc	Capital	2022	$ 4,312,500
Segment 3 Piping Upsize - 16-inc	Capital	2022	$ 1,846,420
Energy Costs - 50 years	O&M	Varies	$ 163,976
City Staff Effort - 50 Years	O&M	Varies	$ 1,906,959
PS Rehab - 30 Years	O&M	Varies	$ 813,179
Total Project Cost			$ 23,703,893

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-1B
Project Name: 400 PZ Alternative 1B

Project Description:

- Add variable frequency drives (VFDs) to the Hawks Prairie Treatment Facility low lift pump station's pumps.
- Construct a pump station at McAllister tank site. The BPS is designed to access dead storage thus expanding the City's 400 PZ's fire suppression storage.

-The two freeway crossing pipes will most likely have to be upsized to enable additional flow from the southern to the northern portion of the 400 PZ Tank. The tank will be isolated from the system when the pump station is running. There might be some reconfiguration to be done to allow this operation.

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-1B
Project Name: 400 PZ Alternative 1B

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
					Water Main Replacement Contingencies-->	19%		6%	
VFDs on the HPWTF low-lift pumps	1	LS	$ 250,000	Capital	$ 250,000	$ 100,000	$ 75,000	$ 12,500	$ 437,500
Booster Pump Station	150	Per HP per Pump	$ 8,200	Capital	$ 1,230,000	$ 492,000	$ 369,000	$ 61,500	$ 2,152,500
BPS Piping - 16-inch	190	LF	$ 240	Capital	$ 45,600	$ 8,664	$ 13,680	$ 2,736	$ 70,680
Segment 1 Piping Upsize - 24-inch	22,210	LF	$ 310	Capital	$ 6,885,100	$ 1,308,169	$ 2,065,530	$ 413,106	$ 10,671,905
Segment 2 Piping Upsize - 16-inch	10,300	LF	$ 240	Capital	$ 2,472,000	$ 469,680	$ 741,600	$ 148,320	$ 3,831,600
Segment 3 Piping Upsize - 16-inch	4,410	LF	$ 240	Capital	$ 1,058,400	$ 201,096	$ 317,520	$ 63,504	$ 1,640,520
Energy Costs - 50 years	1	LS	$ 163,976	O&M	$ 163,976	$ -	$ -	$ -	$ 163,976
City Staff Effort - 50 Years	1	LS	$ 1,906,959	O&M	$ 1,906,959	$ -	$ -	$ -	$ 1,906,959
PS Rehab - 30 Years	1	LS	$ 813,179	O&M	$ 813,179	$ -	$ -	$ -	$ 813,179
					$ -	$ -	$ -	$ -	$ -
Total Project Cost									$ 21,688,819

Notes on Cost Estimation:
See Assumptions tab for details. See Life Cycle costs Tab for O&M costs.

Go to Assumptions Tab

Project Timing:

Project Element		Timing	Cost (Rounded)
VFDs on the HPWTF low-lift p	Capital	2022	$ 492,410
Booster Pump Station	Capital	2022	$ 2,422,658
BPS Piping - 16-inch	Capital	2022	$ 79,551
Segment 1 Piping Upsize - 24-	Capital	2022	$ 12,011,323
Segment 2 Piping Upsize - 16-	Capital	2022	$ 4,312,500
Segment 3 Piping Upsize - 16-	Capital	2022	$ 1,846,420
Energy Costs - 50 years	O&M	Varies	$ 163,976
City Staff Effort - 50 Years	O&M	Varies	$ 1,906,959
PS Rehab - 30 Years	O&M	Varies	$ 813,179
Total Project Cost			$ 24,048,975

City of Lacey
337 PZ Facilities & Pressure Study

Project ID:	400-2
Project Name:	400 PZ Alternative 2

Project Description:

- Add VFDs to the Hawks Prairie Treatment Facility low lift pump station's pumps.
- Construct an elevated tank at the Marvin Road school site. This facility will be referred to as elevated school tank. If the City wants to meet the required fire suppression storage volume this tank must have minimum storage capacity of 0.44 MG. The elevated school tank will be at a minimum 0.50 MG to meet the minimum storage capacity and add some additional for equalization.

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-2
Project Name: 400 PZ Alternative 2

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
Water Main Replacement Contingencies-->						19%		6%	
Elevated Tank	1,000,000	gallon	$ 4.00	Capital	$ 4,000,000	$ 1,600,000	$ 1,200,000	$ 200,000	$ 7,000,000
Field Piping - 16-inch	570	LF	$ 240	Capital	$ 136,800	$ 54,720	$ 41,040	$ 6,840	$ 239,400
VFDs on the HPWTF low-lift pumps	1	LS	$ 250,000	Capital	$ 250,000	$ 100,000	$ 75,000	$ 12,500	$ 437,500
Piping Upsize - 16-inch	1,110	LF	$ 240	Capital	$ 266,400	$ 50,616	$ 79,920	$ 15,984	$ 412,920
Tank Recoating - 30 Years	1	LS	$ 547,207	O&M	$ 547,207	$ -	$ -	$ -	$ 547,207
Energy Costs - 50 years	1	LS	$ 130,893	O&M	$ 130,893	$ -	$ -	$ -	$ 130,893
City Staff Effort - 50 Years	1	LS	$ 1,622,692	O&M	$ 1,622,692	$ -	$ -	$ -	$ 1,622,692
					$ -	$ -	$ -	$ -	$ -
					$ -	$ -	$ -	$ -	$ -
Total Project Cost									$ 10,390,612

Notes on Cost Estimation:

See Assumptions Tab for more information. Elevated tank is 85 ft tall, 40 ft diameter; intererior recoating every 30 years.

Go to Assumptions Tab

Project Timing:

Project Element		Timing	Cost (rounded)
Elevated Tank	Capital	2022	$ 7,878,562
Field Piping - 16-inch	Capital	2022	$ 269,447
VFDs on the HPWTF low-lift p	Capital	2022	$ 492,410
Piping Upsize - 16-inch	Capital	2022	$ 464,745
Tank Recoating - 30 Years	O&M	Varies	$ 547,207
Energy Costs - 50 years	O&M	Varies	$ 130,893
City Staff Effort - 50 Years	O&M	Varies	$ 1,622,692
	$ -		
	$ -		
Total Project Cost			$ 11,405,956

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-3
Project Name: 400 PZ Alternative 3

Project Description:
- Add VFDs to the Hawks Prairie Treatment Facility low lift pump station's pumps.
- Construct a 1.0 MG standpipe sister tank at the Hawks Prairie Site.

City of Lacey
337 PZ Facilities & Pressure Study

Project ID: 400-3
Project Name: 400 PZ Alternative 3

Project Cost Estimate:

Project Element	Quantity	Unit	Unit Cost ($/Unit)	Type of Cost (Capital/O&M)	Subtotal	City Project and Constr. Eng	Contingency	Other	Total Cost
						40%	30%	5%	
Water Main Replacement Contingencies-->						19%		6%	
Standpipe	1,500,000	gallon	$ 2.00	Capital	$ 3,000,000	$ 1,200,000	$ 900,000	$ 150,000	$ 5,250,000
Field Piping - 16-inch	150	LF	$ 240	Capital	$ 36,000	$ 14,400	$ 10,800	$ 1,800	$ 63,000
Pipe Upsizing - 16-inch	1,110	LF	$ 240	Capital	$ 266,400	$ 50,616	$ 79,920	$ 15,984	$ 412,920
Tank Recoating - 30 Years	1	LS	$ 547,207	O&M	$ 547,207	$ -	$ -	$ -	$ 547,207
Energy Costs - 50 years	1	LS	$ 13,089	O&M	$ 13,089	$ -	$ -	$ -	$ 13,089
City Staff Effort - 50 Years	1	LS	$ 1,622,692	O&M	$ 1,622,692	$ -	$ -	$ -	$ 1,622,692
					$ -	$ -	$ -	$ -	$ -
					$ -	$ -	$ -	$ -	$ -
					$ -	$ -		$ -	$ -
Total Project Cost									$ 7,908,908

Notes on Cost Estimation:

See Assumptions tab for details. See Life Cycle costs Tab for O&M costs. Interior recoating every 30 years.

Go to Assumptions Tab

Project Timing:

Project Element		Timing	Cost (rounded)
Standpipe	Capital	2022	$ 5,908,921
Field Piping - 16-inch	Capital	2022	$ 70,907
Pipe Upsizing - 16-inch	Capital	2022	$ 464,745
Tank Recoating - 30 Years	O&M	Varies	$ 547,207
Energy Costs - 50 years	O&M	Varies	$ 13,089
City Staff Effort - 50 Years	O&M	Varies	$ 1,622,692
Total Project Cost			$ 8,627,562

Appendix C

DETAILED MODELING RESULTS FIGURES

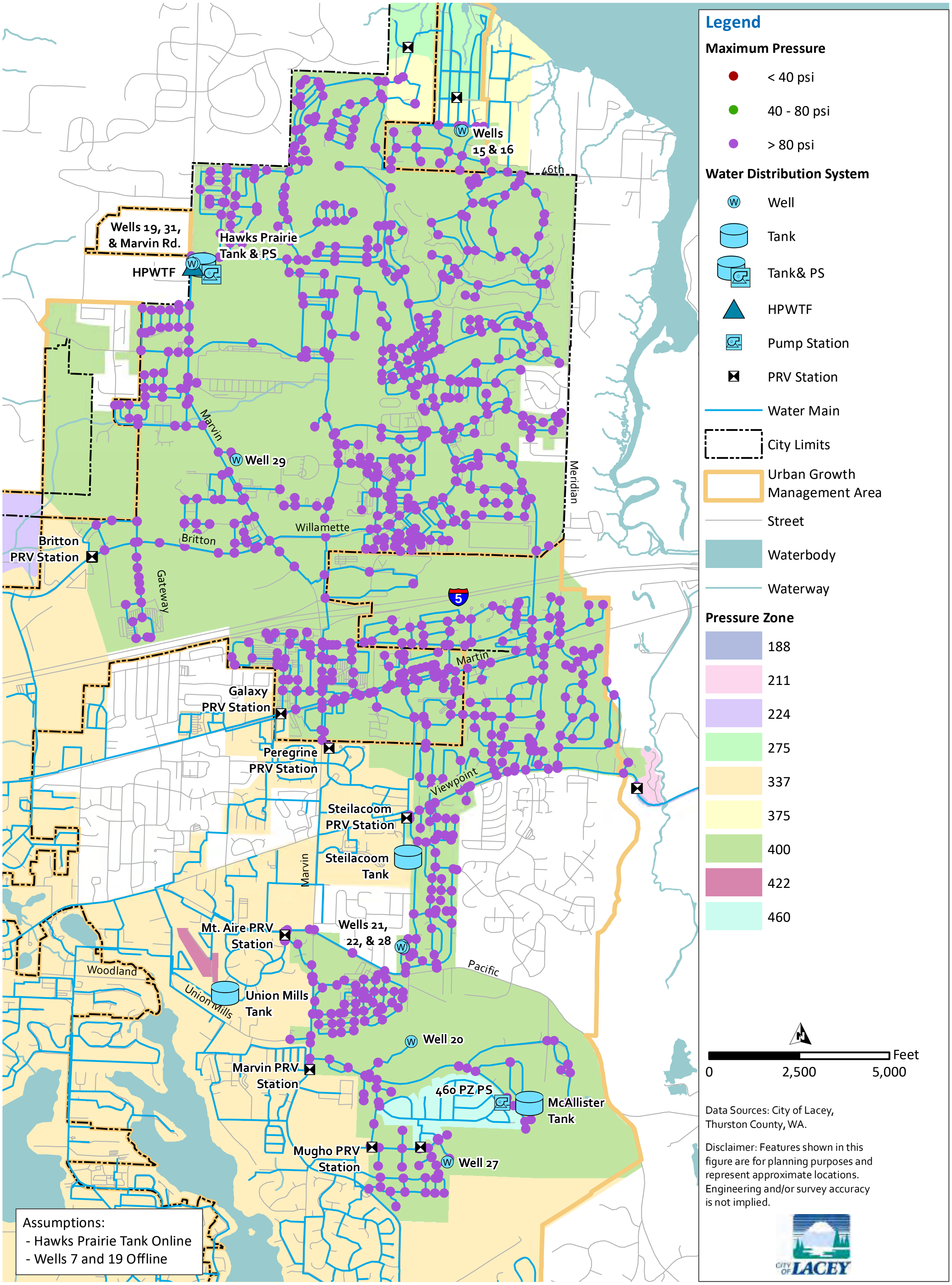


Figure 1 Maximum Pressures under 2022 ADD Conditions - Baseline

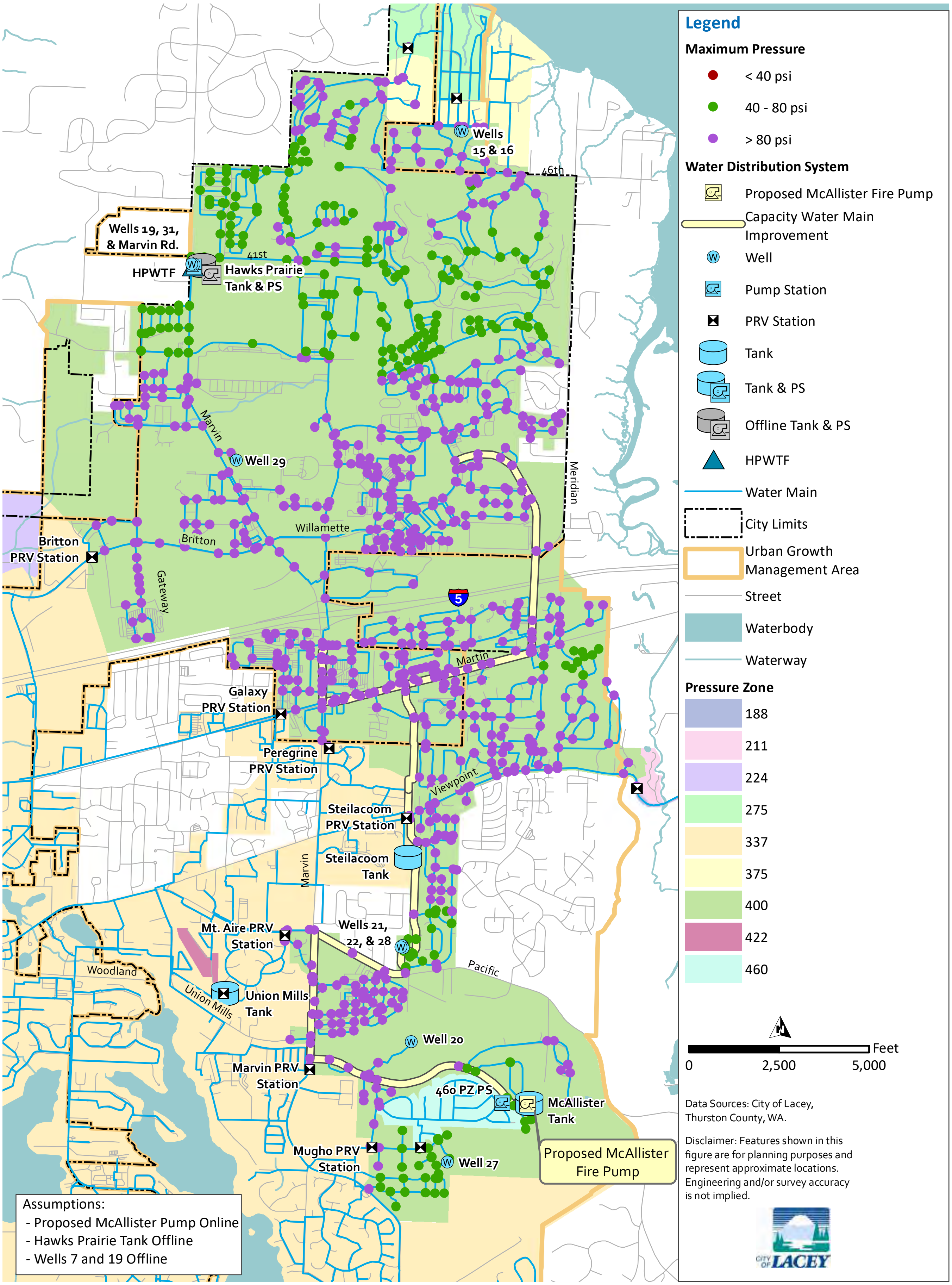


Figure 2 Maximum Pressures under 2022 ADD Conditions - Alt. 1, Hawks Prairie Tank Offline

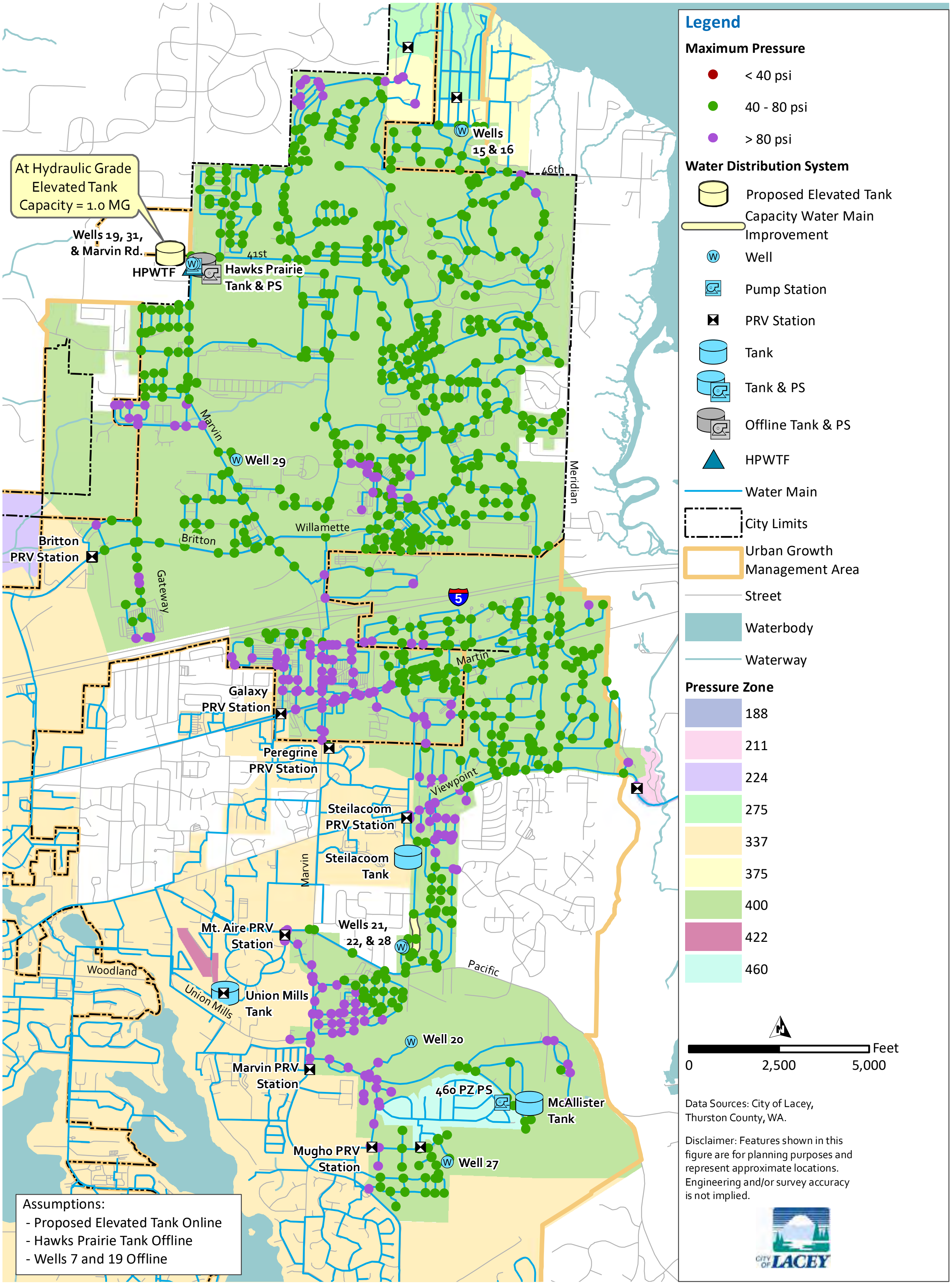


Figure 3 Maximum Pressures under 2022 ADD Conditions - Alt. 2, Hawks Prairie Tank Offline

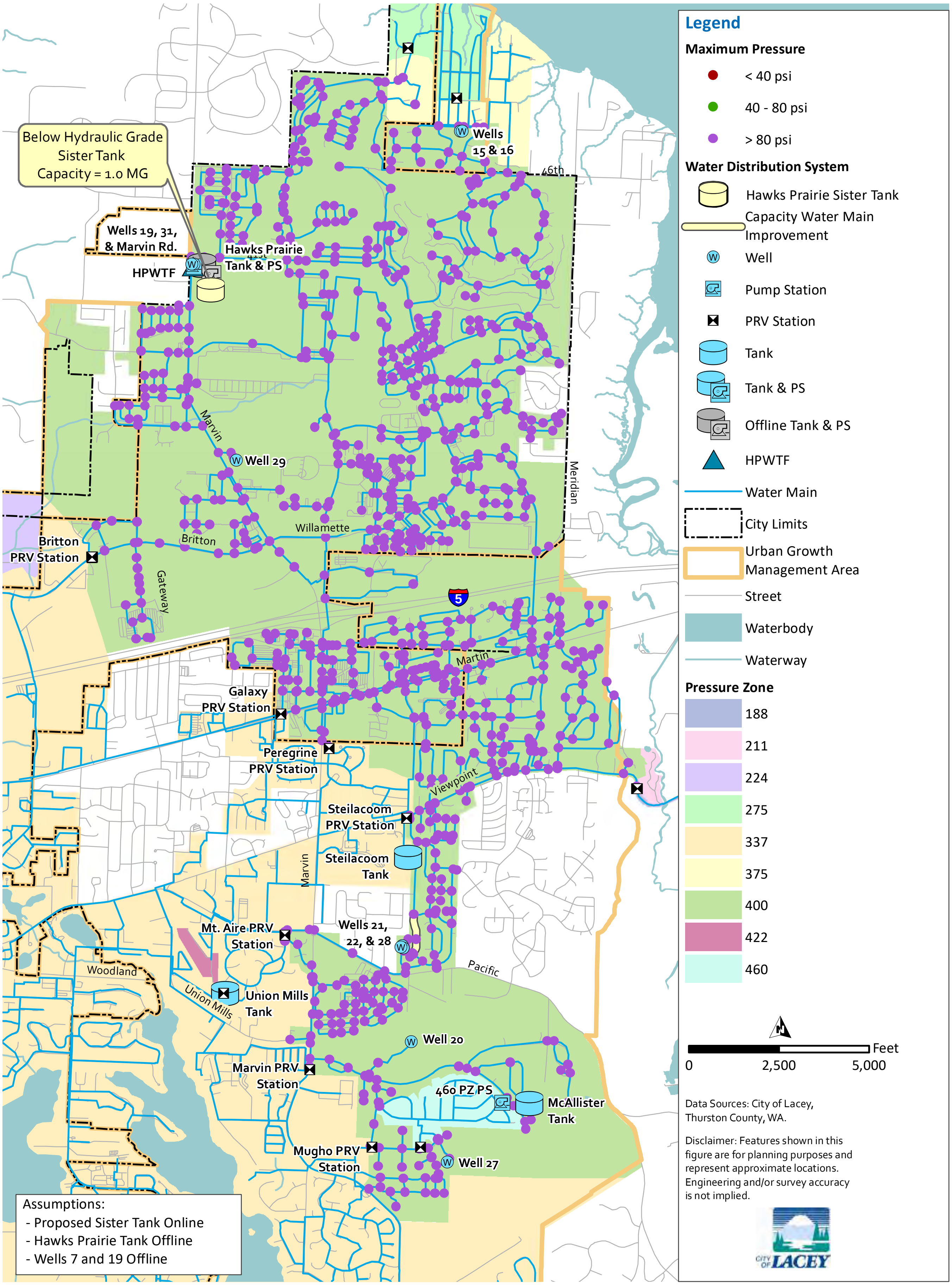


Figure 4 Maximum Pressures under 2022 ADD Conditions - Alt. 3, Hawks Prairie Tank Offline

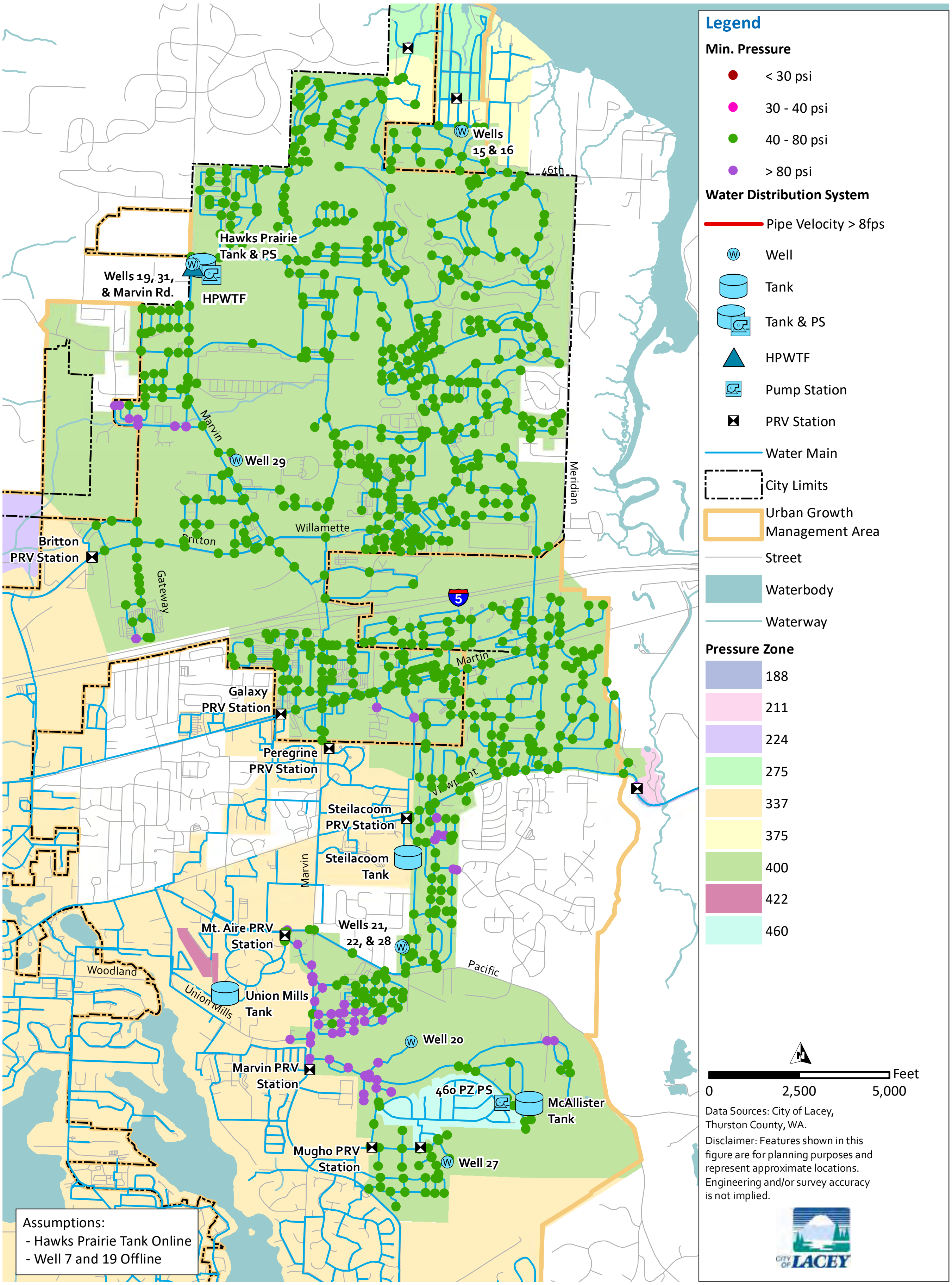


Figure 5 Min. Pressures and Max. Velocity under 2022 PHD Conditions - Baseline

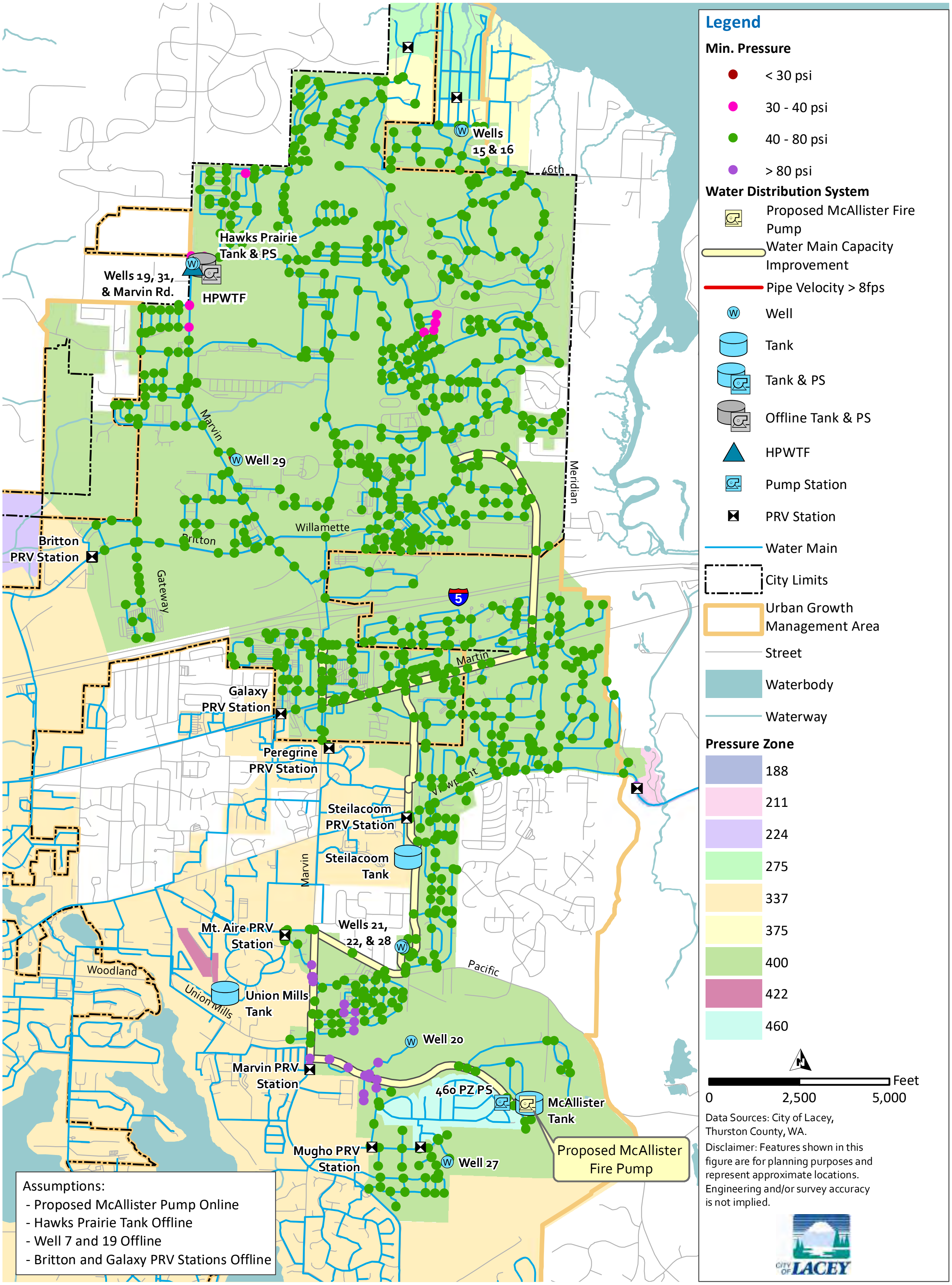


Figure 6 Min. Pressures and Max. Velocity under 2022 PHD Conditions - Alt. 1, Hawks Prairie Tank Offline

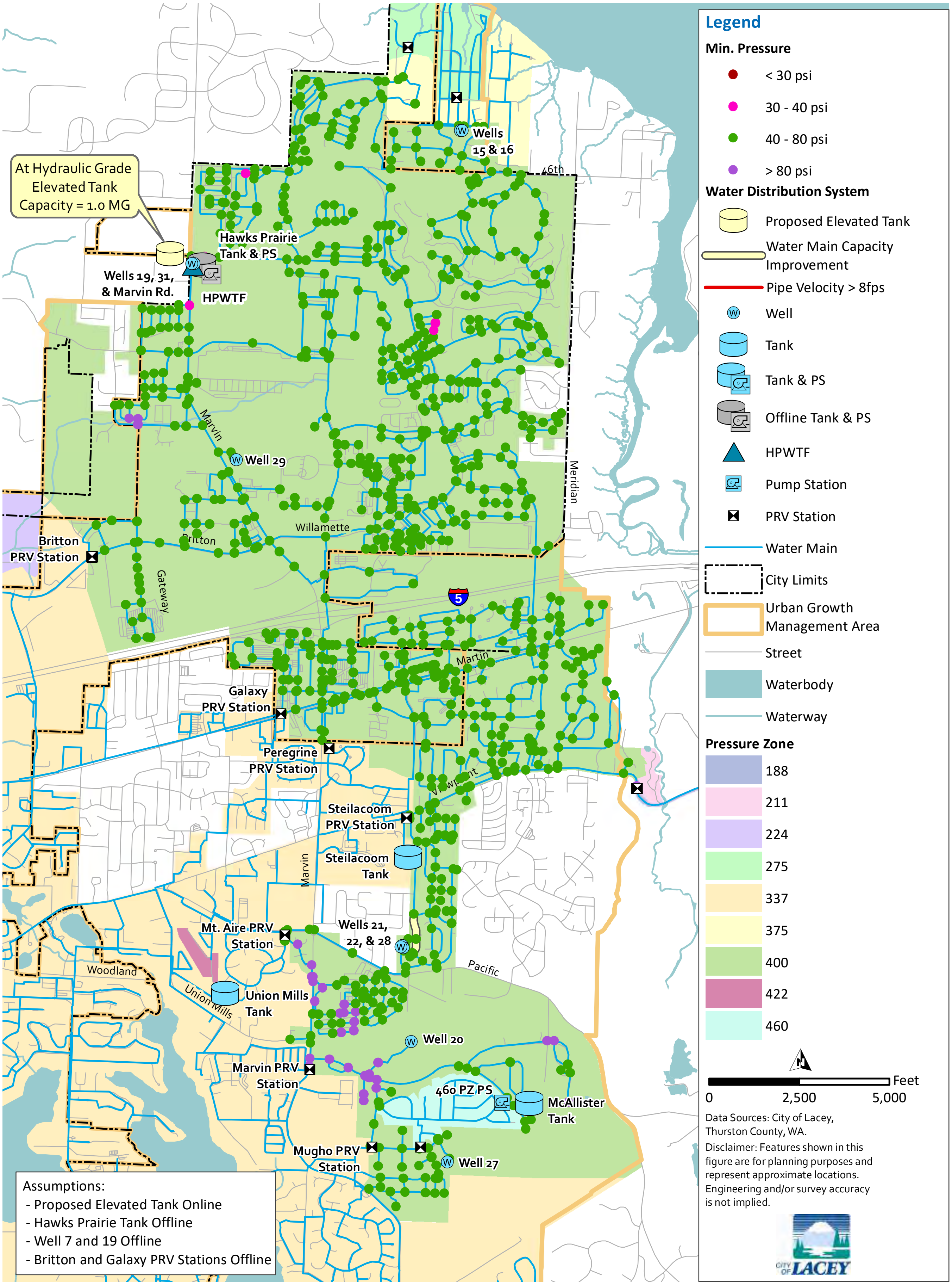


Figure 7 Min. Pressures and Max. Velocity under 2022 PHD Conditions - Alt. 2, Hawks Prairie Tank Offline

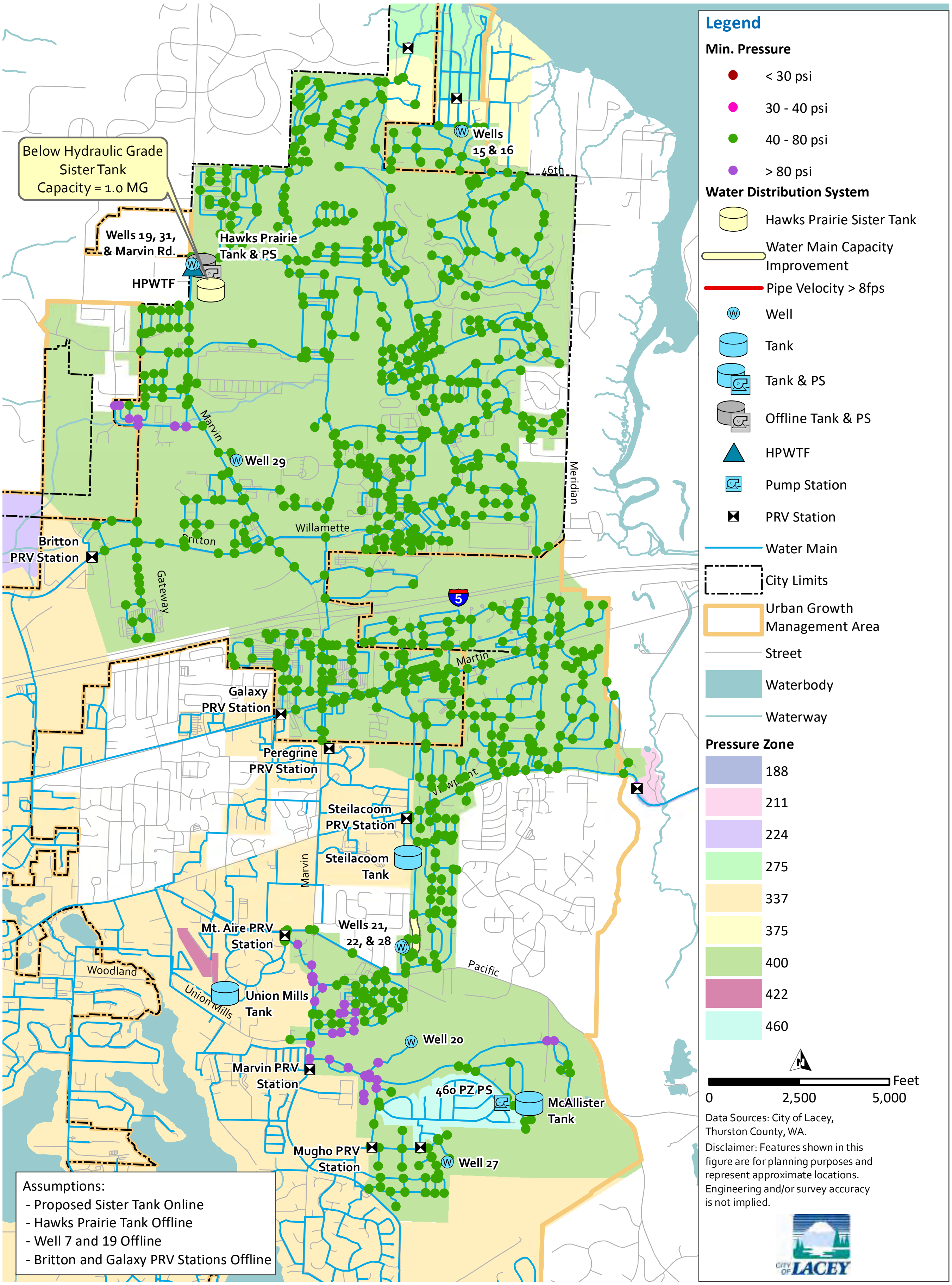


Figure 8 Min. Pressures and Max. Velocity under 2022 PHD Conditions - Alt. 3, Hawks Prairie Tank Offline

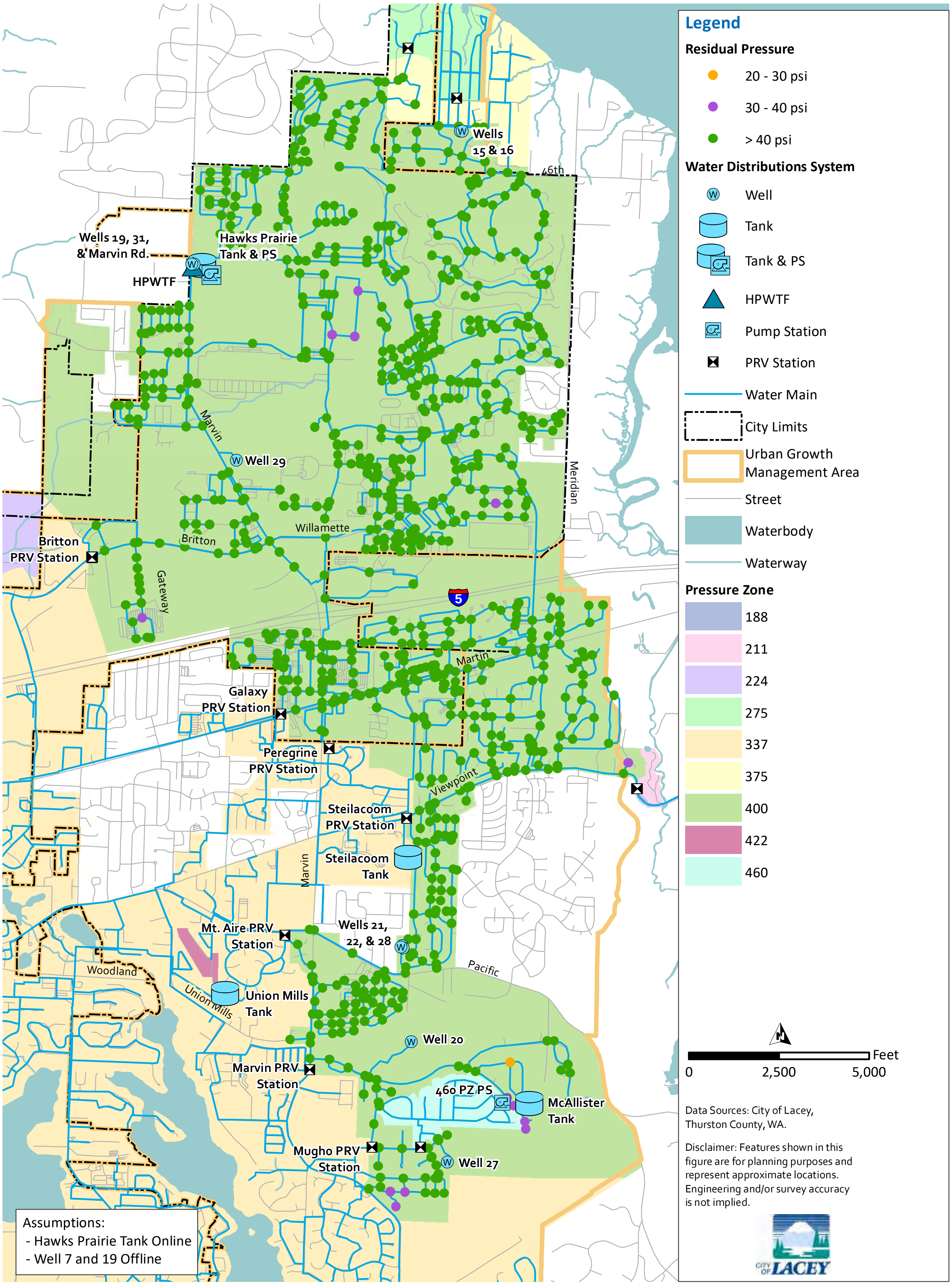
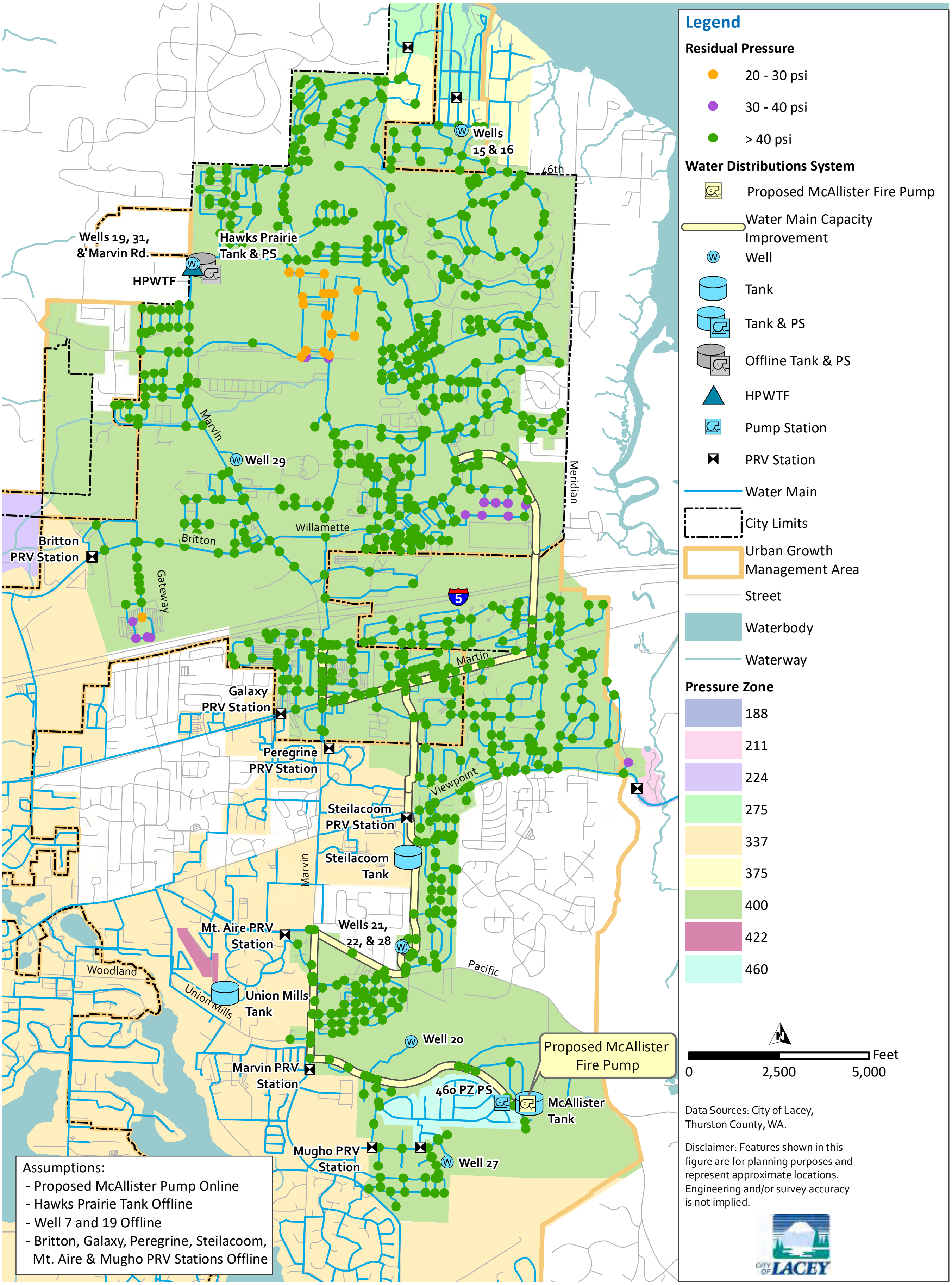


Figure 9 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Baseline



Assumptions:
- Proposed McAllister Pump Online
- Hawks Prairie Tank Offline
- Well 7 and 19 Offline
- Britton, Galaxy, Peregrine, Steilacoom, Mt. Aire & Mugho PRV Stations Offline

Figure 10 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Alt. 1, Hawks Prairie Tank Offline

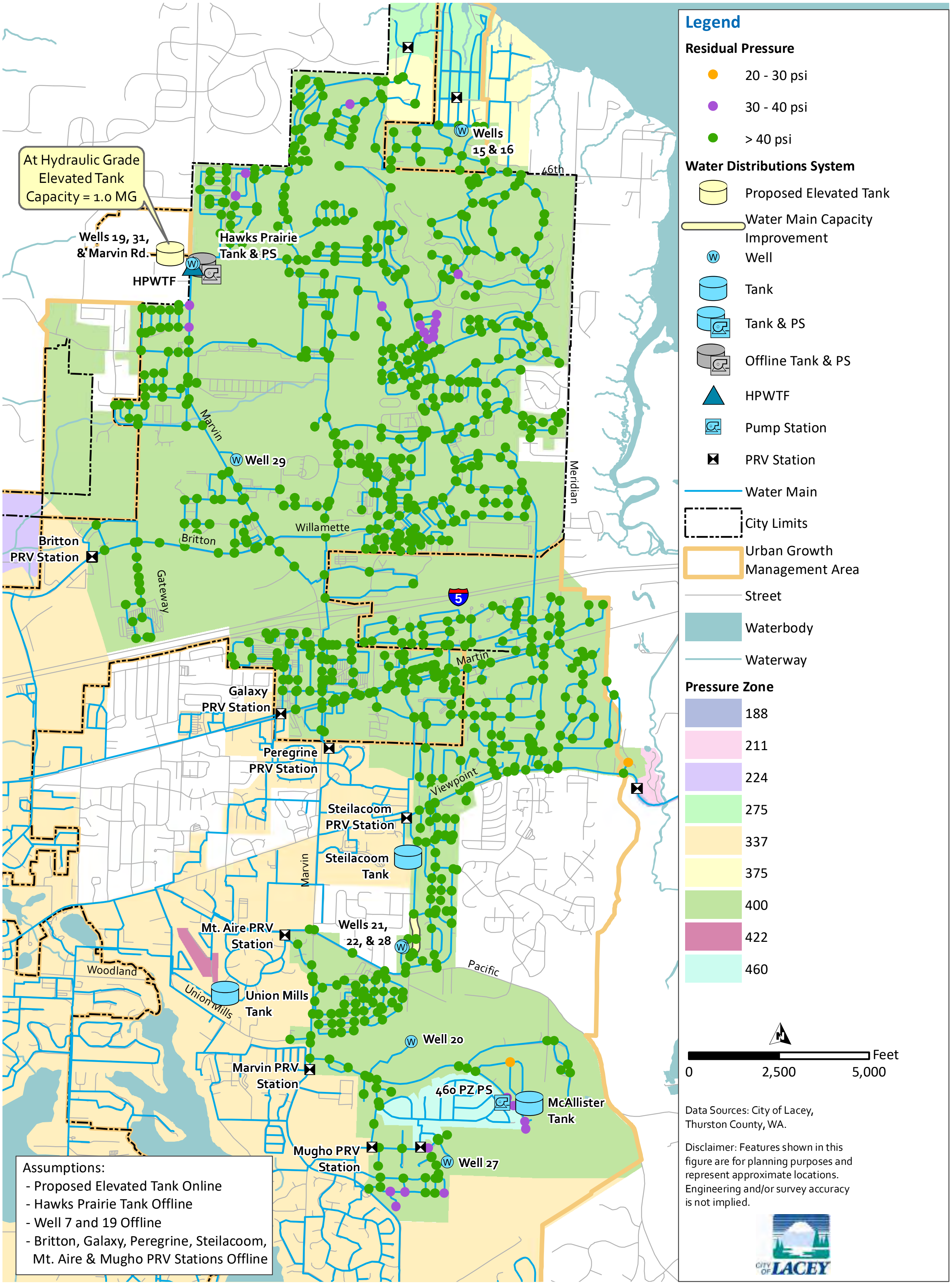


Figure 11 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Alt. 2, Hawks Prairie Tank Offline

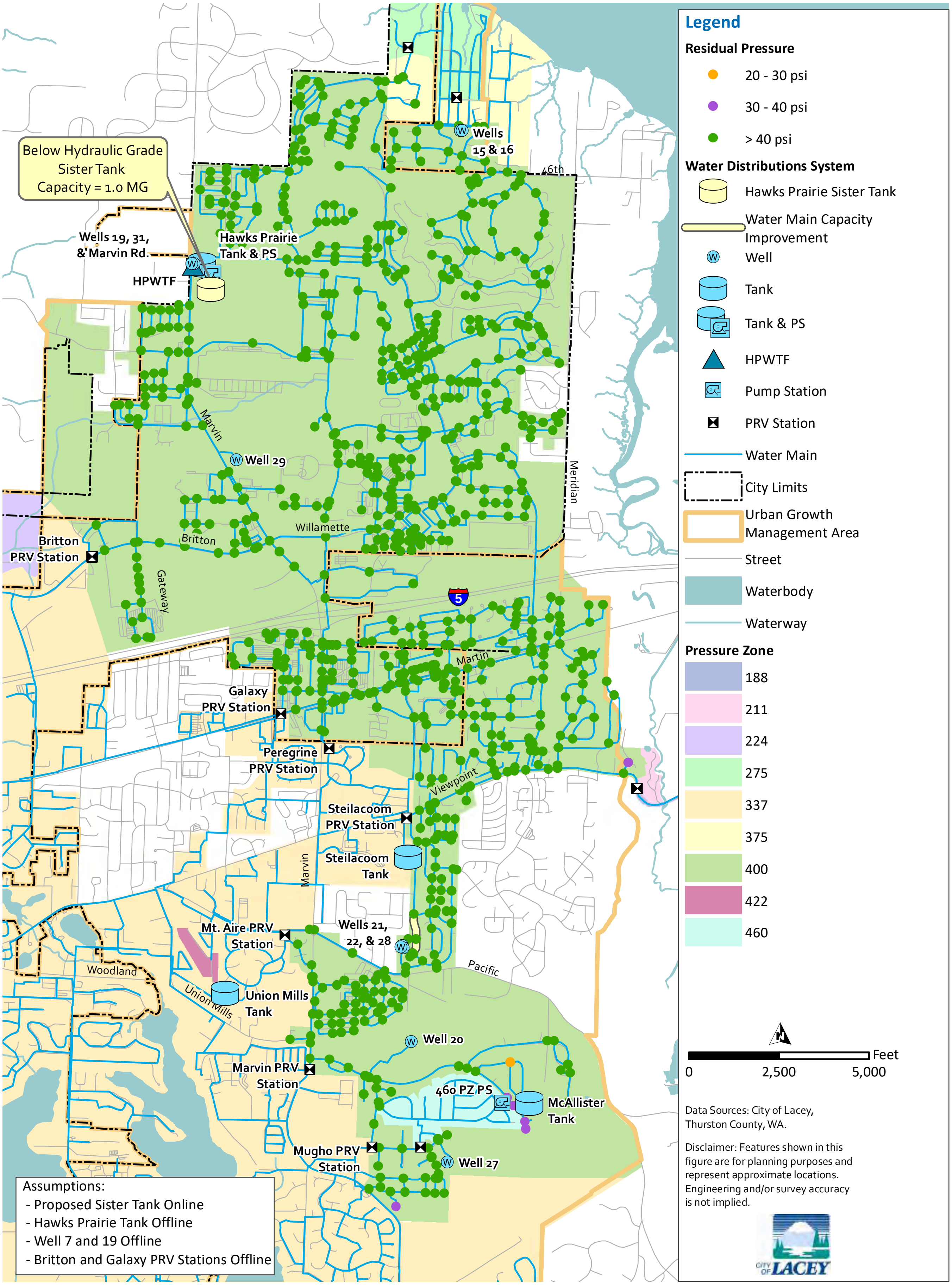
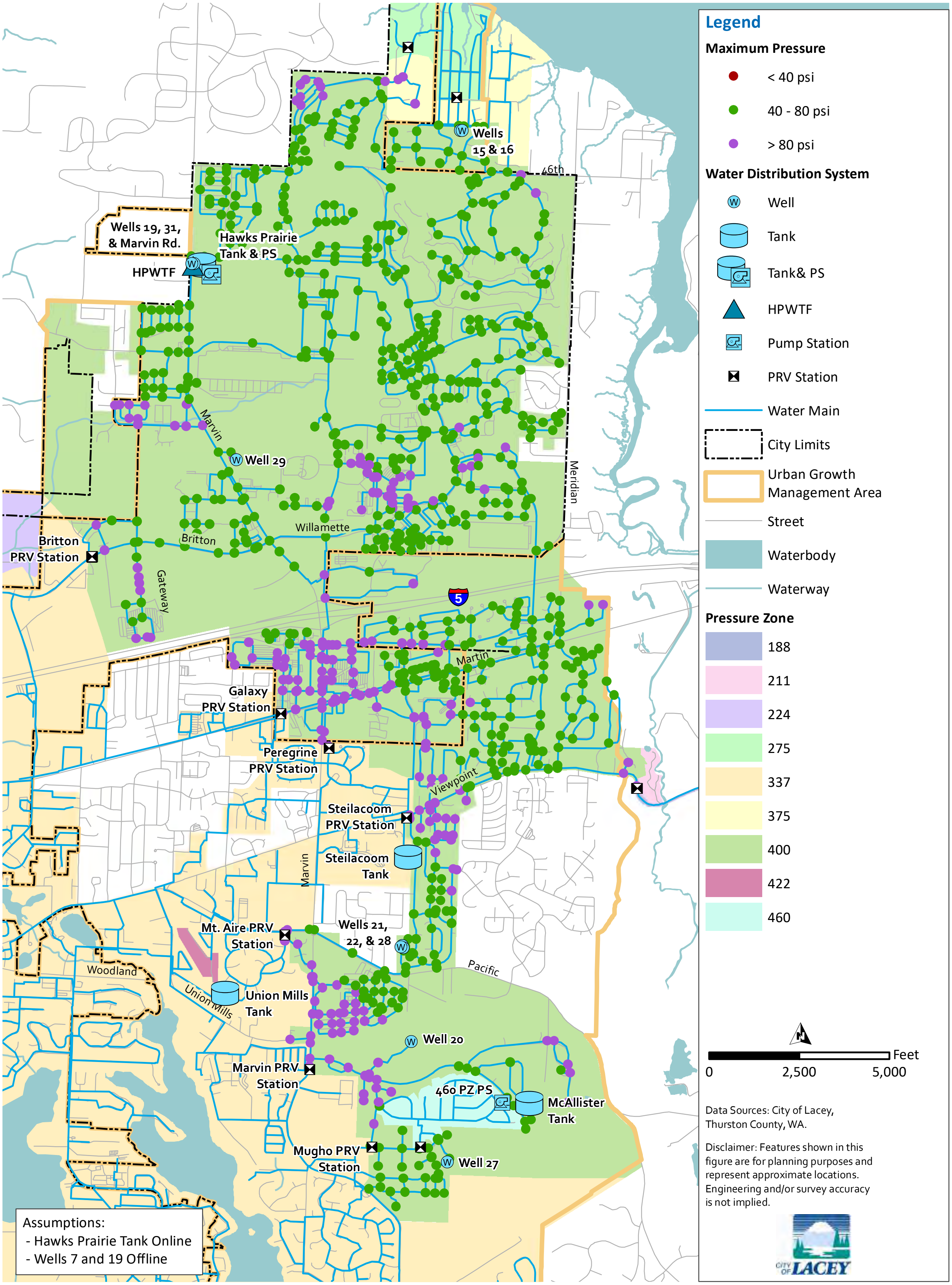


Figure 12 Residual Pressures under 2022 MDD plus Fire Flow Conditions - Alt. 3, Hawks Prairie Tank Offline


Legend
Maximum Pressure
< 40 psi
40 - 80 psi
> 80 psi
Water Distribution System
Well
Tank
Tank& PS
HPWTF
Pump Station
PRV Station
Water Main
City Limits
Urban Growth Management Area
Street
Waterbody
Waterway
Pressure Zone
188
211
224
275
337
375
400
422
460
Feet
0
2,500
5,000
Data Sources: City of Lacey, Thurston County, WA.
Disclaimer: Features shown in this figure are for planning purposes and represent approximate locations. Engineering and/or survey accuracy is not implied.
Wells 15 & 16
46th
Wells 19, 31, & Marvin Rd.
Hawks Prairie Tank & PS
HPWTF
Marvin
Well 29
Meridian
Britton PRV Station
Britton
Willamette
Gateway
5
Martin
Galaxy PRV Station
Peregrine PRV Station
Viewpoint
Steilacoom PRV Station
Steilacoom Tank
Marvin
Mt. Aire PRV Station
Wells 21, 22, & 28
Pacific
Woodland
Union Mills
Union Mills Tank
Well 20
Marvin PRV Station
460 PZ PS
McAllister Tank
Mugho PRV Station
Well 27
Assumptions:
- Hawks Prairie Tank Online
- Wells 7 and 19 Offline

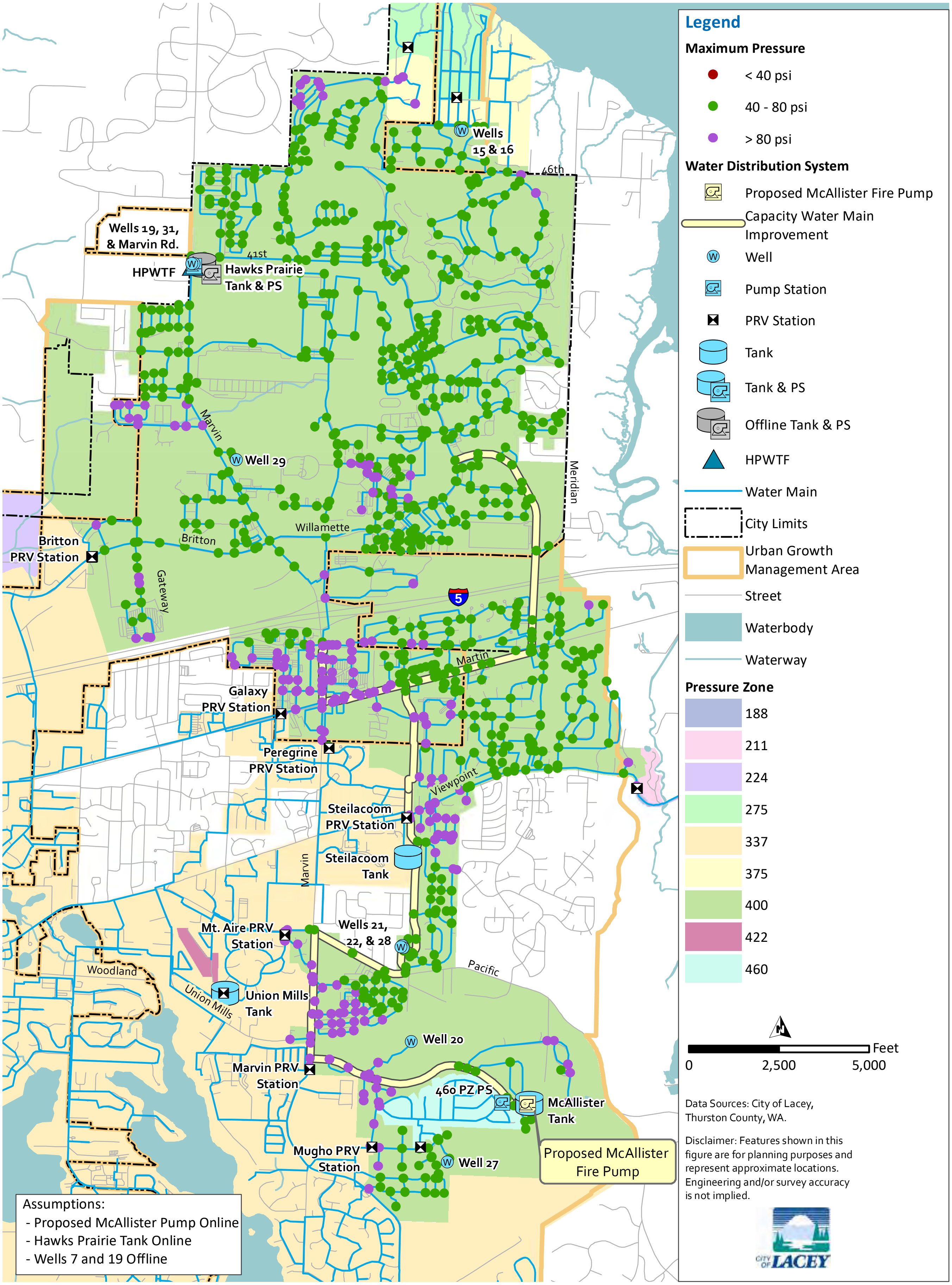


Figure 14 Maximum Pressures under 2028 ADD Conditions - Alt. 1

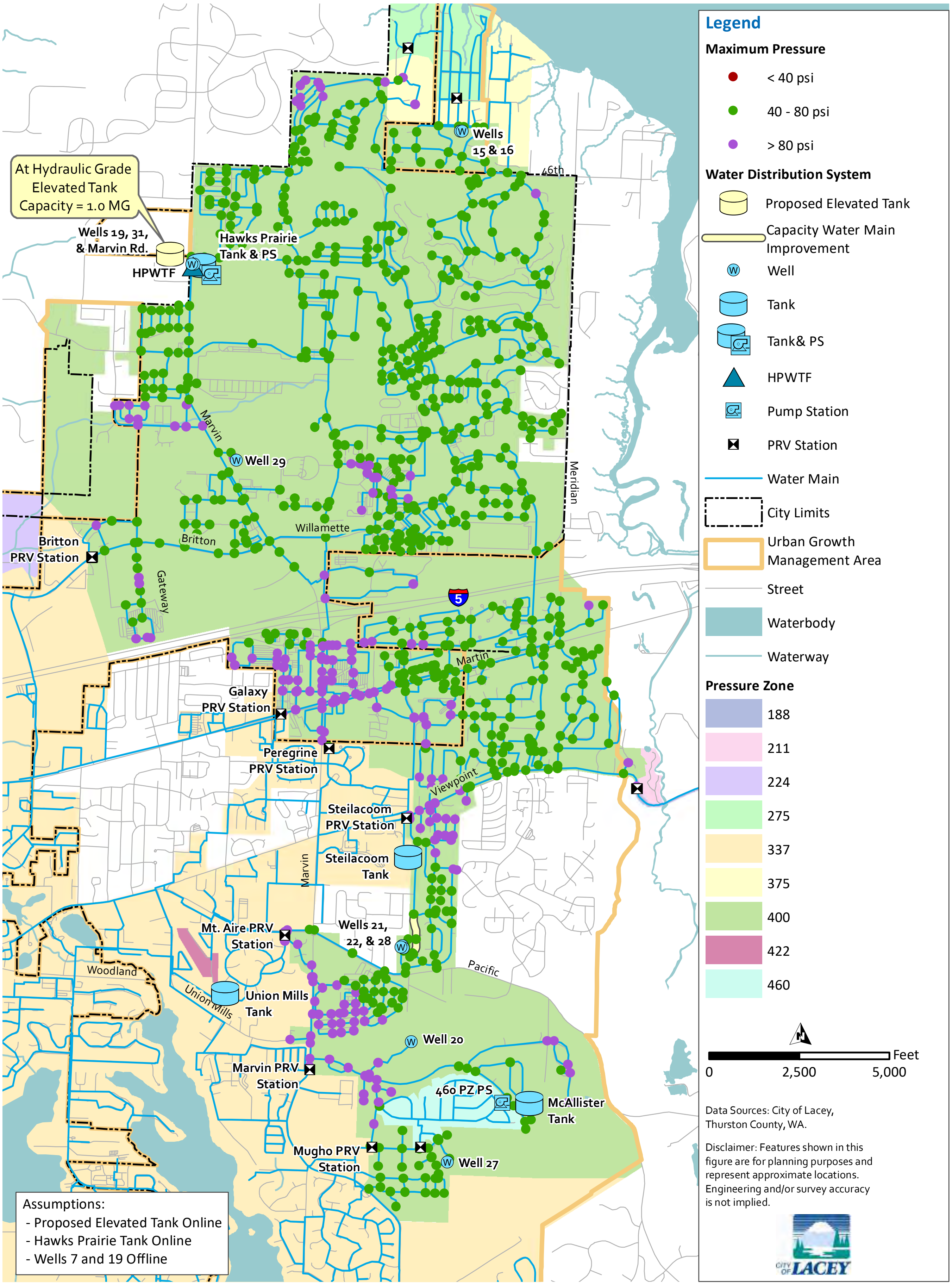


Figure 15 Maximum Pressures under 2028 ADD Conditions - Alt. 2

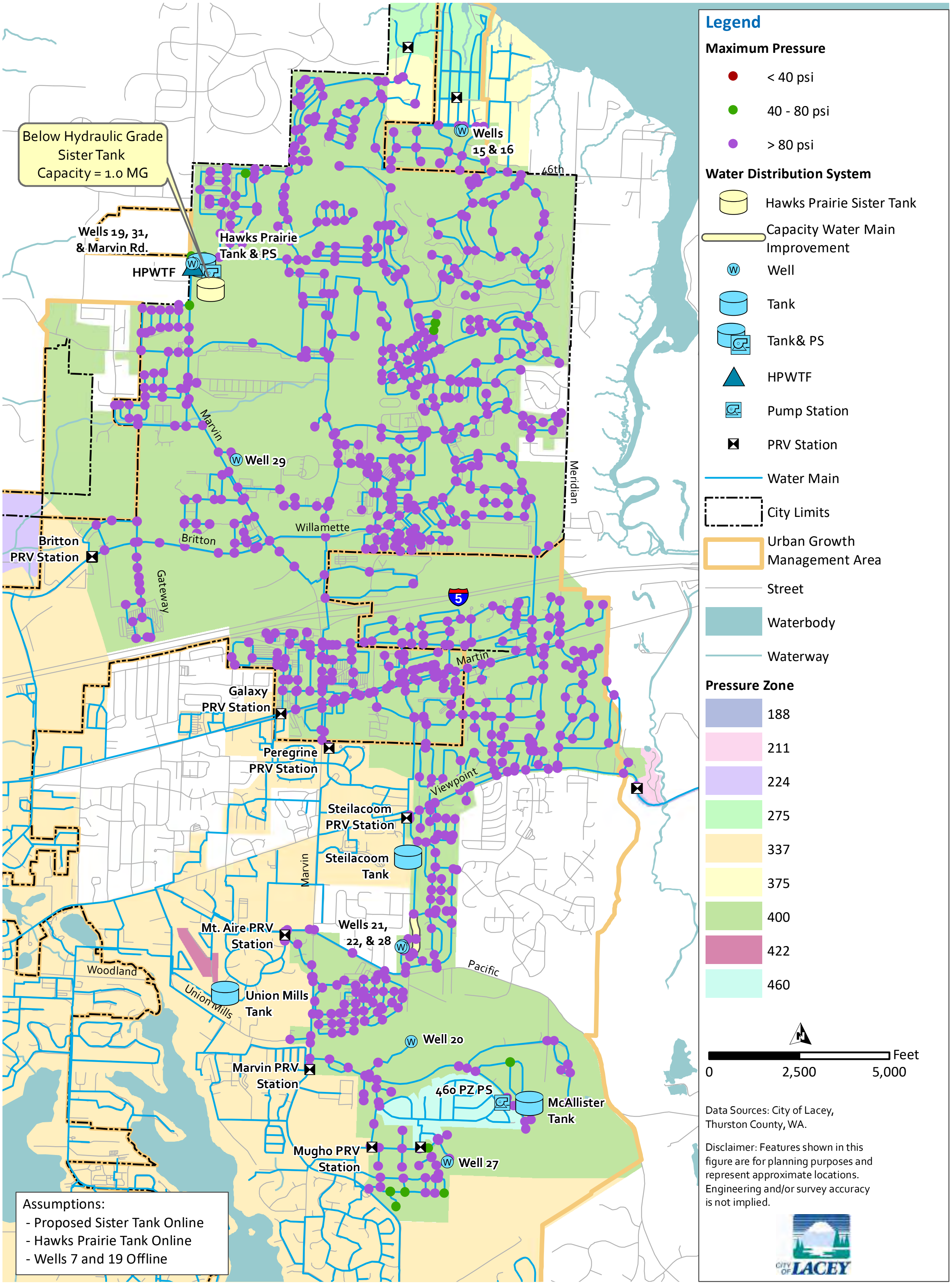
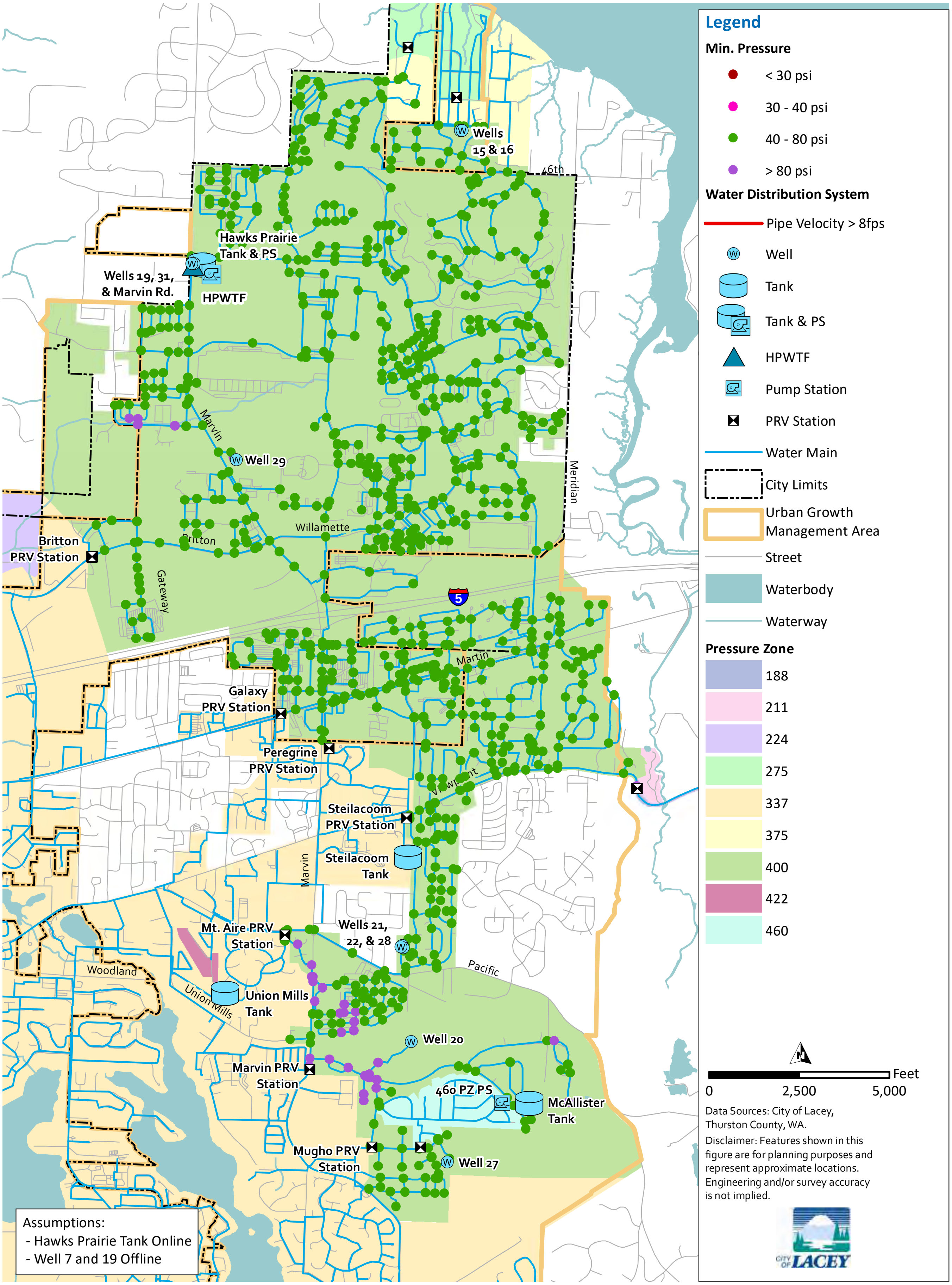


Figure 16 Maximum Pressures under 2028 ADD Conditions - Alt. 3


Legend
Min. Pressure
< 30 psi
30 - 40 psi
40 - 80 psi
> 80 psi
Water Distribution System
Pipe Velocity > 8fps
Well
Tank
Tank & PS
HPWTF
Pump Station
PRV Station
Water Main
City Limits
Urban Growth Management Area
Street
Waterbody
Waterway
Pressure Zone
188
211
224
275
337
375
400
422
460
Feet
0
2,500
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Data Sources: City of Lacey, Thurston County, WA.
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Gateway
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Peregrine PRV Station
Steilacoom PRV Station
Steilacoom Tank
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Union Mills Tank
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460 PZ PS
McAllister Tank
Mugho PRV Station
Well 27
Assumptions:
- Hawks Prairie Tank Online
- Well 7 and 19 Offline

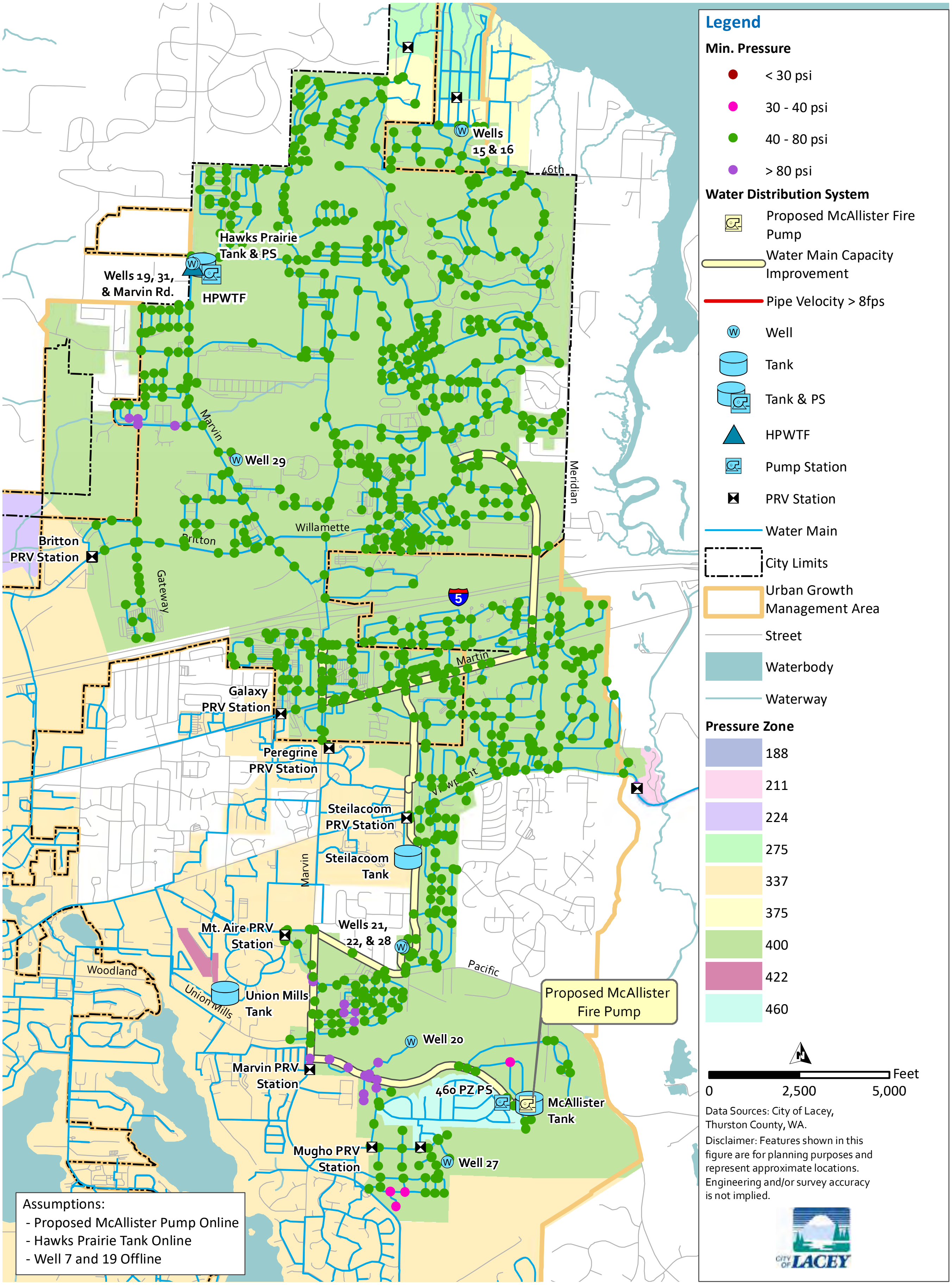

Figure 18 Min. Pressure and Max. Velocity under 2028 PHD Conditions - Alt. 1

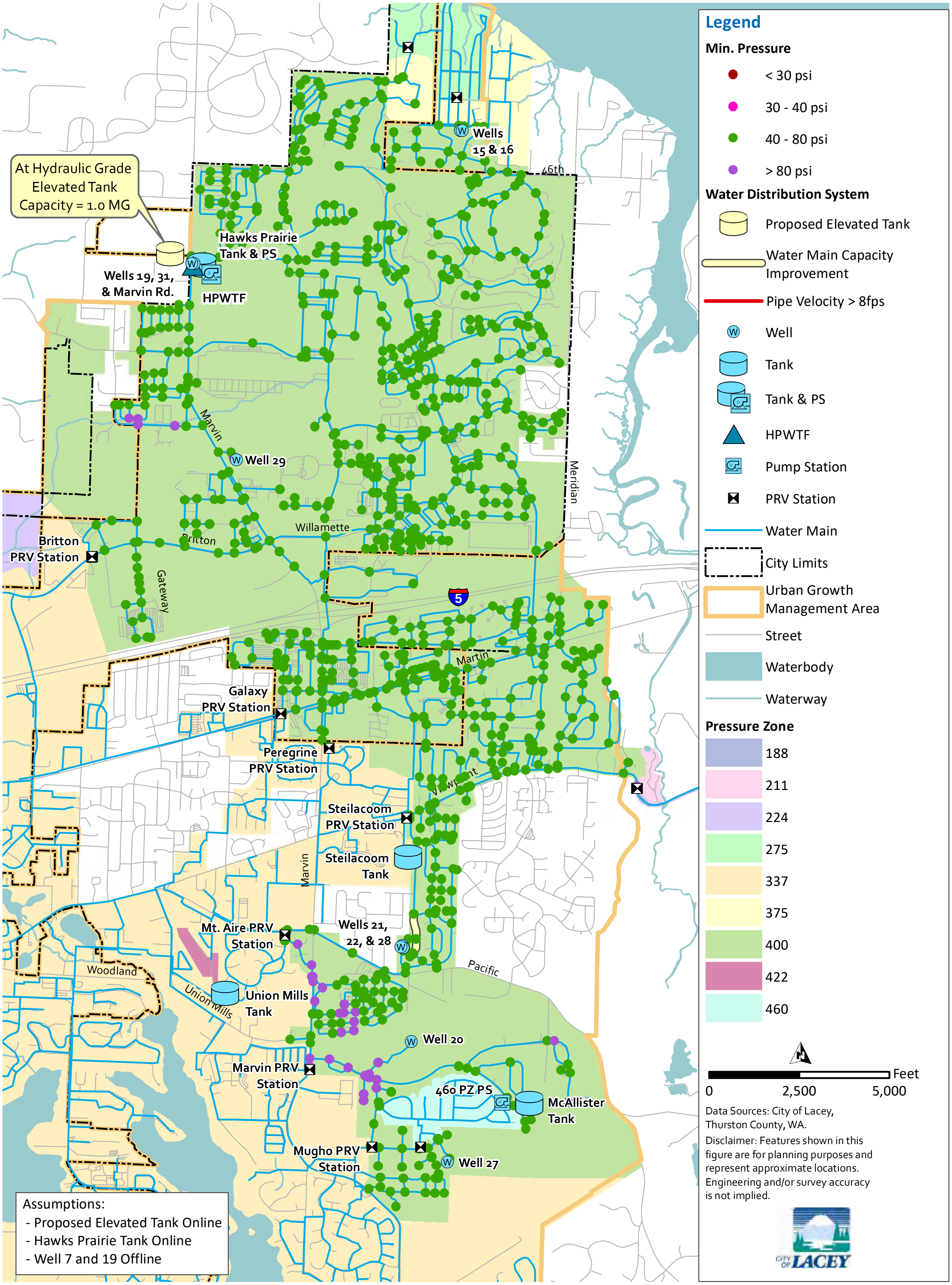

Figure 19 Min. Pressure and Max. Velocity under 2028 PHD Conditions - Alt. 2

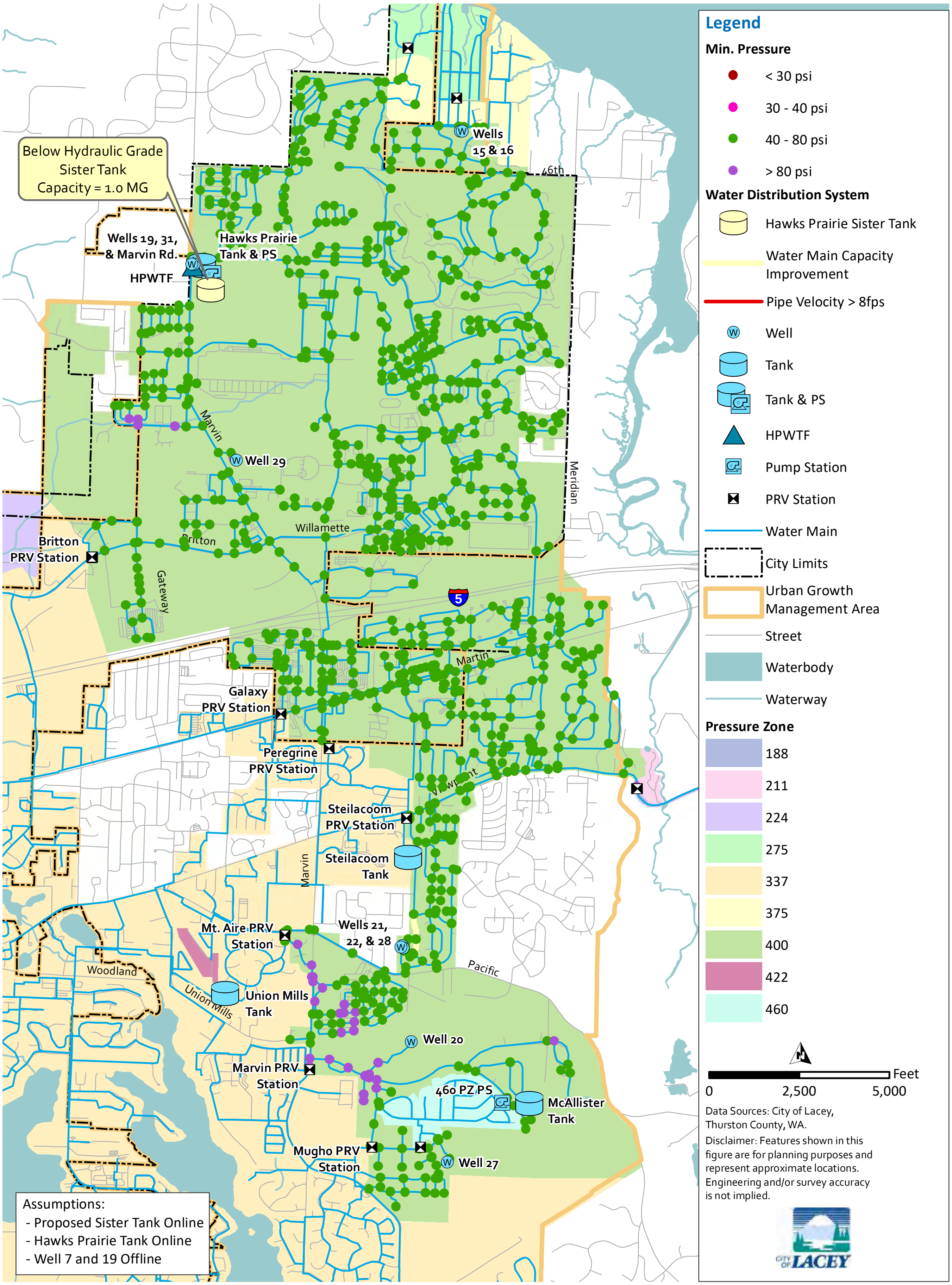

Figure 20 Min. Pressure and Max. Velocity under 2028 PHD Conditions - Alt. 3

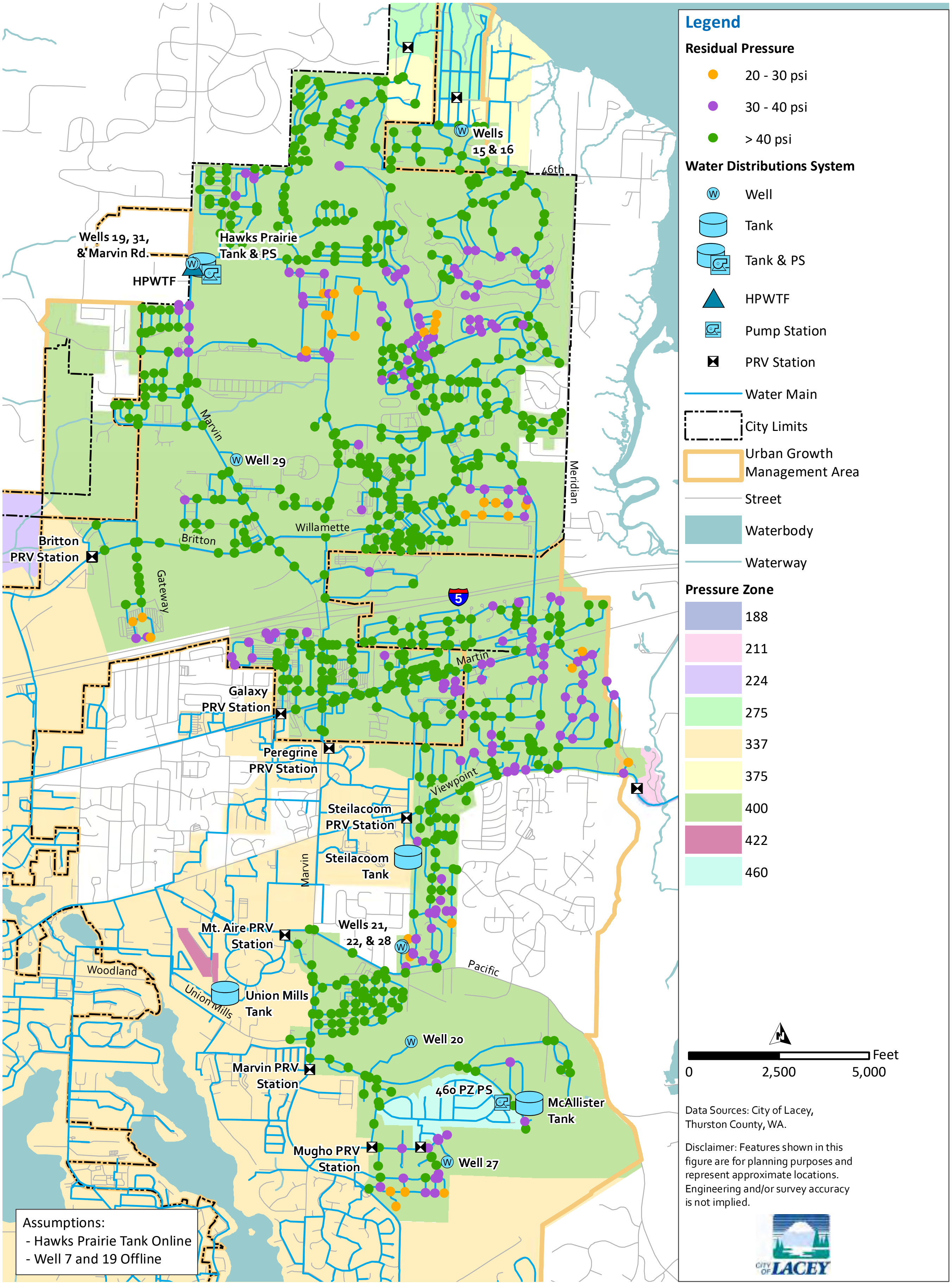

Figure 21 Residual Pressures under 2028 MDD plus Fire Flow Conditions - Baseline

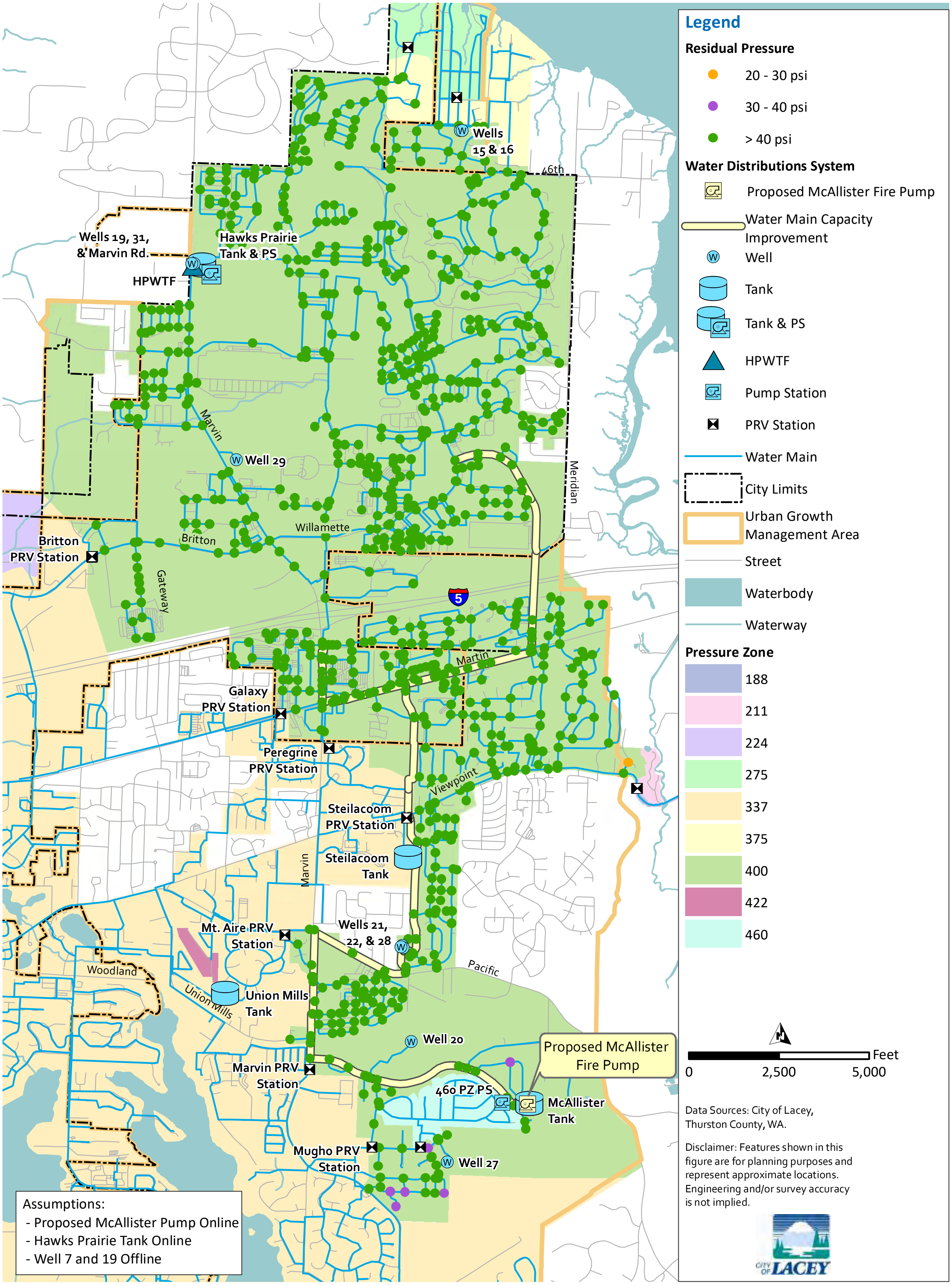

Figure 22 Residual Pressures under 2028 MDD plus Fire Flow Conditions - Alt. 1

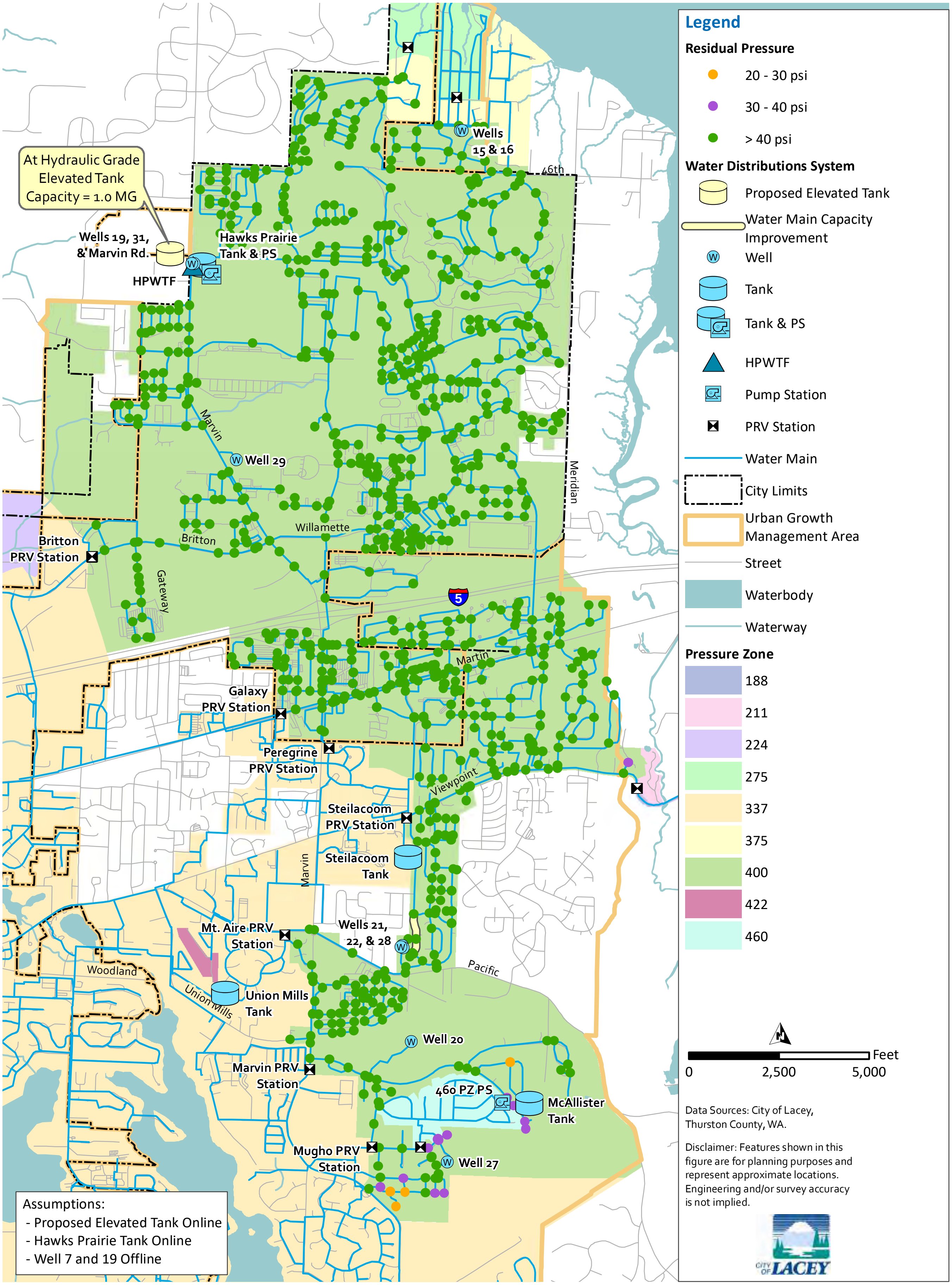

Figure 23 Residual Pressures under 2028 MDD plus Fire Flow Conditions - Alt. 2

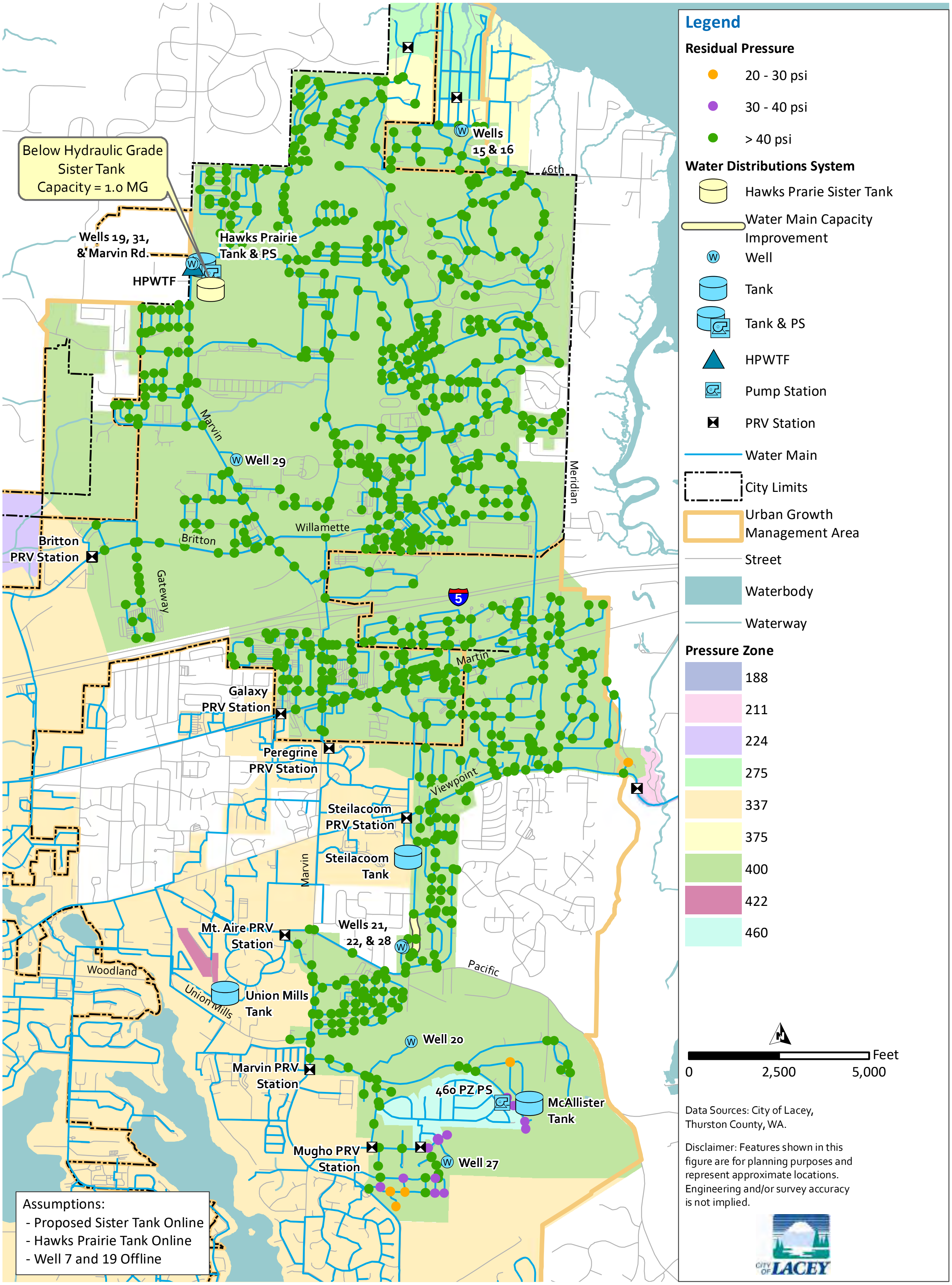

Figure 24 Residual Pressures under 2028 MDD plus Fire Flow Conditions - Alt. 3

Appendix H

North Thurston County
Coordinated Water System Plan

NORTH THURSTON COUNTY COORDINATED WATER SYSTEM PLAN

AREA-WIDE SUPPLEMENT

1996

THURSTON COUNTY
COORDINATED WATER SYSTEM PLAN
AREA-WIDE SUPPLEMENT

ABSTRACT

This report comprises the Area-Wide Supplement portion of a Coordinated System Plan (CWSP) for Thurston County established under the provisions of the Public Water System Coordination Act (RCW 70.116) for the urban area of North Thurston County designated as the Urban Water Supply Service Area (UWSSA).

This is an update of the document approved in 1986. The remaining portions of the CWSP are the individual water system plans prepared by each water system that plans to expand in the future.

This Area-Wide Supplement addresses the following issues:

Designation of the UWSSA	Chapter 1
Water System Service Areas	Chapter 2
Water System Development Standards	Chapter 3
Utility System Review and Approval Process	Chapter 4
Water Rights Reservation	Chapter 5
Joint Facility Potential	Chapter 6
Implementation	Chapter 7

The policies and recommendations contained in this Area-Wide Supplement will encourage the effective coordination and development of water systems capable of meeting the domestic and fire protection water requirements of the property owners and residents of the North Thurston urban area.

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1. SUMMARY AND IMPLEMENTATION

1.1 Purpose of the North Thurston County CWSP

In the 1980's, the Cities of Lacey, Olympia, and Tumwater were concerned regarding the impact of existing policy on future annexations and water system consolidations and the potential added costs to the water system users. Consequently, the cities of Lacey and Olympia formally requested the County to lead a coordination study under the provisions of the Public Water System Coordination Act (RCW 70.116). The Thurston County Coordinated Water System Planning Study was undertaken in 1982-85 by Thurston County in order to develop policies and procedures to improve existing water system development practices in the unincorporated areas of the North Thurston Urban area. In particular, the proliferation of small, inadequate water systems serving individual land development projects was of concern. Many of these systems are built to less than acceptable urban water system standards and are unable to offer fire protection to the properties they serve.

The goals of the North Thurston County Coordinated Water System Plan are to:

- Discourage the proliferation of small, inadequate water systems in the urban growth area.
- Ensure reliable urban-level water service within the North Thurston County Urban Growth Management Area. In the long term, urban-level water service should include fire flow to all developments in the urban area.
- Provide predictability and a timely permitting process for water purveyors, developers and other parties regarding water service in the North County UGA.
- Coordinate timely land use development approvals with long-term water system objectives and plans.

This report is an update of the 1986 Area-Wide Supplement portion of the Coordinated Water System Plan. A Coordinated Water System Plan (CWSP) consists of two elements:

Area-Wide Supplement

A set of provisions applying to all public water systems within a Urban Water Supply Service Area (UWSSA) establishing requirements for the development and coordination of those systems. Minimum requirements for the Area-Wide Supplement specified in State guidelines as of 1/96 include:

- design standards including fire flow,
- service area maps for expanding systems,
- procedures for authorizing new systems which minimize proliferation,

- assessment of potential shared facilities, including intertie and transferring facilities and wheeling of water supplies,
- satellite system management requirements, and
- policies and procedures which generally address failing water systems for which counties may become responsible under RCW 43.70.195.

Individual Water System Plans

Prepared by all water systems required to do so by law, and in particular by all water systems within the UWSSA which plan on expanding their service to new areas in the future. The establishment of recognized future service areas is part of these water system plans.

The water purveyors which have indicated their intent to expand are Lacey, Olympia, Tumwater, South Sound Utility, Pattison and Meadows.

All water systems within the UWSSA which plan to expand have been notified of their requirement under RCW 70.116.060 for the preparation of water system plans.

1.2 Study Process

Establishment of the UWSSA: 1980-86 Planning Process

Following the preliminary assessment, which was prepared by the Department of Social and Health Services (DSHS) in 1980, the Thurston County Commissioners passed a motion in 1984 declaring their intention of implementing the Public Water System Coordination Act within a broad area including all of the urbanizing area of North Thurston County. As called for in the Act, Thurston County was the sponsoring agency for the development of the Coordinated Water System Plan.

In 1984, Thurston County, following the guidelines of the Act, appointed a Water Utility Coordinating Committee (WUCC) composed of representatives of all water systems within the North Thurston area having 50 or more users. The County, together with the WUCC, began the study process by interviewing and selecting a consultant to assist in the preparation of the Area-Wide Supplement. Warren Consultants, Inc. of Seattle was chosen to be the prime consultant. The County also contracted with Thurston Regional Planning Council (TRPC) for local staff support, information, and coordination with the consultant during the study.

The first step by the Consultant and the County staff was to develop a work program for preparing the Area-Wide Supplement. Using this, together with the activities of the WUCC and others involved in water supply in the area, a grant application was prepared and submitted to the Department of Social and Health Services for a 50 percent matching grant to fund the preparation of the Area-Wide Supplement. This grant was approved by DSHS on March 13, 1984 and the study began.

The investigative work of the 1984-86 study was performed by Warren Consultants, Inc. and County Planning staff. Together they developed a series of recommendations regarding each of the study elements. These elements were submitted to the WUCC for discussion and the development of policies. Through a series of more than 35 meetings, WUCC developed policy positions on each of the various study elements, outlined below, and submitted these recommendations to the Thurston County Commissioners for action.

The open public meetings of the WUCC provided a forum for the thorough discussion of issues prior to their presentation to the County Commissioners. This, together with regular mailings to all affected water systems within the study area and the later Urban Water Supply Service Area (UWSSA), ensured that all water systems would have an opportunity to participate in the development of the Area-Wide Supplement and the overall Coordinated Water System Plan.

The original Area-Wide Supplement was adopted by the Board of Thurston County Commissioners in January, 1986 and approved by the Washington State Department of Social and Health Services effective January 29, 1986.

Throughout the 1986 study, every effort was made to incorporate the prior planning and land use determinations of the County and the other jurisdictions within the study area.

1996 CWSP Update

In March 1996, the Board of Thurston County Commissioners referred several draft Areawide Supplement policy and procedure revisions to the WUCC for recommendation. As stipulated by State guidelines, all water systems with over 50 customers were invited to participate on the WUCC. The WUCC met four times to review the items referred by the Board. Seven private purveyors actively participated, along with the three cites, the PUD, the Fire Marshall, and local and State health staff. Several of the participants were involved with formulating the original 1986 CWSP, and provided valuable insight into the original intent of various provisions in the Plan.

The revisions recommended by the WUCC included:

- Increase flexibility in water system construction standards regarding storage and installation of fire hydrants which lack fire flow at the time of development;

- Clarify the water service review process, including encouraging use of the presubmittal review process and specifying alternative service which may be available without altering future water service boundaries of the designated system (such as satellite service or interim service from a neighboring water system).

- Revise the Urban Water Supply Service Area external boundary to be consistent with the current (1996) Urban Growth Area (UGA) boundary. Revise the Growth Management procedures to ensure that future proposed UGA boundary expansions are referred to the WUCC for comment prior to adoption, to ensure that urban-level water is feasible and to keep the UGA and CWSP boundaries as consistent as possible.

- Support for annual meetings of the WUCC to explore issues of mutual interest such as water resource development, CWSP implementation, and failing small water systems.

A number of other changes were proposed by staff to update terminology and reflect current conditions regarding the CWSP.

Comment was specifically solicited from the three cities regarding consistency of the revised CWSP with growth management policies and the municipal water system plans.

Service area maps were updated through requesting information from all Group A Community systems in the UWSSA. This included service areas for designated expanding systems as well as current service areas for non-expanding systems. These maps are available from Thurston County Environmental Health.

1.3 Major Study Elements and Findings

The Water System Coordination Act (RCW 70.116) and the subsequent Washington Department of Health (DOH) administrative regulations (WAC 246-293) provide for specific issues to be addressed in preparing a Coordinated Water System Plan and the Area-Wide Supplement portion thereof. Progress since 1986 and significant new issues addressed by this Area-Wide Supplement are:

1.3.1 Boundaries of the Urban Water Supply Service Area

One of the first requirements for an Area-Wide Supplement for a Coordinated Water System Plan is the establishment of specific legal boundaries for what is known in the Act as the Critical Water Supply Service Area (CWSSA) (WAC 246-293-110). This is the area in which all of the other requirements of the Act will be applied. After a thorough review of a number of planning area options, the WUCC recommended a set of external boundaries for the Thurston County Coordinated Water System Plan to the County Commissioners, titled the Thurston County Urban Water Supply Service Area (UWSSA). The County Commissioners modified the recommended boundary and on October 23, 1984, the County Commissioners adopted an initial boundary for the Urban Water Supply Service Area (UWSSA) comprised of the Urban Growth Management Planning Area boundary plus those areas where existing water systems provided service beyond this boundary. This boundary closely approximated the future water service areas of the three cities, established by mutual agreement and approved by the Boundary Review Board in 1975. Figure 1 shows the 1986 UWSSA boundary adopted by the County Commissioners and approved by DSHS. This boundary was determined to best meet the boundary criteria set forth in WAC 248-56-610. Most importantly, it encompassed the existing and planned urban area and the area with the most coordination needs.

The 1996 update includes revised external boundaries consistent with the original UWSSA boundary rationale (see Figure 2). The 1996 update also includes a process for future revisions intended to maintain consistency between the Urban Growth Area (UGA) and UWSSA boundary. See Section 7, Plan Implementation.

FIGURE 1: 1986 BOUNDARY OF THE URBAN WATER SUPPLY SERVICE AREA

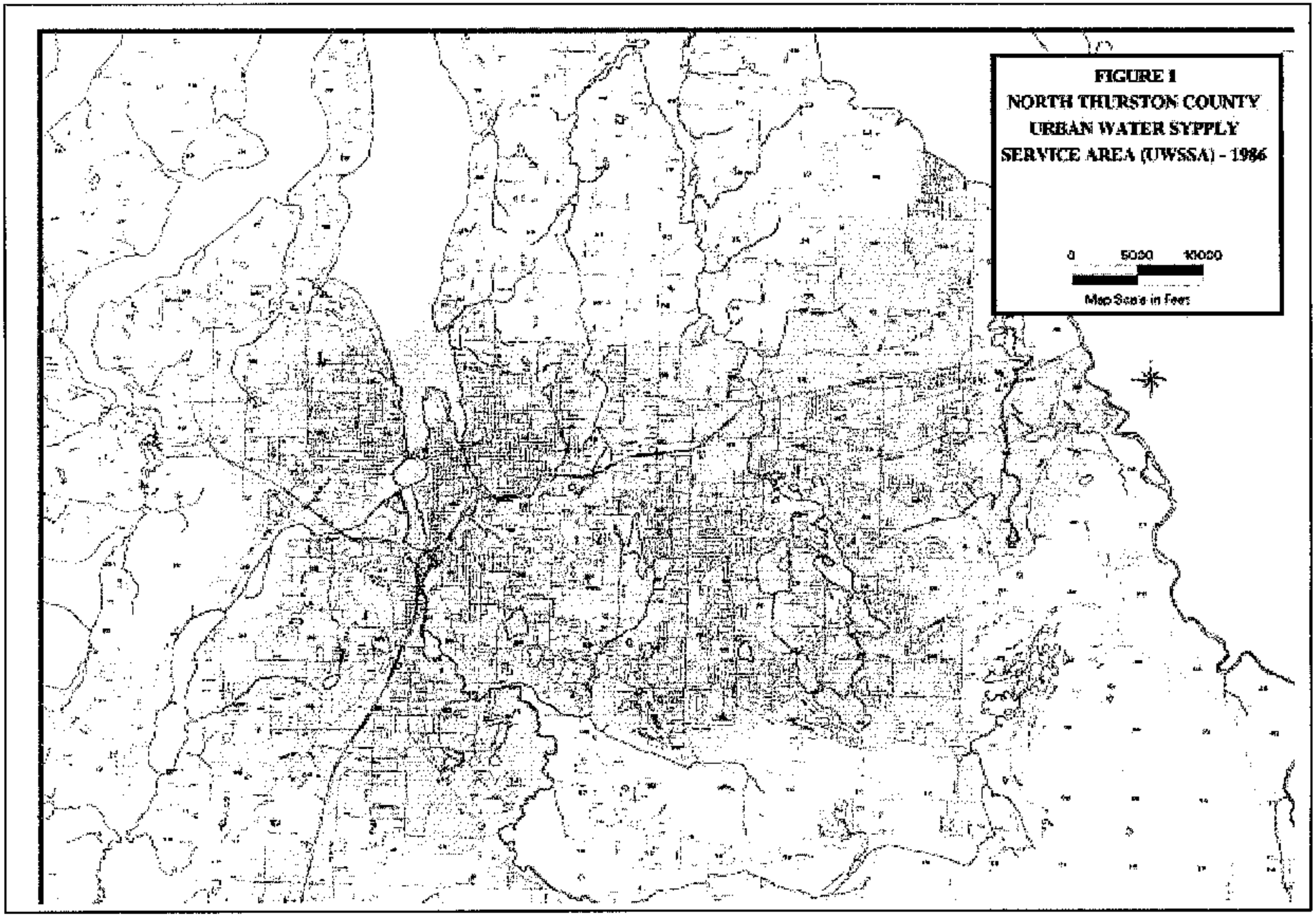
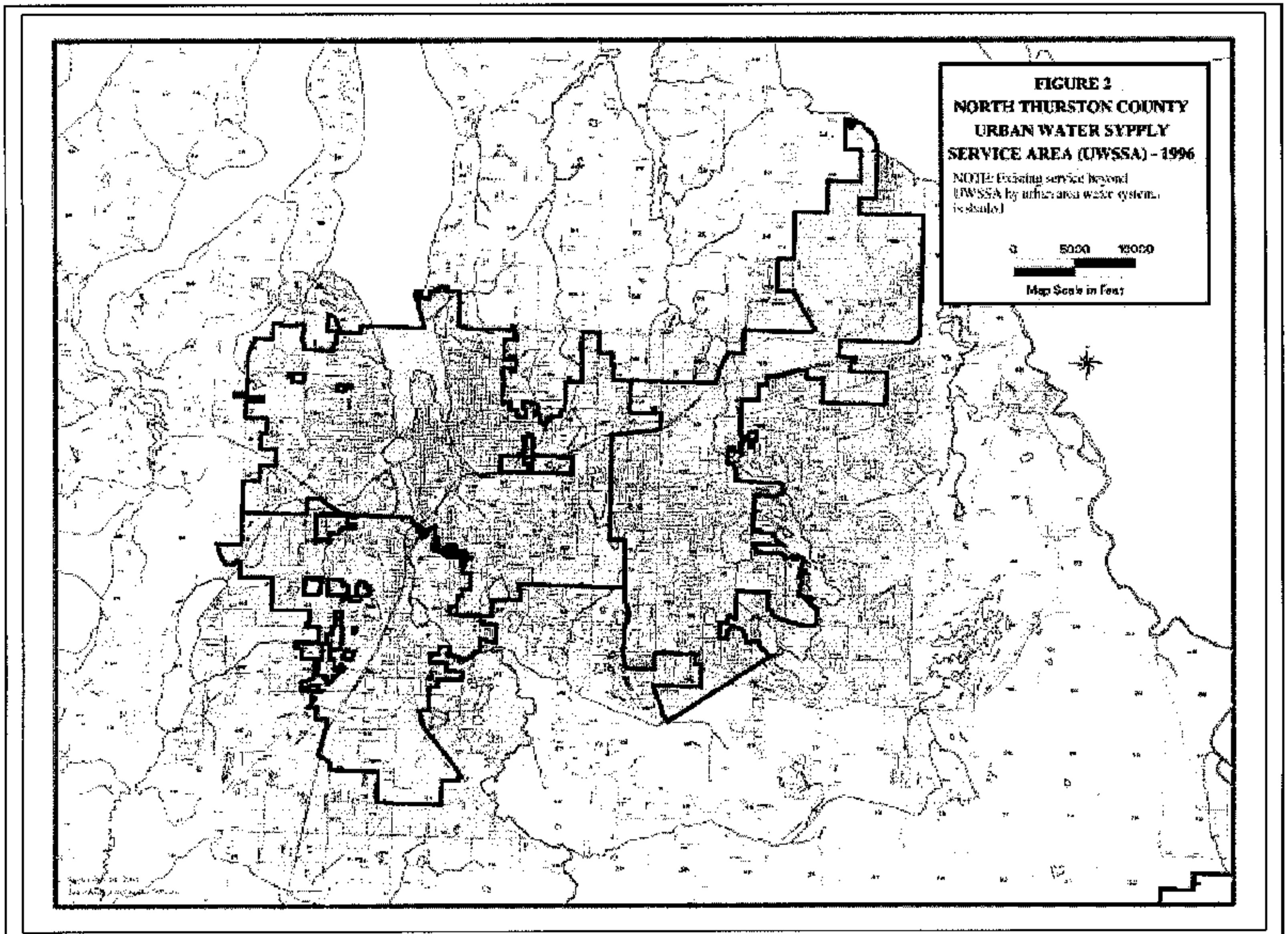


FIGURE 2: 1996 BOUNDARY OF THE URBAN WATER SUPPLY SERVICE AREA



1.3.2 Service Areas and Water System Plans

During the 1984-86 planning process, all water systems within the UWSSA were asked to identify their existing service areas. They were given the opportunity to project and indicate areas where they would plan for and provide water service in the future. Each of the larger water systems having more than 50 users was contacted and interviewed to discuss their existing and potential future boundaries. Following the interview process, all systems within the UWSSA were formally notified of the requirement of the Act and asked to submit maps and descriptions of their existing service and any future boundaries they wish to serve. Where the responses from the water systems indicated that conflict existed with other adjacent water systems, each system was notified of the requirement of the Act that they meet and resolve these conflicts before being awarded a future service area. Twelve systems were identified as having conflicts, including each of the three cities. The process of resolving conflict areas proceeded throughout the 1984-86 study leading to the Area-Wide Supplement and for a time thereafter. In an effort which spanned the period of 1985 to 1995, virtually all service area conflicts were resolved.

During the 1984-86 planning process, the following water systems indicated their intent to expand: Lacey, Olympia, Tumwater, Capital Utilities, Marvin Road Water Company, South Sound Utility, Beachcrest, Meridian Acres, Seasons, Pattison, Meadows, Trails End, and Alderbrook Trailer Park. However, several of these systems either declined to identify future service areas or have been incorporated into city water systems. As of 1996, there are six expanding systems in the UWSSA: Meadows, Pattison, South Sound Utilities and the three cities.

All water systems within the UWSSA which planned to expand were notified in 1986 of their requirement under RCW 70.116.060 for the preparation of water system plans. Water system plans have been completed for all expanding systems in the UWSSA, except Pattison Water Company, following the policy and guidelines established in this Area-Wide Supplement and DOH regulations.

1.3.3 Water System Standards

The Preliminary Assessment prepared in 1984 identified the lack of water system design and development standards within the urban area as one of the most important issues needing coordination. Through their own voluntary coordination process, the three cities (Lacey, Olympia and Tumwater) had over the years preceding the CWSP, developed very similar standards in terms of pipe sizing, fire hydrant placement, and other water system design elements. The cities applied these standards to all developments connected to their systems. The problem, however, was that the majority of water systems developed in the urban area during the rapid growth of the 1970's and 1980's were not connected to a city system and were able to be constructed using only DSHS minimum water system standards without any provisions for fire protection. The Coordination Act requires that the provision of fire flows by all water systems within the UWSSA be addressed.

Therefore, it was essential that water system development standards meeting this goal be prepared and adopted for use throughout the UWSSA.

After an extensive review by the WUCC, standards were recommended to the County in 1985 for the design and construction of all water systems within the UWSSA. After public hearings, standards were adopted by the Thurston County Commissioners on August 5, 1985 through Ordinance No. 8149.

In the ten years since adoption, the standards have been largely effective in serving the objectives of adequate long-term water service within the UWSSA. In the 1996 update, some revisions and clarifications are provided, including additional detail on interim service which may be allowed prior to direct service by the designated expanding water system and greater flexibility regarding calculation of required storage and timing of hydrant installation.

1.3.4 Water System Review and Approval Process

Important to the success of the Coordinated Water System Plan process is a system to discourage the proliferation of small and inadequate water systems within the UWSSA and to coordinate the orderly growth of existing systems.

As a vital component of the 1986 Area-Wide Supplement, a water system review and approval process was developed and adopted. Implementation measures identified in the 1986 plan were accomplished, including establishing administrative rules and fees, agreement with the State Department of Social and Health Services (now Department of Health), and public information materials prepared by the Thurston County Health Department.

Since adoption in 1986, the CWSP has very successfully limited the number of new small water systems. In the ten years since 1986, only about 4 new systems have been created in the UWSSA. Several appeals were heard and resolved by the Hearings Examiner. These mainly concerned timeliness and cost for extending municipal service to properties within future service areas but distant from existing water lines. Most of these resulted in interim water service arrangements. In one case, conditions were offered by both the city (first priority for service) and an existing neighboring utility (second priority) to serve property at Old 99 and 85th Avenue. However, the Examiner sided with the applicant in finding that the terms of service from both purveyors failed to provide timely and reasonable service. A new small independent water system was authorized by the Examiner.

An emerging water service system planning issue of area-wide importance is the existence of over 200 smaller privately operated water systems in the UWSSA. Increasing requirements for water quality monitoring, financial feasibility and wellhead protection are putting increasing pressure on the operators and customers of these systems. The 1996 Area-Wide Supplement update addresses broad objectives regarding this challenging issue.

1.3.5 Water Rights Reservation

The provision of future water for domestic use in the UWSSA is another important part of the Coordination Act planning process. Prior to development of the 1986 study, the three cities had elected to proceed with a Water Rights Reservation petition to the Department of Ecology under the provisions of RCW 90.54. The three cities jointly funded a 1982 study by Economic and Engineering Services, Inc. (EES) of Olympia for the preparation of the Water Rights Reservation petition. The study by EES dated May, 1982 was reviewed as part of the 1984-86 planning program and was found to be complete and adequate to serve as the water supply element of the Area-Wide Supplement. Findings of the 1982 report include:

- The North Thurston urban area is expected to grow to a population of approximately 288,100 by the year 2030. This is the estimated population used for the water reservation. The 1980 census population for the area was 100,560.
- Ground water will continue to be the primary source of the public water supply through the year 2030.
- Additional water rights must be reserved through the Department of Ecology to insure the availability of the estimated 43.3 MGD required in the year 2030.
- Ground water quality must be protected if this source is to continue as the primary domestic water supply for the area.

The "Reservation of Future Public Water Supply for Thurston County" was adopted by the Department of Ecology as WAC 173-591. The WAC was filed on July 14, 1986. The reserved groundwater was generally prorated to a number of source locations in northern Thurston County. The intent of the WAC was that the priority date for future permits for public water supply would be the effective date of the Reservation (7/14/86). DOE was charged in WAC 173-591 with maintaining records of appropriations and available reserves for each subarea. The local governments and DOE were responsible under the WAC for implementing a groundwater and surface water-monitoring program. These have been instituted through a variety of regional and local programs.

1.3.6 Coordination With Other Planning

The Coordinated Water System Plan was fully coordinated with all relevant current local planning including:

- The County Urban Growth Management Agreement approved in June, 1988 and the "Thurston County County-Wide Planning Policies" dated September 8, 1992.

Specifically, the CWSP is consistent with the following provisions excerpted from section II of the County-Wide Planning Policies regarding "promotion of contiguous and orderly development and provision of urban services" through:

a. Compatible development standards and road/street level of service among adjoining jurisdictions;

b. Development occurring within unincorporated growth areas shall conform to the development standards of the associated city or town;

c. No extensions of urban services and facilities, such as sewer and water, beyond urban growth boundaries except to serve existing development in rural areas with public health or water quality problems."

- Local Zoning and Land Use Plans including the joint area plans for the three North Thurston County cities

- Individual Water System Comprehensive Plans

- The Coordinated Water System Plan for Water Rights Reservation for North Thurston County (1982)

- The LOTT, Phase II Wastewater Management Plan (1988) and the Thurston County Sewerage General Plan (1990). In these documents, policies for short-term and long-term UGA sewerage service are defined which are parallel to the water service policies in this Plan. In particular, UGA policies in the LOTT study page IV-4 and Sewerage General Plan page IV-6 stipulate that development beyond the existing sewer system is allowed on interim systems, provided provision is made for future hookup to sewer when it becomes available.

Since water supply appears to be a potential growth limiting factor in the planning area, water system planning is critical to ensuring urban level service to support land use decisions.

1.4 Previous Actions to Implement Study Findings

Following 1985 action by the Board of County Commissioners to establish the Urban Water Supply Service Area boundaries and adopt new water system design standards, the following actions were required to fully implement the Coordinated Water System Plan:

- The 1986 adoption of the Area-Wide Supplement plan including the necessary hearings and environmental determinations required by state and local law.

- Development of internal administrative rules to implement the review and approval process contained herein.

- Completion of the service area agreements for all water systems within the UWSSA that plan to expand.

- Completion of the water system plans by all water systems planning to expand.

1.5 Future Activity Related to the 1996 Coordinated Water System Plan

1.5.1 Each jurisdiction should review their development permit procedures to ensure consistency with the CWSP water service review process, including providing notices of presubmission conferences to the designated water purveyors and providing timely response to requests for water service;

1.5.2 Each jurisdiction should review their Hearings Examiner procedures to accommodate the Examiner's proposed role in resolving service area disputes and approving creation of any new water systems as identified in section 4.3;

1.5.3 Pursue opportunities for joint opportunities in source development, conservation and intertie through the Public Works Director's meeting. Include operators of the larger privately-operated systems where appropriate;

1.5.4 The County should continue the Water Utility Coordinating Committee and should keep them informed of the progress of resolving service area agreements and obtaining completed water system plans. A meeting of the WUCC should be held annually to review the implementation of the recommendations of the Area-Wide Supplement and to determine whether or not any changes or additions are required.

1.5.5 Individual water systems must also update their water system plans every five years and these revisions must comply with any changes to the Coordinated Water System Plan. In particular, the 1996 Area-Wide Supplement update identifies that water system plans should address policies for:

  - Accepting fees in lieu of constructing frontage improvements in locations where final water system engineering is not complete;

  - Satellite service by the city or by contract to another approved satellite system operator when development is distant from existing city water lines;

  - Assisting and/or integrating existing small water systems within the city's water service area, including identifying conditions under which the city may be willing to become an authorized receiver of a failed water system.

1.5.6 The Washington State Department of Health and the Thurston County Environmental Health Department should enhance procedures relating to small water systems. Actions identified in section 4.6 of this Plan include:

- Enhancing the "early warning" system to identify water systems which are encountering problems. Thresholds for response should be identified for both Group A systems (oversight provided by DOH) and Group B systems (oversight provided by Environmental Health). This includes ensuring that Environmental Health is notified when the one-year notice to end water system operation is served by the operator to DOH. Appropriate outreach measures and roles should be identified.

- The state and local health agencies should adopt internal procedures to apply the priority of service review in section 4.3 to changes in ownership of existing small water systems. Under existing regulations, water system operators must notify doh (group a systems) or Thurston County environmental health (group b systems) of intent to transfer ownership or discontinue service. In addition, the health agency may identify essential requirements that an existing water system can no longer meet. When either of these circumstances occurs, the health agency should apply the service priorities in section 4.3 to identify the priority water system owner.

2. SERVICE AREAS

2.1 Existing Conditions

For the past few decades, the North Thurston planning area has been one of the fastest growing urban areas in the State of Washington. During the period 1970 to 1980, the population of the Olympia/Lacey/Tumwater urban area grew from 62,600 to 97,000 in population, an increase of 54 percent. During the 1980-1990 decade, Thurston County was the second fastest growing County in the State in terms of percentage increase, with a population increase of about 30%.

The North Thurston planning area is characterized by the general availability of high quality ground water within 200 feet or less of the ground surface. Additionally, much of the surface soils of the area are generally suitable for septic tank use based on standard percolation criteria. Prior to the invoking of the Public Water System Coordination Act, the County permitted new water systems to be developed to serve each emerging land development. The consequence is that within the 1996 UWSSA, which is the area within which the County hopes to contain the majority of future urban growth, there are about 270 public (community or commercial) water systems including about 80 Class A Community systems (15 or more services). Of these, only about 21 private water purveyors have more than 50 customers. The three cities of Lacey, Olympia and Tumwater are all within the Urban Water Supply Service Area and serve more than 60 percent of the population within that area boundary.

Until the adoption of the UWSSA and the invoking of the Coordination Act, Thurston County had not exercised specific control over the service areas of the many water systems within the urban growth area.

2.2 Requirements of the Public Water System Coordination Act (RCW 70.116)

Water systems designating future service areas are required by the Public Water System Coordination Act to prepare water system plans for their systems including all future service areas. These plans must be coordinated with the adopted area-wide supplement. The original target date was to have all required water system plans completed and approved by October 1986.

For systems that did not identify future service areas during the 1985-87 planning process, this Plan assumes that the systems are not planning to expand. Existing systems are assumed to have service areas that incorporate the areas for which approved water system plans have been previously issued by DOH or the County's Environmental Health Division or as shown on the service area maps established through the CWSP process. The objectives of the CWSP do not infringe on the rights of existing non-expanding systems to continue to operate within their existing service areas under State and County law and regulations.

At the start of the Coordinated Water System Plan 1996 update effort, computer listings for all water systems of record in Thurston County were obtained from DOH. These lists were used to identify all Group A Community water systems in the Urban Water Supply Service Area. Staff contacted all systems by mail, and solicited the designation of their existing or future service areas. Revised service area maps were prepared in 1996 and are adopted by reference as part of this Plan.

2.3 Procedure for Resolving Service Area Conflicts

The Act requires a resolution of future service area conflicts as part of the Coordinated Water System Plan. In the 1986 CWSP Area-wide Supplement, several systems were identified as "indicating intent to expand." Resolution of service area conflicts was a key outstanding action item for the WUCC and Thurston County Environmental Health when the 1986 Area-wide Supplement was adopted. Each water system that was in conflict was notified of the requirements of the Act and the known conflicts that existed, and they were directed to negotiate agreements with all of the water systems with who they were in conflict. The County gave each water system a reasonable time to arrive at an agreement with the other water systems after which the County asked DSHS to invoke the provisions of WAC 246-293 to adjudicate and assigned future water service areas for all unresolved areas.

2.4 Status of Service Area Agreements

The Lacey, Olympia, Tumwater, Meadows, South Sound and Pattison water systems identified future service areas on the CWSP maps prepared in the months following adoption of the 1986 Areawide Supplement. In certain areas, city water systems provide service to adjoining areas within the neighboring municipality. These inconsistencies between existing water service areas and incorporated boundaries are mutually acceptable and do not constitute a conflict in water service area. Examples of these areas are the Southeast Olympia/Tumwater boundary, the Mottman Road area, and the Lilly Road area.

Several of the 13 systems initially listed in 1986 as "potentially expanding" were incorporated into larger systems or have gone out of business (Capital Utilities, Beachcrest, Seasons, Meridian Acres and Trail's End). Other systems in the original list did not identify a future service area during the 1986-87 completion of the service area mapping process (Alderbrook Trailer Park and Marvin Road Water Company).

There were several remaining conflict areas in the initial service area maps prepared in 1986-87. These conflict areas appear to have been resolved at the time of the 1996 CWSP update.

2.5 Status of Water System Plans for Expanding Systems

Expanding water systems are required to produce or update water system plans, which include their future service areas, as part of the Coordinated Water System Act process. Water system plan status of the expanding systems (as of September 1995):