City of Vancouver Comprehensive Water System Plan

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COMPREHENSIVE WATER SYSTEM PLAN

Project No. 9290A.00

December 2015

FINAL

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CITY OF VANCOUVER

COMPREHENSIVE WATER SYSTEM PLAN

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City of Vancouver

COMPREHENSIVE WATER SYSTEM PLAN

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Comprehensive Water System Plan

EXECUTIVE SUMMARY

ES.1 INTRODUCTION

This document is an update to the City of Vancouver's (City's) Comprehensive Water System Plan (Plan), which was last updated in 2007. This Plan has been developed in accordance with Chapter 246-290 of the Washington Administrative Code (WAC), as presented in the Washington State Department of Health (DOH) regulations for Group A Public Water Systems.

The City of Vancouver water system identification number is 91200L. A copy of the City's Water Facilities Inventory Form is included in Appendix 1A and the DOH water system plan checklist and DOH submittal form is provided in Appendix 10C.

The purpose of this Plan is to develop a planning strategy for the City's retail water service area. Updated every six years, the Plan evaluates the existing system and its ability to meet the anticipated requirements for water source, quality, transmission, storage, and distribution over a twenty-year planning period. Water system improvements have been identified to meet changes in regulatory impacts, and population growth, as well as infrastructure repair and replacement. The Plan also identifies planning level costs of the improvement projects and provides a financial plan for funding the projects.

This revised Plan includes several changes since the City's last plan was developed. This Plan provides a full review of the City's policies, criteria, and planning considerations for its water system. New policies were considered regarding supply and pumping reliability and redundancy. The City has actively pursued and completed several needed capacity improvements in the water system since the last plan. As part of this Plan, the City's hydraulic model was updated and recalibrated. Further analysis of Water Station 1 resulted in slightly different capacity improvements (i.e. the St. Johns BPS is not recommended for expansion). Due to the excess storage in lower zones, and the ability to pump that water to the Heights High Zone, additional storage in the Heights High Zone may not be warranted. Other analyses resulted in new recommended transmission capacity improvements in the Heights High Zone to maximize use of all the available supplies to the zone in meeting service pressure requirements. Additionally, since the last plan, the City's fire flow requirements have increased substantially, resulting in fire flow deficiencies in areas of the system that were once considered adequate for fire flow. This Plan provides an updated list of recommended projects and a new Capital Improvement Plan for the City to implement as it continues to provide the best service to its customers.

ES.2 PLAN SUMMARY

This Plan follows the DOH recommended outline for a Water System Plan as outlined in the Water System Handbook (1997), and as recommended in the City's pre-plan agreement with the DOH. The Plan is presented in ten chapters as described below.

- Chapter 1 provides an introduction, plan summary, historical and environmental information about the water system, service area policies, standards and criteria established by the City for the water system, a description of the service area and neighboring purveyors, and a description of existing water system facilities.
- Chapter 2 describes the historical demand and use patterns, calculates the Equivalent Residential Unit (ERU), reviews distribution system leakage, and provides projected annual and maximum day demands for the 6-, 10-, and 20-year time periods.
- Chapter 3 includes a general description and analyses of the entire water system focusing on water treatment, storage and pumping, and the distribution system. Recommendations are evaluated and summarized to meet all system criteria.
- Chapter 4 provides a summary of the existing sources of supply, evaluates water rights against current and future demands, available supply, and a recommended approach for meeting annual and instantaneous future demands. It also includes an evaluation of the City's Water Use Efficiency Program.
- Chapter 5 summarizes the City's current Wellhead Protection Program, including hydrogeologic characteristics and wellhead capture areas, a susceptibility assessment, an inventory of potential sources of contamination that may pose a threat to the supply sources, and the City's groundwater monitoring protection program.
- Chapter 6 summarizes the City's operation and maintenance program, including organization, controls, operation and maintenance, emergency response plan, cross connection control program, deficiencies, and recommendations.
- Chapter 7 provides a summary of the City's design and construction standards.
- Chapter 8 presents a Capital Improvements Program (CIP), including all final recommended projects to address the deficiencies outlined in the previous chapters. The CIP provides cost estimates and a recommended schedule for implementation.
- Chapter 9 presents the financial state of the City's water system, including an evaluation of current water rates and connection fees, funding source alternatives, and a recommended strategy for providing finances to support the CIP projects.
- Chapter 10 summarizes the planning process and provides additional documentation for obtaining State approval of this Plan.

ES.3 DESCRIPTION OF WATER SYSTEM

The City owns and operates its own municipal water system serving the City and surrounding areas of Clark County as delineated by the Retail Water Service Area (RWSA). As of 2012, the City serves approximately 230,000 residents through 67,910 water service connections, making it the fourth largest public water system in Washington State. Through 40 groundwater wells, the City produces an average of approximately 25.4 million gallons per day (2012 average). The City's RWSA boundary encompasses all areas to be served by the City's water system for the next 20 years. The City's RWSA does not expand to serve the entire UGA; areas outside of the RWSA are planned to be served by other utilities, such as the Clark Public Utilities. Several areas outside of the existing City limits are anticipated to be annexed according to the City's Comprehensive Land Use Plan.

The City manages and operates the system to meet all applicable regulations for water quality, system pressures, and other aspects of water system operations. The water system includes wells, treatment facilities, storage reservoirs and tanks, booster pump stations, and distribution pipelines. The City disinfects the groundwater produced at all water stations with chlorine and adds fluoride to promote dental health. Depending on groundwater quality, some water stations provide additional treatment, such as air stripping for volatile organics removal or pH adjustment, greensand filtration for iron and manganese removal, or sodium hydroxide for corrosion control. Treated groundwater is stored in five ground level reservoirs and five elevated tanks for a total storage capacity of 24.15 million gallons. Stored water is gravity fed or booster pumped to pressurize the distribution system. Figure ES.1 presents a map of the City's existing system and facilities.

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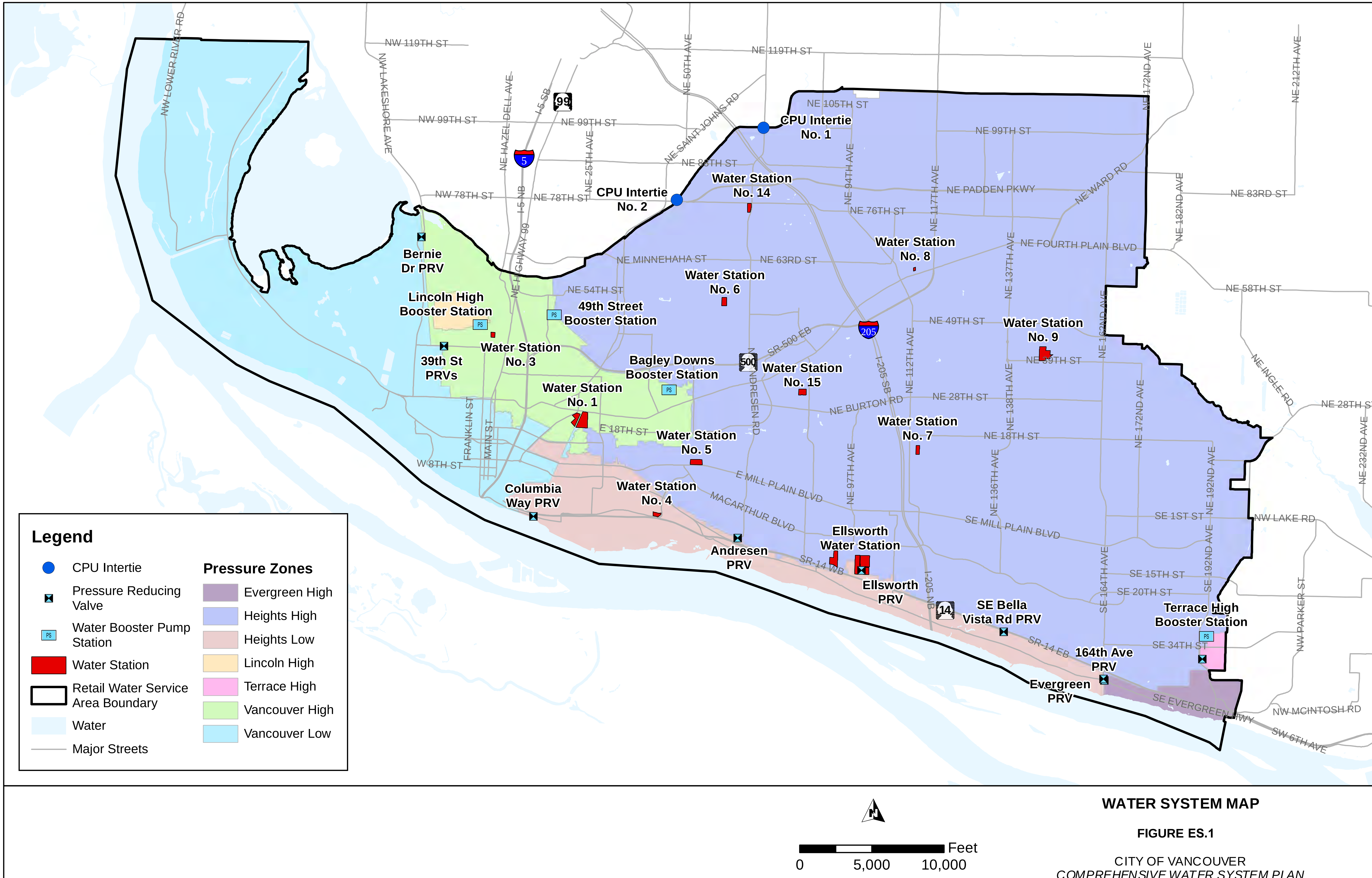

WATER SYSTEM MAP

FIGURE ES.1

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ES.4 PLANNING DATA AND WATER DEMAND FORECAST

Projecting realistic future water demands is necessary for planning infrastructure projects and securing adequate water supply to meet future growth. Future water demands are used as input conditions for the hydraulic analysis of the water system to develop the CIP. Accurate demand projections require a thorough review of historical water demands unique to the City, predicting where and how much growth will occur, and estimating the range of future water use for existing and new customers.

Chapter 2 reviews historical demand data, including water production and customer billing data, as recorded and provided by the City. Single-family residential (SFR) customers currently comprise 90 percent of the City's customer base. Historical customer billing data was used to evaluate the water demands unique to the City's different types of customers. The average water use for SFR customers establishes the City's current Equivalent Residential Unit (ERU) water use. The City's 10-year average water use per ERU is estimated to be 223 gpd. Multi-family residential and non-residential customers are expressed in terms of ERUs based on the comparison of these customers' water use to the current ERU water use. The City's six highest water use customers, herein defined as "Large Users," were identified and evaluated separately.

Production data was used to determine the distribution system leakage (DSL) and to compare the maximum day demand (MDD) to the average day demand (ADD). The City's 10-year average ADD, MDD, and DSL are 26.19 mgd, 53.04 mgd, and 1.6 mgd, respectively. The water use parameters found in the historical production and consumption data were used to predict future water use patterns for existing and new customers. The MDD and ADD were used to develop the average MDD to ADD peaking factor, 2.03.

Demand projections can vary widely based on the accuracy of growth and predicted water use assumptions. Demographic projections provide the range of potential growth in the City's service area, and are further explained in the Vancouver Comprehensive Plan. The City's planning department was consulted to provide development assumptions for low and high build-out conditions for the year 2034 for each of the City's Transportation Analysis Zones (TAZs). The planning assumptions provided are consistent with the Vancouver Comprehensive Plan. TAZs were grouped according to areas with similar rates of growth, herein termed "Development Areas." Given the planning assumptions, the City's residential customer base is expected to grow from 0.8 percent to 1.0 percent annually, and non-residential customers are expected to grow 1.1 percent annually. In comparison, the City's total accounts have grown by an average of 1.2 percent per year since 2003. By 2034, the City's customer base is expected to be 17 to 24 percent larger compared to 2013 data. Using these data, low, average, and high demographic projections were developed for each Development Area to estimate future accounts. Estimated future accounts were then expressed in terms of ERUs. The number of ERUs in the City is anticipated to increase from 110,496 in 2014 to 145,625 in 2034.

Future customer demands were calculated by applying selected low, medium, and high ERU water use to the existing and predicted new ERUs. Future demands for the top six Large Users, and new Industrial users, were predicted and added to the customer demand. The assumed future unmetered water use and DSL was applied to the sum of all other water use to develop future ADD. Lastly, MDD was estimated by multiplying ADD by the MDD to ADD peaking factor.

Low, medium, and high demand projections are summed for the years 2014, 2020, 2024, and 2034, as presented in Table ES.1. The projected 2034 ADD ranges between 33.85 mgd and 37.52 mgd, with a medium projection of 35.46 mgd. The projected 2034 MDD ranges between 64.80 mgd and 75.96 mgd, with a medium projection of 70.31 mgd.

Table ES.1 Total System Demand (mgd)

Parameter	2008	2009	2010	2011	2012	2014			2020			2024			2034		
	Actual	Actual	Actual	Actual	Actual	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Residential Metered Demand	17.45	17.92	16.03	16.29	16.59	17.84	17.86	17.89	18.52	18.61	18.85	18.97	19.12	19.51	20.08	20.35	21.13
Non-Residential Metered Demand	5.24	5.26	4.58	4.53	4.69	4.92	5.00	5.12	5.26	5.40	5.62	5.48	5.65	5.90	6.05	6.33	6.77
Large Users	1.71	1.42	1.43	1.53	1.57	1.59	1.59	1.59	1.70	1.70	1.70	1.89	1.89	1.89	1.99	1.99	1.99
Industrial Reserve	NA	NA	NA	NA	NA	0.20	0.20	0.20	1.03	1.03	1.03	2.00	2.00	2.00	3.80	3.80	3.80
Total Projected Metered Demands	24.40	24.60	22.04	22.35	22.85	24.55	24.65	24.80	26.51	26.74	27.20	28.34	28.66	29.30	31.92	32.47	33.69
Unmetered Uses	0.32	0.33	0.31	0.32	0.58	0.58	0.58	0.58	0.62	0.63	0.64	0.67	0.67	0.69	0.75	0.76	0.79
Unaccounted for Water(1) (DSL)	1.7	0.84	0.95	1.86	1.97	0.91	1.70	2.24	0.98	1.84	2.46	1.05	1.97	2.64	1.18	2.23	3.04
Total ADD	**26.42**	**25.77**	**23.30**	**24.53**	**25.40**	**26.04**	**26.93**	**27.62**	**28.11**	**29.21**	**30.30**	**30.06**	**31.30**	**32.63**	**33.85**	**35.46**	**37.52**
Total MDD(2)	**54.48**	**51.13**	**49.29**	**48.16**	**54.48**	**52.65**	**56.29**	**58.86**	**55.99**	**60.19**	**63.70**	**58.90**	**63.49**	**67.54**	**64.80**	**70.31**	**75.96**

Notes:
(1) See description of DSL calculation in Chapter 2, Section 2.3.4.
(2) No peaking factor was applied to the Industrial Reserve.

ES.5 SYSTEM ANALYSIS

Chapter 3 provides a comprehensive summary of the condition and capacity of all water system facilities, following the DOH Chapter 3 outline. System design criteria and standards are discussed for each analysis including water treatment, storage, pumping, and distribution piping.

The City chlorinates and fluoridates all supply sources and further treats some sources for iron/manganese removal, pH adjustment, and removal of other contaminants. Technical Memorandum (TM) 4 – Water Quality Analysis (Appendix 3A) presents a detailed review of the City's water quality monitoring program, current and future regulatory requirements, and reviews the City's compliance with all regulations. The City is in full compliance with treatment, monitoring, and reporting requirements established by the Washington DOH and the USEPA.

The City performed a high-level condition assessment of its water stations to identify facilities in need of repair, especially those that are also deficient in hydraulic capacity. TM 1 – Water Station Facilities Condition Summary Report (Appendix 3B) presents the results of the condition assessment. In general, the City's water facilities appear to be in good condition, however, several facilities were recommended for repairs including major upgrades at Water Stations 1 and 3. Since completion of the condition assessment, the City has performed a seismic evaluation that recommends structural improvements at several reservoirs and tanks, and a full replacement of the City's largest reservoir at Water Station 5.

The City has established robust design and planning criteria to provide reliability and redundancy. The pumping and storage system analyses were performed using two different distribution system scenarios: 1) the existing system, and 2) the existing system with planned improvements at Water Station 1. The planned improvements greatly enhance reliability at Water Station 1, the City's largest production station, and result in significant improvements in meeting the City's pumping and storage evaluation criteria. Given the results of the pumping analysis, only one pump station was found deficient in meeting one the pumping criteria. Recommendations are provided for increasing fire capacity at the 45th and Daniels Pump Station to meet pumping criterion 3 (ability to provide fire flow and meet peak hour demands).

The planned Water Station 1 projects significantly improve the City's ability to meet storage needs during a widespread power outage and with the largest well or pump offline. After completing the Water Station 1 project, the storage deficits of each zone are able to be addressed through operational changes, such as rezoning and providing back-up power to pump stations, rather than constructing additional storage facilities. However, several facilities are recommended for replacement or structural improvements to address age and seismic deficiencies.

The City's water distribution system was evaluated for having adequate capacity to meet pressure, fire flow, and velocity requirements under future demand conditions. The distribution system analysis was performed using the City's hydraulic model, which was updated in 2014 as described in TM 2 – Hydraulic Model Update (Appendix 3D). Several areas in the water system were found deficient in meeting the City's minimum pressure criteria. The City recognizes that distribution system capacity has not kept up with the needs of the growing water customer base. For example, tanks that should set the hydraulic grade line (HGL) for the Heights High Zone are unable to cycle together due to limited transmission capacity between the facilities. Recommendations for addressing pressure deficiencies include a combination of operational changes and transmission pipe capacity improvements. All recommendations are sized for meeting full build-out demand conditions.

Many fire flow deficiencies were found throughout the water system; these are largely, if not entirely, due to recent changes in the required fire flows per customer type. The City's system was designed and constructed to meet older fire flow codes; the new changes require 67 individual pipe projects to meet future fire flow deficiencies. Recognizing that it could take decades to complete all of these projects due to financial limitations, the fire flow improvements are recommended to be implemented as driven by development or as warranted by pipe repair or replacement. All recommendations found in the system analysis were incorporated into and prioritized in the recommended CIP.

ES.6 WATER RESOURCE ANALYSIS AND WATER USE EFFICIENCY

Through its groundwater wells, the City has a total allowable instantaneous withdrawal (Qi) of 75,072 gpm (108.1 mgd), a total allowable annual withdrawal (Qa) of 50,256.5 AFY (44.86 mgd), and 23,990.5 AFY (21.42 mgd) of additive annual water rights. Washington State DOH Water Rights Evaluation Tables 3 and 4 are provided in Chapter 4 (Tables 4.1 and 4.2). A system-wide supply analysis shows that the City has secured adequate water rights for the 20-year planning horizon to meet both average and maximum day demands. However, some of the City's water system facilities are limited in capacity and could be improved to increase supply redundancy during maximum day demands.

The City would like to achieve supply redundancy should Water Station 1, the City's largest supply source, be offline. With Water Station 1 offline, the City could have a peak supply deficit during the high MDD scenario of 2,975 gpm (4.28 mgd) in 2014, and 14,850 gpm (21.38 mgd) in 2034. Several supply (and demand reduction) alternatives were reviewed for meeting demands in this situation. The recommended strategy includes improving supply reliability at Water Station 1 as planned, rehabilitation or replacement of wells at Water Stations 4, 6, 8 and 15, and if necessary, implement water curtailments or acquire and use a new supply source.

Improving upon the City's current Water Use Efficiency (WUE) Program can help to delay these capital projects and defer construction costs. The City of Vancouver is committed to ensuring Vancouver's water resources are used efficiently to protect and preserve the community's high quality of life for current residents and generations to come. The City's WUE Program engages incentives that encourage wise water use and utilizes technologies and processes associated with City activities to improve water savings. The program includes 11 supply-side measures and 16 demand-side measures. At the heart of the City's program is the Water Resources Education Center, funded and operated directly by the City. The Center provides continuous environmental education through programs, exhibits, events, and volunteer opportunities for the community and thousands of school children each year.

Given the impacts of the WUE Program, along with other influences such as economic conditions, weather, and updated plumbing code standards, the City's water use has declined from over 252 gpd/ERU in 2003 to 207 gpd/ERU in 2012. This represents an 18 percent decrease in unit water use over this ten-year period. The City's MDD to ADD peaking factor and DSL do not appear to be decreasing over time; DSL has remained below 10 percent since 2003.

The City plans to continue its efforts in encouraging efficient water use and protecting water as a valuable resource. The following goals will continue to assist the City in targeting its WUE measures to promote water use efficiency both in its internal operations and for water customers:

- **Supply-Side Goal:** Maintain annual DSL to six (6) percent or less.
- **Demand-Side Goal:** Reduce the average equivalent residential unit annual water consumption by one (1) percent per six years, to achieve 200 gpd/ERU.

With these WUE goals, the projected medium 2034 ADD could be reduced by 1.34 mgd, or 3.8 percent, and the projected medium 2034 MDD could be reduced by 2.83 mgd, or 4.0 percent.

ES.7 WELLHEAD PROTECTION PROGRAM

The City's water supply comes entirely from a number of underground aquifers located beneath the City and extending into Clark County. Groundwater supplies can be susceptible to contamination from the surface, particularly when located in highly urbanized or industrial areas. Vancouver's Wellhead ProtectionES-10 Program consists of the following components for protecting water in the City:

- Vancouver's Critical Aquifer Recharge Area (CARA) is defined in the City's Water Resources Protection Ordinance to encompass all groundwater underlying the City, effectively providing aquifer protection measures throughout the entire City limits. In addition, special wellhead protection area buffers circling the City's water stations incorporate additional restrictions and regulations.
- A City database maintains a detailed inventory of industrial, commercial, and residential sources within the City that have a greater potential to pollute water resources. In addition, the City tracks contamination sites and problematic septic tanks that could pose a threat to water stations outside City limits. Over 100 confirmed, suspected, or previously identified and remediated contamination sites are located within the Vancouver City limits.

- Spill response plans were developed in conjunction with local first responders (police, fire, HAZMAT team, etc.) for the City's facilities. The City's water protection ordinance also requires that businesses and industries identified as potential sources of contamination prepare spill and emergency response plans.
- Contingency plans were made for providing alternate sources of drinking water in the event contamination occurs.
- A Wellhead and Water Protection Management Program was implemented in 2003 with the adoption of the City Water Resources Protection Ordinance (WRPO; VMC 14.26). Program staff inspects businesses and industries throughout the City and investigates when notified of a spill, leak, or other discharge. Similarly, Clark County has a Source Control Inspection Program that conducts similar inspections in unincorporated areas of the water system boundary.

As of September 2014, the City's Water Resources Protection Program has researched over 1,200 commercial, industrial, and residential sites in and around Vancouver. WRPO inspectors have performed detailed inspections on over 300 commercial/industrial Class I/II sites and have also responded to over 800 calls and referrals related to spills, complaints, technical assistance, and investigations. Because the Water Resources Protection program continues actively visiting sites, the inventory of facilities and activities in Vancouver is constantly updated. As additional information on facilities and residential areas is introduced to the program, the WRPO database is changed or supplemented to reflect the changes. Updates are reflected immediately in all reports generated and on GIS mapping displays.

ES.8 OPERATION AND MAINTENANCE PROGRAM

The City's water system is managed and operated under the City's Public Works Department. Duties pertaining to the water system are divided among the Operations, Engineering, Capital Planning, Finance, and Asset Management. Other departments within Public Works provide additional support for the Water Department such as construction management, equipment repair, materials acquisition, grounds keeping, utility billing and office and record keeping assistance. City staff maintains appropriate certifications and participate in regular training to meet all state requirements.

The City effectively operates its large water system through a combination of staff activities and automated controls. Day-to-day operations, such as turning pumps on and off, filling and drawing of reservoirs, are all automated through the City's supervisory control and data acquisition (SCADA) system. The SCADA system monitors and records data for staff monitoring and system evaluation. The City's system meets daily demands through its groundwater supplies and storage facilities. The City operates its system based upon the draw and fill of the City's reservoirs, as well as system pressure. The operational staff of the City manage routine maintenance tasks, new system modifications to the existing infrastructure, and emergencies. The City maintains an extensive inventory of equipment and supplies necessary to support day-to-day operations. The City maintains documentation on operations and maintenance for all facilities, water quality monitoring results, safety procedures, customer complaints, and other record keeping.

The City is in full compliance with its water quality monitoring program. Regular updates of emergency response planning and cross connection control programs are performed. Chapter 6 summarizes recommended improvements for the water system operation and maintenance, including better tracking of flow and pressure at specific facilities, creating an O&M Program Manual, and implementing SCADA improvements.

ES.9 DESIGN AND CONSTRUCTION STANDARDS

All civil engineering projects that connect to or impact the City's water system require plan submittal to the City of Vancouver. These plans are reviewed for adherence to a consistent set of standards that ensure the water supply and distribution system is safe, reliable, durable, and maintainable. Prior to approval by the City Water Engineering Program Manager, all City distribution projects are prepared and reviewed by licensed civil engineers. Each project is prepared and reviewed according to the "City of Vancouver Engineering Services General Requirements and Details for the Design and Construction of Water, Sanitary Sewer and Surface Water Systems" (Appendix 7A). All review submittals from outside parties are completed utilizing the "Water Engineering Review Checklist" for review consistency (Appendix 7B). The City utilizes an integrated review process and applies consistent Civil Plan review procedures for all water engineering projects by outside parties. Capital improvement projects are reviewed separately according to the Water Main Design Procedure checklist provided in Appendix 7D.

ES.10 CAPITAL IMPROVEMENT PLAN

The purpose of the Capital Improvement Plan (CIP) is to provide the City with a guideline for the planning and budgeting of improvements to its water system. The CIP combines all recommended projects identified as part of this Comprehensive Water System Plan. Cost estimates have been prepared for general master planning purposes and for guidance in project evaluation and implementation. All costs are in 2014 dollars, and are based on an Engineering News Record Construction Cost Index (ENR CCI) 20-City Average of 9886 (October 2014). The expected accuracy range is -30 percent to +50 percent, meaning the actual cost should fall in the range of 30 percent below the estimate to 50 percent above the estimate.

The recommended CIP is presented in Table ES.2. Projects are assigned into the Short-Term (2015 to 2020), Mid-Term (2021-2024), and Long-Term (2025-2034). Major projects are included for multiple improvements at Water Stations 1, 3, 5, and for the City's SCADA program. Pipe Improvements and Pipe Repair Programs are recommended for annual budgeting of projects that address additional capacity and pipe replacement due to age and condition, respectively. All CIP projects and other non-CIP recommendations are summarized in Chapter 8.

ES.11 FINANCIAL ANALYSIS

The City is planning to perform a full water rate analysis in 2015 and 2016 that will thoroughly evaluate the City's system development charges and water rates. Chapter 9 – Financial Analysis reviews the projected financial impact of the recommended CIP and provides options that the City can explore more thoroughly as part of the rate study. A calculation of recommended system development charges (SDCs) to meet the recommended CIP was developed. Based on the recommended SDC approach, which includes allocating costs to system growth and reinvestment as appropriate, the proposed water SDC is calculated to be $3,251 (compared to the current value of $2,360).

A financial model was prepared for evaluating the current financial condition of the City and projecting impacts from the new CIP. Through a cost of service study, the model analyzes the main driver of revenue shortfalls as a result of the CIP and presents the potential rate increases under different financing scenarios. The City provided background financial information including a debt service schedule, fixed asset records, current reserve policies and ending fund balances, other revenues, customer growth projections, and other miscellaneous financial information.

The CIP presents significant upcoming expenditures, which, if solely rate funded, would necessitate significant draw-downs in existing reserves in the short-term. Consequently, the City may decide to implement inflation-related rate adjustments or issue additional debt during the 20-year forecast period to fund the CIP projects. Through a cost of service analysis, Chapter 9 addresses the potential impacts on water rates whether debt is available or not.

The City has 5 percent rate increases planned for FY 2015 and FY 2016. With 3 percent inflation-related rate increases in subsequent years, the City could alleviate the CIP's impact on the draw-down of reserves. Debt is a funding vehicle that allows rate increases to be spread over the 20-year planning period. The use of debt in the short term also allows the City to gradually set aside rate revenue in order to build reserves that may (cash) fund capital projects in following years. While the use of debt could minimize the drawdown of reserves and potentially postpone some future rate increases, implementing inflationary annual rate adjustments could be sufficient to minimize the drawdown of reserves. As a result, this financial analysis does not consider using debt to fund the capital improvement program.

Additional recommendations are included to address staffing needs to support implementation of the CIP. All of the data and recommendations in Chapter 9 should be fully reviewed in the City's upcoming rate study.

ES.12 MISCELLANEOUS DOCUMENTS

Chapter 10 summarizes and provides a reference to all remaining documents required for submittal and approval of this Water System Plan, including the State Environmental Policy Act (SEPA) checklist, determination of non-significance (DNS), government consistency statements, and resolutions adopting the Plan.

Table ES.2 Capital Improvements Plan

		Cost Estimate	Short-Term 2015-2020	Mid-Term 2021-2024	Long-Term 2025-2034
GENERAL PROJECTS		**$33,610,000**	**$16,670,000**	**$450,000**	**$16,490,000**
G-1	SCADA System Program Improvement	$7,200,000	$7,200,000	$0	$0
G-2	Rezone Study for Vancouver Low and Vancouver High Zones	$50,000	$50,000	$0	$0
G-3	Comprehensive Water Master Plan Updates	$900,000	$0	$450,000	$450,000
G-4	O&M Program Electronic Manual	$300,000	$300,000	$0	$0
G-5	Water Shortage Response Plan	$40,000	$40,000	$0	$0
G-6	Ongoing SCADA Upgrades	$1,000,000	$0	$0	$1,000,000
G-7	Central Operations Center Remodel	$15,000,000	$0	$0	$15,000,000
G-8	Pump House Roofing	$200,000	$200,000	$0	$0
G-9	SCIP Sewer Project	$8,750,000	$8,750,000	$0	$0
G-10	Study for Heights High Hydraulic Grade Line Balance	$40,000	$0	$0	$40,000
G-11	WS 3 Master Plan	$130,000	$130,000	$0	$0
SUPPLY PROJECTS		**$34,470,000**	**$17,520,000**	**$5,400,000**	**$11,550,000**
S-1	WS 1 General Site Improvements	$14,160,000	$14,160,000	$0	$0
S-2	WS 1 Chlorination Facility Improvement	$890,000	$890,000	$0	$0
S-3	Supply Capacity Improvements Study for WS 4, 6, 8, and 15	$200,000	$200,000	$0	$0
S-4	WS 4 Well Replacement	$1,000,000	$0	$0	$1,000,000
S-5	WS 6 Well/Treatment Installation	$3,000,000	$0	$0	$3,000,000
S-6	WS 8 Replace Wells 2 & 3	$2,000,000	$0	$0	$2,000,000
S-7	WS 15 Replace Wells 1 through 4	$4,000,000	$0	$0	$4,000,000
S-8	WS 1 Replace Wells 2, 4, & 5	$3,000,000	$0	$3,000,000	$0
S-9	WS 4 Well 4 Building Replacement	$310,000	$310,000	$0	$0
S-10	Sodium Hypochlorite Generation System (all except WS1)	$2,150,000	$1,050,000	$1,100,000	$0
S-11	Ellsworth Well Rehabilitation	$870,000	$270,000	$300,000	$300,000
S-12	Ellsworth Greensand Replacement	$500,000	$500,000	$0	$0

Table ES.2 Capital Improvements Plan

		Cost Estimate	Short-Term 2015-2020	Mid-Term 2021-2024	Long-Term 2025-2034
S-13	Well Level Probes	$40,000	$40,000	$0	$0
S-14	WS 9 Lead and Copper Pilot Study	$100,000	$100,000	$0	$0
S-15	WS 3 Replacement of Wells 1 & 2 with One Well	$1,000,000	$0	$0	$1,000,000
S-16	WS 7 Greensand Replacement	$200,000	$0	$0	$200,000
S-17	New Treatment Regulations Compliance	$1,000,000	$0	$1,000,000	$0
S-18	Exploration for New Water Source	$50,000	$0	$0	$50,000
STORAGE PROJECTS		**$40,450,000**	**$13,900,000**	**$25,560,000**	**$990,000**
ST-1	WS 1 Reservoir Improvements	$9,900,000	$9,900,000	$0	$0
ST-2	WS 1 0.25-MG Tank Replacement	$2,500,000	$2,500,000	$0	$0
ST-3	WS 3 1.25-MG Reservoir Replacement	$4,870,000	$0	$4,870,000	$0
ST-4	WS 3 0.25-MG Tank Replacement	$970,000	$0	$0	$970,000
ST-5	WS 5 Tank - Altitude Valve Addition	$120,000	$0	$120,000	$0
ST-6	WS 6 Internal Coating	$400,000	$400,000	$0	$0
ST-7	WS 5, 6, &7 Tanks Seismic Improvements	$1,100,000	$1,100,000	$0	$0
ST-8	WS 5 Reservoir Replacement	$20,570,000	$0	$27,570,000	$0
ST-9	Study for Additional Heights High Tanks	$20,000	$0	$0	$20,000
PUMPING PROJECTS		**$10,250,000**	**$2,930,000**	**$7,310,000**	**$10,000**
BP-1	WS 1 Tower BPS Replacement	$2,930,000	$2,930,000	$0	$0
BP-2	WS 3 BPS - Replace with Reservoir	$5,420,000	$0	$5,420,000	$0
BP-3	WS 5 BPS - Adding Back-up Power	$440,000	$0	$440,000	$0
BP-4	45th Street BPS - Replace for Pump Redundancy and Fire	$1,450,000	$0	$1,450,000	$0
BP-5	Study for Adding 4th Pump to St. Johns BPS	$10,000	$0	$0	$10,000
PIPING PROJECTS		**$60,930,000**	**$21,990,000**	**$12,540,000**	**$26,400,000**
P-1	Pipe Improvement Program	$39,030,000	$16,240,000	$8,490,000	$14,300,000
P-2	Pipe Repair Program	$21,900,000	$5,750,000	$4,050,000	$12,100,000
TOTAL CIP		**$179,710,000**	**$73,010,000**	**$51,260,000**	**$55,440,000**

Chapter 1

DESCRIPTION OF WATER SYSTEM

1.1 INTRODUCTION

The City of Vancouver (City) owns and operates its own municipal water system serving the City and surrounding areas of Clark County as delineated by the Retail Water Service Area (RWSA), further described below. As of 2012, the City serves approximately 230,000 residents through 67,910 water service connections, making it the fourth largest public water system in Washington State. Through 40 groundwater wells, the City supplies an average of approximately 25.5 million gallons per day as of 2012. The water system includes wells, treatment facilities, storage reservoirs and tanks, booster pump stations, and distribution pipelines. The City manages and operates the system to meet all applicable regulations for water quality, system pressures, and other aspects of water system operations.

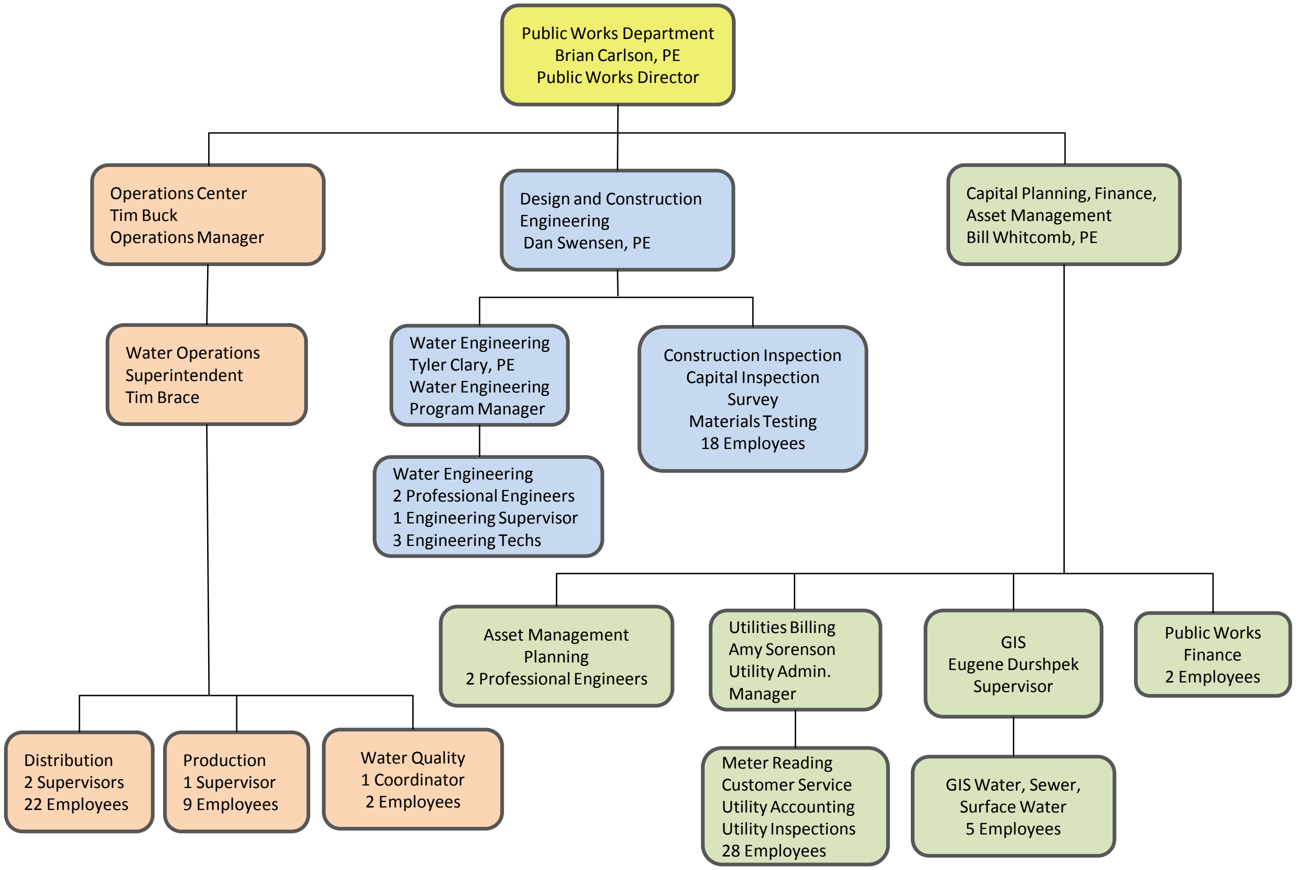
This Chapter summarizes the water system service area characteristics, regional environment, history, ownership and management, related plans and agreements, service policies, and system facilities.

1.2 OWNERSHIP AND MANAGEMENT

The City owns and manages a Group A municipal-type water system (Washington Department of Health Water System Identification number 91200L). A Water Facilities Inventory Form (WFI) is provided to the Washington State Department of Health (DOH) annually. The latest WFI is presented in Appendix 1A.

The water system is managed, supervised, and operated within the City's Public Works Department. Figure 1.1 presents the City's organization chart of the Public Works Department. The chart illustrates the specific personnel positions and corresponding responsibility and authority for the City's municipal water system. Vancouver's Municipal Code Section 14.04.020 authorizes the Director of Public Works with full supervision, charge, and control of the water department and authorizes the Director to make rules and regulations for the efficient administration and regulation of the Department.

Water Utility personnel are divided into three separate divisions: 1) Operations, 2) Engineering, and 3) Capital Planning, Finance, and Asset Management, as shown on Figure 1.1. The Operations Division maintains system integrity and is responsible for the day-to-day operation of the water system. The Operations Division staff is divided into three groups: Distribution, Production, and Water Quality. The Engineering Division provides capital planning, facility design, review of construction plans, wellhead protection, the sewer connection incentive program, conservation planning, and construction inspection. The Capital Planning section serves all the enterprise funds, including the water utility, and oversees asset management planning, billing, GIS, and public works finances.



ABBREVIATED PUBLIC WORKS DEPARTMENT ORGANIZATION CHART

FIGURE 1.1

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

1.3 WATER SYSTEM HISTORY

The Vancouver area was originally inhabited by a variety of Native American tribes. It was explored by Lewis and Clark in 1805. Vancouver began as a garrison town with the demise of the Hudson's Bay post and the establishment of the Vancouver barracks. The City was incorporated in 1857 and in 1868, the Vancouver Water Company was organized with water sourced from Stanger Creek and distributed through a system of wood stave pipes. Until 1937, the water system was operated by a number of private parties until the City purchased the water system from the Peoples Water and Gas Company.

Prior to World War II, Vancouver's population was approximately 25,000. By 1944, the City's population nearly quadrupled to 95,000 due to an influx of workers to the city's shipyards. The Vancouver Housing Authority (VHA) constructed 12,000 living units to accommodate the additional workers in the McLoughlin Heights, Fruit Valley, Fourth Plain Village, Harney Hills, Bagley Downs, and Burton areas. The water systems constructed by the VHA during the war to serve these areas are now a part of the City's Heights High distribution system.

By 1950, the population continued to grow, with new industrial employment opportunities leading to increases in employment. Much of the temporary wartime housing constructed by the VHA was demolished and gradually replaced by suburban developments utilizing the existing water system. These suburban neighborhoods, including Northwood, Northcrest, Bagley Downs, Southcliff, Broadmoor, Braewood, Harney Heights, Fourth Plain Village, Lieser Crest, Anderson Highland, and others were subsequently annexed into the City.

The Orchards Water District was acquired by the City in 1967. In 1973, another water system was acquired from the Foothills Service Company. These acquisitions brought what are now known as Water Stations 8 and 9 to the Vancouver Water System.

By 1974, the City was providing water utility service to over 24,000 connections, with nearly 31,000 connections by 1979. The City and its water system have continued to grow substantially. By the 1990 U.S. Census, the City's population had grown to 46,380 with a total estimated population for the surrounding urban area of 176,447. In 2005, at the time of the last Plan update, the population served by the City's water system (including both the corporate city limits and a substantial surrounding area of unincorporated Clark County) was estimated at 210,000 with approximately 62,000 water service connections. The City has continued to expand its water system to accommodate new customers. The 2010 Census estimates a population of 161,791 within City limits. As of 2012, the City serves approximately 230,000 residents.

1.4 REGIONAL ENVIRONMENT

1.4.1 Climate

The climate in the City of Vancouver and the surrounding greater Clark County area is influenced by the Coast Mountain Range to the west and the Cascade Mountain Range to the east. The

Coast Mountain Range provides some limited protection from the direct influence of the Pacific Ocean. Moist heavy air from the Pacific is cooled as it rises over the Coast Mountain Range and releases moisture as rainfall. The air is further cooled as it approaches the Cascade Mountain Range, resulting in moderate rainfall for lower lying areas such as the City of Vancouver, and heavier precipitation along the west slopes of the Cascades. This results in a large variation of rainfall across the county. The Cascade Mountains also provide a barrier against continental air masses originating over the Columbia Basin to the east.

Clark County has wet, mild winters and warm, dry summers. Average annual precipitation in the City of Vancouver is 41 inches, while the northeastern end of the County receives 144 inches. Approximately 80 to 85 percent of the precipitation occurs between the months of October and May.

Temperatures across Clark County average 37 degrees Fahrenheit in January, increasing to a 65-degree average in July. Winter storms come generally from the southwest, with infrequent snowstorms originating from the Gulf of Alaska. Fall and winter storms can be accompanied by high winds, resulting in power outages.

1.4.2 Topography

Clark County and the greater Vancouver area are located in the Willamette-Puget Trough, a geographic basin formed by the Cascade and Coast Mountain Ranges. The county is bounded on the south and west by the Columbia River, on the north by the Lewis River, and on the east by the foothills of the Cascades.

Clark County can be characterized by four topographic areas. Extending along the Columbia River are low-lying bottomlands with elevations ranging from 20 to 200 feet (ft). From the bottomlands, a series of alluvial plains and terraces extend north and northeast, with elevations ranging from 200 to 400 ft. From the plains and terraces, a 100- to 200-foot high escarpment leads to the uplands, with elevations ranging from 500 to 2000 ft. The uplands extend to the Cascade foothills, with elevations up to 3500 ft, in the north and northeastern portions of the County. The Vancouver water service area include predominantly the alluvial plain and terrace characteristics with bottomlands along the Columbia River in the south and east.

1.4.3 Geology

The Clark County area exhibits traces of its geologic history, including repeated inundation by fluctuating sea levels during glacial epochs, the sedimentary processes of repeated flooding of the Columbia River, volcanic activity, periodic earthquakes, and other tectonic activity. The geologic units in Clark County reflect this varied history and can be placed into two general categories: older consolidated rocks and volcanic rocks. These include Columbia River Basalts and Skamania and Goble volcanic series, and sedimentary rocks incorporating unconsolidated gravels, silts, sands, and clays created by glacial and alluvial processes. Area geology, as it pertains to groundwater aquifer supplies and availability, is further described in Chapter 5.

1.5 SERVICE AREA CHARACTERISTICS

The City of Vancouver is located in southwest Washington State in southern Clark County. Vancouver is located on the southern border of Washington, across the Columbia River from Portland, Oregon, as shown in Figure 1.2.

1.5.1 Retail Water Service Area

The City's Retail Water Service Area encompasses approximately 46,400 acres, including the corporate city limits and a portion of Clark County as shown in Figure 1.3. The southern and western portions of the service area are bordered by the Columbia River, the eastern portion is bordered by the City of Camas, and the northern border is contiguous to Clark Public Utilities' (CPU's) service area boundary. Figure 1.3 also shows the service areas for the City of Camas and CPU.

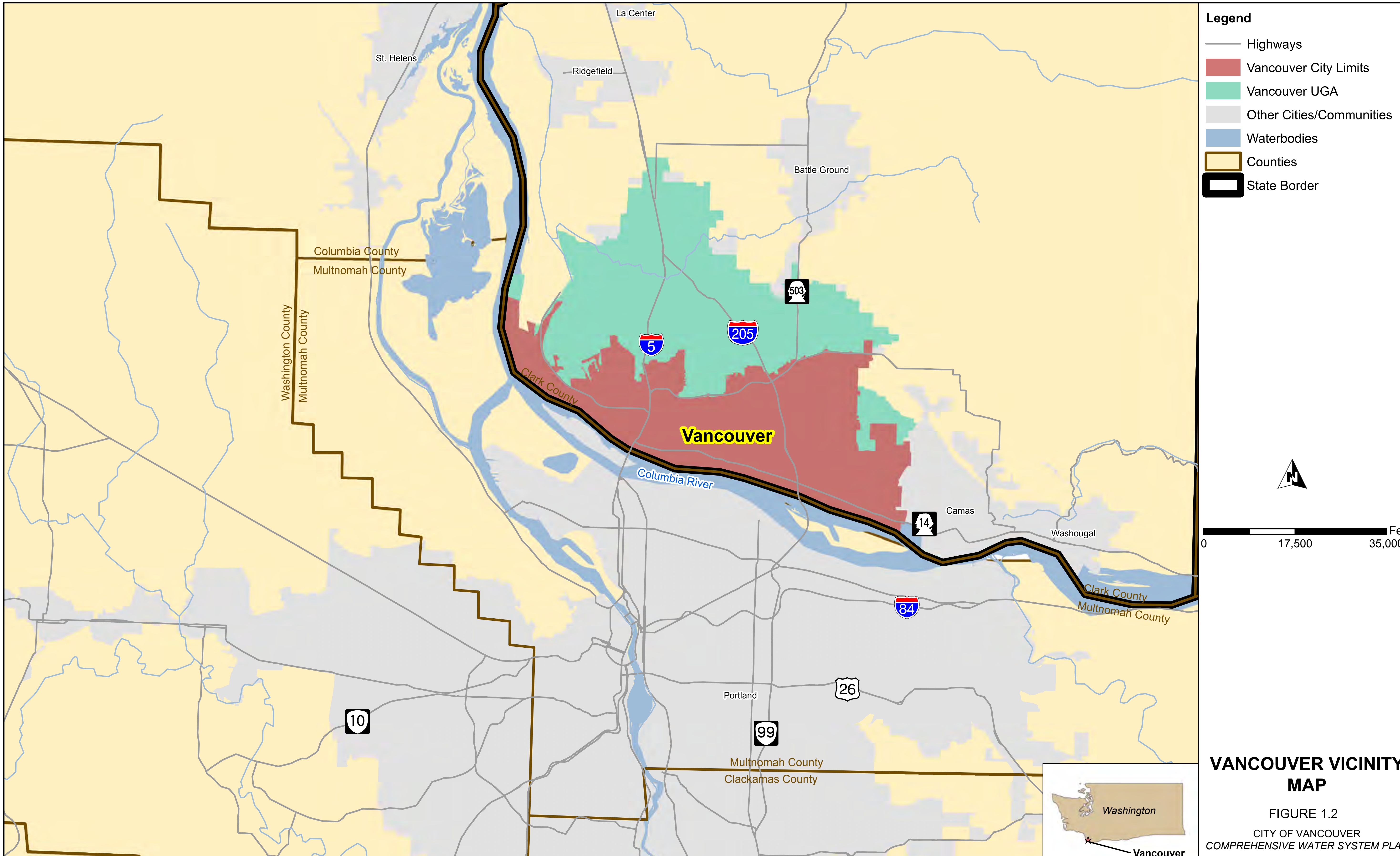
The service area shown in Figure 1.3 is consistent with Vancouver and Clark County comprehensive plans, and the Clark County Coordinated Water System Plan, as further discussed in Section 1.6. Appendix 1B provides the service area agreement between the city and adjacent water purveyors.

1.5.2 Existing Land Use

Existing land use in the City's RWSA is presented in Figure 1.4. The land use shown in this map is based on the location of water meters for the various customer types as provided in the City's GIS data. The City categorizes its water customers into the following types: Single Family Residential, Multi-family Residential, Commercial, Industrial, Government, Non-profit Shelter, and Other. Single Family Residential is the predominant customer category by area and number of connections. Multi-family users are concentrated adjacent to commercial corridors in the central and eastern portions of the City. Commercial users are generally located along the Columbia River, in the vicinity of major transportation routes, and in community centers such as downtown Vancouver and the Vancouver Mall area. Industrial operations are found primarily along the perimeter of urban areas. Table 1.1 presents the number of connections for each customer category.

Table 1.1 Existing Water Connections by Customer Category

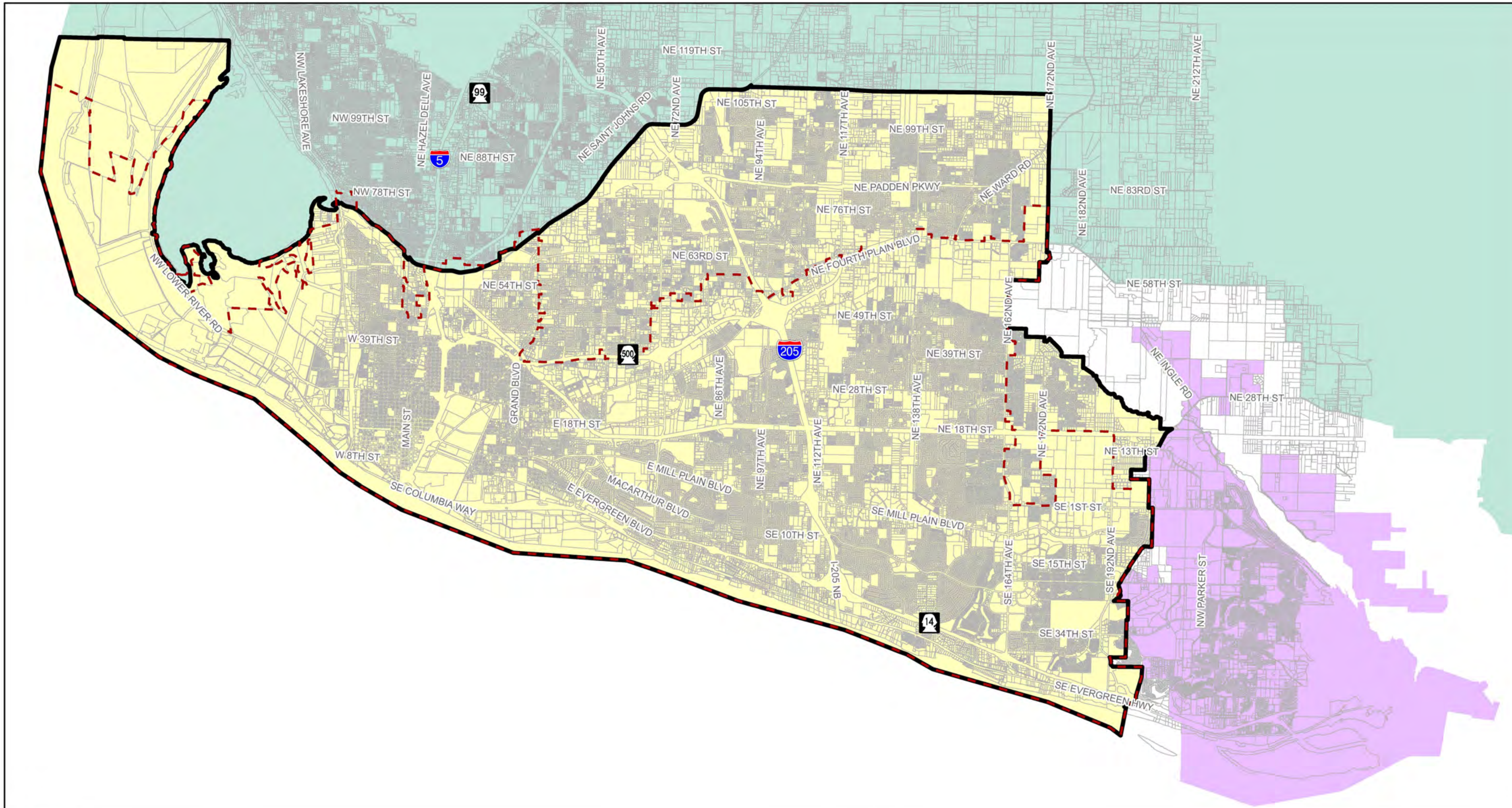
Customer Type	Connections
Single Family Residential	60,950
Multi-family Residential	3,287
Commercial	3,279
Industrial	10
Government	372
Non-profit Shelter	7
Other	5
Total Connections	**67,910**



VANCOUVER VICINITY MAP

FIGURE 1.2

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN



Legend

- City of Vancouver
- Tax Lots
- Clark Public Utilities
- City of Camas
- Retail Water Service Area Boundary

Feet
0 4,000 8,000

RETAIL WATER SERVICE AREA

FIGURE 1.3

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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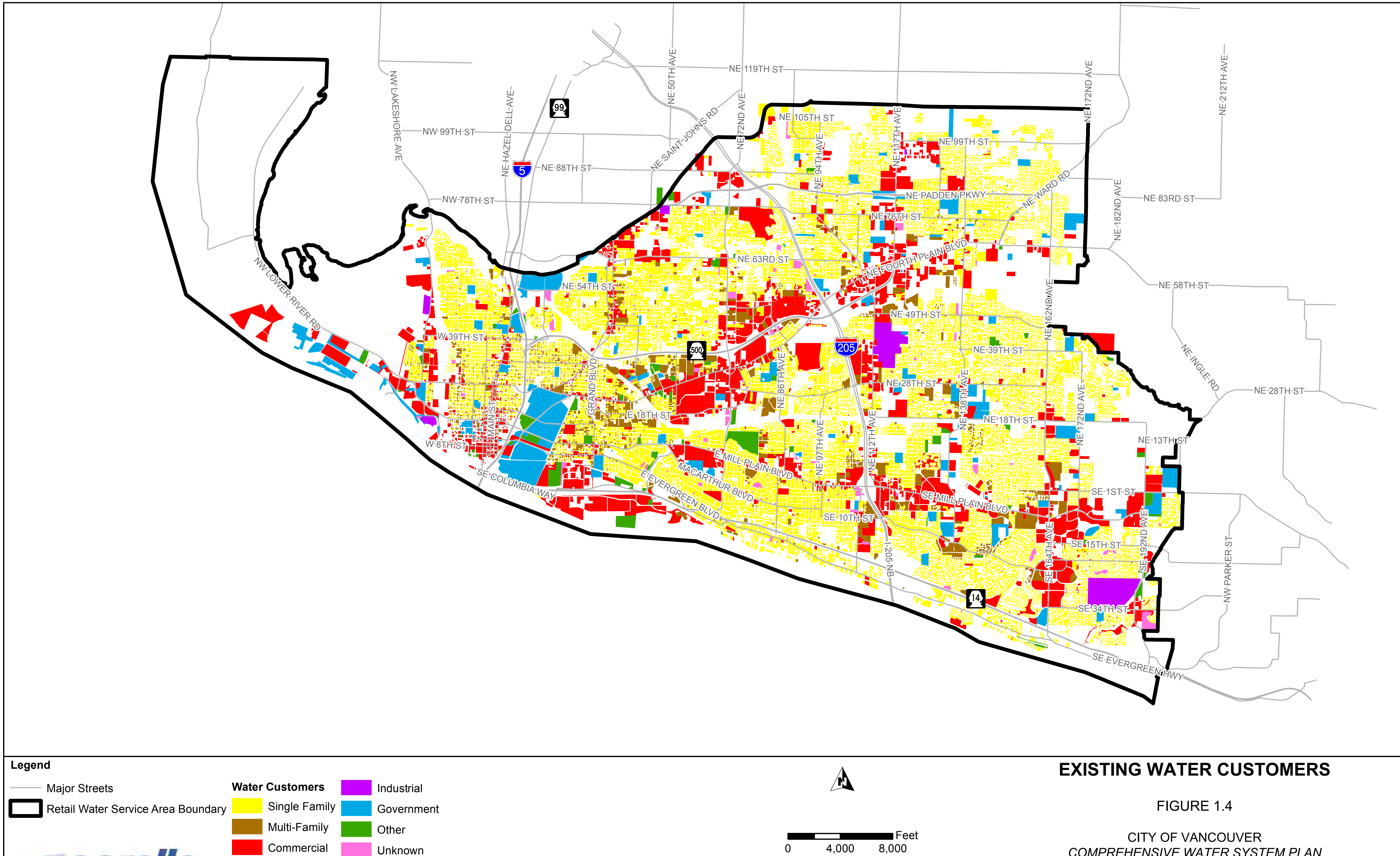

EXISTING WATER CUSTOMERS

FIGURE 1.4

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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1.5.3 Urban Growth Area and Future Land Use

Figure 1.5 presents the City's future Urban Growth Area (UGA), the RWSA, future annexation areas, and planned future land use. The City's RWSA boundary encompasses all areas to be served by the City's water system for the next 20 years. No expansion of the RWSA is anticipated in the future. As seen in the figure, the City's RWSA does not expand to serve the entire UGA; areas outside of the RWSA are planned to be served by other utilities, such as the Clark Public Utilities. Several areas outside of the existing City limits are anticipated to be annexed according to the City's Comprehensive Land Use Plan. These areas of annexation are also shown on Figure 1.5.

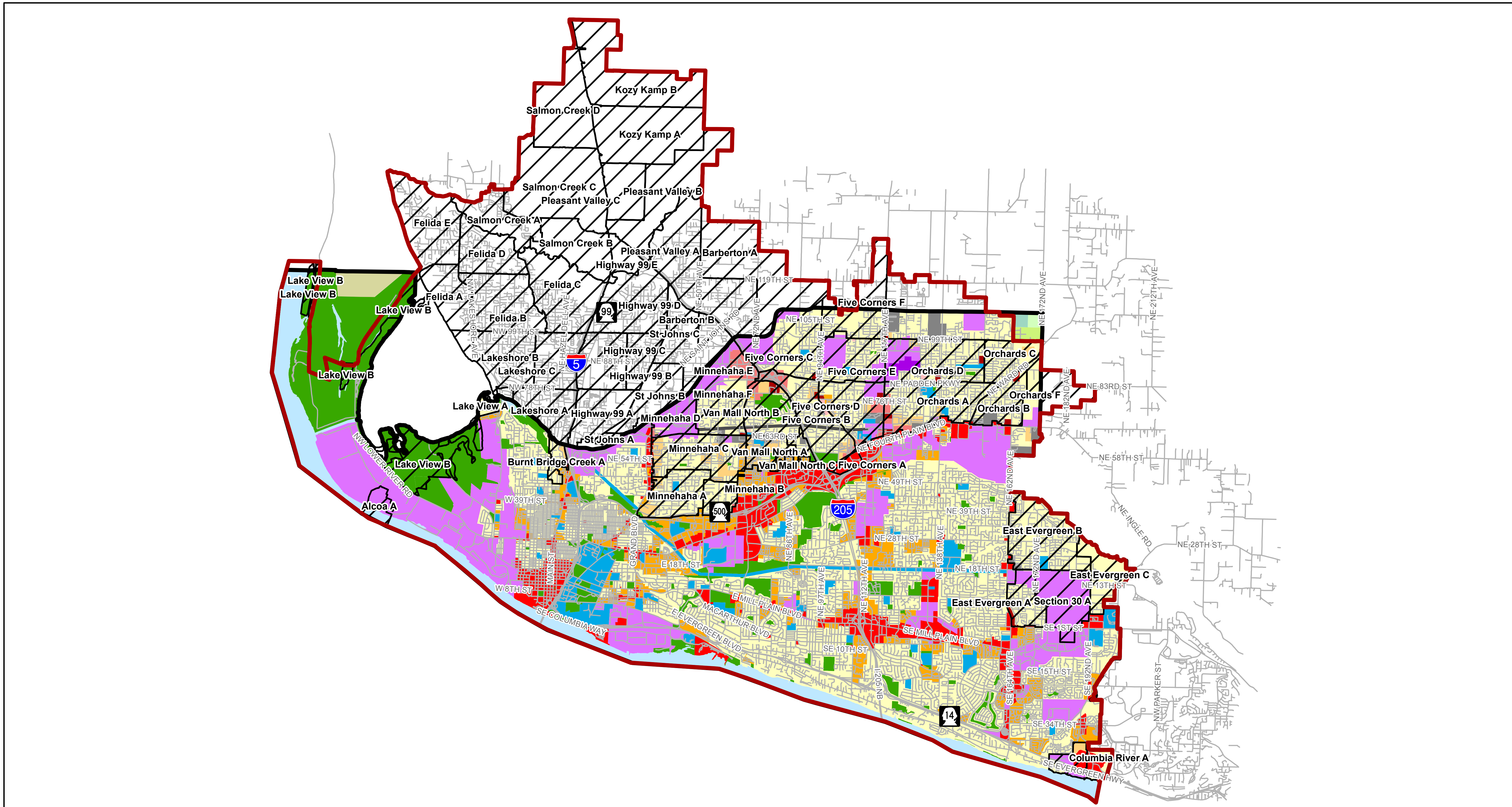
Land use and zoning play important roles in determining growth patterns and future water requirements. Future land use, variations in use, and changing population densities (as determined by applicable zoning ordinances), can significantly impact the water system. Increased residential and commercial densities, as well as new large industrial users, can greatly impact water system demands and the need for additional improvements.

Future land use is governed by zoning requirements established for the Vancouver UGA, which encompasses the City's corporate limits as well as a large area of unincorporated Clark County. Zoning for the UGA is a combination of both City of Vancouver and Clark County zoning designations, as established in their respective Comprehensive Plans (see Section 1.6 for further detail). Table 1.2 presents the aggregate areas for each zoning designation within the RWSA; Figure 1.5 shows the UGA and zoning designations throughout the service area.

Table 1.2 Future Land Use

Land Use Type	Area (acres)
Single Family Residential Subtotal	**21,137**
Urban Low Density	20,269
Urban Medium Density	731
Urban Reserve	85
Rural-10	50
Rural – 5	1
Multi-family Residential Subtotal	**3,217**
Multi-family Low Density[1]	0
Multi-family High Density[1]	0
Urban High Density	3,217
Mixed Use	**439**
Commercial Subtotal	**3,824**
Commercial	3,201
Community Commercial	175
General Commercial	425
Neighborhood Commercial	23
Industrial Subtotal	**7,498**
Industrial	7,420
Light Industrial/Business Park[1]	0
Heavy Industrial	78
Governmental Subtotal	**1,982**
Public Facility	1,870
Bonneville Power Administration	112
Agriculture Subtotal	**306**
Agriculture	43
Agri-Wildlife	263
Parks/Open Space	**5,185**
Other	**2,812**
Total Acres	**46,400**

Notes:
1. No properties of this zoning designation fall within the RWSA.



Legend

- Streets
- Vancouver UGA
- Annexation Area
- Retail Water Service Area Boundary

Comprehensive Land Use

- Agri-Wildlife
- Agriculture
- Bonneville Power Administration
- Commercial
- Community Commercial
- General Commercial
- Neighborhood Commercial
- Light industrial/ Business park
- Heavy Industrial
- Industrial
- Mixed Use
- Multi-Family High
- Multi-Family Low
- Parks/Open Space
- Public Facility
- Rural-10
- Rural-5
- Urban Low Density Residential
- Urban Medium Density Residential
- Urban High Density Residential
- Urban Reserve
- Water

N

0 5,000 10,000 Feet

UGA AND FUTURE LAND USE

FIGURE 1.5

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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1.5.4 Adjacent Water Purveyors

The Clark County Coordinated Water System Plan (CWSP) establishes service area boundaries of Group A water purveyors in Clark County, including Vancouver and its adjacent purveyors. The most recent update of the CWSP was approved by the Board of County Commissioners of Clark County by Resolution 2012-04-08 on April 17th, 2012. The agreement serves to acknowledge and delineate individual service areas and verify there are no service area conflicts with adjacent utilities.

Clark Public Utilities (CPU) provides water service to areas north of the City. CPU provides water service to about 30,000 water service connections and a population of over 86,000. As detailed in its April 2011 Water System Plan, CPU depends on groundwater wells for drinking water supply, with 25 active wells in the Hazel Dell service area and 10 active wells in the Hockinson/Lewis River area. Storage facilities include eight reservoirs serving the Hazel Dell service area, and 16 reservoirs and a pressure tank serving the Hockinson/Lewis River area. If areas within the CPU service area are annexed by the City of Vancouver, CPU will continue to provide water service to these areas unless other agreements are made. Appendix 1C includes a memorandum of understanding (MOU) between the City and CPU to develop an intertie agreement.

The City of Camas borders the City of Vancouver to the east and provides water service to about 16,000 residents through approximately 7,000 water service connections within its own corporate limits and surrounding areas of unincorporated Clark County. The Camas water system includes surface water intake facilities on Jones and Boulder Creeks, a surface water treatment plant, nine wells, and six ground level reservoirs as detailed in its 2010 Water System Comprehensive Plan.

1.6 RELATED PLANS AND AGREEMENTS

Vancouver recognizes that planning activities of governmental entities can affect the water utility. These include several regional and local plans of the southwest region of Washington, such as Clark County. Some related plans affect how Vancouver operates its water system and how it plans to meet future growth. The following section summarizes related plans and addresses the consistency between the City's Water System Plan (WSP) and other local plans. Local government consistency statements are included in Appendix 10F.

1.6.1 Regional Planning Documents

Many governmental entities in the greater Vancouver area make policies that impact regional planning, and coordinate utility, watershed, and transportation planning efforts. Summaries of regional planning documents are presented below, along with assessments of compatibility with the City's WSP.

1.6.1.1 Salmon-Washougal and Lewis Watershed Management Plan (Lower Columbia Fish Recovery Board, July 21, 2006)

The Watershed Management Act (Revised Code of Washington (RCW) Chapter 90.82) provides a framework to address and resolve water resource issues in each of the state's 62 water resource inventory areas (WRIAs). Planning units created for each WRIA are responsible for developing a watershed plan. The planning units consist of citizens, tribes, interest groups, and government agencies where appropriate. Vancouver's water system boundaries and the boundaries of surrounding water providers are within the Salmon-Washougal and Lewis watersheds (WRIAs 27 and 28). Vancouver has been active in the WRIAs 27 and 28 planning effort. The Salmon-Washougal and Lewis Watershed Management Plan (WRIA Plan) was adopted in 2006. The WRIA Plan addresses a range of issues related to water resources, including water supply, stream flow management, water quality, and fish habitat. It reviews alternative approaches for managing water resources in the area and recommends select strategies for implementation. The WRIA Plan discusses Vancouver's sources of supply and projected needs and identifies groundwater in the Vancouver Lake lowlands as a major new source of regional supply. Given this regional source of supply, the WRIA Plan recognizes that Vancouver's regional supply may play a role in assisting other communities within Clark County to meet future demand. The WRIA Plan also encourages new developments and industrial facilities to rely on the City's existing public water system.

The Salmon-Washougal and Lewis Water Resources Management Program rules were adopted in 2008 (Washington Administrative Code (WAC) 173-527 and WAC 173-528). These rules were based on the WRIA Plan and had five key elements:

- Setting Instream Flows,
- Closing sub-basins to future withdrawals,
- Designating "regional supply areas" for future water supply,
- Establishing reservations for water for future use, and
- Specifying conditions of use for access to the water reserves.[1]

The City is located in the Burnt Bridge Creek subbasin. Portions of the service area and UGA are located in the Salmon Creek and Lacamas Creek subbasins. Instream flows have been set in each of the City's three subbasins. The subbasins have been closed to further surface water and groundwater withdrawals, except limited situations provided in WAC 173-528-080 and the designated "regional supply areas." The Vancouver Lake Lowlands Area has been designated a "regional supply area." The City has a small (0.2 cfs) reservation of water in Burnt Bridge creek for future use.

This WSP will remain consistent with the Salmon-Washougal and Lewis Water Resources Management Program rules.

[1] https://fortress.wa.gov/ecy/publications/publications/0811006.pdf

1.6.1.2 Metropolitan Transportation Plan for Clark County, 2011 and 2014 Updates (Southwest Washington Regional Transportation Council)

The Southwest Washington Regional Transportation Council is the region's principal transportation planning organization. As a means to link transportation and land use, the Council periodically produces a regional transportation plan for the metropolitan area of Clark County. The plan is developed through a coordinated process between local jurisdictions in order to develop regional solutions to transportation needs for the next 20 years and to direct the metropolitan transportation planning process.

The demographic analysis and water demand projections, documented in Chapter 2, were developed based on the best available information at the time, 2013, which was the Regional Transportation Plan (RTP) for Clark County, 2011. In order to establish transportation needs over the 20-year planning period, the Council used a regional travel forecasting model. The model is based on historic and future demographic data allocated by Clark County to 665 individual transportation analysis zones (TAZs) within Clark County. Each TAZ was populated with 2010 and future (2035) population, household, and employment demographic data. Historic demographic data was obtained from Census 2010 and future data was based on the results of forecasts performed by the Washington State Office of Financial Management. This demographic data was allocated throughout the county using the 2007 County and City of Vancouver land use data as provided by the respective planning departments. The land use data provided densities, future density assumptions, and zoning characteristics.

The 2014 update, adopted December 2014, extended the planning horizon to 2035 and is compliant with the requirements of the current federal transportation act. The 2014 update continues to support the 2007 County and City of Vancouver land use data, also used in the 2011 Update.

1.6.1.3 Clark County Coordinated Water System Plan (Clark County and EES)

Amended and adopted in 2012, the Coordinated Water System Plan (CWSP) serves as a primary planning document for water purveyors within Clark County. The CWSP was developed to fulfill the requirements of the 1977 Public Water System Coordination Act (RCW 70.116) and the 1971 Water Resource Act (RCW 90.54). The plan is in accordance with the Lewis and Salmon-Washougal Water Resources Management Program rules (WAC 173-527 and WAC 173-528). These acts work together to create a framework for water utilities, which allows for coordinated planning and construction programs among adjacent water utilities. Also, these acts allow utilities in a specified geographical area to reserve water rights required to meet projected municipal and industrial needs for a 50 year period. In order for reservation of water rights and coordination of water system planning to occur, a CWSP is required to be developed.

A Clark County Water Utility Coordinating Committee (WUCC) was created in 1977 and requested that the Washington State Department of Health assess the need for a designation of a Critical Water Supply Service Area. Such designation represents the first step toward the development of a CWSP. The assessment, which was completed in 1980, addressed problems within the county related to inadequate water quality, unreliable service, and the lack of coordinated planning by the water utilities. Based on the findings of the assessment, the County Commissioners declared Clark County a Critical Water Supply Service Area. Following that determination, development of the 1983 CWSP was initiated.

The Coordination Act requires that the CWSP be reviewed and updated by the water utility coordinating committee at a minimum of every five years or sooner, if the water utility coordinating committee feels it necessary; the last update occurring in 2012. The update serves as the regional supplement to local water system plans that have been or will be approved by DOH. The 2012 CWSP:

- Addresses local legislative and CWSP policies.
- Updates water utility service area boundaries.
- Requires consistent water utility design standards.
- Adopts a utility service review procedure.
- Establishes a satellite system management agency.
- Assesses water resources.
- Reviews water supplies.

The 2012 CWSP addressed recent changes to Washington State's satellite system management agency regulations and the Lewis and Salmon-Washougal Water Resources Management Program rules. Vancouver is a member of the WUCC and was actively involved in the 2012 update of the CWSP. This WSP will be consistent with the CWSP.

1.6.2 Local Planning Documents

The following sections summarize local planning documents that are relevant to the City's WSP.

1.6.2.1 Wellhead Protection Regulations

In 2003, the City adopted regulations related to the protection of its groundwater aquifers. Per Vancouver Municipal Code Chapter 14.26, the entire area within the boundary of the City of Vancouver is designated as a Critical Aquifer Recharge Area. Specific activities were identified that could impact the City's ability to use these aquifers as water supplies and were prohibited or restricted. Additional limitations have been imposed on activities within a Special Protection Area within the critical aquifer recharge area. Special Protection Areas are defined as areas inside the Critical Aquifer Recharge Area that are within 1,900 feet of any municipal water supply well. Vancouver's wellhead protection regulations apply to the Vancouver Lake area. These regulations are particularly important because the City intends to meet future demand with water from new wells within the Vancouver Lake area. See Chapter 5 for further details.

1.6.2.2 City of Camas 2010 Water System Comprehensive Plan (Gray & Osborne, Inc)

Camas' Water System Comprehensive Plan was developed to meet the City of Camas' water system needs for a 20-year planning period. The plan was prepared in accordance with DOH WAC 246-290 requirements and includes:

- A water system description.
- Historical and future water use.
- Service area population and water demand projections.
- Water quality and Safe Drinking Water Act impacts.
- A water system analysis, including a computer simulation model.
- Capital Improvement Program (CIP).

The base 6-year CIP includes pipeline, pumping, control, storage, and source improvements. These improvements include the development of multiple well sites and future sources, developing or replacing storage reservoirs throughout the system, transmission and distribution improvements, and booster station improvements. New wells will provide 4,350 gpm of supplies within the 20-year planning period. The elements and the direction of Camas' plan were consistent with activities and plans of this WSP.

1.6.2.3 Clark Public Utilities 2011 Water System Plan (CH2MHill)

This document evaluates the long-term water supply needs and resources available for Clark Public Utilities (CPU). Vancouver reviewed this document to ensure consistency with Vancouver's WSP. The following studies and investigations are included in the CPU Plan: an inventory of existing wells, water supply systems, and interties in the County; an analysis of the population, history, and water requirements to the year 2029; and supplies to serve future water needs. Of note is CPU's South Lake Wellfield. This wellfied is expected to produce 10 MGD and is located southeast of Vancouver Lake within Vancouver's retail water service area. This wellfield is consistent with this WSP and Lewis and Salmon-Washougal Water Resources Management Program rules.

1.6.2.4 City of Vancouver Comprehensive Plan 2011-2030

In response to rapid growth and growth-related pressures in the late 1980s, the State Legislature enacted the Washington State Growth Management Act (GMA) to establish a framework for comprehensive planning efforts by local governments to accommodate anticipated growth and development. The City of Vancouver continues working toward meeting GMA planning requirements and has completed its own comprehensive plan, the City of Vancouver Comprehensive Plan 2011-2030.

The Vancouver Comprehensive Plan 2011-2030, is an update of Vancouver's 2003 comprehensive plan. The plan established a vision of a livable urban area where growth would be tied to the City's ability to provide public services.

The intent of the comprehensive plan is to present a clear vision for Vancouver's future over the next 20 years. The plan includes comprehensive planning elements addressing issues of land use, housing, utilities, transportation, and capital facilities for a twenty year planning horizon. Additionally, the plan contains policy direction relating to growth and development, environmentally sensitive areas, historic places, public services, and other issues. Plan policies are implemented through sub area plans and provisions of the Vancouver Municipal Code and other local standards. The Comprehensive plan also builds on previous planning by the County. The Community Framework Plan (Clark County, City of Vancouver, et al.), adopted by Clark County and its cities in 1993 and updated in 2000 and 2001, provides guidance to local jurisdictions on regional land use and service issues. The Community Framework Plan drove the development of many concepts found within the City's 2003 plan. The City's 2011 Comprehensive Plan is a modest update of the extensively rewritten 2003 plan.

The GMA requires that communities "ensure that facilities and services necessary to support development shall be adequate to serve the development at the time the development is available for occupancy and use without decreasing current service levels below locally established standards" (RCW 36.70A.020.12). This concept is identified as "concurrency" and requires local governments to adopt level-of-service (LOS) standards and to test individual land use proposals to ensure they will not exceed those standards. Proposed developments that would cause these standards to be exceeded cannot be approved unless necessary mitigation is provided. These standards apply to Vancouver's water system capabilities and the capabilities of surrounding suppliers. Section 1.7 presents the City's policies on extending service to new customers.

The development of the City's comprehensive plan has resulted in a number of activities that are of direct relevance to this WSP. These activities include the delineation of a UGA, the completion of land use planning efforts, and the development of population projections. During the development of this WSP, Vancouver adhered to tenets found in the Comprehensive Plan, such as concurrency and the development of levels of service standards, and used relevant elements of the Comprehensive Plan, such as zoning designations.

1.7 SERVICE POLICIES AND PLANNING CONSIDERATIONS

The City of Vancouver (City) manages its water utility in accordance with established water system policies. The policies provide a consistent framework for the design, operation, maintenance, and service of the water system for appropriately implementing programs, designing new infrastructure, and serving additional customers. The policies and planning considerations set forth herein pertain solely to the water system; the City has additional land use, development, and finance policies that may specify additional requirements for development or extension of a water service.

Table 1.3 lays out the City's water service policies and planning considerations. Table 1.4 lists policies regarding interties, water wholesaling, and water wheeling that requires cooperation and coordination with other agencies. Table 1.5 lists water system planning policies, Table 1.6 lists fire protection policies, Table 1.7 lists emergency preparedness policies, Table 1.8 lists water use efficiency policies, and Table 1.9 summarizes the City's environmental stewardship policies.

Tables are divided into:

- Policies that establish the City's position and commitment on an issue,
- Planning considerations that provide direction for the Water System Comprehensive Plan, and
- Design and construction criteria provide specific conditions for the Water System Comprehensive Plan.

The following documents are referenced in Table 1.3 through Table 1.9:

- City of Vancouver Municipal Code (VMC)
- City of Vancouver 2007 Water System Comprehensive Plan (2007 WSCP)
- City of Vancouver General Requirements: Water Design & Construction Requirements (VGR)
- City of Vancouver Comprehensive Plan 2011-2030 (VCP)
- Clark County Coordinated Water System Plan (CWSP)
- Clark County Coordinated Water System Minimum Standards & Specifications (CWSP MSS) (Appendix V-A to the CWSP)
- Clark County Code (CCC)
- International Building Code (IBC).
- Uniform Plumbing Code (UPC).
- International Fire Code (IFC).

Table 1.3 Water Service Policies & Planning Considerations

Name	Type	Policy Statement	Policy Reference
Duty to Serve	Policy	"Provide safe, clean, quality drinking water to every Vancouver home, business, and industry. Discourage development and use of private drinking water wells. Provide water pressures and volumes necessary to support fire suppression hydrants and sprinkler systems. Ensure that the infrastructure to support water service is in place prior to or at the time of development."	VCP Public Facility and Service Policies (PFS) -23, Pg 5-57
Retail Water Service Area	Policy	The City will provide water service to all customers within its Retail Water Service Area.	New
	Planning Considerations	The City has "the exclusive franchise territory" of the retail water service area, "giving the utility the responsibility to plan the water system and exercise primary control over the providing water services within its area."	CWSP Section IV.2, Pg 31
		"As such, Vancouver is responsible for the provision of water to customers throughout its service area."	2007 WSCP Section 1.8.4, Pg 1-27
Future Water Service Area, and Urban Growth Area	Policy	The City's future water service area shall be determined through the Coordinated Water System Plan and adopted through the *Interlocal Agreement for Adjusting or Confirming Future Water Service Area Boundaries Between The Cities of Battle Ground, Camas, Ridgefield, Vancouver, and Washougal, and Clark Public Utilities*.	New
		Water service "should not be extended outside the Vancouver urban growth area except to (a) Remedy a threat to public health or safety, or to water resources; (b) Provide service to public facilities within the urban reserve district if they are required to be served; or (c) Support the type and density of development envisioned in that location in a jurisdiction's comprehensive plan. Water service extensions may be extended if they are consistent with the Clark County Coordinated Water System Plan and do not increase density beyond the adopted Comprehensive Plan. The existence or extension of sewer or water service should not be used to justify changes to the comprehensive plan."	VCP PFS-24, Pg 5-57
	Planning Considerations	The City has adopted its service area (December 2011) through the signing of the *Interlocal Agreement for Adjusting or Confirming Future Water Service Area Boundaries Between The Cities of Battle Ground, Camas, Ridgefield, Vancouver, and Washougal, and Clark Public Utilities*.	CWSP

Table 1.3 Water Service Policies & Planning Considerations

Name	Type	Policy Statement	Policy Reference
		The 2007 WSCP indicates that the entire future service area will be served in the next 20 years. The current retail service area encompasses the entire future service area.	2007 WSCP Section 1.5.1, Pg 1-20
Annexation	Planning Consideration	“The City annexation plan is to incorporate all areas within the Vancouver Urban Growth Boundary. [SIC] The water service boundaries currently in place between Clark Public Utilities Water or the City of Camas and City of Vancouver will not change with annexation. The only water service impact with annexation will be financial as those unincorporated areas served by Vancouver will receive a lower “in-city” user rate upon being annexed to the City.”	2007 WSCP Section 1.8.4, Pg 1-27
Government Consistency	Policy	The City’s Water System Comprehensive Plan will be consistent with local, county, and state land use authorities and plans and will comply with the Washington State Growth Management Act.	New
	Planning Consideration	The City has developed a Comprehensive Plan (VCP), which is consistent with the previous Community Framework Plan (2001), and adopted the CWSP. The CWSP is in full compliance with the Public Water System Coordination Act (WAC 246-93) and Washington State Growth Management Act (RCW 36.70A.010).	2007 WSCP Section 1.4.2, Pg 1-19
Condition of Service	Policy	The conditions of service for those applying for new service are documented in the VMC and VCP. A summary of the most relevant sources of policies and criteria are listed below. • VMC Section 14.04.100 – Conditions of water and/or sewer service • VMC Section 14.04.210 – Water service charges • VCP - Meter and material specifications • VMC 14.04 – Approval process for an application for water service. • VMC Section 14.04.155, WAC 249-290, and COV website – Cross-connection and backflow prevention requirements • VMC Section 14.04.280 – Procedure for extending mains • VMC and VCP – Developer requirements.	VMC, VCP

Table 1.3 Water Service Policies & Planning Considerations

Name	Type	Policy Statement	Policy Reference
	Planning Consideration	"To evaluate the Water Utility's ability to provide service to new customers, the City evaluates applications for development. The evaluation is a comparison of the proposed water system demands to source availability, existing demand, system hydraulics, and storage capacity limitations through the use of a computerized water system model. Through this evaluation process, Vancouver is assured that land use applications will be approved in areas where adequate water service can be provided and growth would not infringe on the integrity of the existing water system."	2007 WSCP Section 1.6, Pg 1-23
Service Extension	Policy	The extension of the water and sewer facilities is essential to the growth and stability of the community. To this end, the City has established a procedure for extending mains in Vancouver Municipal Code Section 14.04.280. In conjunction with the ordinance, the Vancouver General Requirement (VGR) Section 2 also provides design related information for extensions. These codes are too extensive to repeat in full herein. Relevant policies relating to this Plan include the following: "Proposed water and sewer lines must be designed in accordance with master plan sizes, elevations, alignments, and capacities as found necessary by city staff for overall system development and network extensions." "Developing properties must at a minimum extend utility lines to the site, across the property frontage, and through the property, to allow connection and also to allow extensions for the development of adjacent parcels. Additional offsite work may be required at the department's discretion to provide a looped water main for water quality, fire protection, or system redundancy purposes." "All development main extensions must be made from existing public mains."	VMC Section 14.04.280
		"New development within the service area requiring infrastructure upgrades, such as extensions, will be required to be financed by the developer, who must also submit applicable system development charges (SDCs) and fees."	2007 WSCP Section 1.8.4, Pg 1-27
Oversizing	Policy	"If in the judgment of the city it is to the best interests of the city and of the general locality where a new main is contemplated to install a larger main than that needed by the owners immediately abutting upon the street, alley or easement in which the main is to be placed, the city may require installation of such larger main and shall with the Public Works Director's approval pay the increased difference in cost between installation of the smaller and of the larger main or supply the pipe or apply SDC credits."	VMC 14.04.280

Table 1.3 Water Service Policies & Planning Considerations

Name	Type	Policy Statement	Policy Reference
Easements and Right-of-Ways	Policy	"Water mains shall generally be in public rights of way, except where needed to serve onsite fire hydrants, buildings on private roads, and adjacent properties."	VGR 2-1.04, Pg 2-4
		"When public sanitary sewer and water mains are extended outside of public right-of-ways to serve new development, the mains shall be extended in easements dedicated to the City of Vancouver."	VMC 14.04.280
Metering	Policy	"There shall be no unmetered connections to the city water system except to automatic sprinkler systems for fire protection services which are approved by the Director of Public Works. This subsection shall not apply to single-family residential structures; all single-family residential fire protection services shall be metered." "All meters and meter boxes shall be owned, installed and maintained by the department."	VMC Section 14.04.170
Source Meters	Policy	All supply sources will be metered either at individual wells or at a common flow meter.	New
Satellite Systems	Planning Consideration	Clark Public Utilities (Clark) has been "re-designated as the county's primary satellite management area provider. [SIC] In the event that Clark agrees to operate a satellite system within another water utilities [Vancouver] service area, an agreement will be negotiated between Clark and the primary water provider [Vancouver]." The CWSP and will govern these systems.	CWSP Section I, Pg 6
Service Ownership/ Responsibility	Planning Considerations	The City has defined the ownership, installation, and maintenance of the service laterals: • "The department [City] shall install, own and maintain all water service lines from the main to and including the meter." • "Customer lines from the meter to the building or premises shall be installed, owned and maintained by the customer." • Approval of all new, re-laid or relocated customer lines must be secured from the department before water will be turned into the service."	VMC Section 14.04.100

Table 1.3 Water Service Policies & Planning Considerations

Name	Type	Policy Statement	Policy Reference
Reimburse-ment Contracts	Planning Consideration	Latecomer fees are collected through agreements called developer "Reimbursement Contracts." At the request of developers, the City may choose to allow reimbursement contracts. These contracts would be in exchange for permission to develop and allow for reimbursement to the initial developer by future users in the area who will benefit from the system expansion. The developer must be willing to front the initial expense of system expansion. These reimbursement contracts should not negatively impact system expansion; the City anticipates future development by coordinating its water system plan with the City's Comprehensive Plan.	VMC 14.04.285
Mainline Fees	Planning Consideration	For water facilities installed and paid for by the city, "Anyone later desiring to connect a house or building to a main which has been constructed or extended by the city by means other than by formation of a local improvement district may do so only upon payment to the city, in addition to normal connection charges, of a main line fee."	VMC 14.04.280
Selling Water	Planning Consideration	Section 14.04.120 prohibits selling or sharing water to another without first obtaining permission from the City.	VMC Section 14.04.120
Connecting with an Existing Water Source	Planning Consideration	Properties with an on-site well may obtain service from the City, but must comply with "Washington state law (WAC 173-160 and WAC 246-290), and Vancouver Municipal Code (14.04.140 and 14.04.155). City approved reduced-pressure backflow assembly (RPBA) must be installed, inspected, and tested per Section 14.04.155 (COV Website - http://www.cityofvancouver.us/publicworks/page/backflow-and-cross-connection-prevention).	COV Website
	Policies	Premise isolation for all service connections by an approved air gap or reduced pressure backflow assembly is required for all customers with access to unapproved auxiliary water supplies, as defined by WAC 246-290-010, connected to a piping system whether or not an interconnection exists between the unapproved auxiliary water supply and the city water system.	VMC 14.04.155

Table 1.4 Coordination & Cooperation with Other Agencies

Name	Type	Policy Statement	Policy Reference
Interties	Policies	The CWSP recommends that "all major public water systems in the County be interconnected or intertied."	CWSP Section I, Pg 7
	Planning Consideration	The City currently has two emergency intertie with Clark Public Utilities. Two hydrants (one from each city) have been strategically placed at the boundary with Camas in order to allow for an emergency intertie.	Existing System Data Request
Wholesaling Water	Policies	"The City will consider the sale of water on a wholesale basis to water providers should the need arise and should Vancouver have access to available source capacities."	2007 WSCP Section 1.8.4, Pg 1-26
	Planning Consideration	The City does not currently wholesale water.	2007 WSCP Section 2.4.2, Pg 2-13
Wheeling Water	Policies	"The City is amenable to wheeling water to another system provided issues related to water quality, such as blending, quantity, pressure, and fireflow are adequately addressed."	2007 WSCP Section 1.8.4, Pg 1-26
	Planning Consideration	The City does not currently wheel water.	2007 WSCP Section 1.8.4, Pg 1-26

Table 1.5 Water System Planning

Name	Type	Policy Statement	Policy Reference
Booster Pump Stations Reliability & Redundancy	Policy	Booster Pump Station policies are defined as follows: • **Criterion 1 – Back-up Power.** Sources with backup power shall be capable of supplying average day demand (ADD) for the water system. The City will provide auxiliary power to selected booster pumps as part of establishing reliable supply in each pressure zone. • **Criterion 2 – Largest Source Removed.** For zones with storage, sources shall be capable of replenishing depleted fire suppression storage within 72 hours while concurrently supplying the maximum day demand (MDD) for the water system with the largest individual pump or well in the zone out of service. • **Criterion 3 – Closed Zone.** For pressure zones without storage, booster pumps shall be capable of providing fire flows while concurrently supplying peak hour demand (PHD) for the zone.	Updated from 2007 WSCP
Supply System Reliability	Planning Considerations	The following supply criteria was established for evaluating the water system: • Peak redundant source production capacity shall be sufficient to supply maximum day demands. • Reliable source production capacity shall be sufficient to supply average daily demands. The City will provide auxiliary power to selected wells as part of establishing reliable supply in each pressure zone. • “Redundant” is herein defined as total capacity with the largest source offline. • “Reliable” is herein defined as total capacity with back-up power.	New, 2007 WSCP Section 4.2.1, 2007 WSCP 3.4.2
		In establishing the source production capacity, the City’s existing supply source capacity (groundwater wells) are limited to the established annual withdrawal limits and instantaneous withdrawal limits set by the Department of Ecology. The City will consider the peak seasonal yield and annual sustainable yield for each source based on aquifer characteristics, well performance, and as applicable, maintaining Department of Ecology required groundwater levels.	2007 WSCP Section 4.3.4, Pg 4-24

Table 1.5 Water System Planning

Name	Type	Policy Statement	Policy Reference
Required Storage Elements and Storage Sizing	Planning Considerations	The City storage is divided into five separate components: operational, equalizing, standby (emergency), fire suppression, and dead storage. Storage volumes shall exceed the combined quantity of the following elements for each operating area: • Operational storage: calculated as 5% of the volume of each tank or reservoir. • Equalizing storage: calculated as 15% of the maximum day demand. • Standby storage: calculated as the storage required to meet ADD for two days utilizing only wells and pump stations with backup power and with the largest reliable well or booster pump to each operating area off-line. • Fire flow storage: according to the maximum flow and duration requirement for each pressure zone. • The City permits “nesting” of its emergency storage, which requires storage volume to meet the greater of Standby Storage or Fire Storage. • Dead storage: the volume that is below the elevation necessary to provide 20 psi (static) at the meter of the highest customer.	New
System Pressure	Planning Considerations	System piping shall be sized to provide for peak hourly demands at a minimum system pressure of 30 psi. Required fire flows shall be provided under maximum day demands at a minimum system pressure of 20 psi.	Updated from 2007 WSCP
Equivalent Residential Units	Planning Considerations	The water use of one Equivalent Residential Unit (ERU) is herein defined as 223 gpd.	New
Maximum Day Demand Peaking Factor	Planning Considerations	Maximum Day Demands (MDD) are herein defined as 2.10 times Average Day Demands, as established from historical demand data.	
Planning Peak Hour Demand	Planning Considerations	Peak hour demands (PHD) will be calculated using an MDD to PHD ratio of 1.6.	Updated from 2007 WSCP
Water Quality	Planning Considerations	“Minimum treatment standards have been established for water systems by the State of Washington and the EPA. Vancouver does not use surface water for supply; therefore, only groundwater treatment rules apply. At a minimum, Vancouver disinfects source water produced by wells with chlorine, and adds fluoride to promote dental health. Depending on groundwater quality, some water stations provide additional treatment such as air stripping for removal of volatile organics or carbon dioxide, greensand filtration for iron and manganese removal, or sodium hydroxide for corrosion control.”	2007 WSCP Section 3.1.2, Pg 3-1

Table 1.5 Water System Planning

Name	Type	Policy Statement	Policy Reference
Pipe Sizing	Design and Construction Criteria	“Proposed water line sizes and alignments must be designed in accordance with the latest Water System Comprehensive Plan, or other appropriate master plans, as determined by the City staff for overall system development and network extension”	VMC 14.04.280
		The 2007 WSCP and VCP provide minimum size requirements. The minimum diameter of new pipelines is 8 inches and 6 inches for existing looped system, except in dead end mains. Dead end mains 50 feet or shorter, to serve only a hydrant, shall be a minimum of 6 inches in diameter. Dead end runs longer than 50 feet to a fire hydrant shall be a minimum 8 inches in diameter. Dead end mains to the end of a residential cul-de-sac, where the water main cannot be extended in the future, shall be minimum 8 inches in diameter to the last hydrant, and 4 inches in diameter past the last hydrant to the end.	2007 WSCP Section 7.3, Pg 7-9 VGR 2-1.06, Pg 2-5 2007 WSCP, VGR 2-1.06, Pg 2-5
Service Pressure & Flow	Design and Construction Criteria	“Water services shall be sized as required by water demand and on-site fire protection service flow.”	VGR 2-1.06, Pg 2-5
		Service pressures should be “within the range of 30-100 psi with a desired range of 40-90 psi.”	CWSP MSS Pg 3
Pipe Velocities	Design and Construction Criteria	New pipes shall have a “maximum instantaneous velocity for peak hour conditions of 7 feet per second.”	2007 WSCP 3.7.3, Pg 3-47
Distribution System	Design and Construction Criteria	“Looped water mains are desirable for fire flow, system reliability during maintenance, and for water quality. Dead ends shall be avoided, except as needed to provide for future service, and for cul-de-sacs and fire hydrants.”	VGR 2-1.05, Pg 2-4 VMC 14.04.280C
Pressure Reducing Valves	Design and Construction Criteria	“Pressure reducing valves (PRV) should maintain a constant downstream pressure regardless of varying inlet pressure. PRVs should be hydraulically operated, pilot-controlled, diaphragm-type globe or angle style valves.”	CWSP MSS Pg 10
Valving	Design and Construction Criteria	“Isolation valves must be installed to facilitate new connections to the system, and to provide for the isolation of pipe segments during maintenance. Generally two isolation valves per tee, and three isolation valves per cross are required. At least one isolation valve per 1000 feet of main run must be installed.”	VGR 2-1.10, Pg 2-6
Dead End Mains	Design and Construction Criteria	“Dead-end extensions shall be provided with a standard blowoff assembly, or with a standard temporary blowoff assembly”	VGR 2-1.05, Pg 2-4
Pipe Materials	Design and Construction Criteria	“Water mains shall be constructed of ductile iron pipe (Class 52 up to and including 12 inches in diameter, Pressure Class 350 for 14 inches and larger and per the City of Vancouver Water Standard Detail Sheets.”	VGR 2-1.06, Pg 2-5

Table 1.6 Fire Protection Policies

Name	Type	Policy Statement	Reference
Fire Protection Services	Policy	The City will "provide water pressures and volumes necessary to support fire suppression hydrants and sprinkler systems."	VCP PFS-23, Pg 5-57
	Planning Considerations	"Required fire flows shall be provided under maximum day demands at a minimum system pressure of 20 psi."	Updated from 2007 WSCP
Pumping Requirements	Planning Considerations	Required flows shall be defined as follows (Criteria 2 & 3 of the Booster Pump Stations Reliability & Redundancy Policy): • For zones with storage, sources shall be capable of replenishing depleted fire suppression storage within 72 hours while concurrently supplying the maximum day demand (MDD) for the water system with the largest individual pump or well in the zone out of service. • For pressure zones without storage, booster pumps shall be capable of providing fire flows while concurrently supplying peak hour demand (PHD) for the zone.	Updated from 2007 WSCP
Fire Hydrants	Planning Considerations	"All fire hydrants shall be served by the City of Vancouver water system unless the fire code official approves some other system. A water supply shall consist of reservoirs, pressure tanks, elevated tanks, water mains or other fixed systems capable of providing the required fire flow at twenty pounds per square inch residual pressure."	VMC Section 16.04.160
Fire Flow Quantity	Design and Construction Criteria	The CWSP requires a minimum fire flow of 1,000 gpm in urban areas and urban reserve areas.	CWSP Section 5 Pg 36
		Current COV policies establish a fire flow criterion (at no less than 20 psi) of: • For areas zoned for one and two family dwellings, an available fire flow greater than 1,000 gpm • For multi-family and commercial zoned areas, an available fire flow greater than 2,000 gpm • For industrial zoned areas, an available fire flow greater than 4,000 gpm	New

Table 1.6 Fire Protection Policies

<table>
<tr><th>Name</th><th>Type</th><th>Policy Statement</th><th>Reference</th></tr>
<tr><td>Fire Flow Duration</td><td>Design and Construction Criteria</td><td>The following fire flow duration table will be used for the storage analysis:
<table><tr><td>Fire Flow (gpm @ 20 psi)</td><td>Duration (Hours)</td></tr><tr><td>1,499 or less</td><td>1</td></tr><tr><td>1,500 – 2,999</td><td>2</td></tr><tr><td>3,000 – 3,999</td><td>3</td></tr><tr><td>4,000 and above</td><td>4</td></tr></table></td><td>IFC</td></tr>
<tr><td rowspan="4">Hydrants</td><td rowspan="4">Design and Construction Criteria</td><td>“Fire hydrants shall not be installed on mains less than six inches diameter.”</td><td>2007 WSCP Section 7.3.1, Table 7-2, Pg 7-7</td></tr>
<tr><td>“Fire hydrants shall be provided at 400 foot spacing along required fire apparatus access roads” (Section 16.04.160). Longer spacing (600 feet or 1,000 feet) may be allowed based on the criteria detailed in Section 16.04.160. The VGR also provides specifications and standard details for the standard hydrant assembly and retaining wall.</td><td>VMC 16.04.160</td></tr>
<tr><td>507.5.1.5 Spacing (Other than R-3 and U). Fire hydrants serving buildings or portions of buildings or other premises, facilities or uses other than one and two family dwellings and Group U Occupancies shall have a maximum lateral spacing not to exceed 300 feet as a condition of building permit approval, site plan review or change in use. Exception: where the building, facility or premises is protected by an approved automatic sprinkler system or other automatic fire suppression system as approved by the Fire Marshal, the spacing requirements may be modified if in the opinion of the Fire Marshal and the District Chief, or his designee, the level of fire protection is not reduced.</td><td>CCC 15.12.507.5.1</td></tr>
<tr><td>507.5.1.6 Spacing (R-3). Fire hydrants serving one or two family dwellings shall have a maximum lateral spacing of 700 feet with no lot or parcel in excess of 500 feet from a fire hydrant as a condition of approval for residential subdivision or short subdivision. Exception: where the buildings are protected by an approved automatic sprinkler system, the spacing requirements may be modified, if in the opinion of the Fire Marshal and the District Chief or his designee, the level of fire protection is not reduced.</td><td>CCC 15.12.507.5.1</td></tr>
</table>

Table 1.7 Emergency Preparedness Policies

Type	Name	Policy Statement	Policy Reference
General Emergency Preparedness	Policy	The City shall maintain emergency planning documents for its water system including an Emergency Response Plan, a Water Shortage Response Plan, as the City deems appropriate for planning purposes and as required by WAC 246-290.	New
Water Shortage Response	Planning Considerations	The City's maintains an effective water shortage response plan in its 2007 WSCP, as documented in Section 4.6.	2007 WSCP Section 4.6, Pg 4-36
Emergency Preparedness	Planning Consideration	The City's Emergency Response plan is documented in Section 6.5 of the 2007 WSCP. It meets or exceeds the requirements of WAC 246-290-420. The plan includes a vulnerability assessment and detection procedures. Additionally it provides contingency procedures, identification of priority customers, communication chart, and training.	2007 WSCP Section 6.5, Pg 6-23

Table 1.8 Water Use Efficiency Policies

Name	Type	Policy Statement	Policy Reference
Water Use Efficiency	Policy	The City has established the following water use efficiency goals: **Supply-Side Goal:** Maintain annual distribution system leakage (DSL) to six (6) percent or less. **Demand-Side Goal:** Reduce the average equivalent residential unit annual water consumption by one (1) percent per six years, to achieve a goal of 200 gpd/ERU.	New
Water Use Efficiency Program	Planning Considerations	The City's Water Conservation Program exceeds the DOH guidelines and has reduced demand by 18 percent. The City promotes conservation through its Water Resource Education Center and a variety of other communication vehicles. All DOH recommended conservations measures have been implemented, except where there is no customer engaging in that practice (large scale commercial agriculture).	2007 WSCP Section 4.1, Pg 4-1
Irrigation	Planning Considerations	The City has adopted water conservation standards for new or substantially remodeled buildings that limits Turf, high-water-use plantings and water features and encourages xeriscaping.	VMC Section 20.925.100
Water Meters	Planning Considerations	"There shall be no unmetered connections to the city water system except to automatic sprinkler systems for fire protection services which are approved by the Director of Public Works. This subsection shall not apply to single-family residential structures; all single-family residential fire protection services shall be metered."	VMC 14.04.170A
Non-Revenue Water	Planning Considerations	The City maintains annual records of unmetered uses, including main flushing, fire fighter training, fire suppression, street cleaning, and water treatment plant backwash. "Additionally, the Water Utility is now billing for internal uses of water to encourage conservation"	2007 WSCP Section 4.1.3, Pg 4-9
Leak Detection	Planning Considerations	The City conducts regular meter testing, replacement, leak detection surveys, and leak repair, if needed. Leaks and main breaks are now tracked in the city's GIS system to aid in prioritizing water main replacement projects.	2007 WSCP Section 4.1.3, Pg 4-8
Reclaimed Water	Planning Considerations	The City reuses water in its "Westside and Marine Park Water Reclamation facilities for irrigation as a major use in the summer," as well as other uses. It reuses water for backwash at the Ellsworth Water Treatment Plant.	2007 WSCP Section 4.1.3, Pg 4-9

Table 1.9 Environmental Stewardship Policies

Name	Type	Policy Statement	Policy Reference
Environmental Stewardship	Policies	The City will "demonstrate and promote environmental stewardship and education."	VCP Environmental Policies (EN) - 2
Receiving Water Quality Responsibility	Policies	The City will "enhance and protect surface water, stormwater, and groundwater quality from septic discharge, impervious surface runoff, improper waste disposal, and other potential contaminant sources."	VCP EN - 8
Water Use Efficiency	Policies	"Ensure safe and adequate water supplies and promote wise use and conservation of water resources."	VCP EN - 8
Energy Conservation	Policies	The City will "promote and facilitate energy conservation and alternative energy sources and generation."	VCP EN - 3
Water Resource Protection	Planning Considerations	The City water resources statutes are defined in Section 14.26. The statutes are intended to "protect the health, safety and welfare of the residents of the City and the integrity of the City's water resources for the benefit of all by: • Minimizing or eliminating surface and ground water quality degradation; • Preserving and enhancing the suitability of waters for recreation, fishing, wildlife habitat, aquatic life and other beneficial uses; and • Preserving and enhancing the aesthetic quality and biotic integrity of the water."	VMC Section 14.26.100
Wellhead Protection Program	Planning Considerations	The City's wellhead protection program meets all DOH and EPA requirements. "The entire area within the boundary of the City of Vancouver… is designated as a Critical Aquifer Recharge Area," which effectively designates the entire City as a wellhead protection area. VMC Section 14.26.115 defines the minimum standards for the use of best management practices to minimize the potential risks to water resources. Additional Special Protection Areas, which have further development restrictions, are defined as "property within one thousand nine hundred feet (1900') of any municipal water supply well."	VMC Section 14.26.115
		The Wellhead Protection program includes Public education, contaminant source management (i.e. underground storage tanks, hazardous wastes, etc.), and water quality monitoring.	2007 WSCP, Section 5.9, Pg 5-25
Sustainable Development	Planning consideration	The City has adopted the *Creating a more Sustainable Vancouver Plan* that establishes goals for the City.	VCP Pg 1-10
Facility Abandonment	Planning consideration	Property owners abandoning wells must follow "proper abandonment procedures, per Washington state law WAC 173-160, using a licensed well driller. Capping the well or pulling the pump is not proper abandonment and will require installation of a state-approved reduced-pressure backflow assembly device on the water service to the property."	COV Website

1.8 SYSTEM FACILITIES

The City's water system consists of seven pressure zones served by eleven water stations that produce, treat, store and pump water into the distribution piping. Water station sites are typically composed of a variety of facilities including source wells, water treatment facilities, ground level reservoirs, elevated storage tanks, and booster pump stations (BPSs). Four additional separate BPSs transfer water from a lower to higher pressure zone, while eight pressure reducing valve (PRV) vaults transfer water from higher to lower pressure zones. The system also includes two emergency interties with CPU. A map showing the location of the water system's pressure zones and facilities is included as Figure 1.6.

Figure 1.7 is a schematic that shows the pressure zones, facilities and interties and also displays well, pump and storage capacities for each facility.

The City disinfects the groundwater produced at all water stations with chlorine and adds fluoride to promote dental health. Depending on groundwater quality, some water stations provide additional treatment, such as air stripping for removal of volatile organics or carbon dioxide, greensand filtration for iron and manganese removal, or sodium hydroxide for corrosion control. Treated groundwater is stored in five ground level reservoirs and five elevated tanks for a total storage capacity of 24.15 million gallons. Booster pumping stations are operated at ground-level storage reservoirs to pressurize stored water into the distribution system. Additional details on each facility are included on the Water Facility Factsheets in Section 1.8.1 and in the Water Facility Data Tables in Section 1.8.2.

A Supervisory Control and Data Acquisition (SCADA) telemetry and control system provides remote operational control, monitoring, and data recording for all water system facilities and installations. The SCADA system continuously monitors reservoir and elevated tank water levels and automatically activates or deactivates wells, booster pumps, and other water system facilities. The SCADA system uses an autodialer to notify operators of emergency or alarm conditions during non-business hours.

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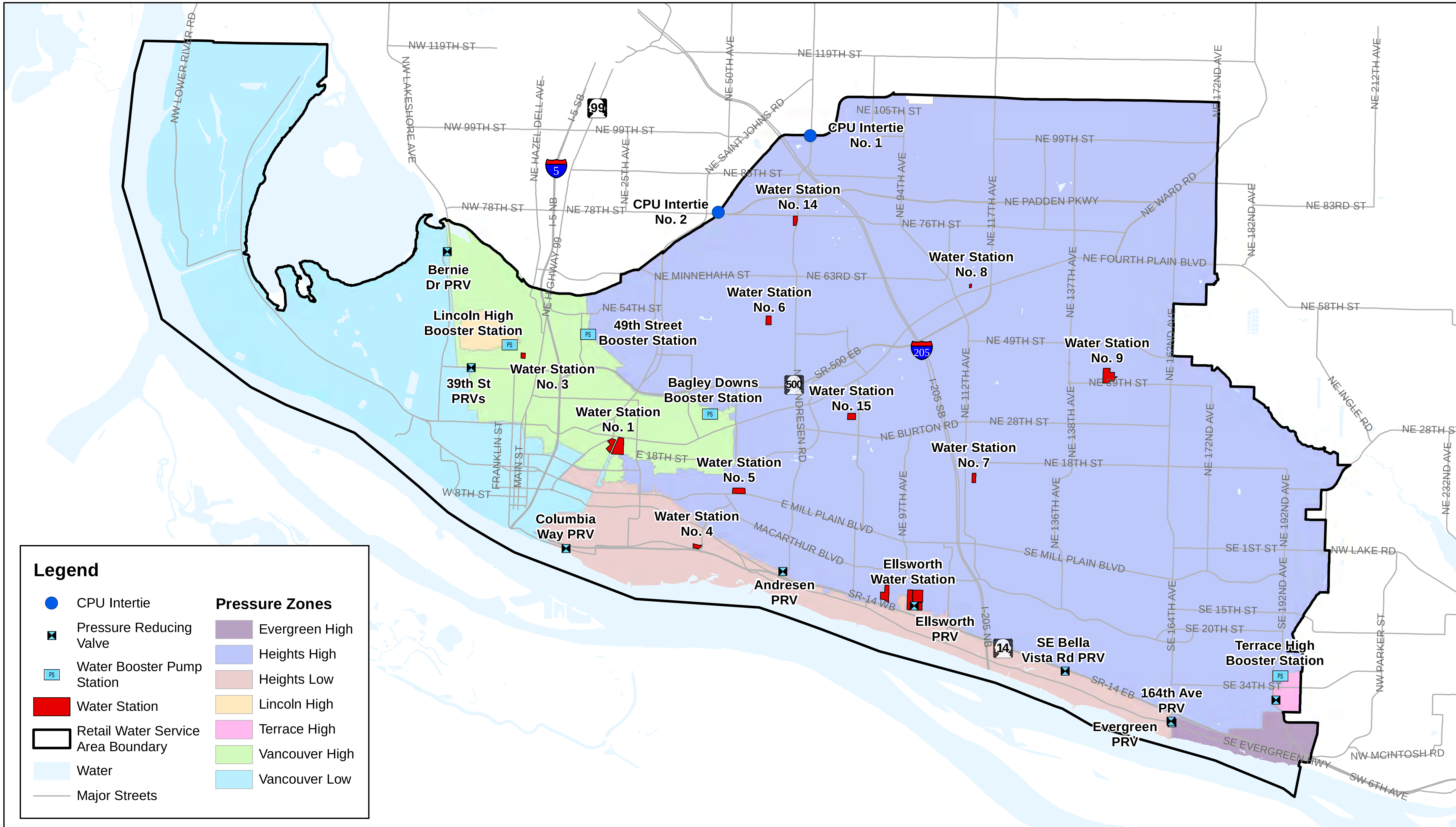
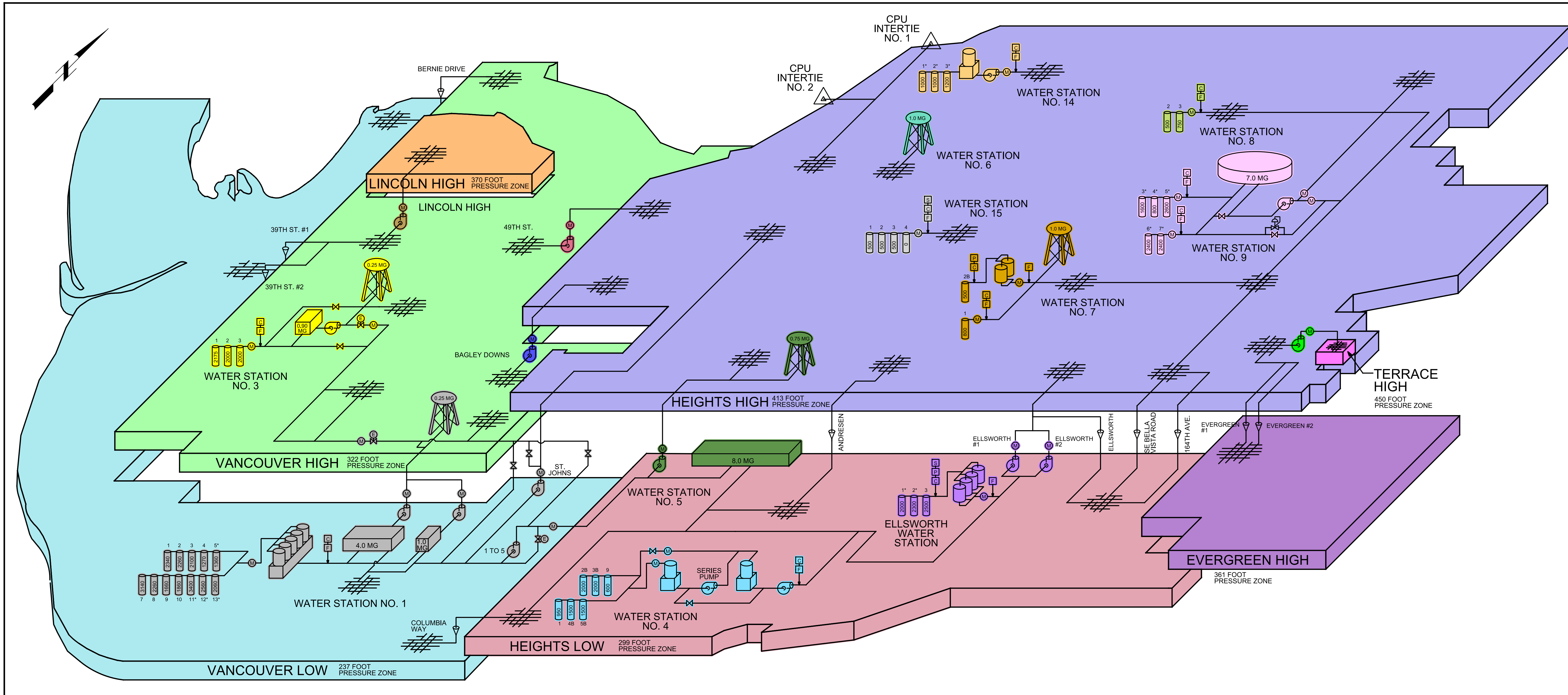


Feet
0 5,000 10,000

WATER SYSTEM MAP

FIGURE 1.6

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN



BOOSTER PUMP STATION	PUMP CAPACITIES (GPM)	
BAGLEY DOWNS	1 - 2200	2 - 1800
LINCOLN HIGH	1 - 1000	
49th STREET	1 - 1100	
TERRACE HIGH	1 - 100 2 - 100	3 - 300 4 - 1900
WATER STATION NO.1 4 MG RESERVOIR	1 - 1500 2 - 1500	3 - 1400
WATER STATION NO.1 1 MG RESERVOIR	1 - 2000	2 - 2000
WATER STATION NO.1 1 TO 5	1 - 2460 2 - 3000 3 - 3000	4 - 3000 5 - 3000
WATER STATION NO.1 ST. JOHNS	1 - 1600 2 - 1600	3 - 1600
WATER STATION NO.3	1 - 2000 2 - 2000	3 - 2000

BOOSTER PUMP STATION	PUMP CAPACITIES (GPM)	
WATER STATION NO.4	1 - 4000 2 - 4000	3 - 4000
WATER STATION NO.5	1 - 1400 2 - 1400 3 - 2450	4 - 3000 5 - 2000
WATER STATION NO.9	1 - 2000 2 - 2000 3 - 2000 4 - 2000 5 - 2000	6 - 2000 7 - 2000 8 - 2000 9 - 2000 10 - 2000
WATER STATION NO.14	1 - 1600	2 - 1600
ELLSWORTH WATER STATION NO.1	1 - 1800 2 - 1800 3 - 1800	4 - 1800 5 - 1800
ELLSWORTH WATER STATION NO.2	1 - 3600 2 - 3600	3 - 3600

LEGEND

- ELECTRIC VALVE
- NORMALLY CLOSED VALVE
- PRESSURE REDUCING VALVE
- CHLORINE ADDITION
- POTASSIUM PERMANGANATE ADDITION
- FLUORIDE ADDITION
- SODIUM HYDROXIDE ADDITION
- WELL SOURCE AND CAPACITY (GPM)
- FLOW METER
- BOOSTER PUMP STATION
- INTERTIE
- IRON AND MANGANESE FILTER
- AIR STRIPPING TOWER
- GROUND LEVEL CONCRETE RESERVOIRS
- ELEVATED TANK
- CONNECTION TO DISTRIBUTION SYSTEM
- * AUXILIARY POWER AVAILABLE
- PRESSURE CONTROL VALVE

WATER SYSTEM SCHEMATIC

FIGURE 1.7

CITY OF VANCOUVER

COMPREHENSIVE WATER SYSTEM PLAN

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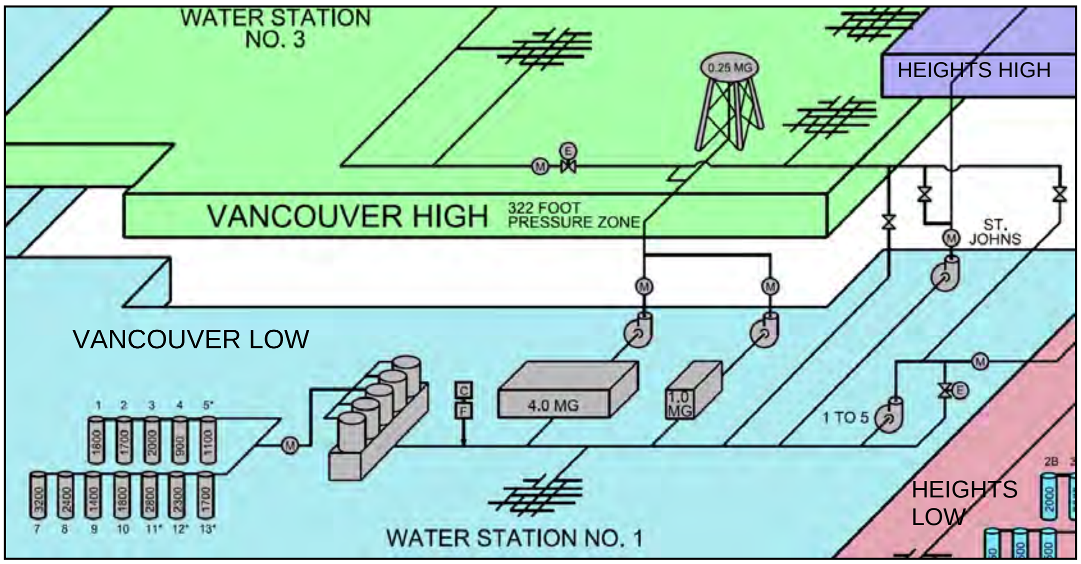
1.8.1 Water Facility Fact Sheets

The following pages contain fact sheets for the 11 water stations and four BPSs that serve the seven pressure zones in the City of Vancouver. Each fact sheet contains a schematic of the station, the location of each station, the pressure zones it supplies, a station description, and other station facility details.

Water Station No. 1

Station Schematic



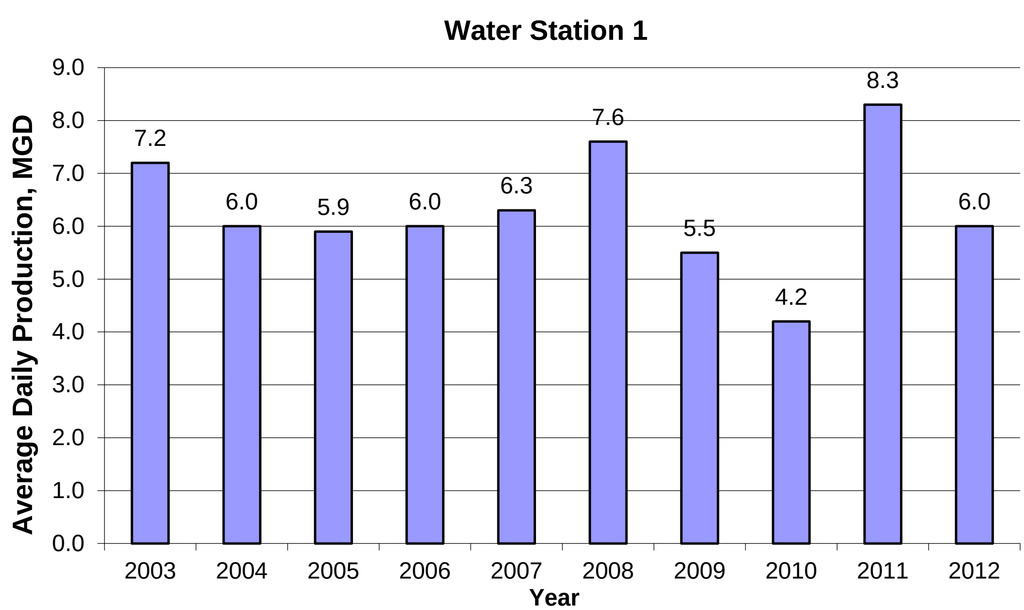
Location:	Water Station No. 1 (WS 1) is located near the boundary of the Vancouver Low and Vancouver High Pressure Zones along East Fourth Plain Boulevard in Waterworks Park.
Pressure Zones Supplied:	Vancouver Low, Heights Low, Vancouver High, and Heights High
Station Description:	Inventory: • 12 active groundwater wells (1 abandoned groundwater well) • 4 booster pump stations • Gas chlorination system with automatic shutoff valves • Fluoride dosing system • 2 ground level storage reservoirs • 1 elevated storage tank • Air stripping treatment facility WS 1 is the largest water source for the City of Vancouver. Each of the twelve wells' water is piped through a common water meter to the station's air stripping treatment facility. Finished water from the air stripping treatment facility is disinfected via a gas chlorination system, dosed with fluoride, and flows by gravity to the station's two ground level reservoirs. The booster stations distribute water to the station's elevated storage facility and pressure zones. The 1-5 Booster Station moves water from WS 1 to WS 5. The station is served by two independent electrical power supplies.

Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	**2,340**	
2	**2,260**	
3	**2,100**	
4	**1,270**	
5	**1,360**	Equipped with right angle drive auxiliary power unit
6	**3,140**	Abandoned
7	**2,260**	Direct probe reports aquifer level (performed manually)
8	**1,660**	
9	**1,860**	
10	**3,400**	
11	**2,560**	
12	**2,060**	
13	**2,340**	
TOTAL	**26,270**	

- Electric generator can supply emergency power to either Well 11 or Wells 12/13, stripping facility, chlorine scrubber, chlorine and fluoride.
- Aquifer level is monitored via direct probe installed at Well 7.
- Well 13 building contains gas chlorine system, the fluoridation system, and a chlorine scrubber.



Booster Pump Stations:

Booster Station	Supply From	Area Served	Pumps	Notes
4 MG Reservoir Booster Station	4.0 MG Reservoir	Vancouver High & WS 1 elevated tank	3 split case centrifugal 2 @ 1,500 gpm 1 @ 1,400 gpm	Pump station instantaneous flow (not totalized) monitored w/ SCADA
1 MG Reservoir Booster Station	1.0 MG Reservoir	Vancouver High & WS 1 elevated tank	2 vertical turbine 2,000 gpm each (nominal capacity) Total actual capacity (3,000 gpm)	Pump station instantaneous flow (not totalized) monitored w/ SCADA
"1 to 5" Booster Station	Both WS 1 reservoirs	8.0 MG Reservoir at Water Station No. 5 (Heights Low Pressure Zone)	5 horizontal split case centrifugal 1 @ 2,460 gpm 4 @ 3,000 gpm each Total capacity 12,000 gpm	Flow rates monitored by flow meter (SCADA). Discharge pressures relayed to SCADA system.
St. John's Booster Station	Both WS 1 reservoirs	Heights High	3 horizontal split case centrifugal 3 @ 1,600 gpm each	Flow rates monitored by flow meter (SCADA). Discharge pressure relayed to SCADA system.

- 1 MG Reservoir Booster Station (Booster Station 4-5) can be powered by the existing 250 KW auxiliary power generator.
- "1 to 5" Booster Station includes an electronically actuated butterfly valve between the suction and discharge headers to allow for gravity backflow from the Water Station No. 5 reservoirs to the Water Station No. 1 reservoirs via dedicated 24-inch diameter transmission main.

Storage:

Reservoir / Tank	Constructed	Material / Geometry	Volume	Pressure Zone Served	SCADA
WS 1 Reservoir 1	1909	Concrete / Rectangular (partially buried)	1.0 MG	Vancouver Low	Level reported via pressure transducer
WS 1 Reservoir 2	1938	Concrete / Rectangular (partially buried)	4.0 MG	Vancouver Low	Level reported via pressure transducer
WS 1 Tank	1938	Elevated/ Steel	0.25 MG	Vancouver High	Level reported via pressure transducer

- Concrete reservoirs have wood framed roof structures with plywood sheathing and "built up" weatherproofing.

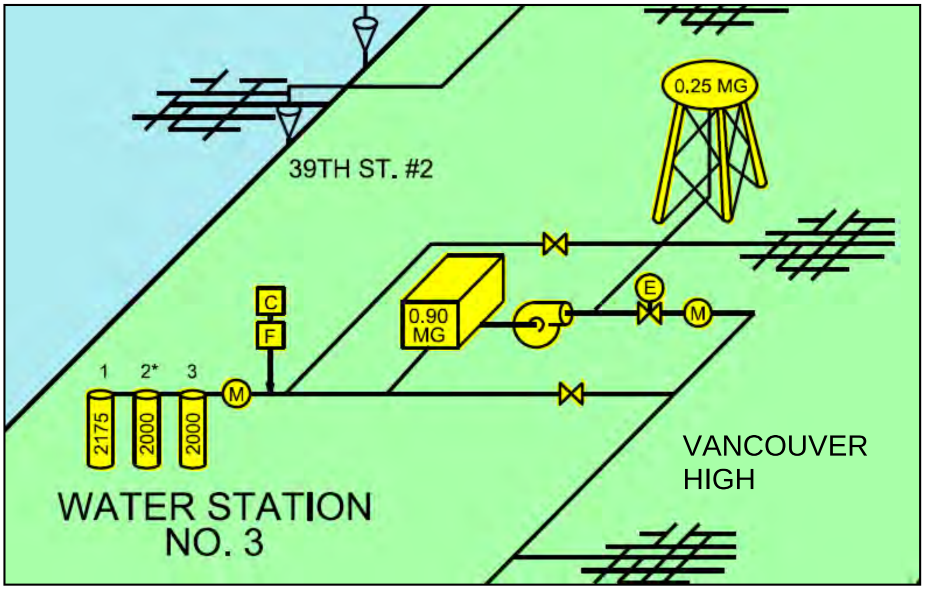
Other Facilities:

Air Stripping Treatment Facility:

- Designed to remove volatile organic compounds from the groundwater wells, specifically perchloroethylene (PCE).
- 5 stripping towers (approximate inlet elevation of 275 feet). Each tower designed to carry 3,800 gpm.
- Design capacity 19,000 gpm at 99% PCE removal.
- Each tower packed with plastic media and has a dedicated air blower.
- Operation: Water from groundwater wells pumped to inlet near top of stripping towers. Water cascades down through the plastic media as outside air is drawn up through the towers by the air blowers to volatilize any contaminants in the water.

Water Station No. 3

Station Schematic



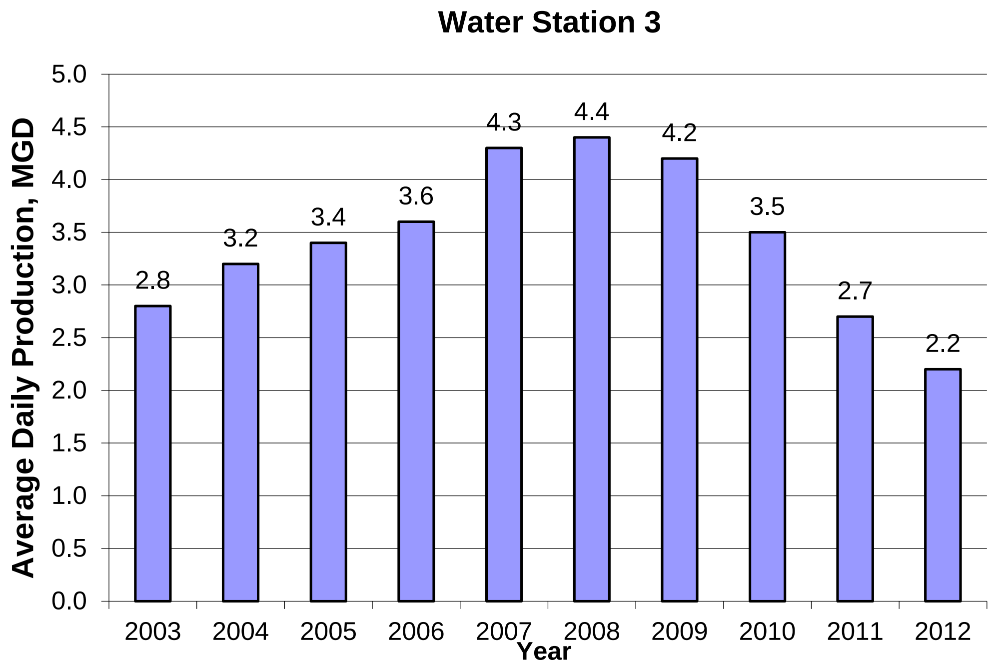
Location:	Water Station No. 3 (WS 3) is located along Northwest Washington Street at Northwest 43rd Street.
Pressure Zone Supplied:	Vancouver High
Station Description:	Inventory: • 3 active groundwater wells • 1 booster pump station • Gas chlorination system with automatic shutoff valves • Fluoride dosing system • 1 ground level storage reservoir • 1 elevated storage tank WS 3 groundwater wells discharge through a common flow meter to the ground level reservoir. Flow from the three wells is disinfected via a gas chlorination system and dosed with fluoride before reaching the ground level reservoir. WS 3 connected to WS 1 via dedicated 24-inch diameter transmission main.

Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	2,175	
2	2,000	
3	2,000	
TOTAL	**6,175**	

- All three wells are equipped with vertical turbine pumps.



Booster Pump Stations:

Booster Station	Supply From	Area Served	Pumps	Notes
WS 3 Booster Station	WS 3 Reservoir	Vancouver High Pressure Zone & WS 3 elevated tank	3 split case centrifugal Total capacity 6,000 gpm	Raw water flow into reservoir monitored.

- Groundwater well pumps normally pump to ground-level reservoir. One pump is sized to pump to the elevated tank in case of reservoir failure.

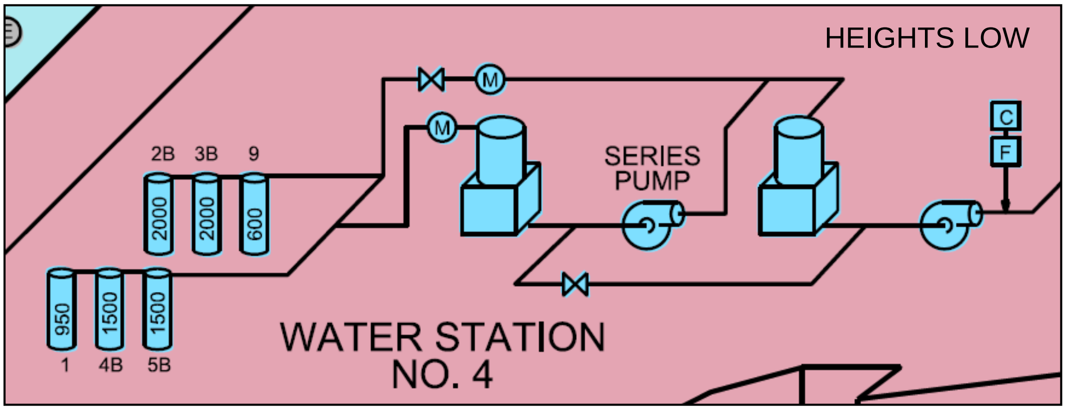
Storage:

Reservoir / Tank	Constructed	Material / Geometry	Volume	Pressure Zone Served	SCADA
WS 3 Reservoir	1957	Concrete / Rectangular (partially buried)	0.9 MG Usable (1.25 MG Originally)	Vancouver High	Level reported via pressure transducer
WS 3 Tank	1945	Elevated/Steel	0.25 MG	Vancouver High	Level reported via pressure transducer

- Reservoir is equipped with an interior dividing well and overflow weir to promote gravity settling of particulate matter due to historical sand production in the station's groundwater wells.
- Concrete reservoir has a reinforced concrete roof. Concrete roof has cracks and re-bar corrosion weakening the structure and reducing its ability to safely store water to the original design level.
- Concrete reservoir level is maintained lower than designed overflow reducing 1.25 MG original capacity to 0.9 MG usable capacity.
- Reservoir unlikely to survive design basis earthquake used in current structural design for the area. Thus reservoir and booster station will likely be replaced in the future.

Water Station No. 4

Station Schematic



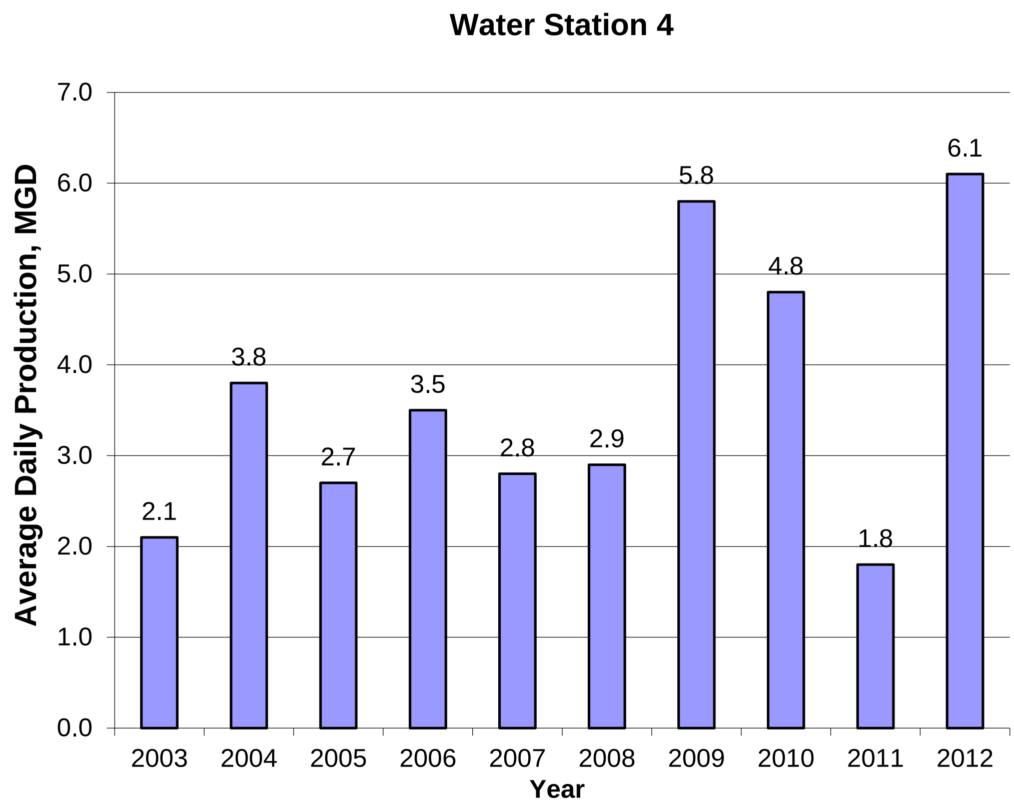
Location:	Water Station No. 4 (WS 4) is located along Blandford Drive at East 5th Street.
Pressure Zone Supplied:	Heights Low
Station Description:	Inventory: • 6 active groundwater wells • 1 booster pump station • Gas chlorination system with automatic shutoff valves • Fluoride dosing system • Air stripping treatment facility • Storage building WS 4 groundwater wells pump through two flow meters to the station's air stripping treatment facility. Water exiting the air stripping treatment facility is disinfected via a gas chlorination system, dosed with fluoride, and piped to a wet well under the WS 4 Heights Low Booster Pump Station.

Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	950	
2B	2,000	
3B	2,000	
4B	1,500	
5B	1,500	
9	600	
TOTAL	**8,550**	

- All wells are equipped with vertical turbine pumps.



Booster Pump Stations:

Booster Station	Supply From	Area Served	Pumps	Notes
WS 4 Heights Low Booster Station	WS 4 Booster Station Wet well	Heights Low & Water Station No. 5	3 vertical turbine Total capacity available 12,000 gpm	Pump discharge controlled by VFD

- Connection from pump station to Water Station No. 5 via a 20-inch diameter transmission main.
- Pumps include variable frequency drives for energy optimization. The VFD speed is adjusted based on the level in the wet well.
- Wet well water level and pump station discharge pressure are reported to the SCADA system.

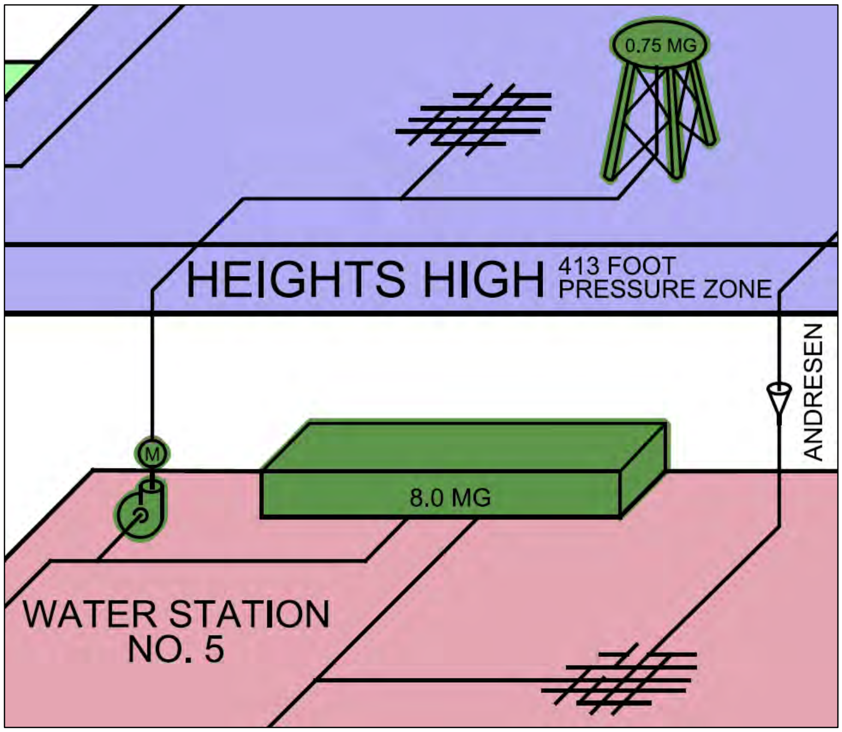
Other Facilities:

Air Stripping Treatment Facility

- Designed to remove volatile perchloroethylene (PCE) from well source water.
- Design similar to WS 1 air stripping treatment facility.
- Designed with 2 stripping towers operating in parallel. Total treatment capacity 8,550 gpm.

Water Station No. 5

Station Schematic



Location:	Water Station No. 5 (WS 5) is located along East Mill Plain Boulevard at East Devine Road.
Pressure Zones Supplied:	Heights Low and Heights High
Station Description:	Inventory: • Booster pump station • Ground level reservoir (split into two cells) • Elevated tank WS 5 booster pump station delivers water from the ground level reservoir to the Heights High pressure zone and the station's elevated storage tank. The ground level reservoir provides flow to the Heights Low pressure zone.

Station Facility Detail

Booster Pump Stations:

Booster Station	Supply From	Area Served	Pumps	Notes
WS 5 Booster Station	WS 5 reservoir	Heights High & WS 5 elevated tank	5 vertical turbine 2 @ 1,400 gpm 1 @ 2,450 gpm 1 @ 3,000 gpm 1 @ 2,000 gpm Total capacity 10,250 gpm	Flow rates monitored by flow meter (SCADA).

- Booster pump No. 5 is operated via a direct drive auxiliary power unit only and not supplied with an electric motor.

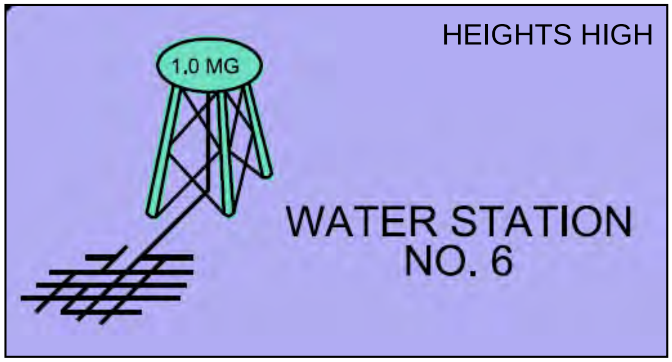
Storage:

Reservoir / Tank	Constructed	Material / Geometry	Volume	Pressure Zone Served	SCADA
WS 5 Reservoir	Mid 1940s	Concrete / Rectangular (partially buried)	8.0 MG	Heights Low & WS 5 BPS	Level reported via pressure transducer
WS 5 Tank	1955	Elevated/ Steel	0.75 MG	Heights High	Level reported via pressure transducer

- Reservoir equipped with wood framed metal roofing system.

Water Station No. 6

Station Schematic



Location:	Water Station No. 6 (WS 6) is located near the intersection of Northeast 65th Avenue and Northeast 53rd Street.
Pressure Zones Supplied:	Heights High
Station Description:	Inventory: • 4 groundwater wells (3 abandoned, 1 currently has a small pump used for off-site irrigation) • Elevated tank WS 6 delivers water to the Heights High pressure zone.

Station Facility Detail

Groundwater Wells:

- Three groundwater wells have been abandoned due to excessive sand production.
- Fourth groundwater well also showed evidence of sand production during initial testing. The City has now installed a small vertical turbine pump in well 4 for tank filling purposes used by the Urban Forestry Department. This well may be used in the future for larger volume production.

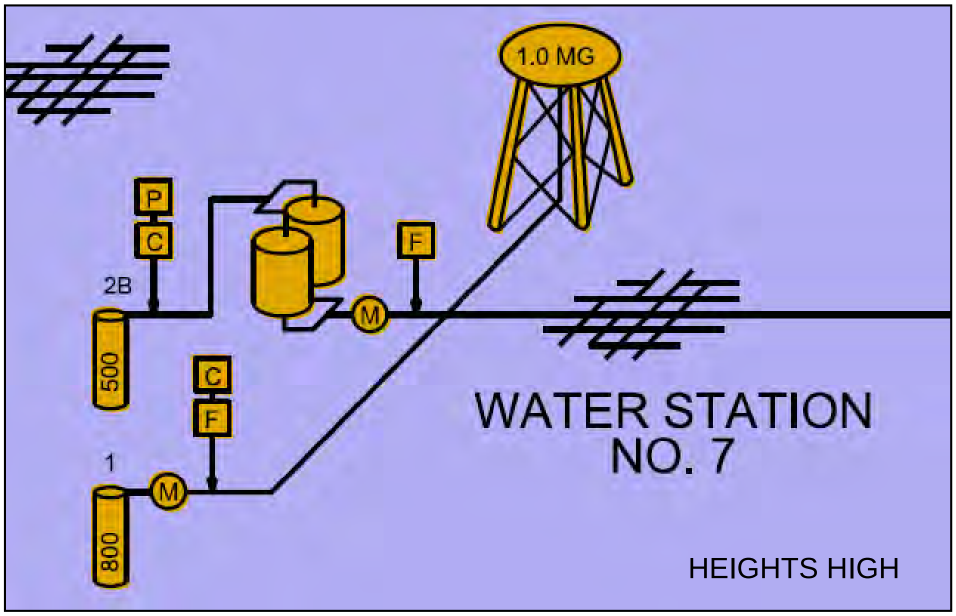
Groundwater Wells:

Well	Capacity (gpm)	Notes
1	---	Abandoned
2	---	Abandoned
3	---	Abandoned
4	85	
TOTAL	**85**	

- Well pump is only used for filling irrigation tanks used by the Urban Forestry Department.

Storage:

Reservoir / Tank	Constructed	Material / Geometry	Volume	Pressure Zone Served	SCADA
WS 6 Tank	1963	Elevated	1.0 MG	Heights High	Level reported via pressure transducer

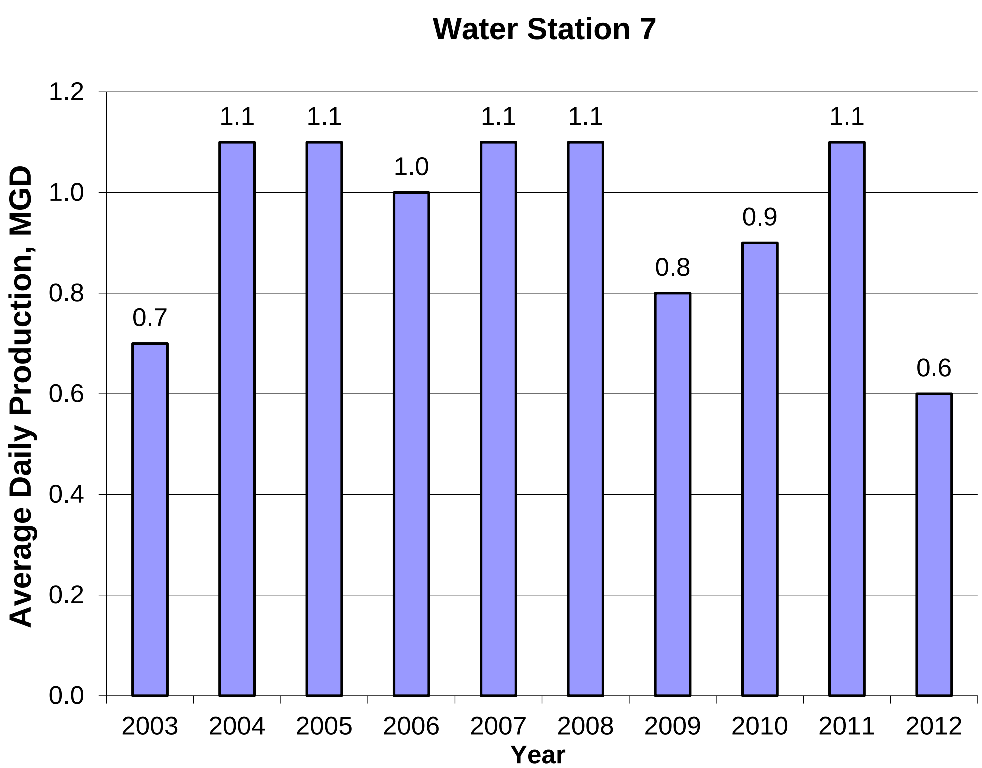
Water Station No. 7	
Station Schematic	
Location:	Water Station No. 7 (WS 7) is located off of Northeast 16th Street near Northeast 112th Avenue.
Pressure Zone Supplied:	Heights High
Station Description:	Inventory: • 2 operational groundwater wells (1 abandoned) • Elevated tank • Hypochlorite generation system • Fluoride dosing system • Iron and manganese greensand filtration facility • Backwash pond and tower overflow WS 7 groundwater well production is reported to SCADA system and supplies the station's elevated tank and the Heights High Pressure Zone. Due to elevated levels of iron and manganese, production from one groundwater well is routed through an iron and manganese greensand filtration facility prior to distribution. All water is disinfected via an on-site hypochlorite generation system in the filtration building and dosed with fluoride.

Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	800	
2	--	Abandoned
2B	500	Elevated iron and manganese levels observed.
TOTAL	**1,300**	

- Well 1 has a vertical turbine pump. Flow from this well is chlorinated via the on-site hypochlorite generation system and dosed with fluoride prior to being routed to the elevated tank or the Heights High Pressure Zone.
- Well 2B has a submersible well pump.
- Well 2B produces water from a deeper aquifer than Well 1 and has demonstrated elevated iron and manganese levels. Flow from this well is routed through the greensand filtration treatment facility prior to distribution to the elevated tank or Heights High Pressure Zone.
- Well 2B is dosed with chlorine (produced from the hypochlorite system) and potassium permanganate upstream of a static mixer and twin greensand pressure filters.
- Chlorination of Well 2B is sufficient to provide for both the chemical oxidation needed for the greensand filtration process, and to leave sufficient chlorine residual.



<table>
<tr>
<td>Storage:</td>
<td>
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<tr><th>Reservoir / Tank</th><th>Constructed</th><th>Material / Geometry</th><th>Volume</th><th>Pressure Zone Served</th><th>SCADA</th></tr>
<tr><td>WS 7 Tank</td><td>1963</td><td>Elevated/ Steel</td><td>1.0 MG</td><td>Heights High</td><td>Level reported via pressure transducer</td></tr>
</table>
WS 7 is connected to WS 9 through a 24-inch diameter transmission main.
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<td>Other Facilities:</td>
<td>
Iron and Manganese Greensand Filtration Facility

Twin greensand pressure filters.
Greensand filtration media – fine sand coated with manganese oxide.
Operation: Prior to filtration, oxidizing agents (chlorine and potassium permanganate) are added to the raw well source water (from Well 2B). Soluble iron is oxidized to form a solid precipitate, which is physically removed in the filter. Dissolved manganese is adsorbed to the manganese coating of the greensand media as it passes through the filter. Once the manganese is adsorbed and detained on the filter media, it is oxidized by the potassium permanganate. The dissolved manganese oxidizes to manganese dioxide and contributes to the coating on the filter media, rejuvenating the media coating.
Maintenance: Periodic backwashing of the greensand to remove solid precipitates that accumulates during the normal filtration process.
Backwash water is pumped to an exterior settling basin where solids are periodically removed and taken to landfill.

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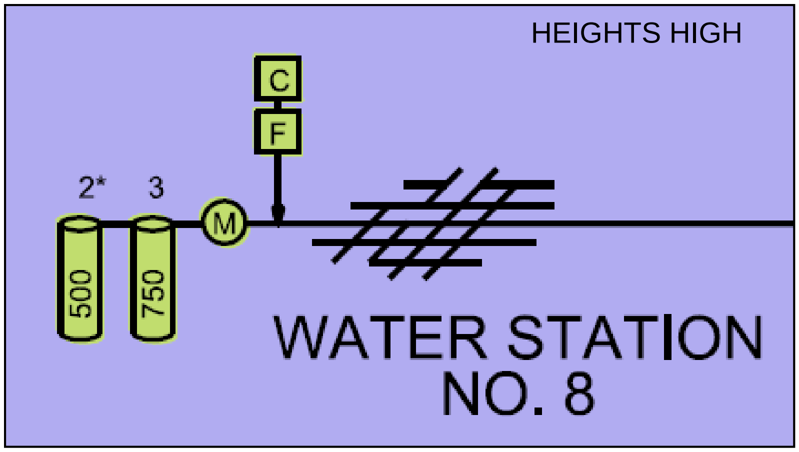
Water Station No. 8

Station Schematic



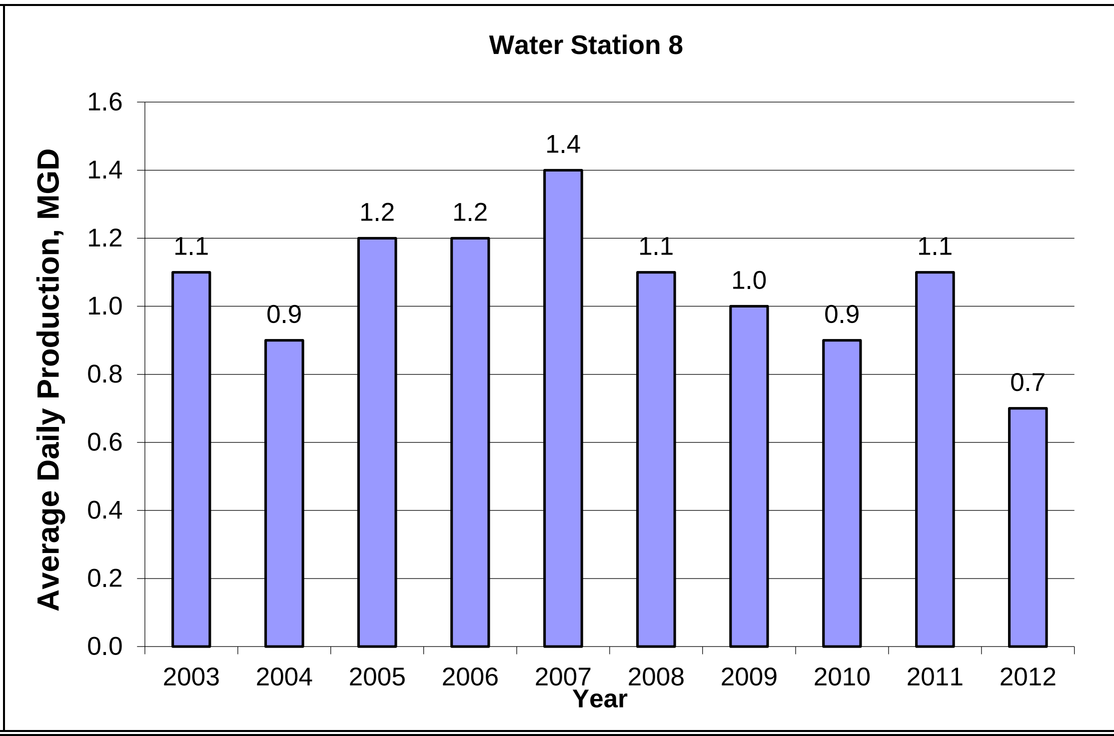
Location:	Water Station No. 8 (WS 8) is located near the intersection of Northeast Fourth Plain Road and Northeast 112th Avenue.
Pressure Zone Supplied:	Heights High
Station Description:	Inventory: • 2 active groundwater wells (1 abandoned) • Hypochlorite generation system • Fluoride dosing system WS 8 groundwater well production is routed through a flow meter and supplies the Heights High Pressure Zone. Water from the station is disinfected via an on-site hypochlorite generation system and dosed with fluoride.

Station Facility Detail

Ground-water Wells:

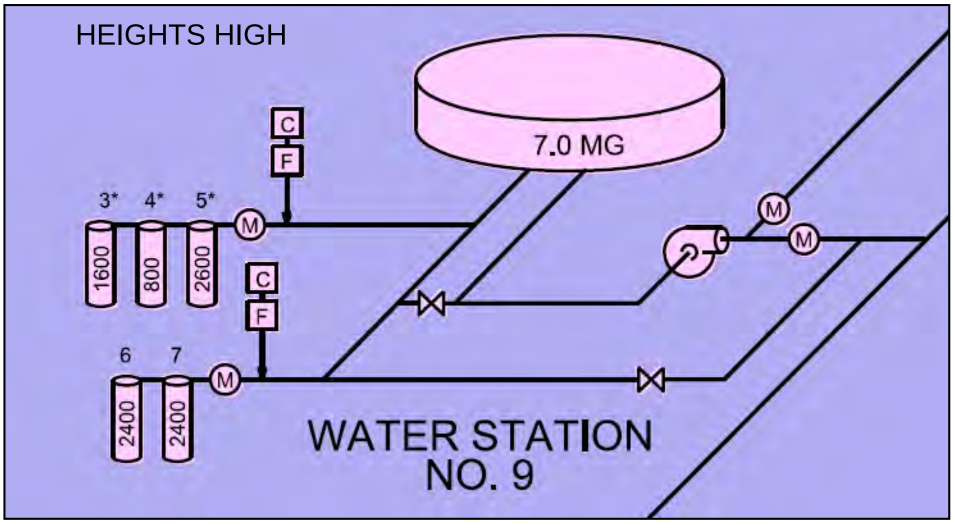
Well	Capacity (gpm)	Notes
1	--	Abandoned – deteriorating well screens
2	500	
3	750	
TOTAL	**1,250**	

- Acquired in 1967 as part of the incorporation of the Orchards Water System.


Water Station 8
Average Daily Production, MGD
Year
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1.1
0.9
1.2
1.2
1.4
1.1
1.0
0.9
1.1
0.7
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Water Station No. 9

Station Schematic



Location: Water Station No. 9 (WS 9) is located along Northeast 39th Street at Northeast 145th Avenue.

Pressure Zone Supplied: Heights High

Station Description:

Inventory:

- 5 operational groundwater wells (1 abandoned and 1 used to monitor water levels)
- Booster pump station
- Ground level reservoir
- Gas chlorination system with automatic shutoff valves
- Fluoride dosing system
- One backflow valve to fill the reservoir from the grid

WS 9 is the City of Vancouver's second largest water station in terms of peak production capacity. Flow from the groundwater wells is piped through two flow meters to the supply station's ground level reservoir and booster pump station. Water from the station's wells receives disinfection treatment provided through a gas chlorination system and dosed with fluoride. A backfill valve is also available to fill the reservoir from the grid.

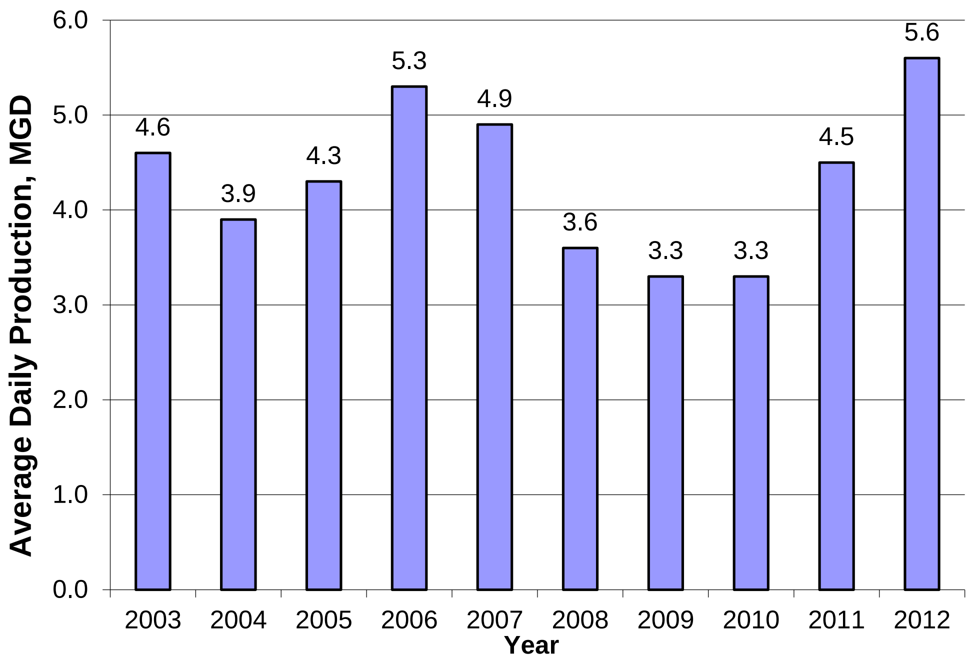
Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	--	Not used for production
2	--	Not in service
3	1,600	
4	800	
5	2,600	
6	2,400	
7	2,400	Direct probe reports aquifer level (SCADA)
TOTAL	**9,800**	

- Wells 3 through 7 are equipped with vertical turbine pumps.
- All wells can be operated via a 600 kW auxiliary power generator as necessary during power outages.
- Combined flow from wells 3 through 5 reported to SCADA
- Combined flow from wells 6 and 7 reported to SCADA

Water Station 9



Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
WS 9 Booster Station	WS 9 reservoir	Heights High	10 split case centrifugal 10 @ 2,000 gpm each Total capacity 20,000 gpm	Pressure transducer reports discharge pressures (SCADA).

- Booster pumps 1 through 5 can be operated from a 515 kW auxiliary power generator.
- Pump station production monitored via two flow meters while discharge pressures are reported to the SCADA control system through a local controlled pressure transducer.
- Pump station delivers water to the Heights High Pressure Zone distribution system through a 24-inch and a 36-inch main.

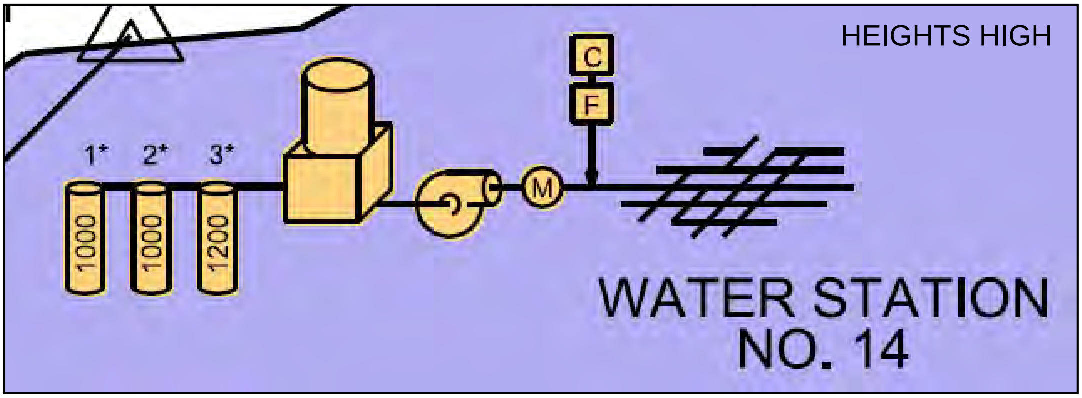
Storage:

Reservoir / Tank	Constructed	Material / Geometry	Volume	Pressure Zone Served	SCADA
WS 9 Reservoir	1989	Concrete / Circular (partially buried)	7.0 MG	Heights High via WS 9 Booster Station	Level reported via pressure transducer

- Reservoir is circular concrete construction with circumferential wire wrapping.

Water Station No. 14

Station Schematic



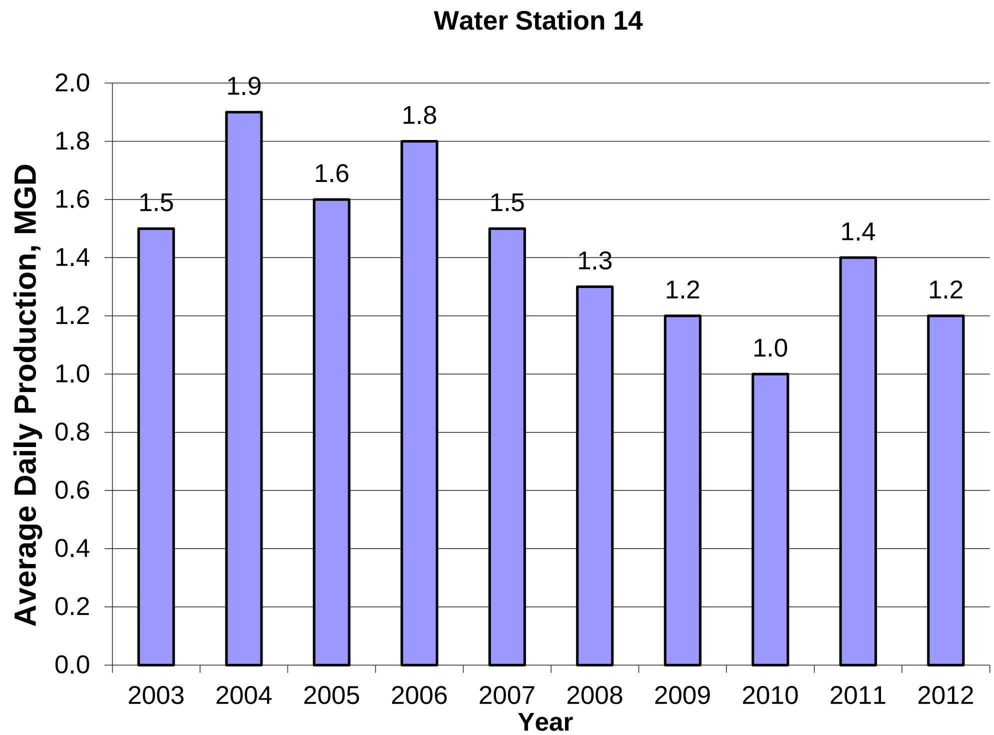
Location:	Water Station No. 14 (WS 14) is located along Northeast 78th Street at Northeast Andresen Road.
Pressure Zone Supplied:	Heights High
Station Description:	Inventory: • 3 groundwater wells • Booster pump station • Gas chlorination system with a chlorine scrubber and automatic shutoff valves • Fluoride dosing system • Single-tower aeration system • Emergency power generator WS 14 groundwater flows through a common flow meter prior to distribution in the Heights High Pressure Zone. Water from the station's wells flow through the single-tower aeration system for pH adjustment, receive disinfection treatment provided via a gas chlorination system and is dosed with fluoride.

Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	1,000	
2	1,000	
3	1,200	
TOTAL	**3,200**	

- Wells are equipped with vertical turbine pumps.
- Entire station can be operated from a 460 kW generator.



Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
WS 14 Wet Well Booster Station	Stripping tower	Heights High	2 variable speed 2 @ 1600 gpm Total capacity 3,200 gpm	

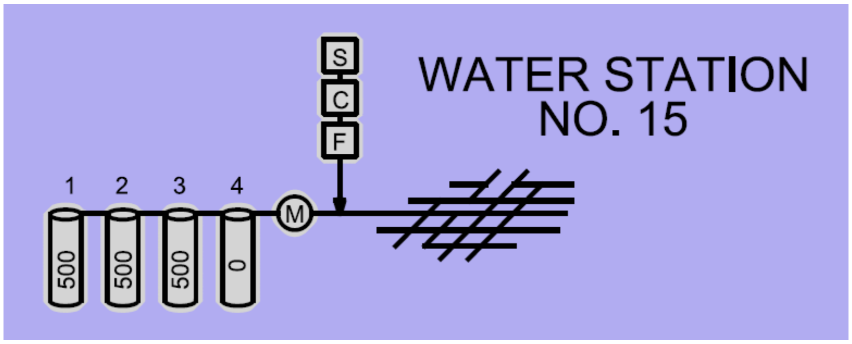
Other Facilities:

Single-tower aeration system

- Added in the late 1990s to remove carbon dioxide, raise the pH, and help ensure compliance with the Lead and Copper Rule.

Water Station No. 15

Station Schematic



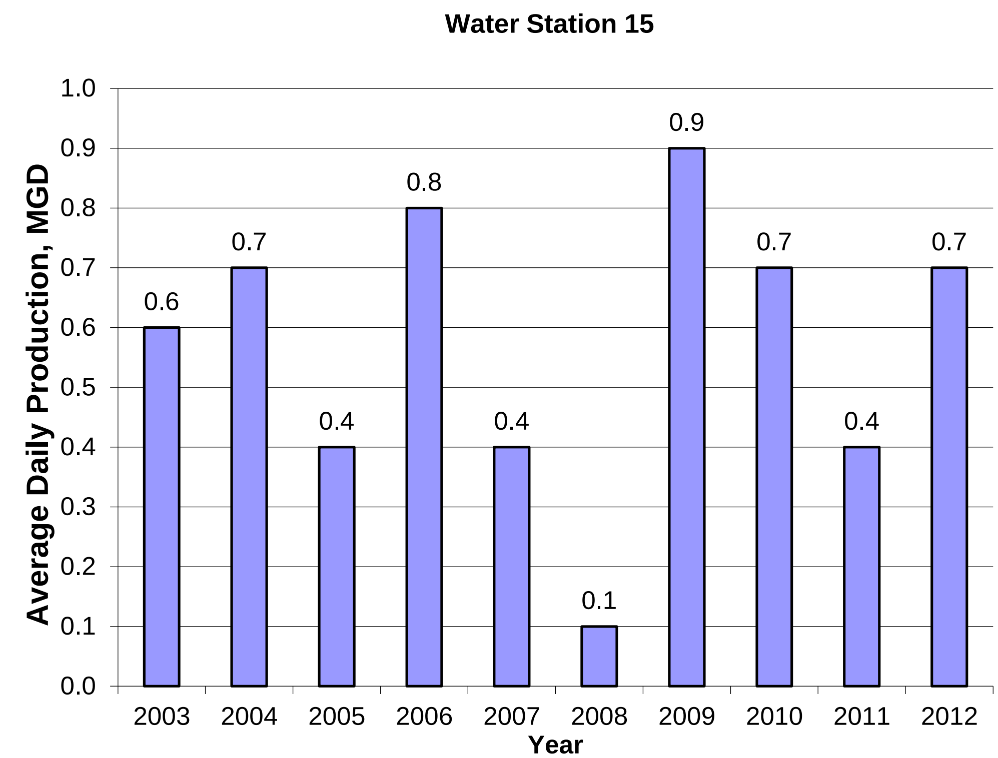
Location:	Water Station No. 15 (WS 15) is located near the intersection of Northeast 27th Street and Northeast 83rd Avenue.
Pressure Zone Supplied:	Heights High
Station Description:	Inventory: • 4 groundwater wells • Hypochlorite generation system • Fluoride dosing system • Sodium hydroxide dosing system WS 15 groundwater flows through a common flow meter prior to distribution in the Heights High Pressure Zone. Water from the station's wells receives disinfection treatment provided through an onsite hypochlorite generation system and dosed with fluoride. Water is also dosed with sodium hydroxide solution to raise the pH and ensure compliance with the Lead and Copper Rule.

Station Facility Detail

Ground-water Wells:

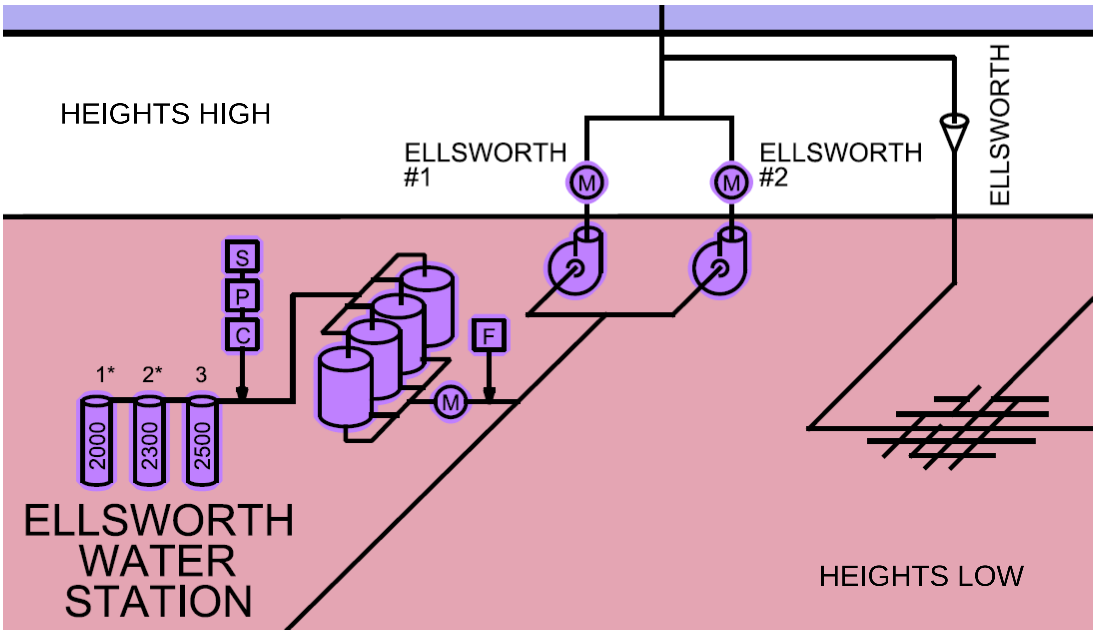
Well	Capacity (gpm)	Notes
1	500	
2	500	
3	500	
4	500	Not used. Well historically produces excess sand.
TOTAL	**2,000**	

- Wells are equipped with vertical turbine pumps.
- Screens for Well 4 are located at an unfavorable level with respect to recent aquifer levels. It is likely that only two wells (any combination of Wells 1, 2, and 3) could be pumped for sustained periods limiting Station capacity to 1,000 gpm or less.
- Long-term sustainable rate may be as low as 500 gpm, but 1,000 gpm is sustainable for a few months at a time.


Water Station 15
Average Daily Production, MGD
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0.6
0.7
0.4
0.8
0.4
0.1
0.9
0.7
0.4
0.7
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Year

Ellsworth Water Station

Station Schematic

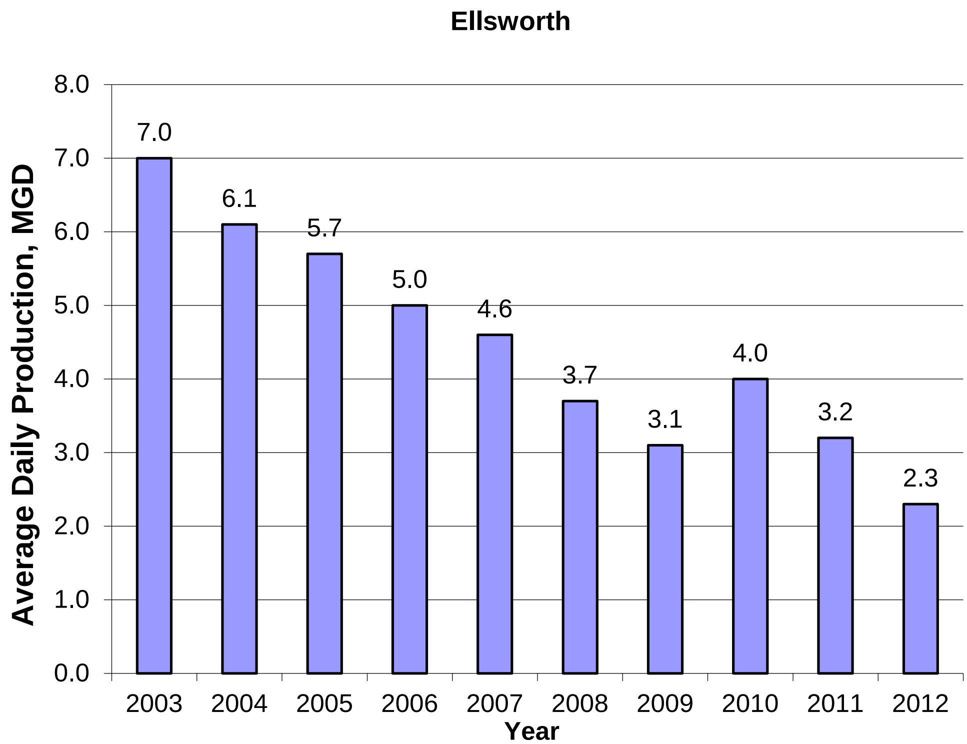


Location:	Ellsworth Water Station is located along Southeast French Road near Southeast 97th Avenue.
Pressure Zone Supplied:	Heights Low and Heights High
Station Description:	Inventory: • 3 groundwater wells • Two Booster pump stations • Gas chlorination system with scrubber and automatic shutoff valves • Fluoride dosing system • Iron and manganese greensand filtration facility Ellsworth Water Station groundwater well production is routed through an iron and manganese greensand filtration facility prior to distribution (similar to the facility at WS 7). Treated water from the filtration facility supplies the Heights Low Pressure Zone through a dedicated 24-inch diameter transmission main to WS 4, and the Heights High Pressure Zone via the two booster pump stations. All water is disinfected via a gas chlorination system in the filtration building and dosed with fluoride.

Station Facility Detail

Ground-water Wells:

Well	Capacity (gpm)	Notes
1	2,000	Direct probe reports aquifer level (SCADA)
2	2,300	Direct probe reports aquifer level (SCADA)
3	2,500	Direct probe reports aquifer level (SCADA)
TOTAL	**6,800**	



Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
Ellsworth Booster Station 1	Heights Low	Heights High	5 vertical turbine Total capacity 9,000 gpm	Suction and discharge pressures and total flow reported
Ellsworth Booster Station 2	Heights Low	Heights High	3 split case pumps Total capacity 10,800 gpm	Suction and discharge pressures and total flow reported

- Pumps deliver water from the Heights Low Pressure Zone to the Heights High Pressure Zone through two 24 inch transmission mains that head north from the site.

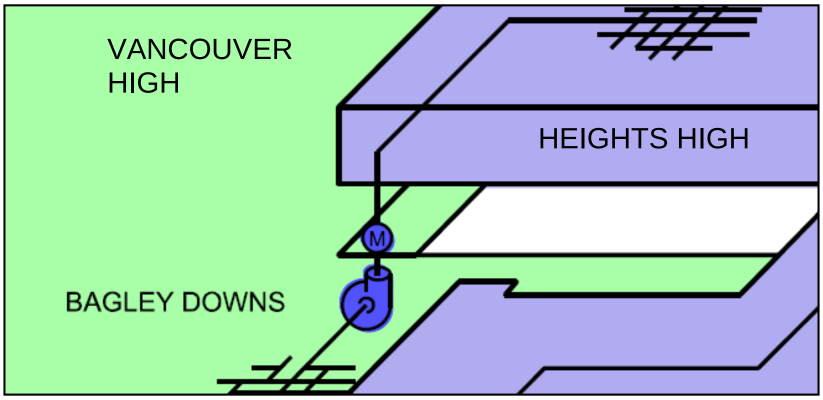
Other Facilities:

Iron and Manganese Greensand Filtration Facility

- Four greensand pressure filters.
- Additional vessel used for chemical mixing upstream of greensand.
- Greensand filtration media – fine sand coated with manganese oxide.
- Design capacity is 6,000 gpm under normal filtration rates. Facility is capable of processing up to 7,500 gpm at peak rates.
- Operation: Prior to filtration, oxidizing agents (chlorine and potassium permanganate) are added to the raw well source water). Soluble iron is oxidized to form a solid precipitate which is physically removed in the filter. Dissolved manganese is adsorbed to the manganese coating of the greensand media as it passes through the filter. Once the manganese is adsorbed and detained on the filter media, it is oxidized by the potassium permanganate. The dissolved manganese oxidizes to manganese dioxide and contributes to the coating on the filter media, rejuvenating the media coating.
- Maintenance: Periodic backwashing of the greensand to remove solid precipitates, which accumulate during the normal filtration process.
- Backwash water is reintroduced to head of plant after heavy particulates settle out.

Bagley Downs Booster Station

Station Schematic



Location:	Bagley Downs Booster Station is located on Plomondon Street at General Anderson Road
Pressure Zone Supplied:	Heights High (from Vancouver High)
Station Description:	Inventory: • 2 split case centrifugal pumps Bagley Downs Booster Station delivers water from the Vancouver High Pressure Zone to the Heights High Pressure Zone.

Station Facility Detail

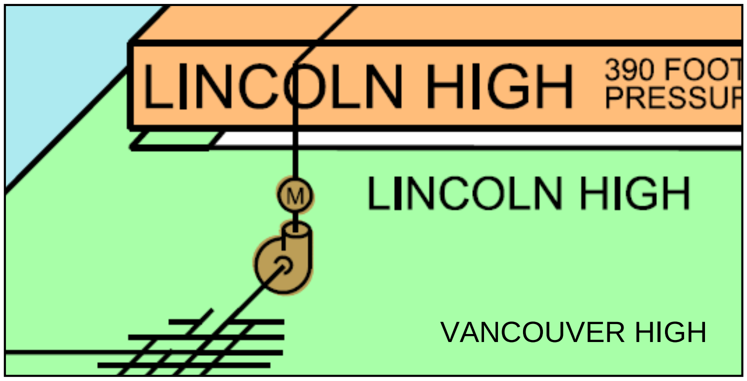
Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
Bagley Downs Booster Station	Vancouver High	Heights High	2 split case centrifugal 1 @ 2,200 gpm 1 @ 1,800 gpm Total capacity 4,000 gpm	

- Pumps deliver water from the Vancouver High Pressure Zone to the Heights High Pressure Zone through a 20-inch transmission main.

45th Street Booster Station

Station Schematic



Location:	45th Street Booster Station is in a vault near the intersection of Northwest 45th Street and Northwest Daniels Street.
Pressure Zone Supplied:	Lincoln High (from Vancouver High)
Station Description:	Inventory: • 1 end suction centrifugal pump 45th Street Booster Station delivers water to the Lincoln High Pressure Zone. This booster station is the sole source of supply to this pressure zone.

Station Facility Detail

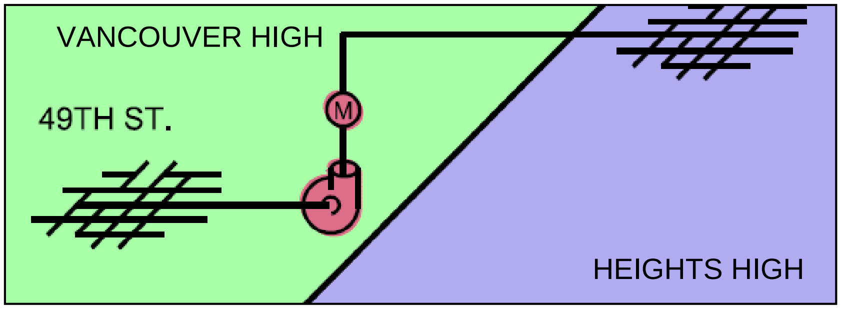
Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
45th Street Booster Station	Vancouver High	Lincoln High	1 end suction centrifugal 1 @ 1,000	Discharge pressure and flow relayed to SCADA system.

- Station is equipped with a single flow meter for monitoring output.
- Pump operates on a VFD to control pressure on the discharge of the pump.

49th Street Booster Station

Station Schematic



Location:	49th Street Booster Station is located near the intersection of Northeast 49th Street and Northeast 16th Avenue.
Pressure Zone Supplied:	Heights High (from Vancouver High)
Station Description:	Inventory: • 1 end suction centrifugal pump 49th Street Booster Station delivers water from the Vancouver High Pressure Zone to the Heights High Pressure Zone.

Station Facility Detail

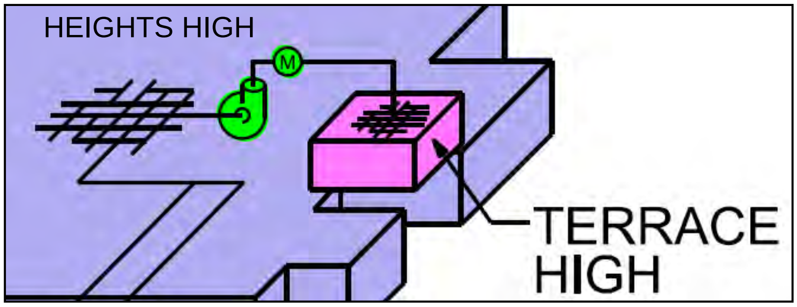
Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
49th Street Booster Station	Vancouver High	Heights High	1 end suction centrifugal 1 @ 1,100 gpm	Suction and discharge pressure and flow relayed to SCADA system.

- Station is equipped with a single flow meter for monitoring output.

Terrace High Booster Station

Station Schematic



Location:	Terrace High Booster Station is near the residential development east of 192nd Avenue and north of Southeast 34th Street.
Pressure Zone Supplied:	Terrace High (from Heights High)
Station Description:	Inventory: • 4 pumps Terrace High Booster Station serves the Terrace High Pressure Zone (small area developed in 1998/1999) from the Heights High Pressure Zone main. This booster station is the sole source of supply to this Pressure Zone. There is a second point of connection to the Heights High Pressure Zone, at the south end of the zone, which allows water into the zone through a check valve if the pumps shut down or if zone pressure drops.

Station Facility Detail

Booster Pump Station:

Booster Station	Supply From	Area Served	Pumps	Notes
Terrace High Booster Station	Heights High	Terrace High	2 @ 100 gpm 1 @ 300 gpm 1 @ 1,900 gpm	Suction and discharge pressure and total flow reported (SCADA)

- All pumps operate with a total dynamic head of 60 ft, except the 1,900 gpm pump which operates with 75 ft total dynamic head.
- Pumps will provide for a range of demands and a hydraulic grade line of about 450 feet MSL.
- The 1,900 gpm pump is intended to provide fire flow during reduced pressure conditions.

1.8.2 Water Facility Data Tables

This section provides detailed information on all the water facilities. Table 1.10 lists the City's interties with Clark Public Utilities (CPU). Table 1.11 and Table 1.12 provide capacity and control information for the production wells and storage facilities, respectively. Pump station information is displayed in Table 1.13. Pressure zone elevation and pressure information is listed in Table 1.14. Table 1.15 provides information on pressure reducing stations, and Table 1.16 lists linear feet of pipe by diameter and material.

Table 1.10 Interties

Name	Meter Size	Location	Elevation (ft)	Pressure Zone	Maximum Flow Rate (gpm)
CPU Intertie 1	6"	72nd Ave – N of 99th St	247	Heights High	1,400
CPU Intertie 2	6"	78th St – E of St. Johns	282	Heights High	1,400

Table 1.11 Production Wells

Water Station	Well Number	Capacity (gpm)	Depth (ft)	Power (HP)	Backup Power Source	Status (Active/Inactive)	Control Reservoir
1	1	2,340	250	200	No	Active	WS 1 – 4.0 MG Reservoir
	2	2,260	280	200	No	Active	WS 1 – 4.0 MG Reservoir
	3	2,100	243	200	No	Active	WS 1 – 4.0 MG Reservoir
	4	1,270	240	150	No	Active	WS 1 – 4.0 MG Reservoir
	5	1,360	235	150	Yes	Active	WS 1 – 4.0 MG Reservoir
	7	3,140	261	350	No	Active	WS 1 – 4.0 MG Reservoir
	8	2,260	265	250	No	Active	WS 1 – 4.0 MG Reservoir
	9	1,660	255	150	No	Active	WS 1 – 4.0 MG Reservoir
	10	1,860	244	200	No	Active	WS 1 – 4.0 MG Reservoir
	11	3,400	260	350	Yes, if 12 and 13 inactive	Active	WS 1 – 4.0 MG Reservoir
	12	2,560	253	250	Yes	Active	WS 1 – 4.0 MG Reservoir
	13	2,060	280	200	Yes	Active	WS 1 – 4.0 MG Reservoir
WS 1 Total		26,270					
3	1	2,175	275	250	No	Active	WS 3 – 1.25 MG Tank
	2	2,000	264	200	No	Active	WS 3 – 1.25 MG Tank
	3	2,000	259	200	No	Active	WS 3 – 1.25 MG Tank
WS 3 Total		6,175					
4	1	950	127	100	No	Active	WS 5 – 8.0 MG Reservoir
	2B	2,000	98	100	No	Active	WS 5 – 8.0 MG Reservoir
	3B	2,000	113	150	No	Active	WS 5 – 8.0 MG Reservoir
	4B	1,500	107	75	No	Active	WS 5 – 8.0 MG Reservoir
	5B	1,500	116	75	No	Active	WS 5 – 8.0 MG Reservoir
	9	600	108	100	No	Active	WS 5 – 8.0 MG Reservoir
WS 4 Total		8,550					
7	1	800	327	100	No	Active	WS 7 – 1.0 MG Tank
	2B	500	1,065	100	No	Active	WS 7 – 1.0 MG Tank
WS 7 Total		1,300					

Table 1.11 Production Wells

Water Station	Well Number	Capacity (gpm)	Depth (ft)	Power (HP)	Backup Power Source	Status (Active/Inactive)	Control Reservoir
8	2	500	109	75	No	Active	WS 6 – 1.0 MG Tank
	3	750	200	75	No	Active	WS 6 – 1.0 MG Tank
WS 8 Total		1,250					
9	3	1,600	147	125	Yes	Active	WS 9 – 7.0 MG Reservoir
	4	800	198	75	Yes	Active	WS 9 – 7.0 MG Reservoir
	5	2,600	235	150	Yes	Active	WS 9 – 7.0 MG Reservoir
	6	2,400	217	150	Yes	Active	WS 9 – 7.0 MG Reservoir
	7	2,400	215	125	Yes	Active	WS 9 – 7.0 MG Reservoir
WS 9 Total		9,800					
14	1	1,000	194	75	Yes	Active	WS 6 – 1.0 MG Tank
	2	1,000	172	100	Yes	Active	WS 6 – 1.0 MG Tank
	3	1,200	178	75	Yes	Active	WS 6 – 1.0 MG Tank
WS 14 Total		3,200					
15	1	500	141	100	No	Active	WS 6 – 1.0 MG Tank
	2	500	124	100	No	Active	WS 6 – 1.0 MG Tank
	3	500	117	100	No	Inactive	WS 6 – 1.0 MG Tank
	4	0	119	100	No	Inactive	WS 6 – 1.0 MG Tank
WS 15 Total		1,000					
Ellsworth	1	2,000	964	350	Yes	Active	WS 5 – 8.0 MG Reservoir
	2	2,300	941	450	Yes	Active	WS 5 – 8.0 MG Reservoir
	3	2,500	1,049	500	No	Active	WS 5 – 8.0 MG Reservoir
Ellsworth Total		6,800					

Table 1.12 Existing Storage Facilities

Name	Pressure Zones Served	Volume (MG)	Equivalent Diameter (ft)	Base Elevation (ft)	Height (ft)	Overflow Elevation (ft)	Material/Geometry	Highest Service Elevation (ft)
WS 1 – 1.0 MG Reservoir	Vancouver Low, Vancouver High, Heights Low, Heights High	1.00	117.9	224.5	12.3	236.8	Concrete/Rectangular (partially buried)	184
WS 1 – 4.0 MG Reservoir		4.00	186.9	217.3	19.5	236.5	Concrete/Rectangular (partially buried)	184
WS 1 – 0.25 MG Tank	Vancouver High	0.25	37.7	292.0	30.0	322.0	Elevated	229
WS 3 – 1.25 MG Reservoir	Vancouver High	1.25[1]	100.9	204.2	12.0	216.2	Concrete/Rectangular (partially buried)	229
WS 3 – 0.25 MG Reservoir	Vancouver High	0.25	37.7	291.0	30	321.0	Elevated	229
WS 5 – 8.0 MG Reservoir	Heights Low, Heights High	8.00	365.4	288.3	10.2	298.5	Concrete/Rectangular (partially buried)	200
WS 5 – 0.75 MG Tank	Heights High	0.75	73.0	388.0	25.0	413.0	Elevated	350
WS 6 – 1.0 MG Tank	Heights High	1.00	86.0	388.0	25.0	413.0	Elevated	350
WS 7 – 1.0 MG Tank	Heights High	1.00	86.0	388.0	25.0	413.0	Elevated	350
WS 9 – 7.0 MG Reservoir	Heights High	7.00	184.5	243.9	35.0	278.9	Concrete/Circular (partially buried)	350

Notes:

1. This reservoir is currently operated at 75 percent of its volume (equivalent of 0.9 MG), due to poor condition of the concrete in the upper reservoir (leaking occurs).

Table 1.13 Booster Pump Stations

Name	Pump Station Total Capacity (gpm)	Zone Pumps From	Zone Pumps To	Pump Number	Pump Capacity (gpm)	Elevation (ft)	Design Head (ft)	Power (HP)	Variable Speed?	Standby Power Type	Pump Control
Bagley Downs	4,000	Vancouver High	Heights High	1	2,200	173	125	75	No	None	WS 5 – 0.75 MG Tank
				2	1,800	173	125	75	No	None	None
45th St.	1,000	Vancouver High	Lincoln High	1	1,000	223	90	25	Yes	None	N/A – Open
49th St	1,100	Vancouver High	Heights High	1	1,100	166	117	40	No	None	WS 6 – 1.0 MG Tank
Terrace High	2,400	Heights High	Terrace High	1	100	269	60	3	No	Auxiliary Generator	N/A – Open
				2	100	269	60	3	No	Auxiliary Generator	Zone Pressure
				3	300	269	60	7.5	No	Auxiliary Generator	Zone Pressure
				4	1,900	269	75	50	No	Auxiliary Generator	Zone Pressure
WS 1 - 4.0 MG Reservoir BPS	4,400	WS 1 4.0 MG Res	Vancouver High	1	1,500	220	95	50	No	None	WS 1 – 0.25 MG Tank Water Level
				2	1,500	220	95	50	No	None	WS 1 – 0.25 MG Tank Water Level
				3	1,400	220	95	50	No	None	WS 1 – 0.25 MG Tank Water Level
WS 1 - 1.0 MG Reservoir BPS	4,000	WS 1 - 1.0 MG Reservoir	Vancouver High	1	2,000	230	106	75	No	Auxiliary Generator	WS 1 – 0.25 MG Tank Water Level
				2	2,000	230	106	75	No	Auxiliary Generator	WS 1 – 0.25 MG Tank Water Level
WS 1 - 1 to 5 BPS	14,460	WS 1 Reservoirs	WS 5	1	2,460	198	100	75	No	None	WS 5 – 8.0 MG Reservoir Water Level
				2	3,000	202	162	150	No	None	WS 5 – 8.0 MG Reservoir Water Level
				3	3,000	204	162	150	No	None	WS 5 – 8.0 MG Reservoir Water Level
				4	3,000	207	162	150	No	None	WS 5 – 8.0 MG Reservoir Water Level
				5	3,000	211	162	150	No	None	WS 5 – 8.0 MG Reservoir Water Level
WS 1 - St. Johns BPS	4,800	WS 1 - 4.0 MG Reservoir	Heights High	1	1,600	180	195	125	No	None	WS 6 – 1.0 MG Tank Water Level
				2	1,600	180	195	125	No	None	WS 6 – 1.0 MG Tank Water Level
				3	1,600	180	195	125	No	None	WS 6 – 1.0 MG Tank Water Level
WS 3 BPS	6,000	WS 3	Vancouver High	1	2,000	220	115	75	No	None	WS 3 – 0.25 MG Tank Water Level
				2	2,000	220	115	75	No	None	WS 3 – 0.25 MG Tank Water Level
				3	2,000	220	115	75	No	None	WS 3 – 0.25 MG Tank Water Level
WS 4 BPS	12,000	WS 4	Heights Low	1	4,000	55	330	450	Yes	None	N/A - Open
				2	4,000	55	330	450	Yes	None	N/A – Open
				3	4,000	55	330	450	Yes	None	N/A - Open

Table 1.13 Booster Pump Stations

Name	Pump Station Total Capacity (gpm)	Zone Pumps From	Zone Pumps To	Pump Number	Pump Capacity (gpm)	Elevation (ft)	Design Head (ft)	Power (HP)	Variable Speed?	Standby Power Type	Pump Control
WS 5 BPS	10,250	Heights Low – 8 MG Reservoir	Heights High	1	1,400	290	114	50	No	None	WS 5 – 0.75 MG Tank Water Level
				2	1,400	290	114	50	No	None	WS 5 – 0.75 MG Tank Water Level
				3	2,450	290	114	75	No	None	WS 5 – 0.75 MG Tank Water Level
				4	3,000	290	114	100	No	None	WS 5 – 0.75 MG Tank Water Level
				5	2,000	290	114	100	No	Direct drive auxiliary power unit	Closed
WS 9 BPS	20,000	WS 9 7 MG Reservoir	Heights High	1	2,000	240	173	125	No	Auxiliary Generator	WS 6 or WS 7 - 1.0 MG Tank Water Level
				2	2,000	240	173	125	No	Auxiliary Generator	WS 6 or WS 7 - 1.0 MG Tank Water Level
				3	2,000	240	173	125	No	Auxiliary Generator	WS 6 or WS 7 - 1.0 MG Tank Water Level
				4	2,000	240	173	125	No	Auxiliary Generator	WS 6 or WS 7 - 1.0 MG Tank Water Level
				5	2,000	240	173	125	No	Auxiliary Generator	WS 6 or WS 7 - 1.0 MG Tank Water Level
				6	2,000	240	173	125	No	None	WS 7 – 1.0 MG Tank Water Level
				7	2,000	240	173	125	No	None	WS 7 – 1.0 MG Tank Water Level
				8	2,000	240	173	125	No	None	WS 7 – 1.0 MG Tank Water Level
				9	2,000	240	173	125	No	None	WS 7 – 1.0 MG Tank Water Level
				10	2,000	240	173	125	No	None	WS 7 – 1.0 MG Tank Water Level
WS 14 BPS	3,200	WS 14	Heights High	1	1,600	260	216	125	Yes	Emergency Power Generator	Stripping Tower
				2	1,600	260	216	125	Yes	Emergency Power Generator	Stripping Tower
Ellsworth #1 BPS	9,000	Heights Low	Heights High	1	1,800	188	200	150	No	None	WS 7 – 1.0 MG Tank Water Level
				2	1,800	189	200	150	No	None	WS 7 – 1.0 MG Tank Water Level
				3	1,800	189	200	150	No	None	WS 7 – 1.0 MG Tank Water Level
				4	1,800	190	200	150	No	None	WS 7 – 1.0 MG Tank Water Level
				5	1,800	190	200	150	No	None	WS 7 – 1.0 MG Tank Water Level
Ellsworth #2 BPS	10,800	Heights Low	Heights High	1	3,600	188	170	200	No	Auxiliary Generator	WS 7 – 1.0 MG Tank Water Level
				2	3,600	188	170	200	No	Auxiliary Generator	WS 7 – 1.0 MG Tank Water Level
				3	3,600	188	170	200	No	Auxiliary Generator	WS 7 – 1.0 MG Tank Water Level

Table 1.14 Pressure Zones – Minimum and Maximum Service Pressures and Elevations

Pressure Zone	Hydraulic Elevation (ft)	Maximum Elevation Served (ft)	Maximum Service Pressure (psi)	Minimum Elevation Served (ft)	Minimum Service Pressure (psi)
Vancouver Low	237	184	92	24	23
Heights Low	299	200	120	22	43
Vancouver High	322	229	121	42	40
Lincoln High	370	234	77	195	59
Heights High	413	350	117	143	27
Terrace High	450	336	75	277	49
Evergreen High	361	267	146	24	41

Table 1.15 Pressure Reducing Stations

Name	Location	Receiving Pressure Zone	Supplying Pressure Zone	Valve Sizes (in)	Valve Elevation (ft)	Pressure Setting (psi)
SE 164th Ave PRV	SE 164th Ave. and SE Evergreen Hwy	Heights Low	Heights High	8	88.2	80
Ellsworth PRV	SE French Rd. near Ellsworth Water Station	Heights Low	Heights High	12	184.1	48
Andresen PRV	S. Andresen Rd north of E. Evergreen Blvd. (SR 14)	Heights Low	Heights High	8	204.3	38
Bernie Drive PRV	NW Bernie Dr. and NW Fruit Valley Rd.	Vancouver Low	Vancouver High	10	44.3	78
39th St. PRV 1	W 39th St. and NV Cherry St.	Vancouver Low	Vancouver High	8	109.1	47
39th St. PRV 2	W 39th St. and NV Cherry St.	Vancouver Low	Vancouver High	3	108.9	52
Columbia Way PRV	SE Columbia Way, SE of I-5	Vancouver Low	Heights Low	8	26.1	86
Bella Vista PRV	SR-14, SW of SE Cascade Park Dr. and SE 138th Ave.	Heights Low	Heights High	10	147.8	60
Evergreen PRV 1	SE Evergreen Hwy, SE of SE 164th Ave.	Evergreen High	Heights High	8	82.4	116
Evergreen PRV 2	SE Evergreen Hwy, SE of SE 164th Ave.	Evergreen High	Heights High	3	82.2	121

Table 1.16 2012 Linear Feet of Pipe by Diameter and Material

Diameter	Ductile Iron (DI)	Steel	Galvanized Pipe	Cast Iron	Matheson Steel	Asbestos Cement (AC)	Plastic	Other	Total	Percentage (%)
<4-inch	6,302	2,234	80,513	10,589	110	0	6,052	1,248	107,049	2.0%
4-inch	230,556	38,670	867	19,911	6,967	8,011	3	1,444	306,429	5.8%
6-inch	829,025	374,532	394	142,211	5,925	3,957	790	0	1,356,835	25.7%
8-inch	1,917,960	68,889	52	58,778	2,136	5,617	1,942	0	2,055,374	38.9%
10-inch	395,897	35,658	45	11,925	863	2,488	0	0	446,876	8.5%
12-inch	559,160	53,195	0	32,438	4,470	281	0	1,369	650,913	12.3%
14-inch	12,077	2,605	0	2,416	0	0	0	0	17,098	0.3%
16-inch	63,390	3,547	0	11,535	36	3,765	0	0	82,272	1.6%
18-inch	40,489	3	0	4,285	0	0	0	462	45,239	0.9%
20-inch	48,105	0	0	7,668	0	0	0	0	55,773	1.1%
24-inch	158,410	25	0	59	0	0	0	0	158,495	3.0%
>24-inch	2,136								2,136	0.0%
Total	4,263,508	579,358	81,871	301,816	20,508	24,119	8,787	4,524	5,284,491	
Percentage (%)	80.7%	11.0%	1.5%	5.7%	0.4%	0.5%	0.2%	0.1%		

Chapter 2

PLANNING DATA AND WATER DEMAND FORECAST

2.1 INTRODUCTION

The existing water demand and projected water requirements for the City of Vancouver's (City's) Retail Water Service Area (service area) are presented in this chapter. Projecting a realistic future water demand is necessary for planning infrastructure projects and securing adequate water supply to meet future growth. Future water demands are used as input conditions for the hydraulic analysis of the water system to develop the Capital Improvement Program (CIP).

Accurate demand projections require a thorough review of historical water demands unique to the City, predicting where and how much growth will occur, and estimating the range of future water use for existing and new customers. This chapter first reviews historical demand data, including water production and customer billing data, as recorded and provided by the City. Historical customer billing data is used to evaluate the water demands unique to the City's different types of customers. The average water use for single-family residential (SFR) customers establishes the City's current Equivalent Residential Unit (ERU) water use. Multi-family residential and non-residential customers are expressed in terms of ERUs based on the comparison of these customers' water use to the current ERU water use. The City's six highest water use customers, herein defined as "Large Users," were identified and evaluated separately.

Production data is used to determine the distribution system leakage (DSL) and to compare the maximum day demand (MDD) to the average day demand (ADD). The resulting water use parameters found in the historical production and consumption data were used to predict future water use patterns for existing and new customers. The DSL, as defined by the Washington Department of Health (DOH), is estimated for the past ten years. The MDD and ADD were used to develop the MDD to ADD peaking factor.

Demand projections can vary widely based on the accuracy of growth and predicted water use assumptions. Demographic projections provide the range of potential growth in the City's service area. The City's planning department was consulted to provide realistic development assumptions for low and high build-out conditions for the year 2034 for each of the City's Transportation Analysis Zones (TAZs). TAZs were grouped according to areas with similar rates of growth, herein termed "Development Areas." Using these data, low, average, and high demographic projections were developed for each Development Area to estimate future accounts. Estimated future accounts were then expressed in terms of ERUs.

Future customer demands were calculated by applying selected low, medium, and high ERU water use to the existing and predicted new ERUs. Future demands for the top six Large Users, and new Industrial users, were predicted and added to the customer demand. The assumed future unmetered water use and DSL was applied to the sum of all other water use to develop future average day demands. Lastly, MDD is estimated by multiplying ADD by the MDD to ADD peaking factor. Low, medium, and high demand projections are summed for each of the planning years of concern, including 2014 through 2020, 2024, and 2034. The following sections describe each of these steps in further detail.

2.2 HISTORICAL DEMAND

Historical demand, or water use, data were obtained from City records for the years 2003 to 2012. The historical demand data was evaluated to characterize the water use of the City's customers. Two key demand parameters were generated from the data: typical water use per customer class, and typical water use per ERU. These parameters were used as the basis of future demand projections.

2.2.1 Historical Accounts

The City divides its customers into seven customer billing categories, plus unmetered (non-revenue) water. The billing categories are:

- Single-Family Residential (SFR).
- Multi-Family Residential (MFR).
- Commercial.
- Industrial.
- Government.
- Non-Profit Shelter.
- Other.

The number of accounts for each customer class was provided by the City for 2003 to 2012, and is summarized in Table 2.1. Accounts correlating to the City's top six large users were identified separately under the column "Large Users." The Large User's accounts (typically commercial and/or industrial) were subtracted from the appropriate commercial or industrial account total. (Note, large user sites, such as the Columbia Technology Center, typically have multiple accounts that serve separate buildings, tenants, etc.) As seen in the table, the total number of customers served by the City has increased from 61,791 in 2003 to 67,909 in 2012.

Table 2.1 Historical Water Accounts Adjusted Using 2013 MFR to SFR Reclassification (2003 – 2012)

Year	SFR	MFR	Commercial	Industrial	Government	Non-Profit Shelter	Other	Large Users	Total[1]
2003	55,951	2,632	2,831	ND[2]	377	ND	ND	ND	61,791
2004	58,281	3,191	2,959	ND	323	ND	ND	ND	64,754
2005	59,722	3,191	3,126	ND	353	ND	ND	ND	66,392
2006[3]	NA[4]	NA	NA	NA	NA	NA	NA	NA	NA
2007	59,439	3,276	3,244	3	433	7	19	70[5]	66,491
2008	59,647	3,319	3,323	2	452	7	3	70	66,823
2009	60,163	3,308	3,313	2	415	8	4	71	67,284
2010	60,234	3,377	3,294	3	450	7	4	70	67,439
2011	60,504	3,292	3,177	5	352	7	3	71	67,411
2012	60,950	3,287	3,210	5	372	7	5	73	67,909
Average	**59,432**	**3,208**	**3,164**	**3**	**392**	**7**	**6**	**71**	**66,255**

Notes:

(1) Total number of connections for each year was provided by City staff.
(2) ND = no data.
(3) Less than a full year of record was available for 2006; therefore, the data was excluded.
(4) NA = not analyzed.
(5) Large users typically have multiple meters/accounts to serve separate buildings, tenants, etc.

The average number of accounts from 2003 to 2012 is also shown in Figure 2.1. As seen in the figure, 90 percent of the City's accounts are SFR customers. MFR and Commercial customers make up the majority of the remaining accounts. The Government billing class includes both internal City accounts and external agencies, such as the School District. The Other billing class includes two metered hydrants and sales to Clark County Public Works and Clark Regional Wastewater District (CRWWD).

In 2013, the City reclassified 4,235 MFR accounts to SFR accounts. The historical accounts and consumption related to both MFR and SFR accounts were adjusted accordingly in the years prior to 2013 in order to provide more accurate consumption assumptions for these two customer categories. This adjustment is apparent when comparing Table 2.1 to previous reports, especially for MFR accounts

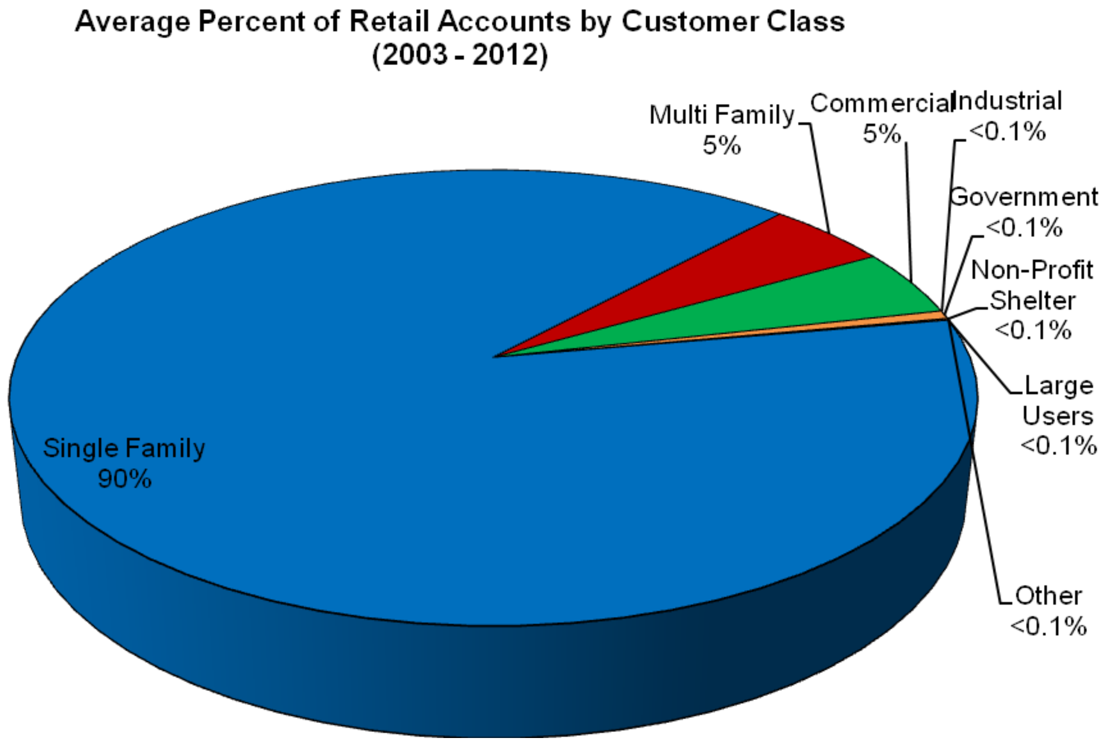
2.2.2 Historical Consumption

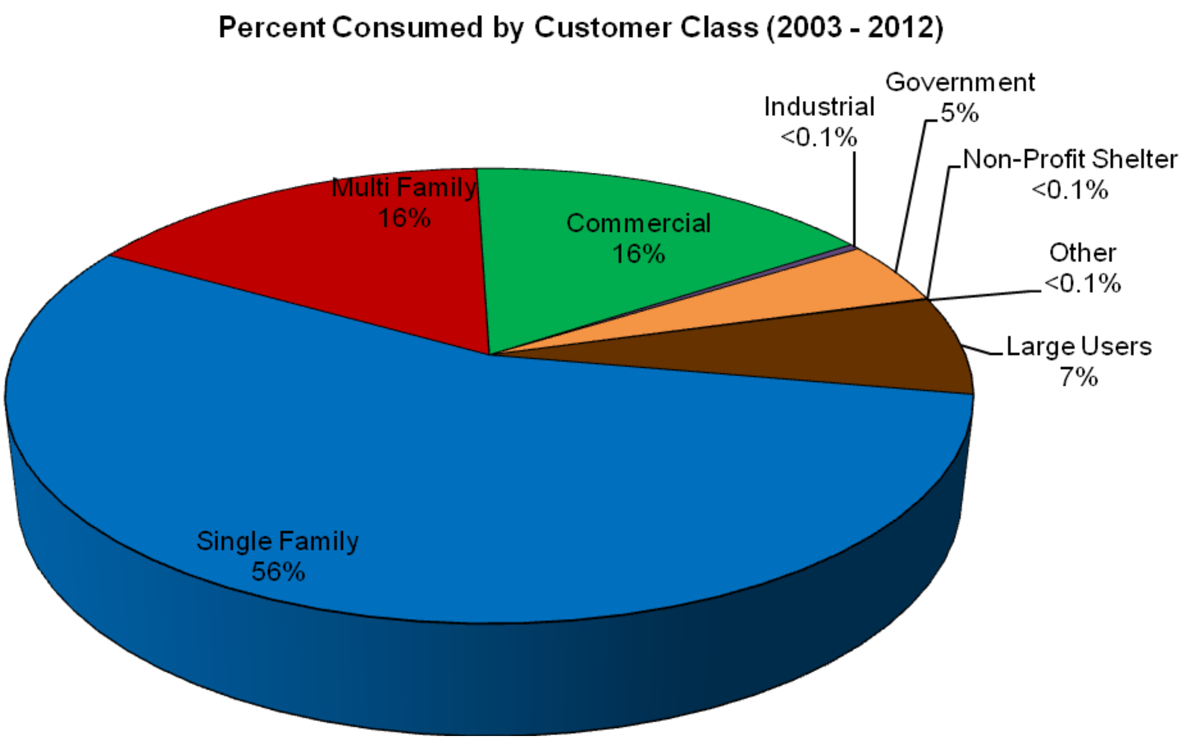
The City's historical annual water consumption was provided for each customer class in millions of gallons per day (mgd) for the years 2003 to 2012, as presented in Table 2.2. The City was able to obtain this data through its billing records. In addition to billing data, the City tracks some unmetered water use, such as street sweeping and hydrant testing, as shown in the table.

In 2007, the City upgraded its billing system, which provides detailed billing records for each account. Due to the upgrade, billing records before 2007 were not available for all customer classes. Complete records for 2006 were unavailable for all customer classes, as well as records from 2003 through 2005 for Industrial, Government, Non-Profit Shelter, Other, Unmetered, and Large User customer accounts, as noted in Table 2.2. However, the City was able to provide the total water consumption for all years except 2006.

Despite the increasing number of accounts (as seen in Table 2.1), the City's total water consumption declined from an average of 25.76 mgd in 2003 to 22.35 mgd in 2010. This steady decline was likely caused by multiple factors, including continued conservation activities, higher water use efficiency in new homes and offices, and possibly the economic downturn from 2008 to 2010. Total water consumption increased slightly in most classes in both 2011 and 2012, though overall water consumption remained below 2009 levels. The 2003 to 2012 average unmetered water use is 2.3 percent of the total metered water use.

The average percentage of accounts and annual water consumption by customer class is presented in **Error! Reference source not found.**. As seen in the figure, SFR customers represent 90 percent of the accounts, yet only use 56 percent of the demand. MFR and Commercial customers each represent five percent of accounts, but each use 16 percent of the demands. This difference in proportional water use is quantified by comparing the historical water use per account for each customer class and water use of an ERU, as described in Table 2.3.





PERCENT OF DEMAND BY CUSTOMER CLASS (2003-2012 AVERAGE)

FIGURE 2.1

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Table 2.2 Historical Water Consumption from 2003 to 2012 (mgd)

Year[(1)]	SFR	MFR	Commercial	Industrial	Government	Non-Profit Shelter	Other	Large Users[(5)]	Un-metered	Total[(6)]
2003	14.11	4.14	ND[(2)]	ND	1.16	ND	ND	ND	0.61	25.76
2004	13.79	4.23	ND	ND	0.96	ND	ND	ND	0.6	25.39
2005	13.27	4.03	ND	ND	0.97	ND	ND	ND	0.76	24.81
2006[(3)]	NA[(4)]	NA	NA	NA	NA	NA	NA	NA	NA	NA
2007	13.17	3.82	3.7	0.19	1.04	0.01	0.03	1.86	1.19	25.01
2008	13.5	3.95	3.95	0.16	1.1	0.02	0.01	1.71	0.32	24.72
2009	13.83	4.09	3.91	0.09	1.25	0.01	0	1.42	0.33	24.93
2010	12.24	3.79	3.3	0.06	1.21	0.01	0	1.43	0.31	22.35
2011	12.39	3.9	3.46	0.03	1.03	0.01	0	1.53	0.32	22.67
2012	12.64	3.95	3.61	0.01	1.06	0.01	0	1.57	0.58	23.43
Average[(7)]	**12.51**	**3.67**	**3.66**	**0.09**	**1.02**	**0.01**	**0.01**	**1.59**	**0.56**	**24.34**

Notes:

(1) Monthly water consumption data by customer type was provided by City staff in the units of 100 cubic feet (ccf). These data were converted into an annual average per customer type, in the units of million gallons per day (mgd).
(2) ND = no data.
(3) Less than a full year of record was available for 2006; therefore, the data was excluded.
(4) NA = not analyzed.
(5) Large user data was not available prior to 2007. Therefore, commercial, industrial, and consumption data was not analyzed before 2007, since the values would not provide an accurate representation of water consumption for the demand projection.
(6) Total consumption provided by the City, including SFR, MFR, commercial, industrial, government, and unmetered consumption.
(7) Calculated averages are based on unrounded numbers to retain precision.

Table 2.3 Historical Water Use Per Account[1] (gpd/Account)

Year	SFR	MFR	Commercial	Industrial	Government	Non-Profit Shelter	Other	Large Users
2003	252	1,573	NA[2]	NA	3,077	ND[3]	ND	ND
2004	237	1,326	NA	NA	2,972	ND	ND	ND
2005	222	1,263	NA	NA	2,748	ND	ND	ND
2006[4]	NA	NA	NA	NA	NA	NA	NA	NA
2007	222	1,166	1,141	63,333	2,402	1,429	1,526	26,571
2008	226	1,190	1,189	80,000	2,434	2,857	2,233	24,429
2009	230	1,236	1,180	45,000	3,012	1,250	0	20,000
2010	203	1,122	1,002	20,000	2,689	1,429	0	20,429
2011	205	1,185	1,089	6,000	2,926	1,429	67	21,549
2012	207	1,202	1,125	2,000	2,849	1,429	420	21,507
Average	**223**	**1,251**	**1,121**	**36,056**	**2,790**	**1,637**	**708**	**22,414**
ERUs per Account[5]	**1**	**6**	**5**	**162**	**13**	**7**	**3**	**101**

Notes:

(1) Historical Water Use per Account = Annual water demand (gpd) / No. of Connections.
(2) NA = not analyzed.
(3) ND = no data.
(4) Less than a full year of record was available for 2006; therefore, the data was excluded.
(5) ERUs per account are calculated by dividing the average consumption per account by the historical average ERU value of 223 gpd/ERU.

2.2.3 Water Use per Account and Equivalent Residential Units (ERUs)

Table 2.3 provides the average water use per account for each of the customer categories. This was calculated by dividing the annual consumption (Table 2.2) by the annual average number of accounts (Table 2.1) for each customer category for a given year. The City's 2003 to 2012 average water use for a SFR account is 223 gallons per day per account (gpd/account). As expected, multi-family and non-residential customer categories have a higher average water use per account than the average SFR account as these customer types have higher water needs.

The conversion of total water use to ERUs provides a means to express water use by non-residential customers as an equivalent number of SFR customers. The water use for one ERU is defined as the amount of water consumed by an average full-time single-family residence; thus, the City's ERU water use is 223 gpd/ERU.

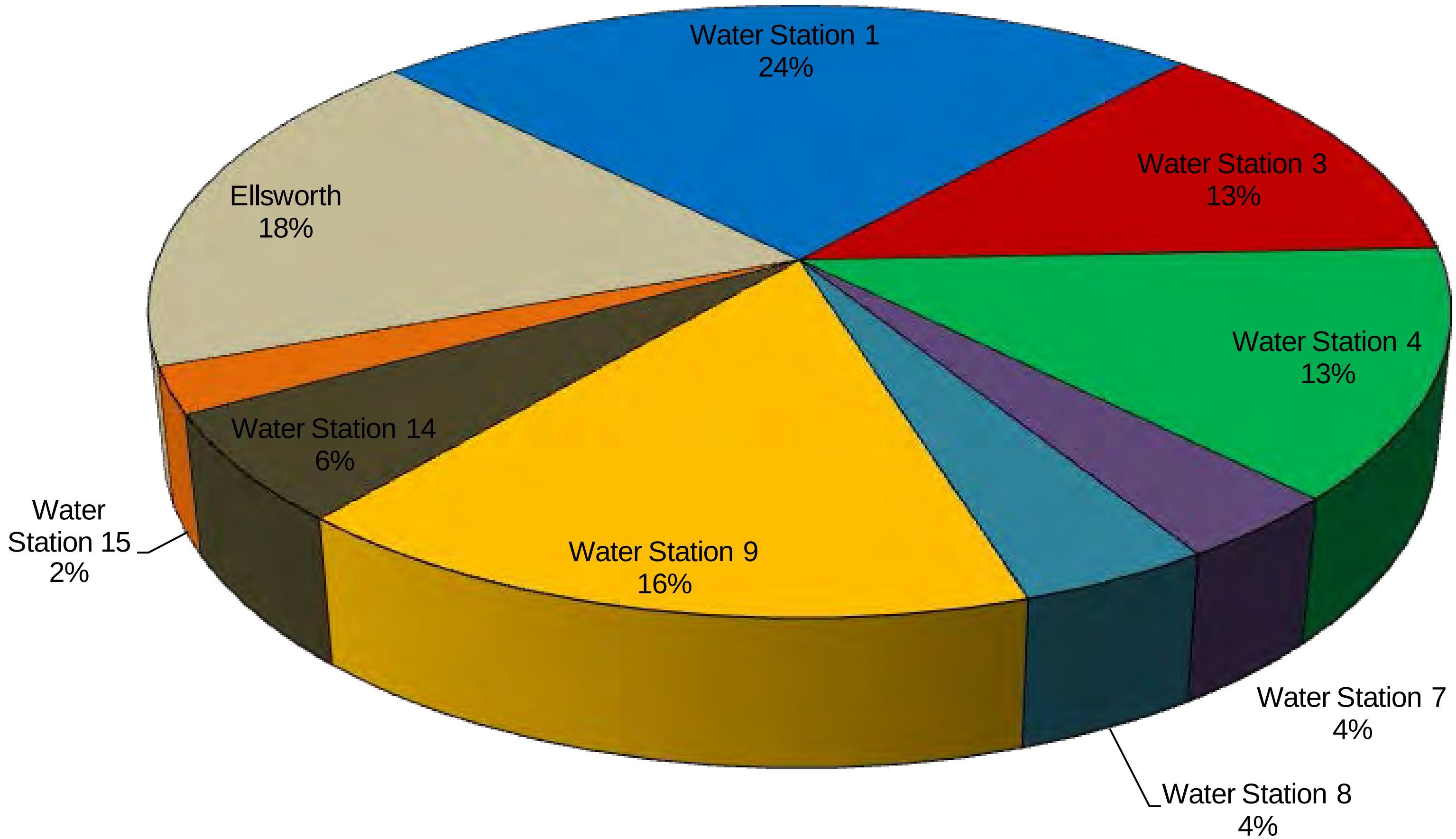
Table 2.3 also presents the ERUs per account for all customer categories. The number of ERUs per account was estimated by dividing the average water use per account by the average ERU value of 223 gpd/ERU.

2.3 HISTORICAL PRODUCTION

The historical average and maximum water demands are important parameters when performing system and supply analyses. The term "water demand" refers to all the water requirements of a system including metered customers, unmetered water use, and unaccounted-for water such as leakage. For this reason, the City production data, which accounts for all water demand, was used to calculate the ADD and MDD for each year. Additionally, historical production or supply allows the City to track system-wide demands on a daily basis, rather than monthly or bi-monthly billing records.

2.3.1 Annual Production

The City produces water for its customers through its multiple well fields. The average annual water produced from 2003 through 2012 is 9,567 million gallons (mg) or 26.19 mgd, as presented in Table 2.4. Water production has varied annually in response to system demand. Production is correlated to weather, development, economic conditions, and conservation activities. The City production rose to a 2006 peak, dropped to a low in 2010, and has risen incrementally since that time. Production has occurred from nine separate water stations. The percent of the annual production from each water station during 2003 through 2012 is presented in Figure 2.2. The City has relied upon Water Station 1 to produce the greatest amount of supply. The City also produced substantial volumes from other sources: Ellsworth, Water Station 9, Water Station 3, and Water Station 4.



AVERAGE WATER PRODUCTION BY SOURCE (2003 – 2012)

FIGURE 2.2

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Table 2.4 Historical Water Production

Year	Annual Production (mg)	ADD (mgd)	MDD (mgd)	MDD Date	MDD/ADD Peaking Factor
2003	10,064	27.57	58.09	7/27/2003	2.11
2004	10,032	27.41	53.00	8/9/2004	1.93
2005	9,569	26.22	51.76	8/14/2005	1.97
2006	10,252	28.09	54.9	7/21/2006	1.95
2007	9,927	27.2	55.15	7/10/2007	2.03
2008	9,662	26.4	54.48	8/15/2008	2.06
2009	9,411	25.78	51.13	8/2/2009	1.98
2010	8,504	23.3	49.29	8/14/2010	2.12
2011	8,951	24.52	48.16	8/26/2011	1.96
2012	9,297	25.4	54.48	8/16/2012	2.14
Average	**9,567**	**26.19**	**53.04**	**-**	**2.03**

2.3.2 Average Day Demand (ADD)

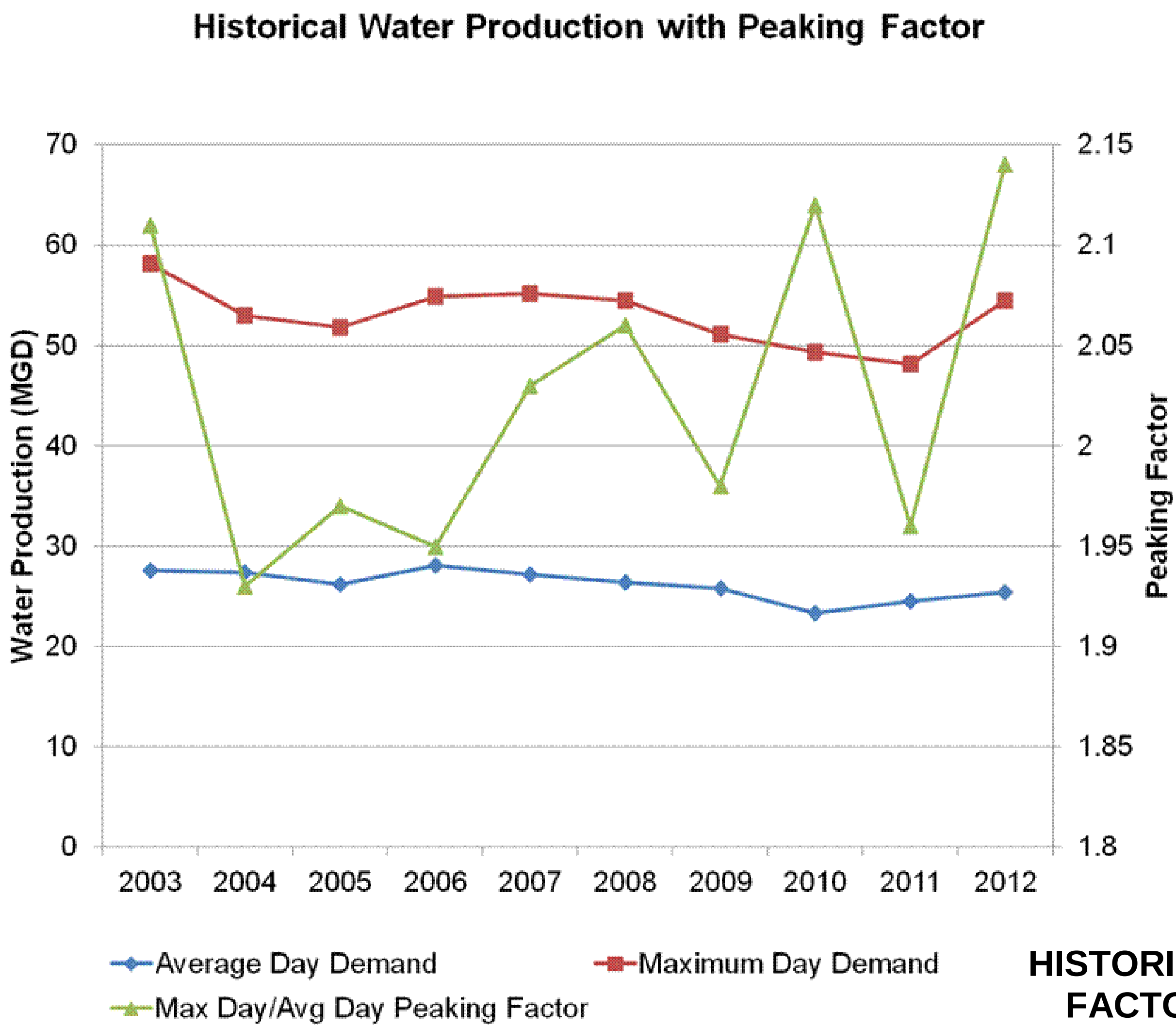
The ADD represents the average daily demand for the year, which is typically used for operational evaluations. It is calculated by dividing the total water produced by the number of days per year (2004, 2008, and 2012 were leap years and include 366 days per year). These values for the years 2002 to 2012 are presented in Table 2.4. As shown in this table, the minimum ADD was 23.30 mgd in 2010, and the maximum ADD was 28.09 mgd in 2006.

2.3.3 Maximum Day Demand (MDD)

Identifying the MDD is critical for establishing system supply capacity, pump station discharge rates, reservoir capacity, and pump sizes. Historical values of MDD are equivalent to the highest production and purchase in one day in a given year, and are usually during the summer when irrigation is occurring. Table 2.4 also presents the recorded MDD and date of occurrence for each year. As shown in this table, the minimum MDD was 48.16 mgd in 2011, and the maximum MDD was 58.09 mgd in 2003.

In order to develop future MDD projections, the historical MDD to ADD peaking factor was calculated, as shown in Table 2.4 and Figure 2.3. The MDD to ADD peaking factor fluctuated between 1.93 in 2004 and 2.14 in 2012. The MDD to ADD peaking factor averaged 2.03 over the period of record.

Peak hour demand (PHD) was calculated for the entire system using historical diurnal patterns of the City’s production (as discussed in Appendix 3B – TM 2 Hydraulic Model Update). The maximum diurnal peak for the system occurs during MDD conditions and is equivalent to 1.6 times the MDD. Thus, the PHD/MDD ratio for the City is assumed to be 1.6 for planning purposes.



HISTORICAL PEAKING FACTOR BY YEAR (2003 – 2012)

FIGURE 2.3

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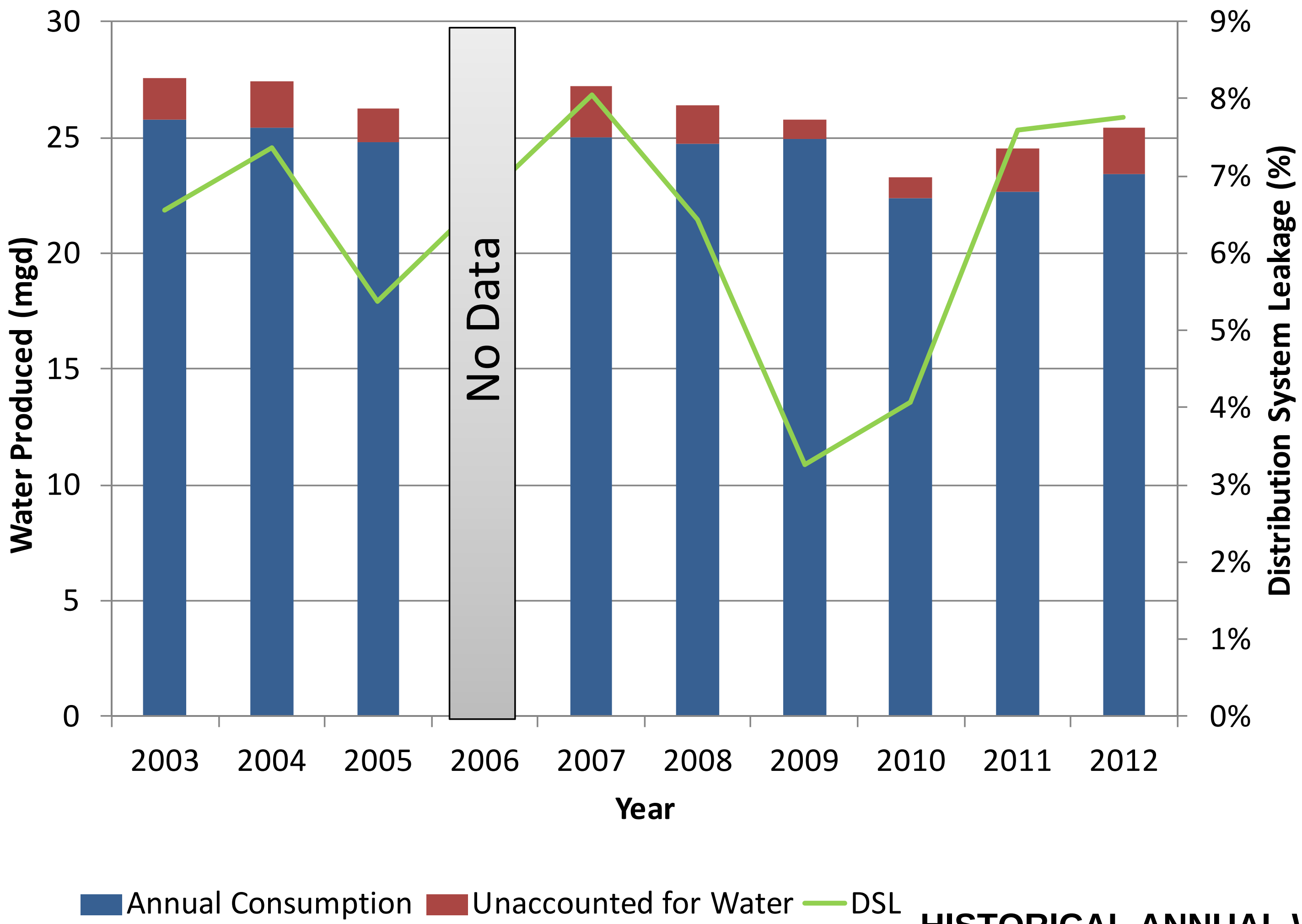
2.3.4 Distribution System Leakage (DSL)

Unaccounted for water, or Distribution System Leakage (DSL), may include inaccurate master and service connection meters, unaccounted-for non-revenue water use, pipeline leakage, and unauthorized use. DSL is determined by subtracting the total documented water use from the total water produced. The Washington State DOH requires the 3-year average DSL to be under 10 percent to minimize water waste. The City's estimated DSL for 2003 through 2012 are presented in Table 2.5 and graphically in Figure 2.4. For the City's water system, the total 3-year rolling average DSL was between 4.6 percent and 6.9 percent of the total production. The City's annual average DSL over the period was 6.3 percent.

Table 2.5 Historical Unaccounted for Water

Year	Total Consumption (mgd)	Total Production (mgd)	Unaccounted for Water		
			(mgd)	(%)	3-yr Rolling Avg. (%)
2003	25.76	27.57	1.81	6.6%	NA
2004	25.39	27.41	2.02	7.4%	NA
2005	24.81	26.22	1.41	5.4%	6.5%
2006	NA[(1)]	28.09	NA	NA	NA
2007	25.01	27.2	2.19	8.1%	6.9%
2008	24.72	26.4	1.68	6.4%	6.6%
2009	24.93	25.78	0.85	3.3%	5.9%
2010	22.35	23.3	0.95	4.1%	4.6%
2011	22.66	24.52	1.86	7.6%	5.0%
2012	23.43	25.4	1.97	7.8%	6.5%
Average	**24.34**	**26.19**	**1.66**	**6.3%**	

Notes:
(1) NA = not analyzed due to unknown consumption data



HISTORICAL ANNUAL WATER CONSUMPTION WITH DSL (2003 – 2012)

FIGURE 2.4

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2.3.5 Seasonal Variations in Water Demand

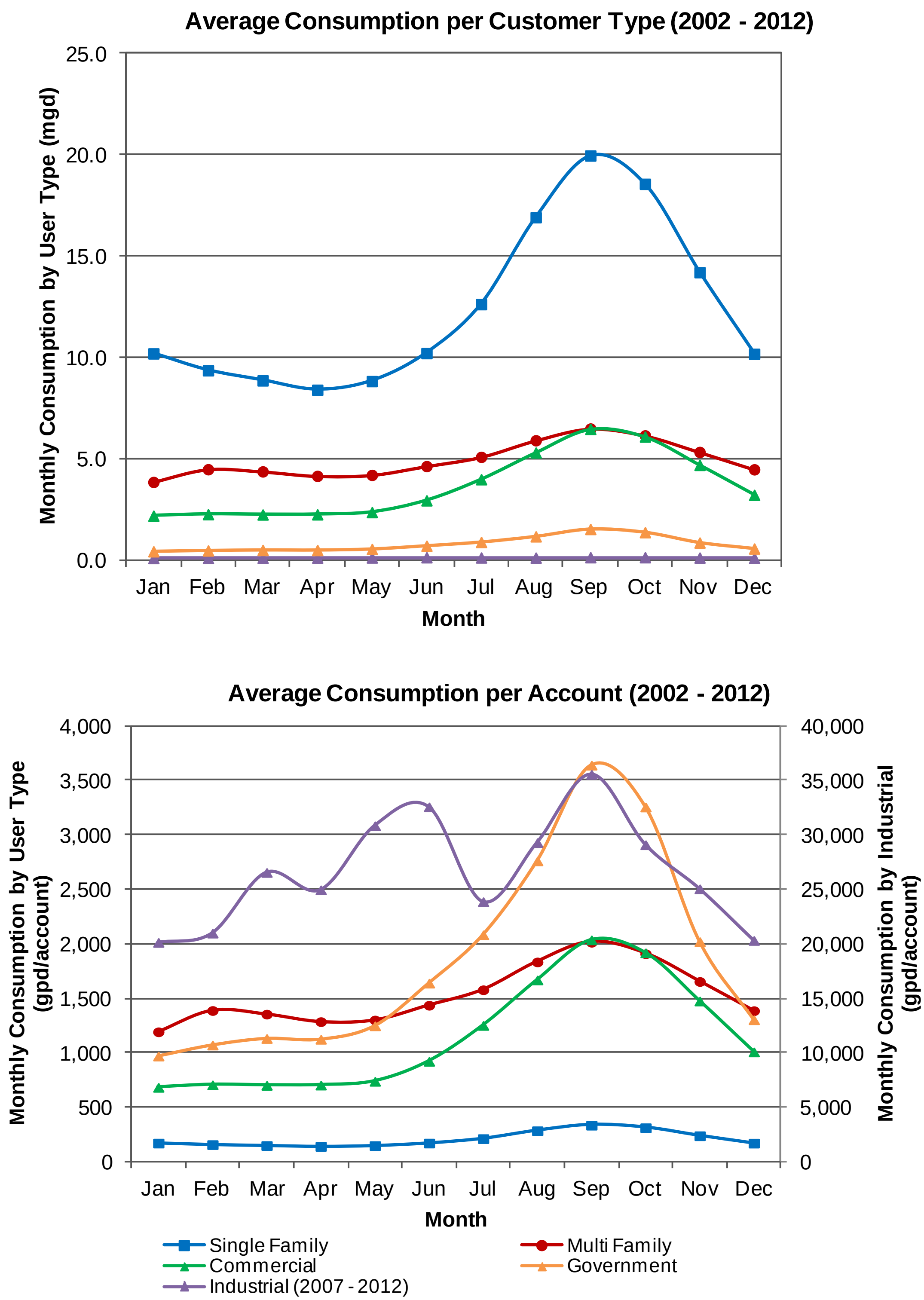
The pattern of water consumption differs between the customer classes. Water use increases significantly during the summer when daylight hours are longer and lawn and landscape watering is prominent. Other outdoor uses, including car washing and recreation, are also at their highest during summer months. The average total monthly consumption and the average monthly consumption per account for each customer type are shown in Figure 2.5. Note, with the exception of some of the city's largest users, the City conducts bi-monthly meter reading, therefore the water consumption was averaged between months to better reflect the actual water consumed in the month. As seen in the top figure, SFR customers show a significant peak in total consumption during the summer months. All other categories, except Industrial, also show a peak in total demands during the summer.

Evaluating monthly water consumption per account, as shown in the bottom chart of Figure 2.5, allows the consumption to be more easily compared between classes. For example, the summer increase in water use per SFR account is significantly lower than that for a Government account. These monthly variations can be used to target water use efficiency efforts and/or to project future water-use patterns for planning purposes.

2.3.6 Climatic Review (2003-2012)

Climate is an important factor driving water use, because temperature, precipitation, and other climate-driven weather patterns affect irrigation, commercial and industrial cooling, etc. Irrigation is common in the summer and early fall, which largely drives the MDD shown in Figure 2.5. However, many additional factors influence demands, including the economy and conservation activities. Vancouver's maritime climate is characterized by wet cool winters and dry warm summers. The City's temperate climate is largely protected from continental weather by the Cascade Mountains to the east. During the period of historical data, annual precipitation was typically at or slightly above normal levels. Temperatures were also within the typical ranges.

While there are many examples that illustrate how climate affects demand, it is typically difficult to find strong statistical correlations between the two. From the available data provided by the City, the MDD/ADD peaking factor provides a good indication of climate-driven water use (i.e. irrigation and cooling) from year to year. By comparing these data to historical temperature and precipitation, it was possible to investigate the statistical correlations between climate and historical demand. Table 2.6 presents the MDD/ADD peaking factors, month the MDD occurred, monthly precipitation, and average maximum daily temperature from the City's long-term climate station (Vancouver 4 NNS). Anecdotally, comparisons did show examples of hot and dry conditions and high demand. For example, the highest MDD/ADD peaking factors occurred during 2003, 2010, and 2012. In all three years there were no appreciable rainfall and near or above average maximum temperatures. However, the fourth highest peaking factor occurred in 2008, which had both above average rainfall and cooler than normal temperatures. These variations show the difficulty in correlating climate and demand over a ten-year period.



HISTORICAL ANNUAL WATER CONSUMPTION BY CUSTOMER CLASS (2003-2012 AVERAGE)

FIGURE 2.5

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Table 2.6 Climate and MDD/ADD Peaking Factor Comparison

Year	MDD/ADD Peaking Factor	MDD Month	Precipitation in MDD Month (in)	Average Maximum Daily Temperature (deg F)
2003	2.11	July	0.00	82.58
2004	1.93	August	2.58	81.32
2005	1.97	August	0.15	82.94
2006	1.95	July	0.39	80.06
2007	2.03	July	0.66	79.70
2008	2.06	August	1.81	78.98
2009	1.98	August	0.89	80.06
2010	2.12	August	0.00	79.34
2011	1.96	August	0.06	78.62
2012	2.14	August	0.00	81.32
Average	**2.03**		**0.65**	**80.49**
Correlation (R^2) to MDD/ADD Peaking Factor			**0.17**	**0.02**

Precipitation amounts were roughly 75 percent of normal for both the 2014 and 2015 water years. The 2015 season was typical until precipitation eased in April and disappeared in May through June. The intense and prolonged high temperatures in June 2015 compounded the situation. In fact, the June 2015 water system demand was the highest ever June production amount. Temperatures moderated to normal during July and August.

The only impact to the City water supplies was the lowering of the Upper Orchards water levels between 5-10 feet across the two years. Some of this level reduction has been attributed to higher use of water stations that pump from the Upper Orchards aquifer due to the fact that these water stations have better energy efficiency. The increased production for energy efficiency combined with the drought and the early demand led to a drop in the Upper Orchards water levels.

The static water level at Water Station 9 dropped below 140.0 feet mean sea level during August. The water rights certificate for Water Station 9 Well 7 has an operating condition to keep its static water level above that elevation. Therefore, Well 7 was taken out of the lineup in late August. Water Station 9 water levels rebounded in September with the reduced production amounts while water was pumped into Heights High from Ellsworth and Water Station 1.

An indirect impact to the City's supply was that Portland utilized their Columbia Wellfield to augment the Bull Run supply on a continuous basis starting in July of 2015. Roughly 60 percent of their groundwater supplies are shared with the City based in the Sand & Gravel Aquifer (SGA). The Ellsworth water levels indicate the water level was lowered twenty (20) feet due to

Portland SGA pumping interference. Ellsworth Wells 1 and 2 were both in production throughout July and August until dynamic water levels were close to reaching the pump intakes. Removing one of the Ellsworth wells from production raised the water level to a safe distance above the pump intake. Decreased well performance is another factor that led to the need to remove one of the wells from service. Regular rehabilitation of these wells is recommended to decrease impacts due to pumping of the Portland wellfield. Prolonged impacts due to drought will continue to be assessed in the coming years.

Statistical correlations were sought for using monthly precipitation or average maximum daily temperature versus single-family residential water use or total consumption. In Vancouver, the greatest statistical correlations were between average maximum daily temperature and total demand, and average maximum daily temperature and SFR demand; with an R^2 value of 0.49 and 0.47, respectively. A weaker correlation was found between monthly precipitation and total demand, and monthly precipitation and SFR demand; R^2 of 0.21 and 0.25, respectively. These moderate correlations indicate that climate does affect demands; however, other factors also significantly influence demands.

Climate experts predict that future weather patterns in the Pacific Northwest may change in the next century. If the Pacific Ocean temperatures rise as is expected, the likely result will be warmer temperatures year-round, wetter winters, with more intense storm events, and drier summers[1]. However, the timing and magnitude of such changes is uncertain. No changes to demand projections were made for the 20-year planning period to account for potential climate change due to the uncertain magnitude and timing of local effects, and the difficulty in correlating historical climate and demand data. It is recognized that demands have the potential to increase in the future given anticipated climate changes. The City may want to develop a model to better track demands with temperature and rainfall for future demand planning. Additionally, it may be beneficial for the City to participate in regional climactic studies to qualify and quantify potential local climate impacts.

2.4 DEMOGRAPHIC FORECAST

Demand projections depend on the future number of customers to be served by the City's water system. As described below, a demographic analysis was performed to estimate the number and type of future customers served by the City's water system. Converting the number of accounts into demand projections is discussed in Section 2.5.

Vancouver's policy is to serve all customers within its service area, thus, it is critical for the City to review potential growth within this area. The City is required to comply with the latest goals set by the Growth Management Act (GMA). The State's largest jurisdictions are required to establish Urban Growth Areas (UGAs) or Potential Annexation Areas (PAAs), which can accommodate planned future growth for the next 20 years. Urban services, such as water,

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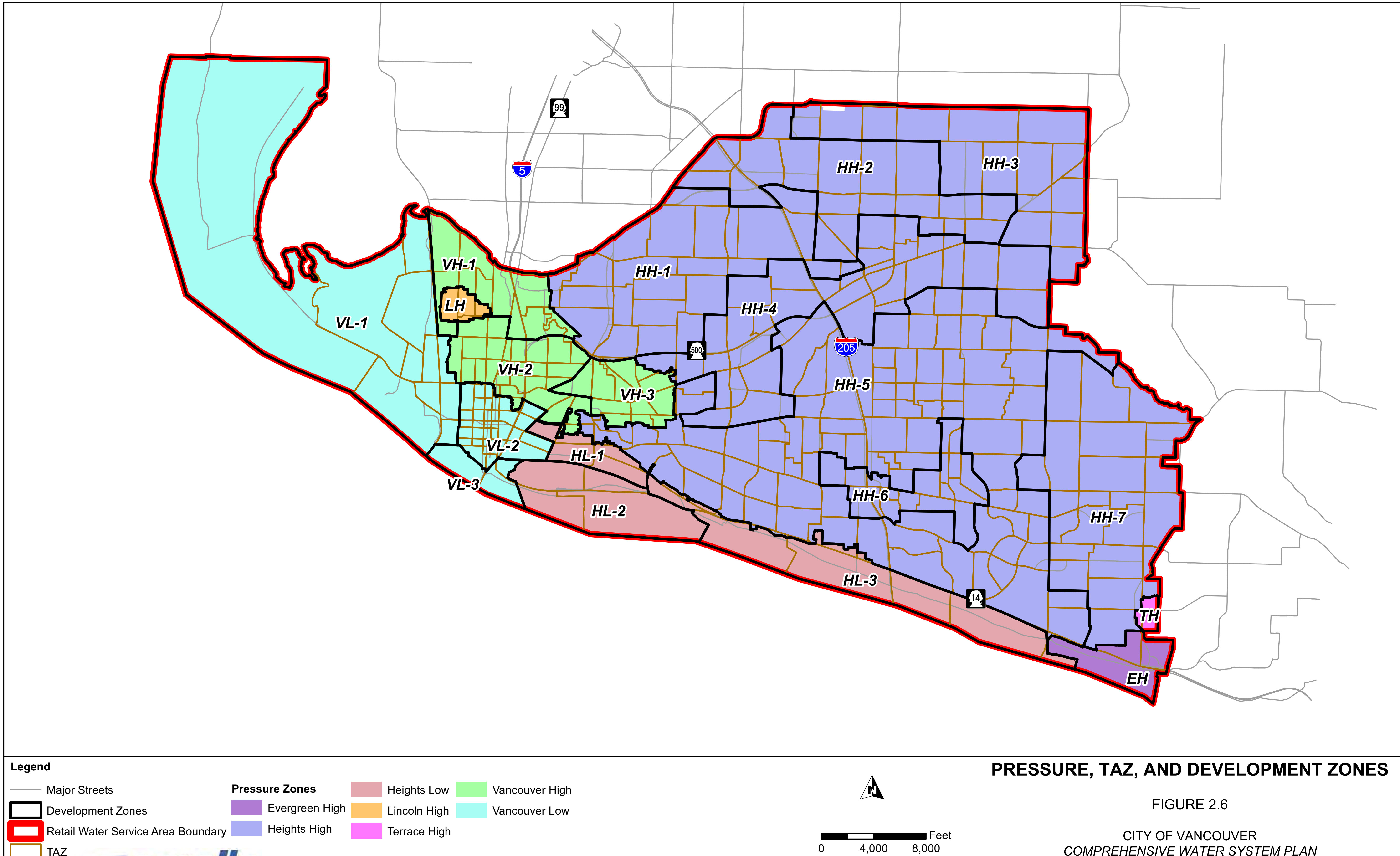
[1] Dalton, M.M., P.W. Mote, and A.K. Snover [Eds.]. 2013. *Climate Change in the Northwest: Implications for Our Landscapes, Waters, and Communities*. Washington, DESIGN CONSULTANT: Island Press.

power, and wastewater collection, must be available or planned for within a reasonable and timely manner inside the UGAs or PAAs. Thus, the City must plan for providing services to the number of future customers estimated by the City's GMA goals.

Existing and future demographic assumptions consistent with the City's GMA goals were provided by the City's planning department. This data came in the form of existing and future (year 2034) housing, population, and employment estimates per Transportation Analysis Zone (TAZ). Two future growth scenarios were considered:

- Low Growth Scenario: this scenario assumed development of vacant and underutilized lots along with some redevelopment as provided by City planning staff
- High Growth Scenario: this scenario assumed full development of the City according to the maximum allowable buildout under current zoning.

Vancouver's water system has seven pressure zones and encompasses 340 different TAZs. The extents of the pressure zones are too large to capture unique areas of growth, while the TAZs are too numerous for the performance of an efficient analysis. To add a level of granularity to the demographic analysis, pressure zones were divided into groups of TAZs based on similar growth rates and land uses. These 19 areas, herein referred to as "Development Zones," were delineated for the demographic analysis of this Plan. Figure 2.6 shows the selected Development Zones compared to the TAZ and pressure zone boundaries. Figure 2.7 shows the Development Zones as well as the high household growth projections in each TAZ. Figure 2.8 similarly displays the high employment growth projections in each TAZ.



PRESSURE, TAZ, AND DEVELOPMENT ZONES

FIGURE 2.6

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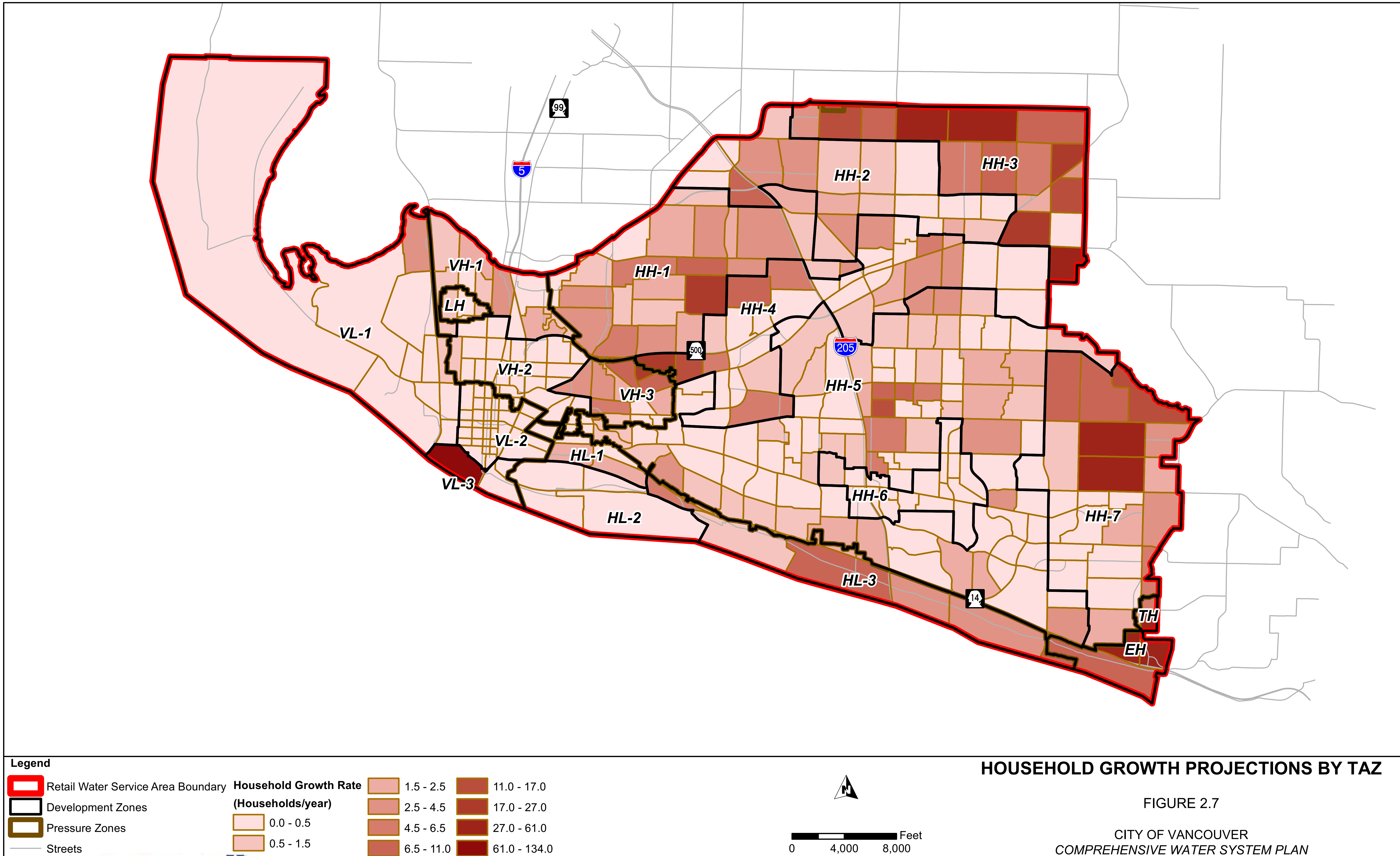

HOUSEHOLD GROWTH PROJECTIONS BY TAZ

FIGURE 2.7

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COMPREHENSIVE WATER SYSTEM PLAN

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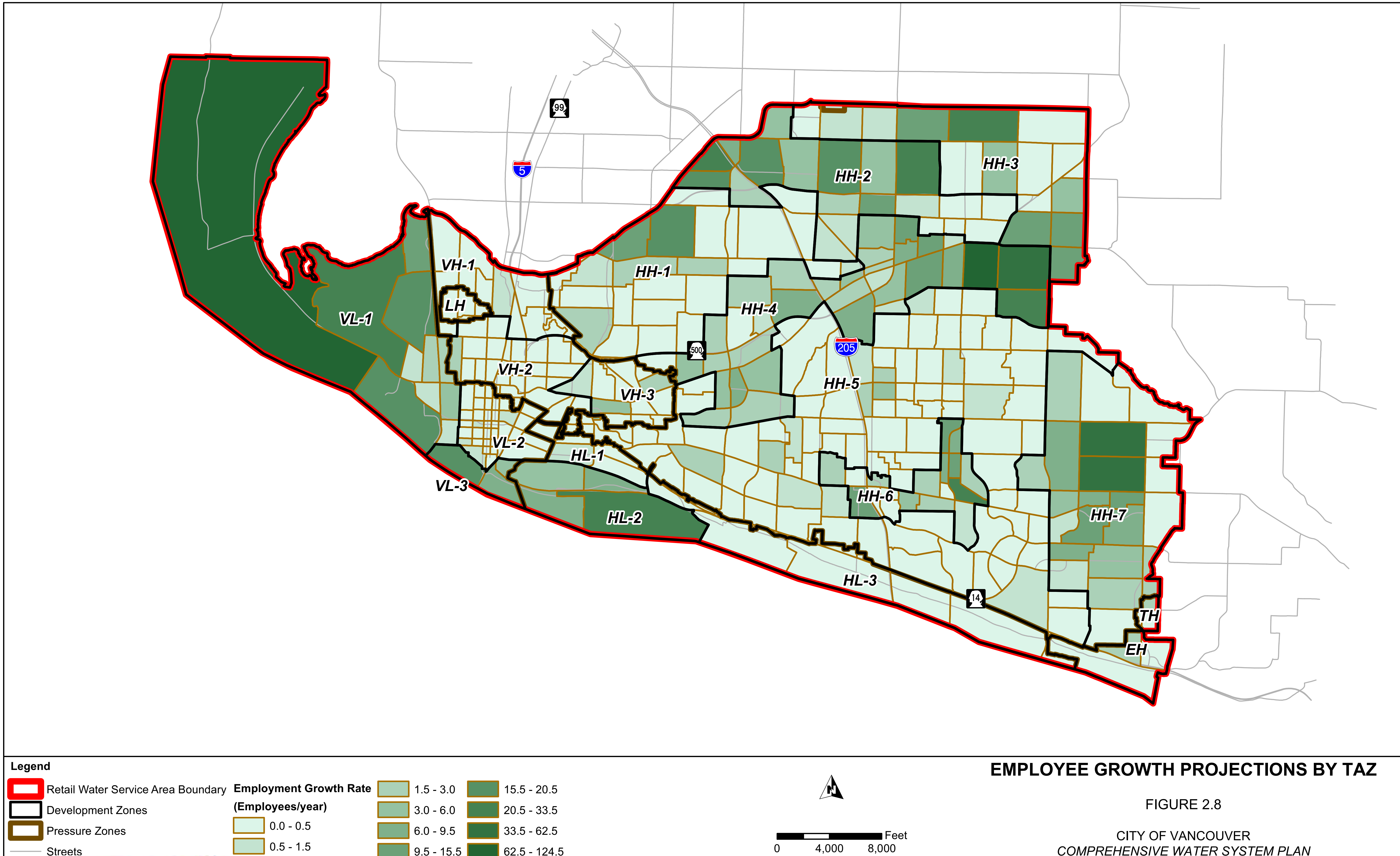

EMPLOYEE GROWTH PROJECTIONS BY TAZ

FIGURE 2.8

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Household and employee growth rates were calculated for each Development Zone based on the low and high growth scenarios. Average growth rates were calculated as the average between the low and high growth scenarios. Table 2.7 shows the average growth rates per Development Zone, while Table 2.8 summarizes overall growth within the service area for each of the planning years from 2013. The table presents total growth compared to 2013 for each of the planning years, and the average annual growth rate.

Table 2.7 Average Growth Rates per Development Zone

Development Zone	Households Per Year	Average Annual Household Growth Rate	Employees Per Year	Average Annual Employee Growth Rate
EH	95	>100% (1)	3	2.6%
HH-1	84	1.0%	44	1.3%
HH-2	29	0.5%	149	2.8%
HH-3	202	3.5%	91	9.1%
HH-4	70	0.7%	274	1.7%
HH-5	106	0.3%	24	0.1%
HH-6	2	0.1%	104	1.1%
HH-7	105	1.3%	191	2.2%
HL-1	5	0.3%	1	0.1%
HL-2	0	0%	43	0.9%
HL-3	34	2.0%	0	0%
LH	1	0.3%	0	0%
TH	0	0%	0	0%
VH-1	12	0.3%	2	0.1%
VH-2	2	0.1%	2	0.2%
VH-3	22	0.5%	7	0.2%
VL-1	4	0.3%	209	4.4%
VL-2	0.4	0%	6	0.1%
VL-3	100	>100% (2)	16	3.4%

Notes:

(1) Growth from 64 households to 1,813 households from 2014 to 2034. Large development planned for 192nd Ave. and Highway 14.

(2) Growth from 1 household to 1,406 households from 2014 to 2034. Waterfront development

Table 2.8 Summary of Overall System Growth

	2020(1)	2024(1)	2034(1)	Avg Annual Growth Rate
Households				
Low	6%	9%	17%	0.8%
Average	7%	10%	20%	0.9%
High	7%	11%	22%	1.0%
Employment				
Low	8%	12%	24%	1.1%
Average	8%	12%	24%	1.1%
High	8%	12%	24%	1.1%

Notes:
(1) Growth compared to 2013.

Once growth rates were established, the number of existing water accounts in each development zone by customer type was extracted from city GIS data. Excluding large demand users, the number of existing accounts were grown by the low, average, and high development zone growth rates from Table 2.7 for each development zone. Single Family Residential and Multi-family Residential account numbers were grown by the household growth rates presented in Table 2.7 for each development zone. Commercial, Industrial, Government, Shelter, and Other customer account types were grown by the employment growth rates presented in Table 2.7 for each development zone. Appendix 2A provides calculations for the low, average, and high number of future accounts in each development zone for the planning years.

Table 2.9 summarizes the total number of accounts for each pressure zone for the average growth projections. (Note, individual largest user demand projections were developed separately; therefore, accounts for these customers were not grown based on the development zone growth rates.) The projected number of future accounts was then used to develop ERUs and demand projections as described below.

Table 2.9 Summary of Accounts by Pressure Zone and Growth Scenario

Pressure Zone	2014	2020	2024	2034
Average Growth Scenario				
Evergreen High	23	109	163	297
Heights High	55,729	58,737	60,742	65,759
Heights Low	2,403	2,561	2,667	2,933
Lincoln High	457	465	470	484
Terrace High	303	303	303	303
Vancouver High	7,132	7,224	7,284	7,437
Vancouver Low	2,520	2,614	2,677	2,835
Total	**68,567**	**72,013**	**74,306**	**80,048**

2.5 DEMAND PROJECTIONS

Projecting future water demand is one of the key elements of the water system planning process. Identification of system improvements such as supply, pumping, storage, and piping requirements are all related to demand projections. This section summarizes the ERU, ADD, and MDD projections, as well as the potential range in future demands associated with various factors, such as water use per ERU, DSL, and demographic growth rate.

2.5.1 Potential Range in Future Water Demand

Numerous factors and assumptions affect the accuracy of projected future water demands. Recognizing that certain assumptions built into the demand projections will vary in the future, the projections were developed for low, medium, and high demand scenarios to provide a range in demands that may be experienced in the future. The medium projection will be used for the system analysis in Chapter 3, while the high projection will be used for the water rights evaluation in Chapter 4. The system analysis determines future pumping, storage, and distribution system deficiencies and identifies potential improvements to achieve the City's established capacity criteria. The water rights evaluation looks at both water rights and overall source supply capacity. The high demand projection helps plan supplies for even the highest demands.

The variables considered in developing the range of demand projections are summarized in Table 2.10 and are discussed below.

- **Growth Rate**: As described above, low and high demographic growth scenarios were determined by the City planning staff based on the development assumptions. These growth assumptions were applied to their respective demand scenario. The medium growth scenario was based on the average of the low and high growth rates.
- **Existing Customer Demand**: The demand projections assume that existing customers will use an average of 223 gpd/ERU, which is the historical average from the last ten years. This provides a conservative estimate as water use for existing customers trended down from 2003 to 2012.
- **New Customer Demand**: New customer demand will likely be below this historical level of water use. For example, all new development should be constructed to meet the updated uniform plumbing code and City landscaping code, which require water efficient fixtures and irrigation, respectively. Table 2.10 presents the assumed adjustments to the ERU water use (223 gpd/ERU) for future customers in the low, medium, and high demand projections.
  - A five percent water use reduction was applied to all new customers in the medium demand scenario. The City's average ERU water use reduced from 252 to 207 gpd/ERU, which equates to a 17 percent decrease from 2003 to 2012. Considering that some of this reduction could be due to other factors such as economic conditions, a reduction value of five percent was selected to be conservative for new water customers.

- The low and high growth adjustments were based on the range of historical variation in water use for each class. For example, the minimum average water use per MFR account from 2003 to 2012 was 1,122 gpd/account, which is 90 percent of the average (1,251 gpd/account); the maximum water use was 1,573 gpd/account, which is 126 percent of the average. This additional variation accounts for potential year to year changes in water use or shifts in water use over time. These adjustments were applied prior to demand adjustments resulting from the City's WUE program, which is considered separately in Chapter 4.

- **Distribution System Leakage**: DSL varied between 3.3 and 8.1 percent of the total City production between 2002 and 2012, with an average of 6.3 percent. The minimum, average, and maximum DSL will be applied to the low, medium, and high demand projections, respectively.

- **Maximum Day/Average Day Peaking Factor**: The maximum day/average day peaking factor has varied annually by over 10 percent. The low growth projections will use the average peaking factor of 2.03. Medium growth projections will use a peaking factor of 2.10, which is equal to the 75th percentile of the historical data. The high growth scenario will use the historical maximum peaking factor of 2.14. These peaking factors were chosen to provide adequate sizing of future infrastructure improvements.

Table 2.10 Proposed Planning Values for Demand Projections

Assumptions	Demand Scenario		
	Low	Medium	High
Existing Customer Water Demand (gpd per ERU)	223	223	223
DSL (%)	3.30%	6.30%	8.10%
MDD/ADD Peaking Factor	2.03	2.10	2.14
New Customer Demand Adjustments			
SFR	91%	95%	113%
MFR	90%	95%	126%
Commercial	89%	95%	106%
Industrial	6%	95%	222%
Government	86%	95%	110%
Shelter	76%	95%	175%
Other (1)	1%	95%	315%

Notes:

(1) Other customer class is based on two hydrant meters, Clark County Public Works service, and Clark Regional WW District service. Demands are very small, ranging from less than a 100 gpd to 28,000 gpd.

2.5.2 Large User Demand Forecast

Vancouver has substantial industrial and commercial water use, which are an integral part of the City's history and future. The City is committed to continuing to provide high quality service at a reasonable cost to these and all of its customers. Customers with high water use are often the biggest demands and fire flows in their pressure zones, which warrant careful consideration in the system and hydraulic analyses. The City identified its top six customers consuming the highest annual volume of water, and provided their associated meters, customer classifications, and historic water use. Individual demand projections were created for these six customers, as presented in Table 2.11 and Figure 2.9. The city recognizes that large customers may at any time shut down and quit using city water. Furthermore, new large industrial customers may create new demands in the future that were not anticipated.

Individual demand projections were made for each user based on the historical demand, the City's current planning based on discussions with users, and overall growth rates. Overall, large users are projected to grow from 1.6 mgd to 2.0 mgd over the planning period. Most of the large user demands decreased during 2009 and/or 2010 and have rebounded in recent years. However, the projected growth into the future varied substantially based on the individual user. A short explanation of the growth for each of the large users is provided below. Note, a long-term growth rate of 0.1 percent was used to represent minimal growth, which was based on the typical TAZ employment growth rate for built out areas of the City that were not expected to redevelop.

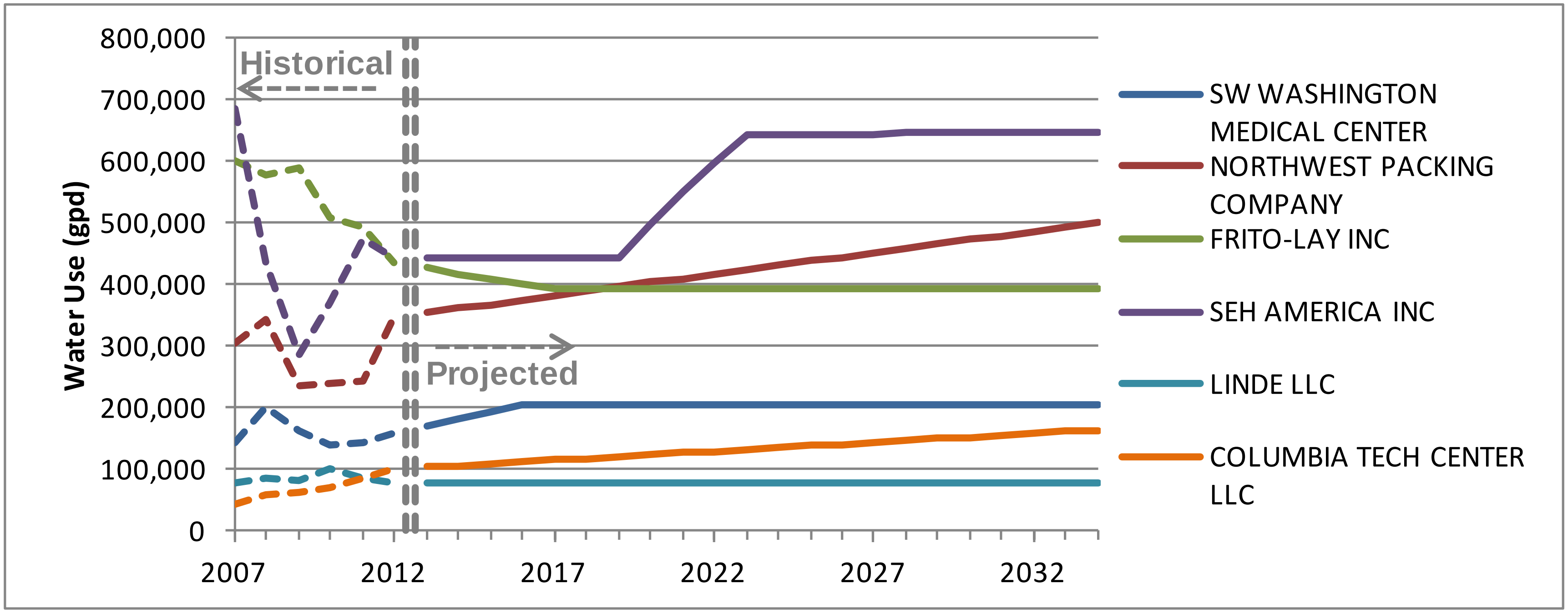
- *Northwest Packing Company*: Northwest Packing is projected to continue to grow through the planning period. Demands at the site were increased by two (2) percent per year to a maximum of 500,000 gpd.
- *Frito-Lay Inc.*: Frito-Lay has instituted an aggressive water conservation program that has reduced demands substantially since 2007. These declines are projected to continue through 2017 at a two (2) percent rate and then remain unchanged for the rest of the planning period.
- *Southwest Washington Medical Center*: Water use at the medical center is projected to return to historical levels by 2016 based on its current increase in water use (7 percent) and then increase at a small rate (0.1 percent) into the future.
- *SEH America Inc.*: The majority of water used for manufacturing at SEH comes from their on-site wells. SEH obtained additional water rights in 2004 and completed construction of an additional well in 2008 that led to a decline in city water use. They obtained an additional water right permit in 2013 that will be used for future plant expansions. Water use at SEH America is projected to continue at current levels for the existing manufacturing facility. A potential plant expansion starting in 2020 is projected to increase demands by 0.2 mgd over four years. Following the plant expansion, water use is expected to grow at a small rate (0.1 percent) into the future.

- *Linde LLC*: Linde LLC was projected to grow at a small rate (0.1 percent) into the future, which was consistent with employment projections for its associated TAZ.
- *Columbia Tech Center LLC*: The Columbia Tech Center is a large commercial and mixed-use development that has grown steadily since 2007. Water use is expected to continue to grow as the remaining vacant parcels are developed. Therefore, the TAZ employment growth rate of three (3) percent was considered to be a good representation of growth in future water use and was used in the forecast.

Table 2.11 Large User Demand Forecasts

Large User[(1)]	Pressure Zone	Dev. Zone	2014 Demand (mgd)	2020 Demand (mgd)	2024 Demand (mgd)	2034 Demand (mgd)
Northwest Packing Company	Vancouver Low	VL-1	0.36	0.4	0.43	0.5
Frito-Lay Inc.	Vancouver Low	VL-1	0.42	0.39	0.39	0.39
Vancouver Low Subtotal			**0.78**	**0.79**	**0.82**	**0.89**
Southwest Washington Medical Center	Heights High	HH-5	0.18	0.2	0.21	0.21
SEH America Inc.	Heights High	HH-5	0.44	0.5	0.64	0.65
Linde LLC	Heights High	HH-1	0.08	0.08	0.08	0.08
Columbia Tech Center LLC	Heights High	HH-7	0.11	0.12	0.14	0.16
Heights High Subtotal			**0.81**	**0.9**	**1.07**	**1.1**
Total			**1.59**	**1.69**	**1.89**	**1.99**

Notes:
(1) Large Users were selected based on the combined historical Industrial and Commercial water use.



LARGE USER DEMAND PROJECTIONS

FIGURE 2.9

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2.5.3 Industrial Reserve

The City has reserved 3.8 MG of demand for new industrial users at three large sites. A demand was allocated to each site based on the City's projections, as shown in Table 2.12. The industrial reserve is in addition to the demands projected based on demographic growth and for large users. No peaking factor was applied to the industrial reserve; therefore, the ADD and MDD were equal.

Table 2.12 Industrial Reserve

Site Name	Pressure Zone	Development Zone	2014 Reserve (mgd)	2020 Reserve (mgd)	2024 Reserve (mgd)	2034 Reserve (mgd)
Old HP Site(1)	Heights High	HH-5	0	0.08	0.4	1.2
Section 30(2)	Heights High	HH-7	0	0.1	0.5	1.5
POV Columbia Gateway(3)	Vancouver Low	VL-1	0.2	0.85	1.1	1.1
Total			**0.2**	**1.03**	**2.0**	**3.8**

Notes:
(1) Linear growth starting in 2020 to an ultimate reserve of 1.2 mgd.
(2) Linear growth starting in 2020 to an ultimate reserve of 1.5 mgd.
(3) Linear growth from 2014 to 2024 to an ultimate reserve of 1.1 mgd.

2.5.4 Wholesale Demand

No wholesale demand is assumed for the 20-year planning period. Adjacent water utilities have recently developed new water supplies and are working toward developing additional sources of supply to meet future demands without purchasing water from the City. The City has no long-term plan to supply wholesale water.

2.5.5 ERU Projection

The ERU projection provides the basis for the ADD and MDD demand projections. The projected number of ERUs for the service area was calculated by multiplying the projected number of accounts provided in Table 2.9 by the number of ERUs per account, as summarized in Table 2.3, for each customer type. The number of ERUs for new customers was reduced according to the adjustments presented in Table 2.10 for the low, medium, and high demand scenarios. The ERU projections were developed for each development zone and include the large user and industrial reserve demands, which were converted to ERUs based on 223 gpd per ERU. Note, the ERU projections do not include unmetered water and DSL, as these are not customer demands; these values are added as a percentage to estimate the ADD, as described below. The total number of ERUs for each pressure zone for 2014, 2020, 2024, and 2034 are presented in Table 2.13 for the medium growth scenario. Appendix 2B, includes detailed ERU tables for all pressure zones.

Table 2.13 Summary of ERUs by Pressure Zone Medium Growth Scenario

Pressure Zone	2014	2020	2024	2034
Evergreen High	23	306	374	546
Heights High	79,264	84,499	91,122	106,349
Heights Low	4,860	5,079	5,228	5,612
Lincoln High	481	489	494	507
Terrace High	364	364	364	364
Vancouver High	12,690	12,843	12,938	13,194
Vancouver Low	12,814	16,307	17,882	19,053
Total	**110,496**	**119,887**	**128,402**	**145,625**

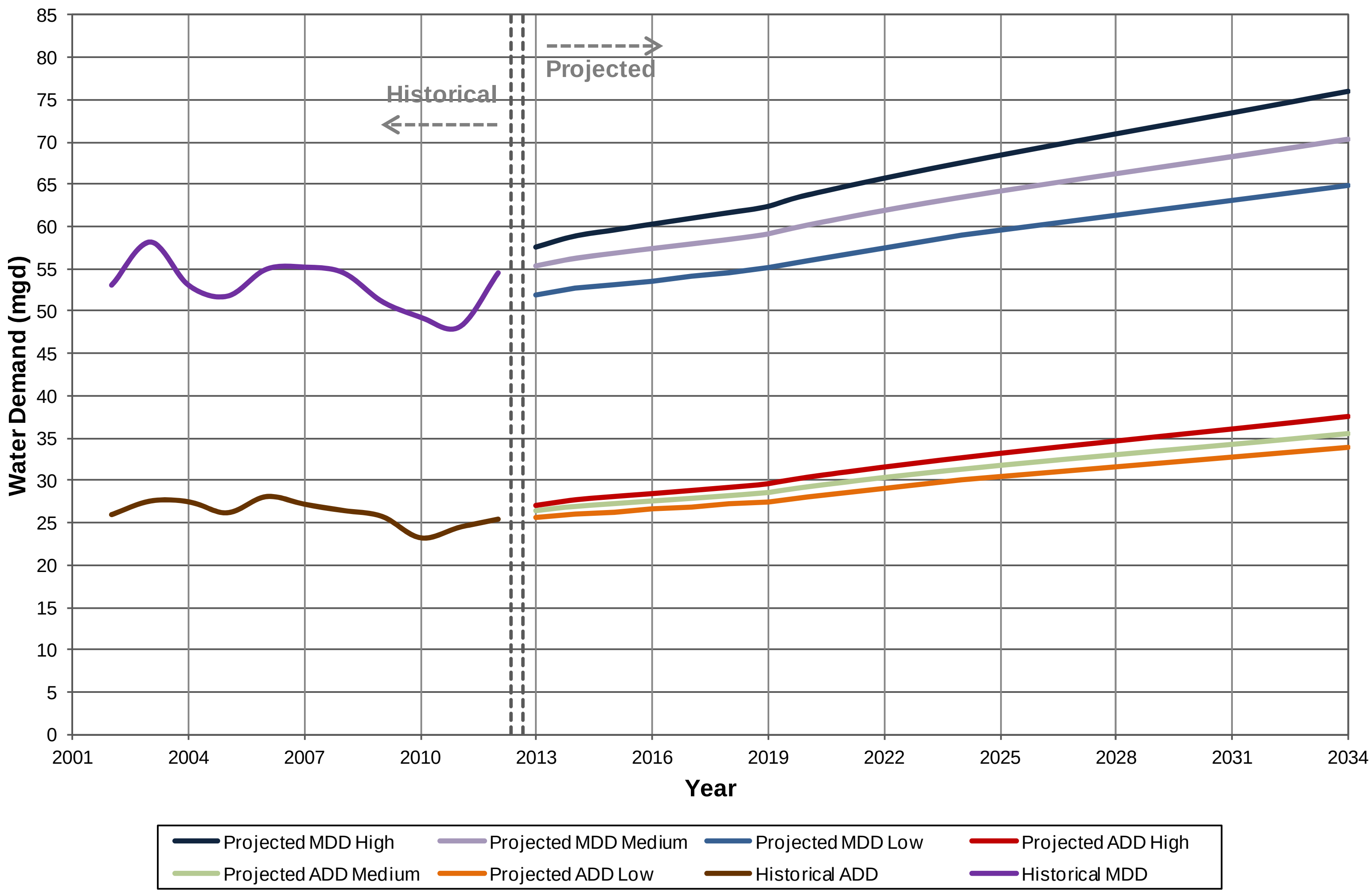
2.5.6 Projected Average Day and Maximum Day Demands

The ADD projections include the projected customer demands, unmetered use, and DSL. The customer demands were calculated by multiplying the projected ERUs shown in Table 2.13 by the average ERU water use (223 gpd/ERU). Unmetered water use was estimated as 2.3 percent (the historical average as noted in Section 2.2) of the customer demands. ADD projections were calculated by summing the customer demands, unmetered use, and applying a DSL as a percentage of total ADD. The following equation demonstrates this calculation:

$$\text{2034 ADD (Medium)} = \frac{\text{(Customer Demands)} + \text{(Unmetered Use)}}{\text{(1 - DSL)}} = \frac{\text{32.47 mgd} + \text{0.76 mgd}}{(1 - 0.063)} = \text{35.46 mgd}$$

In this way, ADD projections were developed for the low, medium, and high demand scenarios using the low, medium, and high DSL assumptions shown in Table 2.10. DSL was then back-calculated by subtracting customer demands and unmetered use from the total ADD. The resulting ADD projections are shown in Figure 2.10 and summarized in Table 2.14. MDD was calculated by multiplying the ADD by the low, medium, and high MDD/ADD peaking factors shown in Table 2.10. The low, medium, and high MDD is also shown in Figure 2.10 and Table 2.14. The inflection point in 2019 in Figure 2.10 is largely due to the industrial reserve and to a lesser extent increased demand at SEH America.

Table 2.14 presents historical and future projections of the major components of the ADD and MDD: residential metered demand, non-residential metered demand, large users, industrial reserve, unmetered use, unaccounted-for water (DSL), ADD, and MDD. The projected 2034 ADD was projected to range between 33.85 mgd and 37.52 mgd, with a medium projection of 35.46 mgd. The projected 2034 MDD ranges between 64.80 mgd and 75.96 mgd, with a medium projection of 70.31 mgd.



PROJECTED ADD & MDD BY GROWTH SCENARIO

FIGURE 2.10

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Table 2.14 Total System Demand (mgd)

Parameter	2008	2009	2010	2011	2012	2014			2020			2024			2034		
	Actual	Actual	Actual	Actual	Actual	Low	Medium	High	Low	Medium	High	Low	Medium	High	Low	Medium	High
Residential Metered Demand	17.45	17.92	16.03	16.29	16.59	17.84	17.86	17.89	18.52	18.61	18.85	18.97	19.12	19.51	20.08	20.35	21.13
Non-Residential Metered Demand	5.24	5.26	4.58	4.53	4.69	4.92	5.00	5.12	5.26	5.40	5.62	5.48	5.65	5.90	6.05	6.33	6.77
Large Users	1.71	1.42	1.43	1.53	1.57	1.59	1.59	1.59	1.70	1.70	1.70	1.89	1.89	1.89	1.99	1.99	1.99
Industrial Reserve	NA	NA	NA	NA	NA	0.20	0.20	0.20	1.03	1.03	1.03	2.00	2.00	2.00	3.80	3.80	3.80
Total Projected Metered Demands	24.40	24.60	22.04	22.35	22.85	24.55	24.65	24.80	26.51	26.74	27.20	28.34	28.66	29.30	31.92	32.47	33.69
Unmetered Uses	0.32	0.33	0.31	0.32	0.58	0.58	0.58	0.58	0.62	0.63	0.64	0.67	0.67	0.69	0.75	0.76	0.79
Unaccounted for Water(1) (DSL)	1.7	0.84	0.95	1.86	1.97	0.91	1.70	2.24	0.98	1.84	2.46	1.05	1.97	2.64	1.18	2.23	3.04
Total ADD	**26.42**	**25.77**	**23.30**	**24.53**	**25.40**	**26.04**	**26.93**	**27.62**	**28.11**	**29.21**	**30.30**	**30.06**	**31.30**	**32.63**	**33.85**	**35.46**	**37.52**
Total MDD(2)	**54.48**	**51.13**	**49.29**	**48.16**	**54.48**	**52.65**	**56.29**	**58.86**	**55.99**	**60.19**	**63.70**	**58.90**	**63.49**	**67.54**	**64.80**	**70.31**	**75.96**

Notes:
(1) See description of DSL calculation in Section2.3.4.
(2) No peaking factor was applied to the Industrial Reserve.

The ADD by pressure zone for the medium demand scenario is summarized in Table 2.15. Appendix 2B provides the low, medium, and high projections for all pressure zones. The majority of the future ADD is projected to remain in the Heights High Zone. This zone also has the greatest growth potential and increase in demands by the year 2034. The largest demand increases in the Heights High Zone are from the industrial reserve, followed by single-family residential development. The Vancouver Low, Heights Low, and Evergreen High Zones are projected to increase substantially; however, these demand increases are only about 25 percent of the increase in the Heights High Zone. While remaining relatively low, the Evergreen High Zone is projected to undergo a demand increase from 10,000 gpd in 2013 to 130,000 gpd in 2034. Growth in the Vancouver Low Zone is expected to occur largely along the waterfront with increased demand from industry, commercial, and government users. Relatively little increase in demand is projected in the Vancouver High Zone and no increase in demand is predicted in the small Lincoln High and Terrace High Zones, as these areas are already generally built out.

Table 2.15 Summary of ADD by Pressure Zone: Medium Demand Scenario (gpd)

Pressure Zone	2014	2020	2024	2034
Evergreen High	10,000	70,000	90,000	130,000
Heights High	19,310,000	20,590,000	22,200,000	25,910,000
Heights Low	1,190,000	1,230,000	1,280,000	1,370,000
Lincoln High	120,000	120,000	120,000	120,000
Terrace High	90,000	90,000	90,000	90,000
Vancouver High	3,090,000	3,140,000	3,150,000	3,210,000
Vancouver Low	3,120,000	3,970,000	4,360,000	4,640,000
Total	**26,930,000**	**29,210,000**	**31,290,000**	**35,470,000**

The MDD by pressure zone for the medium demand scenario is summarized in Table 2.16. Growth in the projected MDD is consistent with the ADD, with the majority of demand projected to remain in the Heights High Zone.

The potential range in future demands presented in this Chapter does not account for demand reductions associated with additional water use efficiency measures by the City. These demands are summarized in Chapter 4.

Table 2.16 Summary of MDD by Pressure Zone: Medium Demand Scenario (gpd)

Pressure Zone	2014(1)	2020(1)	2024(1)	2034(1)
Evergreen High	10,000	160,000	190,000	280,000
Heights High	40,540,000	43,010,000	45,620,000	51,430,000
Heights Low	2,480,000	2,600,000	2,680,000	2,870,000
Lincoln High	250,000	250,000	250,000	260,000
Terrace High	190,000	190,000	190,000	190,000
Vancouver High	6,480,000	6,580,000	6,620,000	6,750,000
Vancouver Low	6,340,000	7,400,000	7,940,000	8,530,000
Total	**56,290,000**	**60,190,000**	**63,490,000**	**70,310,000**

Notes:
(1) No peaking factor was applied to the Industrial Reserve.

Chapter 3

SYSTEM ANALYSIS

3.1 INTRODUCTION

This chapter evaluates the ability of the City of Vancouver's (City's) water system for adequacy in meeting current and future customer demands. Included in this chapter and the associated appendices is a summary of the City's design standards and criteria, water quality analysis, the system descriptions and analyses for the general system, supply sources, water treatment, storage, pumping, and the distribution system, and lastly, a summary of recommended improvements. The items included in this chapter follow the Washington Department of Health (DOH) outline for Chapter 3 – System Analysis.

3.2 SYSTEM DESIGN STANDARDS & CRITERIA

The City's design and operation standards help ensure that the system is able to provide an acceptable level of service to its water customers. The City's standards meet or exceed regulatory requirements established by Washington State Departments of Health and Ecology and/or the United States Environmental Protection Agency (USEPA). A full summary of the City's policies, planning considerations, and design and construction criteria is provided in Chapter 1, Tables 1.3 through 1.9. Chapter 7 summarizes the City's distribution facilities design and construction standards. Related design standards and criteria are summarized under each of the evaluations presented below to establish the goals of each evaluation.

3.3 WATER QUALITY ANALYSIS

The City chlorinates and fluoridates all supply sources and further treats some sources for iron/manganese removal, pH adjustment, and removal of other contaminants. Treatment facilities are summarized for each water station in Chapter 1, Section 1.8. Chapter 1, Section 1.7 presents the City's policies, planning considerations, and design and construction criteria. The following policies relate to water quality:

- Provide safe, clean, quality drinking water to every home, business, and industry in Vancouver's water service area (Table 1.3);
- The City will conduct a water quality monitoring program that meets the requirements of WAC 246-290 (Table 1.9).

Technical Memorandum (TM) 4 – Water Quality Analysis (Appendix 3A) presents a detailed review of the City's water quality monitoring program, current and future regulatory requirements, and reviews the City's compliance with all regulations. The City regularly tests water quality of its source wells raw water, finished water at treatment facilities, and several locations throughout the distribution system. The City's 2007 to 2013 water quality sampling test results and annual water quality reports were reviewed for compliance. As discussed in TM 4, the City is in full compliance with treatment, monitoring, and reporting requirements established by the Washington DOH and the USEPA.

Recent regulations to affect the City include the Stage 2 Disinfectant/Disinfection Byproduct Rule (DBPR) and the revised Total Coliform Rule. The City met the protocol for implementing these new rules and is now in compliance with the associated monitoring requirements. The City is staying abreast of future water quality regulations that may arise.

3.4 GENERAL SYSTEM DESCRIPTION AND ANALYSIS

Chapter 1 provides a detailed description of the City's water supply and distribution system, including a schematic of the City's seven pressure zones, water stations, and pressure regulating valves. Descriptions of each water station are provided in Section 1.8.1 on the water facility fact sheets. The City performed a high-level condition assessment of its water stations to identify facilities in need of repair, especially those that are also identified to have a capacity deficiency. TM 1 – Water Station Facilities Condition Summary Report (Appendix 3B) presents the results of the condition assessment. In general, the City's water facilities appear to be in good condition. Facilities that were recommended for repairs include the following:

Water Station 1

- Wells 3 and 4: Improve or replace existing buildings; ensure proper drainage with new structures.
- 0.25-MG Tank: Replace or retrofit the tank as recommended by the 2012 seismic study to address seismic deficiencies.
- 1-MG Reservoir: Replace or retrofit the reservoir as recommended by the 2012 seismic study to address seismic deficiencies (including roof replacement).
- 4-MG Reservoir: Replace or retrofit the reservoir as recommended by the 2012 seismic study to address seismic deficiencies (including roof replacement).
- Tower BPS (BPS 1, 2, 3):
- Repair roof of the building to address excess leakage;
- Repair or replace Pump 2; or
- Full BPS Replacement.
- Tower BPS (BPS 4, 5): Possible full replacement due to proximity to 1-MG Reservoir.
- Further investigate condition of buried piping that serves the 1 MG and 4 MG booster stations.
- St. Johns BPS: install electrical components to utilize existing flow meter.

Water Station 3

- Replace the existing 1.25-MG reservoir as soon as possible.
- Perform a structural assessment of the 0.25-MG tank to assess for a retrofit or replacement.
- Replace Booster Pump No. 1;
- Consider replacement of entire Water Station 3 BPS facility when the reservoir is replaced.
- Add flow meters at each BPS pump.

Water Station 4

- Replace Well 4 building.
- Address leak at the base of Well 3.

Water Station 5

- Install electrical components to allow BPS pump flow meter to function.

Water Station 7

- Repair structural damage caused by fluoride corrosion.

Water Station 8

- Use a wet-vacuum or sump pump to keep floor of fluoride room dry.

Water Station 9

- Replace BPS pump flow meters. Since completion of TM 1, the City noted that the pump impellers are also in need of replacement.

Water Station 15

- Resolve screening issues on Well 4 to increase production from this station.

Ellsworth Water Station

- Repair roof of treatment building to prevent further water damage to equipment.
- Replace BPS 1 flow meter.

Remaining Useful Life Pipe Replacement Schedule

- Given the remaining useful life of pipes based on age and material, continue to replace approximately 5,000 LF of pipe per year until an asset management program provides further direction.

The following sections provide the description and analysis for supply sources, water treatment, storage, pumping, and the distribution system in more detail.

3.5 SUPPLY SOURCES DESCRIPTION AND ANALYSIS

3.5.1 General Description & Condition

The City's supplies are described in Chapter 1, Section 1.8. The condition of the supply facilities was reviewed in TM 1 – Water Station Facilities Condition Summary Report (Appendix 3B). Additionally, Table 3.1 presents a water station source capacity inventory that reviews the water rights and well pumping, booster pumping, treatment, and backup capacities associated with each water station. Table 3.1 was updated to include the capacities after the Water Station 1 Upgrade Project is complete that is currently under design. Given the capacities of each of these components, the limiting capacity is also noted. A review of well water rights is provided in Chapter 4.

The City's wells rely on a series of aquifers. The information contained in Section 3.5.1.1 through Section 3.5.1.6 on the aquifers underlying the City is repeated from the City's last water master plan; this Plan did not update the aquifer data.

Table 3.1 Water Station Source Capacity Inventory – After Water Station 1 Improvements

Water Station	Instantaneous Water Rights (gpm)	Well Pumping Capacity (gpm)	Back-up Well Pumping Capacity (gpm)	Treatment Capacity (gpm)	Zone Served by Well	BPS	BPS Capacity (gpm)	Back-up BPS Capacity (gpm)	Zone Served by BPS	Limiting Capacity (gpm)	Limiting Component	Storage Capacity (MG)	Zone Served by Storage
1	23,400	26,270	16,280[5]	19,000[1]	Vancouver Low	Tower	6,780	3,000[5]	Vancouver High	23,400[1]	Water Rights	1.0	Vancouver Low
						St. Johns	4,480	3,200[5]	Heights High			4.0	Vancouver Low
						1 to 5	14,460	6,000[5]	Heights Low			0.25	Vancouver high
3	6,000	6,175	0	NA	Vancouver High	WS 3 BPS	6,000	0	Vancouver High	6,000	BPS Capacity and Water Rights	0.9	Vancouver High
												0.25	Vancouver High
4	10,700	8,550	0	8,550	Heights Low	WS 4 BPS	12,000	0	Heights Low	8,550	Well Pumping & Treatment Capacity	NA	NA
5	NA	NA	NA	NA	NA	WS 5 BPS	8,250	0	Heights High	NA	NA	0.75	Heights High
												8.0	Heights Low
6	2,400	0	0	NA	NA		NA		NA	NA	NA	1.0	Heights High
7	1,750	1,300	0	500[2]	Heights High		NA		Heights High	1,300[2]	Well Pumping Capacity	1.0	Heights High
8	2,750	1,250	0	NA	Heights High		NA		Heights High	1,250	Well Pumping Capacity	NA	NA
9	10,872	9,800	9,800	NA	Heights High	WS 9 BPS	20,000	10,000	Heights High	9,800	Well Pumping Capacity	7.0	Heights High
14	3,200	3,200	3,200	3,200	Heights High	WS 14 BPS	3,200	3,200	Heights High	3,200	All Equal	NA	NA
15	5,000	1,000	0	1,000	Heights High	WS 15 BPS	NA	NA	Heights High	1,000	Well Pumping & Treatment Capacity	NA	NA
Ellsworth	9,000	6,800	4,300	7,500[3]	Heights High	Ellsworth BPS	19,800	7,200	Heights High	6,800	Well Pumping Capacity	NA	NA
Total (gpm)	75,072	64,345	33,580				94,970[4]	32,600[4]		61,300		24.15	
Total (mgd)	108.1	92.7	48.4				136.8[4]	46.9[4]		88.3			

Notes:

(1) Not all WS 1 wells require treatment. Therefore, treatment capacity does not limit WS 1 capacity.
(2) The WS 7 greensand filter (500-gpm capacity) treats Well 2b only. Therefore, treatment capacity does not limit WS 7 capacity.
(3) Treatment capacity of 7,500 gpm represents the peak rate. Design capacity under normal filtration rates is 6,000 gpm.
(4) Does not include BPS capacity at the 45th Street, 49th Street, Bagley Downs, or Terrace High Booster Pump Stations.
(5) Back-up capacity after currently planned improvements are made at WS 1.

3.5.1.1 Aquifer Sources and Hydrogeology

The greater Vancouver/Portland area is underlain by a series of aquifers within unconsolidated to semi-consolidated sediments found above the basalt bedrock of the region. The shallowest of these is the Upper Orchards Aquifer found beneath the upland areas north of the Columbia River. The next aquifer is the Lower Orchards Aquifer, which exists at and somewhat below sea level and is typically associated with the more recent deposits of the Columbia River.

The Pleistocene Alluvium has two distinct facies. The Pleistocene Alluvium consists of a series of sand deposits laid down by the relatively recent processes of the Columbia River and subsequently covered by the silt and fine sand associated with flood events in recent time. In some cases, the Columbia River Deposits are laid directly over the Lower Orchards Aquifer, forming a single hydrogeologic unit. The Lower Orchards Aquifer is underlain by the Troutdale Aquifer.

Because the upper portions of the Troutdale Aquifer generally exhibit substantially lower hydraulic conductivity than deeper portions, the Troutdale Aquifer functions as a confined aquifer system with the upper portions of the geologic unit serving as the confining unit. The Troutdale Aquifer is underlain by a series of lacustrine deposits dominated by silt and clay. This unit is referred to as the Lower confining unit and it is often several hundred feet thick. Beneath the Lower Confining unit, a 100-foot-thick sequence of unconsolidated to semi-consolidated sand and gravel is encountered throughout the region. This unit is identified as the Sand and Gravel Aquifer (SGA).

The City's wells provide potable water from three distinct regional aquifers. The upper two aquifers, the Orchards Aquifer (Upper and Lower) and the Upper Troutdale Aquifer, are comprised of unconsolidated sediments and serve as the principal municipal water supply aquifers in Clark County. Where these two shallow aquifers are not present, the deeper SGA can be a significant source of groundwater. This aquifer is a source of supply for several Clark Public Utilities and City of Vancouver public water supply wells. It is also a principal groundwater supply for the City of Portland. It was historically termed the Sandy River Mudstone Aquifer. It will be used throughout this document as the Sand and Gravel Aquifer (SGA).

The Orchards and Upper Troutdale aquifers are generally unconfined and receive recharge directly from the land surface as rainfall infiltration, drywells that receive storm water, septic system return flows, and infiltration from rivers and other surface water bodies. In most areas, the deeper SGA aquifer is recharged by downward migration of groundwater from the shallower aquifers and induced infiltration from the Columbia River. In general, recharged water moves downward from where it first enters the ground to the first saturated sediments. It then moves laterally toward a discharge point such as streams, rivers, or lakes. In the Clark County area, groundwater generally flows in a westerly or southerly direction from the foothills of the Cascades toward the Columbia River, which serves as the regional discharge point for the regional systems. Shallower aquifers whose base is at a higher elevation than the Columbia can discharge in part to more local surface water features such as the tributary streams of the Columbia. Ellsworth and other springs along Highway 14 are an example where the Upper Orchards aquifer discharges as a surface feature.

The Pleistocene Alluvial Aquifer is not currently used as a source aquifer by the City, though several test wells have been completed and tested on the west side of Vancouver Lake and adjacent to the Columbia River. The Pleistocene Alluvial Aquifer under the Vancouver Lake Lowlands receives recharge from the upland Clark County aquifers as flows make their way toward the Columbia River. It is conceivable that the City will avail itself of this resource in future source development projects.

A list of wells operating at each water station and the corresponding aquifer system from which it produces is included in Table 3.2. All of the wells in Water Stations 1, 3, and 4 are screened in the Lower Orchards Aquifer, while the remaining wells in Water Stations 8, 9, 14, and 15 are screened in the Upper Orchards Aquifer. One of the wells in Water Station 7 is screened in the Upper Troutdale Aquifer and the other well is screened in the Sand & Gravel. Finally, all of the wells at the Ellsworth Station (the City's newest production facility) are screened in the SGA.

Table 3.2 Aquifer Source by Water Station

Water Station	Well Number	Aquifer Supply
1	1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13	Lower Orchards (Well 6 abandoned)
3	1, 2, 3	Lower Orchards
4	1, 2B, 3B, 4B, 5B, 9	Lower Orchards
6	Well 4	Upper Orchards
7	1, 2B	1 - Upper Troutdale 2B – Sand and Gravel
8	2, 3	Upper Orchards
9	3, 4, 5, 6, 7	Upper Orchards
14	1, 2, 3	Upper Orchards
15	1, 2, 3, 4	Upper Orchards
Ellsworth	1, 2, 3	Sand and Gravel

3.5.1.2 Hydrogeology

The U.S. Geological Survey (USGS) report, *A Description of Hydrogeologic Untis in the Portland Basin, Oregon and Washington* (Report 90-4196), was the basis for the USGS numerical groundwater model for the Vancouver area. Appendix 3E - Hydrogeologic Cross Sections presents three figures that show a simplified depiction of the cross-sections of the major aquifers and confining units in the Vancouver and Portland area. The figures depict the aquifers, their relationship, and the specific hydrogeologic unit names used on both sides of the river. The geology for Clark County and the Portland area is described by Mundorf (1964) and by Trimble (1963), respectively. The plan adopts the use of hydrogeologic nomenclature rather than geologic unit names to maintain the focus on the groundwater flow characteristics. In those situations where the hydrogeologic unit names are similar to the geologic formation name, the formation name is modified to designate it as an aquifer. For instance, the Upper Troutdale Aquifer is designated as a hydrogeologic unit. Both the Upper Troutdale Aquifer and the Orchards aquifers have been identified as being in the Troutdale geologic formation.

The two uppermost aquifers are subdivided into the Upper and Lower Orchards aquifer based on water table elevation. The water table in the Upper Orchards Aquifer is at an elevation above 50 feet, whereas the water levels in the Lower Orchards Aquifer are at elevations below 50 feet. The Lower Orchards aquifer is connected to the Columbia River either directly or through the more recent Columbia River Deposits Aquifer. This can result in flow from the river into the aquifer during sustained pumping periods. It is postulated that the Upper and Lower Orchards aquifers were formed predominantly by the catastrophic floods of the Pleistocene period. These high-energy events deposited sands and gravels over the broad lowlands along the Columbia River near Vancouver.

The Orchards aquifers are classified as unconfined. Beneath the Upper and Lower Orchards aquifers (and the hydrologically associated Columbia River Deposits), the Upper Troutdale Aquifer is encountered throughout the greater Vancouver area. The Upper Troutdale Aquifer is composed of semi-consolidated sand and gravel with some interbedded fine-grained material. Below the Upper Troutdale formation lies the Lower Troutdale formation. The Lower Troutdale Formation may be correlative with the Troutdale Sandstone Aquifer (TSA) that has been identified in the Portland area. The Lower Troutdale does not support any known wells in the Vancouver area. The lowest portions of the Troutdale consist of silt and clay dominated deposits and functions as a confining unit throughout the region. Below the Troutdale aquifers and the deeper confining material, the Sand and Gravel Aquifer is encountered. In the Vancouver area, the coarse upper section of the aquifer is largely absent and the aquifer includes more fine-grained material.

The three cross-sections shown in Appendix 3E show graphically the hydrogeologic relationships between the aquifers and confining units that define the groundwater resources of the region. Insets showing the plan view locations of these cross-sections are included the figures. Though the primary intent is to describe the aquifers serving the City, where appropriate, sections have been extended to the Portland area. Where this is done, correlation with the hydrogeologic unit names used in the Portland area is provided. Appendix 3E Figures 3.2 and 3.3 show the regional hydrogeology in an east-west and north-south orientation. Appendix 3E Figure 3.4 shows the north-south section through the shallower hydrogeology of Vancouver's Westside where recent resource development efforts have taken place. The subsections below include descriptions of the water level and water quality characteristics of the three primary aquifer sources.

3.5.1.3 Upper Orchards

The Upper Orchards Aquifer supports Troutdale wells at Water Stations 8, 9, 14 and 15. This aquifer is recharged primarily from infiltration of rainfall. The quantity of water available from the aquifer on a sustainable basis is, therefore, highly dependent on the local precipitation pattern. Under normal precipitation conditions, water level elevations in this aquifer range from about 140 to 150 feet above mean sea level depending on the location in the basin (the gradient of this aquifer is quite flat in the area). Water levels in the Upper Orchard Aquifer appear to be very sensitive to precipitation patterns and have historically exhibited seasonal declines of as much as 15 feet. In addition, the smoothed plot of current water levels in this aquifer appears to show a three to five feet lower average than observations made in the late 1970s. Based on this water level trend, future development of wells or well fields in the Upper Orchards Aquifer should be regarded only after a thorough analysis.

The primary water quality concern in the Upper Orchards Aquifer is the presence of nitrate in groundwater, specifically at Water Stations 8, 9 and 14. The City of Vancouver has aggressively addressed this nitrate issue with the development of a septic tank elimination program. The City is constructing sanitary sewers to hundreds of homes near these well fields to eliminate the drain field nitrate contributions. The City does not treat to remove nitrate from the groundwater at Water Station 8 and 9. However, it is conducting monitoring of nitrate concentration as required by the DOH.

3.5.1.4 Lower Orchards

The Lower Orchards Aquifer supports all the wells at Stations 1, 3, and 4. The water levels in this aquifer are slightly above sea level and close to the stage height of the Columbia River. The Columbia River is believed to provide downstream hydraulic stability for the Lower Orchards Aquifer. Thus, the potential yield from properly located well fields in the Orchards Low Level Aquifer is strongly drought resistant. Water levels in this aquifer are resistant to pumping and fluctuate very little under heavy use. The static water levels have shown little or no decline since construction of the oldest wells in the 1940s. With respect to water production and yield, the Lower Orchards Aquifer is the most promising aquifer available to the City.

Water quality concerns have been identified for the Lower Orchards Aquifer. Air stripping towers are installed at Water Stations 1 and 4 to remove any VOC concentrations from these wells. There are a number of environmental cleanup sites within the greater Vancouver area. Most do not present a threat to the City water sources. The exception would be the plume of Tetracholorethylene (PCE) that became known in the late 1980’s. The air stripping towers were installed in response to this contamination. Since the last master plan, the PCE influent levels present at both Water Station 1 and 4 have dropped below the maximum contaminant level. The City continues to operate the stripping towers based on a public commitment. In addition, the strippers provide significant and stable pH adjustment that benefits corrosion control efforts within the water distribution system.

3.5.1.5 Upper Troutdale Aquifer

Well 1 at Water Station 7 produces water from the Upper Troutdale Aquifer. This aquifer is recharged from a downward movement of groundwater from the overlying aquifers, including Upper Orchards Aquifer. Well yields in the Upper Troutdale Aquifer are typically lower than those for the Orchards aquifers. Well and aquifer test data suggest that production from the Upper Troutdale is generally limited by physical characteristics of the aquifer. This aquifer is limited from a quantity standpoint and future development of wells or well fields would provide limited production wells similar to Well 1 at Water Station 7.

The Upper Troutdale Aquifer may be susceptible to contamination from downward leakage from the Upper and Lower Orchards aquifers because there is no regionally significant overlying confining unit. In December 2013, a gas spill from a petroleum shipping company ruptured during an accident discharging over 2,500 gallons to the subsurface. Though there has been no evidence of contamination to the aquifer, the City has hired a consulting firm to model and analyze groundwater movement in response to this spill. Early indicators show there’s an upper layer that follows surface drainage. It is unknown whether or not this localized area contributes significantly to the Upper Troutdale Aquifer and this site will continue to be monitored.

3.5.1.6 Sand & Gravel (SGA)

The Sand & Gravel Aquifer supports Well 2B at Water Station 7 and all the wells at the Ellsworth Water Station. This deep aquifer underlies a large portion of the greater Vancouver area and has a massive volume of stored water. The SGA is believed to receive recharge via infiltration from shallower aquifers and perhaps directly from the Columbia River some distance upstream of the City. The static water levels in this aquifer are typically about 35 feet above sea level. Aquifer characteristics of this highly confined regional groundwater system reflect considerable water level changes in response to pumping. These responses are seen in distant wells and can require several days or weeks for recovery after pumping has stopped. Because the monitoring of this aquifer occurs during almost continuous use, the water levels at Ellsworth reflect as much as 50 feet of drawdown or residual drawdown most of the time. Water levels in Station 7, Well 2B also respond to pumping of the aquifer and are about 20 feet lower than when the well was constructed in 1998. Similar fluctuations in water level responses have been observed in deep wells used by the Cities of Portland and Troutdale, Oregon. The City of Vancouver continues to work closely with other aquifer users, the City of Portland, and SEH America, to better understand the SGA.

The SGA aquifer is a highly confined aquifer with corresponding low vulnerability to surface contamination; however, wells completed in the SGA aquifer show elevated levels of naturally occurring iron and manganese. Treatment facilities have been installed at Water Station 7 (Well 2B) and Ellsworth to remove iron and manganese from water produced by the wells. Iron and manganese are the only water quality concerns associated with the SGA aquifer.

3.5.1.7 Capacity Analysis

Chapter 1, Section 1.7, Table 1.5 presents the City's supply capacity criteria, which is summarized below:

- "Peak redundant source production capacity shall be sufficient to supply maximum day demands."
- "Reliable source production capacity shall be sufficient to supply average daily demands. The City will provide auxiliary power to selected wells as part of establishing reliable supply in each pressure zone."
- "In establishing the source production capacity, the City's existing supply source capacity (groundwater wells) are limited to the established annual withdrawal limits and instantaneous withdrawal limits set by the Department of Ecology. The City will consider the peak seasonal yield and annual sustainable yield for each source based on aquifer characteristics, well performance, and as applicable, maintaining Department of Ecology required groundwater levels."

An analysis comparing existing water supply to future demands is presented in Chapter 4 – Water Rights Analysis and Water Use Efficiency. As reported in the chapter, the City should have adequate supply capacity, given all current water station capacity limitations, to meet future demands for the entire system. However, supply capacity improvements are recommended to provide supply redundancy should the City's largest supply facility, Water Station 1, be offline in the case of an emergency. These improvements include utilizing the full water rights at Water Stations 4, 6, 8, and 15, yielding a potential 10,050 gpm (14.47 mgd) of redundant supply capacity. Supply capacity for each pressure zone is not addressed in Chapter 4, but is included as part of the pumping analysis in Section 3.7.

3.6 WATER TREATMENT DESCRIPTION AND ANALYSIS

3.6.1 General Description & Condition

Chapter 1, Section 1.8 describes the active treatment facilities at each water station. The City disinfects the groundwater produced at its nine water production stations with chlorine and adds fluoride to promote dental health. Three water stations have air stripping towers for removal of VOCs and/or pH adjustment, while two water stations have greensand filtration for iron and manganese removal. One water station adds caustic soda also for pH adjustment. Table 3.1, discussed earlier, summarizes the maximum treatment capacity at each facility.

TM 1 – Water Station Facilities Condition Summary Report (Appendix 3B) summarizes the condition assessment performed at each water station, including the treatment facilities. As noted in TM 1, the treatment facilities are generally in good operation and few repairs relating to treatment facilities are recommended, as summarized in Section 3.4. TM 4 – Water Quality Analysis (Appendix 3A) presents the current monitoring program, historical compliance with water quality regulations, and anticipation of future regulations. Water quality monitoring records from 2007 to 2013 were reviewed for compliance. The City is in full compliance with all Safe Water Drinking Act and Washington State water quality regulations. The City is planning on converting its gas chlorination facilities to use onsite sodium hypochlorite facilities to improve safety and avoid the escalating costs of chlorine gas.

3.6.2 Capacity Analysis

Section 4.3 in Chapter 4 – Water Resources Analysis and Water Use Efficiency compares the supply capacity of all water stations, as limited by water rights, ability to pump, or treatment capacity, to the total system demands.

As described in Chapter 4, treatment capacity limitations were considered at Water Stations 4, 14, and 15. The treatment capacities at Water Stations 1, 7, and Ellsworth were not considered in the evaluation, as they are not assumed to limit production. At Water Station 1, the water quality meets applicable regulations with treatment conducted for public commitment reasons; at Water Station 7 and Ellsworth, the treatment systems are capable of treating the entire capacity of wells that require treatment and capacity is only limited during backwash of the greensand filters.

As summarized in Chapter 4, the City should have adequate supply capacity, given the current water station capacity limitations, to meet future demands for the entire system. However, supply capacity improvements are recommended to provide supply redundancy should Water Station 1 be offline. Any expansion of production at Water Stations 4, 14, or 15 will require expansion of the treatment facilities as well.

3.7 STORAGE AND PUMPING DESCRIPTION AND ANALYSIS

3.7.1 General Description & Condition

Chapter 1, Section 1.8 describes the storage and pumping facilities at each water station. TM 1 – Water Station Facilities Condition Summary Report (Appendix 3B) summarizes the condition assessment performed at each water station, including the storage and pumping facilities. Recommendations from this TM are summarized in Section 3.4 above. The following sections present the supply scenarios used, definitions, and the capacity evaluations for the City's pumping and storage facilities.

3.7.2 Storage and Pumping Analysis Scenarios

Two different distribution system scenarios were evaluated as part of the pumping and storage system analyses: Scenario 1 – Existing System, and Scenario 2 – Water Station 1 Improvements. Scenario 1 consists of the existing distribution system. Scenario 2 consists of the distribution system as it will be configured after completion of the Water Station 1 Upgrade Project. The Water Station (WS) 1 capacity-related improvements include additional back-up power to the wells and booster pump stations (BPSs), replacing the 1-MG Reservoir with a new 3-MG Reservoir, and replacing the 0.25-MG Tank with a 1.0-MG Tank. After Water Station 1 improvements, the Water Station 1 wells will have a total back-up capacity of 16,200 gpm, the Tower BPS will have a back-up capacity of 3,000 gpm, the St. Johns BPS will have a back-up capacity of 3,200 gpm, and the 1 to 5 BPS will have a back-up capacity of 6,000 gpm. Both scenarios were evaluated for the years 2020, 2024, and 2034. Table 3.1, previously presented, summarizes the inventory of the water stations that represents the water system after Water Station 1 improvements.

It was determined as a result of the pumping and storage analyses that the new supplies that are recommended in Chapter 4 (Water Stations 4, 6, 8, and 15) are not required from a pumping and storage perspective. Therefore, the analysis presented in this chapter evaluates the system with the existing supply capacity at these four water stations. The following sections outline the methodology, identified deficiencies, and improvement alternatives for each evaluation.

3.7.3 Definitions

In the discussions below, several terms relating to supply and pumping capacity are used. These are defined as follows:

- **Total capacity** is that capacity provided by the facility with all units operating.
- **Firm capacity** refers to that capacity from any supply that remains after the single largest unit is removed from service. For example, in the case of a pump station housing multiple pumps, the firm capacity would be the capacity of that pump station with the single largest pump offline.
- **Reliable capacity** refers to capacity that is or can be supplied by back-up power. A source is considered reliable if it has back-up power.
- **Reliable, firm capacity** indicates the capacity that remains after the single largest unit is removed from the reliable sources.
- **Source Capacity** is the well capacity in a zone prior to boosting water from another zone.
- **Utilized Capacity** is the well or BPS capacity required to be utilized in order to meet a specific criterion.
- **Redundancy** refers to capacity with the largest source offline.

Additional terms are defined where applicable in the analyses below.

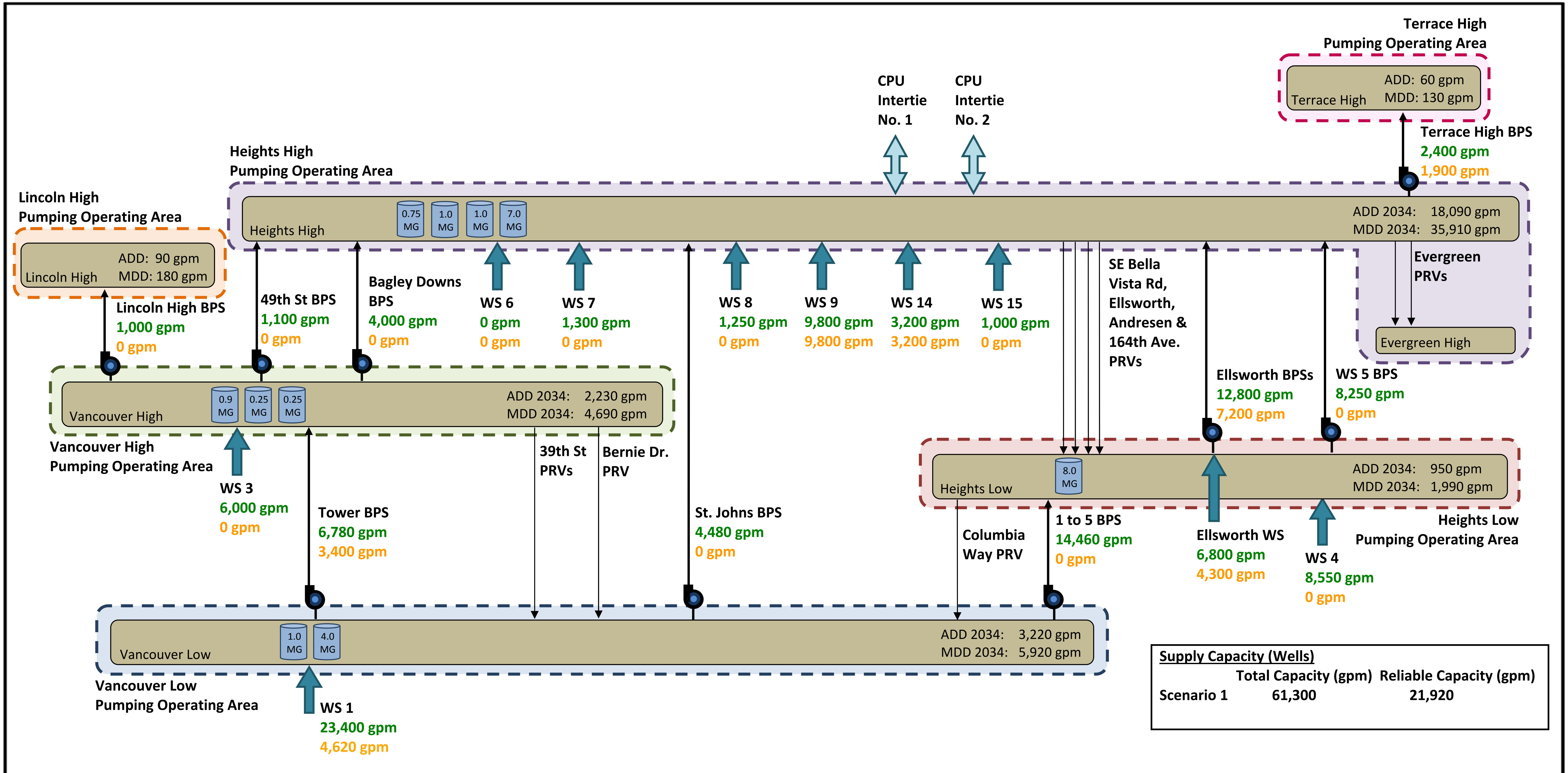
3.7.4 Pumping Analysis

The City's well and booster pump station (BPS) pumping capacity was evaluated for redundancy and reliability based on several criteria, as described below. The criteria were applied to pumping operating areas under conditions of projected future demand based on the medium growth assumptions presented in Chapter 2 to ensure adequate pumping capacity is available to meet increasing future demands. Appendix 3C provides detailed calculations for the pumping evaluation.

3.7.4.1 Pumping Operating Areas

The first step of the pumping analysis was to identify the pressure zones that are served by the same pump stations, herein called “pumping operating areas.” (Specific “storage operating areas” are defined in Section 3.7.5.1). As shown in Figure 3.1, each pressure zone is considered its own pumping operating area except that Evergreen High is part of the Heights High Pumping Operating Area because Evergreen High is served by a pressure-reducing valve (PRV) from the Heights High Zone and therefore relies on the same wells and BPSs as Heights High.

Schematics of the distribution system are shown in Figure 3.1 and Figure 3.2, representing Scenario 1 – Existing System and Scenario 2 – Water Station 1 Improvements, respectively. Green text indicates well and pump station total capacities, as provided by the City. Well and pump station reliable capacities are shown in orange text. As shown in Figure 3.2 compared to Figure 3.1, the reliable capacity increases for Water Station 1 facilities, as well as the storage volumes.



LEGEND

Pressure Zone
Storage Tank
Pump Station
Well Supply Source
Emergency Interties
XXX gpm Total Capacity
XXX gpm Reliable Capacity

Figure 3.1
Pumping Operating Areas – Scenario 1
Comprehensive Water System Plan
City of Vancouver

carollo

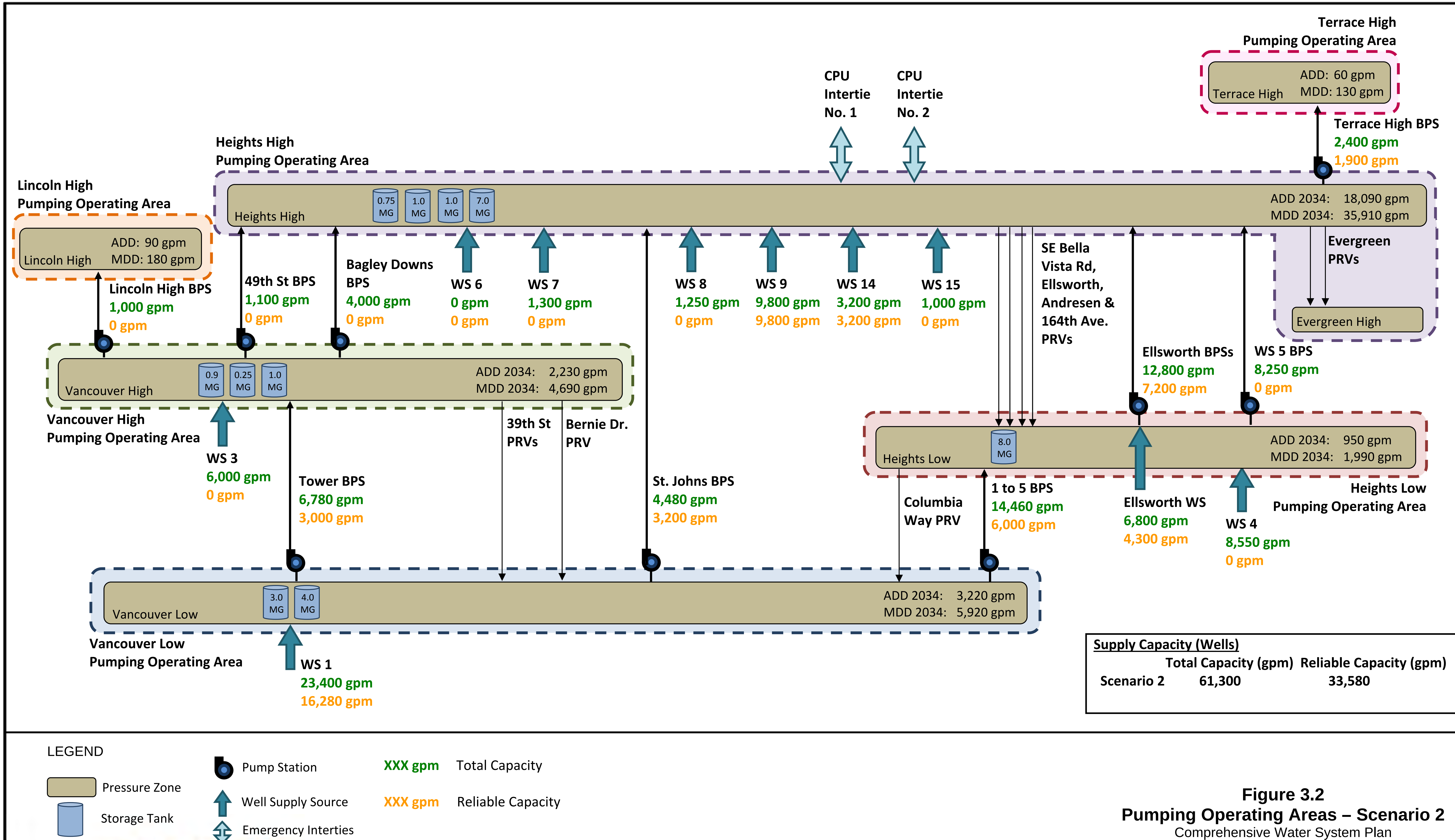


Figure 3.2
Pumping Operating Areas – Scenario 2
Comprehensive Water System Plan
City of Vancouver

3.7.4.2 Pumping Criteria

The City water system's well and BPS capacity for each of the pumping operating areas was evaluated against the following three criteria, established in Chapter 1, Section 1.7, Table 1.5:

1. **Criterion 1 – Back-up Power.** Sources with backup power shall be capable of supplying average day demand (ADD) for the water system. The City will provide auxiliary power to selected booster pumps as part of establishing reliable supply in each pressure zone.
2. **Criterion 2 – Largest Source Removed.** For zones with storage, sources shall be capable of replenishing depleted fire suppression storage within 72 hours while concurrently supplying the maximum day demand (MDD) for the water system with the largest individual pump or well in the zone out of service.
3. **Criterion 3 – Closed Zone.** For pressure zones without storage, booster pumps shall be capable of providing fire flows while concurrently supplying peak hour demand (PHD) for the zone.

The following sections summarize the results of evaluating the system under each criterion.

3.7.4.3 Criterion 1 - Back-up Power

Criterion 1 states:

> "Sources with backup power shall be capable of supplying average day demand (ADD) for the water system. The City will provide auxiliary power to selected booster pumps as part of establishing reliable supply in each pressure zone."

To meet this criterion, booster pumps with backup power are utilized to transfer excess supply from the Vancouver Low and Heights High Pumping Operating Areas to other operating areas.

3.7.4.3.1 *Scenario 1 - Existing System*

Under Scenario 1, five of the six pumping operating areas are not able to provide ADD with only backup sources by 2034. This result is due to the fact that by 2034 the total reliable supply capacity of the entire water system is not sufficient to meet ADD. Figure 3.3 shows how water was assumed to be transferred through the distribution system to meet ADD with only reliable sources. Orange text indicates the reliable capacity and purple text indicates the capacity utilized to meet demands. The supply from wells with back-up power were first used to meet demands in the zone where they are located. Purple arrows represent flow boosted to upper zones from lower zones in which excess supply was available. Values in red boxes indicate the supply deficit in each area after transfer of supply through the BPSs.

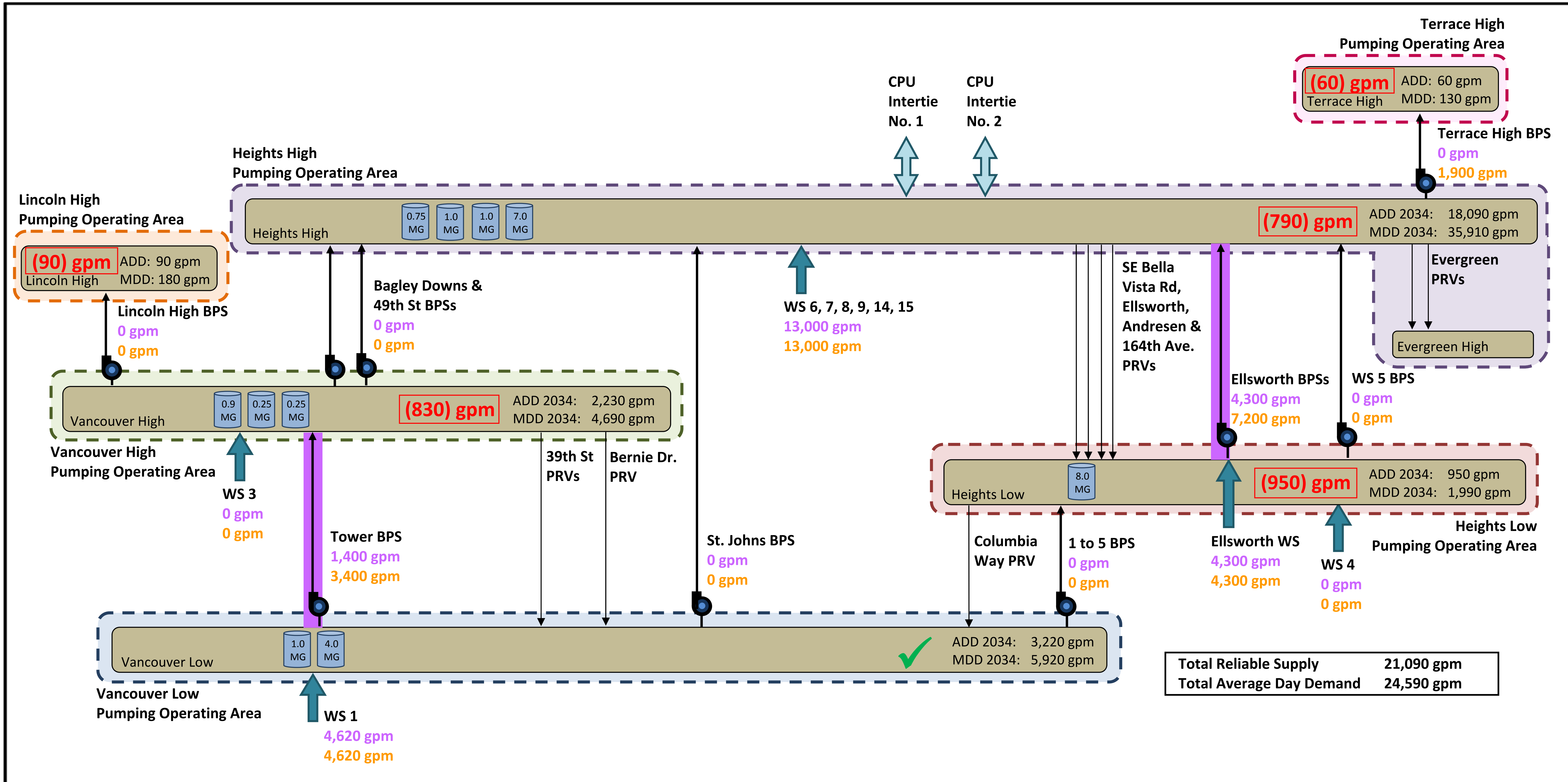
The calculations for this analysis are shown in Table 3.3. The term "source capacity" herein refers to the well capacity in a zone prior to boosting water from another zone. The Ellsworth wells are considered part of the Heights High source capacity because their flow is typically boosted directly to the Heights High Zone.

Heights Low, Heights High, and Terrace High meet Criterion 1 for years 2020 and 2024, but have deficits in 2034. Lincoln High and Vancouver High do not meet Criterion 1 in any of the planning years. However, the Lincoln High Zone can be supplied the ADD at 30 psi when the pump station is offline via a bypass pipe connected to the Vancouver High Zone. Therefore, the Lincoln High Zone is not considered deficient under Criterion 1.

Vancouver High has no wells with backup power and the existing backup capacity of the Tower BPS is not sufficient to supply ADD for the Vancouver High Operating Area. Furthermore, there are no PRVs from the Heights High Operating Area to the Vancouver High Operating Area, so none of the surplus supply in the Heights High Zone, which is available in years 2020 and 2024, can be transferred to the Vancouver High Zone under Criterion 1 conditions. Full calculation tables are supplied in Appendix 3C. Table P-1 in the appendix shows the calculations for Criterion 1, Scenario 1.

3.7.4.3.2 *Scenario 2 - Water Station 1 Improvements*

Under Scenario 2, with the Water Station 1 improvements, total reliable supply is sufficient to meet total ADD of the system in all the planning years. This is due to the back-up power improvements that increase reliable well production and reliable capacities at the Water Station 1 BPSs. Although the 45th Street BPS only has one pump without back-up power supplying the Lincoln High Operating area, the bypass line around the pump allows water to be supplied from the Vancouver High operating area at a lower pressure. Under Scenario 2, there is adequate reliable supply from the Vancouver High operating area to supply the Lincoln High operating area. The resulting ADD pumping scheme for Scenario 2, year 2034 is presented in Figure 3.4. Calculations for Criterion 1, Scenario 2 are presented in Table 3.4.



LEGEND

- Pressure Zone
- Storage Tank
- Pump Station
- Well Supply Source
- Emergency Interties
- XXX gpm Utilized Capacity
- XXX gpm Reliable Capacity
- (XXX) gpm Supply Deficit
- Indicates Operating Area Meets Criterion

Figure 3.3
Criterion 1, Scenario 1,
ADD Pumping Scheme 2034
Comprehensive Water System Plan
City of Vancouver

carollo

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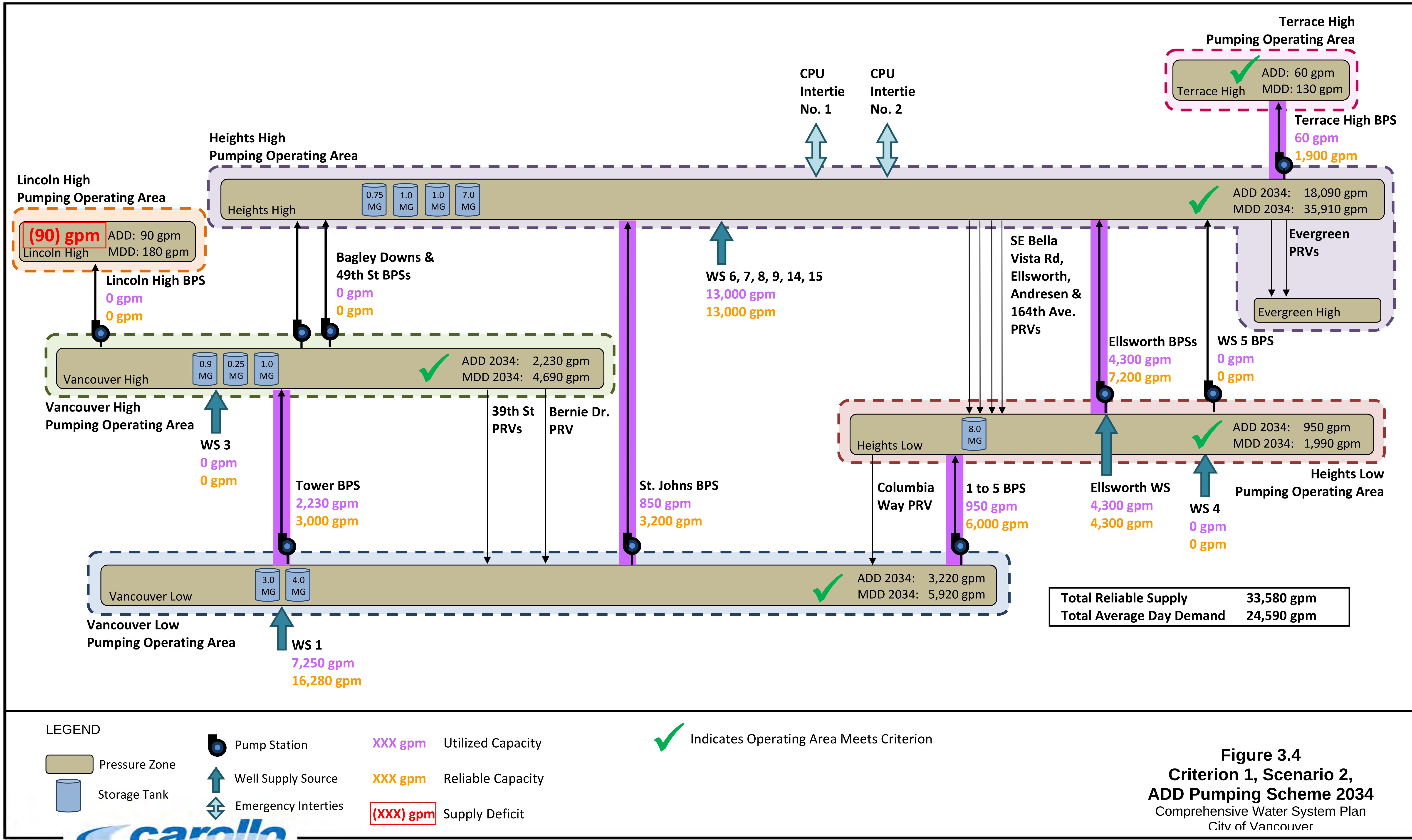

Figure 3.4
Criterion 1, Scenario 2,
ADD Pumping Scheme 2034
Comprehensive Water System Plan
City of Vancouver

Table 3.3 Pumping Analysis Criterion 1 – Back-up Power Results, Scenario 1 – Existing System

	Vancouver Low			**Heights Low**			**Vancouver High**			**Lincoln High**			**Heights High**			**Terrace High**		
	2020	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Total Source Capacity (gpm)	23,400	23,400	23,400	8,500	8,500	8,500	6,000	6,000	6,000	0	0	0	23,350	23,350	23,350	0	0	0
Reliable Source Capacity (gpm)	4,620	4,620	4,620	0	0	0	0	0	0	0	0	0	17,300	17,300	17,300	0	0	0
Requirement, ADD (gpm)	2,760	3,030	3,220	850	890	950	2,180	2,190	2,230	80	80	90	14,350	15,480	18,090	60	60	60
Total Surplus/(Deficit) (gpm)	1,860	1,590	1,400	(850)	(890)	(950)	(2,180)	(2,190)	(2,230)	(80)	(80)	(90)	2,950	1,820	(790)	(60)	(60)	(60)
Booster Pumping Into Area (gpm)							1,860	1,590	1,400							60	60	0
Booster Pumping Out of Area (gpm)	1,860	1,590	1,400										60	60				
PRV Transfer Into Area (gpm)				850	890													
PRV Transfer Out of Area (gpm)													850	890				
Total Surplus/(Deficit), with Flow Transfer (gpm)	**0**	**0**	**0**	**0**	**0**	**(950)**	**(320)**	**(600)**	**(830)**	**0**[1]	**0**[1]	**0**[1]	**2,040**	**870**	**(790)**	**0**	**0**	**(60)**

Notes:
(1) Though Lincoln High Zone appears deficient given the pumping calculations, the zone is able to be supplied through a bypass pipe when the 45th Street BPS is offline.

Table 3.4 Pumping Analysis Criterion 1 – Back-up Power Results, Scenario 2 – Water Station 1 Improvements

	Vancouver Low			**Heights Low**			**Vancouver High**			**Lincoln High**			**Heights High**			**Terrace High**		
	2020	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Total Source Capacity (gpm)	23,400	23,400	23,400	10,700	10	700	6,000	6,000	6,000	0	0	0	31,250	31,250	31,250	0	0	0
Reliable Source Capacity (gpm)	16,280	16,280	16,280	0	0	0	0	0	0	0	0	0	17,300	17,300	17,300	0	0	0
Requirement, ADD (gpm)	2,760	3,030	3,220	850	890	950	2,180	2,190	2,230	80	80	90	14,350	15,480	18,090	60	60	60
Total Surplus/(Deficit) (gpm)	13,520	13,250	13,060	(850)	(890)	(950)	(2,180)	(2,190)	(2,230)	(80)	(80)	(90)	2,950	1,820	(790)	(60)	(60)	(60)
Booster Pumping Into Area (gpm)						950	2,180	2,190	2,230						850	60	60	60
Booster Pumping Out of Area (gpm)	2,180	2,190	4,030										60	60	60			
PRV Transfer Into Area (gpm)				850	890													
PRV Transfer Out of Area (gpm)													850	890				
Total Surplus/(Deficit), with Flow Transfer (gpm)	**11,340**	**11,060**	**9,030**	**0**	**0**	**0**	**0**	**0**	**0**	**0**[1]	**0**[1]	**0**[1]	**2,040**	**870**	**0**	**0**	**0**	**0**

Notes:
(1) Though Lincoln High Zone appears deficient given the pumping calculations, the zone is able to be supplied through a bypass pipe when the 45th Street BPS is offline.

3.7.4.4 Criterion 2 - Largest Source Removed

Criterion 2 states:

> "For zones with storage, sources shall be capable of replenishing depleted fire suppression storage within 72 hours while concurrently supplying the maximum day demand (MDD) for the water system with the largest individual pump or well in the zone out of service."

The results for Pumping Criterion 2 do not differ between Scenario 1 and Scenario 2 because Criterion 2 is not affected by the amount of backup pumping capacity available, which is the only difference between the two scenarios. The volume of fire suppression storage (4,000 gpm for 4 hours = 0.96 million gallons) is the same for each operating area that has storage facilities. The flow required to replenish fire suppression storage within 72 hours is 220 gpm. Lincoln High and Terrace High do not have storage facilities; therefore, the fire storage replenishment requirement is zero.

To evaluate Criterion 2, a baseline MDD flow transfer scheme was developed to show how supply must be transferred throughout the water system in order to provide MDD. The assumed MDD flow transfer scheme for year 2034 is shown in Figure 3.5. Water must be boosted to the Terrace High and Lincoln High zones and excess supply from Vancouver Low, Heights Low, and Vancouver High is boosted to the Heights High Operating Area. In the 2034 scenario, the Vancouver Low Operating Area has a surplus capacity of 12,480 gpm after transferring all supply needed in the upper zones.

After the MDD flow transfer scheme was established, each zone was evaluated independently for its ability to meet Criterion 2. For each zone's evaluation, the largest pump or well supplying the zone was taken offline and the MDD pumping scheme was modified to determine if the remaining zone wells and booster pumps could meet the requirement. Both available supply and booster pumping capacity were taken into consideration when modifying the MDD pumping scheme. Table 3.5 shows the details of the Criterion 2 evaluation for each Operating Area. Each operating area is able to meet Criterion 2.

The Vancouver Low Operating Area is able to meet MDD plus the 220 gpm fire suppression storage replenishment demand even with the largest well pump, which is Well 11 with a 3,400-gpm capacity, offline. In the Vancouver High Operating Area, the largest source is Water Station 3, Well 1 with a 2,000-gpm capacity. As shown in Table 3.5, with this well offline, 2,220 gpm is pumped through the Tower BPS to meet MDD plus fire suppression storage in Vancouver High.

For 2034 in the Heights Low Operating Area, when the 2,000-gpm Water Station 4, Well 2B is offline, a total of 2,740 gpm must be pumped from Vancouver Low to supply Heights Low. This is shown in Table 3.5. In the baseline MDD flow transfer scheme, 520 gpm is pumped from Vancouver Low to supply Heights Low through the 1 to 5 BPS. An additional 2,220 gpm is required to replace the 2,000-gpm Water Station 4, Well 2B that is offline plus the 220-gpm fire suppression storage replenishment demand. This additional 2,220-gpm flow can be pumped through the 1 to 5 BPS from the Vancouver Low Zone for a total boosted flow of 2,740 gpm.

To meet the criteria when evaluating the Heights High Pumping Operating Area in 2034, the largest pump taken offline, is Water Station 5, Pump 4 (capacity of 3,000 gpm). All other pumps in Water Station 5 are operated at full capacity for a total of 5,250 gpm pumped into Heights High. This flow rate (5,250 gpm) is 1,830 gpm less than the baseline MDD transfer scheme flow of 7,080 gpm through Water Station 5. The 1,830 gpm reduction of supply from Water Station 5 plus the additional 220 gpm flow required to replenish fire storage in Heights High (for a total of 2,050 gpm) can be replaced by pumping surplus capacity from Vancouver Low through the Tower BPS and then boosting again from Vancouver High to Heights High through the Bagley Downs and 49th St BPSs. Vancouver Low has sufficient excess supply and the BPSs have sufficient excess capacity to transfer the required 2,050 gpm. Therefore, Heights High meets Criterion 2. Other water transfer schemes could also meet the criterion, such as boosting through the 1 to 5 BPS and then the Ellsworth BPSs.

The Lincoln High Operating Area is able to meet Criterion 2 because the area is still supplied water through a bypass pipe when the 45th Street BPS is offline.

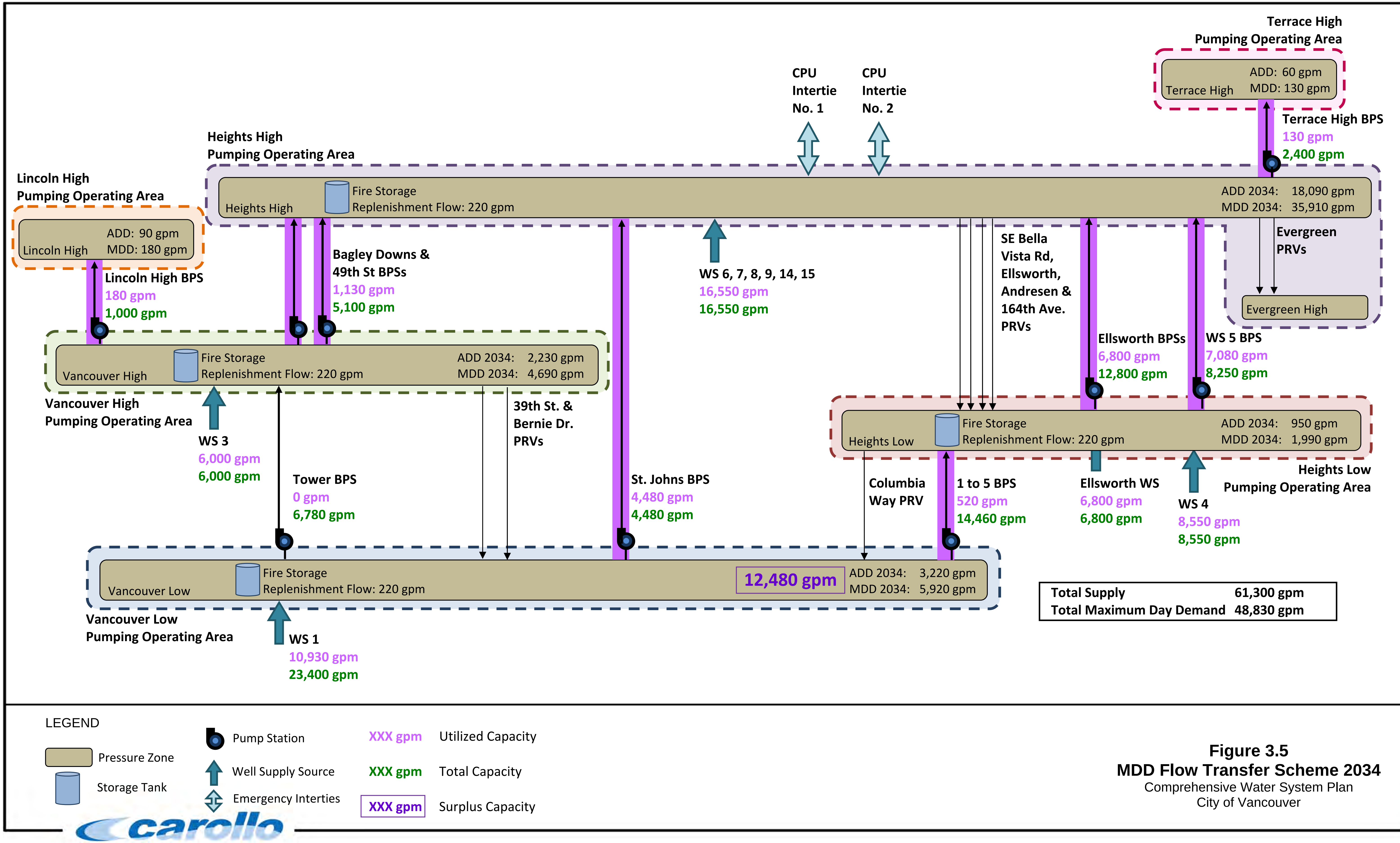

Figure 3.5
MDD Flow Transfer Scheme 2034
Comprehensive Water System Plan
City of Vancouver

Table 3.5 Pumping Analysis Criterion 2 - Largest Source Removed Results

	Vancouver Low			Vancouver High			Lincoln High		
	2020	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Total Source Capacity (gpm)	23,400	23,400	23,400	6,000	6,000	6,000	0	0	0
Largest Pump/Well	WS 1, Well 11	WS 1, Well 11	WS 1, Well 11	WS 3, Well 1	WS 3, Well 1	WS 3, Well 1	LH, BP 1	LH, BP 1	LH, BP 1
Capacity of Largest Pump/Well (gpm)	3,400	3,400	3,400	2,000	2,000	2,000	1,000	1,000	1,000
Firm Source Capacity (gpm)	**20,000**	**20,000**	**20,000**	**4,000**	**4,000**	**4,000**	**0**	**0**	**0**
MDD (gpm)	5,140	5,510	5,920	4,570	4,600	4,690	170	180	180
Fire Storage Replenishment Flow(1) (gpm)	220	220	220	220	220	220	0	0	0
Boosted Flow to Upper Zones for MDD(2) (gpm)	0	680	5,000	1,430(3)	1,400(3)	1,330(3)	0	0	0
Total Requirement (gpm)	**5,360**	**6,410**	**11,140**	**6,220**	**6,220**	**6,220**	**170**	**180**	**180**
Total Surplus/(Deficit) no Boosted Flow (gpm)	14,640	13,590	8,860	(2,220)	(2,220)	(2,220)	(170)	(180)	(180)
Available Flow to Boost into Area (gpm)	0	0	0	6,780	6,780	6,780	170(4)	180(4)	180(4)
Boosted Flow into Area	0	0	0	2,220	2,220	2,220	170(4)	180(4)	180(4)
Total Surplus/(Deficit) with Boosted Flow (gpm)	**14,640**	**13,590**	**8,860**	**0**	**0**	**0**	**0**	**0**	**0**

	Heights Low			Heights High			Terrace High		
	2020	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Total Source Capacity(5) (gpm)	8,550	8,550	8,550	23,350	23,350	23,350	0	0	0
Largest Pump/Well	WS 4, Well 2B	WS 4, Well 2B	WS 4, Well 2B	WS 5, BP 4	WS 5, BP 4	WS 5, BP 4	TH, BP 4	TH, BP 4	TH, BP 4
Capacity of Largest Pump/Well (gpm)	2,000	2,000	2,000	3,000	3,000	3,000	1,900	1,900	1,900
Firm Source Capacity (gpm)	**6,550**	**6,550**	**6,550**	**23,350**	**23,350**	**23,350**	0	0	0
MDD (gpm)	1,810	1,860	1,990	29,980	31,810	35,910	130	130	130
Fire Storage Replenishment Flow(1) (gpm)	220	220	220	220	220	220	0	0	0
Boosted Flow to Upper Zones for MDD(2) (gpm)	5,500	6,690	7,080	130	130	130	0	0	0
Total Requirement (gpm)	**7,530**	**8,770**	**9,290**	**30,330**	**32,160**	**36,260**	**130**	**130**	**130**
Total Surplus/(Deficit) no Boosted Flow (gpm)	(980)	(2,220)	(2,740)	(6,980)	(8,820)	(12,910)	(130)	(130)	(130)
Available Flow to Boost into Area (gpm)	14,460(6)	14,460(6)	12,480(6)	14,830(7)	14,830(7)	14,830(7)	500	500	500
Boosted Flow into Area	980	2,220	2,740	6,980	8,820	12,910	130	130	130
Total Surplus/(Deficit) with Boosted Flow (gpm)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Notes:
(1) Based on replenishing the volume of the design fire flow (4,000 gpm for 4 hours = 960,000 gallons) in 72 hours.
(2) See Figure 3.5 for flow boosted to upper zones in 2034. A similar flow transfer was assumed for earlier years, as shown in the table.
(3) Flow boosted to Heights High and Lincoln High Zones. Available surplus supply from lower zones decreases over time.
(4) Flow is supplied to the area via a bypass pipe when the 45th Street pump is offline.
(5) The Ellsworth supply is assumed to be pumped directly to the Heights High Zone.
(6) Excess flow available from Vancouver Low Zone. In 2020 and 2024, this is the 1 to 5 BPS capacity. In 2034, this is limited by the surplus supply in Vancouver Low Zone.
(7) Includes 4,480 gpm from Vancouver Low Zone, 5,100 gpm from Vancouver High Zone, and 5,250 gpm from Heights Low Zone (WS 5 Pump 4 is offline for the Heights High analysis).

3.7.4.5 Criterion 3 - Closed Zone

Criterion 3 states:

> "For pressure zones without storage, booster pumps shall be capable of providing fire flows while concurrently supplying PHD for the zone."

The Vancouver water system has two closed zones: Lincoln High and Terrace High. Peak hour demand was determined using the City's historical peaking factor of 1.6 applied to the projected MDD for these zones. The Terrace High BPS has sufficient capacity to meet Criterion 3 as shown in Table 3.6. The 45th Street BPS does not have sufficient capacity to pump fire flow plus PHD. The results for Criterion 3 are the same for Scenario 1 and Scenario 2 as the booster pump capacity to these zones is independent of improvements to Water Station 1.

Table 3.6 Pumping Analysis Criterion 3 - Closed Zone Results

	Lincoln High			Terrace High		
Operating Area	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Boost Pump Capacity (gpm)	1,000	1,000	1,000	2,400	2,400	2,400
Peak Hour Demand (gpm)	280	280	290	210	210	210
Fire Flow (gpm)	2,000	2,000	2,000	2,000	2,000	2,000
Surplus/(Deficit) (gpm)	**(1,280)**	**(1,280)**	**(1,290)**	**190**	**190**	**190**

3.7.4.6 Summary of Results

The City's water system has adequate pumping capacity to meet its pumping criteria for the majority of its pumping operating areas throughout all planning years. The pumping analysis results are summarized in Table 3.7. The Water Station 1 upgrades that are planned to be implemented in 2015 add significant pumping reliability to the water system and eliminate Criterion 1 deficiencies for all of the Pumping Operating Areas.

Chapter 4 recommends additional redundant supplies at Water Station 4, 6, 8 and 15 should Water Station 1 be offline. This analysis excludes those additional supplies, and the results indicate that they are not needed to meet the pumping criteria. In general, these new supplies would decrease the amount of pumping required from other zones into the Heights Low and Heights High Pumping Operating Areas.

Table 3.7 Pumping Analysis Results

Pumping Operating Area	Is the Criterion Met?				
	Criterion 1 - Back-up Power			Criterion 2 - Largest Source Removed	Criterion 3 - Closed Zone
	2020	2024	2034	All Planning Years	
Scenario 1 – Existing System					
Vancouver Low	Yes	Yes	Yes	Yes	N/A
Heights Low	Yes	Yes	**No**	Yes	N/A
Vancouver High	**No**	**No**	**No**	Yes	N/A
Lincoln High	Yes(1)	Yes(1)	Yes(1)	Yes(1)	**No**
Heights High	Yes	Yes	**No**	Yes	N/A
Terrace High	Yes	Yes	**No**	Yes	Yes
Scenario 2 – Water Station 1 Improvements					
Vancouver Low	Yes	Yes	Yes	Yes	N/A
Heights Low	Yes	Yes	Yes	Yes	N/A
Vancouver High	Yes	Yes	Yes	Yes	N/A
Lincoln High	Yes(1)	Yes(1)	Yes(1)	Yes(1)	**No**
Heights High	Yes	Yes	Yes	Yes	N/A
Terrace High	Yes	Yes	Yes	Yes	Yes

Notes:
(1) Thought the 45th Street BPS does not meet the pumping criteria, the Lincoln High Operating Area is still supplied water at over 30 psi through a bypass pipe around the pump station.

3.7.4.7 Pumping Recommendations

Given the results of the analysis, the first pumping recommendation is to complete the Water Station 1 improvements as planned. The 45th Street Pump Station serving the Lincoln High Operating Area does not meet Criterion 3 due to insufficient capacity. It is recommended that an additional 1,500 gpm of reliable pumping capacity be installed for the Lincoln High Zone to maintain adequate pressure and supply during a fire in the area. Providing back-up power at this capacity would also improve reliability and redundancy and would provide greater pressure to customers than relying on the existing bypass pipe.

3.7.5 Storage Analysis

The City's storage requirements are based on the water system configuration, projected "medium" demand water use and the reliability of various water system components. The following sections describe the five components of storage, summarize the capacity of the system under both Scenario 1 and Scenario 2 to meet the storage needs of each storage operating area, and present recommendations to address identified storage deficits. As previously described, Scenario 1 is the existing system, and Scenario 2 includes the planned Water Station 1 improvements. The Water Station 1 improvements include additional storage volume in the Vancouver Low and Vancouver High Zones, as noted in the evaluations below. Appendix 3C provides detailed calculations for the storage evaluation.

3.7.5.1 Storage Operating Areas

The water system was grouped into operating areas for the purpose of the storage analysis similar to the pumping analysis. A "storage operating area" is comprised of the pressure zones that rely on the same storage facilities. Figure 3.6 and Figure 3.7 present the four storage operating areas for Scenarios 1 and 2, respectively. The Lincoln High Pressure Zone is part of the Vancouver High Storage Operating Area. The Terrace High and Evergreen High Pressure Zones are part of the Heights High Storage Operating Area.

3.7.5.2 Storage Components and Governing Criteria

Following the Department of Health storage volume requirements (WAC 246-290-235(3)) and Water System Design Manual, Chapter 9, the five components of storage listed below and illustrated in Figure 3.8 must be considered for any water system:

1. Operational Storage.
2. Equalizing Storage.
3. Standby Storage.
4. Fire Storage.
5. Dead Storage.

Operational and Equalizing Storage must be available to all customers at a residual pressure of at least 30 psi under PHD flow conditions. Standby and Fire Storage must be available to all customers at a residual pressure of at least 20 psi under MDD.

Figure 3.8 shows the components of storage required by DOH as well as the hydraulic grade lines (HGL) in a tank that represents the minimum water surface elevations (WSE) that can supply water at 20 psi or 30 psi to all customers. All tank volumes above the HGL are available storage. Thus, there are two blocks of available storage: the volume of storage available to all customers with a pressure of at least 20 psi, and the volume of storage available to all customers at pressure of at least 30 psi. Dead Storage is volume in the tank that cannot be used to serve the highest customer with a pressure of at least 20 psi.

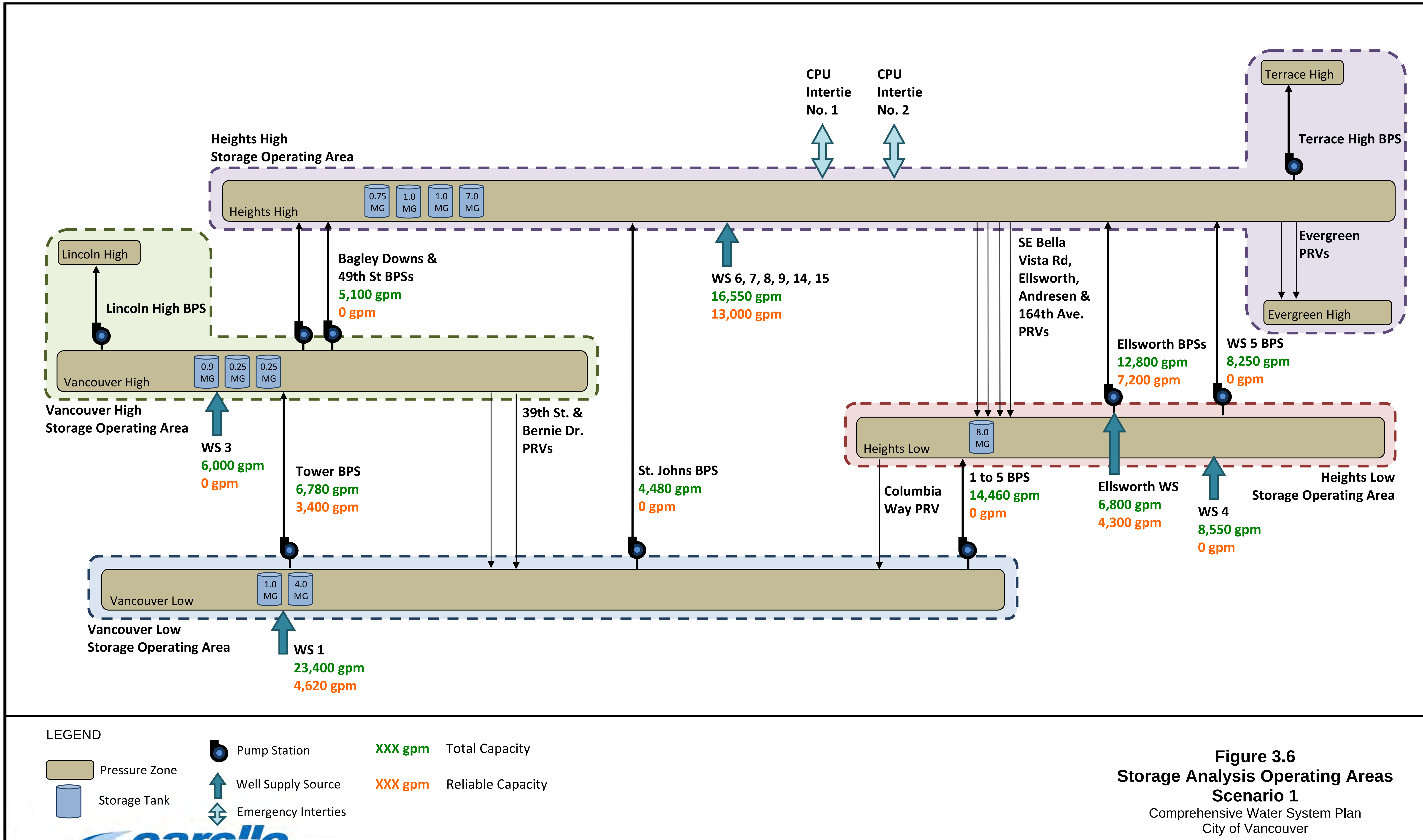

Figure 3.6
Storage Analysis Operating Areas
Scenario 1
Comprehensive Water System Plan
City of Vancouver

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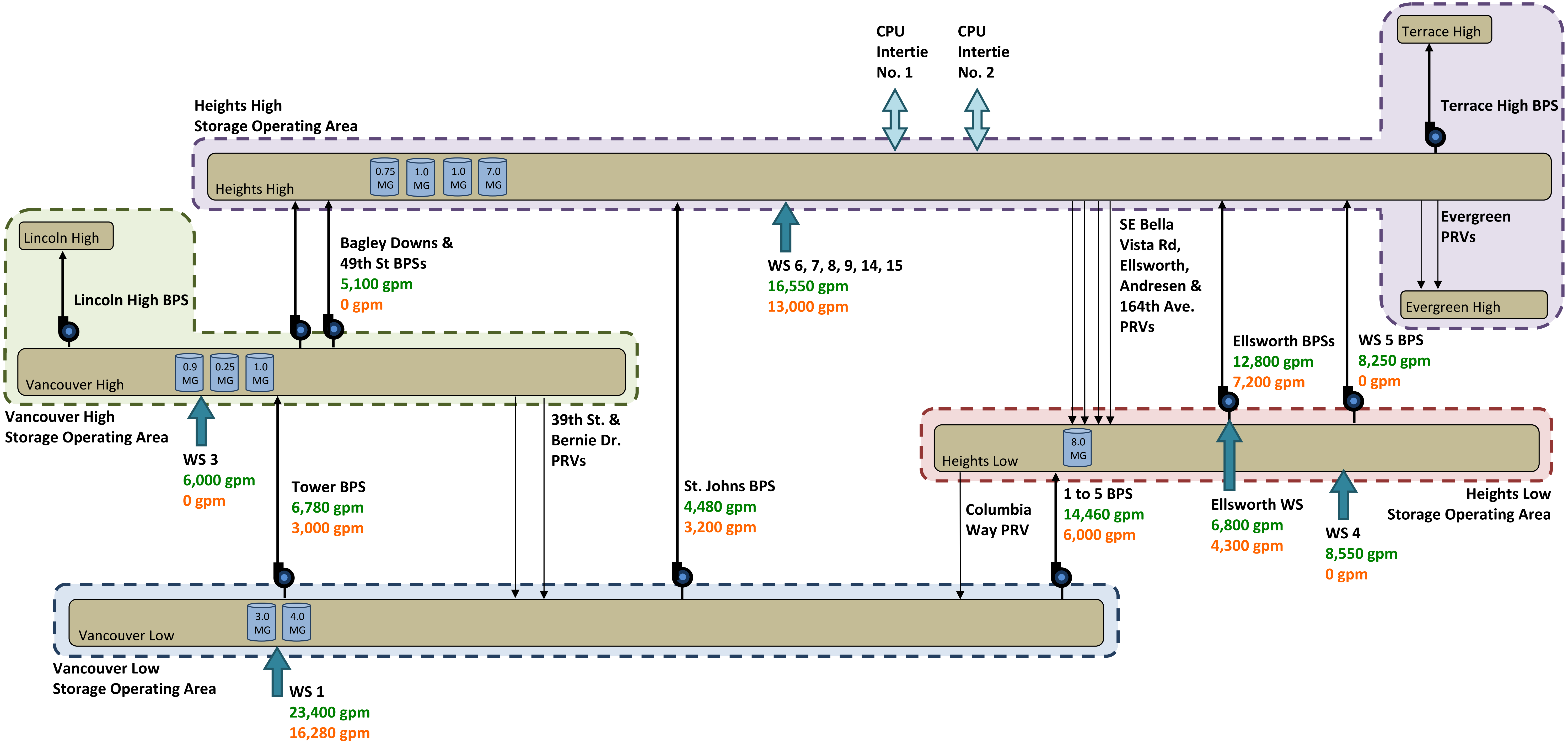

LEGEND

- Pressure Zone
- Storage Tank
- Pump Station
- Well Supply Source
- Emergency Interties
- XXX gpm — Total Capacity
- XXX gpm — Reliable Capacity

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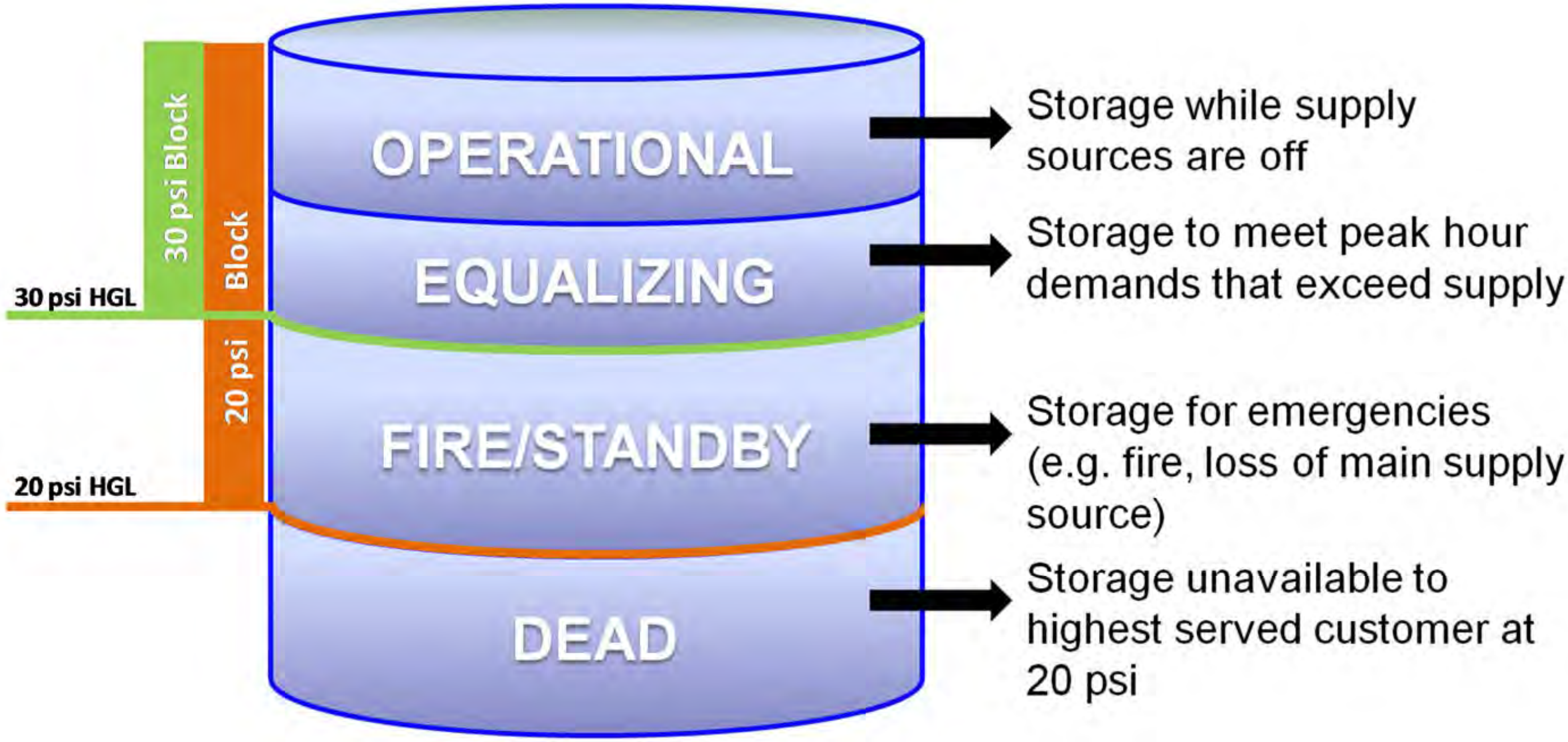
Figure 3.7
Storage Analysis Operating Areas
Scenario 2
Comprehensive Water System Plan
City of Vancouver



STORAGE COMPONENTS

FIGURE 3.8

COMPREHENSIVE WATER SYSTEM PLAN
CITY OF VANCOUVER

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3.7.5.3 Available Storage

The City's water system has 24.15 million gallons (MG) of total storage in its 10 reservoirs. However, the available storage excluding dead storage is significantly less. The available storage in each operating area is controlled by the elevation of the highest customer in the operating area and the HGL required to serve that customer with a pressure of at least 20 psi in the case of a fire or other emergency, or 30 psi under normal conditions. Table 3.8 and Table 3.9 show the highest service elevation in each operating area and the amount of available storage in each operating area meeting the 30 psi and 20 psi requirements for Scenarios 1 and 2, respectively.

Table 3.8 Available Storage, Scenario 1 – Existing System

Operating Area	Vancouver Low	Vancouver High	Heights Low	Heights High
Total Storage (MG)	5.00	1.40	8.00	9.75
Zone HGL (Tank overflow) (ft)	237	322	299	413
Highest Service Elevation (ft)	184	229	200	350
Storage Available above 30 psi HGL (MG)	0	1.25	8.00	7.00
Percent Available above 30 psi HGL	0%	90%	100%	72%
Storage Available above 20 psi HGL (MG)	1.27	1.40	8.00	8.74
Percent Available above 20 psi HGL	25%	100%	100%	90%

Due to high elevation customers, the percent of Vancouver Low storage that is considered available is very low. Vancouver Low has no storage volume that can serve the highest customers at a pressure of 30 psi. Only 25 percent of the Vancouver Low storage is above the 20 psi HGL. Therefore, 75 percent of the Vancouver Low storage is considered dead storage, meaning it is unavailable for meeting the storage requirements of the area when served by gravity from the storage facilities. In the other operating areas, most of the storage is available above the 30 psi and 20 psi HGLs.

As shown in Table 3.9, the total Vancouver Low storage increases by 2.00 MG as a result of replacing the 1-MG Reservoir with a new 3-MG Reservoir. The improvements are estimated to increase the available Vancouver Low storage above the 20 psi HGL to 2.80 MG or 40 percent. Similarly, the Vancouver High storage increases by approximately 0.75 MG as a result of replacing the 0.25-MG Tower 1 with a new 1.0-MG standpipe. However, only portions of the new storage will meet customer pressure requirements in Vancouver High.

Table 3.9 Available Storage, Scenario 2 – Water Station 1 Improvements

Operating Area	Vancouver Low	Vancouver High	Heights Low	Heights High
Total Storage (MG)	7.00	2.15	8.00	9.75
Zone HGL	237	322	299	413
Highest Service Elevation (ft)	184	229	200	350
Storage Available above 30 psi HGL (MG)	0	1.31	8.00	7.00
Percent Available above 30 psi HGL	0%	61%	100%	72%
Storage Available above 20 psi HGL (MG)	2.80	1.64	8.00	8.74
Percent Available above 20 psi HGL	40%	76%	100%	90%

3.7.5.4 Required Storage – Operational

Operational Storage is the band of storage within each reservoir that is utilized during periods of average demand. It is typically estimated based on the amount each reservoir drops prior to calling on the supply sources, and is measured as the volume of water stored between the pump call-off and pump call-on levels. The city defines Operational Storage as five percent of the volume of each tank or reservoir. Operational Storage volumes for each Operating Area are shown in Table 3.10.

3.7.5.5 Required Storage – Equalizing

Equalizing Storage is the volume needed to satisfy the PHD. The City defines required Equalizing Storage for a Storage Operating Area as 15 percent of MDD. Equalizing Storage requirements are shown in Table 3.10.

3.7.5.6 Required Storage – Fire and Standby

Storage for emergencies is comprised of Fire Storage and Standby Storage. For the City water system, these two components of storage are nested, which means that the volume of storage reserved for emergencies consists of whichever requirement is greater, Fire Storage or Standby Storage.

Fire Storage is the volume of storage required to deliver fire flows as prescribed by local fire protection authorities, while maintaining a minimum pressure of 20 psi throughout the entire water system. Since a fire can occur at any time during the day, the fire storage must be in addition to the equalizing and operational storage.

The maximum fire flow required in each of the storage operating areas is 4,000 gpm for a duration of 240 minutes (4 hours). This results in a Fire Storage requirement of 0.96 MG for each operating area.

Standby Storage is the volume of storage required to supply reasonable system demands during a system emergency, such as disruption of the water supply. Disruptions could be caused by transmission pipeline or equipment failure, power outage, valve failure, or other system interruptions. The computation of emergency/standby storage requirements includes consideration of reasonable system disruptions that can be expected to occur within normal planning contingencies, and does not consider major system emergencies, such as earthquakes that result in shutdown of water supplies and multiple distribution system breaks. These types of emergencies should be covered under emergency system operation planning.

The City's Standby Storage policy is that each storage operating area should have enough Standby Storage to supply ADD for two days utilizing only wells and pump stations with backup power and with the largest reliable well or booster pump to each operating area off-line. The following equation is used to calculate required Standby Storage volumes.

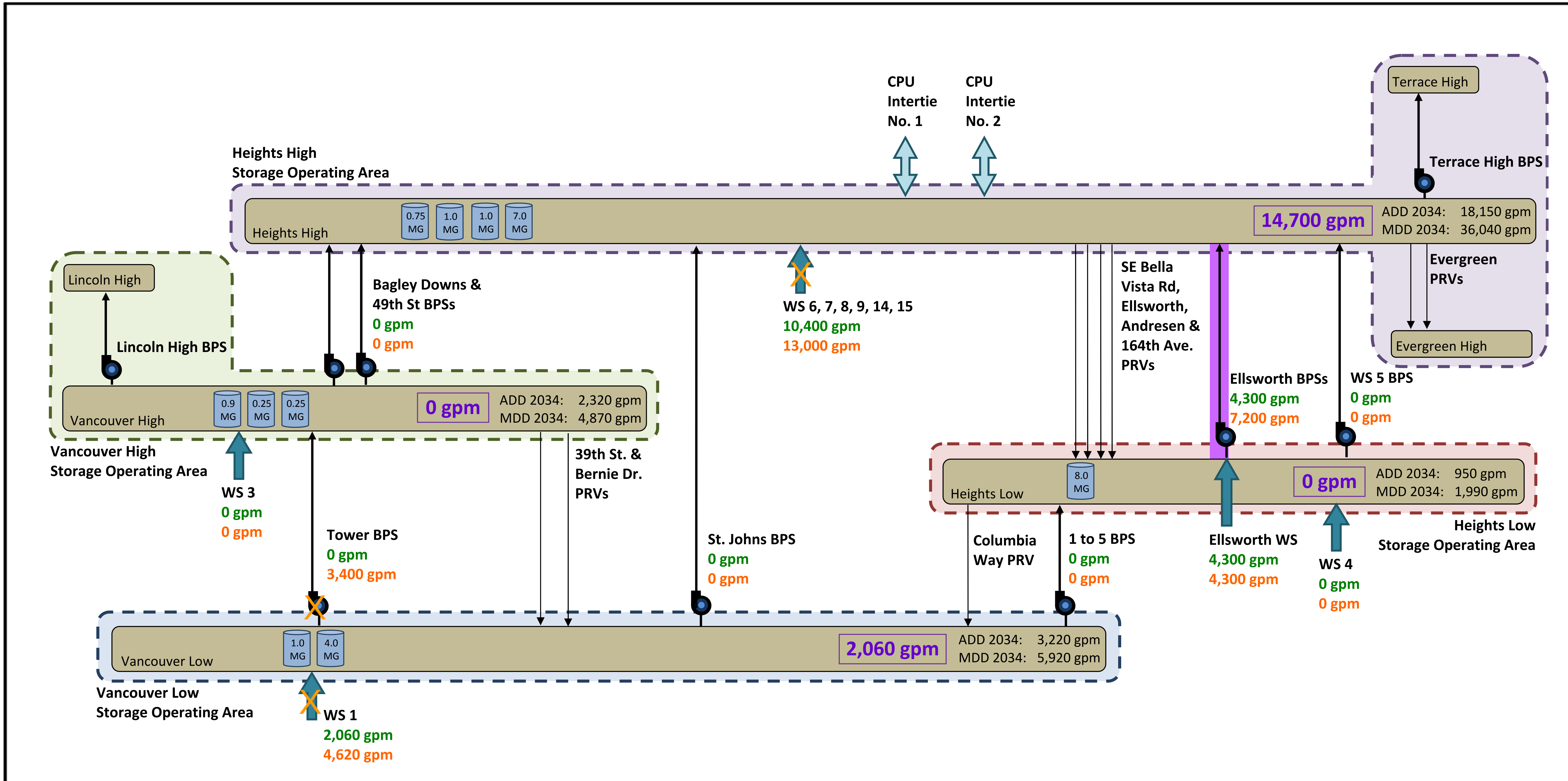
$$SS = 2 \text{ days} * (ADD - Q_{R,F})$$

Where: SS = Standby storage volume, in gallons.

ADD = Average day demand, in gpd.

$Q_{R,F}$ = Sum of all reliable supply capacities to the operating area, with the largest reliable supply out of service, in gpd.

The sum of all reliable supply capacities to the operating area includes both reliable well supplies and supply boosted to the operating area by reliable booster pump stations on a maximum demand day. For each scenario, an Emergency MDD transfer scheme was established to determine the reliable, firm supply ($Q_{R,F}$) for each operating area to be used to calculate standby storage. These are shown in Figure 3.9 and Figure 3.10. The Emergency MDD transfer scheme is different than the MDD flow transfer scheme used for the pumping analysis. In the figures, $Q_{R,F}$ is called the "adjusted operating area reliable, firm supply" to indicate that it includes not only well supply, but also takes into account supply boosted into and out of the operating area. These values were used in the equation above to determine the standby storage volume required. Appendix 3C presents detailed calculations for the storage requirements. The Fire and Standby Storage requirements for each operating area, for both scenarios are shown in Table 3.10.



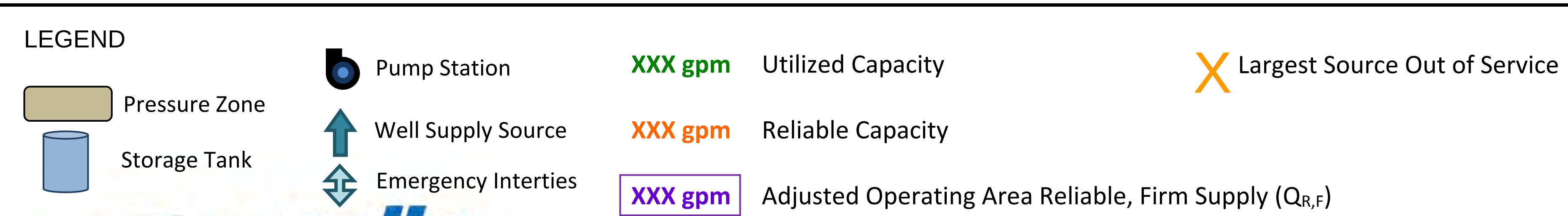
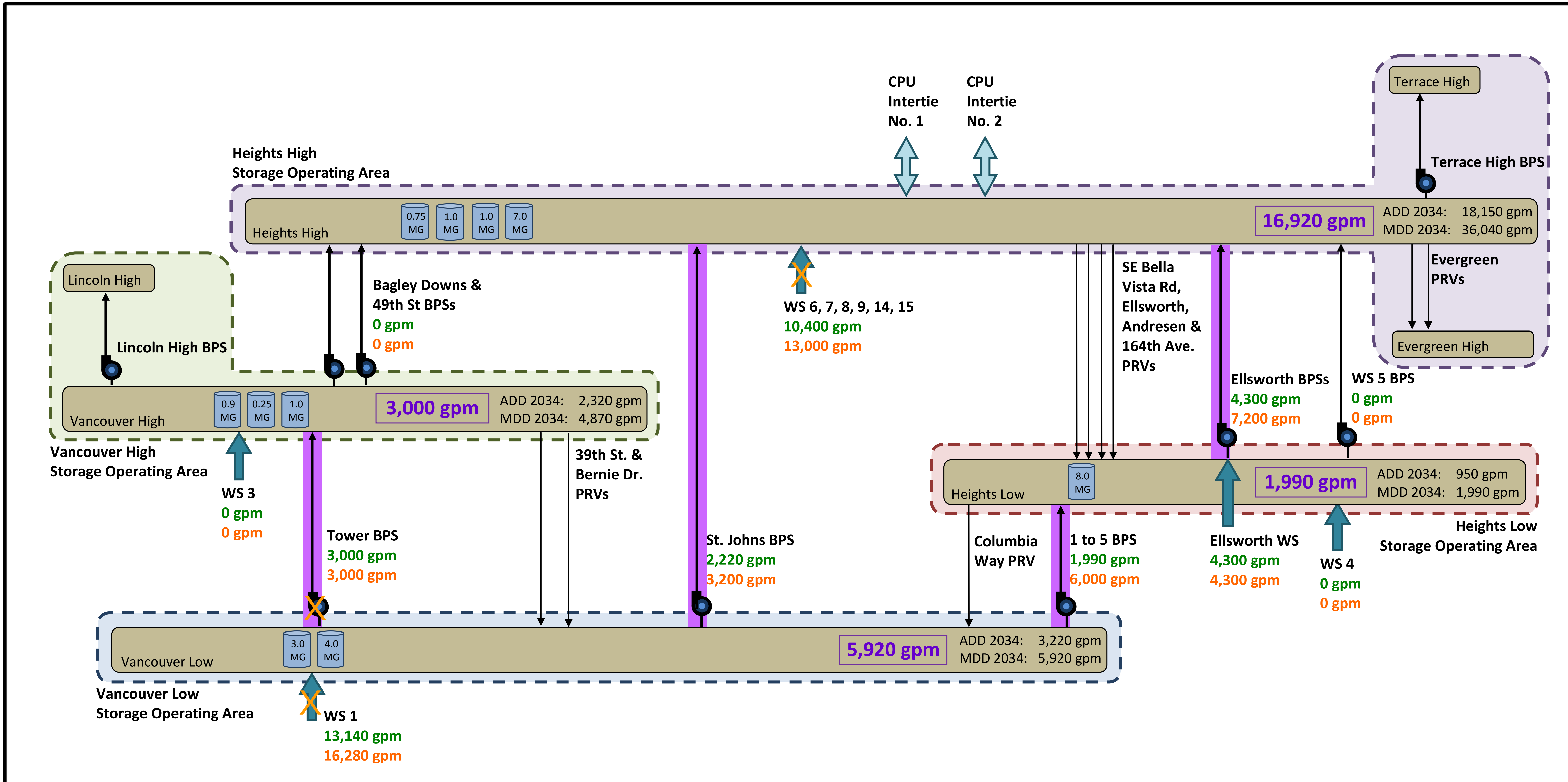


Figure 3.9
Emergency MDD Transfer Scheme
Scenario 1
Comprehensive Water System Plan
City of Vancouver



LEGEND

- Pressure Zone
- Storage Tank
- Pump Station
- Well Supply Source
- Emergency Interties
- XXX gpm — Utilized Capacity
- XXX gpm — Reliable Capacity
- XXX gpm — Adjusted Operating Area Reliable, Firm Supply ($Q_{R,F}$)
- X — Largest Source Out of Service

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EMERGENCY MDD TRANSFER SCHEME, SCENARIO 2

FIGURE 3.10

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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The adjusted operating area reliable, firm supplies for Scenario 2 are greater than those for Scenario 1 in each operating area due to the increased reliability of Water Station 1 after the upgrade project. Therefore, Standby Storage requirements are significantly lower for Scenario 2. As shown in Table 3.10, the Heights High Operating Area standby storage requirement increases significantly over the three planning years due to increased demands and limited supply. The table also shows that the Standby Storage requirement generally exceeds the fire flow storage requirement for all operating areas.

3.7.5.7 Available Versus Required Storage Comparison

Table 3.10 summarizes the storage volumes required for each component of storage by each operating area for the planning years 2020, 2024, 2034. Table 3.11 and Table 3.12 show required storage, available storage, and the storage surplus or deficit in each operating area for Scenarios 1 and 2.

As shown in Table 3.11, under Scenario 1, Vancouver Low, Vancouver High, and Heights High all have significant storage deficits by 2034. Heights Low is the only operating area with a storage surplus. The reliability upgrades to Water Station 1 significantly reduce the amount of Standby Storage required for each operating area, thereby reducing the total storage deficits. This is shown by the fact that the storage deficits of each operating area are significantly lower for Scenario 2 than Scenario 1 when comparing Table 3.11 and Table 3.12.

Under Scenario 2, Vancouver Low has a storage deficit of 1.5 MG by 2034 due to Operational and Equalizing Storage requirements. Vancouver Low currently has no available storage that can serve the highest customers in the zone at a pressure of at least 30 psi, which is required for Operational and Equalizing Storage. The Vancouver High Operating Area has a storage deficit of 0.4 MG by 2034. Projected demand increases in the Heights High Operating Area lead to large future Equalizing and Standby Storage requirements resulting in a storage deficit of 3.1 MG by 2034.

Table 3.10 Required Storage

Operating Area	Vancouver Low			Heights Low			Vancouver High			Heights High		
Planning Year	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Operational Storage (MG)	0.25	0.25	0.25	0.40	0.40	0.40	0.07	0.07	0.07	0.49	0.49	0.49
Equalizing Storage (MG)	1.11	1.19	1.28	0.39	0.40	0.43	1.03	1.03	1.05	6.50	6.90	7.78
Fire Storage (MG)	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Standby Storage (MG) Scenario 1 – Existing Sys.	2.01	2.79	3.35	2.46	2.56	2.74	6.52	6.54	6.67	0.00	2.42	9.93
Standby Storage (MG) Scenario 2 – WS 1 Imp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.52

Table 3.11 Storage Analysis, Scenario 1 – Existing System

Operating Area	Vancouver Low			Heights Low			Vancouver High			Heights High		
Planning Year	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Required Storage (MG) (Table 3.10)												
Above 30 psi HGL(1)	1.36	1.44	1.53	0.79	0.80	0.83	1.09	1.10	1.12	6.99	7.39	8.27
Above 20 psi HGL(2)	3.37	4.23	4.88	3.25	3.36	3.57	7.61	7.64	7.79	7.95	9.81	18.20
Available Storage (MG) (Table 3.8)												
Above 30 psi HGL	0	0	0	8.00	8.00	8.00	1.25	1.25	1.25	7.00	7.00	7.00
Above 20 psi HGL	1.27	1.27	1.27	8.00	8.00	8.00	1.40	1.40	1.40	8.74	8.74	8.74
Storage Surplus/(Deficit) (MG)												
Above 30 psi HGL	(1.36)	(1.44)	(1.53)	7.21	7.20	7.17	0.16	0.15	0.13	(0.01)	(0.39)	(1.27)
Above 20 psi HGL	(2.10)	(2.96)	(3.61)	4.75	4.64	4.43	(6.21)	(6.24)	(6.39)	0.79	(1.07)	(9.46)
Total Surplus/(Deficit) (MG)	**(2.1)**	**(3.0)**	**(3.6)**	**4.8**	**4.6**	**4.4**	**(6.2)**	**(6.2)**	**(6.4)**	**0**	**(1.1)**	**(9.5)**

Notes:

(1) Sum of Operational and Equalizing Storage.
(2) Sum of Operational, Equalizing, and the maximum of Fire or Standby Storage.

Table 3.12 Storage Analysis, Scenario 2 – Water Station 1 Improvements

Operating Area	Vancouver Low			Heights Low			Vancouver High			Heights High		
Planning Year	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**	**2020**	**2024**	**2034**
Required Storage (MG) (Table 3.10)												
Above 30 psi HGL(1)	1.36	1.44	1.53	0.79	0.80	0.83	1.09	1.10	1.12	6.99	7.39	8.27
Above 20 psi HGL(2)	2.32	2.40	2.49	1.75	1.76	1.79	2.05	2.06	2.08	7.95	8.35	11.80
Available Storage (MG) (Table 3.9)												
Above 30 psi HGL	0.00	0.00	0.00	8.00	8.00	8.00	1.31	1.31	1.31	7.00	7.00	7.00
Above 20 psi HGL	2.80	2.80	2.80	8.00	8.00	8.00	1.64	1.64	1.64	8.74	8.74	8.74
Storage Surplus/(Deficit) (MG)												
Above 30 psi HGL	(1.36)	(1.44)	(1.53)	7.21	7.20	7.17	0.22	0.21	0.19	0.01	(0.39)	(1.27)
Above 20 psi HGL	0.48	0.39	0.31	6.25	6.24	6.21	(0.41)	(0.42)	(0.44)	0.79	0.39	(3.06)
Total Surplus/(Deficit) (MG)	**(1.4)**	**(1.4)**	**(1.5)**	**6.3**	**6.2**	**6.2**	**(0.4)**	**(0.4)**	**(0.4)**	**0**	**(0.4)**	**(3.1)**

Notes:

(1) Sum of Operational and Equalizing Storage.
(2) Sum of Operational, Equalizing, and the maximum of Fire or Standby Storage.

3.7.5.8 Storage Recommendations

Given the storage evaluation above, it is clear that improvements to supply reliability at Water Station 1 (Scenario 2) are critical for meeting the standby storage requirements, and therefore reducing the overall storage needs. The additional back-up capacity provided at the wells and Water Station 1 BPSs is critical for meeting emergency conditions in all zones. Therefore, the currently planned back-up capacity improvements at Water Station 1 are highly recommended.

The following sections outline additional recommendations for eliminating future storage deficits in each of the storage operating areas. All recommendations assume Scenario 2, in which the Water Station 1 improvements have been implemented.

3.7.5.8.1 *Vancouver Low*

Vancouver Low has a storage deficit of 1.4 MG by 2020. The deficiency is due to the fact that the Vancouver Low Operating Area has no available storage above the 30 psi HGL to serve the highest customer. In order to use 100 percent of the available storage in the Vancouver Low Zone, the highest customer able to be served is at 146 feet. This is calculated by subtracting 30 psi (approximately 69 feet) and two feet of head loss (as calculated in the model) from the base elevation of the lowest reservoir (217 feet). Therefore, rezoning the Vancouver Low customers that are located above an elevation of 146 ft to a higher pressure zone would make all of the Vancouver Low storage available and would eliminate the Vancouver Low storage deficiency.

Vancouver Low customers located above an elevation of 146 ft are identified in red in Figure 3.11. As seen in the figure, these customers are located in East Reserve Street adjacent to the Vancouver High Zone. The customers could possibly be served by extending the Vancouver High Zone piping into East Reserve Street and reconnecting service lines.

The City may be able to rezone fewer customers if the City aims to only address the storage deficit in the zone (up to 1.5 MG), but not use 100 percent of the storage. Calculations for what elevations can be served while just meeting the storage criteria are dependent on the elevation and dimensions of the new 3.0-MG Reservoir. To decrease dead storage and address the storage deficiency, it is recommended that the City conduct a rezoning study for the high-elevation customers in the Vancouver Low Zone once the dimensions of the new Water Station 1 3.0-MG Reservoir are known.

3.7.5.8.2 *Vancouver High*

Vancouver High has a storage deficit of 0.4 MG by 2020. This storage deficit is due to limited available storage above the 30 psi HGL to serve the highest customers. The City is planning to replace the existing 1.25-MG Reservoir due to its aging condition and the fact that only 0.9 MG of the total volume can be utilized. Because this reservoir is equipped with a pump station, none of its storage is assumed to be dead storage and this project will add 0.35 MG of storage volume if it is determined that the same size reservoir will fit on the site. The remaining storage deficit (0.05 MG) can be met in a few ways. First, the new Water Station 1 1.0-MG Tank could be sized and configured to provide enough available storage above the 30 psi HGL. Second, the highest customers could be rezoned to be served by a higher zone, thus reducing the dead storage calculation. Last, the City could increase the capacity of the Water Station 3 0.25-MG Tower concurrent with replacement of the tower due to condition (providing a seismic study of this tower is a recommendation from the Condition Assessment in Section 3.4). It is recommended that a Rezone Study be implemented first to review the viability of rezoning high customers. It is also recommended that a site master plan for Water Station 3 be completed that includes an evaluation of potential tank sizes that will fit on the site.

3.7.5.8.3 *Heights Low*

Heights Low has a storage surplus. No projects are recommended for Heights Low.

3.7.5.8.4 *Heights High*

Heights High has a small storage deficit by 2024 and a storage deficit of 3.1 MG by 2034. This deficit is due to large standby storage and equalizing storage requirements of the Heights High Operating Area. Additional storage was evaluated in the hydraulic model to review its impact on pressures in the Heights High Zone. Minor pressure improvements were observed when evaluating a new 2.0-MG tank in the northeast corner of the zone, where the City owns property (this is further discussed in Section 3.8.5.2.3). Additionally, the City was considering construction of additional storage for the Heights High Zone in the southeast in the future.

Given the excess storage capacity in the Heights Low Zone (6.2 MG in 2034), the City could meet the Heights High storage requirements by pumping the excess storage from the Heights Low Zone rather than constructing additional storage facilities. Ample pumping capacity is available at the Water Station 5 and Ellsworth BPSs beyond what is already used to meet the zone’s MDD (as shown in Figure 3.10). However, it is recommended that the Water Station 5 BPS be equipped with back-up power to ensure the reliability of this operation. Adding back-up capacity at Water Station 5 Pumps 1, 2, and 3 (for a total of 5,250 gpm) meets the Standby Storage requirement.

The recommendations outlined above are summarized in Section 3.9 below.

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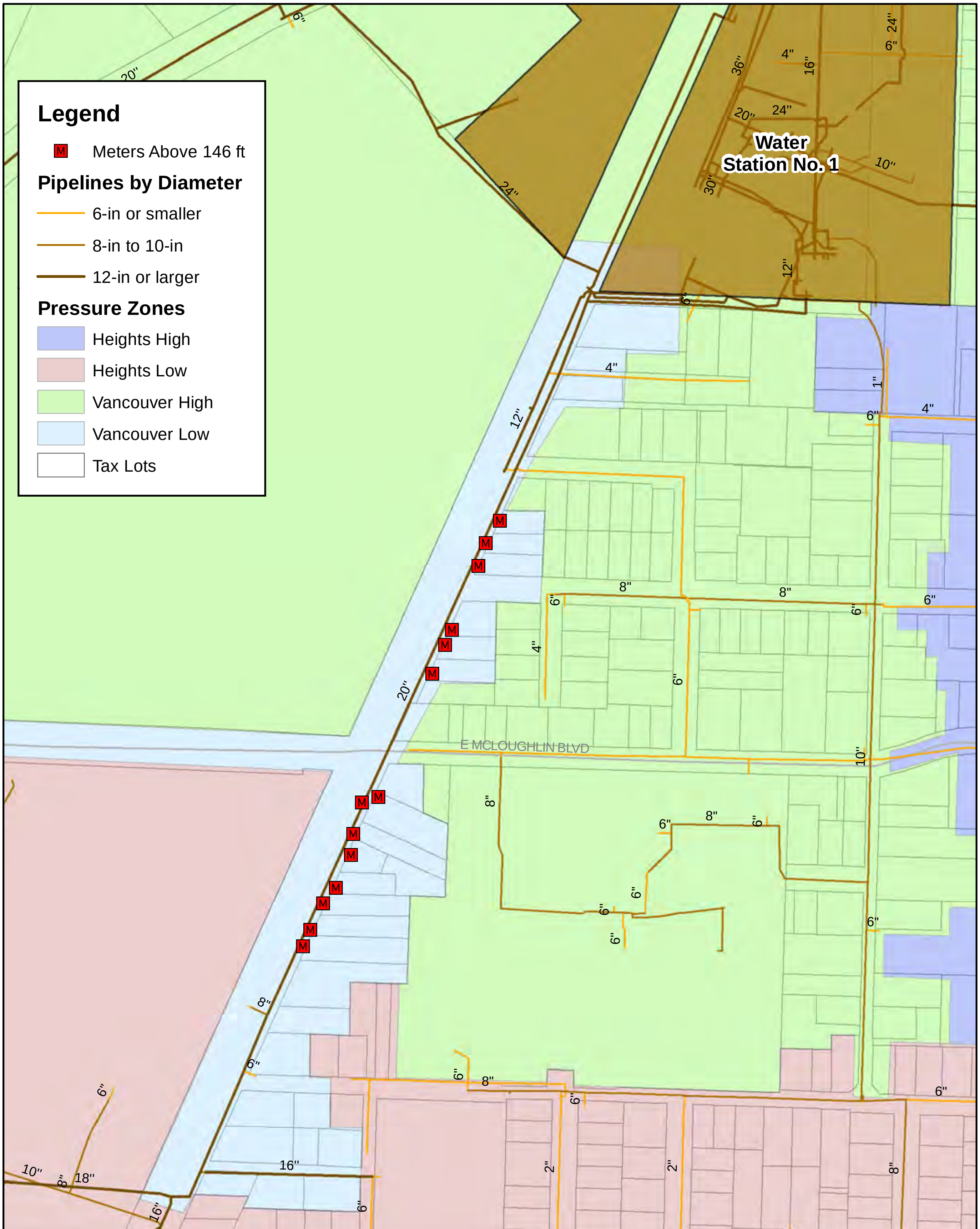

Feet
0 200 400

VANCOUVER LOW HIGH ELEVATION CUSTOMERS

FIGURE 3.11

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COMPREHENSIVE WATER SYSTEM PLAN

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3.8 DISTRIBUTION SYSTEM DESCRIPTION AND ANALYSIS

3.8.1 Distribution System Description

Chapter 1, Section 1.3 describes the water distribution system. TM 1 – Water Station Facilities Condition Summary Report (Appendix 3B) includes a high-level assessment of the remaining useful life of the City's water pipes given age and material. Over 900 miles of pipeline was included in this evaluation, through the use of GIS. The evaluation resulted in a recommended annual pipe replacement program to address pipes that reach the end of their useful life. The following sections present the capacity evaluation for the City's distribution system using the hydraulic model.

3.8.2 Distribution System Analysis

In addition to the storage and pumping, the City's water distribution system was evaluated for having adequate capacity to meet pressure, fire flow, and velocity requirements under future demand conditions. The distribution system analysis was performed using the City's hydraulic model, which was updated in 2014 as described in TM 2 – Hydraulic Model Update (Appendix 3D). The model was loaded with the projected demands for the years 2020, 2024, and 2034.

3.8.3 Evaluation Criteria

The City's water system criteria related to pressure, velocity, and fire are listed below, as summarized in Chapter 1:

1. Pressure:
   a. System piping shall be sized to provide for peak hourly demands (PHD) at a minimum system pressure of 30 psi.
   b. Required fire flows shall be provided under maximum day demand (MDD) at a minimum system pressure of 20 psi.
2. Velocity:
   a. New pipes shall have a maximum instantaneous velocity for PHD conditions of 7 feet per second.
3. Fire Flow Requirements:
   a. For areas zoned for one and two family dwellings, an available fire flow greater than 1,000 gpm;
   b. For multi-family and commercial zoned areas, an available fire flow greater than 2,000 gpm;
   c. For industrial zoned areas, an available fire flow greater than 4,000 gpm.
4. Reliability:
   a. Reliable sources shall be sufficient to provide for average day demands (ADD) at a minimum pressure of 30 psi.

5. Redundancy:
   a. Maintain system pressures of 30 psi during MDD with Water Station 1 offline.

3.8.4 Model Configuration

Demands for 2020, 2024, and 2034 were added to the model to simulate future conditions. Planned capacity improvements at Water Station 1 were not included in the initial future model simulations. Improvements including a new 8,000 gpm Tower BPS, replacement of the 1-MG Reservoir with a 3-MG Reservoir, and replacement of the 0.25-MG Tower with a 1-MG Tower were included and simulated in the model prior to making and testing other possible system improvements. All future model runs were updated with recently updated PRV data provided by the City.

TM 2 – Hydraulic Model Update (Appendix 3D) discusses the roughness coefficients that were assigned to pipes in the hydraulic model in order to calibrate the model. The roughness coefficients are unusually low, representing high head losses found during the City's hydrant tests. It is recommended that the City perform an evaluation to assess distribution system conditions in order to identify and reduce head losses. The analyses described below (pressure, velocity, and fire) can be greatly influenced by distribution system head loss as these analyses test the system during high demands. For each of these analyses, roughness coefficients for all pipes in the model were increased to 110 (C=110) as this represents a more typical distribution system. This change assumes that the City is able to improve head loss to an equivalent value through the recommended head loss evaluation program. This recommendation is included in the final recommendations listed in Section 3.9.

To represent fire conditions, fire flows were assigned to all demand nodes in the model according to the existing or future associated planned land use (whichever required a higher fire flow). Note, this evaluation did not include all hydrants in the system.

3.8.5 Pressure and Velocity Analysis

Typically, pressure evaluations are performed using a steady state model run with initial settings established to represent PHD conditions. For pressure evaluations, the water levels in tanks are typically set equal to the bottom of the calculated operational and equalizing storage to represent minimum system pressures during PHD. The City's model was configured accordingly and run for steady state analyses; minimum pressure nodes were identified on a map.

During the evaluation of Water Station 1 (TM 3 – Water Station 1 Pumping Capacity Evaluation), the model was run in an extended period simulation (EPS) for one week under future MDD conditions. Minimum pressures were reviewed as part of that study and were found to be lower (i.e. worse) than the steady state pressure evaluation runs for the Heights High Zone. It was determined that the pressures were lower during the EPS runs than during the steady state runs because pressures in the Heights High Zone are very dependent on the pressure provided from BPSs. During the steady state runs, most BPSs are operating due to the low tank levels, resulting in higher pressures in the upper zones. During the EPS runs, the pumps turn off occasionally due to tanks being full. Some areas in the Heights High Zone appear to be more dependent on the pressure provided from pump stations than the water level in nearby tanks.

3.8.5.1 Identified Deficiencies

Given the above results, the pressure results from the EPS runs were considered to be the most critical and improvements were identified to resolve deficiencies during the EPS model runs. The EPS model runs provide the same evaluation conditions under Criterion 1 (providing PHD while maintaining 30 psi), as the EPS runs include diurnal demand fluctuations that reach PHD conditions for each zone. Figure 3.12 through Figure 3.14 present the 2020, 2024, and 2034 pressure and velocity deficiencies from the EPS model runs. Orange and red nodes represent deficiencies (i.e. under 30 psi). As seen in the figures, more deficiencies occur as demands increase. As seen in Figure 3.14, at build-out conditions, the Heights High has two significant areas of pressure deficiencies. These correlate to high elevation customers within the zone. Additionally, many deficiencies are found at the far west end of the system in the Vancouver Low Zone. The model predicts some low pressures (below 30 psi) to occur in some BPS suction pipes, and well discharge pipes; because these pipes do not directly serve customers, these pipes were not considered deficient. Velocities that exceed the velocity criteria were not found in the analysis.

3.8.5.2 Pressure Improvements

To address the identified deficiencies, results from the EPS run were reviewed closely. Recommended projects to address low pressures are typically targeted in areas of high head loss, or where large changes in the hydraulic grade line (HGL) occur. This approach generally results in improving transmission capacity to benefit multiple areas, rather than smaller distribution projects benefitting only local customers. Projects were also targeted in areas where existing pipes are aging or are undersized. Highway, railroad, and other bridge crossings were avoided as much as possible to simplify construction and reduce project costs. Streets with more than one water pipe were also avoided.

Improvements were identified to bring the City's water system into conformance with its criteria. Improving pressure beyond the minimum was not evaluated, unless specifically noted. All improvements are sized for meeting the requirements during 2034 demand conditions.

The final recommended projects for resolving pressure deficiencies are listed in Table 3.14 and shown in Figure 3.19 in Section 3.9.

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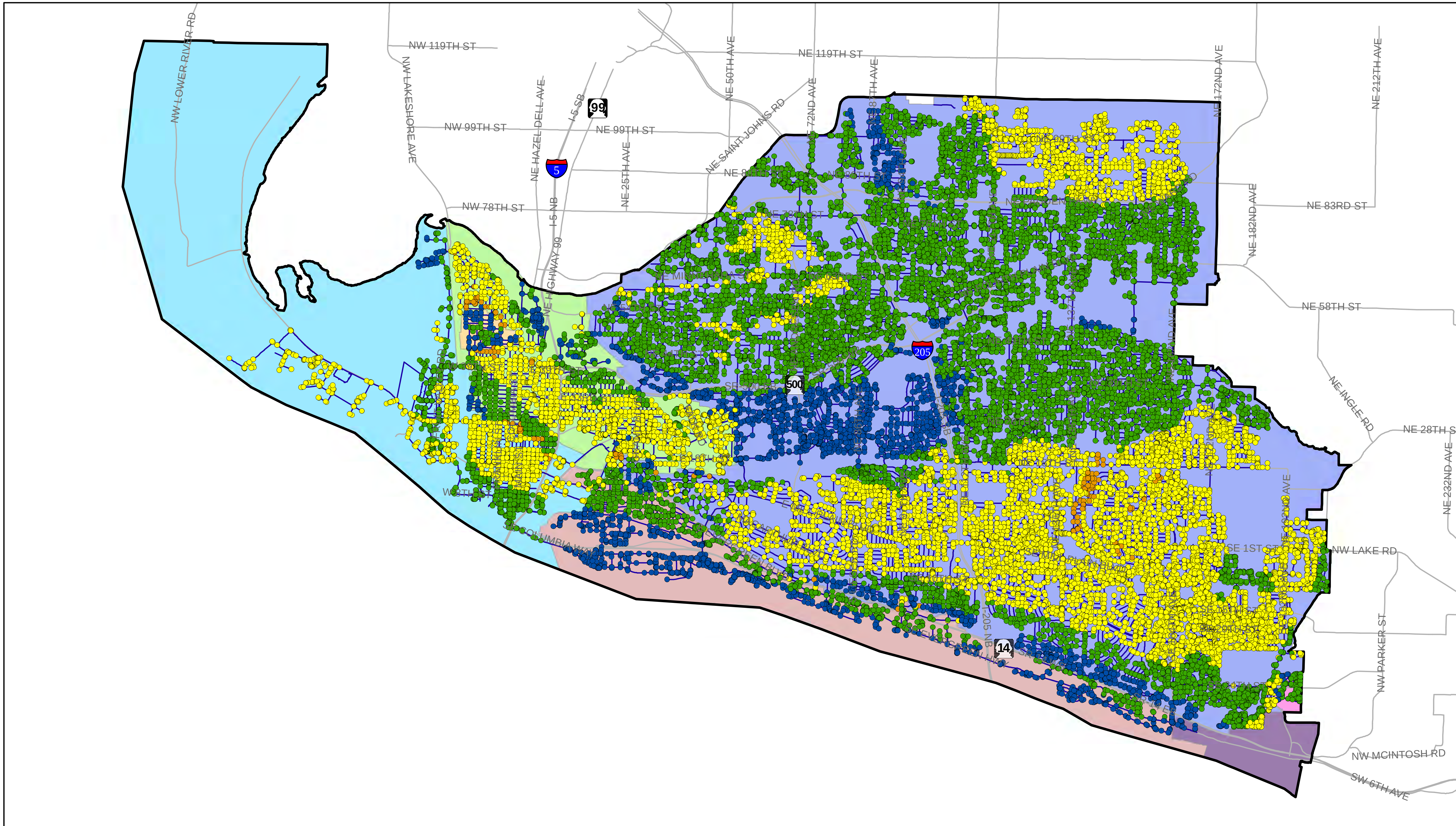

Legend

- Major Streets
- Retail Water Service Area Boundary

Pressure Zones

- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

Minimum Pressures

- less than 0
- 0 - 20 psi
- 20 - 30 psi
- 30 - 50 psi
- 50 - 80 psi
- greater than 80 psi

N

0 4,000 8,000 Feet

2020 PRESSURE DEFICIENCIES

FIGURE 3.12

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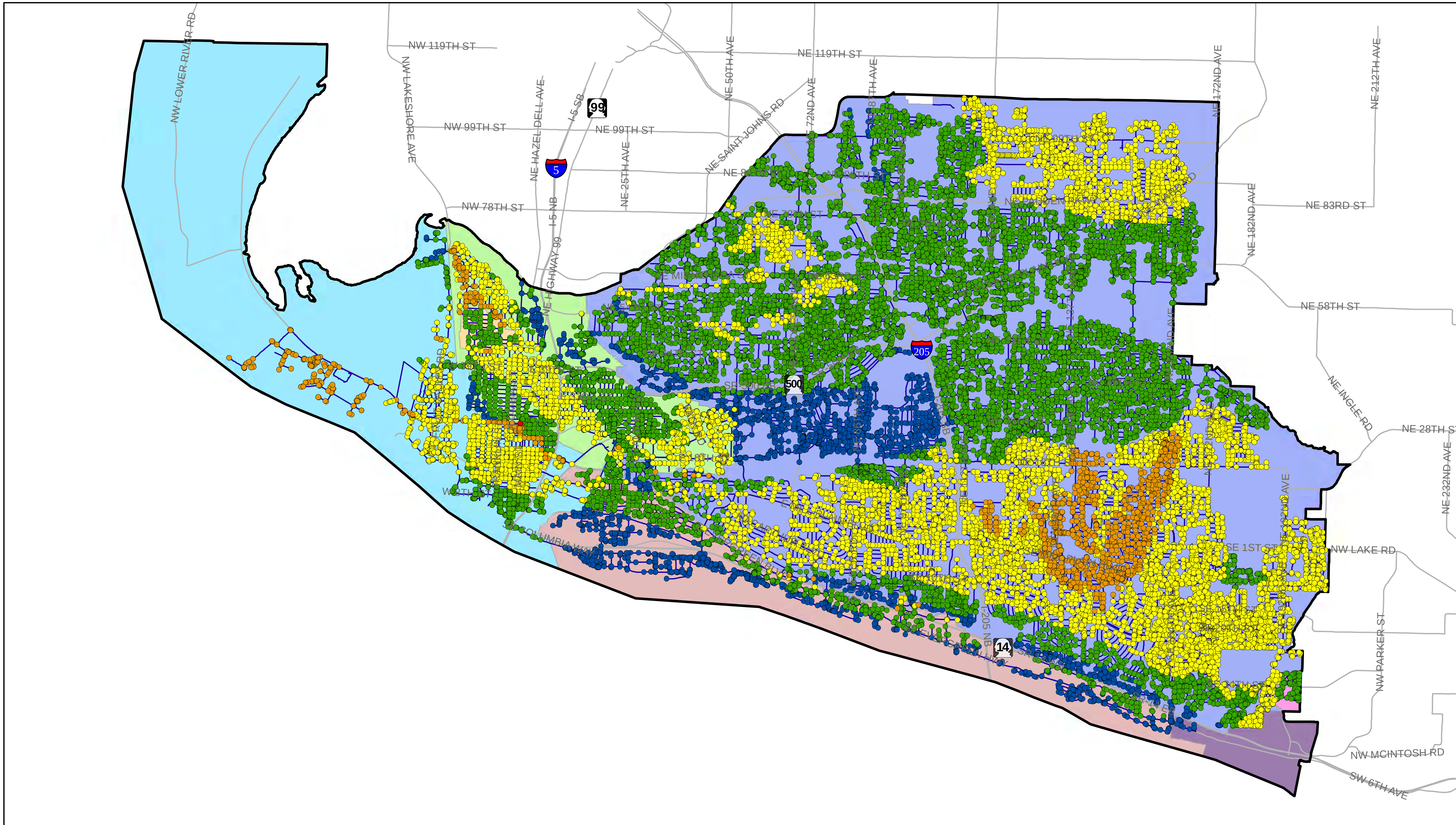

Legend

- Major Streets
- Retail Water Service Area Boundary

Pressure Zones

- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

MinP_2024

- less than 0
- 0 - 20 psi
- 20 - 30 psi
- 30 - 50 psi
- 50 - 80 psi
- greater than 80 psi

0 4,000 8,000 Feet

2024 PRESSURE DEFICIENCIES

FIGURE 3.13

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COMPREHENSIVE WATER SYSTEM PLAN

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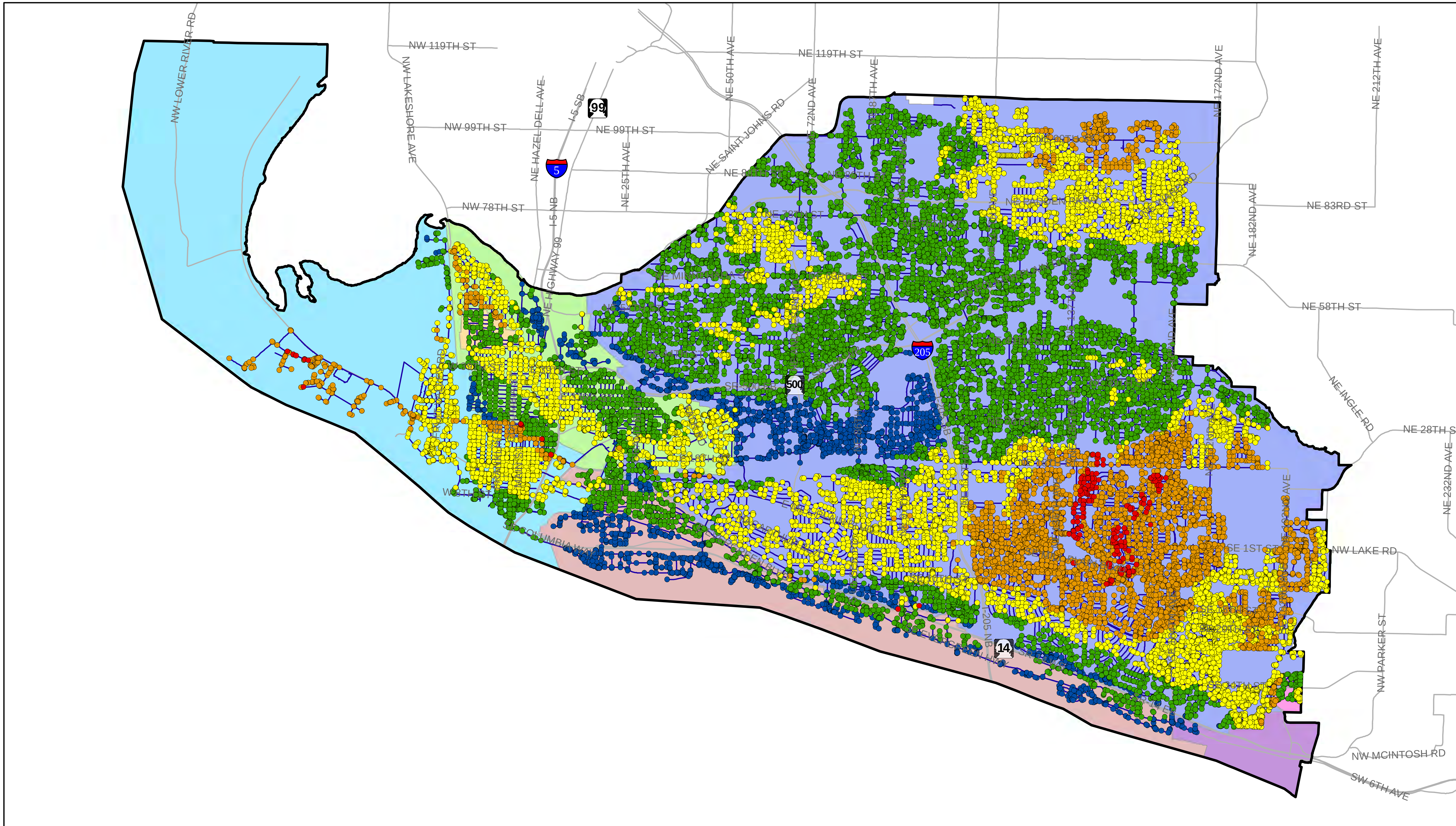

Legend

Major Streets

Retail Water Service Area Boundary

Pressure Zones

- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

Minimum Pressures

- less than 0
- 0 - 20 psi
- 20 - 30 psi
- 30 - 50 psi
- 50 - 80 psi
- greater than 80 psi

0 4,000 8,000 Feet

2034 PRESSURE DEFICIENCIES

FIGURE 3.14

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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3.8.5.2.1 *Vancouver Low*

In the Vancouver Low Zone, the model predicts that the HGL drops approximately 145 feet from the Water Station 1 Reservoirs (which set the HGL for the zone) to the far west end of the zone under 2034 conditions. Some low pressures occur near Water Station 1 due to their high elevations (as predicted in the storage analysis above). High head loss (36 feet) was found in the transmission pipe in Fort Vancouver Way from Water Station 1 to its connection to the distribution grid. Pressures below 30 and sometimes 20 psi were predicted to occur at higher elevation customers north of the downtown area, near Fourth Plain Blvd. The HGL in this area was found to be up to 50 feet less than the HGL provided at the Water Station 1 Reservoirs. An additional 35 feet of head loss occurs across the downtown Vancouver system grid from east to west. Low pressures also occur in the far west end of the zone; these are higher demand industrial customers that are served by undersized transmission pipes.

To address the pressure deficiencies, several improvements were evaluated in the model. First, the Water Station 1 improvements were implemented, as noted in Section 3.8.4. Next, a parallel 18-inch pipe in Fort Vancouver Way was added to increase capacity and therefore the HGL where the supply transmission lines connect to the grid. Several undersized pipes (2-, 4-, and some 6-inch) were replaced with larger pipes to improve capacity to high elevation customers near Fourth Plain Blvd. City staff agreed that it would be better to improve transmission capacity in the downtown grid, rather than in Fort Vancouver Way due to construction constraints under the freeway and because many pipes in the downtown grid require replacement and/or upsizing anyway. Given this change, several pipes in the downtown grid were replaced with 12-inch pipe to increase transmission capacity from east to west, and the parallel pipe in Fort Vancouver Way was not used.

Regarding the pressure deficiencies in the far west end of the zone, a transmission bottleneck was found to occur in Fourth Plain Boulevard where an existing 12-inch pipe crosses the railroad tracks and extends west to an existing 24-inch pipe. The west end of the Vancouver Low Zone is supplied almost entirely from this pipe and through a parallel pipe further south in West 8th Street. A new parallel 24-inch pipe (Project T-3) was proposed to cross the railroad tracks and extend west to connect to the existing 24-inch. The proposed projects alleviate all pressure deficiencies in the Vancouver Low Zone.

3.8.5.2.2 *Vancouver High*

The model predicts a large area of low pressure in the Vancouver High Zone north of the Lincoln High Zone. This is largely due to the high flow rate (up to 2,000 gpm during the EPS run) predicted in the Bernie Street PRV serving the Vancouver Low Zone. High flows in the PRV create a large demand across the Vancouver High Zone through a limited distribution system. Through discussions with City staff, it was agreed that it is more efficient from a supply and pumping perspective to serve the Vancouver Low customers downstream of the Bernie Street PRV from the Vancouver Low Zone, not the Vancouver High Zone. By closing the Bernie Street PRV, pressure in this area meet the pressure criteria.

One additional low pressure node is predicted by the model at the end of Ash Street. This node represents a few high-elevation customers in the East 18th Street area. Fire deficiencies were found in this area; improvements were evaluated and sized to meet the fire requirements as discussed in Section 3.8.6.2.2.

3.8.5.2.3 *Heights High*

In addition to low pressures, the EPS model runs predict low water levels in the Heights High Zone. The Water Station 9 Reservoir is predicted to mostly drain during 2034 demands with no improvements. The first improvement to the Heights High Zone was to implement the Water Station 1 planned improvements. However, per the Water Station 1 Pumping Capacity Evaluation, it was already established that these improvements would not alleviate pressure issues in the Heights High Zone. The next step of improving pressure was to increase supply to the zone to reduce draining of the tanks and reservoirs. This was accomplished by adjusting the on and off setpoints of the Water Station 5 and 9 BPS pumps to turn on more frequently. The City currently does not operate the Water Station 5 up to its full capacity because it results in overflowing the Water Station 5 Tank. It is recommended that an altitude valve be placed on the tank to prevent overfilling, while allowing more pumping from the Water Station 5 BPS. Increasing the supply to the zone through these two supplies greatly improved the tank levels and alleviated many of the pressure deficiencies.

Figure 3.15 shows the remaining pressure deficiencies after the Water Station 1 improvements and changes to the pumping operation (this includes the assumption that Water Station 5 is equipped with an altitude valve). In particular, increasing supply eliminated the pressure deficiencies in the southeast area of the zone. Figure 3.15 also differs from Figure 3.14 in other areas of the system; these differences are due to other Water Station 1 improvements, such as a larger storage volume and therefore higher pressures during the model simulations.

The transmission capacity projects already considered by the City in Heights High (as listed in Table 3.13) were evaluated to alleviate low pressures. The first pipe evaluated is an improvement to the transmission piping that supplies the Ellsworth BPS. The Ellsworth BPS is built for a capacity of 19,800 gpm. However, the maximum flow predicted by the model is 12,700 gpm, which is slightly more than the City actually observes with all pumps on. It is assumed that capacity is limited largely by head loss occurring in the suction piping (head loss of 92 feet predicted by the model in 2034 MDD), which results in a suction pressure at the BPS of approximately 5 psi. Project T-26 replaces a leaking 12-inch Heights Low distribution pipe with a new 24-inch pipe that would also connect to the Ellsworth BPS suction piping. The addition of this pipe results in increasing the Ellsworth BPS suction pressure to 17 psi, and increases maximum flow to 15,500 gpm. This improvement further alleviates pressure deficiencies in the Heights High Zone and further increases tank water levels in the zone. The model was also used to evaluate the impact of this 24-inch transmission main installation on Heights Low Zone customers if the Ellsworth BPS suction line draws from the Heights Low Zone. It was found that pressure fluctuations in the Heights Low Zone change from a range of 51 to 63 psi to 47 to 64 psi. When Water Station 4 is offline, more flow is required in a 20-inch line that supplies the Heights Low Zone from Water Station 5. With Project T-26 in place, the velocity criterion were exceeded in this 20-inch pipe. Therefore, project T-51 is also recommended.

Revised: January 27, 2015
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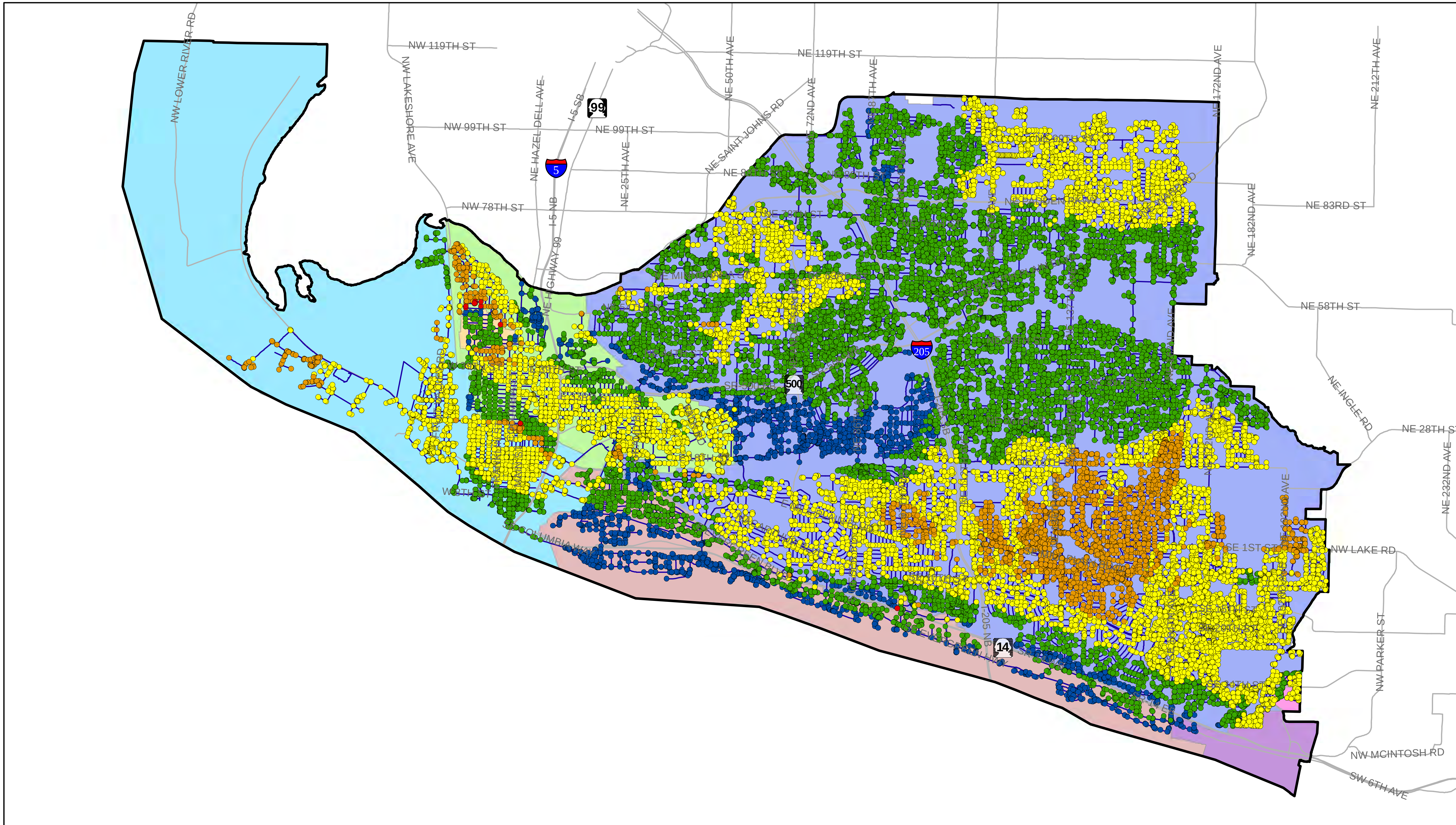

Legend

Retail Water Service Area Boundary
Major Streets

Pressure Zones

- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

Minimum Pressures

- less than 0
- 0 - 20 psi
- 20 - 30 psi
- 30 - 50 psi
- 50 - 80 psi
- greater than 80 psi

Feet
0 4,000 8,000

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Engineers...Working Wonders With Water®

2034 PRESSURE DEFICIENCIES WITH OPERATIONAL CHANGES

FIGURE 3.15

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

A Heights High pipe improvement project previously identified by the City is shown as Project T-27 and improves transmission capacity from Water Station 5 to the east. The project reduces head loss in the pipe from 30 feet to 5 feet, thereby maintaining the HGL across the zone. However, this project was not shown to improve specific pressure deficiencies in the zone. Project CP-5, T-31, and T-33 are currently planned in the northeast corner of the Heights High Zone. These projects do not address specific pressure deficiencies (below 30 psi), but do improve local pressures from 38 psi to above 50 psi.

Projects T-34 and T-35 are currently planned for improving transmission capacity across the Heights High Zone in the vicinity of Water Station 7. These projects alone were not sufficient to alleviate the pressure issues found southeast of Water Station 7, but do reduce head loss and increase the HGL east of the improvements. The model predicts high head loss from Water Station 7 Tank to the low pressure nodes southeast of the tank. Projects T-36, T-37, T-45, and T-46 were identified to improve capacity in pipes with the most head loss while attempting to avoid challenging areas of construction. This combination of pipe improvements alleviated all pressure deficiencies in the Heights High Zone.

The City requested that system pressure be evaluated in the northeast area of the Heights High Zone if a new 2.0-MG tank was constructed. Pressure deficiencies in the area were already resolved through operational changes, particularly by increasing pumping at Water Station 9 (as discussed above). The hydraulic model was used to evaluate a 2.0-MG standpipe with a BPS to make all of the volume available. The addition of the facility increased local pressures by approximately 4 psi (minimum pressure increased from 50 to 54 psi). Whether or not to construct this tank is discussed in Chapter 8 – Capital Improvements Plan.

3.8.6 Fire Analysis

For the fire analysis, the model was used to predict the maximum available flow to each specified fire flow node while maintaining 20 psi at the node and at all other locations. For fire evaluations, the water levels in tanks were set equal to the bottom of the calculated fire storage. Setting the tanks to bottom of the fire storage volume creates the pressure conditions expected just after a fire has depleted the stored fire volume, which is the minimum pressure condition during a fire flow and therefore the most conservative. If the predicted maximum fire flow is less than the required fire flow, then the node is considered deficient. It is important to note that prior to this Plan, the City’s fire flow requirements were lower for multi-family residential, commercial, and industrial customers. The fire flow requirements in this Plan were established by the City Fire Marshal. Many, if not all, of the identified deficiencies are due to the higher fire flow requirements. Identified deficiencies and recommended improvements are discussed below.

3.8.6.1 Identified Deficiencies

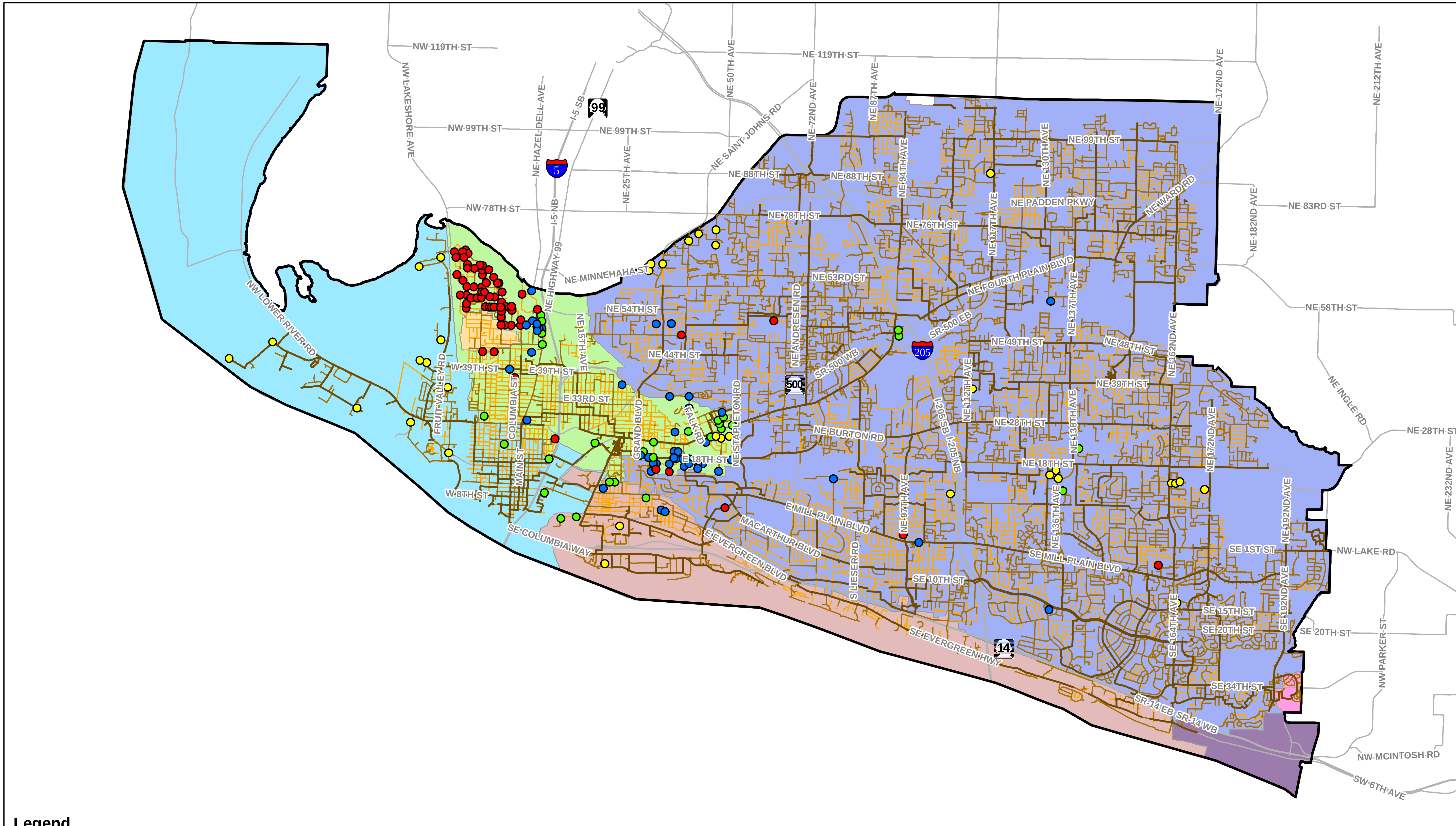
Fire flows in the water system were simulated in the hydraulic model to identify available fire flow under the existing system. Figure 3.16 through Figure 3.18 present the resulting fire deficiencies under the 2020, 2024, and 2034 demand conditions. Highlighted nodes represent fire flow deficiencies for single-family residential, multi-family residential, commercial, and industrial fire flow requirements, as shown in the legend. As seen in the figures, more deficiencies occur as demands increase; however, most deficiencies occur in the first planning year, as seen in Figure 3.16. As stated above, the high number of deficiencies is due to the new higher fire flow requirements.

The Vancouver Low Zone has fire flow deficiencies in several areas. The deficiencies to the east are due to limited transmission capacity as noted in the pressure analysis. The deficiencies at the north end of Fruit Valley Road are due to the inability to meet fire flows while maintaining 20 psi at all customers in the Vancouver High Zone. During a fire in this area, the Bernie Drive PRV opens to supply almost all of the fire flow rather than supplying flow through the piping in Fruit Valley Road. This in turn drops pressures in the Vancouver High Zone, which has limited transmission capacity to the Bernie Drive PRV.

The Vancouver High Zone has three significant areas of fire flow deficiencies. The first area is just north of the Lincoln High Zone. Fire flows were found to be deficient in this area due to high flow rates to meet the fire flow demand and to supply normal demands to the Vancouver Low Zone through Bernie Drive PRV. In combination, these flow rates cause significant head losses through the distribution system pipes from Water Station 3 towards the Bernie Drive PRV, such that 20 psi of pressure was unable to be maintained at nodes representing higher elevation customers.

The second significant area of fire flow deficiencies occurs south of East Fourth Plain Boulevard and east of Grand Boulevard. The majority of these nodes are deficient due to the inability to maintain 20 psi at the specific fire flow node, or at nodes representing high-elevation customers nearby. The far eastern end of the Vancouver High Zone has some industrial-zoned properties requiring 4,000 gpm of fire flow. South of East Fourth Plain Boulevard, several 2,000 gpm fire flows are required. This area consists of several 6-inch diameter pipes, which are insufficient to meet the new fire flow requirements.

As seen in Figure 3.18, the last significant area of fire flow deficiencies is south of the Lincoln High Zone at the western edge of the Vancouver High Zone. These deficiencies appear under higher demands, and seem to be caused by limited distribution capacity to serve the required fire flows as well as the 39th Street PRV. Improvements to address these deficiencies are discussed below.



Legend

Fire Flow Deficiency
- Single-Family Residential
- Multi-Family Residential
- Commercial (Non-Res)
- Industrial

Pipelines by Diameter
- 6-in or smaller
- 8-in to 10-in
- 12-in or larger

Pressure Zones
- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

- Major Streets
- Retail Water Service Area Boundary

0 4,000 8,000 Feet

Figure 3.16
2020 Fire Flow Deficiencies
Comprehensive Water System Plan
City of Vancouver

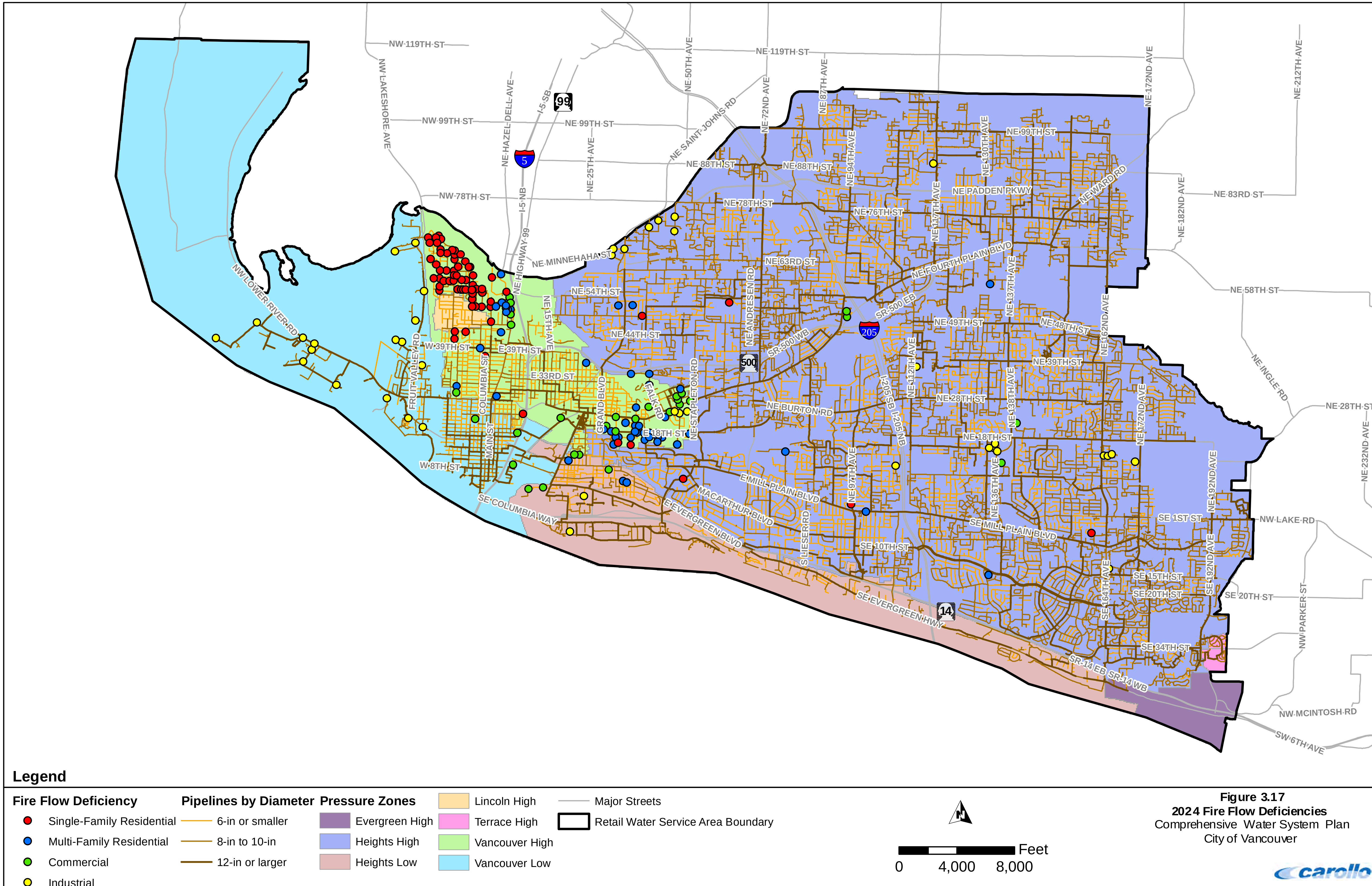
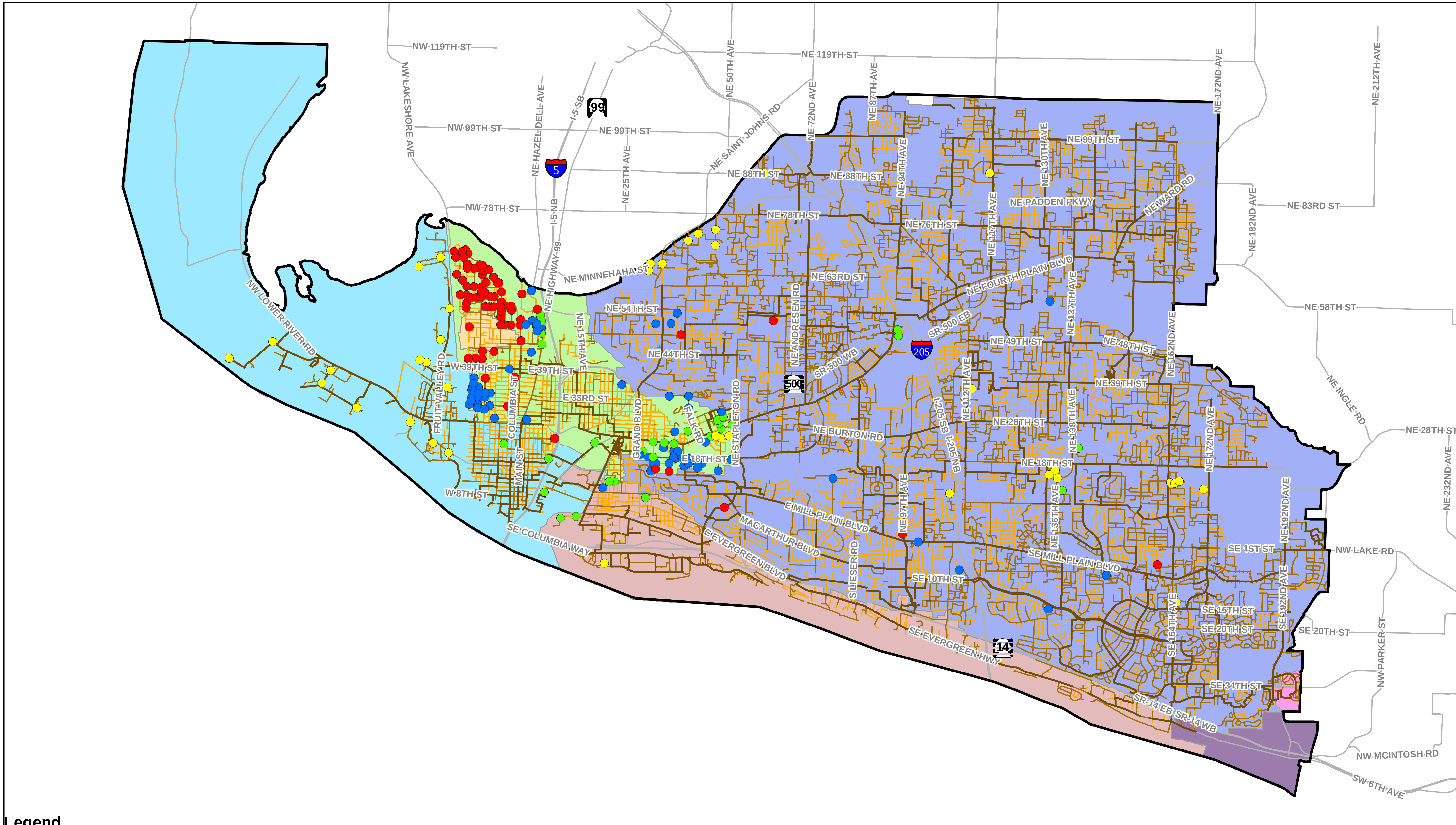


Figure 3.17
2024 Fire Flow Deficiencies
Comprehensive Water System Plan
City of Vancouver



Legend

Fire Flow Deficiency
- Single Family Residential
- Mulit-Family Residential
- Commercial
- Industrial

Pipelines by Diameter
- 6-in or smaller
- 8-in to 10-in
- 12-in or larger

Pressure Zones
- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

- Major Streets
- Retail Water Service Area Boundary

N

0 4,000 8,000 Feet

Figure 3.18
2034 Fire Flow Deficiencies
Comprehensive Water System Plan
City of Vancouver

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3.8.6.2 Fire Flow Improvements

The fire flow requirements updated for the City for this Plan require a greater distribution system capacity to meet the requirements citywide. It is anticipated that it will take years for the City to increase its system capacity to meet the new fire flow requirements.

To address the identified deficiencies, results from the fire flow analyses were reviewed closely. Recommended projects were prioritized similar to projects addressing pressure deficiencies, as discussed above. The first step in addressing fire deficiencies was to implement the recommended projects that resolve pressure deficiencies. In some locations, these projects were increased in size to also meet fire flow requirements. Improvements were identified to bring the City's water system into conformance with its criteria. Improving fire flows beyond the minimum was not evaluated. All improvements are sized for meeting the requirements during 2034 demand conditions. The final recommended projects for resolving pressure and fire deficiencies are listed in Table 3.15 and shown in Figure 3.19 (distribution projects) and Figure 3.20 (transmission projects). presents the fire and pressure deficiencies after implementing all recommended projects; as seen in the figure, all deficiencies should be resolved. The following sections address the deficiencies noted and recommended improvements in each pressure zone.

3.8.6.2.1 *Vancouver Low*

To meet the new fire flow requirements in Vancouver Low, some of the pipe projects recommended for pressure requirements were increased in size (such as Project T-3). Other specific improvements are shown on Figure 3.19 and Figure 20. A significant recommended project addressing fire flow is Project T-9 in NW Fruit Valley Road. This project replaces a 12-inch pipe with an 18-inch pipe in order to provide adequate flow and pressure to the industrial customers at the north end of the Vancouver Low Zone under the higher fire flow requirements (4,000 gpm for industrial customers). Prior to the recommended improvement, fire flows in this area were drawing most of the fire flow supply through the Bernie Drive PRV, and thereby causing pressure to drop below 20 psi in the Vancouver High Zone upstream of the valve. By implementing Project T-9 and closing the Bernie Drive PRV, pressures were maintained at all locations during the fire flow runs. This approach is recommended as it reduces the amount of water pumped to the Vancouver High Zone and then drained to the Vancouver Low Zone through the Bernie Drive PRV. The City noted that a pipe may be installed parallel to the NW Fruit Valley Road under future development; if a parallel 12-inch pipe is installed, then Project T-9 would not be needed where it runs parallel.

3.8.6.2.2 *Vancouver High*

After implementing the recommended pressure projects, closing the Bernie Drive PRV, and implementing Project T-9, the fire flow deficiencies in the north end of the Vancouver High Zone, and in the Lincoln High Zone, were almost completely resolved. This was due to eliminating the flow through the Bernie Drive PRVs. In the Vancouver High Zone south of Lincoln High, fire flow deficiencies were also largely reduced with the Vancouver Low recommended projects, which improve supply to customers in NW Fruit Valley Road, thereby reducing demands through the 39th Street PRV. Some additional projects shown in Figure 3.19 and Figure 3.20 address the remaining fire flow deficiencies around the Lincoln High Area.

To address fire flow deficiencies south of East Fourth Plain Boulevard, the first recommended project was to increase the pipe size of the 16-inch pipe in East Fourth Plain Boulevard. During a fire flow simulation in this area (which includes up to 4,000 gpm fire flows), pressure in the existing 16-inch pipe dropped significantly from Water Station 1 to the Bagley Downs BPS, resulting in many nodes with pressure below 20 psi. Project T-14 replaces the 16-inch pipe (which the City notes may need to be replaced soon due to age) with a 24-inch pipe. A pipe of this size showed limited head loss during a 4,000-gpm fire at the eastern end of the pipe while supplying the Bagley Downs BPS. Several additional projects were still required in this area to meet the higher fire flow requirements, as seen in Figure 3.19 and Figure 3.20.

3.8.6.2.3 *Heights Low*

The fire flow deficiencies identified in the Heights Low Zone were each related to local pipes undersized for meeting the higher fire flow requirements. Specific projects are shown in Figure 3.19 and Figure 3.20.

3.8.6.2.4 *Heights High*

The fire flow deficiencies identified in the Heights High Zone were still found to be deficient after implementing the recommendations to address pressure deficiencies. Figure 3.19 and Figure 3.20 include recommended projects required to address the fire flow deficiencies.

3.8.7 Reliability

As stated in Section 3.8.3, the reliability criteria states that reliable sources shall be sufficient to meet average day demands at a minimum pressure of 30 psi, where “reliable” means supplies with back-up power. For this analysis, the 2034 ADD model scenario was used. All previously recommended improvements were included; this analysis is a check if any further improvements are needed to meet the reliability criteria. Reliable wells and BPSs were controlled such that flow through these facilities did not exceed their back-up capacity. The model was run for a full week of simulations. The results showed that tanks were able to cycle similar to normal conditions, and no low system pressures (under 30 psi) were found. Given the results of the reliability analysis, no improvements are recommended to meet the reliability criteria.

3.8.8 Redundancy

Section 3.8.3 states the redundancy criteria, which requires the system to maintain pressure during MDD with Water Station 1 offline. The redundancy scenario was evaluated system-wide from a supply standpoint in Chapter 4, and summarized in Section 3.5.1.3. As noted in Chapter 4, with Water Station 1 offline, the City is unable to meet its 2034 MDD with the existing system. Improvements in production capacity were recommended at Water Stations 4, 6, 8, and 15 to help meet the redundancy criteria. Additionally, it was recommended that demands be curtailed by 15 percent in 2034 under this redundancy scenario.

The redundancy scenario was further analyzed in the hydraulic model to check the impacts in each pressure zone should Water Station 1 be offline. The model was used to simulate 2034 MDD. For this scenario, the recommended improvements at Water Stations 4, 6, 8, and 15 were implemented (which assumes production equals the water right), and demands were curtailed by 15 percent. The wells and BSPs at Water Station 1 were deactivated. The model results indicate that the system is able to meet demands and the minimum pressure criteria (30 psi) throughout the system under this scenario. Because Water Station 1 is the only supply to the Vancouver Low Zone, if it is offline, supply from upper zones will be required to meet Vancouver Low demands. The model produced the best results when a PRV was used between the Heights High Zone and Vancouver High Zone (near Nicholson Street) to share excess supply from Heights High to Vancouver High, which can then supply Vancouver Low through existing PRVs.

The City is planning several major upgrades to Water Station 1 that will improve reliability, thus it is not anticipated that the system will need to operate without this water station.

3.9 WATER SYSTEM PHYSICAL CAPACITY

Appendix 3F presents the calculated capacity of the water system following the DOH guidelines. Capacities were calculated excluding the Water Station 1 improvements. Source capacity was calculated using the available average and peak supply capacity from all sources, considering the water rights, treatment, and pumping limitations as evaluated in Chapter 4, Tables 4.5 and 4.3, respectively. Storage capacity was calculated from the available equalizing and standby storage system-wide. Distribution and transmission capacity was calculated using the hydraulic model to predict the maximum system demands with no pressure deficiencies. The model calculations for the transmission and distribution system capacity are largely dependent on operational controls of pump stations and supplies; thus, the calculated capacity can vary greatly. All capacities are expressed in terms of ERUs, given the assumed ERU water use of 223 gpd for ADD, and 468 gpd for MDD (assumes a factor of 2.1 for peaking from ADD to MDD).

The results indicate that the limiting capacity of the entire physical system is the distribution and transmission system with a capacity of 123,852 ERUs. The next most limiting capacity is due to limitations in Standby Storage. The improvements identified throughout this Plan address these limitations so that the City can meet its performance criteria for all future customers.

3.10 SUMMARY OF RECOMMENDATIONS

The above sections discuss the condition and capacity analyses for all elements of the City's water system including supply, water quality, pumping, storage, and distribution piping. Recommendations were provided in each section above, and are summarized below. Chapter 8 – Capital Improvements Plan provides a final project list that combines these recommendations along with all other recommendations in the plan. Cost estimates and proposed timing are established in Chapter 8.

3.10.1 General Facilities

The following improvements are summarized from Section 3.4:

Water Station 1

- Wells 3 & 4: Improve or replace existing buildings; ensure proper drainage with new structures.
- 0.25-MG Tank: Replace or retrofit the tank as recommended by the 2012 seismic study to address seismic deficiencies.
- 1-MG Reservoir: Replace or retrofit the reservoir as recommended by the 2012 seismic study to address seismic deficiencies (including roof replacement).
- 4.0-MG Reservoir: Replace or retrofit the reservoir as recommended by the 2012 seismic study to address seismic deficiencies (including roof replacement).
- 4-MG Reservoir BPS (BPS 1, 2, 3):
  - Repair roof of the building to address excess leakage;
  - Repair or replace Pump 2; or
  - Full BPS Replacement.
- 1-MG Reservoir BPS (BPS 4, 5): Possible full replacement due to proximity to 1-MG Reservoir.
- Further investigate condition of buried piping that serves the 1 MG and 4 MG booster stations.
- St. Johns BPS: install electrical components to utilize existing flow meter.

Water Station 3

- Replace the existing 1.25 MG reservoir as soon as possible.
- Perform a structural assessment of the 0.25-MG tank to assess for a retrofit or replacement.
- Replace Booster Pump No. 1;
- Consider replacement of entire Water Station 3 BPS facility when the reservoir is replaced.

- Add flow meters at each BPS pump.

Water Station 4

- Replace Well 4 building.
- Address leak at the base of Well 3.

Water Station 5

- Install electrical components to allow BPS pump flow meters to function.

Water Station 7

- Repair structural damage caused by fluoride corrosion.

Water Station 8

- Use a wet-vacuum or sump pump to keep floor of fluoride room dry.

Water Station 9

- Replace BPS pump flow meters and impellers.

Water Station 15

- Resolve screening issues on Well 4 to increase production from this station.

Ellsworth Water Station

- Repair roof of treatment building to prevent further water damage to equipment.
- Replace BPS 1 flow meter.

Remaining Useful Life Pipe Replacement Schedule

- Given the remaining useful life of pipes based on age and material, continue to replace approximately 5,000 LF of pipe per year until an asset management program provides further direction.

3.10.2 Supply

Make necessary production and treatment system improvements required to utilize all available water rights at Water Stations 4, 6, 8, and 15, yielding an additional 10,050 gpm (14.47 mgd) of redundant supply capacity.

3.10.3 Water Quality

The City is planning on converting its gas chlorination facilities to use onsite sodium hypochlorite facilities to improve safety and avoid the escalating costs of chlorine gas.

3.10.4 Pumping

Implement the Water Station 1 improvements, specifically back-up power capacity improvements to wells and BPSs to help meet the City's pumping criteria.

It is recommended that an additional 1,500 gpm of pumping capacity be installed for the Lincoln High Zone to provide reliability, redundancy and sufficient capacity to supply fire flows concurrently with PHD.

3.10.5 Storage

- Implement the Water Station 1 improvements, specifically back-up power capacity improvements to wells and BPSs to help meet the City's storage criteria.
- Vancouver Low: Perform a rezone study for high-elevation customers in East Reserve Road after Water Station 1 3.0-MG Reservoir has been constructed and dimensions are known.
- Vancouver High:
  - Replace Water Station 3 1.25-MG Reservoir
  - Perform a rezone study for high-elevation customers south of East Fourth Plain Boulevard. Given the results, re-evaluate storage needs for Vancouver High.
- Heights High:
  - Allow sharing of Heights Low excess storage capacity to serve Heights High through pumping of Water Station 5 and Ellsworth BPSs.
  - Add back-up capacity to Water Station 5 Pumps 1, 2, and 3 (total of 5,250 gpm) .

3.10.6 Distribution System Piping

Table 3.13, Table 3.14, and Table 3.15 present the recommended pipe improvements to address pressure and fire flow deficiencies. Table 3.13 summarizes currently planned City projects that were included in the evaluation above. Table 3.14 summarizes all projects for addressing pressure deficiencies (including those that address pressure and fire deficiencies, and those that balance the Heights High Zone HGL). Table 3.15 summarizes all projects recommended for addressing fire flow deficiencies.

As seen in Table 3.13 tables, projects are labeled with a "D" for distribution pipes (under 12-inches), "T" for a transmission pipe improvement (12-inches and larger), and "CP" for projects already planned by the City. The project type, including a new pipe or replacement of the existing pipe is noted, along with the recommended minimum diameter and total length of pipe. The purpose of each project is noted, whether to alleviate a pressure or fire deficiency (or both in some cases), or whether the project assists in improving the HGL of the zone.

Table 3.13 Recommended Pipe Improvements – City Planned Projects

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Planning Horizon Completion Year
CP-01	New	12 8	4270 2790	Southwest of Old Lower River Rd., northwest of Gateway Ave.	Currently planned City project	2020
CP-02	New	12	1690	Railroad tracks East of Gateway Ave.	Currently planned City project	2020
CP-03	New	10	980	68th St. - 51st Pl. to 47th Ave., 47th Ave. - 68th St. to 300 ft.	Currently planned City project	2020
CP-04	New	10	700	68th St. - End of existing at 53rd way to end of existing at 56th Ave.	Currently planned City project	2020
CP-05	New	24	7830	86th St. - 94th Ave. to 111th Ave., 111th Ave. - 86th St. to 99th St.	Currently planned City project	2020

Table 3.14 Recommended Pipe Improvements – Pressure Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
D-03	Replace	8	740	17th St. to McLoughlin Blvd., F St. to I-5	Pressure and Fire Deficiency	60%	2020
D-06	Replace	6	380	52nd St., Daniels St. to Columbia St.	Pressure Deficiency	80%	
D-10	Replace	8	3210	41st St. and 43rd St., Lincoln Ave. to Daniels St.	Pressure and Fire Deficiency	70%	2020
D-18	Replace	8	370	Ash St. - south of 17th St.	Pressure and Fire Deficiency	30%	2020
T-03	New	24	4120	4th Plain Blvd., 36th Ave. to Lincoln Ave.	Pressure Deficiency		2020
T-04	Replace	12	1590	4th Plain Blvd. and 25th St., Loncoln Ave. to Grant St.	Pressure Deficiency		2024

Table 3.14 Recommended Pipe Improvements – Pressure Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
T-05	New	12	280	25th St. , Grant St. to Franklin St.	Pressure Deficiency		2024
T-06	Replace	12	3040	Daniels St. to Main St., 19th St. to 4th Plain Blvd.	Pressure Deficiency		2020
T-07	Replace	12	1550	E St., 16th St. to 22nd St.	Pressure Deficiency		2020
T-11	Replace	24 16	880 830	Washington St., 42nd St. to 45th St.	Pressure Deficiency		
T-12	Replace	12	530	Grant St., 39th St. to 41st St.	Pressure and Fire Deficiency	70%	2020
T-26	Replace	24	6540	Evergreen Blvd., Blanford Dr. to Sleret Ave.	Pressure Deficiency		2020
T-27	Replace	24	10370	Idaho St., Kansas St., and 12th St. from Ogden Ave. to 87th Ave.	Balances HH HGL		2034
T-31	Replace	24 16	1350 10	99th St - 115th Ave. to Eastridge Blvd.	Balances HH HGL		2034
T-33	New	18 12	8540 130	99th St - 140th Ct. to 152nd Ave., 152nd Ave. - 99th St. to Ward Rd.	Balances HH HGL		2034
T-34	New	24	10420	Burton Rd. - 98th Ave. to 124th Ave., 110th Ave. - Burton Rd. to 18th St.	Balances HH HGL		2034
T-36	Replace	24 18	10380 4390	9th Ave. to 18th St., 112th Ave. to 129th Ave.	Pressure Deficiency		2024
T-37	New	16	670	Haagen Park, north of 9th St.	Pressure Deficiency		2024
T-40	New	24	8060	18th St. - 130th Ave. to 162nd Ave.	Balances HH HGL		2034
T-45	Replace	10 6	1350 1110	Chkalov Dr., south of Mill Plain Blvd.	Pressure Deficiency		2024

Table 3.14 Recommended Pipe Improvements – Pressure Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
T-46	Replace	18	2560	Mill Plain Blvd. - 124th Ave. to 131st Ave.	Pressure Deficiency		2024
T-51	Replace	30	2077	N Blandford Dr., north of East Evergreen Blvd to existing 24-inch	Pressure Deficiency		2020

Table 3.15 Recommended Pipe Improvements – Fire Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
D-01	Replace	8	240	Between 21st St. and 20th St., west of Daniels St.	Fire Flow Deficiency	70%	
D-02	Replace	8	1080	15th St. to 17th St., E St. to F St.	Fire Flow Deficiency	60%	
D-04	Replace	10	520	Whitney Rd, west of Lakeshore Ave.	Fire Flow Deficiency	70%	
D-05	Replace	12 8	1010 1000	58th St., Cherry St. to Lincoln Ave.	Fire Flow Deficiency	80%	
D-07	Replace	8	1350	50th St and Newhouse Rd., Washington St. to Hazel Dell Ave.	Fire Flow Deficiency	20%	
D-08	Replace	8 6	4510 40	Alki Rd. and Hazel Dell Ave., south of 56th Cir.	Fire Flow Deficiency	10%	
D-09	Replace	8	1620	44th St. and 43rd St., east of Washington St.	Fire Flow Deficiency	30%	
D-11	Replace	8	3000	39th St. to 43rd St., Olive St. to Lincoln Ave.	Fire Flow Deficiency	0%	
D-12	Replace	8	880	37th St. to 39th St., Daniels St. to Columbia St.	Fire Flow Deficiency	80%	

Table 3.15 Recommended Pipe Improvements – Fire Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
D-13	Replace	8	150	27th St., Main St. to Broadway St.	Fire Flow Deficiency	90%	
D-14	Replace	8	950	Ball Park/24th St. to 25th St., F St. to G St.	Fire Flow Deficiency	90%	
D-15	Replace	8	1040	19th St. to 22nd St., G St. to H St.	Fire Flow Deficiency	90%	
D-16	Replace	8	450	Y St. - 35th St. to 37th St.	Fire Flow Deficiency	60%	
D-17	Replace	8	220	19th St. - east of Grand St.	Fire Flow Deficiency	50%	
D-19	Replace	8	530	Date St., 15th St. to 17th St.	Fire Flow Deficiency	40%	
D-20	Replace	8	470	Brandt Rd. - south of 18th St.	Fire Flow Deficiency	60%	
D-21	Replace	8	310	Larsen Way - south of 18th st.	Fire Flow Deficiency	40%	
D-22	Replace	8	920	17th St. to 18th St., Bryant St. to 200 ft east	Fire Flow Deficiency	30%	
D-23	Replace	8	640	Linda Ln. - west of Falk Rd.	Fire Flow Deficiency	40%	
D-24	Replace	8	490	11 St. - Reserve St. to U St.	Fire Flow Deficiency	90%	
D-25	Replace	8	720	V St. - Mill Plain Blvd. to 13th St.	Fire Flow Deficiency	90%	
D-26	Replace	8	650	9th St. to Mill Plain Blvd., Grand Blvd. to Gillis St.	Fire Flow Deficiency	90%	
D-27	Replace	10	2970	59th St. - 22nd Ave. to St. Johns Rd.	Fire Flow Deficiency	80%	
D-28	Replace	8	130	St. James Rd. and 51st St.	Fire Flow Deficiency	90%	
D-29	Replace	12 8	1270 1240	52nd St. - St. Johns Rd. to 38th Ave.	Fire Flow Deficiency	50%	
D-30	Replace	8	600	52nd St. to 54th St., 63rd Ave. to 64th Ave.	Fire Flow Deficiency	40%	
D-31	Replace	8	20	116th Ave.- south of Conifer Dr.	Fire Flow Deficiency	80%	

Table 3.15 Recommended Pipe Improvements – Fire Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
D-32	Replace	8	650	South of 59th St., east of 131st Ave.	Fire Flow Deficiency	80%	
D-33	Replace	8	390	22nd St - east of 138th Ave.	Fire Flow Deficiency	60%	
D-34	Replace	8	710	Vancouver Mall Dr. - east of 94th Ave.	Fire Flow Deficiency	60%	
D-35	Replace	8	970	108th Ave. - 11th St. to 14 th St.	Fire Flow Deficiency	70%	
D-37	Replace	8	650	97th Ave., 2nd St. to 4th St.	Fire Flow Deficiency	70%	
D-38	Replace	8	1070	101st Ave., 5th St. to Mill Plain Blvd.	Fire Flow Deficiency	90%	
D-39	Replace	8	1930	13th St., Grand Blvd. to McLoughlin Blvd.	Fire Flow Deficiency	80%	
T-01	Replace	16	1840	Southwest of Old Lower River Rd., near Mathews Point	Fire Flow Deficiency	60%	
T-02	New	12	970	Lower River Rd., Gateway Ave. to Old Lower River Rd.	Fire Flow Deficiency	90%	
T-08	Replace	12	2000	South of Lakeside Rd., west of Witney Rd.	Fire Flow Deficiency	70%	
T-09	Replace	18 12	7340 20	Fruit Valley Rd., Lakeside Rd. to 39th St.	Fire Flow Deficiency	0%	
T-10	Replace	12	790	Hazel Dell Ave., Newhouse Rd. to Alki Rd.	Fire Flow Deficiency	30%	
T-13	Replace	12	390	South of 4th Plain Blvd., east of Plain Blvd.	Fire Flow Deficiency	70%	
T-14	Replace	24 18	7650 1370	4th Plain Blvd., Fort Vancouver Way to Carlson Rd.	Fire Flow Deficiency	70%	
T-15	Replace	12	710	Fairmount Ave., 20th St. to 4th Plain Blvd.	Fire Flow Deficiency	50%	

Table 3.15 Recommended Pipe Improvements – Fire Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
T-16	Replace	18 12	4470 4420	17th St. to 4th Plain Blvd., Norris Rd. to Todd Rd.	Fire Flow Deficiency	20%	
T-17	Replace	12	2530	10th St. to 4th Plain Blvd., Brandt Rd. to dogwood Blvd.	Fire Flow Deficiency	40%	
T-18	Replace	18 12	630 70	Winler Dr. - 4th Plain Blvd. to Sheridan Dr., 100 ft. on Sheridan Dr.	Fire Flow Deficiency	20%	
T-19	Replace	12	1950	Wahchellah Ave. to 4th Plain Blvd., General Anderson Rd. to Carlson Rd.	Fire Flow Deficiency	30%	
T-20	Replace	12	2340	General Anderson Rd. - Wahclellah Ave to 18th St., 18th St - General Anderson Rd. to Carlson Rd.	Fire Flow Deficiency	40%	
T-21	Replace	12	420	Thunderbird Village Apartments	Fire Flow Deficiency	40%	
T-22	Replace	18	610	Falk Rd., The Glen Apartments to Plomondon Ln.	Fire Flow Deficiency	80%	
T-23	Replace	12	1630	Nicholson Rd. - Burnt Bridge Creek Park to 42nd Rd., and 200 ft on Falk Rd.	Fire Flow Deficiency	30%	
T-24	Replace	12	1970	Pearson Airfield, west of Reserve St.	Fire Flow Deficiency	40%	
T-25	Replace	12	710	Access Rd., west of Maritime Ave.	Fire Flow Deficiency	80%	
T-28	Replace	12	1570	Garrison Rd. - 12th St. to 14th St.	Fire Flow Deficiency	60%	
T-29	Replace	12	810	65th St., west of St. Johns Rd.	Fire Flow Deficiency	20%	
T-30	Replace	12	4380	40th Ave. - 60th St. to 70th St., 43rd Ave. to St. Johns Rd.	Fire Flow Deficiency	70%	
T-32	Replace	12	220	West of 117th Ave., south of 91st Cir.	Fire Flow Deficiency	80%	

Table 3.15 Recommended Pipe Improvements – Fire Deficiencies

Project Number	CIP Type	Proposed Diameter (inches)	Length (ft)	Location	Purpose	Percentage of Required Fire Flow Available (%)	Planning Horizon Completion Year
T-35	Replace	18 12	3340 650	14th St. - 97th Ave. to 109th Ave.	Fire Flow Deficiency	70%	
T-38	Replace	12	180	North of 16th St., east of 130th Ave.	Fire Flow Deficiency	70%	
T-39	Replace	12 8	3200 20	138th Ave., south of 18th St.	Fire Flow Deficiency	40%	
T-41	Replace	12	1060	15th St. - 162nd Ave. to 164th Ave.	Fire Flow Deficiency	80%	
T-42	Replace	12	620	Leroy Haagen Memorial Dr. - Haagen Park to 136th Ave.	Fire Flow Deficiency	80%	
T-43	Replace	12	780	South of Leroy Haagen Memorial Dr., East of 136th Ave.	Fire Flow Deficiency	80%	
T-44	New	16	310	9th St. at 139th Ave.	Fire Flow Deficiency	80%	
T-47	Replace	12	680	Talton Ave. - 17th St. to McGillivray Blvd.	Fire Flow Deficiency	90%	
T-48	Replace	12	190	Parkcrest Ave. south of 7th St.	Fire Flow Deficiency	90%	
T-49	Replace	12	380	164th Ave. - 15th St. to 12th St.	Fire Flow Deficiency	60%	
T-50	Replace	12	310	North of 12th St. west of 172nd Ave.	Fire Flow Deficiency	60%	

As seen in Figure 3.19 and Figure 3.20, projects are color coded as follows:

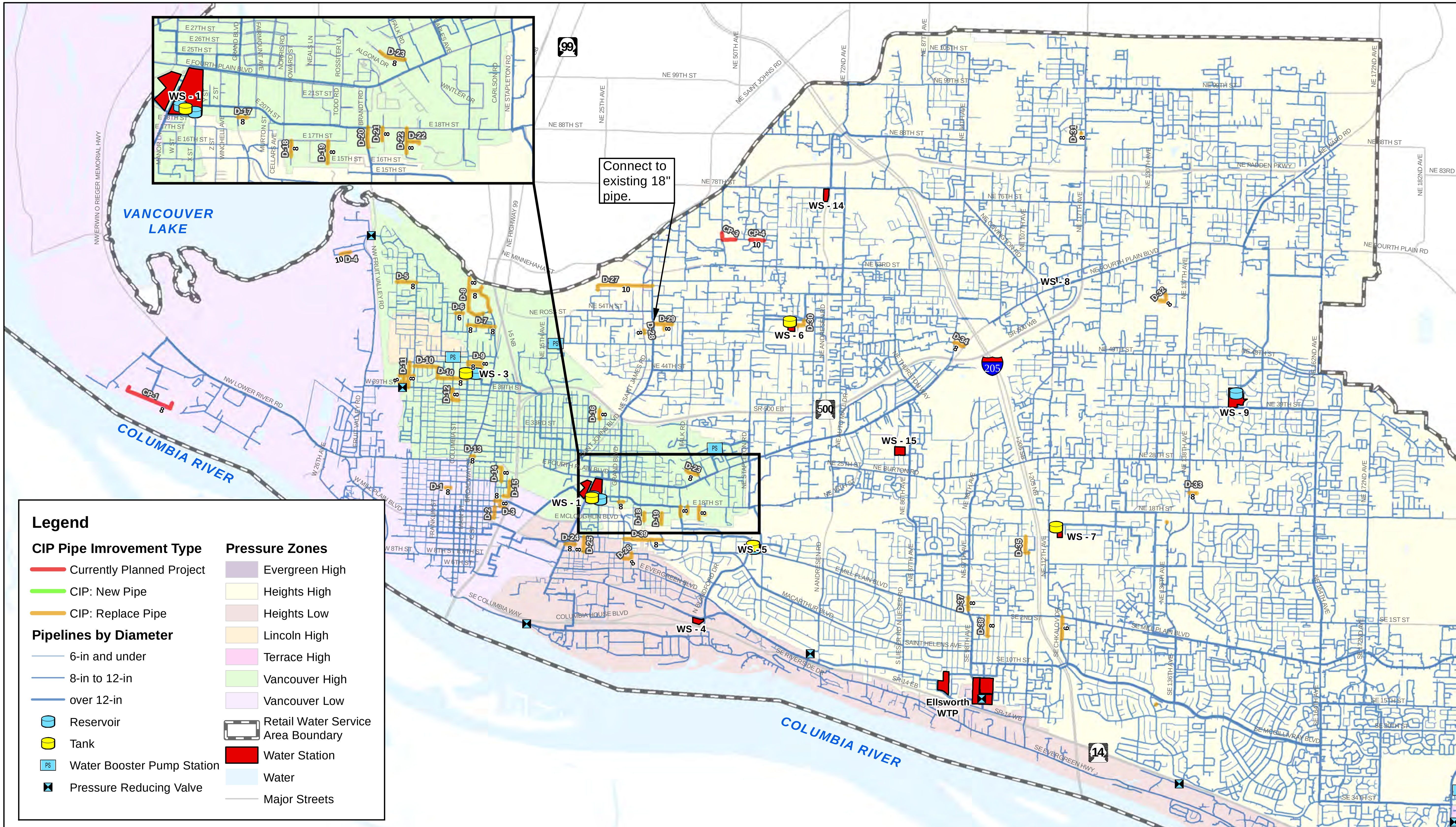
Red = Currently planned City project

Green = New pipe recommendation

Orange = Replace existing pipe recommendation.

Additionally, it is recommended that the city investigate the condition of distribution piping to resolve high head losses experienced during fire flow tests. Figure 3.21 presents the resulting fire flow deficiencies after implementing the above recommended projects.

Revised: April 06, 2015
File Path: M:\Client\Vancouver\GIS\mxd\Fig 03_19 Recommended Distribution Pipe Improvements.mxd



RECOMMENDED PIPE IMPROVEMENT - DISTRIBUTION

FIGURE 3.19

0 4,000 8,000 Feet

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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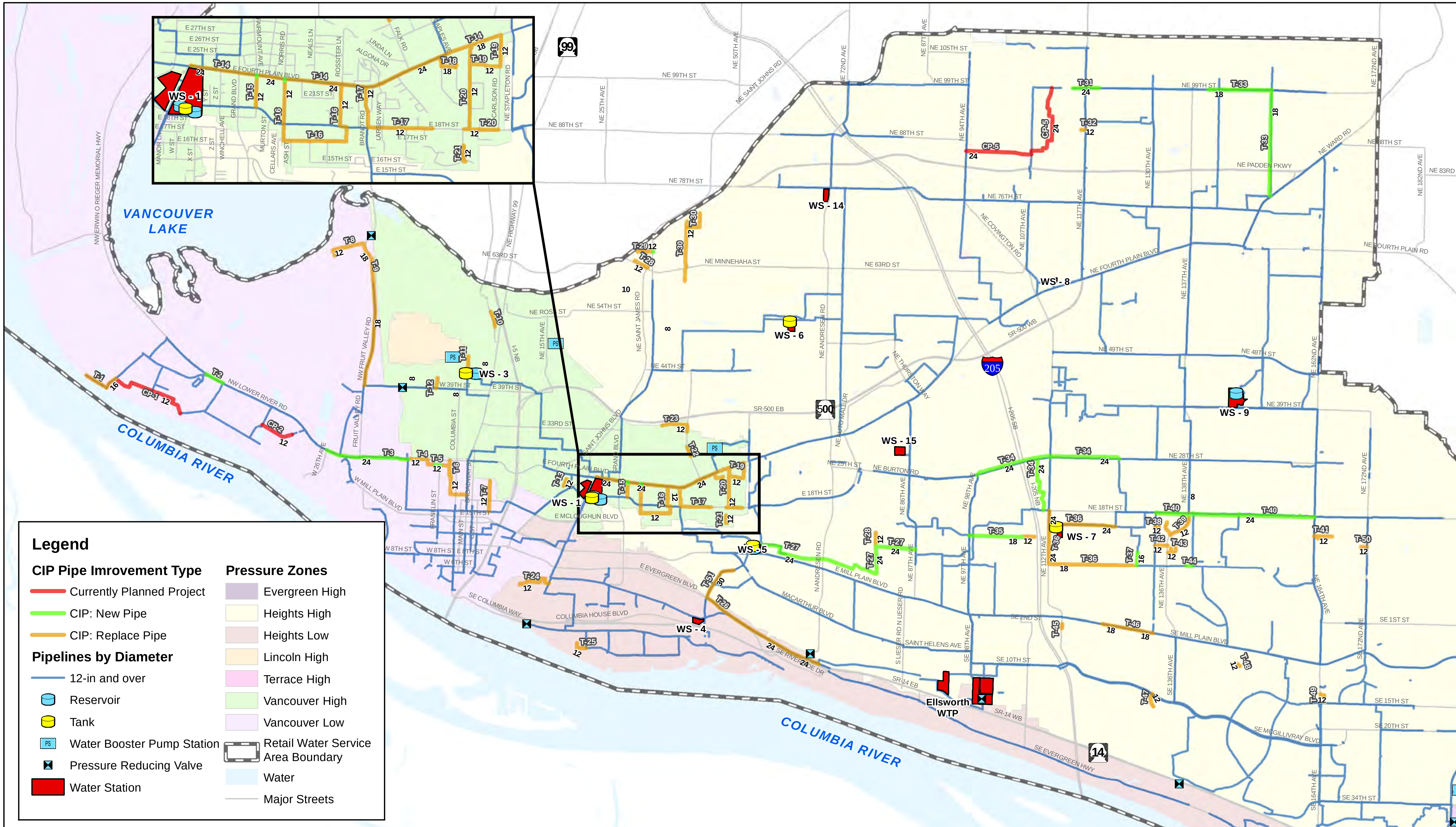
Revised: April 06, 2015
File Path: M:\Client\Vancouver\GIS\mxd\Fig 03_20 Recommended Transmission Pipe Improvements.mxd



Feet
0 4,000 8,000

RECOMMENDED PIPE IMPROVEMENT - TRANSMISSION

FIGURE 3.20

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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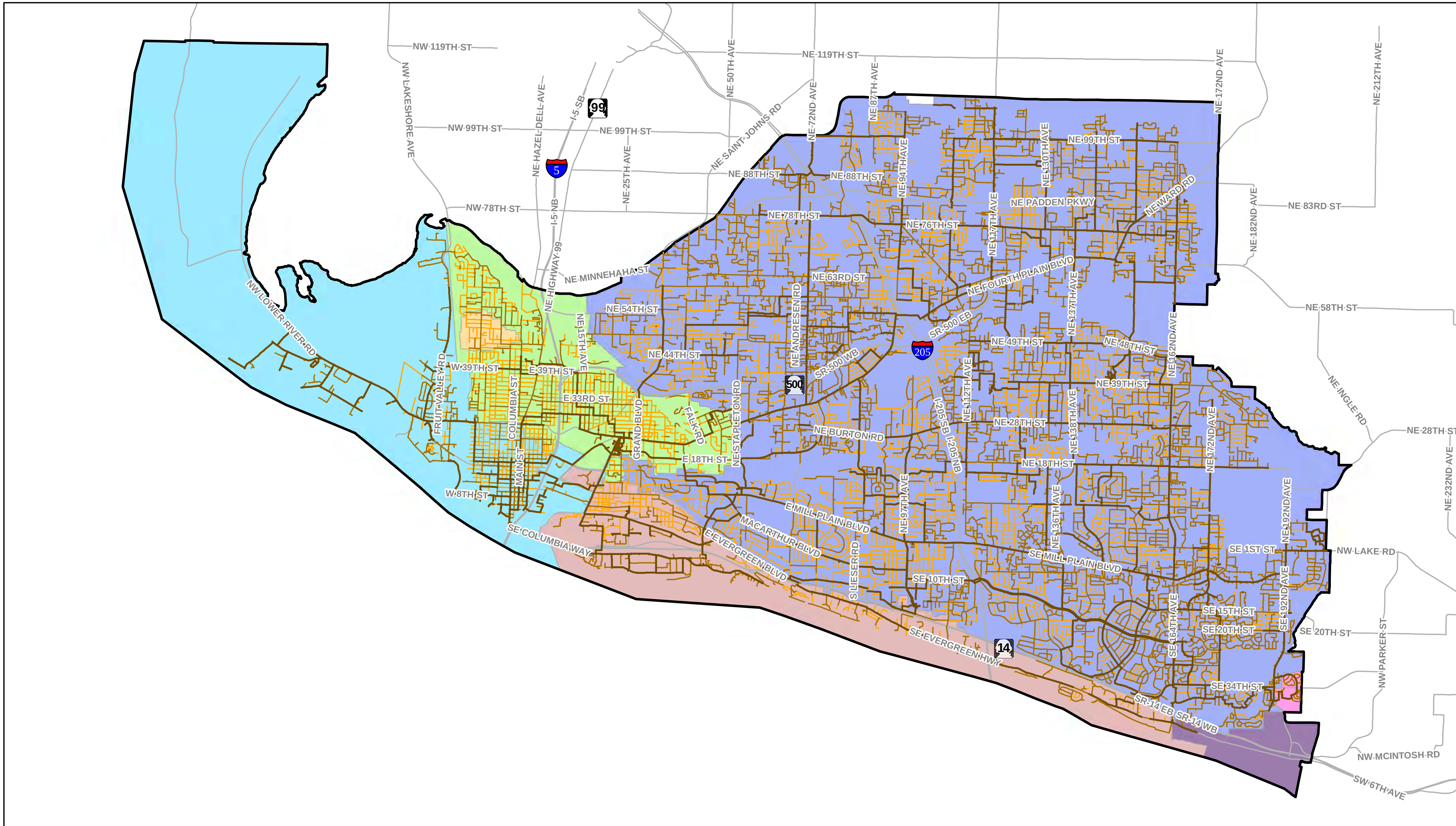
Revised: January 26, 2015
File Path: M:\Client\Vancouver\GIS\mxd\Fig 03_21 Pressure and Fire Flow Deficiencies.mxd



Legend

- 2064 Fire Flow Deficiencies
- Major Streets
- Retail Water Service Area Boundary

Pipelines by Diameter

- 6-in or smaller
- 8-in to 10-in
- 12-in or larger

Pressure Zones

- Evergreen High
- Heights High
- Heights Low
- Lincoln High
- Terrace High
- Vancouver High
- Vancouver Low

N

Feet
0 4,000 8,000

Figure 3.21
Pressure and Fire Flow Deficiencies after Improvements
Comprehensive Water System Plan
City of Vancouver

carollo

Chapter 4

WATER RESOURCE ANALYSIS & WATER USE EFFICIENCY

4.1 INTRODUCTION

The City of Vancouver (City) obtains its drinking water from 40 active wells at 10 water stations that produce, treat, store, and pump water into the distribution system. These wells draw from the Orchards, Troutdale, and Sand & Gravel regional aquifers below the City that also serve neighboring communities in Clark and Multnomah Counties. Proper management of these aquifers is imperative to ensuring adequate water supply to sustain the local population and supporting environment, now and in the future.

This chapter summarizes the City's water rights, supply capacity, and water use efficiency (WUE) plan. The supply analysis below shows that the City has secured adequate water rights for the 20-year planning horizon to meet both average and maximum day demands. However, some of the City's water system facilities are limited in capacity and could be improved to increase supply redundancy during maximum day demands. Recommended supply improvements are outlined in Section 4.3.3. As described in Section 4.4, improving upon the City's current WUE Program can help to delay these capital projects and defer construction costs. By improving water use efficiency, the City's water system will be able to serve more customers with its current water supply sources.

4.2 WATER RIGHTS ANALYSIS

The City's water is supplied from 10 groundwater well fields, called water stations. Each water station has between one and 12 groundwater wells and associated treatment, storage, and distribution facilities. Details on the wells and water station facilities are presented in Chapter 1, and shown graphically on Figure 1.6. The City has groundwater water rights associated with each of its currently active wells, as described in Section 4.2.1. Although the City had surface water rights at the Ellsworth Water Station in the past, the City currently has no surface water rights and does not rely on any interties with other local utilities for normal supply. No future municipal water rights are pending at this time.

4.2.1 Existing Water Rights Status

The City's groundwater rights for each well are presented in Table 4.1. This table presents the data required for evaluating the City's existing water rights status, called "Table 3" in the DOH Water System Planning Handbook. The table includes the permit certificate or claim number by water station, priority date of the water right, source name/number (well number), instantaneous flow rate in gallons per minute (gpm), and the annual flow rate in acre-feet per year (AFY) for both primary and additive rights. (Note, Water Station 4 Wells 4B, 5B, and 6 water right claims were established before the 1945 Ground Water Code and are therefore presented separately in Table 4.1.) Certificates for the water rights and claims are included in Appendix 4A. Water rights for these wells are administered by the Washington Department of Ecology (Ecology). As seen in Table 4.1, the City has a total allowable instantaneous withdrawal (Qi) of 75,072 gpm (108.1 mgd), a total allowable annual withdrawal (Qa) of 50,256.5 AFY (44.86 mgd), and 23,990.5 AFY (21.42 mgd) of additive annual water rights. Wells with additive water rights (previously called “supplemental rights”) can be used concurrently with other wells as long as instantaneous pumping does not exceed the total Qi, and annual pumping does not exceed the total primary Qa. Further, the primary Qa used by the additive water rights is typically only allowed to supplement production of wells within the same aquifer. DOE has allowed exceptions for the Ellsworth wells and Water Station 7, Well 2B, which are able to supplement production of wells in any aquifer.

Table 4.1 also compares the City’s water rights to its existing pumping capacity, and identifies excess or deficient water rights at each well and for the entire system. The maximum instantaneous well pumping capacity shown in the table is the current well pumping capacity, as provided by City staff. As seen in the table, some of the City’s wells have insufficient pumping capacity to use their full Qi. Some of the well capacities exceed the current water right. However, the total existing pumping capacity at the water station with these wells does not exceed the sum of the individual existing instantaneous water rights, except Water Station 1. The combined production of Water Station 1 currently and historically has been metered and the City operates the water station to ensure the production does not exceed the Qi. Recent work at Water Station 1 has determined that the individual well pumping capacities are higher than historically thought; however, the City will continue to ensure the combined Water Station 1 pumping does not exceed the Qi in the future. Overall, the City has 10,727 gpm (15.45 mgd) of unused instantaneous water rights due to well pumping limitations.

As the City does not run all of its pumps at full capacity at the same time, another valuable comparison is the Qi and the current 2012 maximum day demand (MDD) of 37,847 gpm (54.48 mgd). Comparing the Qi of 75,072 gpm (108.10 mgd) to a MDD of 37,847 gpm (54.48 mgd) yields a total excess of 37,225 gpm (53.60 mgd) of instantaneous water rights. However, it should be noted that the maximum day demand is the total production over the entire day, not an instantaneous pumping rate.

Table 4.1 also presents the 2012 Annual Production as 28,530 AFY (25.47 mgd); this year represents the most recent data used for this study. Compared to the total Qa of 50,256.5 AFY (44.86 mgd), the City has a current excess of 21,726.5 AFY (19.39 mgd) of unused primary water rights in 2012.

Table 4.1 Existing Water Rights Status

Permit Certificate or Claim #	Priority Date	Source Number	Well Number	Existing Water Rights			Existing Production Capacity		Current Water Rights Status Excess/(Deficiency)	
				Maximum Instantaneous Flow Rate (Qi) (gpm)	Primary Annual Volume (Qa) (AFY)	Additive Annual Volume (AFY)	Maximum Instantaneous Well Pumping Capacity(1) (Qi) (gpm)	2012 Annual Production (Qa) (AFY)	Maximum Instantaneous Flow Rate (Qi) (gpm)	2012 Annual Volume (Qa) (AFY)
Water Station 1										
64D74	3/1/1938	S14	1	2,000.	2,030.0		2,340		(340)	
65D75	1/1/1939	S15	2	2,000	2,100.0		2,260		(260)	
66D76	9/1/1943	S16	3	2,000	2,442.0		2,100		(100)	
67D77	6/1/1944	S17	4	1,200	923.0		1,270		(70)	
4920A	2/16/1962	S18, S19	5, 6	2,200		3,520.0	1,360		840	
G2-23395C	11/27/1974	S20	7	2,000	1,600.0		3,140		(1,140)	
G2-26309C	3/2/1983	S21, S22, S23, S24, S25, S26	8, 9, 10, 11, 12, 13	12,000	258.5	9,419.5	13,800		(1,800)	
Water Station 3										
14-A-C	1/26/1946	S27	1	2,000	2,580.0		2,175		(175)	
1745-A-C	1/11/1951	S28	2	2,000	2,580.0		2,000		0	
G2-25363C	9/10/1979	S29	3	2,000	1,613.0		2,000		0	
Water Station 4										
1649A	1/23/1952	S30	1	1,000	1,600.0		950		50	
386-D	7/1/1942	S31	2B	2,500	2,472.0		2,000		500	
388D	8/1/1942	S32	3B	2,400	2,312.0		2,000		400	
G2-25365C	9/10/1979	S35	9	800	645.0		600		200	
Water Station 6										
G2-00171C	5/7/1969		1	2,000	2,400.0		0		2,000	
G2-25364C	9/10/1979		3	400	323.0		0		400	
Water Station 7										
G2-001070C	5/7/1969	S05	1	1,250	1,500.0		800		450	
G2-27670C	8/13/1986	S10	2B	500		807.0	500		0	
Water Station 8										
3437-A	9/23/1957	S36	1, 2	750	360.0		500		250	
G2-20646C	12/4/1972	S37	3	2,000	1,600.0		750		1,250	

Table 4.1 Existing Water Rights Status

Permit Certificate or Claim #	Priority Date	Source Number	Well Number	Existing Water Rights			Existing Production Capacity		Current Water Rights Status Excess/(Deficiency)	
				Maximum Instantaneous Flow Rate (Qi) (gpm)	Primary Annual Volume (Qa) (AFY)	Additive Annual Volume (AFY)	Maximum Instantaneous Well Pumping Capacity(1) (Qi) (gpm)	2012 Annual Production (Qa) (AFY)	Maximum Instantaneous Flow Rate (Qi) (gpm)	2012 Annual Volume (Qa) (AFY)
Water Station 9										
G2-000854C	4/14/1969		1	72	30.0		0		72	
G2-22659C	6/14/1974	S38, S39	3, 4	2,800	3,600.0		2,400		400	
G2-25711C	8/11/1980	S40	5	3,000	2,419.5		2,600		400	
G2-25712C	8/11/1980	S41	6	2,500	2,016.0		2,400		100	
G2-27460C	8/13/1986	S42	7	2,500		2,016.0	2,400		100	
Water Station 14										
G2-25360C	9/10/1979	S43	1	1,000	807.0		1,000		0	
G2-25710C	8/11/1980	S44	2	1,000	806.5		1,000		0	
G2-27459C	8/13/1986	S45	3	1,200		968.0	1,200		0	
Water Station 15										
G2-25961C	7/21/1981	S46, S47, S48, S49	1, 2, 3, 4	5,000	4,839.0		1,000		4,000	
Ellsworth										
G2-27671P	8/13/1986	S50	1	3,000	0.0	2,420.0	2,000		1,000	
G2-28027C	8/13/1986	S51	2	3,000	0.0	2,420.0	2,300		700	
G2-28076C	8/13/1986	S12	3	3,000	0.0	2,420.0	2,500		500	
Claims **Water Station 4**										
G2-136136CL	8/1/1942	S33	4B	1,400	2,240.0		1,500		(100)	
G2-136137CL	8/1/1942	S34	5B	1,400	2,240.0		1,500		(100)	
136138CL	8/1/1943		6	1,200	1,920.0		0		1,200	
Total				**75,072**	**50,256.5**	**23,990.5**	**64,345**	**28,530**	**10,727**	**21,726.5**
Total (mgd)				**108.10**	**44.86**	**21.42**	**92.66**	**25.47**	**15.45**	**19.39**

Notes:
(1) Well pumping capacity as provided by City staff.

4.2.2 Forecasted Water Right Status

Table 4.2 compares the existing water rights to anticipated future demands. Table 4.2 presents the data required for evaluating the City's future water rights, called "Table 4" in the DOH Water System Planning Handbook. (Appendix 4B includes the City's 6-year water rights self-assessment form.) The projected 20-year (2034) average day demand (ADD) and maximum day demand (MDD) were developed in Chapter 2, and are presented in Table 4.2 under "Forecasted Water Use From Sources (20-Year High Demand)". The ADD and MDD used in this evaluation correspond to the high demand scenario. To compare MDD to the City's Qi, the MDD was converted to units of gpm assuming constant use throughout the day. To compare ADD to the City's Qa, the ADD was converted to units of AFY.

As seen in Table 4.2, comparing the 2034 high MDD of 52,750 gpm (75.96 mgd) to the Qi of 75,072 gpm (108.10 mgd) yields an excess instantaneous water right of 22,322 gpm (32.14 mgd). Comparing the 2034 High ADD of 42,042 AFY (37.52 mgd) to the current Qa of 50,256.5 AFY (44.86 mgd) yields an excess annual water right of 8,214.5 AFY (7.34 mgd). Given that the projected high MDD is 70 percent of the Qi and projected high ADD is 84 percent of the Qa, no new water rights are required during the planning period.

4.2.3 Summary of Water Rights Status

Based on the existing and future water rights analysis, no new water rights are required during the 20-year planning period. The pumping capacities of several of the City's wells are below the well's water right and could be increased to make full use of the right. The following summarizes the results of the existing and future water rights status:

Existing Water Rights Status:

- Qi exceeds current Instantaneous Pumping Capacity by 10,727 gpm (15.45 mgd).
- Qi exceeds 2012 Maximum Day Production by 37,225 gpm (53.60 mgd).
- Qa exceeds 2012 Annual Production by 21,726.5 AFY (19.39 mgd).

Forecasted Water Rights Status:

- Qi exceeds 20-Year (2034) High MDD by 22,322 gpm (32.14 mgd).
- Qa exceeds 20-Year (2034) High ADD by 8,214.5 AFY (7.34mgd).

The City is committed to making full use of all its water rights. Additionally, for wells whose pumping capacity exceeds the individual water right, the City will continue to work with Ecology to make the instantaneous withdrawal rates consistent with existing well capacities. Individual water station limitations beyond well pumping capacity are evaluated in more detail in Section 4.3.

Table 4.2 Forecasted Water Rights Status

Permit Certificate or Claim #	Priority Date	Source Name	Well Number	Existing Water Rights			Forecasted Water Use From Sources (20 Year High Demand)		Forecasted Water Rights Status Excess/(Deficiency) (20 Year Demand in Water Right)	
				Maximum Instantaneous Flow Rate (Qi) (gpm)	Primary Annual Volume (Qa) (AFY)	Additive Annual Volume (Qa) (AFY)	2034 Maximum Day Demand (Qi) (gpm)	2034 Average Day Demand (Qa) (AFY)	Maximum Instantaneous Flow Rate (Qi) (gpm)	Maximum Annual Volume (Qa) (AFY)
Water Station 1										
64D74	3/1/1938	S14	1	2,000	2,030.0					
65D75	1/1/1939	S15	2	2,000	2,100.0					
66D76	9/1/1943	S16	3	2,000	2,442.0					
67D77	6/1/1944	S17	4	1,200	923.0					
4920A	2/16/1962	S18, S19	5, 6	2,200		3,520.0				
G2-23395C	11/27/1974	S20	7	2,000	1,600.0					
G2-26309C	3/2/1983	S21, S22, S23, S24, S25, S26	8, 9, 10, 11, 12, 13	12,000	258.5	9,419.5				
Water Station 3										
14-A-C	1/26/1946	S27	1	2,000	2,580.0					
1745-A-C	1/11/1951	S28	2	2,000	2,580.0					
G2-25363C	9/10/1979	S29	3	2,000	1,613.0					
Water Station 4										
1649A	1/23/1952	S30	1	1,000	1,600.0					
386-D	7/1/1942	S31	2B	2,500	2,472.0					
388D	8/1/1942	S32	3B	2,400	2,312.0					
G2-25365C	9/10/1979	S35	9	800	645.0					
Water Station 6										
G2-00171C	5/7/1969		1	2,000	2,400.0					
G2-25364C	9/10/1979		3	400	323.0					
Water Station 7										
G2-001070C	5/7/1969	S05	1	1,250	1,500.0					
G2-27670C	8/13/1986	S10	2B	500		807.0				
Water Station 8										
3437-A	9/23/1957	S36	1, 2	750	360.0					
G2-20646C	12/4/1972	S37	3	2,000	1,600.0					

Table 4.2 Forecasted Water Rights Status

Permit Certificate or Claim #	Priority Date	Source Name	Well Number	Existing Water Rights			Forecasted Water Use From Sources (20 Year High Demand)		Forecasted Water Rights Status Excess/(Deficiency) (20 Year Demand in Water Right)	
				Maximum Instantaneous Flow Rate (Qi) (gpm)	Primary Annual Volume (Qa) (AFY)	Additive Annual Volume (Qa) (AFY)	2034 Maximum Day Demand (Qi) (gpm)	2034 Average Day Demand (Qa) (AFY)	Maximum Instantaneous Flow Rate (Qi) (gpm)	Maximum Annual Volume (Qa) (AFY)
Water Station 9										
G2-000854C	4/14/1969		1	72	30.0					
G2-22659C	6/14/1974	S38, S39	3, 4	2,800	3,600.0					
G2-25711C	8/11/1980	S40	5	3,000	2,419.5					
G2-25712C	8/11/1980	S41	6	2,500	2,016.0					
G2-27460C	8/13/1986	S42	7	2,500		2,016.0				
Water Station 14										
G2-25360C	9/10/1979	S43	1	1,000	807.0					
G2-25710C	8/11/1980	S44	2	1,000	806.5					
G2-27459C	8/13/1986	S45	3	1,200		968.0				
Water Station 15										
G2-25961C	7/21/1981	S46, S47, S48, S49	1, 2, 3, 4	5,000	4,839.0					
Ellsworth										
G2-27671C	8/13/1986	S50	1	3,000	0	2,420.0				
G2-28027C	8/13/1986	S51	2	3,000	0	2,420.0				
G2-28076C	8/13/1986	S12	3	3,000	0	2,420.0				
Claims **Water Station 4**										
G2-136136CL	8/1/1942	S33	4B	1,400	2,240.0					
G2-136137CL	8/1/1942	S34	5B	1,400	2,240.0					
136138CL	8/1/1943		6	1,200	1,920.0					
Total				**75,072**	**50,256.5**	**23,990.5**	**52,750**	**42,042**	**22,322**	**8,214.5**
Total (mgd)				**108.100**	**44.86**	**21.42**	**75.96**	**37.52**	**32.14**	**7.34**

4.3 SUPPLY CAPACITY EVALUATION

The City's supplies were further evaluated for meeting future demands given source limitations other than strictly water rights. The following supply capacity evaluation considers the production capacity of each water station considering well pumping capacity, treatment capacity, water rights, and other unique limitations. The City's supplies are compared to future system-wide annual and maximum demands developed in Chapter 2, and presented in Table 4.2. The ADD and MDD used in this evaluation correspond to the high demand scenario. A detailed evaluation of supply limitations to specific pressure zones and in the distribution system is presented in Chapter 3. The supply capacity evaluations below consider peak and annual demands separately. A base scenario and a redundancy scenario were considered for each demand condition. Recommendations to address identified deficiencies are summarized in Section 4.3.3.

4.3.1 Peak Supply Capacity Evaluation

Peak supply capacity evaluates the ability of the City's sources to supply the system-wide MDD for short-term periods. Demands above the MDD (such as peak hour demands or fire flow) are evaluated as part of the storage analysis; equalizing storage should supply peak hour demands, and fire suppression storage should supply fire demands. Therefore, supplies are only evaluated for providing MDD.

The peak supply capacity was compared to the projected high MDD, as developed in Chapter 2, under two scenarios: standard and redundancy. The standard scenario represents the City's ability to meet MDD with all sources pumping continuously (24 hours per day). The redundancy scenario represents the City's ability to meet MDD with the largest source, Water Station 1 offline. The results of the comparison are described below.

4.3.1.1 Standard MDD Scenario

The Standard MDD Scenario compares the City's peak supply capacity to MDD assuming all sources are online. During maximum demand days, the City may use its sources continuously (24 hours per day). This represents the maximum quantity of water that can be physically produced. However, water rights and treatment capacity limitations may restrict the production of a particular water station. The pumping capacity, water rights, and treatment capacity were compared to determine the limiting component for each water station, as presented in Table 4.3. The table consists of the following components:

- 24-Hour Pumping Capacity: The sum of well pumping capacities at each water station as provided by the City.
- Instantaneous Water Right (Qi): The sum of instantaneous water rights at each water station.
- Treatment Capacity: The total treatment capacity of each water station as provided by the City. Treatment capacities were considered at Water Stations 4, 14, and 15. The treatment capacities at Water Stations 1, 7, and Ellsworth were not considered in this evaluation, as

they are not assumed to limit production. At Water Station 1, the water quality meets applicable regulations with treatment conducted for public commitment reasons; at Water Stations 7 and Ellsworth, the treatment systems are capable of treating the entire capacity of wells that require treatment and capacity is only limited during backwash of the greensand filters.

- Peak Supply Capacity: The maximum water station production given pumping, water right, and treatment limitations.

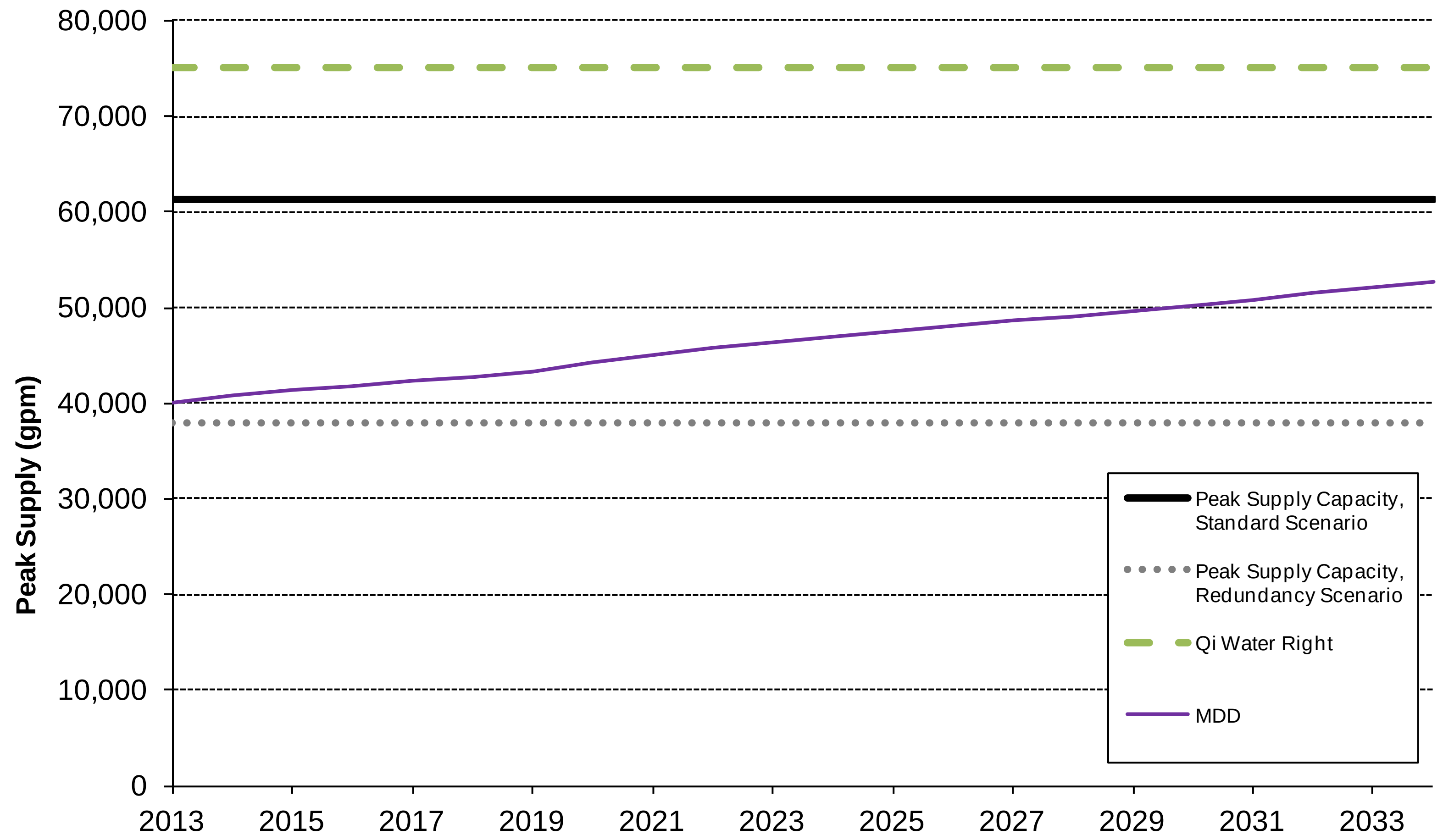
As seen in Table 4.3, the Qi exceeds the pumping capacity for all water stations, except for Water Stations 3 and 14. Treatment capacity is equal to pumping capacity for Water Stations 4, 14, and 15. In general, pumping and treatment capacities are the limiting factor for peak supply, not water rights. Considering pumping, treatment, and water rights limitations, the City has a peak supply capacity of 61,300 gpm (88.27 mgd), which is approximately 82 percent of the Qi.

Table 4.3 Peak Supply Capacity – Standard MDD Scenario

Water Station 1	24-Hour Pumping Capacity (gpm)	Instantaneous Water Right (Qi) (gpm)	Treatment Capacity (gpm)	Peak Supply Capacity (gpm)
1	26,270	23,400	NA(1)	23,400
3	6,175	6,000	NA	6,000
4	8,550	10,700	8,550	8,550
6	0	2,400	NA	0
7	1,300	1,750	NA	1,300
8	1,250	2,750	NA	1,250
9	9,800	10,872	NA	9,800
14	3,200	3,200	3,200	3,200
15	1,000	5,000	1,000	1,000
Ellsworth	6,800	9,000	NA	6,800
Total (gpm)	**64,345**	**75,072**		**61,300**
Total (mgd)	**92.66**	**108.10**		**88.27**

Notes:
(1) NA = Not applicable.

Figure 4.1 presents the peak supply capacity, Qi water right, and projected MDD over the planning period. As seen in the figure, the Qi of 75,072 gpm (108.10 mgd) and the peak supply capacity of 61,300 gpm (88.27 mgd) are well above the projected 2034 MDD of 52,750 gpm (75.96 mgd). Therefore, the City's existing source infrastructure has the capacity to meet MDD throughout the planning period. The 2034 excess of peak supply capacity is approximately 8,550 gpm (61,300 gpm - 52,750 gpm = 8,550 gpm, 12.31 mgd). This evaluation shows that no supply improvements are needed to meet the forecasted 2034 High MDD for the entire system with all supplies online.



PEAK SUPPLY CAPACITY EXCESS AND DEFICIENCIES (2014 - 2034)

FIGURE 4.1

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pw://Carollo/Documents/Client/WA/Vancouver/9290A00/Deliverables/Chapter 04/Fig_04_01.docx

4.3.1.2 MDD Redundancy Scenario

To provide a level of supply redundancy, the City also evaluated the ability to meet the high MDD with its largest source offline. Water Station 1 is the City's largest water station and is capable of producing 37 percent of the total peak supply. Table 4.4 repeats the pumping capacity, Qi water right, treatment capacity, and total peak supply capacity for each water station as shown in Table 4.3. However, in Table 4.4, the pumping capacity of Water Station 1 was reduced to zero to represent the largest water source being offline. Under this scenario, the City has a redundant peak supply capacity of 37,900 gpm (54.58 mgd).

Table 4.4 Peak Supply Capacity – MDD Redundancy Scenario

Water Station	24-Hour Pumping Capacity(1) (gpm)	Instantaneous Water Right (Qi) (gpm)	Treatment Capacity (gpm)	Peak Supply Capacity - Redundancy Scenario (gpm)
1	0	23,400	NA(2)	0
3	6,175	6,000	NA	6,000
4	8,550	10,700	8,550	8,550
6	0	2,400	NA	0
7	1,300	1,750	NA	1,300
8	1,250	2,750	NA	1,250
9	9,800	10,872	NA	9,800
14	3,200	3,200	3,200	3,200
15	1,000	5,000	1,000	1,000
Ellsworth	6,800	9,000	NA	6,800
Total	**38,075**	**75,072**		**37,900**
Total (mgd)	**54.83**	**108.10**		**54.58**

Notes:
(1) Assumes Water Station 1, the largest supply source, is offline.
(2) NA = Not applicable.

Figure 4.1 also shows the peak supply capacity for the redundant supply scenario. As seen in the figure, the redundant supply capacity of 37,900 gpm (54.58 mgd) is below the 2014 projected MDD of 40,875 gpm (58.86 mgd). With Water Station 1 offline in 2014, the City could have a supply deficiency of 2,996 gpm (40,875 gpm - 37,900 gpm = 2,975 gpm, 4.28 mgd). Additionally, by 2034 the City could fall short of meeting the forecasted high MDD of 52,750 gpm (75.96 mgd) with a supply deficiency of 14,850 gpm (52,750 gpm - 37,900 gpm = 14,850 gpm, 21.38 mgd). Improvements to increase supply capacity and eliminate this deficiency are discussed Section 4.3.3.

This redundancy analysis highlights the importance of Water Station 1 for the City's overall supply strategy. The City has recognized this importance and has an ongoing project to improve the reliability of Water Station 1, thereby reducing the risk of substantial supply reductions in the future.

4.3.2 Annual Supply Capacity Evaluation

The annual supply capacity evaluation confirms the ability of the City to supply its system-wide annual demand volume over an entire year. The annual demand volume is represented by the volume of ADD converted to units of AFY. Similar to the peak supply capacity evaluation, this evaluation considers pumping capacity, treatment capacity, and limiting water rights for each water station. Since the total pumping capacity was able to meet the demands for the standard MDD scenario, annual pumping capacity was not expected to be a limitation on an annual basis. Therefore, the evaluation focused on water rights (Qa), treatment capacity, and other regulatory limitations.

The annual supply capacity evaluation considered two scenarios: standard and redundancy. The standard scenario represents the City's ability to meet the ADD volume with all sources pumping continuously. The City recognizes that there are aquifer limitations that limit source operation and that all sources cannot be pumped 24-hours a day 365 days a year. Instead of limiting the operation of all sources in the evaluation, the City has chosen to be conservative and meet the annual demand volume with the largest source, Water Station 1 offline, in the redundancy scenario. These two scenarios are further described below.

4.3.2.1 Standard ADD Scenario

The Standard ADD Scenario considers the ability of the City's sources to meet the annual demand volume, assuming all sources are online. Pumping, treatment, water rights, and other limitations were compared to determine the annual capacity for each water station, as presented in Table 4.5. The table consists of the following components:

- Annual Pumping Capacity: The sum of well pumping capacities at each water station (as provided by the City) summed for 24-hours of pumping, 365 days of the year; converted to AFY.
- Primary Annual Water Right (Qa): The sum of primary annual water rights at each water station.
- Additive Annual Water Right: The sum of additive annual water rights at each water station.
- Treatment Capacity: The total treatment capacity of each water station (as provided by the City), summed for 24-hours of treatment, 365 days of the year; converted to AFY. Treatment capacities were considered at Water Stations 4, 14, and 15. The treatment capacities at Water Stations 1, 7, and Ellsworth were not considered in this evaluation, as they are not assumed to limit production. At Water Station 1, the water quality meets applicable regulations with treatment conducted for public commitment reasons; at Water Stations 7 and Ellsworth, the treatment systems are capable of treating the entire capacity

of wells that require treatment and capacity is only limited during backwash of the greensand filters.

- Annual Supply Capacity: The maximum annual Water Station production given pumping, water right used, treatment, and other regulatory limitations.

As seen in Table 4.5, on an annual basis, the water stations are limited by primary water rights, except Water Stations 6, 15, and Ellsworth. Water Stations 6 and 15 currently have infrastructure constraints that are limiting their ability to pump, as discussed in Chapter 1, and also seen in the peak supply capacity evaluation above. The City's substantial additive rights allow the flexibility needed to make full use of the total annual Qa with existing infrastructure. The City's current operating procedure is to utilize the unused primary Qa from Water Stations 6 and 15, to allow production from other water stations that have available annual additive water rights.

As shown in Table 4.5, additive rights are available to utilize the unused primary rights in Water Stations 6 and 15, which equates to 5,949 AFY. The majority of these additive rights are for the Ellsworth Water Station. The Ellsworth Water Station and Water Station 7 Well 2B have no primary rights, but are able to supplement the other water stations for which the full primary right is unused, not to exceed the full Qa. Based on existing system operations, it is expected that the unused primary water rights will be used at these sources; however, they may also be used at Water Stations 1 and 14. These sources provide the City the operational flexibility to make full use of the primary Qa.

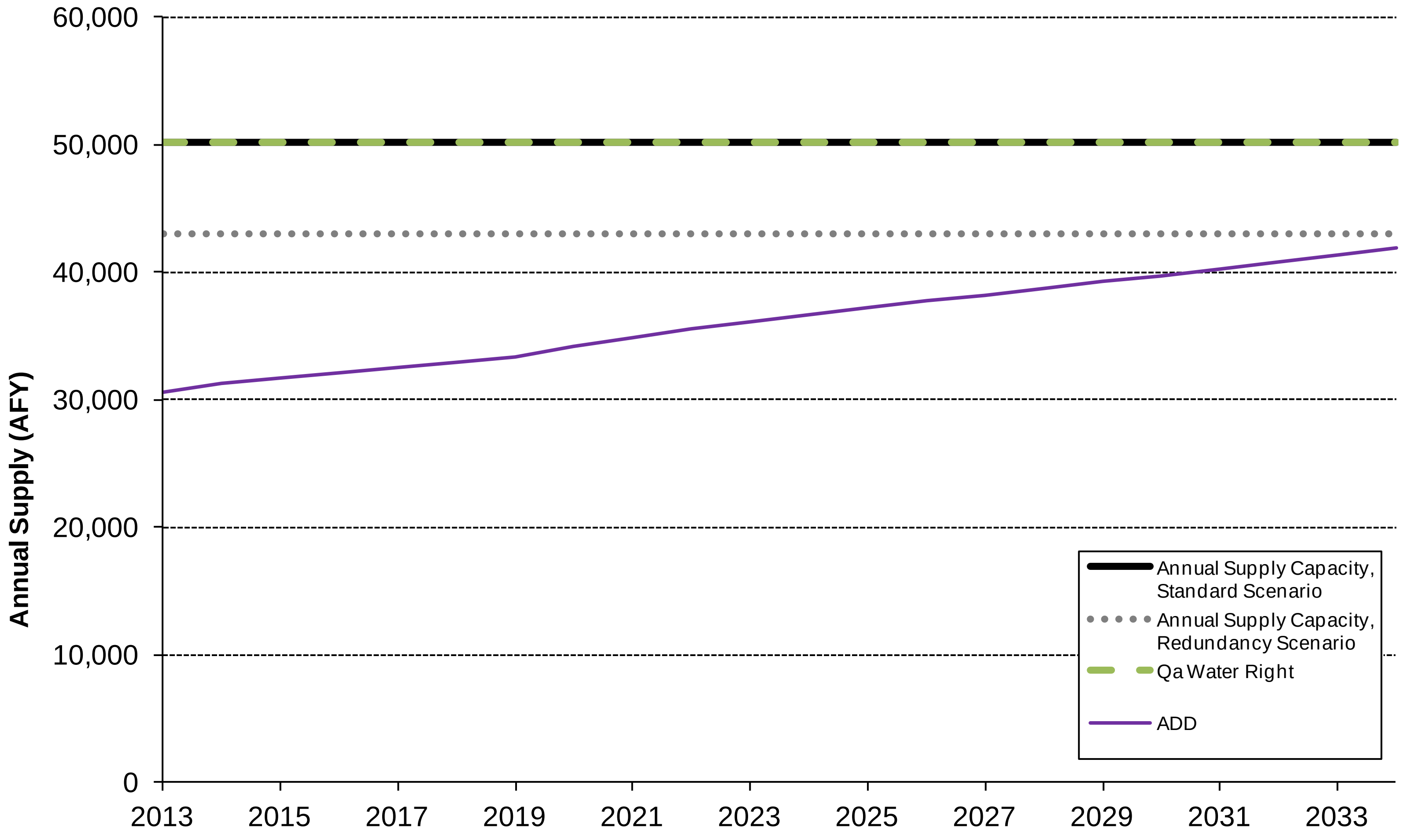
Considering pumping, treatment, and water rights limitations, the City has an annual supply capacity of 50,256.5 AFY (44.86 mgd), which is equal to the City's primary water right capacity. Figure 4.2 presents the annual supply capacity, Qa water right, and projected ADD over the planning period. As seen in the figure, the City's existing infrastructure provides an excess of annual supply capacity throughout the planning period. As seen in the figure, the Qa of 50,256.5 AFY (44.86 mgd), which is also the standard scenario's annual supply capacity, is above the projected 2034 High ADD of 42,059 AFY (37.52 mgd). Therefore, the City's existing source infrastructure has the capacity to meet ADD throughout the planning period. The 2034 excess of annual supply capacity is 8,197.5 AFY (50,256.5 AFY - 42,059 AFY = 8,197.5 AFY, 7.32 mgd). This evaluation shows that no supply improvements are needed to meet forecasted 2034 High ADD for the entire system with all supplies online.

Table 4.5 Annual Supply Capacity - Standard ADD Scenario

Water Station	Annual Pumping Capacity (AFY)	Primary Annual Water Right (Qa) (AFY)	Additive Annual Water Right (Qa) (AFY)	Treatment Capacity (AFY)	Annual Supply Capacity – Standard Scenario (AFY)
1	42,377	9,353.5	12,939.5	NA	9,353.5
3	9,961	6,773	0	NA	6,773
4	13,792	13,429	0	13,792	13,429
6	0	2,723	0	NA	0
7	2,097	1,500	807	NA	1,500
8	2,016	1,960	0	NA	1,960
9[1]	15,809	8,065.5	2,016[1]	NA	8,065.5[2]
14	5,162	1,613.5	968	5,162	1,613.5
15	1,613	4,839	0	1,613	1,613
Ellsworth	10,969	0	7,260	NA	As Additive Right
Available Additive Rights	NA	NA	9,035[3]	NA	5,949[4]
Total (AFY)	**103,796**	**50,256.5**	**23,990.5**		**50,256.5**
Total (mgd)	**92.66**	**44.86**	**21.42**		**44.86**

Notes

(1) Water Station 9 Well 7 (Qa of 2,016 AFY) is only authorized for use when water levels in Monitoring Well #1 are at or above 140 feet elevation relative to mean sea level (msl).
(2) Well 7 certificate restricts total Water Station 9 annual withdrawal quantity to 8,065.5 AFY. No additive rights can be used beyond this value.
(3) Additive Rights from Water Stations 7, 14, and Ellsworth.
(4) Unused primary water rights at Water Stations 6 and 15 equal 5,949 AFY, which may be used by additive rights in Water Stations 7, 14, and Ellsworth.



ANNUAL SUPPLY CAPACITY EXCESS AND DEFICIENCIES (2014 - 2034)

FIGURE 4.2

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4.3.2.2 Annual Redundancy Scenario

The redundancy scenario for the annual supply capacity considers the ability to meet the annual demand volume with the largest water station offline. As with the previous evaluation, the limitations in each Water Station were compared to determine the annual supply capacity, as shown in Table 4.6. The annual pumping capacity for Water Station 1 was reduced to zero to represent the largest water source being offline. While it is unlikely that Water Station 1 would be unable to provide supply for an entire year, the scenario provides an evaluation of the worst-case condition.

Additive rights allow the City to effectively manage long-term impacts of a large supply reduction. With Water Station 1 offline, more primary water rights are unused. The unused primary rights at Water Stations 1, 6, and 15 under this redundancy scenario sum to 15,302 AFY (13.66 mgd). The total additive rights are 11,051 AFY (9.86 mgd) (excluding Water Station 1), and therefore cannot make up the full Qa. The additive rights are used as much as possible at each water station as shown in Table 4.6 without exceeding other limitations. Therefore, with Water Station 1 offline, the annual supply capacity is reduced from 50,256.5 AFY (44.86 mgd) to 43,779 AFY (39.08 mgd).

As shown in Figure 4.2, even with Water Station 1 offline, the annual supply capacity is adequate to meet the 2034 ADD. As seen in the figure, the Qa of 43,779 AFY (39.08 mgd) is above the projected 2034 High ADD of 42,059 AFY (37.52 mgd). The 2034 excess of annual supply capacity is 1,720 AFY (43,779 AFY - 42,059 AFY = 1,720 AFY, 1.54 mgd). Therefore, the City's existing source infrastructure has the capacity to meet ADD throughout the planning period. However, if ADD continues to increase at the same projected rate beyond 2034, it will likely exceed the redundant supply capacity only a few years beyond 2034. This again emphasizes the importance of supply from Water Station 1. Long-term reductions in supply that may affect the annual supply capacity of Water Station 1 or other water stations are likely due to non-infrastructure related issues, such as wellhead contamination or drought. This highlights the importance of the City's Wellhead Protection program, presented in Chapter 5, and other programs that reduce the risk of supply disruptions.

Table 4.6 Annual Supply Capacity – Annual Redundancy Scenario

Water Station	Annual Pumping Capacity (AFY)	Primary Annual Water Right (Qa) (AFY)	Additive Annual Water Right (Qa) (AFY)	Treatment Capacity (AFY)	Annual Supply Capacity - Redundancy Scenario (AFY)
1	0	9,353.5	12,939.5	NA	0
3	9,961	6,773	0	NA	6,773
4	13,792	13,429	0	13,792	13,429
6	0	2,723	0	0	0
7	2,097	1,500	807	NA	1,500(2)
8	2,016	1,960	0	NA	1,960
9(1)	15,809	8,065.5	2,016	NA	8,065.5(3)
14	5,162	1,613.5	968	5,162	1,613.5
15	1,613	4,839	0	1,613	1,613
Ellsworth	10,969	0	7,260	NA	As Additive Right(2)
Available Additive Rights	NA	NA	9,035(4)	NA	9,035(5)
Total	**61,419**	**50,256.5**	**23,990.5**		**43,779.0**
Total (mgd)	**54.83**	**44.86**	**21.42**		**39.08**

Notes

(1) Water Station 9 Well 7 (Qa of 2,016 AFY) is only authorized for use when water levels in Monitoring Well #1 are at or above 140 feet elevation relative to mean sea level (msl).
(2) Additive rights are used unless production capacities limit them while not exceeding the total system primary rights.
(3) Well 7 certificate restricts total Water Station 9 annual withdrawal quantity to 8,065.5 AFY. No additive rights can be used beyond this value.
(4) Additive Rights from Water Station 7, Water Station 14, and Ellsworth.
(5) Unused primary water rights at Water Station 1, 6, and 15 equal 15,302 AFY; therefore, all available additive rights are used.

4.3.3 Supply Capacity Improvements

The results of the supply capacity analysis show that with all sources online, the City has adequate supply capacity to meet average and maximum day demands under the standard scenario in the year 2034 with no further supply improvements. However, under the redundancy scenario the City will be challenged to meet its maximum day demands in the event that Water Station 1 is unavailable. The following sections discuss alternatives to improving the City's supply redundancy, followed by a recommended supply strategy.

4.3.3.1 Well Rehabilitation or Replacement

Well rehabilitation and replacement (R&R) improvements may allow the City to increase the supply capacity without developing new water sources. The current water rights status presented in Table 4.1 provides a good indication of the potential for well R&R to create additional supply capacity. The last two columns of the table present the difference between water rights, and current pumping capacity. Positive values in the second to last column indicate the amount of flow the well may be improved. The difference between the existing infrastructure capacity and water rights may be caused by many factors, including declining performance due to age, changes in head due to treatment or distribution system upgrades, or changes in aquifer conditions. The City's preference is to make full use of these existing wells to the extent practical through R&R before developing new supplies.

To address supply capacity, major well R&R projects were identified, as presented in Table 4.7. These improvements increase supply capacity in each water station to at or near their Qi. To maintain cost effectiveness, the well R&R improvement projects were limited to those water stations that could provide substantial increases with the improvements to one or two wells. As seen in the table, Water Stations 4, 6, 8, and 15 have a total of 10,050 gpm (14.47 mgd) of potential to be improved up to their water rights.

Hydrogeological investigations are required to determine well specific improvements to each water station listed below. R&R of wells at other water stations not listed in Table 4.7 could also be considered based on age, operating challenges, or other system evaluations. Assuming all remaining wells pump their full Qi (without exceeding the Qi), the City could gain an additional 6.6 mgd of capacity. This is calculated as the sum of excess water rights for all wells in Table 4.1, except for Water Stations 4, 6, 8, and 15. The City should continue to monitor the water levels and pumping capacity of each well to evaluate if R&R is needed at all wells in the system.

Table 4.7 Supply Capacity Improvements – Major Well Rehabilitation or Replacement Projects

Water Station(1)	Water Station Water Right (gpm)	Existing Water Station Capacity (gpm)	Potential Capacity Increase(2) (gpm)	Potential Supply Increase(2) (mgd)
Water Station 4	10,700	8,550	2,150	3.10
Water Station 6	2,400	0	2,400	3.46
Water Station 8	2,750	1,250	1,500	2.16
Water Station 15	5,000	1,000	4,000	5.76
Total	**22,600**		**10,050**	**14.47**

Notes:
(1) Hydrogeological investigations are required to identify well specific preferred Improvements.
(2) Calculated as the total water station water rights minus the existing water station capacity.

4.3.3.2 Treatment

The City treats sources as needed to meet applicable standards and operational concerns. As noted in Section 4.3.1.2, treatment was not found to be a supply capacity constraint; however, production improvements at the water stations shown in Table 4.7 would likely need to be matched by equal improvements in treatment capacity. It is assumed that existing chlorination and fluoride dosing systems can meet increased pumping capacity at Water Stations 4, 8, and 15. Additionally, the Water Station 15 sodium hydroxide dosing system is also assumed to be able to meet the increased pumping at that station. The following additional treatment improvements may be required to meet the increased pumping capacity:

- Improvements to Water Station 4 Air stripping treatment facility;
- Chlorination and fluoride dosing system at Water Station 6.

The recommended treatment improvements listed above are based on high-level planning information. A detailed analysis of water quality and needed treatment should be conducted during the design of the chosen supply capacity improvements. These detailed analyses may result in the need for new treatment facilities and potentially the expansion of existing treatment systems.

4.3.3.3 Aquifer Storage and Recovery

Aquifer Storage and Recovery (ASR) involves infiltrating or directly storing water in an aquifer for later withdrawal. Previous City evaluations did not find opportunities for ASR due to the complicated nature of water quality requirements and the lack of a significant source for recharge water. Therefore, the City is not pursuing a formal ASR program at this time. Any ASR program would have to be consistent with the 2006 Salmon-Washougal and Lewis Watershed Management Plan, which stated “ASR is not currently an attractive water supply option in WRIAs 27 and 28.”

4.3.3.4 Reclaimed Water, Reuse, and Other Nonpotable Sources

Current State regulations pertaining to reclaimed water were developed based on Revised Code of Washington (RCW) 90.46, which sets forth the Washington State legislature's finding that "to the extent reclaimed water is appropriate for beneficial uses, it should be so used to preserve potable water for drinking purposes" (RCW 90.46.005). DOH and Ecology jointly published a set of guidelines for water reuse projects in September of 1997. This document, entitled Water Reclamation and Reuse Standards (Standards), defines the various degrees of wastewater effluent treatment necessary to produce usable reclaimed water, and describes the requirements for application of such water.

Water reclamation on a large scale typically involves the use of wastewater effluent from municipal wastewater treatment plants; however, reclaimed industrial process and cooling waters are also often used for water recycling purposes within an industrial plant. Because of important differences, feasibility for these two categories should be examined separately. In addition to source identification, source considerations in specific reclamation projects include the following: flow variations and characteristics, water quality parameters and the required level of treatment, and potential impacts on instream flows and other downstream users (i.e., in some cases water reuse may decrease the amount of water in a stream due to discharged effluent being rerouted for other applications).

Given the potential sources of reclaimed water and the nature of the communities within the planning area, the most feasible reuse applications include landscape irrigation, maintenance/enhancement of wetlands, industrial recycle and reuse, and direct aquifer recharge.

A review of potential sources of reclaimed water and their reuse applications was conducted as part of the watershed planning process for Water Resources Inventory Area 27 and 28 (EES, 2002). The City participated heavily in this effort and helped identify the following major municipal and industrial reuse scenarios applicable to the City:

- **Marine Park Water Reclamation Facility.** Reclaimed water from the Marine Park Water Reclamation Facility is currently used for onsite operation purposes (i.e. seal water for pumps, sprays for surface control of floating foam and solids, and washing and cleaning of basins). If the reclaimed water was treated to Class A standards, then the reclaimed water could potentially be used for irrigation of the adjacent 12-acre park. However, other water sources are currently available for irrigation as the park is adjacent to the Columbia River. Another potential user identified by the plant staff is an industrial park located adjacent to the facility. This option would require a large capital investment for additional treatment of the water and development of a dedicated distribution system. No industrial user in the City has expressed interest in using reclaimed water from the facility at this point.
- **Westside Water Reclamation Facility.** Reclaimed water from the Westside Water Reclamation Facility is currently being used for onsite operation purposes (i.e. seal water for pumps, sprays for surface control of floating foam and solids, washing and cleaning of

basins, and air pollution control), and onsite irrigation. The effluent could potentially be treated and used for cooling or other industrial operations. The level of treatment will vary based on the end user. It would also require a large capital investment in dedicated infrastructure to deliver the water to customers adjacent to the facility. Currently, no industrial customers have been identified.

- **Salmon Creek Sewage Treatment Plant.** The Salmon Creek Sewage Treatment Plant is owned by Clark County. Due to the remote location of the plant relative to potential users, there have been no specific applications for reuse identified in the City.
- **Ellsworth Water Treatment Plant.** Backwash water is recycled by settling out solids and pumping the remaining water into treatment filters.

The following discussion summarizes the reclaimed water issues related to the types of customers that make up the largest users in the Vancouver service area.

- **Food Processing.** Reclaimed water use from food processing would likely be restricted to irrigation. Frito Lay has an aggressive program to reduce its impact to resources, and may be willing to consider this use if the resource was available; however, their landscaped area is relatively small, and the impact would be minimal. Northwest Packing has no landscaping to consider. Reuse in cooling towers would have to address dissolved solids concerns.
- **Silicon Chip Manufacturing.** Parts of the silicon chip manufacturing process require ultrapure water, and dissolved solids are a critical concern to these facilities. SEH routinely reclaims water within its process, reusing spent ultrapure water in processes that do not require high purity water. Reject water from the systems that create high purity water is used where possible on site. Dissolved solids are the primary concern, and the dissolved solids from wastewater treatment plant effluent would be an impediment to reuse in the industrial processes, and would likely impede its reuse in cooling towers.
- **Cooling Tower Water.** The dissolved solids in cooling tower water are also a concern, although the requirements are not as stringent as other potential industrial processes. Industries routinely blow water down to the sewers and add fresh water based on the conductivity of the water, which is related directly to the dissolved solids.
- Linde, LLC, formerly BOC gases, explored reusing water from the Boomsnub/Airco site, as that water is drinking water quality. They found the silica content was too high and it would foul their cooling towers.
- **Irrigation.** Reclaimed water could be used to provide irrigation to parks, residential customers, and commercial customers, such as golf courses. Providing reclaimed water to these customers would require large capital investments in additional treatment to create Class A reclaimed water, as well as pumping and transmission piping to the customers. The City is not currently developing a Class A reclaimed water system. As previously mentioned, the City will continue to use reclaimed water for onsite irrigation at its water reclamation facilities.

The City considers that, in relation to other water supply alternatives, municipal and industrial wastewater reclamation and reuse is not currently an attractive water supply strategy for Vancouver in the future. This is due primarily to the high implementation costs of municipal wastewater reuse projects (which include additional treatment, pumping, and transmission piping) and sufficient existing supplies. Furthermore, most industries in Vancouver are hesitant to utilize such water due to reduced ability to manage their water supplies and potential water quality issues.

The City of Vancouver will periodically re-evaluate wastewater reclamation and reuse as a future water supply option and continue to seek feasibility improvement.

Several recent commercial developments within the City's retail water service area have begun to utilize on-site rainwater collection systems in an effort to minimize City water use. The City views this as a viable non-potable source of water, but does not anticipate these types of system being used extensively enough to reduce forecasted demands.

4.3.3.5 Development of a New Water Source

Under Washington Administrative Code (WAC) 173-500-040, Water Resource Inventory Areas (WRIAs) were formalized and the Department of Ecology was given responsibility for the development and management of these planning boundaries. The Salmon-Washougal and Lewis Watershed Management Plan WRIAs 27 and 28 (Lower Columbia Fish Recovery Board 2006) and subsequent Detailed Implementation Plan (Lower Columbia Fish Recovery Board 2008) were created to address a range of issues related to water resources, including water supply, stream flow management, water quality, and fish habitat.

The completion of WRIA 27 and 28 watershed plans in 2008 eliminated the water rights reservation established by Washington Administrative Code (WAC) 173-592 and replaced them with regional water supply areas and some stream allocations in WAC 173-527 for the Lewis River Basin (WRIA 27) and WAC 173-528 for the Salmon Creek-Washougal River Basin (WRIA 28). The regional water supply areas are designated as:

- Tidally Affected areas west of Interstate 5 on the east fork of the Lewis River and the Main Stem of the Lewis River and north of the Lewis River within the Lower Lewis River Sub-basin. The Vancouver Lake lowlands area, west of the Burlington Northern rail line.
- In the vicinity of Steigerwald Wildlife Refugee near Washougal.

The Watershed Management Plan discusses Vancouver's sources of supply and projected needs and identifies groundwater in the Vancouver Lake lowlands as a major new source of regional supply. DOE has closed other areas near the City where essentially no new surface water diversions and groundwater wells will be permitted. Therefore, any new water source will come from the Vancouver Lake lowlands.

The City of Vancouver and Clark Public Utilities conducted a test drilling program for a new well field near Vancouver Lake Park in 2003 that was documented in a report by Pacific Groundwater Group in 2004 (PGG, 2004). This source is referred to as the Westside well field.

The results of this program indicate a prolific aquifer exists at a depth of about 250 feet that is capable of supporting wells that will individually produce over 3,000 gpm (4.32 mgd). The estimated yield from a well field was over 20 mgd. At one time the City was targeting a new well field in this area with a target capacity of 6,000 gpm (8.64 mgd) to 10,000 gpm (14.4 mgd). Water quality testing at this site indicates some wells will require treatment to remove iron, manganese, and arsenic, and potential hardness. Organic fouling was suspected in some of the wells. A 24-inch production/test well was recommended to facilitate the extended pumping tests and additional water quality testing needed to verify source viability. The Aluminum Company of America (ALCOA) constructed multiple production wells with similar capabilities at their plant, which is approximately three miles south of the Westside well field. Most of their wells are less than 200 feet deep and suffered problems related to water quality, well construction, and loss of yield as documented in a report by Robinson and Roberts (R&R, 1955). The ALCOA experience indicates a productive Westside well field is possible, provided important design considerations they developed for their newer wells are incorporated into the well field design.

The Vancouver Lake Park area is sufficiently distant from the Port of Vancouver and any future industrial development in this vicinity will need to comply with wellhead protection provisions included in the 2002 Water Resources Protection Ordinance.

Vancouver has not proceeded with any further groundwater testing in the vicinity of Vancouver Lake Park. The City does not currently have any short-term plans for well field development in this area, but the City recognizes that any future source developments will take place in the Vancouver Lake vicinity.

Based on the new requirements established in the WRIA planning process, Clark Public Utilities has developed a new well field east of Vancouver Lake referred to as the Southlake Well field and has planned development of the Paradise Point Well field located at the confluence of the East and North Forks of the Lewis River.

The Watershed Management Plan allocated a portion of the available groundwater supply in WRIAs 27 and 28 to the Cities of Camas and Washougal, specifically a well field near the Steigerwald Wildlife Refuge. Similar to the Vancouver Lake lowlands, the Steigerwald National Wildlife Refuge was identified as a major new source of regional supply. A property has been selected at the Port of Washougal and the Cities of Camas and Washougal have filed a joint water rights application, submitted in 2009.

4.3.3.6 Water Shortage Response Program

A water shortage response program provides a curtailment in demand to minimize the impacts of emergencies such as natural disasters, water contamination, water outage due to loss of power or major service disruptions, etc. The program is typically documented in a Water Shortage Response Plan (WSRP). The WSRP may incorporate short term or long-term curtailment of demands, as well as supply augmentation if available. Curtailment of demands focuses on immediate conservation, which is separate from a City's water use efficiency (WUE) program.

While some voluntary actions typically overlap, the WSRP is typically more aggressive and may require mandatory restrictions and rationing.

DOH's publication *Preparing Water Shortage Response Plans* (2011) provides guidance on preparing WSRPs. The guide's estimate on the effectiveness of different stages of demand reduction actions are as follows.

- Voluntary Measures: 5 to 10 percent.
- Mandatory Program: 10 to 20 percent.
- Rationing Program: 20 to 30 percent.

The City's 2007 Plan outlines the requirements of a WSRP. It is recommended that the City update the plan to create a stand-alone document that is readily available to staff. Due to the potential importance of this plan, it is recommended that the plan the detail measures to be taken in the event of different emergencies and clearly document communication channels (phone, text, social media, mailers, etc.), as well as coordination with other agencies. To offset a complete outage of Water Station 1 with no other supply improvements, demand curtailments of over 20 percent (which would require rationing) would be required in order to meet the high MDD in the year 2034. To reduce the level of curtailments needed, additional supply capacity should be improved in other water stations.

An important aspect of its water shortage response is the Hazard and Vulnerability assessment and mitigation projects. The City conducted a detailed analysis of all major system components and determined the vulnerability based on seven potential hazards (loss of power, severe weather, hazardous spill or transportation accident, fire, groundwater contamination, sabotage/vandalism, and earthquake). The City has ongoing capital improvement projects to mitigate these hazards at major system components, including Water Station 1. These improvements reduce the risk of water shortages occurring and minimize the severity of shortages that may occur.

Although the WSRP is important for the City to meet demands in an emergency, the City recognizes that existing redundancy in the water system aids in the ability to meet system demands when problems occur at one or more of its water stations. The City supply can come from multiple sources located throughout the water service area. No water curtailment notices have been issued by the City over the last 10 years because of this source redundancy.

4.3.3.7 Water Station 1 Improvements

The peak supply scenarios discussed above show the critical need for supply from Water Station 1 to meet MDD. Improving reliability at this water station is therefore a critical component of the supply strategy. The City is in the process of a multi-phase improvement program at Water Station 1 that replaces aging infrastructure (including wells, pump stations, piping, and storage tanks), provides back-up power to key wells and pump stations, improves security, and improves overall electrical controls. These improvements will reduce the risk of supply interruption at Water Station 1 from power outages, vandalism, equipment failure, and other operational disruptions.

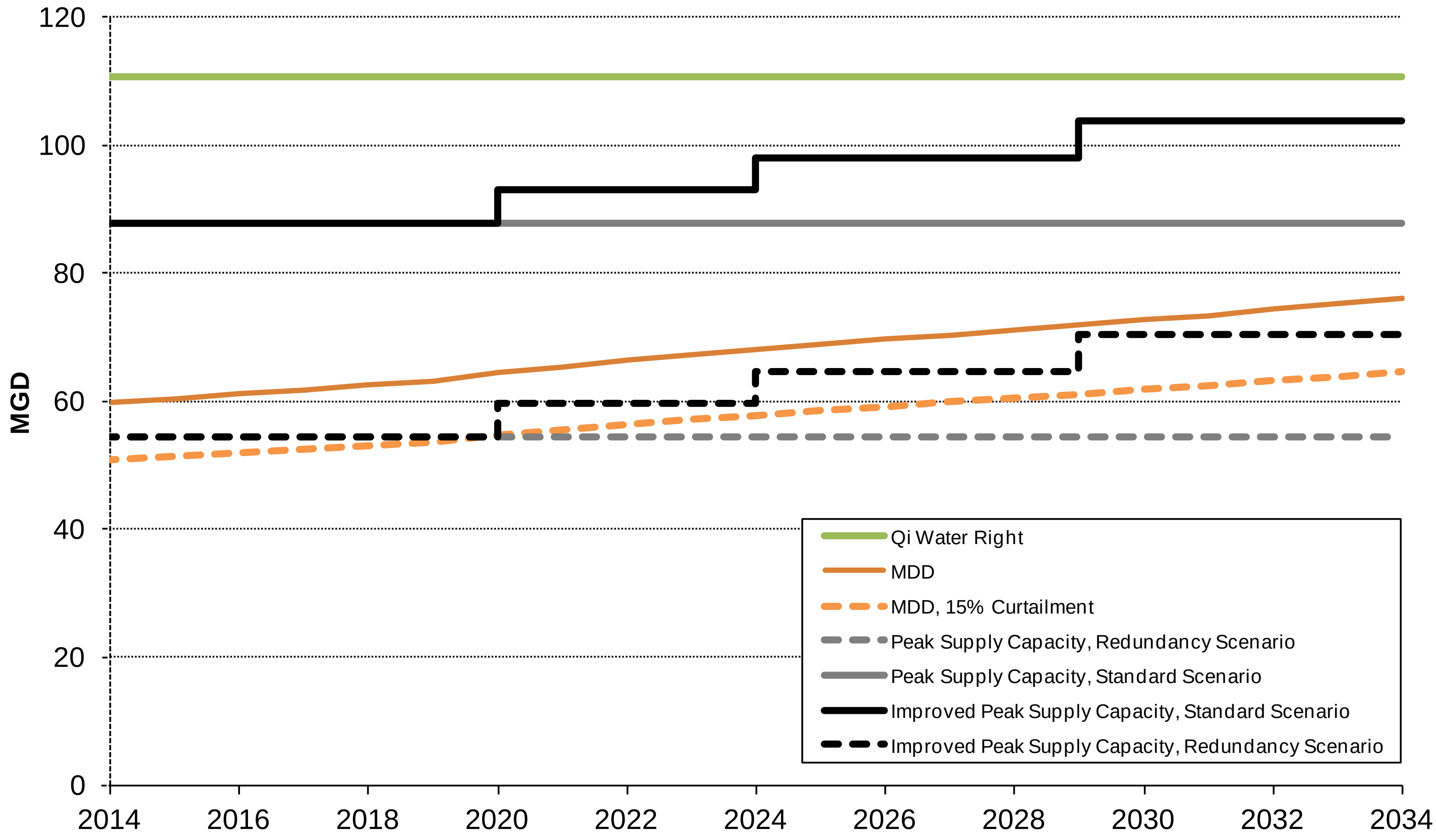
4.3.4 Recommended Supply Strategy

The City has adequate supply capacity to meet average and maximum demands in the year 2034 with no further supply improvements. However, the City is concerned about supply redundancy should Water Station 1, the City's largest supply source, be offline. With Water Station 1 offline, the City could have a peak supply deficit during the high MDD scenario of 2,996 gpm (4.28 mgd) in 2014, and 14,850 gpm (21.38 mgd) in 2034, as noted in Section 4.3.1.2. To improve supply redundancy, it is recommended the City increase its peak redundant supply capacity and temporarily reduce demands through a combination of the improvement alternatives listed above. Four of the seven alternatives were determined viable to improve peak supply redundancy: water curtailments, well R&R, developing a new supply source, and Water Station 1 improvements.

Implementing demand curtailments during a Water Station 1 outage is considered the most likely alternative to eliminate the deficiency in first years of the short-term planning horizon. Therefore, it is recommended that the WSRP be reviewed and updated to be a stand-alone document, as needed, to achieve demand curtailments until other improvements can be implemented. In addition, it is recommended that the City continue its ongoing capital improvement projects to mitigate hazards at major system components, including the Water Station 1 Improvements Program. These improvements increase the reliability of the system and reduce the risk of water station outages. It is also recommended that all of the major well R&R projects identified in Table 4.7 be implemented in order to make full use of the City's Qi and improve supply redundancy. If pumping at these water stations are improved to equal the Qi, an additional 14.47 mgd of supply would be achieved. Combined with demand curtailments, these improvements can eliminate the 2034 peak redundant supply deficiency. These recommended well improvements are well matched with areas of demand growth (i.e. Heights High Pressure Zone), which should provide the City with increased operational flexibility and system redundancy. A hydrogeologic study is recommended to determine the most effective manner to improve each water station.

Developing a new supply at Vancouver Lake would require significant capital investments: permitting, water rights, wells and treatment system construction, a substantial transmission main, etc. If the City can achieve 14.47 mgd of well capacity improvements and relies on demand curtailments, a new Vancouver Lake supply can be delayed beyond the planning period. However, it is recommended that the City begin the development of a new supply source in the Vancouver Lake lowlands during the long-term planning horizon (2024 – 2034) to serve demand beyond this plan.

The timing of the improvements is important to ensure the City maintains its ability to meet potential demands during its redundancy scenario. Figure 4.3 presents the projected MDD, the MDD under 15 percent curtailments, the total peak capacity (88.27 mgd), the redundant peak capacity (54.58 mgd), and the total and redundant peak capacities considering the recommended strategy. Temporary demand curtailments of 15 percent would delay the need for additional redundant peak capacity until the year 2020, as seen in the figure.



RECOMMENDED SUPPLY CAPACITY IMPROVEMENTS (2014 - 2034)
FIGURE 4.3

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It is recommended that the City complete approximately 5 mgd of well R&R by the year 2020; approximately 3 mgd by the year 2024; and approximately 6 mgd by the year 2034, in order to maintain peak redundant supply above MDD with 15 percent curtailment. These peak supply capacity increases could be achieved using multiple combinations of the identified major well R&R improvements. Figure 4.3 is based on the recommendation that Water Stations 8 and 6 (5.62 mgd) undergo R&R by 2020, Water Station 4 (3.10 mgd) undergoes R&R by 2024, and Water Station 15 (5.76 mgd) undergoes R&R by 2034. However, the timing and scope of these projects may change based on the findings of the hydrogeologic study.

As the recommended well R&R improvements are completed, the need for temporary demand curtailments will decrease. For example, the peak redundant supply capacity is increased from 54.58 to 69.05 mgd by 2034, which is still 6.91 mgd (9 percent) below the 2034 projected MDD (75.96 mgd). At this level, six percent, the City can continue to rely on voluntary WSRP activities in the case of a supply outage, rather than the typically mandatory restrictions required to reach greater demand reductions.

In lieu of the recommended improvements, the City may also choose to pursue additional supplies from Vancouver Lake. Additionally, the City could offset some of the need for improvements by relying on the City's emergency interties with CPU during a supply outage.

The following summarizes the short-, mid-, and long-term strategy to provide peak supply redundancy:

<u>Short-Term (2014 – 2020)</u>

- Update Water Shortage Response Plan; implement curtailments up to 15 percent;
- Continue ongoing capital improvement projects to mitigate hazards at major system components, including Water Station 1 Improvement Program;
- Perform hydrogeologic studies at Water Stations 4, 6, 8, and 15 to determine specific well improvements and to confirm capacity.
- Complete 5 mgd of well R&R (i.e. Water Stations 6 & 8).

<u>Mid-Term (2021 – 2024)</u>

- Implement curtailments up to 15 percent;
- Complete an additional 3 mgd of well R&R (i.e. Water Station 4).

<u>Long-Term (2024 – 2034)</u>

- Complete the remaining 5 mgd of well R&R (i.e. Water Station 15); and
- One of the following:
  - Implement curtailments up to 15 percent, or
  - Acquire and use new supply source from Vancouver Lake (if complete by 2034).

Beyond 2034

- Continue to pursue a new supply source from Vancouver Lake to meet demands beyond 2034.
- Rely on emergency interties with CPU as needed.

4.4 WATER USE EFFICIENCY PROGRAM

The City of Vancouver is committed to ensuring Vancouver's water resources are used efficiently to protect and preserve the community's high quality of life for current residents and generations to come. In keeping with this commitment, the City employs a comprehensive approach to water use efficiency that combines water system design, engineering, and operations with community education and outreach. The City's Water Use Efficiency (WUE) Program activities affect thousands of its water utility customers annually. The program engages incentives that encourage wise water use and utilizes technologies and processes associated with City activities to improve water savings.

This section presents the City's Water Use Efficiency (WUE) Program for the next six years.

4.4.1 WUE Program Background

In 2003, the Washington State Legislature passed the Engrossed Second Substitute House Bill 1338, known as the Municipal Water Law or the Water Use Efficiency (WUE) rule, to address the increasing demand on Washington's water resources. This law established that all municipal water suppliers (MWS) must use water more efficiently in exchange for water right certainty and flexibility to help them meet future demand.

The WUE rule, which became effective on January 22, 2007, emphasizes the importance of measuring water use and evaluating the effectiveness of the water supplier's WUE program. The intent is to minimize water withdrawals and water use by implementing water saving activities and adopting policies, resolutions, ordinances, or bylaws. This chapter follows the guidelines set forth in the Water Use Efficiency Guide Book, Third Edition, (January 2011) as well as the Water System Planning Handbook (April 1997). The WUE Guide replaces the Conservation Planning Requirements, March 1994.

As part of a WUE Program, municipal water purveyors must establish supply-side and demand-side water use efficiency goals, approved by the elected governing board or the governing body of the utility (WAC 246-290-830(1)).

The City has an ongoing, successful WUE Program (previously called the Conservation Program). Prior to this report, the City updated its water conservation goals in 2009 to meet the DOH requirements. The following goals were adopted by the Mayor and City Council in 2009:

- **Supply-Side Goal:** Reduce annual water loss from the water distribution system to six (6) percent or less within six years.

- **Demand-Side Goal:** Reduce the average equivalent residential unit annual water consumption by one (1) percent within six years.
- The following sections describe the current program and its effectiveness.

4.4.2 Water Supply Characteristics

As summarized in Chapter 1 and Section 4.4.1 above, the City obtains its drinking water from 40 active wells at 10 water stations that produce, treat, store, and pump water into the distribution system. These wells draw from the Orchards, Troutdale, and Sand & Gravel regional aquifers below the City that also serve neighboring communities in Clark and Multnomah Counties. Proper management of these aquifers is imperative to ensuring adequate water supply to sustain the local population and supporting environment, now and in the future.

The supply analysis above shows that the City has secured adequate water rights for the 20-year planning horizon to meet both average and maximum day demands. However, some of the City's water system facilities are limited in capacity and require improvement to meet higher water demands from new customers, especially peak season demands. Implementing a WUE Program will help to delay these capital projects and defer construction costs, as described below. By improving water use efficiency, the City's water system will be able to serve more customers without acquiring new water supply sources.

4.4.3 Current WUE Program

The City's current WUE Program includes multiple measures to encourage efficient water use for supply and demand. The following summarizes the current program.

4.4.3.1 Supply-Side Measures

The City implements the following supply-side measures to meet its supply-side goal:

1. Record and monitor supply source production.
2. Test and re-calibrate supply well metering.
3. Record and monitor customer demands through customer water meters.
4. Replace water meters exceeding two million gallons of use.
5. Record end-line flushing and main or service line leaks.
6. Work with the Vancouver Fire Department and Fire District 5 to measure water used in training exercises, hydrant testing, and firefighting.
7. Record backwash water discharged from water treatment facilities.
8. Replace deteriorating water mains.
9. Pursue cases of water theft without appropriate meter and connection, using newly adopted penalties.

10. Reclaimed Water: the City implemented a reclaimed water system at its Westside and Marine Park Water Reclamation Facilities. Reclaimed water is used for irrigation during the summer, seal water for pumps, sprays for surface control of floating foam and solids, and washing and cleaning of basins. At the Westside Water Reclamation Facility, reused water is also used for the air pollution equipment. The Ellsworth Water Treatment Plant recycles backwash water by settling out solids and pumping the remaining water into treatment filters.
11. Perform regular leak studies of the distribution system piping and repair leaks.

4.4.3.2 Demand-Side Measures

The following measures are implemented by the City to meet its demand-side goal:

1. Promote efficient water use by including a volumetric charge in its water rates.
2. Include comparisons of current and past water consumption on customer's utility bills.
3. Promote water use efficiency through billing inserts.
4. Alert customers who show a significant water increase to the potential of leaks at their service.
5. Assist customers in identifying the location of water leaks beyond the water meter.
6. Promote WUE and provide tips on the City website.
7. Establish efficient water use through City standards for landscaping (VMC 7592 20.925.100).

8-16. Public Education Measures (see below).

4.4.3.3 Public Education – Water Resources Education Center

Public education has long been a vital component of the City's ongoing conservation program. At the heart of the City's program is the Water Resources Education Center, funded and operated directly by the City of Vancouver. Opened in 1996, the Water Resources Education Center was established to help ensure a safe and healthy water supply for current and future generations of people, plants, and animals. The 16,000-square-foot Center, overlooking the Columbia River near Marine Park in Vancouver, provides continuous environmental education through programs, exhibits, events, and volunteer opportunities for the community and thousands of school children each year. Water Center staff members are also responsible for stewardship of the city's adjacent 50 acres of wetlands that serve as a natural outdoor laboratory for students of all ages.

The Center, a division of the City's Public Works Department, receives ongoing funding primarily through Vancouver's water, sewer and storm water utility revenues, with supplemental support from grants, private donations and community room rental income.

The City seeks to inform the local and regional community about upcoming events at the Center through, quarterly and annual reports, flyers, websites, YouTube videos, and limited advertising in select publications. The following demand-side measures in public education are achieved through the Center:

8. Present on water issues to neighborhood associations and other interested groups.
9. Maintain WUE exhibits at the Center. The Center had a total of 5,240 walk-in visitors in 2014. An additional 9,624 visitors attended events booked in the Bruce E. Hagensen Community Room.
10. Maintain a demonstration garden promoting native and low-water use plants.
11. Host school group visits at the center. During 2014, the Center hosted 41 classroom visits serving a total of 1,772 students plus their teachers and chaperones.
12. Promote WUE at school science fairs and local festivals.
13. Lead the Student Watershed Monitoring Network. This water quality monitoring program served 2,626 students from 21 schools and was supported by 53 teachers during the 2014/2015 school year.
14. Hold Special Events: Sturgeon Festival, Science in the Park (weekly during summer), Second Saturday activities, St. Paddy's Day Event, The Home and Garden Idea Fair, The Street Team Earth Day Event, the Heritage Farm Springs Event, World Water Day, Columbia River Watershed Festival, and the Old Apple Tree Festival.
15. Coordinate regular teacher workshops and multi-day camps for K-12 teachers to provide curricula and activities focused on water.
16. Partnerships & Joint Activities:
    a. EPA Water Sense.
    b. "Food and Film Series" (Vancouver Watersheds Alliance (VWA)).
    c. Columbia Springs Environmental Education and Outreach Program.
    d. Xeriscaping Workshops for Landscape Professionals (Clark County Department of Environmental Services and Washington State University Clark County Extension.

4.4.4 Effectiveness of Current WUE Program

The City's current WUE Program comprises measures for which quantifying improved water use efficiency is difficult to estimate. The program relies heavily on public education through the Water Center, and very little on rebates or give-aways of low-water use devices and appliances, which are easier to track in terms of numbers and measurable water reduction. Published water savings as a result of WUE public education programs is limited, and is highly variable for each water agency.

The effectiveness of the City's current WUE Program can be evaluated by reviewing historical trends in water use developed in Chapter 2. The water use parameters of interest for assessing demand-side WUE efforts include the average water use per ERU, and the MDD to ADD peaking factors. Figure 4.4 presents the water use per single-family residential customer. As seen in the figure, water use has declined from over 252 gpd/ERU to 207 gpd/ERU from 2003 to 2012. This represents an 18 percent decrease in water use over this ten-year period. In 2009, when the City's goals were last established, the water use per ERU was 230 gpd.

Compared to the average in 2012 (207 gpd/ERU), the City's water use is decreasing by approximately 3 percent per year. Thus, the City is already exceeding its 2009 demand-side WUE goal. It is important to note that decreasing water use trends may also be influenced by weather, economics, new development with higher-efficiency requirements, and the natural turnover rate of low-efficiency appliances and fixtures.

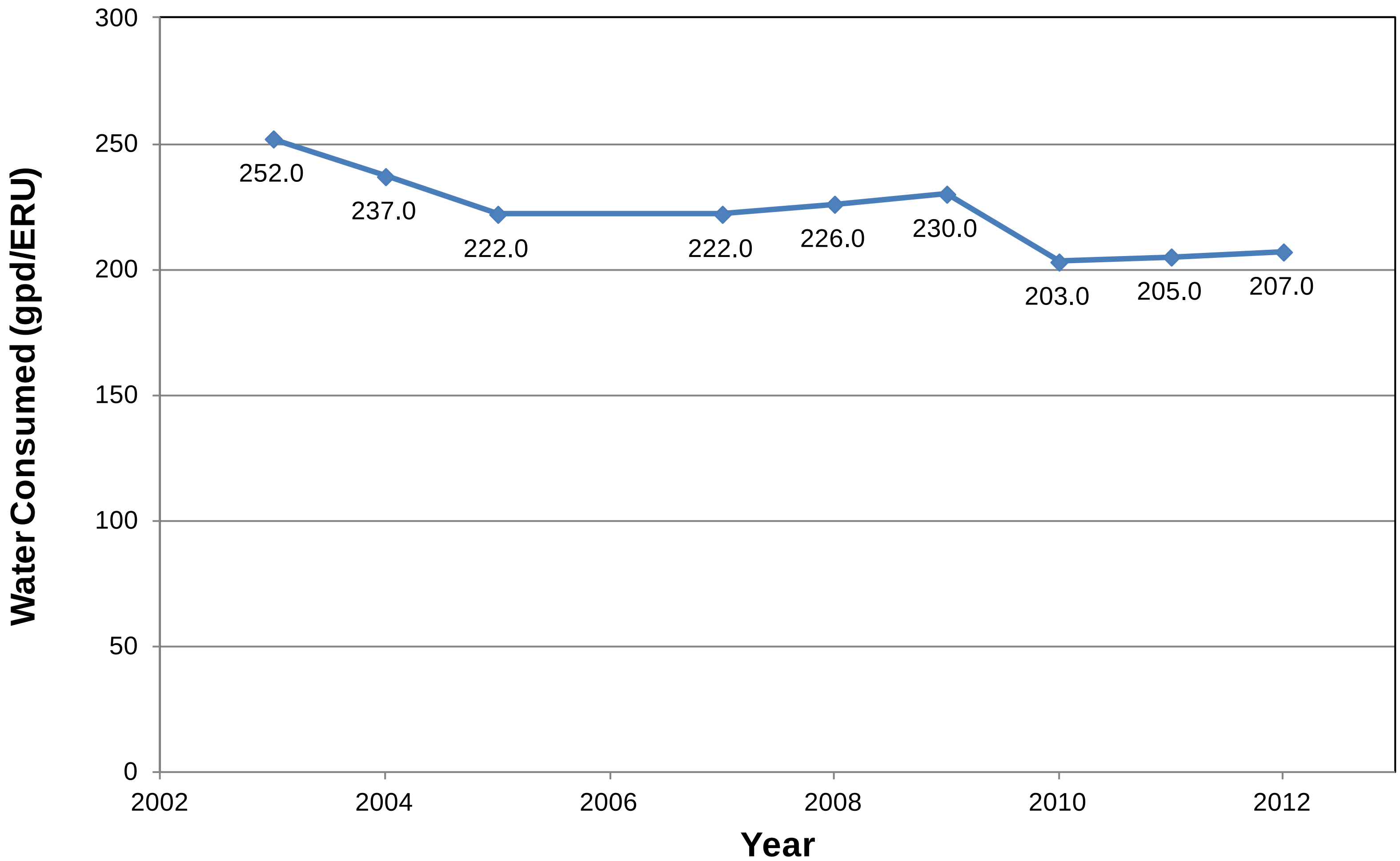
Figure 4.5 presents the MDD to ADD peaking factor from 2003 to 2012. The peaking factor varies from 1.93 to 2.14, and does not appear to be decreasing over this time period. This may indicate that WUE efforts do not target outdoor water use as effectively as indoor water use. However, the peaking factor trend is also very dependent on temperature, humidity, and rainfall for a given year and short-term extreme events during the dry season.

4.4.4.1 Distribution System Leakage

The water use parameter of interest for assessing supply-side WUE effectiveness is distribution system leakage (DSL) as discussed in Section 2.3.4. The estimate of DSL is largely dependent on accurate meter readings for both supply sources and customer meters, and accounting of non-revenue water use such as fire hydrant flushing, street cleaning, and water used for construction. Table 2.6 and Figure 4.6 present the historic trend in DSL from 2003 to 2012. As seen in the table, DSL varies from 3.3 to 8.1 percent of total production, and has not exceeded 10 percent (the maximum value recommended by DOH) during this time period. Overall, DSL does not appear to be decreasing with time. It is likely that the variability year to year of DSL reflects changes in accounting for non-revenue water and possibly errors in recorded meter data. A comparison of DSL to the City's goals is discussed below.

In an effort to reduce DSL, the City contracted with a leak detection company in 2013 to locate leaks in the City's water distribution network. Leak detection was performed on all of the City's non-ductile iron pipe in the water system that was not planned for replacement, (total of 182 miles). In total, 125 leaks were detected amounting to approximately 459 gpm, the majority of which were on hydrants and water mains. The City anticipates providing similar leak detection services in the future and may expand the service to include all mains in the distribution system.

The City is implementing changes to its existing Hansen and SCADA systems that will provide additional data that can assist in prioritizing projects that improve the integrity of the distribution system. The Hansen system improvements are planned for incorporation into the City's asset management program.



ANNUAL WATER CONSUMPTION: SINGLE FAMILY RESIDENCES
FIGURE 4.4

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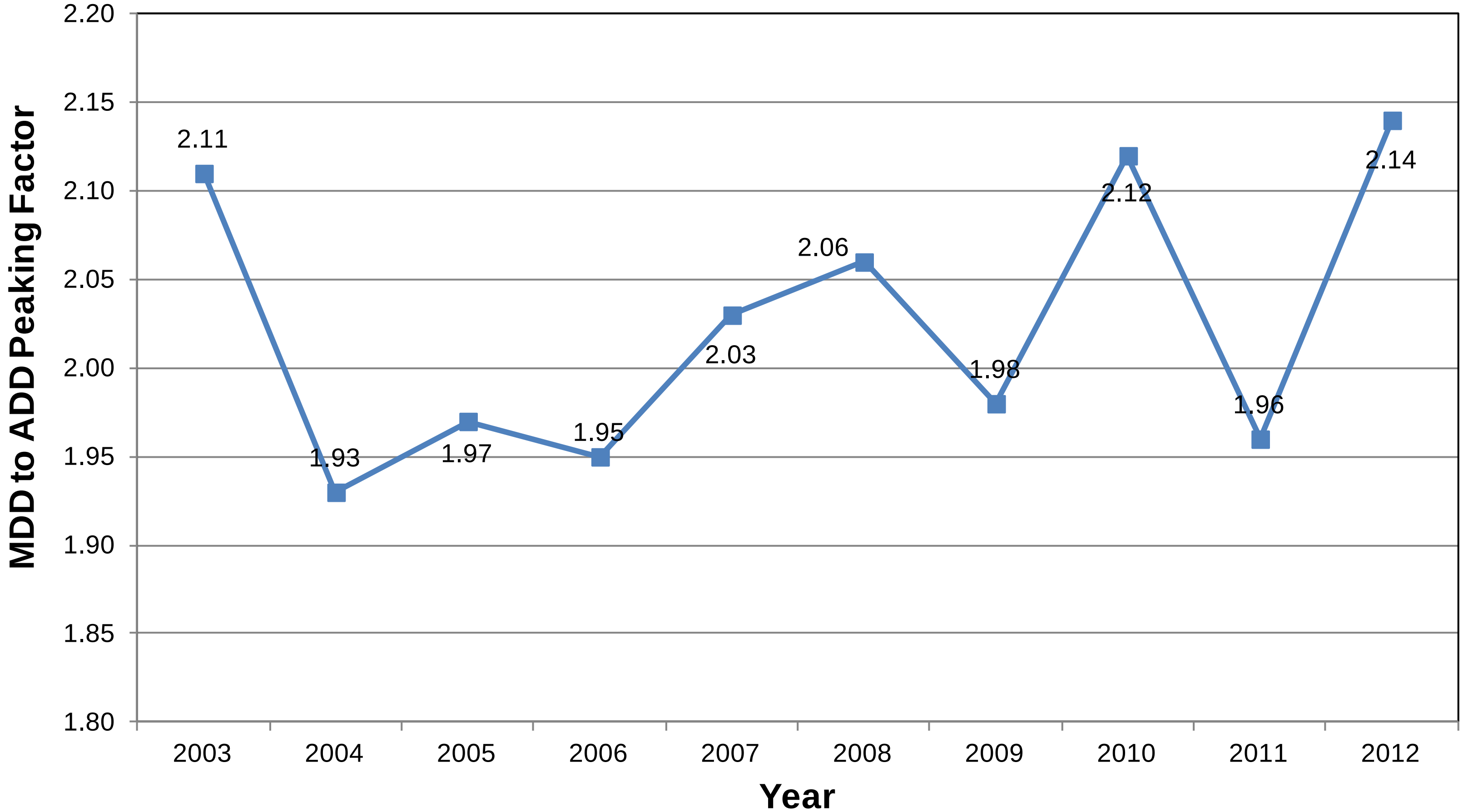

ANNUAL MDD TO ADD PEAKING FACTOR

FIGURE 4.5

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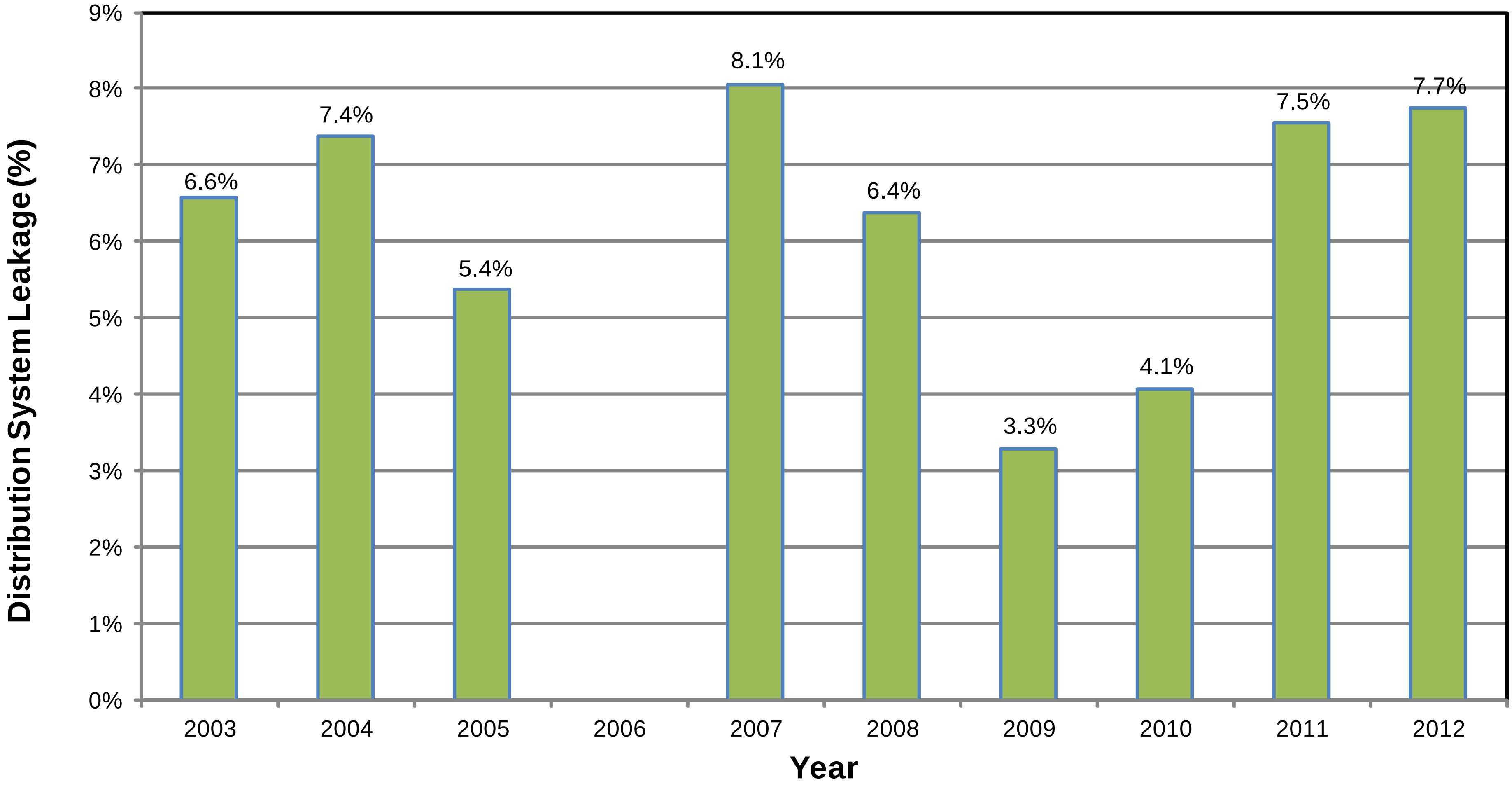

DISTRIBUTION SYSTEM LEAKAGE
FIGURE 4.6

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4.4.5 Future WUE Program

The City plans to continue its efforts in encouraging efficient water use and protecting water as a valuable resource. With ongoing investments in the Water Resources Education Center, its metering program, leak detection program, and others, the City is saving money by deferring capital investments and ensuring sufficient water for current and future customers. The following sections outline the City's WUE goals, measures to meet the goals, and anticipated program effectiveness. This program was reviewed and adopted by the City Council through a formal public process as part of adopting this Comprehensive Water System Plan as described in Chapter 10.

4.4.5.1 WUE Goals

The following goals will continue to assist the City in targeting its WUE measures to promote water use efficiency both in its internal operations and for water customers:

- **Supply-Side Goal:** Maintain annual distribution system leakage (DSL) to six (6) percent or less.
- **Demand-Side Goal:** Reduce the average equivalent residential unit annual water consumption by one (1) percent per six years, to achieve 200 gpd/ERU.

These WUE goals were presented to City Council in a public workshop on August 10, 2015. A public meeting was held following this workshop in order to allow the public to comment on the goals. This public meeting was advertised on both the DOH website and in Vancouver's local newspaper, The Columbian. Vancouver City Council approved the goals on September 14, 2015. Appendix 10D includes the meeting notifications and results.

4.4.5.2 Future WUE Measures

To meet the established goals, the City intends to continue its current 11 supply-side and 16 demand-side WUE measures, as listed in Section 4.4.3. No additional demand-side measures are proposed at this time as the current level of effort for the program is already exceeding the City's established demand-side goal. The 2009 goal was to reduce water use per ERU by one percent over six years. Through the established WUE measures, the City has achieved an average reduction of 1.8 percent per year (compared to 2003), as noted in Section 4.4.4. The City will continue to track production, customer billing, and unmetered water use such as hydrant flushing, construction watering, etc., in order to decrease estimated DSL to meet its supply-side goal.

4.4.5.3 Projected Demands with WUE Goals

Projected demands considering the City's future WUE goals were developed to estimate the water savings as a result of the WUE Program. Chapter 2, Section 2.5.1 presents the projected water demands, including a low, medium, and high projection. The demand projection with WUE goals was compared to the medium demand projection provided in Chapter 2. The medium demand projection assumes a 2014 demand of 223 gpd/ERU, an average peaking factor of 2.10, and an initial DSL value of 6.3 percent. For the WUE projections, this demand was reduced at a rate of one percent over six years, with a minimum average demand of 200 gpd/ERU over the duration of the planning period (2014-2034). At this rate of reduction, the ERU water use reduces to 215.2 gpd/ERU by the year 2034, thus the minimum is not reached. DSL was maintained at 6.0 percent rather than 6.3 percent.

Table 4.8 presents the comparison of WUE demands to the medium demand projections for the year 2034. With improvements in WUE, the medium ADD was reduced by 1.34 mgd, or 3.8 percent, by 2034. MDD was calculated by multiplying ADD (excluding 3.80 mgd of industrial reserve demands) by a peaking factor of 2.10, corresponding to the medium demand scenario in Chapter 2. The 2034 MDD was estimated to be reduced by 2.83 mgd, or 4.0 percent. Figure 4.7 shows projected demands with and without WUE goals included.

Table 4.8 WUE Demand Projections

Demand Scenario	2034 Medium Projection (mgd)	2034 WUE Projection(1) (mgd)	Water Savings (mgd)	Percent Savings
ADD(2)	35.46	34.12	1.34	3.8%
MDD(3)	70.31	67.48	2.83	4.0%

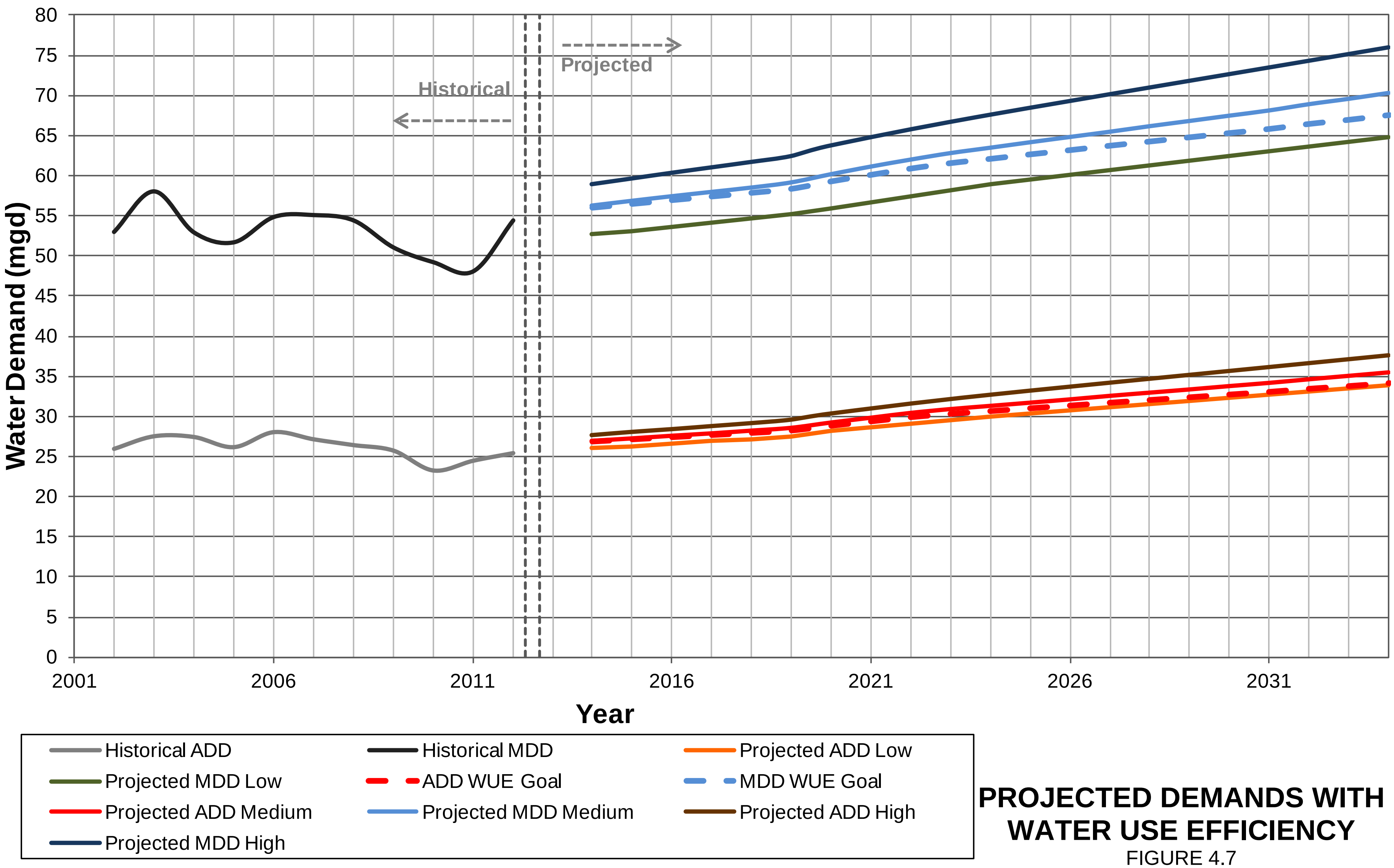
Notes:
(1) Based on water use per ERU reduction of 1% per six years and a DSL value of 6%.
(2) Includes a 2034 industrial reserve of 3.80 mgd.
(3) No peaking factor was applied for the industrial reserve.

4.4.5.4 Future WUE Program Effectiveness

As noted above, estimating the actual water savings directly resulting from the City's WUE Program is difficult because the measures are not directly quantifiable. Measures such as rebates for low-efficient washing machines, toilets, showerheads, etc. have correlating water savings for each rebate provided to a customer. The impacts on customer water use as a result of public education, which is the main focus of the City's WUE Program, is challenging to measure, as the response of each participant varies greatly.

One method to measure the effectiveness of the City's WUE program, is to target its public education programs to customers in a particular area. This area could be limited to a particular pressure zone, group of neighborhoods, etc., but should be an area for which the City can track water use before and after participation in WUE activities or events. The first step is to establish a baseline water use, such as average monthly water use per household for one year. Winter months would provide an estimate on indoor water use, since outdoor water use, such as irrigation, are kept to a minimum during the winter. Summer months could provide an estimate on total indoor and outdoor water use. The second step is to evaluate the resulting water use after promoting WUE through targeted activities and events to customers in the defined area. It is recommended that water use be tracked monthly for an additional year to identify seasonal trends. Some consideration would need to be given to variations in weather and economic conditions.

Another method would be to perform the same before/after water use analysis for WUE Program participants who volunteer and provide their address. Both suggested methods of evaluating the City's WUE Program may require the involvement of several City staff. The resulting information would be valuable for the City to correlate its WUE Program efforts with direct water savings for its customers.



PROJECTED DEMANDS WITH WATER USE EFFICIENCY

FIGURE 4.7

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Chapter 5

WELLHEAD PROTECTION PROGRAM

5.1 INTRODUCTION

Vancouver serves more than 230,000 residents with the City of Vancouver municipal water system. This water supply comes entirely from a number of underground aquifers located beneath the City and extends into Clark County. Groundwater supplies can be susceptible to contamination from the surface, particularly when located in highly urbanized or industrial areas.

To protect groundwater supplies, the U.S. Environmental Protection Agency (EPA) and the State of Washington Department of Health (DOH) require public water utilities to develop a wellhead protection program as a component of their water system comprehensive plans. The Wellhead Protection Program details local utilities plans and methods to prevent groundwater contamination. Vancouver's Wellhead Protection Program consists of a number of components for protecting water in the City. These programs described below form the basis of the chapter that follows:

- Vancouver's critical aquifer recharge area (CARA) is defined in the City's Water Resources Protection Ordinance to encompass all groundwater underlying the City, effectively providing aquifer protection measures throughout the entire City limits. In addition, special wellhead protection area buffers circling the City's water stations incorporate additional restrictions and regulations.
- A City database maintains a detailed inventory of industrial, commercial, and residential sources within the City that have a greater potential to pollute water resources. In addition, the City tracks contamination sites and problematic septic tanks that could pose a threat to water stations outside City limits.
- Spill response plans were developed in conjunction with local first responders (police, fire, HAZMAT team, etc.) for the City's facilities. The City's water protection ordinance also requires that businesses and industries identified as potential sources of contamination prepare spill and emergency response plans.
- Contingency plans were made for providing alternate sources of drinking water in the event contamination occurs.
- A Water Resources Protection Program was implemented in 2003 with the adoption of the City Water Resources Protection Ordinance (VMC 14.26). Program staff inspects businesses and industries throughout the City and investigates when notified of a spill, leak, or other discharge. Similarly, Clark County has a Source Control Inspection Program that conducts similar inspections in unincorporated areas of the water system boundary. Groundwater sources in unincorporated Clark County rely on the County's Source Control Inspection Program for protection. Both programs have proven effective in reducing the likelihood that potential contaminant sources will pollute the drinking water supply.

5.2 SUPPORTING DOCUMENTS

The Vancouver and surrounding Clark County areas have been the subject of a number of technical planning studies. These planning efforts have focused on water quality impacts rising from growth and development within the Vancouver urban area. A summary and brief discussion of the more pertinent documents consulted in the preparation of this report are listed below:

- *Burnt Bridge Creek Watershed Plan, Clark County Water Quality Division, November 1995* - In the late 1970's and early 1980's, the City of Vancouver and Clark County established the Burnt Bridge Creek Utility to improve water quality and control flooding along the creek. Potential contaminant sources identified within the watershed include sites listed in a report by the Department of Ecology, entitled, "Confirmed and Suspected Contamination Sites." Additional significant pollution sources were determined by field surveys. The plan also discusses storm water policies to protect groundwater and improve construction and management of storm water infiltration facilities. The City of Vancouver's Septic Tank Elimination Program, as described in subsequent sections of the report, played an important role in controlling effects of septic system effluent on the creek. Program recommendations include the construction of more storm water control/water quality facilities, monitoring for accidental or illegal discharge to the creek, expanding public education/outreach programs, and pursuit of more federal, state, and private sector grants and loans.
- *2003 Engineering Services Business Plan - Septic Tank Elimination Program* - The City of Vancouver's Septic Tank Elimination Program, which includes the Sewer Connection Incentive Program (SCIP), plays an important role in reducing threats to Burnt Bridge Creek and drinking water wells. It was developed to help eliminate septic tank systems and provide construction of affordable sanitary sewers to homeowners of single-family residences.

  The purpose of the SCIP program is to protect our water resources from failing septic systems and help homeowners eliminate unreliable septic service. Septic systems have been found to be a source of increased nitrates in the groundwater, and can fail to fully treat wastes. The contaminated water can then migrate into a nearby stream, lake, or shallow aquifer that provides source water to a drinking water well. Failed drain systems that lead to partially treated waste ponding in a yard can create a severe health hazard for residents and neighbors.

  This program provides an easy and affordable means for the homeowner to connect to the sanitary sewer. To carry out the program, the City designs and constructs a sanitary sewer extension in the street and a lateral to the edge of each property. The homeowner then hires a plumber to connect this lateral to their house plumbing and properly abandon the septic system. The City offers low interest financing for these costs and an upfront guaranteed maximum cost for sewer construction work in the right-of-way. Based on these costs, a neighborhood can decide whether to support the project. There is no cost to a homeowner unless they connect their home to the sewer.

The Sewer Connection Incentive Program is a voluntary program. In the future, mandatory connection to sanitary sewer could become a requirement. State, federal, and local regulations addressing watershed management, water supply protection, endangered species, and higher quality streams and lakes are growing increasingly more stringent.

Eligibility for this program is on a priority basis. There are many neighborhoods on septic systems in the Vancouver service area. Program funding is limited; therefore, strong neighborhood support is a key factor in the selection process. The City selects projects through a rating system. The criteria used are health hazard, proximity to drinking water supply, proximity to surface water, septic system failure rate in the area, and support of homeowners for the project. The City works in concert with the Clark County Health Department to prioritize projects.

- *Methods to Determine Wellhead Protection Areas for Public Supply Wells in Clark County, Washington, Intergovernmental Resources Center, February 1992* - This report assesses the standard methods of determining zones of contribution for wellhead protection areas and presents appropriate methods of wellhead protection area delineation for Washington State. The determination of the most appropriate methods of delineation was made using a qualitative assessment of the data requirements, applicability, level of confidence in the method, and cost. The first section of the report discusses preferred delineation methods, while the remainder of the document (the appendices) provides reports describing the application of the EPA delineation methods to the public supply wells in Clark County.
- *Method to Evaluate Aquifer Vulnerability through Conjunctive Use of a Groundwater Flow Model and a Geographic Information System, Clark County Water Quality Division, January 1994* - This document addresses groundwater issues associated with urban development in Clark County. The purpose of the report was to develop a vulnerability assessment method that incorporates simulation of groundwater flow and the use of GIS to map and analyze data. The report provided additional analysis to augment the general vulnerability model and methodology developed by the US Geological Survey in Portland, Oregon. The appendices of the report describe the use of GIS and modeling to define recharge areas and critical groundwater resource areas, describe the method to establish the contaminant potential loading rates, provide a comparison of local water quality data with land use and susceptibility, describe the inventory of wellhead protection areas through the use of GIS, and provides a map of the zones of contribution for the municipal wells in Clark County, including the City of Vancouver’s wells.
- *Groundwater Management Plan for Clark County, Washington, Groundwater Advisory Committee for Clark County, December 1992* - This document serves as a guide for the proper management of groundwater resources in Clark County. Volume 1 of the plan discusses groundwater protection, public awareness, education, commercial chemical management, wellhead protection, emergency management, groundwater supply

planning, and stormwater management. The report recommends management strategies, such as providing technical assistance to businesses that handle hazardous materials, increasing groundwater quality monitoring, and enforcement of state underground storage tank regulations at a local level. Volume 2, Technical Appendices, includes 10 issue papers covering existing institutional responsibilities, abandoned wells, industrial waste discharges, septic systems, municipal sludge, animal waste disposal, underground storage tanks, groundwater rights and reservation law, pesticides, fertilizers, hazardous materials spills, contamination sites, landfills, and stormwater runoff.

- *Clark Public Utilities Salmon Creek Wellhead Protection Plan, Economic and Engineering Services, Inc., December 1994* - A wellhead protection program was prepared for the CPU District's Hazel Dell well field, which lies in the Salmon Creek Drainage Basin. The 1-, 5-, and 10-year zones of contribution for each of PUD's Hazel Dell production wells are delineated. Existing and potential sources of contamination within the zones of contribution are identified and the degree of hazard assessed. The plan discusses strategies to protect groundwater sources and develops a contingency plan for alternate sources of supply. Utilization of monitoring wells was recommended to provide early warning of contamination in wellhead protection areas.
- *Vancouver Comprehensive Plan, City of Vancouver, 2011* - The Vancouver Comprehensive Plan is a comprehensive land use plan prepared to address requirements of the Growth Management Act (GMA). The plan was officially adopted by the City Council in 1994. It established a vision of a livable urban area, with growth tied to the ability to provide services, and a range of residential options including more intensive development in urban centers. The Vancouver Comprehensive Plan was completely rewritten in 2004, following an extensive public process involving Clark County, local cities, stakeholders, and the community at large. A more modest update was completed in 2011. The next major update is anticipated in 2016.
- *City of Vancouver Ordinance No. M-3970, Pretreatment Ordinance, VMC 14.10, November 15, 2010* - Ordinance M-2706 was adopted on August 3, 1987 and established measures to protect the City of Vancouver's Publicly Owned Treatment Works (POTW) from potential harm by establishing clear standards and requirements for pretreatment of non-domestic waste. Ordinance M-2706 was replaced by ordinance M-3264 in 1996 and M-3264 was updated and replaced by ordinance M-3970 in 2010. The Industrial Pretreatment Program (IPP) is managed within the City's Public Works Department and is responsible for implementation of Ordinance requirements. The Pretreatment Ordinance applies to non-domestic discharges and includes general and specific discharge prohibitions and requirements for non-domestic users. Some of the requirements include the completion of periodic surveys, the requirements for Significant Industrial Users (SIU) to obtain discharge permits, to monitor discharge and to submit periodic compliance reports, the installation of flow monitoring facilities, access for IPP inspectors, and notification to the City of noncompliant discharges, slug discharges, and process changes.

The ordinance also provides enforcement remedies for noncompliance including the authority to assess fines.

- *City of Vancouver, Ordinance No. M-3600, Water Resources Protection, VMC14.26, November 4, 2002* - The original Water Resources Protection Ordinance (WRPO) was approved and signed by the City Council in 2002 and became law in February 2003. To incorporate stormwater permit mandates the ordinance was revised and re-adopted on June 15, 2009. This ordinance established measures to protect the City of Vancouver's water resources that include both surface and groundwater. Contained within the ordinance are provisions prohibiting certain high risk industries, a listing of minimum best management practices that apply to all businesses and industries in the City, classification procedures for classifying those operations that manage hazardous materials, best management practices and reporting requirements for classified industries, and the establishment of "special protection areas" around water wellheads. A Water Resources Protection Program was established to implement ordinance provisions and is managed within the City's Public Works Department.

5.3 LOCAL HYDROGEOLOGY AND AQUIFER SUSCEPTIBILITY

5.3.1 Local Hydrogeology

An analysis of the local hydrogeology forms the basis for understanding groundwater flow in the aquifers underlying Vancouver. The U.S. Geological Survey (USGS) report titled *A Description of Hydrogeologic Units in the Portland Basin, Oregon and Washington*, was the basis for the USGS numerical groundwater model for the Vancouver area. Simplified depictions sections of the three major aquifer's cross-sections in the Vancouver area are illustrated in Appendix 3F. Based on water table elevation, the uppermost aquifer is subdivided into the Upper and Lower Orchards aquifer. The water table in the Upper Orchards aquifer is at an elevation of above 150 feet and the Lower Orchards aquifer is at an elevation below 50 feet from mean sea level. The Lower Orchards aquifer is connected to the Columbia River, which can result in flow from the river into the aquifer during sustained pumping periods.

The aquifer system can be grouped into two major subsystems with an upper sedimentary system formed from the catastrophic floods of the Pleistocene period and are composed of sands and gravels. The upper system aquifers, Upper/Lower Orchards and Upper Troutdale are unconfined. Most City wells are located in the unconfined, upper sedimentary system.

The lower sedimentary portion contains the Lower Troutdale formation below a confining layer that forms the top of the lower hydrogeology units. The Sand and Gravel aquifer (SGA) lays below another confining layer adjacent to the Lower Troutdale. The City has no wells in the Lower Troutdale formation and four deep wells that pull groundwater from the SGA aquifer. The SGA is the lowermost unit and forms the boundary to the older rocks formation, which is not water bearing with low permeability. In areas further west of the Portland Basin, the SGA aquifer appears to consist of coarse-grained materials. In the Vancouver area, however, the coarse upper section of the aquifer is largely absent and appears to be composed of fine-grained material. The major aquifers are summarized in Table 5.1.

Table 5.1 Aquifer Hydrogeologic Characteristics

Aquifer	Geology	Approximate Depth Range (Elevation, MSL)	Source of Recharge
Upper Sedimentary System			
Upper Orchards	Unconsolidated coarse-grain sediments;	Ground surface to 50 feet	Rainfall, dry wells, septic, surface water
Lower Orchards	Unconsolidated coarse-grain sediments;	Ground surface to -100 feet	Rainfall, dry wells, septic, surface water
Upper Troutdale	Compact sand and gravel with interbedded clay	Upper: 150 feet to -100 feet	Groundwater percolation from Orchards Aquifer
Lower Sedimentary System			
Lower Troutdale	Coarse-grained sandstone with streaks of fine to medium sand and silt under a confining layer	Lower: -150 feet to -300 feet	Groundwater percolation from the Upper Sedimentary System
Sand and Gravel	Semi-consolidated fine to medium sand under two fine-grained confining layers	-300 feet to Columbia River Basalt; thickness uncertain	Groundwater percolation from Troutdale Aquifer

5.3.2 Recharge and Discharge Zones

Aquifer recharge for the Vancouver area is derived primarily from local precipitation. Discharge from local aquifers is from wells, springs, streams, and the Columbia River. Groundwater naturally flows from a recharge area to a discharge area. Both recharge and discharge zones occur throughout the City. This is significant because, should contaminants enter the groundwater in a recharge zone, they could travel to a discharge zone such as a City well field.

5.3.3 Aquifer Susceptibility

As required by WAC 246-290-135, susceptibility assessments for the City of Vancouver's wells have been completed by the Operations Division. Depending on factors such as well construction, casing, and location in a geologic setting, drinking water wells vary in their susceptibility to contaminants discharged at the surface. Wells with poor construction or improper casing have an increased susceptibility to contaminants. Although the City's wells are properly constructed, privately owned wells within the area may not have used proper drilling methods. In addition, wells located in a geologic setting without a confining layer between the aquifer and the ground surface have a higher susceptibility than deep wells with impermeable layers above the aquifer. Table 5.2 provides the source aquifer, transmissivity, and well production capacities for the City's wells. A brief discussion of the hydrogeologic characteristics of the aquifers was provided in Section 5.3.1, Local Hydrogeology. A more detailed discussion is presented in Chapter 3.

Table 5.2 Water Supply Sources

Water Station No.	Well No.	Source Aquifer	Transmissivity (gal/day/ft)	Well Production Capacities
1	All wells	Lower Orchards	586,000 to 2,000,000	1,000 to 3,500 gpm per well
3	All wells	Lower Orchards	586,000 to 2,000,000	2,000 gpm per well
4	All wells	Lower Orchards	586,000 to 2,000,000	600 to 2,000 gpm per well
7	1	Upper Troutdale	18,000	750 gpm from only well in aquifer
7	2	Sand and Gravel	114,000	500 gpm
8	All wells	Upper Orchards	110,000 to 3,200,000	500 to 750 gpm per well
9	All wells	Upper Orchards	110,000 to 3,200,000	800 to 3,000 gpm per well
14	All wells	Upper Orchards	110,000 to 3,200,000	1,000 gpm per well
15	All wells	Upper Orchards	110,000 to 3,200,000	500 gpm per well
Ellsworth	All wells	Sand and Gravel	114,000	Single well 2,000 to 3,000 gpm; well field 7,000 gpm

As shown in Table 5.2, the majority of the wells draw from the Orchards aquifer. The aquifer draws much of its recharge from precipitation located within areas of dry wells and septic drain fields; therefore, this aquifer is the most susceptible to contamination from road runoff, spills, and illegal disposal of waste. The Lower Troutdale aquifer and, more importantly the Sand & Gravel aquifer, are relatively less susceptible to contaminants due to the depth and layers of confining material between the aquifer and ground surface.

5.3.4 Troutdale Aquifer Sole Source Aquifer Designation

After being petitioned by a group of Clark County residents, the U.S. Environmental Protection Agency (EPA) Region 10 Administrator determined that the Troutdale aquifer system, in Clark County, Washington, is a sole or principal source of drinking water (Federal Register Vol. 71, No. 172, September 6, 2006). The federal government defines a sole source aquifer (SSA) as one that provides at least 50 percent of the drinking water consumed in an area where there is no feasible alternative source. With this decision, the EPA has designated 14 sole source aquifers in Washington.

The finding was based on the following information:

- The aquifer system is the principal source of drinking water (approximately 99.4%) for the people in the Troutdale aquifer system area and there are no alternate sources that can physically, legally, and economically supply all those who depend upon the aquifer for drinking water.
- Contamination of the aquifer system would create a significant hazard to public health. The aquifer system is vulnerable to contamination because recharge occurs essentially over the entire area, the aquifer is highly permeable, and there are many human activities that have released, or have the potential to release, contaminants to the aquifers.

The sole source aquifer designation, promulgated September 20, 2006, requires that all Federal financially assisted projects proposed over the designated aquifer system be subject to EPA review to ensure they do not create a significant hazard to public health. Projects that are funded entirely by state, local, or private dollars do not receive EPA review. The City has prepared and submitted multiple Sole Source Aquifer Reports to the EPA since promulgation in 2006.

Figure 5.1 shows the Troutdale Aquifer SSA boundaries. The description of the aquifer boundaries included in the Troutdale aquifer system SSA as documented in CFR Vol. 71, No. 172 is as follows:

"The Columbia River forms the southern and western boundaries of the Troutdale aquifer system. The northern boundary follows the North Fork of the Lewis River from its confluence with the Columbia River, east to the confluence of Cedar Creek. Cedar Creek is used as the northeast boundary… The aquifer boundary follows Cedar Creek east where the boundary turns southeast and follows the mapped geologic contact between the Troutdale Formation and the older rocks unit. The eastern boundary follows the geologic contact south to the Little Washougal River, and then follows the Little Washougal River to its confluence with the Washougal River. The boundary then follows the Washougal River south to Woodburn Hill, where it turns northwest and follows the geologic contact along a small outcrop of the older rocks unit. The boundary follows the geologic contact through the City of Camas, and meets the Columbia River. In the northern part of the area, the aquifer system boundary is drawn around Bald Mountain, which is excluded from the aquifer system because it is composed of the older rocks unit."

TROUTDALE AQUIFER SSA BOUNDARIES

FIGURE 5.1

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

5.4 WELLHEAD PROTECTION AREA DELINEATIONS

The purpose of delineation is to identify areas in the City that could contribute potential contaminants. In the case of Vancouver, the entire City is underlain by aquifers. Therefore, contamination anywhere in the City could present a threat to these aquifers. The following describes how the City has recognized this concern and created a wellhead protection area that effectively covers all property within the City limits.

5.4.1 The Critical Aquifer Recharge Area

The City's 1996 Water Comprehensive Plan originally defined limited areas, referred to as Zones of Contribution (ZOCs), to provide a basis for focusing groundwater protection efforts. Many communities incorporate 1-, 5-, 10- and 20-year ZOCs to help define areas around water stations for applying protective measures and best management practices (BMPs).

In 2002, the City, working with the Department of Ecology, found that defined ZOCs would not provide sufficient groundwater protection in Vancouver. The City's Water Resources Protection Ordinance (WRPO) was developed with help from Ecology, other regulatory agencies, businesses, and citizen groups. This ordinance recognizes that ***any contamination in any part of the City poses a threat to underlying aquifers*** and designates the entire City of Vancouver as a Critical Aquifer Recharge Area (CARA). The City is, therefore, one large designated Wellhead Protection Area. Management practices and restrictions listed in the ordinance apply to all businesses, industries, government facilities, and residents in the City and, in effect, provide many more protections than were previously designated for the 1-, 5-, 10- or 20-year ZOCs.

5.4.2 Special Protection Buffer Areas

The City's WRPO also creates Special Protection Areas (SPAs) around each wellhead that are subject to more stringent protective restrictions than specified in the citywide Wellhead Protection Area. Within the SPA's the City will not allow development of a fueling operation or the installation of septic systems or heating oil tanks without prior approval. Infiltration systems, such as drywells, will not be approved at sites that store and manage hazardous materials unless a groundwater impact evaluation is prepared and submitted.

The ordinance defines two radial extents around municipal water wellheads. One is a 1900-foot buffer, which was derived from modeling and roughly represents an average one-year zone of contribution around City water stations. The other is a 1000-foot buffer in which there are a few additional protective provisions related to property conformance and development restrictions. Because Zones of Contributions are usually calculated from models based on water rate withdrawals and other changing parameters, updating wellhead protection boundaries can lead to uncertainty. Using specific distances to define the radial extents of protective wellhead buffers is preferable for providing existing and proposed developments with stable boundary lines.

5.4.3 Groundwater Modeling Considerations

A Portland Basin numeric Modflow groundwater model was originally employed to help delineate zones of contribution around the City of Vancouver's water stations. As discussed previously, the City and Ecology have agreed that ZOCs do not adequately protect Vancouver's aquifers; therefore, the entire City is now a delineated Wellhead Protection Area (defined by ordinance as a CARA) and modeling is no longer deemed necessary for delineating protection zones. The modeling data was used, however, to help better define areas in Vancouver that present greater risks of contamination to the aquifer. See the discussion of the Aquifer Vulnerability Study and GIS Mapping in Section 5.7.2.

5.5 INVENTORY OF POTENTIAL CONTAMINANT SOURCES

5.5.1 Potential Contaminant Sources

There are many diverse activities that may contaminate an aquifer, thereby jeopardizing the water supply. It is important these activities are properly inventoried and, if necessary, regulated to prevent degradation of the groundwater supply. These activities include land use and zoning practices, landfills, commercial and industrial operations, underground storage tanks, septic tanks, dry wells and catch basins, and known sites of contamination. A discussion of these practices, their potential effects on groundwater, and the regulatory requirements that may apply, are included in the following sections.

5.5.1.1 Landfills

A landfill is a disposal facility in which solid waste is permanently placed and is not a land treatment facility. Minimum functional standards for solid waste hauling are regulated by the Washington State Department of Ecology under WAC 173-304. These regulations set siting and closure criteria, performance standards, and operating requirements for landfills. The City's WRPO limits new development of landfills within the CARA.

Past landfill practices were not so restrictive. Abandoned and improperly maintained landfills and dumpsites are often a major source of groundwater contamination. The Department of Ecology is responsible for mitigating dumpsite cleanup when potentially hazardous leachates are present.

5.5.1.2 Commercial and Industrial Activity

The City has areas of land zoned for commercial and industrial uses. Businesses within these commercially zoned areas that may contribute contaminants to the groundwater include dry cleaners, gas stations and other fuel storage tanks, auto repair shops, metal plating, asphalt and concrete facilities, and machine shops. Wastes generated at these businesses include such substances as petroleum products, solvents, surfactants, heavy metals, and other organic materials. These wastes can potentially enter the groundwater through inadequate disposal practices or accidental spills. Table 5.3 presents typical commercial and industrial activities currently located within the City of Vancouver. The table also lists potentially hazardous chemicals commonly used by these businesses.

Table 5.3 Chemicals Associated with Commercial and Industrial Activities

Commercial/Industrial Activity	**Contaminants**
Automobile/Truck Service	Waste oils, solvents, acids, paints, soaps, detergents, gasoline
Boat Yards/Marinas	Diesel fuels, batteries, oil, seepage from boat waste disposal areas, wood preservative and treatment chemicals, paints, waxes, varnishes, automotive wastes
Dry Cleaners	Solvents (perchloroethylene, petroleum solvents, Freon), spotting chemicals, (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amylacetate
Cemeteries	Leachate (formaldehyde), lawn and garden maintenance chemicals
Country Clubs/Golf Courses	Fertilizers, herbicides, pesticides, swimming pool chemicals, automotive wastes
Electric/Electronic Equipment Manufacturers	Nitric, hydrochloric and sulfuric acid, heavy metal sludge, ammonium persulfate, cutting oil and degreasing solvent, corrosive soldering flux, waste plating solution, cyanide, methylene chloride, perchloroethylene, trichloroethane, acetone, methanol
Furniture/Wood Manufacturing	Paints, solvents, degreasing and solvent recovery sludge
Metal Plating Shops	Sodium and hydrogen cyanide, metallic salts, alkaline solutions, acids, spent solvents, heavy metal contaminated wastewater/sludge
Lawns and Gardens	Fertilizers, herbicides, and other pesticides used for lawn and garden maintenance
Printers, Publishers, and Allied Industries	Solvents, inks, dyes, oils, miscellaneous organics, photographic chemicals
Sand and Gravel Mining	Diesel fuel, motor oil, hydraulic fluids
Scrap, Salvage, and Junk Yards	Used oil, gasoline, antifreeze, PCB-contaminated oils, lead acid batteries

The siting and operation of facilities that treat, store, or dispose of hazardous waste are subject to the requirements of the RCRA, Subtitle C. In Washington State, the Department of Ecology regulates facilities that generate more than 220 pounds of hazardous waste under WAC 173-303, Dangerous Waste Regulations. The regulations are significant in that they establish a number of requirements for these facilities, including surveillance and monitoring, record keeping, performance and design criteria, and siting and closure procedures. Ecology divides the facilities into three levels of hazardous waste accumulation: Level 1 facilities generate 2,200 pounds of waste or more; level 2 facilities generate between 220 and 2,200 pounds; and level 3 facilities generate less than 220 pounds. Level 3 generators are exempt from regulations. All level 1 and 2 facilities must initially file a report of their activities with Ecology and update those activities annually. From these reports, an identifier code is established for each facility. This code is required by a transporter to deliver or accept shipments. A summary of those activities are published annually by Ecology, thereby allowing water purveyors the opportunity to determine the types of activities present within their community.

Ecology routinely inspects hazardous waste facilities for compliance with current regulations and policies. Secondary containment is required for all hazardous waste facilities in operation since 1986. If an inspector ascertains there is potential for an environmental hazard, containment can also be required for existing facilities in operation before 1986. Most of the requirements in the Dangerous Waste Regulations apply regardless of facility age. The City regularly meets with Ecology to discuss and compare notes on hazardous waste generators throughout the City.

5.5.1.3 Underground Storage Tanks

Leaking underground storage tanks (USTs) are a major threat to groundwater quality. USTs generally contain petroleum products, which may also contain impurities that can be mobile in the groundwater system. . The most common causes of leaks are structural failure, corrosion, improper fittings, improper installation, and natural phenomena.

Ecology regulates underground storage tanks in Washington State under WAC 173-360. The regulations require that owners and operators of underground storage tanks comply with the following sections of the regulations:

- Notification, reporting, and record keeping.
- Performance standards and operating closure requirements.
- Registration and licensing.
- Financial responsibility.

The WAC allows a number of exemptions, including tanks whose capacity is 110 gallons or less, farm and residential tanks with less than 1,100 gallons, heating oil less than 1,100 gallons per premises, and septic tanks.

As of July 1, 1991, owners and operators of all existing nonexempt underground tanks must have a permit from Ecology. A valid permit is a requirement for delivery of regulated substances and must be updated annually. As a condition of the permit, the owner must have completed the following requirements:

- An assessment of the tank condition by an Ecology-licensed tank service provider.
- Replacement of leaking tanks and site cleanup, if required.
- Installation of leak detection devices.

- Proof of insurance to compensate a third party in the event of bodily injury or property damage resulting from a leaking tank. One million dollars insurance is required for petroleum-marketing facilities that handle over 10,000 gallons per month.

As of 1998, all existing nonexempt underground storage tanks were required to provide cathodic protection and spill and overflow containment, in addition to the above requirements. Installation and replacement of underground storage tanks must meet the specifications, performance, and design standards identified in the WAC. Ecology follows the federal UST guidelines, which at this time do not require double wall vessels.

Underground storage tank inspections are performed by Ecology through the information developed in the permitting process. Although routine annual inspections are not performed, Ecology inspectors do prioritize sites considered potentially hazardous. Technical assistance visits are also conducted at the request of the owner/operator. This provides another avenue in which Ecology can monitor the status of USTs. Ecology maintains a file on all permitted USTs in Washington State, as required by RCRA, Subtitle 1. The file provides the site name and address, tank identification number, date of installation, size, tank status, and the substance stored at the site.

5.5.1.4 Septic Systems

The Clark County Public Health (CCPH) department, formerly known as the Southwest Washington Health District (SWHD) is responsible for regulating and permitting residential and small commercial on-site sewage disposal systems in Clark County. In 1992, the SWHD, in coordination with Clark County and the City of Vancouver, started a mandatory septic tank inspection program in areas of higher concern that included areas with groundwater issues and sensitive sites near surface water. Using information collected by Clark County and the City of Vancouver, the SWHD began sending out notices to septic system owners. The notices explain that inspections of septic systems will be required every four years as part of the septic maintenance program. These inspections may result in pumping of the system. In 1993, the areas of concern expanded to all areas within the urban growth boundary including all areas within 1000 feet of a municipal drinking water well. In 2007, Clark County adopted WAC requirements for routine inspection of all septic systems in Clark County. The scope of the inspection was expanded to evaluate all components of the system. Large on-site waste disposal systems (over 3,500 gallons per day), are regulated by the Washington State DOH. In past years, septic systems were commonly installed for properties in which extending sewers was cost prohibitive. Some water stations located in previously rural areas of Vancouver are now surrounded by septic systems. Although sanitary sewer is now available in many of these areas, property owners continue to use their septic systems. As long as these septic systems are maintained properly, many will adequately treat the wastewater generated protecting the groundwater source.

Contaminants associated with septic tank effluent include pathogenic organisms, toxic substances, and nitrogen compounds. Ammonia and nitrate nitrogen are highly soluble in water.

A 1985 report completed by Sweet-Edwards and Associates studied the effects of septic tank effluent on groundwater in an area of greater concern for Vancouver, the Burtonwood and Serencourt subdivisions. Two thirds of the 270 homes in the neighborhood used septic systems, while the remaining one third was connected to the public sewer system. The report showed that nitrate levels measured as high as 10.4 mg/l in monitoring wells located within the subdivisions. The City SCIP program has since completed projects making public sewer available to all homes within both subdivisions. Currently, the maximum contaminant level allowed for nitrate in drinking water is 10.0 mg/l, and remediation action is necessary at levels of 5.0 mg/l or greater. Annual water quality monitoring samples are taken and tested for nitrates at each water station. Since 2007, all results were below the action level of 5.0 parts per million (ppm). Wells in the Upper Orchards have consistent levels above 4 ppm. Lower Orchards Wells at Water Stations 1, 3, and 4 are consistently above 3 ppm. All wells in the Sand & Gravel Aquifer have always had no nitrate detected. Finally, the one well in the Upper Troutdale typically has no amount detected.

As part of the Septic Tank Elimination Program, the City initiated phase 1 of the Sewer Connection Incentive Program (SCIP) in 1992. This phase of the program provided monetary assistance to water customers currently on septic systems who wish to hook up to an available sewer system. Phase 2 of the SCIP program was adopted in 1998. As of year-end 2013, phase 2 of the program has extended public sewer to 3,721 taxlots, of which 1,270 connected to sewer and decommissioned their existing septic systems.

5.5.1.5 Drywells and Catch Basins

Storm water serves as a source of groundwater recharge, but it can also be a source of groundwater contamination. Runoff from streets, parking lots, and other impervious surfaces can contain heavy metals, hydrocarbons, petroleum products, pesticides, and animal wastes. Drywells are used for stormwater, septic waste, or other wastewater disposal at commercial, industrial, and multifamily residential sites. Many of these drywells and catch basins are located along transportation corridors. Contaminants generated along transportation routes include petroleum products, lead, and other emission products. Hazardous materials being transported through the area are a potential source of contamination as well. Drywells and catch basins are likely sites of contamination because their intended use often discharges contaminants directly into the groundwater.

Both the City of Vancouver and Clark County require storm water runoff mitigation measures. The City of Vancouver has adopted Stormwater Control and Erosion Control Ordinances and funds these programs with utility fees.

The Department of Ecology has issued an NPDES Phase II Stormwater permit to Vancouver that includes compliance measures for installing and maintaining catch basins and treatment systems, including those that infiltrate storm runoff. To meet permit requirements the City modified its Water Resources Protection Ordinance to match NPDES drywell and catch basin regulations for residents, businesses, and industries. All new development must now incorporate appropriate water quality treatment of stormwater regardless whether the runoff infiltrates or drains to surface water.

In 2006, the WA Department of Ecology initiated Underground Injection Control (UIC) regulations requiring that drywells and other infiltration facilities be assessed and registered with the state. UIC wells must meet a "non-endangerment standard," which means that drywells must be constructed, operated, maintained, and decommissioned in a manner that protects groundwater quality. To meet state requirements, owners of drywells must show that there is adequate separation between the bottom of a drywell and the top of seasonal high groundwater and that stormwater runoff receives appropriate treatment prior to infiltration.

5.5.2 Inventory Data Sources

Using a number of data sources from Clark County, the Department of Ecology, and the EPA, the City has developed inventories of sites that have the potential to contaminate groundwater.

5.5.2.1 Potential Contaminant Risk Inventories

Agencies such as Ecology and EPA maintain a variety of databases of sites that store and manage potential contaminants. In addition, many sites are considered higher risk to groundwater because there is an underground storage tank or a septic tank on the site. The following databases are used to maintain the City of Vancouver's inventories of potential risks to groundwater:

- *Underground Storage Tanks* - The Underground Storage Tank Report is periodically updated by Ecology's Toxic Cleanup Program. This report provides the City's Water Resources Protection Program with detailed information on facilities containing underground storage tanks that could present a risk to drinking water aquifers.
- *Hazardous Waste and Materials Generators (RCRA)* - The RCRA report lists the hazardous facilities, including the site name, address, EPA identification number, and generator level. SARA Title III Tier II Facilities are also identified in these reports.
- *Septic Systems* - The Clark County Public Health Department maintains a digital database for all septic system permitting in Clark County going back to 1985. The City of Vancouver within the sewer service boundary is the source for much of the septic system data as a result of an exhaustive sewer connection inventory. The septic system coverage used to develop the City's inventory was compiled by Clark County Water Quality Division, the Department of Assessment, and County GIS.
- *Zoning* - Electronic files containing zoning designations are kept by the Department of Community Development. Descriptions of zoning throughout the City are publicly accessible through County GIS applications.
- *Base Map File and City Sewer and Stormwater Information* - The City of Vancouver's Sewer, Water, and Surface Water Engineering Departments maintain GIS base maps with overlays. The Engineering Department also has access to files for County facilities.

- *WRPO Inspections and Investigations* - The City has employed a water protection inspector since 2003 to visit potential sources of contamination. These sites include businesses, industries, and residential areas of concern. Data from all inspections and investigations are stored in a City-maintained Access database.

5.5.2.2 Confirmed and Suspected Contamination Sites

Under the Model Toxic Control Act, WAC 173-340, Ecology is responsible for ensuring all hazardous waste sites are properly remediated. This includes confirmed and suspected sites of contamination as well as leaking USTs. A separate inventory for each, which includes the status of cleanup efforts, is maintained by Ecology. Ecology conducts an initial site investigation within 90 days of learning of a potentially contaminated site. If this investigation shows that remediation action is required, the site will appear on the Confirmed and Suspected Contaminated Sites Report.

The sites are also given a Washington Ranking Mode Bin Number between 1 and 5. A rank of 1 indicates the greatest assessed risk to human health and the environment. The contaminant type and affected media, such as groundwater, is also noted. Once the remedial action has been completed, Ecology's Toxics Cleanup Program determines if the site can be removed from the list.

As of 2011, there are over 100 confirmed, suspected, or previously identified and remediated contamination sites within the Vancouver City limits. A number of these are from past business practices that have resulted in soil and groundwater contamination in and around the City. Some are from underground storage tanks that have leaked fuel into adjacent soils.

Appendix 5A provides a current comprehensive listing of confirmed and suspected sites created by the City using the following sources of data:

- *Confirmed and Suspected Contaminated Site* - Ecology updates the Confirmed and Suspected Contamination Sites Report continuously as new information becomes available. Each site is given a site status code indicating the status of the cleanup process.
- *Landfills* - Landfill coverage is maintained by the Intergovernmental Resource Center. Their inventories present background information, contamination instances, cleanup costs, risk assessment, and strategies to address landfills.
- *Leaking Underground Storage Tank* - The Leaking Underground Storage Tank Report is periodically updated by Ecology's Toxic Cleanup Program. This report is used to identify leaking underground storage tanks throughout the City and to provide status of remedial actions along with tank ages and volumes.

5.6 SOURCE RISKING AND WATER STATION INVENTORIES

5.6.1 Risking Methodology

A method for classifying industries managing hazardous materials was developed for the Water Resources Protection Ordinance. This classification system assumes a business or industry managing certain chemicals presents a risk to groundwater.

Industries that handle over 2200 pounds of specific hazardous materials are defined as Class II industries. The hazardous materials for Class II designation in the ordinance include a listing of 42 halogenated solvents and the list of “Dangerous” materials from the Washington Administrative Code Toxicity Characteristic List. Those that handle over 220 pounds of an expanded list of over 700 specific hazardous materials from the Code of Federal Regulations Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) are considered Class I industries.

Designating industries as Class I or II helps the City effectively enforce BMPs and other requirements. Based on these classifications, City inspection staff can clearly identify riskier industries and focus more inspection and enforcement time on the approximately 260 Class I and II industries located within the City limits.

The tables in Appendix 5A provide a listing of the facilities currently identified as Class I and II within the City’s Critical Aquifer Recharge Area and Special Protection Areas. Information on these tables includes the facility’s name, address, Ecology ID, site notes, and status.

5.6.2 City Water Stations

The following sections provide details regarding the presence of Class I and II facilities in proximity to the individual City water stations. Along with locations and descriptions of the aquifers tapped, well capacities are also provided. The sections also contain a discussion of nearby facilities and sites that could present a risk to that area’s groundwater. Maps of the water stations and their corresponding facilities/sites of concern are shown in Appendix 5C.

5.6.2.1 Water Station 1

Water Station 1, located on East Fourth Plain Boulevard in Waterworks Park, is the largest water station in the City’s water system. There are twelve wells at Water Station 1, all of which tap the Lower Orchards aquifer. A large air stripping treatment facility is located at Water Station 1 to remove VOCs, (more specifically perchloroethylene (PCE), from water produced at the wells. The wells at Water Station 1 have a peak supply capacity of 33.7 mgd. There are ten Class I/II facilities located near Water Station 1. All of them have been inspected by the WRPO program and are in compliance:

- Four automotive shops (Mac’s Radiator, Kadel’s Auto Body, Villegas Auto Shop, and Meineke Muffler).
- Three gas stations (Quick Shop Minit Mart, Towne Pump, and 76 Station).

- One dry cleaner (4th Plain One Hour Cleaner).
- Two other facilities, which store some chemicals of concern (Clark College and VA Medical Center).

5.6.2.2 Water Station 3

Water Station 3, located along Northwest Washington Street at Northwest 43rd Street, has three wells that tap the Lower Orchards aquifer. The peak supply capacity of Water Station 3 is 8.6 mgd. There are five Class I/II facilities located near Water Station 3:

- Two gas stations (Arco and BBC Petroleum).
- Two automotive shops (Tech Transmission and Paul's Motor).
- Washington's Dept. of Transportation facility.

All of these facilities have been inspected by the WRPO program and are in compliance. In addition, the Bonneville Power (BPA) facility is located northeast of the well field. The City's Water Resources Protection Program performed site inspections in 2006 and 2011 and it is being monitored as a Tier II facility within the Community Right-to-Know program.

5.6.2.3 Water Station 4

Water Station 4, located along Blanford Drive at East 5th Street, includes six wells that tap the Lower Orchards aquifer. An air stripping treatment facility is also located at this water station to remove PCE from the well source water. The peak supply capacity of Water Station 4 is 12.3 mgd. There are many potential contaminant sources within the zones of contribution because the wellhead protection areas encompass major transportation corridors. East Fourth Plain Boulevard is of concern as well as industrial areas along Columbia Way. There are five Class I/II facilities located near Water Station 4:

- Two manufacturing operations (Christensen Shipyards, and Portco).
- One facility that stores and blends chemicals (Diacon Technologies).
- One gas station (VOCI Cardlot at Columbia Way).
- The City's Marine Park Water Reclamation Facility.
- One dry cleaning shop located northeast of the water station (Pilgrim Cleaners).

All of these facilities have been inspected by the WRPO program and are in compliance.

5.6.2.4 Water Station 7

Water Station 7, located near Northeast 112th Avenue off Northeast 16th Street, has two wells. Well 1 taps the Upper Troutdale aquifer, while Well 2 taps the Sand and Gravel aquifer. Well 2 has demonstrated elevated iron and manganese levels and has been equipped with a greensand filtration treatment facility. The peak supply capacity of Water Station 7 is 1.9 mgd.

No Class I/II facilities are located near Water Station 7.

5.6.2.5 Water Station 8

There are two wells located at Water Station 8, located near the intersection of Northeast Fourth Plain Road and Northeast 112th Avenue that tap the Upper Orchards aquifer at a shallow depth. The peak supply capacity at Water Station 8 is rated at 1.8 mgd.

Although Water Station 8 is located outside City limits, it is very close to the City limit boundary and there are classified facilities near the site. Five Class I/II facilities are located near Water Station 8:

- Pro-Caliber Motorsports.
- Oil Can Henrys.
- Qwest Corp.
- Water Reclaim Services.
- Precision, Inc.

There is also a site currently listed on Ecology's Confirmed and Suspected Contamination site list (Commercial Radiator) which is located close to Station 8. Any updates to the status of this site will be recorded in the WRPO database.

5.6.2.6 Water Station 9

Water Station 9, located along Northeast 39th Street at northeast 145th Avenue has five wells tapping the Upper Orchards aquifer. The peak supply capacity of Water Station 9 is 14.1 mgd.

No Class I/II facilities are located near Water Station 9.

5.6.2.7 Water Station 14

Water Station 14, located along Northeast 78th Street at Northeast Andresen Road, has three wells tapping the Upper Orchards aquifer. The peak supply capacity of these wells is 4.6 mgd.

Since Water Station 14 lies outside City limits, there are no Class I/II facilities located near the site. One closed operation, Leichner Landfill, is being monitored by the Dept. of Ecology as a known contamination site. Leichner was required to comply with a number of Ecology stipulated measures as part of their final landfill closure plan. These included capping the landfill and installing gas extraction wells with flares to burn landfill gas. Test sampling and remedial action are still in progress at the site and will continue for the next 25 years.

5.6.2.8 Water Station 15

Water Station 15, located near the intersection of Northeast 27th Street and Northeast 83rd Avenue, includes four wells tapping the Upper Orchards aquifer. The peak supply capacity is considered to be 1.4 mgd.

Six Class I/II operations are located within a half mile of Water Station 15:

- Hannah Auto Center (various facilities).
- A&B Radiator.
- Maaco of Vancouver.
- Gemini Goodyear.
- City Bark Recycling.
- Carr Group Auto Sales.

All of these facilities have been inspected by the WRPO program and are in compliance. The Royal Oaks Golf Course, located northeast of the water station, will also continue to be monitored by the City. Other potential sources of concern include two known contamination sites, A&B Radiator and a ConocoPhillips fueling operation.

5.6.2.9 Ellsworth Water Station

The Ellsworth Water Station, located near Southeast 97th Avenue along Southeast French Road, includes three wells all tapping the Sand and Gravel Aquifer. The water station is equipped with a greensand filtration facility to remove iron and manganese. The peak supply capacity of the Ellsworth Water Station will be 9.8 mgd.

Although potential sources of contamination are nearby, including septic tanks, dry wells, and catch basins, the aquifer tapped by the Ellsworth wells is protected from surface contamination by a thick sedimentary clay layer. The three wells are drilled and cased through and past the clay layer with water intake screens placed in the confined aquifer.

5.6.2.10 Clark Public Utilities (CPU) Southlake Wellfield

The new CPU Southlake Wellfield water station located on Fruit Valley Road and NW 59th St. became active in 2010. From this site, CPU produces approximately 3.7 mgd from the Sand and Gravel Aquifer at a screened depth of approximately 420 feet below ground surface.

Five Class I industrial facilities are located near the Southlake Wellfield:

- Pac Paper, Inc.
- Pacific Die Casting.
- NuStar Energy.
- Nalco Chemical.
- Frito-Lay.

There is one nearby classified non-industrial site, the Vancouver School District Grounds shop.

5.7 GIS WATER PROTECTION MAPPING APPLICATIONS

5.7.1 Inspection and Site Mapping

The City's Water Resources Protection Program has developed a GIS Site Atlas, which provides a tool for mapping and managing all sites and property in the City. Maps from this GIS application can be accessed, built, and viewed by other departments in the City and County, including Community and Economic Development, Fire Dept., Engineering Services, and Operations. They are also available to regulatory agencies such as the Clark County Health, the Dept. of Ecology and other interested environmental agencies. GIS maps are also publicly available on the City's website so that citizens can view wellhead protection-related activities and better recognize potential impacts on groundwater quality.

The Site Atlas has been developed on GeoCortex GIS software employing ESRI-compatible data and shape files. The user can create custom GIS displays allowing a variety of views and layer depictions, including the following map display layer options:

- Class I and II facilities.
- Sanitary sewer, surface water, water mains, and utility details.
- Classified visited industries and businesses.
- Critical aquifer recharge area delineation and special areas of additional protections around City water stations.
- Urban sensitive areas for pesticide applications.
- Tier II community right-to-know facilities (see discussion in 5.10.1).
- Permitted industrial pretreatment facilities.
- Urban growth boundary.
- Known, suspected, and cleaned up contaminated sites.
- Ortho (aerial) photos.
- Topography contours and soil types.

Utility related layers are obtained from the City's Engineering Division GIS database, from the City's Sewer, Surface Water Management, and Water departments. Information on facilities of concern came from City WRPO records, Ecology reports, and site visits. The locations and summaries on confirmed and suspected contamination sites were gathered from Ecology and confirmed through field inventories.

5.7.2 Aquifer Vulnerability Study and GIS Mapping

In 2010, a study was initiated to identify, quantify, and map aquifer vulnerability risks throughout the Vancouver area. Several risk factors were considered in establishing vulnerability. These factors were divided into aquifer susceptibility and infiltration risks.

Aquifer susceptibility refers to hydrogeologic characteristics that dictate how quickly a contaminant can move to a point of withdrawal in the aquifer. The two main susceptibility characteristics considered were "depth to aquifer", which is measured from surface to the top of well screens, and "time of travel" which refers to the time, typically in years, that it would take a "particle" of groundwater to move horizontally through to a City water station. An example of the depth map created is shown in Figure 5.2.

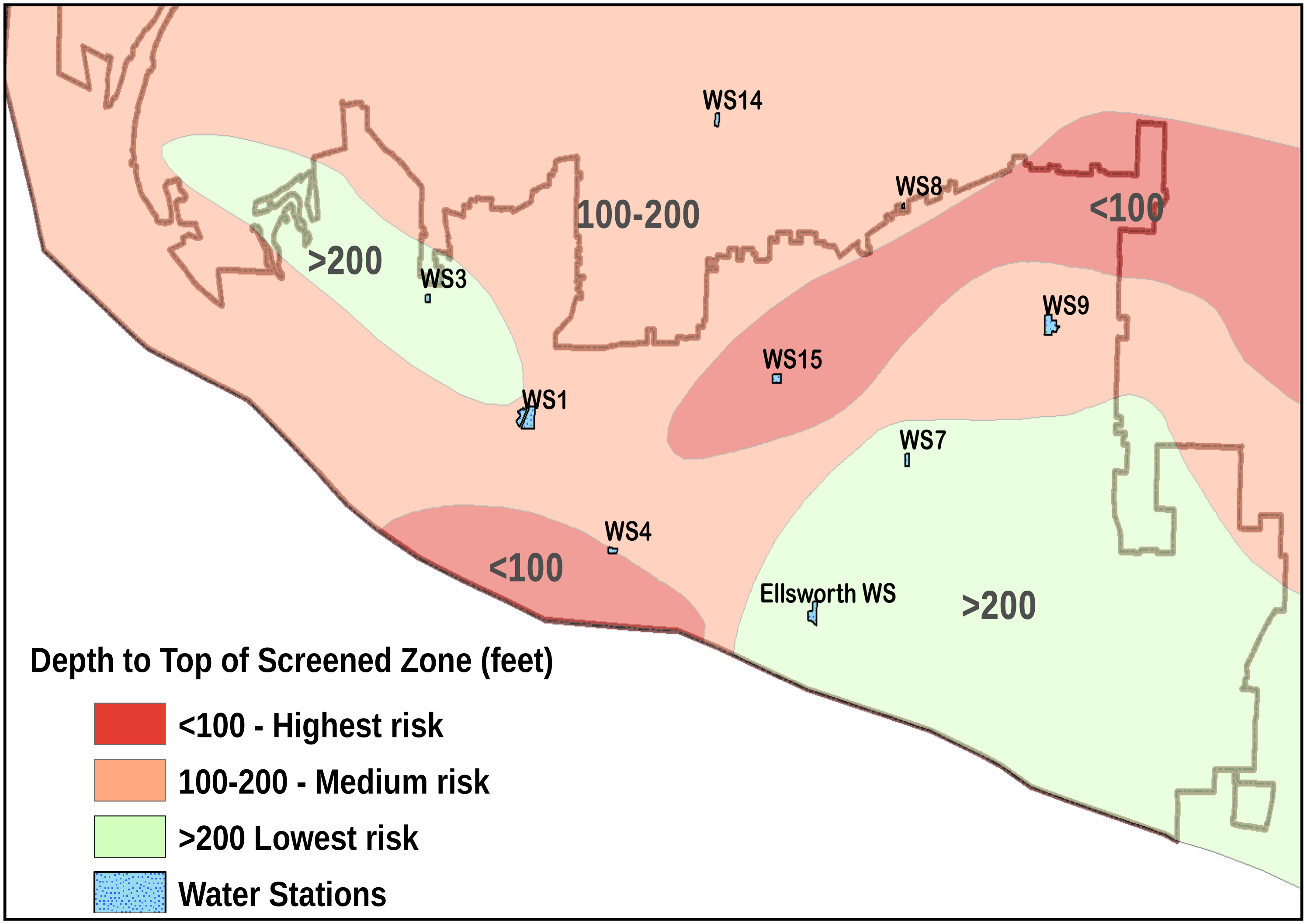
Infiltration risks were identified by discreet discharge points such as infiltration drywells (see Figure 5.3) and septic tanks that can allow a contaminant to enter the vadose zone (below the soil surface). Aging sanitary sewer pipes also present an increased risk of contamination infiltrating toward groundwater, and there are heightened risks if a spills occur at commercial or industrial (Class I and II) facilities that manage hazardous materials.

The identified aquifer susceptibility and infiltration risk factors selected for the evaluation of aquifer vulnerability in Vancouver's urban setting is shown in Table 5.4.

Table 5.4 Vancouver Aquifer Vulnerability Parameters

Vulnerability Factors	**Weighting**	**Map Raster Formats**
<u>Aquifer Susceptibility</u>		Susceptibility Maps
Wellhead time of travel (Vtrvl)	4	Polygons
Depth to drinking water aquifer (Vaqdp)	4	Polygons
<u>Infiltration Risk Sources</u>		Infiltration Risk Maps
Class I,II Facilities – parcels (Vclss)	4	Parcel polygon centers converted to density
Drywells (Vdrwl)	4	Points converted to density
Septic tanks (Vsptc)	4	Points converted to density
Known/suspected contamination sites (Vcont)	3	Points converted to density
Underground storage tanks (Vust)	3	Points converted to density
Perforated storm drainage pipe (Vperf)	2	Lines converted to density
Age sanitary sewer pipes installed (Vsanp)	2	Polygons

The parameters chosen for calculating vulnerability had to meet three criteria: 1) they clearly represent a susceptibility or infiltration risk, 2) they have been identified through research or experience, and 3) they are measurable and therefore "mappable." Vulnerability parameters were weighted based on the potential risk each represents to the aquifers. The Raster Format describes how the weighted factors were input as maps so that they could be manipulated and combined.



EXAMPLE DEPTH MAP

FIGURE 5.2

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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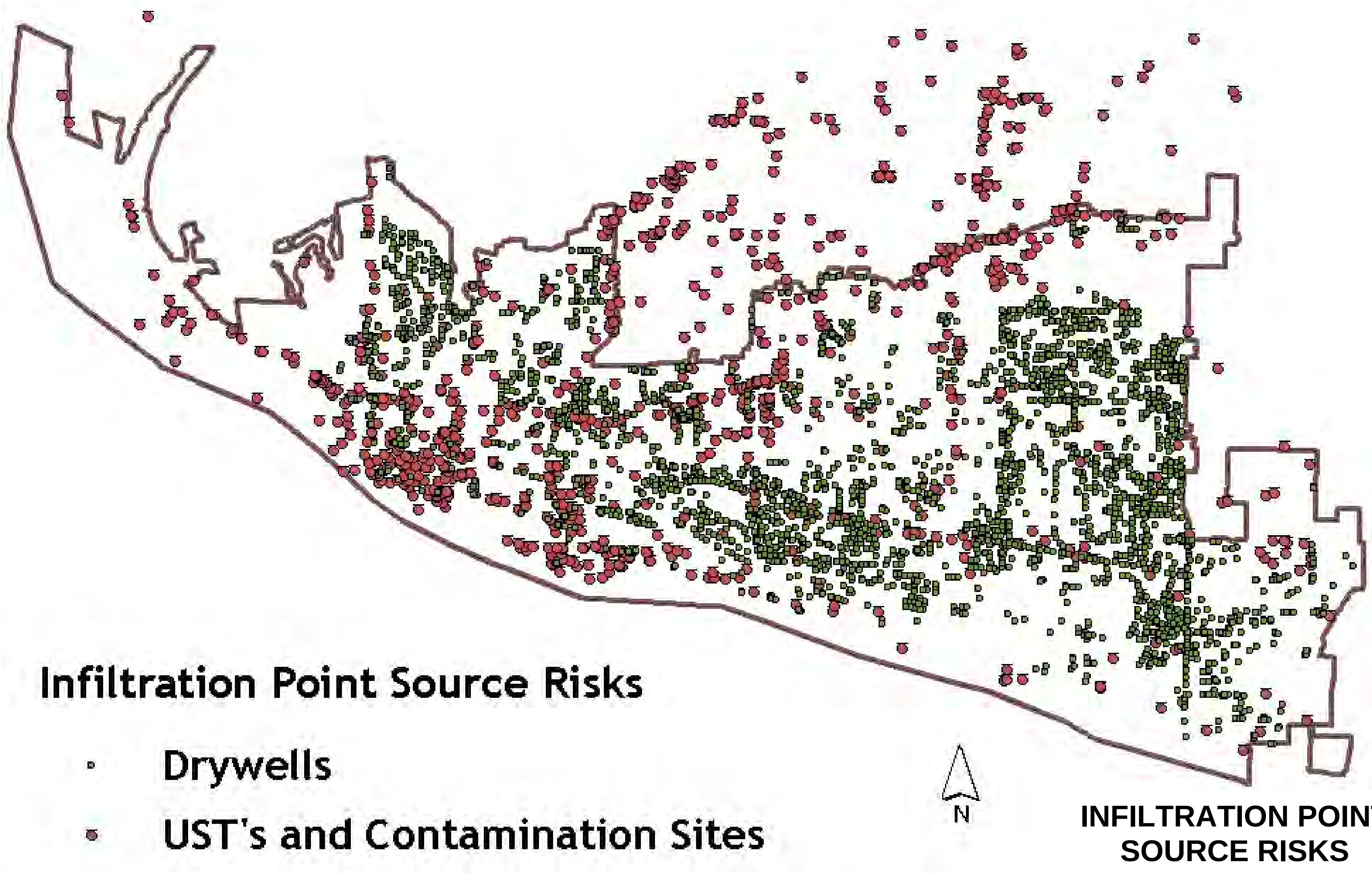
pw:// - DRAFTCarollo/Documents/Client/WA/Vancouver/9290A00/Deliverables/Chapter 05/Fig_05_02



INFILTRATION POINT SOURCE RISKS

FIGURE 5.3

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

carollo

By weighting and merging the individual hydrogeologic susceptibility factors and pollutant risk infiltration factors in a GIS application, a composite vulnerability map was created. In Figure 5.4, the areas which are considered to have a relatively higher risk for contamination to drinking water in the City are shaded red, while lower risk areas are shaded green.

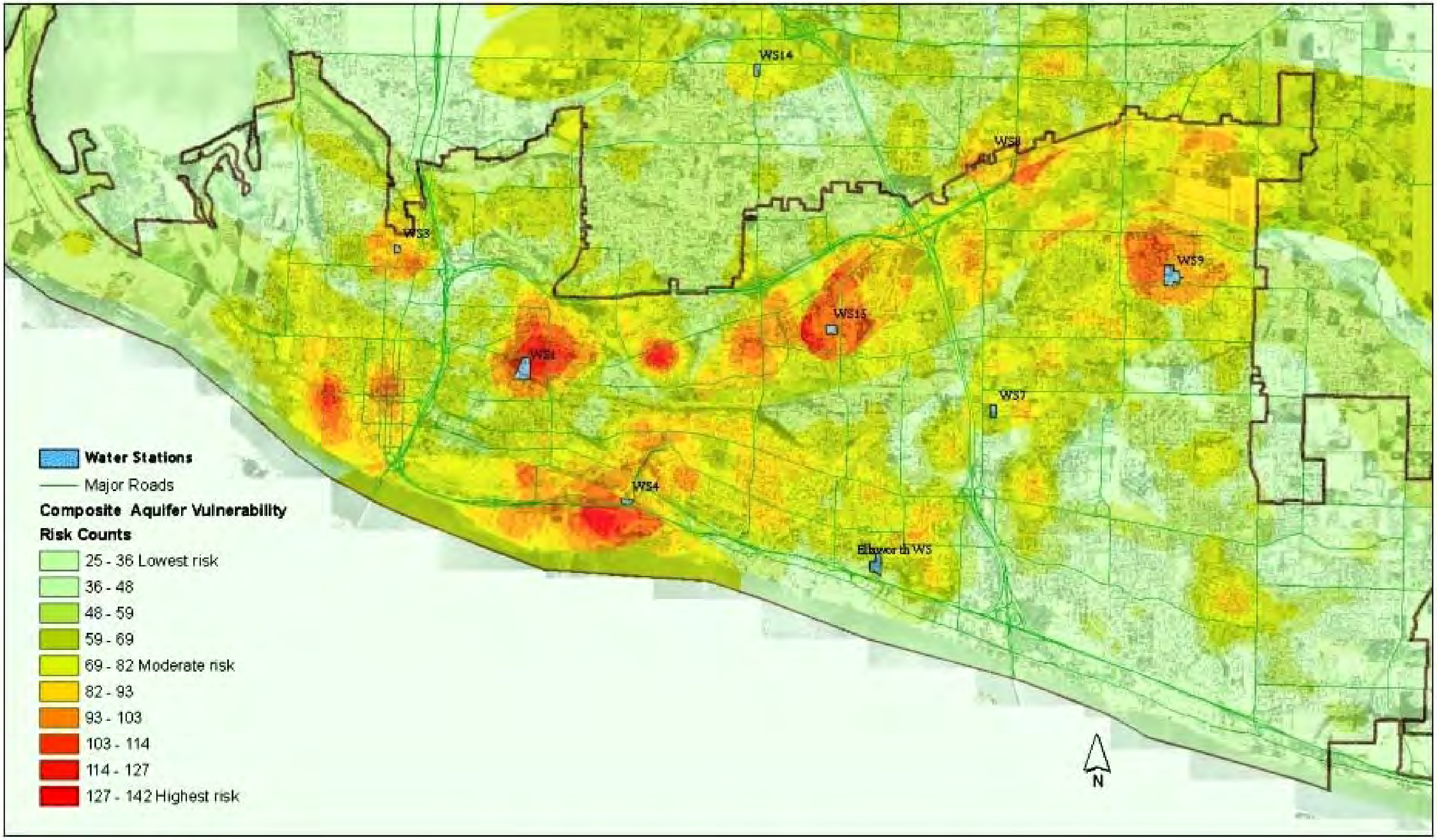
The composite aquifer vulnerability map is a valuable tool for identifying areas in the City that need to be more closely monitored by the City's Water Resources Protection Program. Targeted inspections and investigations help verify that commercial and industrial facilities in those areas implement practices that are protective of water quality and the environment.

5.8 SPILL RESPONSE

Spill response planning is an important aspect of both an emergency management plan and a wellhead protection program. The release of hazardous materials can create problems other than initial contamination of soil and surface water; a spill could eventually contaminate aquifers that supply the City's drinking water. Planning for spill response in the City reflects the needs and concerns of the community while maintaining the quality of the groundwater.

In order for spill response procedures to be effectively executed, it is imperative that coordination, cooperation, and communication take place among the responding agencies, organizations, and individuals. There are many spill response organizations at the local, state, and federal levels. Depending on the magnitude and type of the release, any of the following organizations may be involved in a spill response for a wellhead protection area in Washington State:

- *Environmental Protection Agency (EPA)* - The EPA is responsible for all land spills, including spills that occur on inland U.S. waters not under the jurisdiction of the United States Coast Guard.
- *Department of Ecology (Ecology)* - Ecology's Spill Response Team is responsible for determining the source and cause of the release and the responsible party. If the responsible party is unknown, Ecology will investigate to determine who is responsible and ensure that containment, clean up, and disposal proceedings begin. Clark County Department of Emergency Services is generally responsible for requesting a site cleanup contractor through Ecology.
- *Department of Health (DOH)* - The Washington DOH developed guidance for emergency response entitled "*Emergency Response Planning Guide for Drinking Water Systems*" (2003). In 2010, the DOH developed a "Wellhead Protection Program Guidance Document" which includes a discussion on establishing wellhead protection practices, details on implementing contingency plans, and a chapter on responding to spills and incidents. The DOH updated guidance for emergency response in 2011 in a "Water System Security and Emergency Response Planning" document. DOH also developed a set of standard operating procedures that first responders can use in wellhead protection areas, critical aquifer recharge areas, and other sensitive groundwater areas and provides assistance through laboratory support and services, if necessary, to the cleanup effort.



Aquifer Vulnerability - Vancouver, WA

AQUIFER VULNERABILITY

FIGURE 5.4

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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- *Clark County Department of Emergency Services (DES)* - Emergency response coordination within Clark County, in addition to the 911 dispatch center, are located and managed in the Clark County Emergency Services building in Vancouver. DES is responsible for ensuring that Ecology is notified for final clean up action.
- *Department of Community Trade and Economic Development (DCTED)* - Responsibilities of the Emergency Management Division of the DCTED include developing and maintaining a State Comprehensive Emergency Management Plan and providing 24-hour spill response notifications.
- *Washington State Department of Transportation (WSDOT)* - WSDOT can provide spill response assistance through traffic control, equipment, and personnel for nonhazardous cleanup activities on state and interstate highways.
- *State Patrol* - The state patrol is responsible for managing spills on interstate and state highways.
- *Vancouver Fire Department* - Initial response to a hazardous spill will most likely be from the local fire department. The Vancouver Fire Department is the area's hazardous materials response agency and is trained and equipped for responding to HAZMAT incidents.
- *City Operations and WRPO Staff* - If there is a small spill that could threaten surface or groundwater within the City limits, a call to the City dispatcher will be directed to Operations staff for cleanup and WRPO staff to perform a full site investigation and initiate corrective actions when needed.

Many spill response plans exist in Washington State. These plans address specific geographical areas such as wellhead protection areas and types of materials such as oil discharges. Examples of the types of general federal, state, and local plans are listed below:

- *Oil and Hazardous Substance Pollution Contingency Plan for Federal Region Ten* - This plan divides responsibilities among federal, state, and local governments; provides procedures for establishing local contingency plans and response actions in accordance with the Clean Water Act and Comprehensive Environmental Response, Compensation, and Liability Act.
- *Washington Statewide Master Oil and Hazardous Substance Spill Contingency Plan* - This plan provides a means for coordinating statewide response to spills by Ecology and other state agencies.
- *Wellhead Protection Program Guidance Document-Spill/Incident Response Planning* - As stated previously, the public water system is required to coordinate with local emergency responders, Ecology's Spill Operations Section, the DCTED's Emergency Management Program, the local health department, and any local emergency planning committees.
- *Vancouver Water System Emergency Response Plan (ERP), Updated 2011* - The intent of the ERP is to identify procedures that would assist in the response to malevolent acts

such as system contamination or physical damage. This document also outlines measures that can be used in day-to-day system operations to minimize the chance or impact of intentional acts.

5.8.1 WRPO Spill Plan Requirements for Facilities

In addition to the general spill guidelines listed above, the City of Vancouver has stipulated, by ordinance, that business and industries of concern develop and continually update Spill and Emergency Response Plans at their facilities.

The WRPO requires any new business or industry that is Classified I or II because of chemicals and hazardous materials at the site to prepare and submit a Spill and Emergency Response Plan prior to occupying the site. Existing classified businesses and industries will be evaluated by City staff and, if deemed necessary, will also be required to prepare a Spill Plan.

The ordinance lists the sections that must be in the plan. These include drawings, floor plans, operation layouts, entrance and exit routes, and areas where hazardous materials are managed. The Spill Plan will also provide a list of all chemicals stored at the site and the spill protection/emergency response equipment available. The Spill and Emergency Response Plan will contain a chain of command and listing of response agencies for notification and will be updated at least every 5 years. As a classified facility, the City must also report spills and respond when discharges occur on City property. When a spill occurs or if an unknown, potentially hazardous container is found abandoned in the field abandoned, City personnel fill out the City of Vancouver Operations Spill Procedure & Reporting form shown in Figures 5.5 and 5.6, and follow the procedure indicated on the form. Additional discussion of emergency procedures is also documented in Chapter 6 and Appendix 6B of this water system plan.

City of Vancouver Operations
Spill Procedures & Reporting

Spill is hazardous, unknown &/or presents an immediate threat to the public health:

- **Evacuate and secure the area**
- **Call 911 and Ecology's 24 hr Emergency Spill Response at 360-407-6300 ERTS#**____________________
- Contact Dispatch at 696-8177 - After hours Call Drainage Pager at 418-5133
- After hours for sanitary sewer call Wastewater Pager 759-2586 & Westside Plant 772-1852
- Notify Betsy Scrivner at 487-7181

Spill is 5 gallons or more & non-hazardous OR may enter storm drains or waterbodies:

- Safely stop the flow & determine where it's going (waterbody, storm drain, soil, etc.)
- Immediately call Ecology's 24 hr Emergency Spill Response: 360-407-6300 ERTS#____________________
- If flowing to Columbia River, call the Coast Guard National Response Center: 1-800-424-8802
- Contact Dispatch at 696-8177 - After hours Call Drainage Pager at 418-5133
- Notify Betsy Scrivner at 487-7181

Spill is less than 5 gallons & will not enter storm drains or waterbodies:

- Safely stop the flow & clean up the spill
- If less than 1 gallon, securely bag spill clean up materials and place in trash
- If 1 to 5 gallons, place materials in labeled container, take to Ops storage area, notify Brandon Lo'Re 759-4493

Responsible Party

Who is responsible for spill?____ Phone# ______________

Vehicle license# ____________________ Address ____

Other identification____

The party responsible for the spill should contact a cleanup contractor:

- Clean Harbors - 1-800-645-8265
- NRC Environmental - 1-800-337-7455

Incident Details (If in County, call 360-397-2446) SR/WO#________________________

Notified of Event Date__________Time ______am/pm Responded to Event Date________ Time______am/pm

Spill Location ____

Cause of spill ____

What spilled? ____ How much? ___________

Where did it flow to?______________________________________ How much recovered?___________

List all persons responding____ ______________

Actions taken ____

____

____

Report prepared by ____Date ______________________

EMAIL THIS COMPLETED REPORT TO Tim Buck, Richard Hoiland & Rhonda Morgan

Rev 6-28-13

SPILL PROCEDURES & REPORTING

FIGURE 5.5

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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City of Vancouver Operations

Abandoned Containers Procedures & Reporting

(If container is Leaking, use Spill Procedures on other side
If in County, call 360-397-2446)

SAFETY FIRST - ANY ABANDONED CONTAINER MAY BE HAZARDOUS

IF YOU DON'T KNOW WHAT IT IS, DON'T TOUCH IT!!!

Date found ____________________ Time _____________ am pm SR/WO#__ __________________________

Where? ____

What? ____ How much? ______________

Know to be hazardous?
Unusual odor or color?
Bubbling, smoking,
Burning or melting?
Just don't know?

→ Evacuate & Secure Area

→ CALL: 911
Ecology 360-407-6300
Dispatch - 696-8177
Betsy Scrivner - 487-7181

ERTS#________________

Obviously automotive fluids (antifreeze, oils, diesel, hydraulic fluid) or other known and non-hazardous materials?

→ Secure Container

→ Call Ecology
360-407-6300

Is Spill Response Team in area to pick up right away?

Yes → Wait with container until Ecology arrives

No → Store in closed, labeled container & transport to Ecology pickup cabinet at Central Operations

→ Notify
Brandon Lo'Re
759-4493

Actions taken

____

____

____

____

____

Report prepared by ____ Date ____________________

EMAIL THIS COMPLETED REPORT TO Tim Buck, Richard Hoiland & Rhonda Morgan

Rev 6-28-13

ABANDONED CONTAINERS PROCEDURES & REPORTING

FIGURE 5.6

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

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5.9 CONTINGENCY PLANNING

Contingency planning is an important component of a wellhead protection program. Careful planning cannot always account for unanticipated incidents. All water stations, except Ellsworth and Water Station 7 with wells in the deep, confined Sand & Gravel Aquifer, are considered vulnerable sources due to their shallow, unconfined aquifers, which have a high vulnerability to groundwater contamination. A worst-case scenario would be if an entire water station had to be abandoned due to groundwater contamination. Contamination occurs because of leaks, spills, accidental releases, illegal discharges, and other activities. The City's contingency plan helps ensure the water system and local officials are prepared to respond to emergency situations. Contingency planning also includes provision of alternative sources of drinking water. The following steps have been taken as part of the City's contingency plan:

- Maximum capacities of the City's existing system have been investigated as to source, distribution system, and water rights restrictions. Among other scenarios, the City's ability to meet demand assuming the loss of its largest water station was evaluated.
- Expansion options of the existing system's supplies relative to existing water rights were evaluated.
- Existing or potential interties with other public water systems were investigated. The City currently has two emergency interties with Clark Public Utilities.
- Current procedures were detailed and recommendations made on contingency plans for emergency events.

The first three steps above are discussed in detail in Chapters 3 and 4, while the emergency planning is documented in the City's *Emergency Response Plan*, included in Appendix 6D.

In the event of serious groundwater contamination, an entire water station may be taken out of service. Chapter 4 (Section 4.3) presents an analysis evaluating the ability of the water system to meet maximum day demands system-wide with the largest water station (Water Station 1) taken off-line. The results indicate that additional capacity is warranted at Water Stations 4, 6, 8, and 15, at which production is less than existing water rights. Chapter 3 (Section 3.8.8) presents an analysis evaluating the ability of the water system to meet maximum day demands in each pressure zone with Water Station 1 off-line. Given the recommended improvements at Water Stations 4, 6, 8, and 15, and 15 percent curtailment, the City is able to meet all customer demands through 2034.

The City's previous Water System Plan evaluated the ability to meet customer demands should any individual water station be offline. The results of the previous study show that, with the exception of Water Station 1, it is possible to meet 2005 maximum day demand with each of the other water stations out of service. The City has plans to develop new source capacity and auxiliary power to improve system reliability as discussed in Chapter 3. This is necessary to mitigate the source capacity deficit if Water Station 1 is out of service, and to mitigate reliability issues related to power outages. In considering future sources of supply for the City of Vancouver water system, limitations of available groundwater and surface water sources must be considered with respect to quantity, quality, and water rights. These considerations are discussed in Chapters 3 and 4.

The contingency plan was implemented in 2013 when a fuel spill located approximately 1,400 feet upgradient of Water Station 7 temporarily impacted operation of both wells at the site. Operation of the wells was restored within a year of the spill. Continued monitoring was implemented and spill clean-up is anticipated to last for several years following the spill.

5.10 WATER RESOURCES PROTECTION STRATEGIES

Development of management strategies is essential for a successful wellhead protection program. Without proper management, potential contaminant sources are likely to become a reality. Wellhead protection components that are included in the City's Program are described in the following sections.

5.10.1 Public Education

Public education is an important aspect of wellhead and overall water protection. If the public is aware that their actions may affect the water they drink, they may be more willing to change their practices. The City's three methods of facilitating public education and involvement in the Program are: 1) Water Resources Protection Outreach Program, 2) Exhibits at the Water Resources Education Center, and 3) through the Annual Water Quality Report.

5.10.1.1 Water Resources Protection Outreach

The Water Resources Protection Outreach Program has funds dedicated to providing educational and technical assistance to both businesses and residents of Vancouver. The program focuses on both groundwater protection and surface water issues, because in Vancouver some storm water may be directed through dry wells directly into the ground. Also, the City recognizes the importance of protecting the local Burnt Bridge Creek and Columbia River as a part of any water protection program.

Some of the outreach programs being performed include a car wash program, floor drain plugging program for local auto shops, a storm medallion installation program for catch basins that drain to dry wells near water stations or that drain directly to a river or stream, and a campaign focused on stormwater management.

5.10.1.2 Water Resources Education Center

The Water Resources Education Center provides information to the community about water resources and has areas available for meetings. Various exhibits will be displayed at the center to educate the public about their water supply. These exhibits include a variety of materials on wellhead protection and pollution prevention. The education center provides an excellent means to communicate the need for water protection to the public.

5.10.1.3 Annual Water Quality Report

The Annual Water Quality Report is a publication for educating water customers about water quality issues. The report consists of information such as water quality test results, minimizing water pollution from household hazardous wastes, and tips for water conservation. This report serves as an effective tool for relaying information to customers.

5.10.2 Pollutant Source Management Strategies

With its comprehensive inventory of potential sources of risk to water resources, the City can effectively oversee and manage these sources. Source management strategies include: inspections and investigations of sites that may contain materials that, if mismanaged, could threaten water resources; working with other regulatory agencies to ensure consistent enforcement of existing regulations; technical assistance for property owners; requiring and helping sites develop spill response documents; and enforcing best management practices as detailed in the Water Resources Protection Ordinance.

5.10.2.1 Best Management Practices

BMPs are defined as physical, structural, and/or managerial practices that, when used singly or in combination, prevent or reduce water pollution. BMPs and water protection management strategies are clearly specified in the City's WRPO and are also included in the Burnt Bridge Creek Watershed Plan and some state and county guidance documents.

BMPs are an effective tool in any pollution prevention program. As a part of the Water Resources Protection Program, businesses and residences throughout Vancouver are visited and evaluated for the risk they present to water resources. The WRPO provides detailed BMP's for leaks and spills, oil/water separators, pesticides, storm water treatment, and decommissioning wells that apply to all businesses and residents.

For any facilities that are found to be Class I or II based on the hazardous materials they store and manage onsite, greater standards and BMPs are stipulated. These include structural BMPs, drum labeling, secondary containment, compatibility verifications, ancillary equipment design standards, and operating procedures. In visiting sites, the City often finds many facilities are regulated under RCRA or SARA, and adequate BMP's may already be in place.

The BMPs from the Burnt Bridge Creek Watershed Plan include the use of biofiltration, level spreaders to distribute sheet flow, wetpond and wetland treatment, pollutant source control, and dry well rehabilitation. The City has applied for and received several grants for water quality improvements in the Burnt Bridge Creek watershed. Many of these projects will include installing infiltration facilities to capture and treat storm runoff.

Ecology's Stormwater Management Manual for Western Washington provides an excellent reference for technical design approaches and BMPs. The manual addresses BMPs associated with construction and development, erosion control, managing hazardous materials on construction sites, storm water detention and infiltration, and biofilter and wetland management.

To meet NPDES Phase II Stormwater Permit requirements, the City has adopted the provisions of the manual as part of the water protection, stormwater management, and erosion prevention ordinances.

5.10.2.2 Underground Storage Tanks

The Water Resources Protection team is actively involved in inventorying UST's throughout the citywide wellhead protection area. All data and information from site visits and other research has been stored in the WRPO database and is now available on the GIS mapping facility.

In cases where City regulations are not sufficient to guarantee adequate water protection, Ecology is contacted to participate in WRPO/Ecology co-visits of a facility.

5.10.2.3 Toxic Cleanup Program

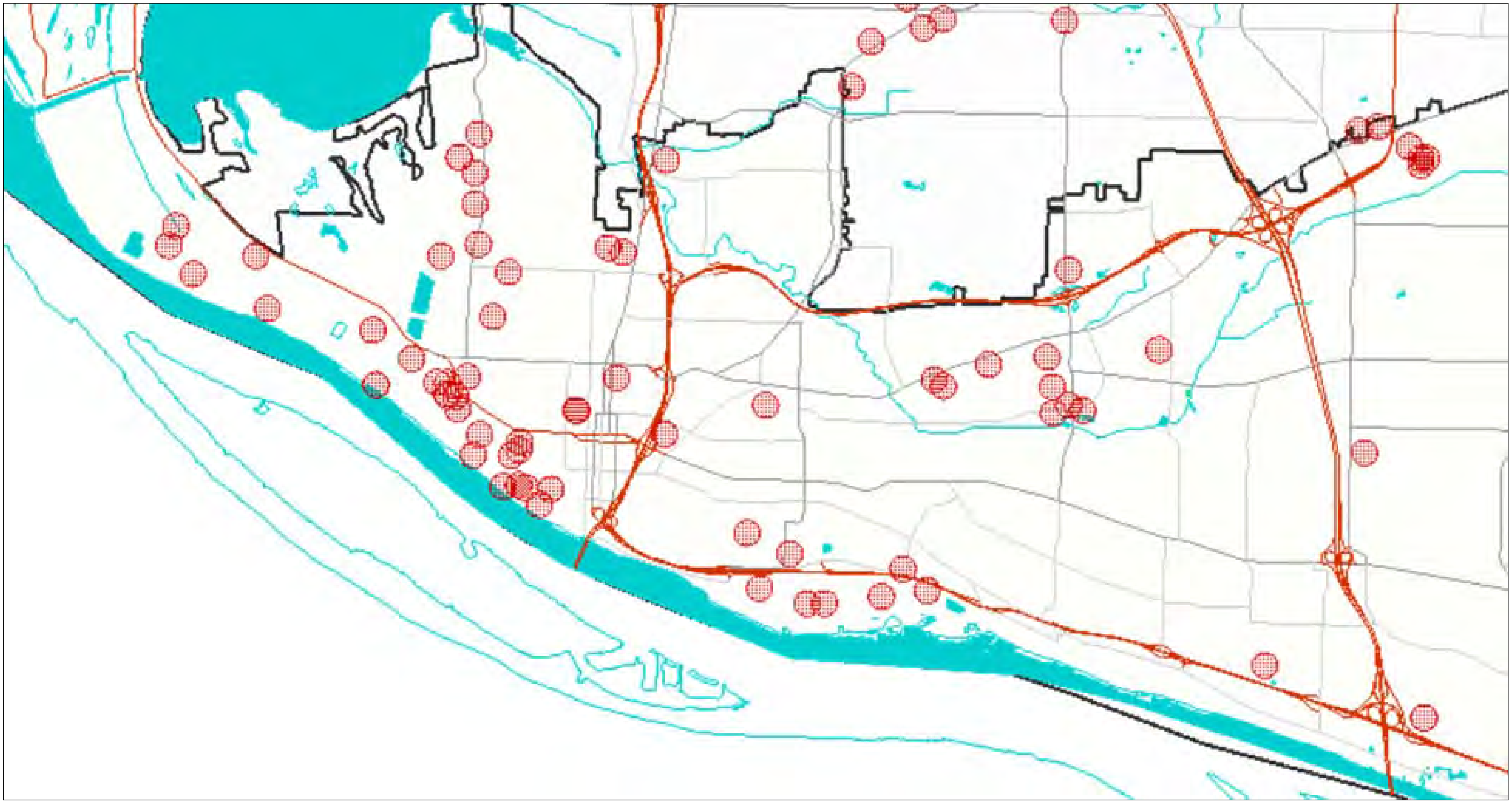
Ecology's Toxic Cleanup program is responsible for ensuring the cleanup of leaking USTs and remediating confirmed and suspected contamination sites. The City's WRPO staff meets regularly with Ecology to review contamination site information, obtain details for GIS contamination site mapping, and update monitoring data. These maps and the detailed site information that the City maintains will be available to Ecology and other agencies as needed.

5.10.2.4 Hazardous Waste Generators

The Dangerous Waste Regulations, administered by Ecology, requires facilities with more than 220 pounds of hazardous waste to comply with a number of performance standards. This same minimum quantity cutoff is incorporated into the Water Resources Protection Ordinance to define which facilities are Class I for purposes of water protection regulation. Based on these quantity designations, the City may require secondary containment, spill plans, inspection protocols, and facility management. Ecology can request information on local facilities from the City's database and utilize the WRPO's GIS mapping facility to better expand their knowledge of potentially dangerous facilities located in Vancouver.

5.10.2.5 Tier II Facilities

The federal government requires that certain businesses in a community submit a listing of the hazardous materials stored at their site. These businesses and industries are called Tier II Facilities and that information is reported as a part of the Community Right-to-Know legislation. WRPO has incorporated this information into their program's database and now has the ability to highlight any Tier II facility on the GIS Site Atlas. This allows the City, other regulators, and members of the community to easily locate those operations that could present a threat to water resources. The red circles in Figure 5.7 indicate the locations of Tier II facilities in Vancouver - from the City's water protection database and GIS Site Atlas.



TIER II FACILITY LOCATIONS

FIGURE 5.7

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

carollo

5.10.2.6 Septic Systems and the Connection Incentive Program

Failing septic tanks represent another threat to the groundwater in and around the City. The CCPH department is responsible for the review and approval of new septic systems and for repairs to failed systems.

To better protect Vancouver's water, the City has implemented an effective incentive program for septic tank owners called the Sewer Connection Incentive Program (SCIP) with a goal to provide sanitary sewer service to existing homes and eliminate on-site septic systems. Refer to Section 5.5.1.4, Potential Contaminant Sources - Septic Systems.

As of 2014, the number of septic systems remaining in the City's service area is detailed in Table 5.5.

Table 5.5 Summary of Septic Systems Within City's Water Service Area (2014)

Septic System Inventory and Sewer Availability	Parcels with Septic Systems(1)	Parcels with Sewer Available(2)	Parcels Needing Sewer(3)
COV Water Service Boundary (COV Sewer)	5,893	3,366	2,527
COV Water Service Boundary (CRWWD Sewer)	1,715	476	1,239
COV Water Service Boundary (Outside Sewer Boundary)	50	0	50

Notes:
(1) Could be more than one septic system on a given parcel.
(2) Inside completed SCIP project boundaries or are within 60 ft. of existing sewer
(3) Inside planned SCIP project boundaries or are farther than 60 feet from existing sewer

The Water Resources Protection Ordinance includes specific language restricting development of new septic systems within water station special protection areas. WRPO staff also continues to work directly with the CCPH on septic tank identification, installations, and regulatory work. A mapping feature on the GIS allows CCPH staff to easily locate areas of the City in which septic tanks cannot be installed.

5.10.2.7 Other Management Tools

In addition to the previously discussed management strategies, the City currently uses many other management options to help protect water resources:

- Building Codes - Building codes are a useful tool for requiring special water protection standards, such as preventing floor drains from being routed to dry wells.
- Purchase of Property or Development Rights - The purchase of property or development rights is occasionally used to ensure better control of land uses. This tool is preferred

when regulatory restrictions on land use are not politically feasible and the land purchase is affordable.

- Site Plan Review - For development in Vancouver, developers must go through pre-application screenings and then submit site plans for review and approval.
- Source Prohibitions - The WRPO restricts seven industrial uses from being developed in the City limits. These are chrome plating operations, wood preserving facilities, chemical lagoons, sewage cesspools, hazardous material disposal sites, radioactive waste disposal sites, and municipal waste disposal facilities.

5.10.3 Monitoring

The City has an aggressive water quality monitoring program where each year the municipal well fields are sampled for regulated compounds, for compounds that have been identified as troublesome in other locales, and various other compounds. More than 238 compounds are evaluated per well field per year. At well fields where the City has treatment facilities to remove compounds above action levels, testing is performed daily and weekly. Bacteriological testing throughout the City is more comprehensive than regulations require, providing complete service area monitoring of the water served to the community.

There are also hundreds of private, county, state, and federal monitoring wells scattered throughout Vancouver. These are typically located near an industrial area or past contaminant source, such as in the Port of Vancouver area or near an EPA National Priority Site Listings (NPL) such as Frontier Hard Chrome, Boomsnub and the City of Vancouver Water Stations 1 and 4. Copies of industrial site monitoring results are either submitted periodically to the City or are often available on request. Besides monitoring data from the production wells, the City uses this information to monitor ground water quality.

5.11 WATER RESOURCES PROTECTION ORDINANCE

A goal of the City's Water Resources Protection Ordinance (VMC 14.26) has been to provide effective legislation without over-burdening existing businesses and residents. By having citizens and businesses represented during the development stage, both the public and business groups accepted the new legislation. In the ordinance are provisions that:

- Prohibit activities that are deemed serious threats to groundwater, such as chrome plating operations and hazardous waste disposal.
- Establish minimum standards that all businesses and residents must follow.
- Classify some businesses high or moderate risk based on the amounts and types of hazardous materials managed at the site.
- Stipulate greater standards and practices for classified businesses.

5.12 IMPLEMENTING AND UPDATING THE WELLHEAD PROTECTION PROGRAM

The City of Vancouver employs a variety of means for implementing their Wellhead Protection Program. The City's WRPO provides the legal basis for inspecting facilities of concern, requiring water protection BMPs, providing technical assistance and public outreach, and stipulating enforcement measures.

The City's wellhead protection program, as implemented, contains the following elements as required by WAC 246-290,135(4):

- Susceptibility assessment of water wells.
- Delineation of a citywide wellhead protection area.
- List of known, suspected, and previously active contamination sites within the City limits.
- Documentation of site visits of classified facilities that store or manage materials deemed potentially hazardous to water resources.
- Contingency plan to ensure consumers have an adequate supply of potable water in the event contamination results in the temporary or permanent loss of the principal source of supply.
- Documentation of coordination with local emergency spill responders (police, fire, and health departments).

The following management strategy provides effective water protection throughout the City of Vancouver:

1. Using the City's Water Resources Protection Ordinance, VMC 14.26, the City enforces compliance with water quality protection standards.
2. Businesses and industries are designated either Class I or II depending on the types of liquid materials stored at the site. Classified commercial sites must meet greater standards of site practices and materials management.
3. A coordinator, a facility inspector, and a technician make up the City's water protection staff to effectively meet the needs and requirements of the program.
4. All site related records are stored in a program database. A GIS Site Atlas uses map layers to display information from the database. This mapping application is available on the City's website.
5. The City's water protection inspector works with inspectors from other programs including Clark County, the Dept. of Ecology and other regulatory agencies through the Local Interagency Network Cooperative (LINC).
6. Outreach materials are developed to assist businesses, industries, and residents in maintaining compliance with the program.

5.12.1 Inspections and Investigations

As of September 2014, the City's Water Resources Protection Program has researched over 1,200 commercial, industrial, and residential sites in and around Vancouver. WRPO inspectors have performed detailed inspections on over 300 commercial/industrial Class I/II sites and have also responded to over 800 calls and referrals related to spills, complaints, technical assistance, and investigations. The table in Appendix 5B lists the inspections performed by WRPO inspectors.

As part of the NPDES permit requirements the City's Surface Water program must now inspect private stormwater facilities throughout the City. These facilities typically infiltrate stormwater. Over 90 private facilities have been inspected since this program was initiated in 2011. The inspection and investigation program is fully funded with Surface Water Management utility fees and state grants.

Because the Water Resources Protection program continues actively visiting sites, the inventory of facilities and activities in Vancouver is constantly updated. As additional information on facilities and residential areas is introduced to the program, the WRPO database is changed or supplemented to reflect the changes. Updates are reflected immediately in all reports generated and on GIS mapping displays.

5.13 FINANCIAL CONSIDERATIONS

Recognizing that it is more cost effective to implement proactive pollution prevention, the City of Vancouver has allocated substantial funds to wellhead and water resources protection. In 2003, Ecology awarded the City with a Centennial Clean Water Grant to get the Water Resources Protection Program started. Grant funds were used to purchase needed startup equipment, hire staff, and perform initial inspections on facilities of concern.

Since then, several other grants have been awarded to Vancouver by the Department of Ecology to support the Program. The most recent grants have provided funds to install stormwater retrofits, which remove runoff from surface drainage, directing it to treatment and infiltration. Some grant funds have also strengthened the City's inspection and investigation activities.

City management continues to fund the Program with Surface Water Management utility funds. Budgets are approved by Council every two years and the City has water protection staff and other program components budgeted as part of their long term commitment to the community. In addition, the septic tank elimination program is solidly funded within the Water and Sewer Utility Funds.

Chapter 6

OPERATION AND MAINTENANCE PROGRAM

6.1 INTRODUCTION

This chapter provides an overview of the City of Vancouver's (City's) water utility operation and maintenance systems. The purpose of this chapter is to document existing procedures and to identify areas where improvements or changes could enhance system operation. The City's operation and maintenance program is reviewed in relation to regional, state, and national water operation standards.

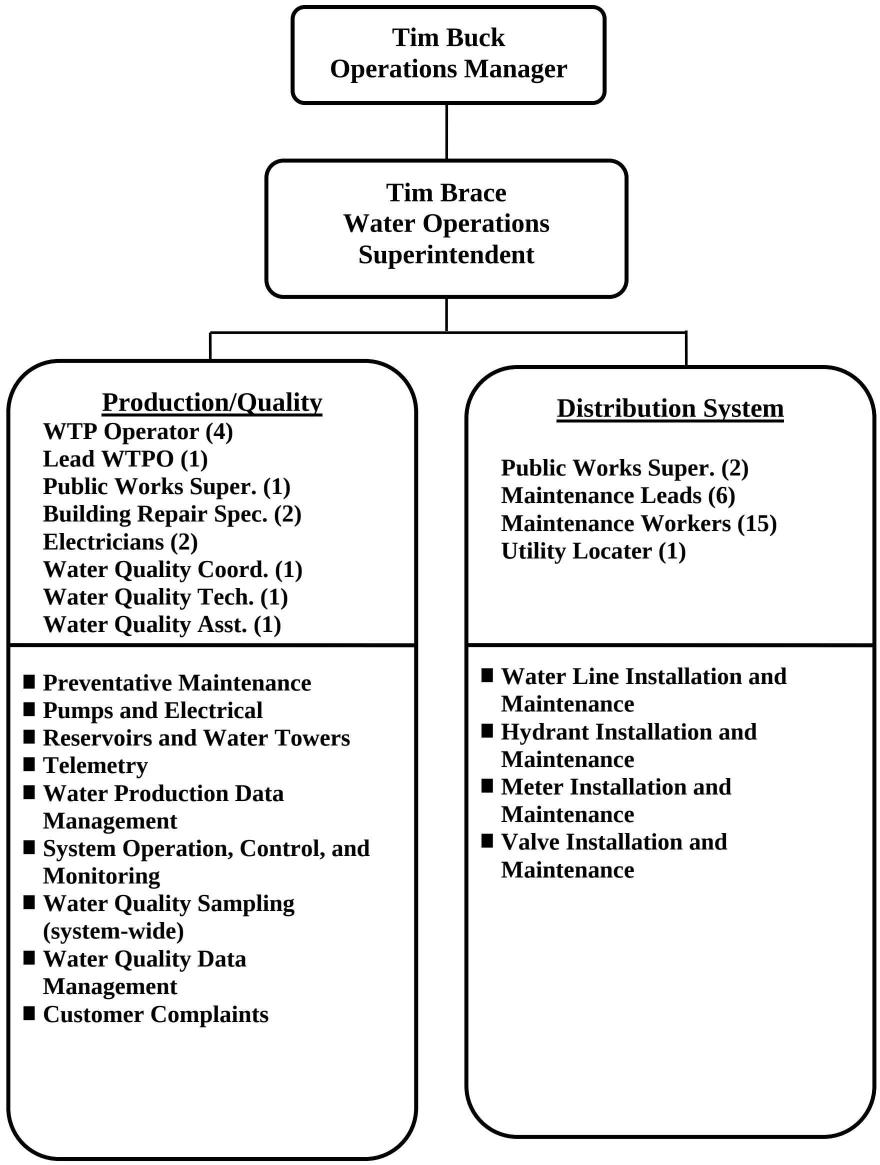
6.2 WATER SYSTEM MANAGEMENT

As discussed in Chapter 1, the City's water system is managed and operated under the City's Public Works Department. An organization chart depicting the City's water system management, operation, and control structural hierarchy is shown in Chapter 1, Figure 1.1. Critical decision-making follows the upward chain of command as presented in the organizational chart. Duties pertaining to the water system are divided amongst the Operations, Engineering, and Capital Planning, Finance, and Asset Management, as described in Chapter 1.

Figure 6.1 presents the title of each staff member and lists the duties and responsibilities of the two branches in the Operations Division.

Other departments within Public Works provide additional support for the Water Department such as construction management, equipment repair, materials acquisition, grounds keeping, utility billing and office and record keeping assistance.

Proper documentation of the responsibilities of water system managers and operators can increase system performance and improve emergency response time. In emergency situations, critical time can be lost if the correct decision-making personnel are not kept informed. Therefore, an established ranking of decision-making individuals is documented. A list of contact information for all employees is also kept updated, as described in the City's Emergency Response Plan.



OPERATIONS CHAIN OF COMMAND AND RESPONSIBILITIES

FIGURE 6.1

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

6.3 OPERATOR CERTIFICATION

6.3.1 Certification Requirements

The Waterworks Operator Certification, required under WAC 246-292-020, mandates that Washington State public water systems employ individuals who are certified, by examination, as competent in water supply operation and management. The rule was recently changed to strengthen Washington State Department of Health (DOH) authority and take enforcement actions. The DOH determines the required level and number of certified positions based on the population and complexity of the water system. Under the current certification requirements, the City must provide three mandatory certification positions: a Water Distribution manager (WDM) Level 4, Water Treatment Plant Operator (WTPO) Level 2, and a Cross Connection Specialist (CCS). It is also required that personnel with supporting certifications be available for each of the three mandatory certification positions. The supporting certificates may be one grade lower than the mandatory position and can be held by the same employee. Table 6.1 presents the certified staff for the City.

6.3.2 Professional Growth Requirements

The City's certified operators attend training courses and conferences to obtain continuing education units (CEU's) as required by Washington State for various certifications. Trainings include instruction on various topics such as new industry standards, technology, safety, and regulatory requirements. All staff is current with respect to the CEU requirements. Common programs for acquiring CEUs include American Water Works Association (AWWA) conferences and trainings and the Washington Environmental Training Resources Center (WETRC).

Table 6.1 Certifications

Department	Division	Title	Name	Certification Number	Water Distribution Specialist	Water Distribution Manager	Water Treatment Plant Operator	Cross Connection Control Specialist	Backflow Assembly Tester
Water		Water Division Superintendent	Brace, Tim	3711	WDS	WDM4	BTO, WTPO3	CCS	
Water	Distribution	Water Distribution Supervisors	O'Neil, Denny	7249	WDS	WDM3		CCS	
Water	Distribution	Water Distribution Supervisors	Permin, Mike	3665	WDS	WDM3		CCS	
Water	Distribution	Water Distribution Leads	Fritz, Cevin	7633	WDS				
Water	Distribution	Water Distribution Leads	Silvis, Loren	7595		WDM2			
Water	Distribution	Water Distribution Leads	Steuben, Mike	7695	WDS	WDM1			
Water	Distribution	Water Distribution Leads	Brown, Eric	7615	WDS				
Water	Distribution	Water Distribution Leads	Jackson, Dennis	9576	WDS	WDM1			
Water	Distribution	Water Distribution Leads	Spencer, Travis	11794	WDS	WDM1			
Water	Distribution	Water Distribution Maintenance Workers	Blancas, Dale	11485	WDS				
Water	Distribution	Water Distribution Maintenance Workers	Jones, Jeremiah	13138	WDS				
Water	Distribution	Water Distribution Maintenance Workers	Kuhn, Ed	6752	WDS				
Water	Distribution	Water Distribution Maintenance Workers	MacQuarrie, Nick	13455		WDM1			
Water	Distribution	Water Distribution Maintenance Workers	Leach, Dillon	13040		WDM1			
Water	Distribution	Water Distribution Maintenance Workers	Lewis, Jim	12446		WDM1	WTPOIT		
Water	Distribution	Water Distribution Maintenance Workers	Marshall, Rod	13106	WDS				
Water	Distribution	Water Distribution Maintenance Workers	McGuire, Brian	13070	WDS				
Water	Distribution	Water Distribution Maintenance Workers	Orme, Jeff	13448	WDS				
Water	Distribution	Water Distribution Maintenance Workers	Peterson, Daren	12337	WDS				
Water	Distribution	Water Distribution Maintenance Workers	Weglage, Will	12451		WDM1			
Water		Water Production Supervisor	Trenda, Allen	5157	WDS	WDM3	BTO, WTPO3		
Water		Water Treatment Lead	Sloniker, Bruce	9974	WDS	WDM3	WTPO2		
Traffic	Operations	Water Treatment Plant Operator	Leedom, Lance	9592	WDS		WTPOIT		
Water	Operations	Water Treatment Plant Operator	Weber, Rob	11248	WDS	WDM3	WTPO2		
Water	Operations	Water Treatment Plant Operator	Scott, Toby	11013	WDS	WDM1	WTPO2		
Water	Operations	Water Treatment Plant Operator	Jochim, Leo	12942		WDM1	WTOPOIT		
Water	Water Quality	Water Quality Coordinator	Huff, Johanna	10969	WDS			CCS	BAT
Water	Water Quality	Water Quality Assistant	Lucht, Kristi	11147	WDS	WDM2	WTOPIT	CCS	

6.4 SYSTEM OPERATION, MONITORING, & CONTROL

The City effectively operates its large water system through a combination of staff activities and automated controls. Day-to-day operations, such as turning pumps on and off, filling and drawing of reservoirs, are all automated through the City's supervisory control and data acquisition (SCADA) system. Controls are set to meet varying conditions such as high demands, and to maintain reservoir levels and system pressure. The SCADA system monitors and records data for staff monitoring and system evaluation. The operation, monitoring, and control are discussed below.

6.4.1 Normal Operation

As detailed in Chapter 1, the City's water system is comprised of wells, treatment facilities, pump stations, ground reservoirs, and elevated storage tanks grouped together at the City's Water Stations. The City's water system is controlled by a SCADA computerized telemetry system, and is manned eight hours a day by the operations staff. After normal working hours, the SCADA system can automatically contact off-duty staff to alert them of an emergency situation. The Water Operations Division is located in the Operations Center on Fourth Plain Boulevard and General Anderson Road.

The City's system meets daily demands through its groundwater supplies and storage facilities. The City operates its system based upon the draw and fill of the City's reservoirs, as well as system pressure. As the water level in the reservoirs and/or system pressures drop, different wells and booster pumps are called on based upon set points determined by operations staff. Likewise, the wells will be shut off when the reservoir water level and/or system pressure rises to the set point determined by operations staff. The reservoir water level set points that operate the wells are controlled and monitored by the City's SCADA system, which is operated from a terminal located at the Water Utility Operations Center. Due to the large variation in water demand between the summer months and the rest of the year, the City periodically changes the set points for the wells and booster pump stations.

6.4.1.1 Start-up and Shutdown Procedures

Facility start-up and shutdown procedures are specific to each water station facility. In general, all pumps and systems are switched from off to automatic mode for start-up. Once in automatic mode, pumps start and stop based on specified level or pressure setpoints. To shut down a facility, individual pumps are shut down manually and then disabled to prevent them from being called on automatically for operation. For the more complex systems relying on filtration (Ellsworth and Water Station 7), specific start-up and shut down sequences are identified in the Operations and Maintenance manuals located on-site at that facility and at the Water Utility Operations Center.

6.4.1.2 SCADA System

The City's existing SCADA system provides the City with automation of its facilities and the ability to monitor and control remote sites from a centralized location. Since its original design and implementation beginning in 1989, the City has completed several SCADA upgrades at its facilities, creating a SCADA system where some remote facilities are able to communicate directly with one another (multi-master approach) while others remain in a master-slave arrangement (that is, the remote facilities are only able to communicate with the master computer).

Currently, the singular master system is located at the Operations Center and includes a full control panel and two computer HMI stations. These two computers are configured to talk to a local master PLC to convey information to and from the remaining master-slave facilities via dedicated point-to-point phone lines. These two computers also communicate with the multi-master facilities using virtual private network (VPN) technology across the Internet. While some of the remote facilities have been upgraded to support the multi-master approach and VPN technologies, the overall SCADA system has not been reprogrammed to communicate or utilize the full capability of the remote facility upgrades.

The City is currently planning significant upgrades to its SCADA system. Appendix 6F provides details on the existing facility and the planned improvements. Currently planned SCADA improvements are included in Chapter 8 – Improvements Program.

6.4.1.3 Source Production Facilities

The water system's source facilities include well fields and treatment facilities. Operation and control of the well pumps is performed remotely by the SCADA system. Several of the water stations are equipped with auxiliary power for their well pumps, as summarized in Appendix 3C. Each production water station has chlorine and fluoride treatment facilities. Water Stations 7, 8, and 15 have on-site sodium hypochlorite generation systems. Water Stations 1, 3, 4, 9, 14, and Ellsworth are all equipped with gas chlorination systems. Chlorinators are controlled manually or are flow proportioned from the source meter. Fluoride feed pumps are controlled by the source meter so the fluoride feed rate is flow proportional and maintains a 0.7 mg/L fluoride residual.

In addition to chlorine and fluoride addition, Water Stations 1 and 4 have air stripping towers to remove volatile organic contaminants (VOCs). Water Station 7 and the Ellsworth Water Station have treatment facilities to remove nuisance levels of iron and manganese through a greensand pressure filtration process. Water Stations 14 and 15 have pH adjustment through air stripping and caustic soda addition, respectively. All components of the air stripping facilities, greensand filters, and caustic soda addition are controlled by the local PLC that receives well on/off signals from the main PLC. The Water Station 7 greensand filter backwashing system is automatically activated when a designated run time is achieved. The Ellsworth greensand filter backwashing system is manually activated when a designated head loss is achieved.

To ensure source of supply reliability, static and dynamic water elevation in each aquifer is monitored on a monthly basis at each well field, with some exceptions. At Water Station 7, water elevations at both wells are measured since they are in two different aquifers. At Ellsworth Water Station, the electrical demand charges to bring a well online are large, so water elevations are only measured if the well is already in operation. Both static and dynamic water levels are measured manually using a sounding probe. The City is required to send an annual aquifer water level report to the Department of Ecology for Water Stations 7 (well 2), 9, 14, and Ellsworth. The City currently has level probes installed on some wells that are connected to the SCADA system for continuous tracking of well performance.

Well pump motor vibration is monitored automatically using motor vibration sensors. Controls are set to automatically shut down the pump should vibration levels exceed a safe level for the pump. Where available, the SCADA system monitors and records pump motor run time in hours of operation. Where not available through the SCADA system, runtime hour meters located on the pump starters are read and recorded manually. Total runtime is tracked on a spreadsheet that is used to initiate maintenance.

6.4.1.4 Storage Facilities

The City's ground level reservoirs and elevated tanks are operated to maintain pressure in the system, meet hourly demand fluctuations, and provide storage for fire flow and emergency demands. Storage facilities are operated and monitored by the SCADA system. Pressure transducers measure the pressure generated by the water level in each reservoir or tank and report this information back to the SCADA system. The SCADA system continuously monitors and records water levels. If the water levels reach either the high alarm or low alarm elevations, the SCADA system sends an alarm to the Operations Center. If severe fluctuations in reservoir capacity occur, the SCADA system can assist the operator in determining the source of the problem.

6.4.1.5 Booster Pump Stations

All Booster Pump Stations (BPSs) are operated and controlled by the SCADA system. At some pump stations the SCADA system continuously monitors BPS discharge pressure and flow. Alarms notify an operator in the event of a pump failure. Booster pumps that supply closed zones (i.e. Lincoln High and Terrace High) typically runs continuously, but can be turned on or off from the Operations Center. Several water stations have auxiliary power for their BPSs, as summarized in Appendix 3C.

Pump motor vibration is monitored automatically using motor vibration sensors. Controls are set to automatically shut down the pump should vibration levels exceed a safe level for the pump. Where available, the SCADA system monitors and records pump motor run time in hours of operation. Where not available through the SCADA system, runtime hour meters located on the pump starters are read and recorded manually. Total runtime is tracked on a spreadsheet that is used to initiate maintenance.

6.4.1.6 Distribution System

The distribution system components include water mains, pressure regulating valves (PRVs), water main valves, fire hydrants, bridge crossings, and other related appurtenances. All of the distribution system components are operated manually. The PRV installations are being integrated into the SCADA with the 39th St. and Evergreen Blvd. sites currently connected.

6.4.1.7 Customer Meters

Residential meters are read every two months, while commercial and industrial meters are read every month. Meter reading is conducted by contract employees. Residential and most low-use commercial and industrial meters are not tested for accuracy unless requested by the customer. Residential and most low-use commercial and industrial meters are replaced based on the total consumption meter reading. High-use commercial and industrial meters are tested by city staff at least every three years, with many as frequently as every six months. Faulty residential and ill performing commercial/industrial meters are either repaired or replaced.

6.5 ROUTINE AND PREVENTATIVE MAINTENANCE

Effective maintenance is an essential component of managing a water system. The operational staff of the City must manage routine maintenance tasks, new system modifications to the existing infrastructure, and emergencies. The following sections describe maintenance of the various water system components, and makes recommendations for revisions to the existing maintenance programs.

6.5.1 Hansen Maintenance Management System

The City implemented a Hansen Maintenance Management System (MMS) in 2007, for general management of its maintenance system. The program has been used to generate work orders in the past. In order to allow operations staff to utilize more functions of the program, including asset management, the City completed an upgrade to Infor 8 in January 2015.

6.5.2 Source Production Facilities

The City's water production facilities are inspected daily by the operations staff. During inspection, chlorine gas cylinders are changed out and sodium fluoride compound is added to the fluoride mix tanks as needed. The City keeps a maintenance schedule for repair or replacement of pumps, well casings and screens, source meters, interior and exterior of buildings, and treatment facilities that is based upon recommendations by manufacturers, AWWA, industry standards, and historical operating experience. It is performed at defined, reoccurring intervals.

6.5.3 Storage Facilities

Reservoirs and elevated tanks are visited daily by operations staff as part of a daily facility check. Reservoirs and tanks are fully inspected monthly, including a condition assessment of hatches, screens, vents, ladders, cages, security devices, roof, and gutters. A more in-depth inspection is completed every five years to inspect the concrete and steel integrity, and coatings. Interior cleaning, inspection, and repair is performed by a contracted dive service. The elevated tanks were last internally cleaned and inspected in 2011. Faulty items are repaired or replaced as needed.

6.5.4 Booster Pump Stations

Booster pumps are serviced based on the results of daily inspections, motor vibration sensors, and motor run time records. The pump and motor services are initiated based on hours of operation and are performed by an outside contractor. Auxiliary power systems are operated monthly for 30 minutes; generators are load tested, serviced, and checked annually.

6.5.5 Distribution System

The distribution system components maintained by the City include piping, valves, PRVs, fire hydrants, bridge crossings, and service meters. The City has an annual pipe replacement program focused on replacing substandard size pipes and old lines. The City just completed a leak detection survey for its non-ductile iron pipes, performed by Utility Services Association, Inc. The study was triggered by increasing calculated water loss. All 125 identified leaks have been repaired saving roughly 459 gpm. The City plans to implement additional leak studies as needed to manage water loss.

The City regularly flushes areas of the system where water quality suffers or where complaints have been received, such as dead-ends or low demand areas. Additional maintenance activities focus on nonresidential meters, valves, hydrants, and PRVs. AWWA standards recommend that each valve and hydrant be exercised on an annual basis, but recognizes that most systems do not have the work force to meet this goal. All hydrants are operated and maintained annually. All meters three inches and larger are inspected (and repaired as needed) semi-annually. All system valves 16 inches and larger are inspected and maintained annually. Smaller valves are inspected and exercised every two years. PRVs are operated and maintained annually.

6.5.6 Equipment, Supplies, and Chemical Inventory

The City maintains an extensive inventory of equipment and supplies necessary to support day-to-day operations. This includes items such as pipe, fittings, and repair clamps for each size and material of distribution main in order to restore service as soon as possible should a break or failure occur. Inventories of various chemicals necessary for the treatment, disinfection, testing, and flushing of water are also kept.

The inventory is stored in a warehouse located adjacent to the Operations Center, and is managed by the Material Control Administrator. The parts and material inventory is recorded in a database with all pertinent information. A separate inventory of spare parts is stored for individual water stations, such as for specific treatment facilities and meters. The system has adequate redundancy to allow a well or booster pump to be offline until it can be repaired or replaced. The City has contracts with large volume chemical suppliers for chlorine, fluoride, and caustic soda. All other products are ordered on an as-needed basis.

6.5.7 Operations and Maintenance Manuals

Operations and Maintenance (O&M) Manuals, containing O&M literature provided by the manufacturer, parts lists, dimension drawings, as-built drawings of the facility and any other relevant information, are kept and maintained by the City.

6.6 WATER QUALITY MONITORING

The City's water quality monitoring program and regulatory compliance are summarized in Appendix 3A *TM 4 – Water Quality and Regulatory Compliance*. The TM summarizes all current and upcoming water quality regulations applicable to the City's water system, and describes the monitoring program. The City is in full compliance with regulations regarding monitoring, water quality, and reporting. The City monitors for inorganic chemicals, volatile organic chemicals, synthetic organic chemicals, physical characteristics, and nitrates. The program is administered by Water Quality staff within the Operations Division.

Though the City does not have contracts with laboratories to perform water quality testing, the City uses the following certified laboratories for all testing:

- BSK (formerly AddyLabs): PO Box 719, Vancouver, WA 98666
- Eurofins: 750 Royal Oaks Drive, Suite 100, Monrovia, California 91016

Appendix 6A provides the City's Coliform Monitoring Plan; Consumer Confidence Reports are in Appendix 6D. Appendix 6E presents the DOH requirements for water quality monitoring.

6.7 EMERGENCY RESPONSE PLAN

WAC 246-290-440 (2), water utilities must develop and implement an emergency response plan as part of their Operations and Maintenance Program. At a minimum, the plan must include general procedures for routine or major emergencies within the water system, and vulnerability analysis and contingency plan for facilities that may become inoperable in a major emergency.

The City's Emergency Response Plan (ERP) is included in Appendix 6B. The ERP was developed based on AWWA's Emergency Planning for Water Utility Management and was updated in 2011. It includes a hazard summary and vulnerability assessment, mitigation actions, priority facilities, emergency procedures, a boil water notice, a communications protocol, priority customers, training, crew and equipment repairs, and recommendations. The ERP is owned and managed by the Water Operations Superintendent.

Given changes in communication technology over the last decade, it is recommended that the City update its Emergency Response Plan to incorporate new communication protocol for internal staff as well as informing the public of emergencies.

6.8 SAFETY PROCEDURES

Safety procedures and material safety data sheets are described in the City's Safety Manual. Safety Manuals for site-specific equipment are kept at the sites with the equipment. Safety Procedures are kept in the Superintendent's office. In addition, all employees are given a safety manual to keep as an available resource to address issues related to their specific job functions and responsibilities. Safety papers having to do with the transportation of hazardous chemicals are carried in each vehicle that transports chemicals. Material Safety Data Sheets (MSDS) are kept at the treatment facilities where they are applicable and the City's intranet website, which can be accessed by the operators.

The City employs a safety coordinator to oversee the training of water system personnel and ensure that water system staff is meeting the appropriate safety and certification requirements, such as required by the Occupational Safety and Health Administration (OSHA) and the Washington State Department of Labor and Industries. Training is provided in the following areas:

- Bloodborne pathogens.
- Boom truck training.
- Confined space entry.
- Defensive driving.
- Fire evacuation.
- Flagging/traffic control.
- Forklift operation.
- Emergency response awareness.
- Hearing conservation.
- Trenching/shoring.
- Hazard communication.
- New employee orientation.

The objectives of safety training are to ensure all personnel follow safety regulations and safety procedures. In response to this need, the City has developed a Safety Manual. As a condition of employment, new employees are required to thoroughly understand the safety procedures set forth in the document. The manual includes the following:

- Safety and health policy statement.
- Program responsibilities.
- Safety orientation.
- Safety committee scope of activities and self-inspections.

- Training.
- Accident investigation and reporting.
- Emergency medical procedures.
- Occupational injury and illness record keeping.
- Safety bulletin boards.
- First aid training, kits, posters.
- General safety rules.
- Reporting unsafe acts.
- Conduct on the job.
- Hearing protection.
- Eye and face protection.
- Housekeeping.
- Clothing and personal protective equipment.
- Lifting.
- Tools.
- Departmental accident prevention programs.
- Office safety.

The Operations Division has a Safety Committee, including a chair person and a representative from each of the operations groups. The department representative conducts a minimum of one safety meeting per month with operations staff to address and discuss safety concerns. All operations staff is responsible for conducting inspections of their group's work area, equipment and facilities. Safety Committee meetings are conducted monthly to address a specific safety topic and discuss issues brought to the committee by each representative.

6.9 CROSS CONNECTION CONTROL PROGRAM

The Washington Administrative Code (WAC) 246-290-490, Cross Connection Control, requires that public water systems develop and implement a cross connection control program acceptable to the DOH. The major elements required of the program include cross connection control policies and enforcement authority.

The City has adopted WAC 246-290-490 in full under the Vancouver Municipal Code (VMC) 14.04.155 (Appendix 6C). The VMC summarizes the City's commitment to an aggressive cross connection control effort and addresses inspection, testing, and repair. The responsibility for the organization and implementation of the Cross Connection Control Program is assumed by the

Operations Superintendent. As presented in Table 6.1, the City has five water division employees who are certified as Cross Connection Control Specialists (CCS) and one water division employee certified as a as Backflow Assembly Tester (BAT), who, along with four other BATs at the City, test all City owned backflow assemblies annually. Qualifications for serving as a CCS or BAT are in accordance with the DOH Water Works Certification Program Guidelines.

The Water Department currently conducts an extensive cross connection control program throughout the City's water service area. More than 14,000 devices are tracked annually through notices issued to customers.

Prior to providing water service, the Water Engineering Department reviews plans for new construction both inside and outside City corporate limits to ensure a cross connection device is provided. Testing of the assembly is required by certified testers upon installation. Test results are provided to the City and the device is then added into the City's database for annual testing notification.

Additionally, the City continues an ongoing effort to ensure prevention devices are provided on existing services, which are prioritized as follows:

1. Pose a health and safety concern,
2. Are aesthetically objectionable,
3. Do not pose a health and safety concern.

Records are researched to identify existing facilities in each category, starting with services posing health and safety concerns. Once a service requiring an inspection is identified, the owner is notified. An inspection of the premises is conducted by the Water Department with the owner or owner's representative present. If the owner is uncooperative, a written summary of findings is sent to the owner and follow-up action is taken to ensure installation of the required device.

The Water Department regularly inspects devices installed at severe and high health hazard facilities to ensure that required prevention devices are installed correctly and maintained per City standards. Devices considered a low health cross-connection hazard are not regularly inspected by City staff.

Testing and inspection of cross connection devices are performed by Certified Testers. The City maintains a list of tester's certification numbers on their website. The City requires that testers provide their current certificate from DOH, along with a copy of the certification of their test gauges each year. Inspection and test reports are not accepted unless the City has this documentation. Required inspections, tests, and protocol for notifying customers are summarized in Appendix 6C. Record keeping and monitoring is performed through a software package designed specifically for this purpose.

Education is an important element of the overall program. Water Department staff work with local groups and citizens to promote the program's overall objectives. The Vancouver Water department has traditionally been active in cross connection training programs, particularly those sponsored by the AWWA. The City has previously sponsored training courses for AWWA in cross connection control. The Water Resources Education Center offers an additional opportunity for an increase in public awareness of cross connection issues through presentations and displays. In addition, Cross Connection Control information is provided to customers in the annual Water Quality Report, through the Water Resource Education Center, and informational flyers. Direct information to the customers is also provided by the Water Quality Coordinator and the Water Quality Technician on an as-needed basis.

6.10 CUSTOMER COMPLAINT RESPONSE PROGRAM

Drinking water related complaints come in through Operations Dispatch and are entered into the City's database. Complaints are then routed to the appropriate department (Water Quality, Water Distribution, etc.) for resolution. The City maintains records of drinking water related complaints within its database. Reports on complaints are generated from this database for review.
Table 6.2 summarizes the complaints received and addressed by the City from 2008 to 2013.

Table 6.2 Customer Problem Calls

Year	Pressure Calls	Taste, Odor, & Color Calls
2008	165	95
2009	129	74
2010	145	49
2011	133	51
2012	125	53
2013	44	21

6.11 RECORD KEEPING

The City maintains records on all aspects of the water system. Because of the increasing volume and need to readily access these records, the City has been transitioning to electronic retention, whenever possible, allowing originals to be archived. Unfortunately, some files only exist as original paper copies, which have proven to further slow and complicate the transition to an efficient, electronic filing system. Additionally, older records tend to be of lower quality, incomplete, and in rare instances missing. As a result, the City goes to great lengths to ensure that new records are complete, detailed, and stored in multiple formats, increasing the survivability and reproduction quality. Table 6.3 summarizes the types of records, length of time, and format for which they are retained.

Table 6.3 Record Keeping		
Record Type	**Length of Retention**	**Retention Format**
Capital Project Files	Indefinitely	Paper and/or Electronic
Capital Project Record Drawings	Indefinitely	Paper and Electronic
Developer Record Drawings	Indefinitely	Mylar and Electronic
Developer Project Files	Indefinitely	Electronic
System Maps	Indefinitely	GIS
Valve and Hydrant Records	Indefinitely	Paper and/or Electronic Data Base
Water Production	Indefinitely	Paper and Electronic
Water Use Efficiency	Indefinitely	Electronic
Water Sales	Indefinitely	Electronic Data Base
Maintenance and Repair	Indefinitely	Electronic Data Base
Facility Equipment and Testing	Indefinitely	Paper and/or Electronic
Interlocal Agreements	Indefinitely	Paper and/or Electronic
Water Sampling/Monitoring	Indefinitely	Paper and/or Electronic
Backflow Assembly Testing	5 years	Paper
	Indefinitely	Electronic Data Base
SCADA	10 years	Electronic Data Base
Regulatory Reports/ Correspondence	Indefinitely	Paper and/or Electronic
Customer Complaints	Indefinitely	Electronic Data Base

Maintenance and operating records are an essential tool in utility management and operation. They also provide the supporting data necessary for long-term planning. The Water Utility keeps several types of records: water quality sampling for operations and mandatory water quality sampling records; chemical dosing records; water main disinfection records; hydrant flushing records; source production, and booster pump station pumping records; reservoir level records; aquifer static and drawdown level records; personnel records; meter records; inventory records, etc. The City's records are legible, permanent, accurate, and accessible. Depending on the specific record, hard copies of the records are maintained at the Water Operations Superintendent's office, the Marine Park Engineering office or at the City's Central Records office. The Water Operations Department maintains electronic copies (MS Excel files) of information on mandatory water quality sampling test results and operational records on one of the City's network servers. The Water Operations Department maintains records of backflow assembly test results, tester certifications, test notifications, backflow assembly information and cross connection information in a database.

The SCADA system (as further described in Appendix 6F) records the production flow rates of all water stations and most booster pumps; pump pressures; water levels in reservoirs and some production wells; levels in chemical storage tanks; pH levels of treated water; pump starts and fails; alarm conditions; power consumption of some equipment; and various other data.

The City of Vancouver utilizes Enterprise GIS (Geographic Information System) and Enterprise MMS (Maintenance Management System - Info IPS 8) to map, inventory and mange Water, Sewer, Surface Water and Transportation related assets. Multiple departments across the city utilize some form of GIS to access utility system maps. These departments include Engineering Services, Construction Services, Community Development Department, Operations Department, and the Fire Department. The geospatial and asset information is maintained in ESRI's ArcSDE enterprise geodatabases and are replicated out nightly and weekly to File GeoDatabases for publishing to various clients which include, ArcGIS for Desktop, ArcReader, ArcGIS for Server (used with Infor IPS 8 MapDrawer and ArcGIS Online) and Marshall GeoKNX. Attribute information is also synchronized with the city's Enterprise MMS. Engineering Services, Community Development Department and the Fire Department utilize ArcGIS for Desktop to access GIS mapping; while Construction Services utilizes ArcReader which is installed on laptop computers for field use. The Operations Department uses a combination of laptop computers, ToughPad Tablets and Toughbooks equipped with Citrix, NetMotion, Marshall GeoKNX, Infor IPS 8 & MapDrawer to access GIS maps which are integrated with the Enterprise MMS, meaning users can utilize maps to help manage field work.

Records are kept in accordance with Revised Code of Washington and Washington Administrative Code requirements.

6.12 O&M RECOMMENDATIONS

The City has developed a very thorough O&M Program. The following section provides recommendations for improvements to the City's program. Recommendations are generally based on requirements and suggestions from the AWWA Standards and Manuals, and other industry standards.

6.12.1 SCADA System Improvements

Upgrade the existing SCADA program per recommendations listed in Appendix 6F. Near-term planned projects are included in Chapter 8 – Improvements Program.

6.12.2 O&M Program Manual

It is recommended that the City create an O&M Program Manual to be used by all operations staff. The manual would be a compilation of the existing O&M related procedures, protocol, and scheduling as summarized in this Chapter. Creating an electronic manual would allow the City to perform regular updates as procedures and schedules change.

6.12.3 Flow and Pressure Monitoring

It is recommended that the City install flow meters and pressure recorders at each of the City's pump stations. Tracking flow and pressure data is very useful for managing and maintaining pumping equipment as well as evaluating system operations. For example, flow metering data at each pumping facility will provide the City with better information to understand periods of peak demands in each pressure zone over time. The following facilities currently lack functioning flow metering devices:

- WS 3 BPS
- WS 4 BPS (though flow through the treatment facility is available and should represent BPS flow)
- WS 5 BPS
- WS 9 BPS
- Ellsworth Booster Station 1

The following facilities lack pressure gauges (or ability to attach a gauge) on the pump discharge piping:

- WS 3 BPS
- WS 5 BPS

While the City tracks total well production at its well fields, flow data for individual wells would benefit the City in tracking well performance. The following facilities lack functioning flow metering devices on individual wells:

- WS 1 Wells
- WS 3 Wells
- WS 4 Wells
- WS 7 Wells
- WS 8 Wells
- WS 9 Wells
- WS 14 Wells
- WS 15 Wells
- Ellsworth Wells

While the City conducts manual static and dynamic aquifer level testing at each water station monthly and water level testing in each well annually, continuously tracked level data for individual wells would benefit the City in tracking well performance and condition. The following facilities lack continuous well level transmitters.

- WS 1 Wells 2, 3, 4, 5, 8, 9, and 10
- WS 3 Wells 1 and 2
- WS 4 Wells 1, 2B, 3B, 4B, 5B and 9
- WS 8 Wells 2
- WS 9 Wells 3, 4 and 5
- WS 14 Wells 1 and 3
- WS 15 Wells 2, 3 and 4

Additionally, it is suggested that the City track flow as well as upstream and downstream pressure at its critical PRV stations, including the following:

- Bernie Drive PRV
- Columbia Way PRV
- Andresen PRV
- Ellsworth PRV (differential pressure available)
- SE Bella Vista Road PRV
- Evergreen PRV

6.12.4 Storage Facilities

The City should continue to follow AWWA Standards for reservoir maintenance. The AWWA Standards require internal inspection of reservoirs every three years and cleaning no less frequently than every five years. Visual inspection for environmental damage and integrity of vents and screens should be done on a seasonal basis (AWWA G200.4.3.1). AWWA Manual M42 recommends monthly, if not weekly, inspection of foundations, leaks, cathodic protection, exterior corrosion, vandalism, ladders, platforms, lighting, overflow, manholes, vents, and wind damage.

6.12.5 Emergency Response Plan

As noted above, it is recommended that the City update its Emergency Response Plan to incorporate new communications protocol to internal staff and the public using the latest communication technology.

Chapter 7

DESIGN AND CONSTRUCTION STANDARDS

7.1 INTRODUCTION

The following chapter summarizes the approval process by which the City of Vancouver reviews water distribution-related projects to ensure they are compliant with local and state standards. Relevant projects include reservoirs, storage tanks, booster pump facilities, transmission mains, distribution mains, pipe linings, and tank coatings. Information regarding design, performance, and construction standards is provided, along with the corresponding review procedures and regulatory requirements.

7.2 PROJECT REVIEW PROCEDURES

Prior to approval by the City Water Engineering Program Manager, all City of Vancouver distribution projects are prepared and reviewed by licensed civil engineers. Each project is prepared and reviewed according to the “City of Vancouver Engineering Services General Requirements and Details for the Design and Construction of Water, Sanitary Sewer and Surface Water Systems” shown in Appendix 7A. All review submittals from outside parties are completed utilizing the “Water Engineering Review Checklist” for review consistency as shown in Appendix 7B. As described in more detail in Section 7.5, the design criteria in Appendix 7A are based on published regulations and standards. Additionally, Water Engineering has included system specific criteria that are based on the operations and maintenance history for specific components.

The City utilizes an integrated review process and applies consistent Civil Plan review procedures for all water engineering projects by outside parties. A plan submittal will typically encounter the following processes throughout the review progression:

- Fully Complete Review.
- Staff Report Decision.
- Civil Plan Review.
- Civil Plan Approval.
- Construction Oversight and Inspection.
- As Built Approval.
- Final Plat or Site Plan Approval.

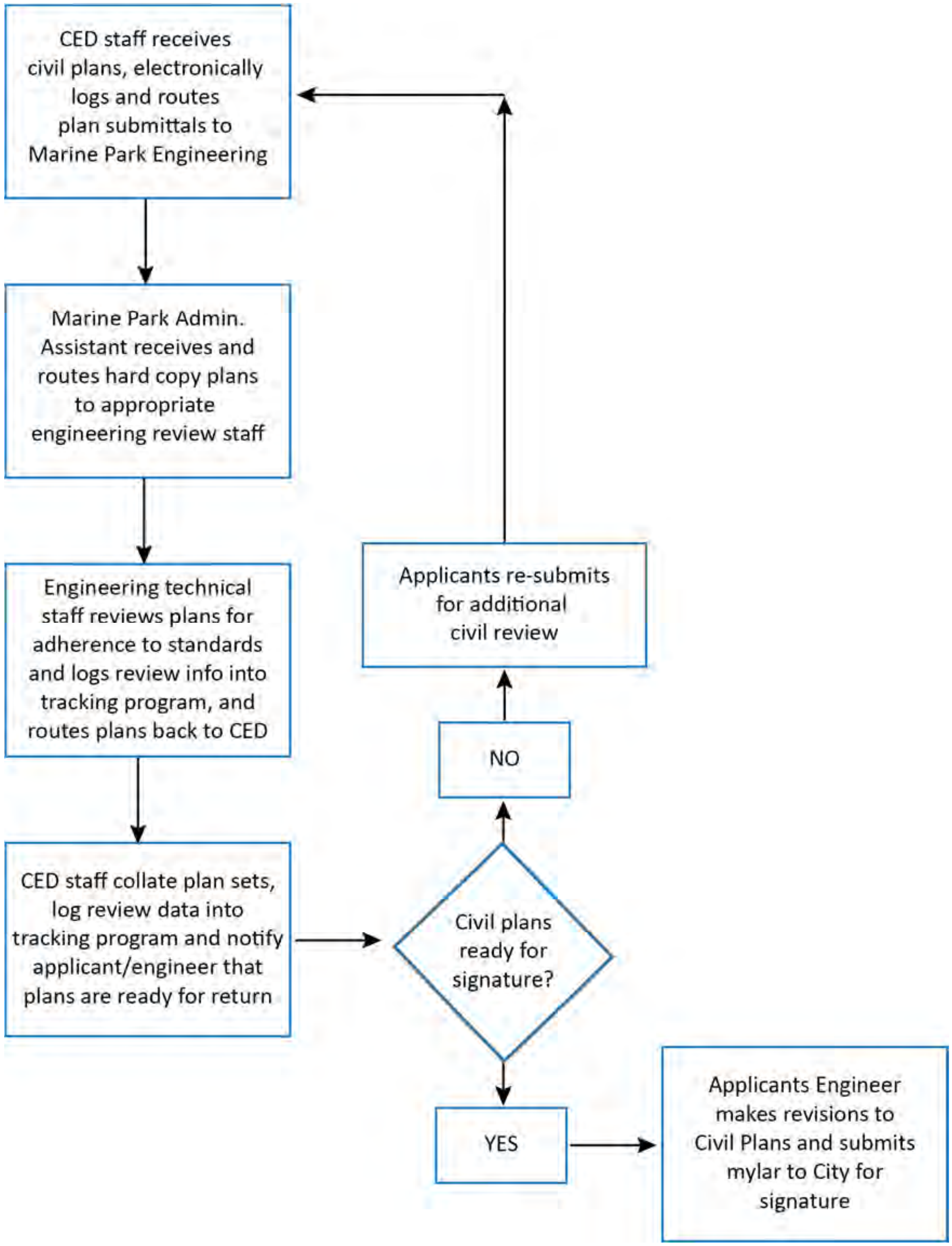
All civil engineering projects that connect to or impact the City’s water system require plan submittal to the City of Vancouver. These plans are reviewed for adherence to a consistent set of standards that ensure the water supply and distribution system is safe, reliable, durable, and maintainable.

During the civil plan review process, the developer or applicant will submit review plan sets to the Community and Economic Development (CED) Engineering Services Counter located at City Hall. Plans are submitted and routed for Water Engineering review as well as for Transportation, Surface Water, and Sanitary Sewer. The City employs an electronic tracking system that is coordinated with the physical routing of the hard copy review plans. Timely reviews are performed by Water Engineering Staff to determine if they meet the standards presented in the “City of Vancouver Engineering Services General Requirements and Details for the Design and Construction of Water, Sanitary Sewer and Surface Water Systems” as shown in Appendix 7A. For each water plan review, a Water Engineering Review Checklist is completed (Appendix 7B). When each review is completed the “redlined” plans and Review Checklist are routed back to CED and returned to the applicant. The City has a 28-calendar day review timeline in which to return the reviewed plans to the customer. This process is duplicated until a time when all disciplines are satisfied with the design and have indicated they are ready for the “signature” phase. At this time, the applicant is instructed to submit a fully revised set of plans with a “Mylar” cover sheet including one of the signature blocks in Appendix 7C for signature. The City’s in-house timeline for completing the signature phase is 14 calendar days. When all approval block signatures have been obtained, the signed plans are returned to the applicant. Approved plan copies are then submitted by the applicant and a preconstruction conference is scheduled. Following a successful preconstruction conference, permits can be obtained and construction work can begin. Once construction commences, City construction staff oversee the installation to ensure compliance with plans and design standards. Figure 7.1 summarizes the physical routing and electronic tracking of Water Engineering Civil plan submittals.

Capital improvements projects are reviewed separately according to the Water Main Design Procedure checklist provided in Appendix 7D.

7.3 POLICIES AND REQUIREMENTS FOR OUTSIDE PARTIES

The City has policies and requirements for outside parties, such as developers, as discussed above and presented in Appendix 7A and 7B, including policies for distribution system extensions, looping, requirements for easements, etc. These policies and others are also summarized in Chapter 1, Tables 1.3 through 1.9, and are further discussed below.



CIVIL PLAN REVIEW ROUTING

FIGURE 7.1

CITY OF VANCOUVER
COMPREHENSIVE WATER SYSTEM PLAN

7.4 DESIGN AND PERFORMANCE STANDARDS

The City of Vancouver's water system must be able to reliably and economically supply water, in compliance with state standards, in sufficient quantities and at adequate pressures to meet projected demands. This chapter presents the performance and design criteria on which the Vancouver water system will be analyzed in order to evaluate its ability to meet this goal. The performance and design criteria address the following components of the City's water system: source and supply, storage, transmission, distribution, and water quality. A discussion of monitoring and control system and auxiliary power capabilities is also included.

The public agency most responsible for regulating public water systems (Washington State DOH) relies on other agencies, various publications, and the utility itself to establish appropriate design criteria. The design standards of the Department's drinking water regulations, WAC 246-290-200, cite a number of resources appropriate in the determination of municipal standards. Performance and design standards from the following sources were reviewed to establish criteria for the City of Vancouver:

- Washington State Department of Health Group A Public Water System Regulations, WAC246-290.
- Safe Drinking Water Act (SDWA) and Amendments.
- Washington State Department of Health Water System Design Manual.
- Washington State Water System Coordination Act, WAC 246-293.
- PNWS-AWWA Cross-Connection Control Manual.
- International Building Code.
- AWWA Standard Specifications.
- Salmon Washougal and Lewis Watershed Management Plan, 2006.
- Clark County Coordinated Water System Plan (CWSP) Update, Regional supplement, November 2011.
- Recommended Standards for Water Works, A Committee Report of the Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers, commonly referred to as the "Ten State Standards."
- International Fire Code, 2012.

Public water systems must be able to meet all reasonable and anticipated water demands. In general, the water source, storage, and pumping facilities must be sized such that, in combination, they can supply peak system and fire flow demands when they occur, while maintaining levels of service above minimum standards. Specific criteria appropriate for the

City of Vancouver water system are presented in Table 7.1. These criteria were selected and developed for consistency with the cited standards for performance and design, and to realistically address specific needs and characteristics of the City's current water system. Additional information regarding system performance and design standards is discussed in Chapter 3, System Analysis.

7.4.1 Design Standards

The City of Vancouver provides engineering, standards, and review for the design of modifications and improvements to their water supply and distribution system. This information is presented in Section 2-1 of Appendix 7A, "City of Vancouver Engineering Services General Requirements and Details for the Design and Construction of Water, Sanitary Sewer and Surface Water Systems." Design requirements for outside parties and all COV capital projects are discussed in Appendix 7A and address the following:

- Distribution System Extensions to Support Development (Section 2-1.02).
- Connection to Existing System (Section 2-1.03).
- Water Main Locations; Easements (Section 2-1.04).
- System Reliability; Looping (Section 2-1.05).
- Water Pipe Material and Size (Section 2-1.06).
- Depth of Cover (Section 2-1.07).
- Coordination with Other Utilities; Water Main Profiles (Section 2-1.08).
- Valves (Section 2-1.09 and 2-1.10).
- Thrust Blocks and Restrained Joints (Section 2-1.11).
- Deflection at Pipe Joints (Section 2-1.12).
- Cross-connection Control (Section 2-1.13).
- Water Demand vs. Meter Size (Section 2-1.14).
- WSDOT/Railroad Crossings (2-1.15).
- Fire Hydrant Spacing (Section 2-1-16).

The City provides a Water and Sewer Review checklist, presented in Appendix 7B, that is intended to serve as guidance for the review of water main design submittals by outside parties.

Table 7.1 City of Vancouver Water System Performance and Design Criteria Summary

Source and Supply	Storage	Pumping	Transmission	Distribution System
Peak redundant source production capacity shall be sufficient to supply maximum day demands.[1] Reliable source production capacity shall be sufficient to supply average daily demands. The City will provide auxiliary power to selected wells as part of establishing reliable supply in each pressure zone. [2] In establishing the source production capacity, the City's existing supply source capacity (groundwater wells) are limited to the established annual withdrawal limits and instantaneous withdrawal limits set by the Department of Ecology. The City will consider the peak seasonal yield and annual sustainable yield for each source based on aquifer characteristics, well performance, and as applicable, maintaining Department of Ecology required groundwater levels.	Storage volumes shall exceed the combined quantity of: Operational storage calculated as 5% of the volume of each tank or reservoir. Equalizing storage calculated as 15% of the maximum day demand. Standby storage calculated as the storage required to meet ADD for two days utilizing only wells and pump stations with backup power and with the largest reliable well or booster pump to each operating area off-line. Fire flow storage according to the maximum flow and duration requirement for each pressure zone. The City permits "nesting" of its emergency storage, which requires storage volume to meet the greater of Standby Storage or Fire Storage.	Criterion 1 – Back-up Power. Sources with backup power shall be capable of supplying average day demand (ADD) for the water system. The City will provide auxiliary power to selected booster pumps as part of establishing reliable supply in each pressure zone. Criterion 2 – Largest Source Removed. For zones with storage, sources shall be capable of replenishing depleted fire suppression storage within 72 hours while concurrently supplying the maximum day demand (MDD) for the water system with the largest individual pump or well in the zone out of service. Criterion 3 – Closed Zone. For pressure zones without storage, booster pumps shall be capable of providing fire flows while concurrently supplying peak hour demand (PHD) for the zone.	Transmission facilities including pump stations, transmission mains, and PRVs shall be capable of supplying the peak demands of each pressure zone in conjunction with available sources and storage facilities. Where fire flows are supplied by pumping, systems shall be capable of providing required flows with the largest pump or treated water source out of service.	System piping shall be sized to provide for peak hourly demands at a minimum system pressure of 30 psi. Required fire flows shall be provided under peak hourly demands in zones without storage and under maximum day demands in zones with storage at a minimum system pressure of 20 psi. Mains shall be sized by a hydraulic analysis. The minimum pipe diameter shall be six inches unless otherwise justified by a hydraulic analysis. Fire hydrants shall not be installed on mains less than six inches diameter. The City will provide pressure reducing stations to control pressures in the distribution system and avoid high pressures. It is the customer's responsibility to install a pressure-reducing valve on the customer side of the water meter to reduce pressures over 80 psi.

<u>Notes</u>:

(1) "Redundant" is herein defined as total capacity with the largest source off-line.
(2) "Reliable" is herein defined as total capacity with back-up power.

7.4.2 Design Standards

The City of Vancouver provides engineering, standards, and review for the design of modifications and improvements to their water supply and distribution system. This information is presented in Section 2-1 of Appendix 7A, “City of Vancouver Engineering Services General Requirements and Details for the Design and Construction of Water, Sanitary Sewer and Surface Water Systems.” Design requirements for outside parties and all COV capital projects are discussed in Appendix 7A and address the following:

- Distribution System Extensions to Support Development (Section 2-1.02).
- Connection to Existing System (Section 2-1.03).
- Water Main Locations; Easements (Section 2-1.04).
- System Reliability; Looping (Section 2-1.05).
- Water Pipe Material and Size (Section 2-1.06).
- Depth of Cover (Section 2-1.07).
- Coordination with Other Utilities; Water Main Profiles (Section 2-1.08).
- Valves (Section 2-1.09 and 2-1.10).
- Thrust Blocks and Restrained Joints (Section 2-1.11).
- Deflection at Pipe Joints (Section 2-1.12).
- Cross-connection Control (Section 2-1.13).
- Water Demand vs. Meter Size (Section 2-1.14).
- WSDOT/Railroad Crossings (2-1.15).
- Fire Hydrant Spacing (Section 2-1-16).

The City provides a Water and Sewer Review checklist, presented in Appendix 7B, that is intended to serve as guidance for the review of water main design submittals by outside parties.

7.4.3 Performance Standards

7.4.3.1 Source and Supply

Water source production capacity is typically sized to meet maximum day demands (MDD), which allows water storage to be replenished by the end of a maximum day. Demands that exceed MDD levels, such as fire flow, diurnal, and peak hour demands, are generally met through storage. Total annual withdrawals must be limited so as not to affect the sustainability of future yields. Specific requirements for source and supply as established for the City of Vancouver water system are presented in Table 7.1.

7.4.3.2 Storage

Water reservoirs provide storage to meet fluctuations in demand, equalize water system pressures, satisfy emergency demands in the event of a system failure, and provide water for fighting fires. Storage capacity requirements are, therefore, usually based on the following four components: operational storage, equalizing storage, standby storage, and fire flow storage.

Operational storage is the volume of storage devoted to supplying the water system under normal operating conditions, while the sources of supply are in the “off” status.

Equalization storage is typically used to meet daily (diurnal) variations in demand. The volume of equalizing storage needed depends on peak system demands, the magnitude of diurnal water system demand variations, the source production rate, and the mode of system operation. Sufficient equalizing storage must be provided in combination with available water sources and pumping facilities such that peak system demands can be satisfied. The criteria shown in Table 7.1 was determined from estimated historical diurnal water use during maximum day demands.

Standby storage is provided in order to meet demands in the event of a system failure such as a power outage, an interruption of supply, or break in a major transmission line. The amount of emergency storage should be based on the reliability of supply and pumping equipment, standby power sources, and the anticipated length of time the system could be out of service.

Fire flow storage is provided to ensure the volume of water required for fighting fires is available when necessary. Fire flow storage also reduces the impact of firefighting on distribution system water pressure. The rate at which water must be supplied to fight a fire is so great that fire flows usually account for the largest short-term increase in water system demands.

The amount of water required for firefighting purposes is specified in terms of rate of flow in an associated duration. Fire flows must be provided at a residual water system pressure of at least 20 psi. Minimum fire flow standards for the City of Vancouver, in accordance with the International Fire Code are presented in Chapter 1, Table 1.7. The firefighting demand required for specific structures depends on the type of construction, floor area, height, type of occupancy, and other factors. The fire flow requirement for an area that contains more than one building is usually assumed to be equal to the firefighting demand of the building within the area that has the largest fire flow requirement. In some communities, fire flow is limited to prevent excessive storage requirements for just a few services.

Additionally, the City permits “nesting” of its emergency storage, which requires storage volume to meet the greater of Standby Storage or Fire Storage.

Specific storage requirements established for the City’s water system are presented in Table 7.1.

7.4.3.3 Pumping

The criteria for pumping facilities addresses reliability and redundancy, and considers whether pump stations serve pressure zones with or without storage. The City's pump criteria is summarized in Table 7.1. Criterion 1 addresses reliability and recommends additional back-up capacity at pump stations that are unable to meet average day demands in the water system. Average day demands are considered because in the event of a system-wide power outage, it is too conservative to assume that the City can meet MDD for all pressure zones through supplies and pump stations with back-up power.

Criterion 2 addresses pumping redundancy for zones with storage; storage thereby meeting peak hour demands and fire flow volumes. The criteria requires the total pumping capacity for a zone to have adequate capacity to meet MDD and refill storage tanks that have been depleted from fire flow with the largest individual pump or well out of service.

The last pumping criterion, Criterion 3, addresses pump station redundancy for zones without storage, which therefore require pumping capacity to meet peak hour demands and fire flows, concurrently.

7.4.3.4 Transmission

The transmission components of the City's water system include booster pump stations, transmission mains, and pressure reducing valves between pressure zones. Transmission lines can be defined as water mains used to move water from one point in the system to another with few, if any, connections to the distribution system piping in between. The criteria established for the City's water transmission facilities are presented in Table 7.1.

7.4.3.5 Distribution System

The piping system grid, which makes water available to individual water service connections and to system fire hydrants, is commonly referred to as the distribution system. Design requirements for distribution systems typically include physical characteristics such as minimum water main sizes, valve and fire hydrant locations, as well as performance characteristics such as minimum and maximum water system pressures to be maintained under various conditions of flow. Distribution system requirements established for the City of Vancouver's water system are presented in Table 7.1.

According to the CWSP, fire hydrant locations within the distribution system should be determined by the appropriate local fire authority. In general, hydrants should have an average normal spacing of 600 feet within residential areas and should be located at intersections wherever possible and located to minimize the hazard of damage by traffic. In no case are hydrants to be placed farther than 700 feet apart in residential areas and no lot will be more than 500 feet from the nearest hydrant. In commercial and industrial areas, the maximum hydrant spacing will be 300 to 400 feet. Hydrant spacing in remote rural areas should be determined by the local fire authority and designated utility with a desirable spacing of 1,000 feet. Fire hydrants will be connected to a 6-inch-minimum diameter main. A minimum

6-inch diameter lateral pipe is required for connecting hydrants located 50 feet or less from a main pipeline, and a minimum of 8-inch diameter lateral pipe is required where hydrants are located more than 50 feet from an 8-inch or larger main.

A sufficient number of valves should be provided on water mains to permit for isolation of lines. The CWSP recommends that valves be located at not more than 500-foot intervals in commercial or multifamily residential districts, and at less than 800-foot intervals in single family residential areas. The City of Vancouver generally requires two isolation valves per tee, and three isolation valves per cross and at least one isolation valve per 1,000 feet of main run.

7.4.3.6 Operational Monitoring and Control Systems

A monitoring system should be capable of providing adequate data to allow the water system personnel to operate the system efficiently and make informed planning decisions about the water system. At a minimum, records should indicate the volume of water produced, the volume of water treated, booster station pumping volumes, volume of water passed through each pressure-reducing valve, and the volume of water metered at the individual service connections. It is desirable to have a central location where the status of all the system facilities can be monitored. Control may be added to a central monitoring station to allow system components to be operated from a remote location.

7.4.3.7 Auxiliary Power

Water supply facilities are often equipped with auxiliary power to allow for continued operation during power outages.

Depending on the system's sensitivity to power supply outages at its various facilities, auxiliary power can be provided at a number of levels to include provisions for portable power generators, installation of dedicated internal combustion drive units for individual pumps, or auxiliary power generators capable of operating any portion of a water system facility.

The need for auxiliary power must be assessed based on factors such as the vulnerability of the power supply grid, its history of outages and failures, the redundancy of power supplies, as well as the system's level of dependence on each water system facility.

7.5 CONSTRUCTION STANDARDS

Section 2-2 of Appendix 7A, provides standards for construction materials and methods and addresses each of the following:

- General Construction Requirements (Section 2-2.01).
- Ductile Iron Pipe (Section 2-2.02).
- Ductile Iron Fittings (Section 2-2.03).
- Restrained Push-on Joints (Section 2-2.04).

- Restrained Mechanical Joints (Section 2-2.05).
- Valves (Section 2-2.06).
- Valve Boxes (Section 2-2.07).
- Standard Air Release Valves (Section 2-2.08).
- Standard Blowoff Assemblies (Section 2-2.09).
- Tapping Sleeves (Section 2-2.10).
- Tapping Valves (Section 2-2.11).
- Standard Fire Hydrant Assembly (Section 2-2.12).
- Trench Excavation, Bedding, and Backfill (Section 2-2.13).
- Compaction of Backfill (Section 2-2.14)
- Cutting and Plugging Existing Pipe (Section 2-2.15).
- Water Services (Section 2-2.16).
- Relocating of Existing Water Services (Section 2-2.17).
- Abandoning Water Service (Section 2-2.18).
- Hydrostatic Testing (Section 2-2.19).
- Disinfecting Water Mains (Section 2-2.20).
- Connection to Existing System (Section 2-2.21).

All City of Vancouver Standard Plan Detail Sheets are shown in Appendix 7A.

7.6 CONSTRUCTION CERTIFICATION AND FOLLOW-UP PROCEDURES

7.6.1 Construction Inspection, Testing, and Follow-Up Procedures

The procedure followed by the City of Vancouver during the construction process is described below:

- Pre-Construction Meeting and Initiation of Construction: Following approval of a construction project, a pre-construction meeting will be held that will involve the Contractor and the City's Inspection Team, which includes the Sr. Civil Engineer for Construction Services, as well as the inspector assigned to the project by the City. Other parties that may attend are the developer, design engineer, and representatives from other City departments. During the pre-construction meeting, the attending parties will discuss required permits, required changes to the plans, and standards and details with which the contractor must comply. At the close of the meeting, the Contractor can obtain a Right-Of-Way Permit from the Community and Economic Development Engineering Services

Counter. If six months elapse after the permit has been issued and construction has not been initiated, the Contractor will need to reapply for a new permit. In addition, if the project is located on a road, the Contractor must submit plans to Transportation Services and obtain a Traffic Control Plan. The Contractor is permitted to begin construction after these two items have been issued by the City.

- Inspection: The City employs seven inspectors who each are responsible for inspecting 10 – 15 projects at any given time. The Inspector is present at the site of a project up to once per day to ensure that construction materials and procedures conform to City standards and construction plans.
- Testing Procedures: In Section 2-1.03 of Appendix 7A, the City states that connection to an existing main is allowed only after disinfection, pressure testing, bacteriological testing, and approval of the new main by City staff. Requirements concerning the installation of a new hookup and water meter are described in Section 2-2.16, which states that water meters are to be installed by the City when the following have been satisfied a) acceptance of the newly installed mains and services after disinfection, flushing, and testing of mains, and b) payment of required hookup fees and main charges. During construction, the City Inspector is present at the time the Contractor conducts a pressure test of the line and during disinfection of the line. Following disinfection, the line will be flushed and the Contractor must submit a "Flushing Report" to indicate the quantity of water used to flush the line. Also, the Inspector will take a "Bac-T sample" which will be sent to a certified laboratory for bacteriological testing. After all testing is satisfied and approved, the City Inspector will authorize the Developer to purchase, and request the installation of water meters.
- "Final Acceptance": After "Completion of Construction" is issued, the Developer/Contractor must submit as-built drawings, easements, and costs and quantities for review by the Inspector and City. When approved, the City will complete a "Bill of Sale" which gives ownership of the newly constructed water main to the City.

7.6.2 Procedures for the Preparation and Retention of Design and Construction Record Drawings

The City reviews all design and construction drawings for technical content and clarity. All approved plan submittals include the City's Standard details and approval blocks. See **Appendices 7A** and **7C,** respectively for examples of these documents. At the completion of every construction project, the City requires submittal and approval of "As-built" drawings. The drawings reflect all new installation, and/or modifications to the water system. As-built drawing submittals are required in electronic format and hard copy versions of the drawings. The City maintains a tracking system for all administrative and water system improvement records, including master planning documents and water rights certificates, pipelines, services, water stations, wells, and related improvements. A list indexing all records is updated on the City's computer network.

Chapter 8

CAPITAL IMPROVEMENT PLAN

8.1 INTRODUCTION

This chapter summarizes the Capital Improvement Plan (CIP) for the City of Vancouver's (City's) Comprehensive Water Master Plan (Plan). The purpose of this CIP is to provide the City with a guideline for the planning and budgeting of improvements to its water system. The CIP combines all recommended projects described in the previous chapters. The CIP consists of the cost estimates and schedule for implementing recommended improvements.

For the purpose of this plan, the following terms will be used to represent projects associated with condition problems and capacity requirements:

- "Repair" = Repair or rehabilitation of infrastructure. These projects are recommended to renew infrastructure in poor condition. Chapter 3 summarizes the recommended repair projects related to facility condition.
- "Improvement" = Increase in capacity of infrastructure to meet capacity requirements of the water service area. These projects are recommended to meet the capacity evaluation criteria, as evaluated and recommended in Chapters 3 & 4.

Recommended projects have been assigned a project name associated with the type of project. The following abbreviations were used:

- "G" = General
- "S" = Supply
- "ST" = Storage
- "BP" = Booster Pump Station
- "P" = Pipeline

Project phasing is developed for the 6-year planning period (Short-Term): 2015 through 2020; the 10-year planning period (Mid-Term): 2021 through 2024; and the 20-year planning period (Long-Term): 2025 through 2034. The following sections present the general cost estimating assumptions, an overview of improvements, detailed project descriptions and cost estimates for each recommended project, and a summary of the final CIP.

8.2 COST ESTIMATING ASSUMPTIONS

The cost estimates presented in this CIP are opinions developed from bid tabulations, cost curves, information obtained from previous studies, City estimates, and Carollo Engineers experience on other projects. The cost estimates have been prepared for general master planning purposes and for guidance in project evaluation and implementation. Final costs of a project will depend on actual labor and material costs, competitive market conditions, final project scope, implementation schedule, and other variable factors such as preliminary alignment generation, investigation of alternative routings, and detailed utility and topography surveys.

All costs are in 2014 dollars, and are based on an Engineering News Record Construction Cost Index (ENR CCI) 20-City Average of 9886 (October 2014). Escalated costs are used the financial analysis discussed in Chapter 9. Cost estimates were developed using a Class 3 budget estimate, as established by the American Association of Cost Estimators. This level of estimate is used for budgeting and feasibility studies and assumes a 10 percent to 40 percent level of project definition. The expected accuracy range is -30 percent to +50 percent, meaning the actual cost should fall in the range of 30 percent below the estimate to 50 percent above the estimate.

Cost assumptions for pipelines are described in Section 8.2.1. In general, for all other projects, direct material and labor costs are increased according to the following mark-ups: 30 percent contingency, 10 percent general conditions, and 15 percent contractor overhead and profit. Together, these costs result in what is called “construction costs.” To develop total project costs, the construction costs are increased by an additional 50 percent for planning, engineering, legal, and administration costs. The CIP cost estimates should be periodically reevaluated to account for changes in inflation.

Acquisition of property, easements, and right-of-way (ROW) may be required for some of the recommended projects. However, for the purpose of this Plan, pipeline corridor, or easements are assumed to be in public ROW, and therefore do not require land acquisition. For this reason, land acquisition is not included in the cost estimates.

8.2.1 Pipeline Unit Costs

Pipeline improvements range in size from 6-inches to 30-inches in diameter. Pipeline unit costs are shown in Table 8.1. These costs were provided from the City based on recent pipe projects implemented by City staff. To be conservative, these unit costs assume open-trench construction in improved areas. Costs include pavement cutting, excavation, hauling, shoring, pipe materials and installation, backfill material and installation, and pavement replacement. These costs are unit construction costs; to develop total project costs, the unit construction costs are increased by 30% contingency and 15% for planning, engineering, legal, and administrative costs.

Table 8.1 Pipeline Unit Construction Costs

Pipe Size (inches)	Pipeline Unit Cost ($/Linear Foot)
6	$130
8	$133
10	$148
12	$163
14	$176
16	$208
18	$215
20	$220
24	$250
30	$300

8.3 OVERVIEW OF RECOMMENDED IMPROVEMENTS

The following sections present an overview of the major recommended projects, including the general supply strategy, improvements at Water Stations 1 and 3, the Pipe Improvement and Pipe Repair Programs. All other projects are described further in Section 8.4.

8.3.1 Supply Strategy

Given the supply analysis summarized in Chapter 4, the City has adequate supply to meet maximum day demands through the year 2034. However, additional supply is needed to meet the City's redundancy criteria (largest water station is offline) under future demands. As recommended in Chapter 4, four water stations were identified whose production is lower than the well field's water rights. Utilizing the full water rights at Water Stations 4, 6, 8, and 15, would yield an additional 10,050 gpm (14.47 mgd) of redundant supply capacity. Project S-3 is a study to evaluate improvements for fully utilizing water rights at these four water stations. It is planned for completion before 2020 so that the City can begin planning for the actual water station improvements. However, because these projects address supply redundancy and not direct supply needs, they are considered a lower priority and are scheduled for a later time. The water station improvements are listed in Section 8.4 as projects S-4, S-5, S-6, and S-7. The City has some understanding of the required improvements at Water Stations 4, 6, 8, and 15, which is reflected in the current cost estimate for these projects. It is assumed that these costs will be refined once the study (Project S-3) is complete.

8.3.2 Water Station 1

The City's previous master planning efforts identified several required improvements at Water Station 1, the water system's largest production source. The most recent evaluations included in Chapters 3 and 4 concur with the recommendations to improve back-up power capacity, and address aging facilities. The City is in the design phase of implementing Phase 1 improvements, which include the following improvements:

- S-1 Water Station 1 General Site Improvements & Backup Power.
- S-2 Water Station 1 Chlorination Facility Improvement.
- BP-1 Water Station 1 Tower BPS Replacement.

The following projects are scheduled for future phases of the improvements:

- ST-1 Water Station 1 Reservoir Improvements.
- ST-2 Water Station 1 0.25-MG Tank Replacement.
- S-8 Water Station 1 Replace Wells 3, 4, and 5.

Detailed descriptions including a cost estimate and timing of each project are provided in 8.4 Project Descriptions.

8.3.3 Water Station 3 Improvements

After Water Station 1, Water Station 3 is the next water station requiring major improvements. The leaking 1.25-MG reservoir and aging equipment require replacement and in some cases increased capacity. A master plan of improvements is recommended under Project ST-3, which should confirm final sizing and site planning for several improvements. The following Water Station 3 projects are included in the CIP:

- G-11 Water Station 3 Master Plan.
- ST-3 Water Station 3 1.25-MG Reservoir Replacement.
- ST-4 Water Station 3 0.25-MG Tank Replacement.
- S-15 Water Station 3 Wells 1 and 2 Replacement.
- BP-2 Water Station 3 BPS Replacement.
- BP-4 45th Street BPS Replacement.
- S-10 Water Station 3 Sodium Hypochlorite Generation System

Detailed descriptions including a cost estimate and timing of each project are provided in 8.4 Project Descriptions.

8.3.4 Pipe Improvements Program

The Pipe Improvements Program is a recommended program, which includes currently planned and recommended future pipe improvements that increase distribution capacity to accommodate future demands due to additional water system customers. Table 8.2 lists all projects included in the Pipe Improvements Program, herein called Project P-1. The program includes all pipe projects recommended to address pressure deficiencies and to balance the Heights High HGL (as part of the system analysis in Chapter 3 – see Table 3.14), and specific projects already identified by the City to accommodate growth, as listed under "City Projects" in Table 8.2. Some of the City's specifically identified projects were evaluated in Chapter 3, Table 3.13. For these projects, cost estimates were provided by the City.

Table 8.2 Pipe Improvements Program
Pressure Improvements (see Table 3.14)
Heights High Zone HGL Balance Improvements (see Table 3.14)
City Projects
Water Demand Response (for oversizing pipes concurrent with potential development projects or for unplanned projects)
Southwest of Lower River Rd., northwest of Gateway Ave. (also included as Project CP-1)
Port Water System Upgrade (also included as Project CP-2)
NE 47th Ave - 68th North County (Also listed as Projects CP-3 & CP-4)
Transmission Main – Water Station 14 to Water Station 9 Ph 2 (also included as Project CP-5)
Transmission Main – NE 99th St - 115th Ave. to Eastridge Blvd. (Water Station 14 to Water Station 9 Transmission Main - Ph 3, also included as Project T-31)
Transmission Main – 99th St - 140th Ct to Ward Rd (WS 14 to WS 9 Transmission Main – Ph 4, also included as Project T-33)
Transmission Main - Burton Rd (also included as Project T-34)
Vancouver Mall Drive Transportation Coordination
WS 5 to WS 9 Transmission Main (also included as Project T-27)
WS 5 to Ellsworth Transmission Main (also included as Project T-51)
Evergreen Transmission Main (also included as Project T-26)
99th Street Extension, 94th Ave to 104th Ave (County Road Project)

Chapter 3, Table 3.15 also includes several pipe projects to increase the available fire flow to meet higher fire flow requirements. These projects are not specifically identified in the CIP (as discussed under Section 8.6). It is recommended that the Pipe Replacement and Pipe Repair Program address these fire flow projects when adjacent development or pipe repair warrants pipe replacement.

8.3.5 Pipe Repair Program

The Pipe Repair Program is a recommended program to address all condition-related pipe repair projects. The City has an annual Leak Abatement budget and a Sewer Connection Incentive Program (SCIP) Coordination budget to address replacement of aging pipes and has identified several specific pipe replacement projects for the 2015-2016 capital budget. Coinciding with the budget cycle, projects are identified every two years for inclusion in the Pipe Repair Program and funds are used from the Leak Abatement and SCIP Coordination budgets. Table 8.3 summarizes the City's projects included in the Pipe Repair Program. Chapter 3 recommended an annual pipe replacement program due to remaining useful life; prioritization of aging and/or leaking pipes will be addressed as part of the City's asset management program and will be funded through the Pipe Repair Program, described here.

Table 8.3 Pipe Repair Program
PRV Flowmeters/SCADA System Connections
Water Main NE 49th St: NE 15th Ave to St. Johns
SR 500/I-5 Interchange (move 24-inch)
Bernie PRV Replacement
K & L St - E 29th to 32nd St Water Main
W 28th St Grant & Daniels Water Main
W Mcloughlin - Lincoln to Kauffman Water Main
NE 54th St - 40th Ave to 45th Ave Water Main
Claire St Water Main
Linde 2" Water Service
Alleys E & W of G St - 19th St to 20th St
Bunch Plastic - 4th Plain & 103rd Ave
SE Morgan Rd - S of Middle Way
141st Ave - 28th St North
<u>Annual Budget Line Items that Hold Funds for Future Projects:</u>
Leak Abatement
Sewer Connection Incentive Program (SCIP) Coordination Projects

8.4 PROJECT DESCRIPTIONS

The following sections provide detailed project descriptions, cost estimates, and timing for each recommended project. Table 8.4 summarizes all projects, total costs, and cost by planning term.

8.4.1 General Improvements

- **G-1 SCADA System Program Improvement.** The City is initiating upgrades to its control system at Water Station 1 to enable Water Station 1 to become a redundant main control system. Water Station 1 will become an emergency command center for the Water Utility to ensure resilient operation in the event of a failure of the system at the City's Operations Center. In order to facilitate this multi-master approach, additional SCADA upgrades at the Operations Center and other supply, treatment, booster pump, and pressure reducing valve stations are required. These upgrades include several phases of work that will take place over the years 2015 to 2018 and is anticipated to cost $7.2 million (M).

- **G-2 Rezone Study for Vancouver Low and Vancouver High Zones.** A rezone study was recommended to alleviate dead storage in the Vancouver Low and Vancouver High Zones by addressing high-elevation customers, as described in Chapter 3. The following elements are recommended for the study:
  - Vancouver Low: Perform a rezone study for high-elevation customers in East Reserve Road after Water Station 1 3.0-MG Reservoir has been constructed and dimensions are known.
  - Vancouver High: Perform a rezone study for high-elevation customers south of East Fourth Plain Boulevard. Given the results, re-evaluate storage needs for Vancouver High.

    This project is estimated to cost approximately $50,000 and is recommended for completion prior to 2020 to address storage requirements for these two zones.
- **G-3 Comprehensive Water System Plan Updates.** The City will be required to perform at least two additional updates to its Comprehensive Water System Plan by 2034. Each plan update is anticipated to cost approximately $450,000.
- **G-4 Operational & Maintenance (O&M) Program Electronic Manual.** Compiling all of the City's O&M documents, records, procedures, safety manuals, etc. into one electronic database (or possibly a web-based tool) is recommended for the City to improve overall management of the City's O&M Program, as discussed in Chapter 5. An electronic database of information would allow timely updates to information and immediate access for staff to relevant O&M information. A cost of $300,000 is recommended for development of this tool, which includes assembling all existing documents, scanning hardcopies as needed, and developing descriptions of facility operations.
- **G-5 Water Shortage Response Plan**. It is recommended that the City prepare a current Water Shortage Response Plan that outlines City procedures to meet customer demands during the event of a water shortage (as recommended in Chapter 4). Development of a plan is estimated to cost $40,000.
- **G-6 Ongoing SCADA Upgrades.** The City anticipates costs associated with future upgrades to the new SCADA system.
- **G-7 Central Operations Center Remodel.** The City's operations center building, which is owned by the Water Utility is aging and in need of remodeling and seismic upgrades. The City anticipates a cost of approximately $15M to complete.
- **G-8 Pump House Roofing**. City staff have periodically replaced aging composition roofs with more durable metal roofing on several water facility buildings. However, some projects are too large and require a contractor to perform the work. The City estimates a cost of $200,000 over the years 2015 and 2016 to replace the roofs at the following facilities:
  - St. Johns BPS.
  - 1 to 5 BPS.

  - Ellsworth BPS 1.
  - Water Station 8 well houses.
  - Water Station 7, Well 2 well house.
  - Water Station 9 BPS.
  - Water Station 14 BPS.
  - Water Station 15 Hypochlorite Facility.

- **G-9 SCIP Sewer Projects.** The City's SCIP program is currently funded by the Water Utility through 2016. These projects provides sewer service to areas that do not currently have public sewer service in order to protect water resources. The City has currently allocated $8,750,000 through 2016 for these projects.

- **G-10 Study for Heights High Hydraulic Grade Line Balance.** The Heights High Zone comprises a very large area of the City's water system. Due to its size and limited transmission capacity, balancing supply into the zone, tank cycling, and overall pressures in the zone has historically proved challenging to operations staff. The City has invested in improving the zone's transmission capacity to keep up with increasing demands. This study is recommended to identify additional transmission improvements that continue to improve operations in this zone. A project cost of $40,000 is estimated to include hydraulic modeling of the zone, and identification and cost estimates of recommended improvements.

- **G-11 Water Station 3 Master Plan.** Once Water Station 1 improvements are complete, the next water station in major need of review and improvements is Water Station 3. A master plan is recommended for confirming recommendations and site planning. The plan is estimated to cost $130,000 and is scheduled for completion prior to 2020. Projects ST-4, ST-5, BP-2, and BP-4 are anticipated to be further reviewed in this study.

8.4.2 Supply

- **S-1 Water Station 1 General Site Improvements & Backup Power.** This portion of the Water Station 1 improvements project includes all site civil, piping, and electrical improvements. The electrical component includes an entire site electrical and telemetry upgrade to support new backup power to Wells 2, 3, 7, 8, 11, 12, and 13, and the new Tower BPS, St. Johns BPS, and the 1 to 5 BPS. This project is currently in the design phase, and is expected to cost $14,160,000.

- **S-2 Water Station 1 Chlorination Facility Improvement.** The City is planning to convert existing chlorine gas systems to onsite sodium hypochlorite generation systems to improve safety and avoid the escalating costs of chlorine gas. At Water Station 1, this conversion will also require construction of a new building. Project costs are estimated at $890,000. This project is planned for completion by 2016.

- **S-3 Supply Capacity Improvements Study for Water Stations 4, 6, 8, and 15.** As discussed above, this project is a study to evaluate improvements for fully utilizing water rights at Water Stations 4, 6, 8, and 15. The study is estimated to cost $200,000. It is planned for completion before 2020 so that the City can begin planning for the actual water station improvements. However, because these projects address supply redundancy and not direct supply needs, they are considered a lower priority and are scheduled for a later time. The water station improvements are listed below as projects S-4, S-5, S-6, and S-7.

- **S-4 Water Station 4 Well Replacement.** This project includes replacement of Well 1 and is estimated to cost $1M. This well was constructed in 1950 with a perforated casing and is now showing wear. Water production could be increased and reliability improved with the replacement of the well. Currently, the water station produces 2,150 gpm lower than the instantaneous water right. However, additional capacity is only needed for supply redundancy, thus the project is not scheduled for completion until prior to 2034. Project S-3 may result in additional improvements at Water Station 4 to fully utilize the water right. The scale of additional improvements required to fully utilize water rights are currently unknown; additional costs are not included at this time.
- **S-5 Water Station 6 Well and Treatment Installation.** This project includes developing a new well and treatment facility at Water Station 6, and is estimated to cost $3M. Water Station 6 has 2,400 gpm of instantaneous water rights that are currently unused. However, additional supply is only needed for supply redundancy, thus the project is not scheduled for completion until prior to 2034. Project S-3 may result in additional improvements at Water Station 6 to perfect the water right. The scale of additional improvements required to fully utilize the water rights are currently unknown; additional costs are not included at this time.
- **S-6 Water Station 8 Replace Wells 2 and 3.** This project includes replacing Wells 2 and 3 at Water Station 8, and is estimated to cost $2M. Currently, the water station produces 1,500 gpm lower than the instantaneous water right. However, additional supply is only needed for supply redundancy, thus the project is not scheduled for completion until prior to 2034. Project S-3 may result in additional improvements at Water Station 8 to fully utilize the water right. The scale of additional improvements required to fully utilize the water rights are currently unknown; additional costs are not included at this time.
- **S-7 Water Station 15 Replace Wells 1 through 4.** This project includes replacing Wells 1 through 4 at Water Station 15, and is estimated to cost $4M. Currently, the wells produce 4,000 gpm lower than the instantaneous water right. However, additional supply is only needed for supply redundancy, thus the project is not scheduled for completion until prior to 2034. Project S-3 may result in additional improvements at Water Station 15 to fully utilize the water right. The scale of additional improvements required to fully utilize the water rights are currently unknown; additional costs are not included at this time.
- **S-8 Water Station 1 Replace Wells 3, 4, and 5.** Wells 3, 4, and 5 at Water Station 1 are planned for replacement due to age and condition of the wells and facility buildings. A cost of $3M is estimated for replacing the three wells to maintain current well pumping capacities. This project is scheduled for completion prior to 2024.

- **S-9 Water Station 4 Well 4 Building Replacement.** The building that houses Water Station 4 Well 4 has been structurally compromised by ground settling and requires replacement. This project is estimated to cost $310,000 and is recommended for completion prior to 2020.
- **S-10 Sodium Hypochlorite Generation System.** The City is planning to convert its gas chlorination facilities to onsite sodium hypochlorite generation facilities to improve safety and avoid the escalating costs of chlorine gas. The City also intends to replace three onsite sodium hypochlorite generation systems located at Water Stations 7, 8 and 15. An estimated cost of $2,150,000 includes replacement of the facilities at all water stations other than Water Station 1 (Project S-2). Water Stations 9, 14, 15, and Ellsworth are planned for conversion prior to 2020; Water Stations 3, 4, 7, and 8 are planned for conversion prior to 2024.
- **S-11 Ellsworth Well Rehabilitation.** Periodic well maintenance is required at the Ellsworth Water Station. The City estimates three periodic rehabilitation projects prior to 2034 with a total cost of $870,000.
- **S-12 Ellsworth Greensand Replacement.** The greensand filtration media at the Ellsworth Water Station treatment facility is in need of replacement. The City estimates a cost of $500,000, and expects to complete this project in 2015.
- **S-13 Well Level Probes.** Water level tracking in the City's production wells is critical for monitoring and understanding long-term trends in well performance. The City estimates a project cost of $40,000 for implementing well level probes in wells currently without water level devices. This project is scheduled for completion prior to 2020.
- **S-14 Water Station 9 Lead and Copper Pilot Study.** This project includes conducting a pilot study for lead and copper treatment alternatives to increase the pH of the water produced at Water Station 9 to meet DOH standards. The City estimates a cost of $100,000 and plans to complete this study prior to 2020. The City currently plans to replace the gas chlorination facilities with on-sit sodium hypochlorite generation (Project S-10). Based on current calculations, it is anticipated that no additional treatment for pH adjustment will be required. If additional treatment is required, funds will be utilized from Project S-17.
- **S-15 Water Station 3 Wells 1 and 2 Replacement.** Wells 1 and 2 at Water Station 3 are planned for replacement due to age and condition. The City is planning to replace these wells with one new well. Project costs are estimated at $1M, and the project is planned for completion prior to 2034.
- **S-16 Water Station 7 Greensand Replacement.** The greensand filtration media at Water Station 7 will need replacement around the year 2026. The City estimates a cost of $200,000 at that time.
- **S-17 New Treatment Regulations Compliance.** Though no new water treatment regulations are currently scheduled for release (as discussed in Appendix 3A – TM 4 Water

Quality Analysis), the City is preparing should the regulations currently under review be promulgated. A budget of $1M is set aside for potential treatment upgrades that might be required during the mid-term planning period.

- **S-18 Exploration for New Water Source.** Chapter 4 discussed the option of securing an additional water source for meeting future demands when a major water station is offline. Vancouver Lake has previously been identified as the next best water supply option for the City, but an exploration study would confirm this and would identify associated costs and impacts to operations. A project cost of $50,000 is estimated. As this project is not needed until after 2024, it is recommended for completion prior to 2034.

8.4.3 Storage

- **ST-1 Water Station 1 Reservoir Improvements.** This Water Station 1 project includes seismic upgrades to the 4.0-MG Reservoir and replacing the existing 1.0-MG Reservoir with a 3.0-MG reservoir due to seismic deficiencies. Recent cost estimates for this project assume $9.9M to complete the upgrade. The City is planning to complete these two projects by 2018.
- **ST-2 Water Station 1 0.25-MG Tank Replacement.** This Water Station 1 project includes replacing the existing 0.25-MG Tank with a new 1.0-MG Tank due to seismic deficiencies and the need for additional capacity. This project is estimated at $2.5M and is scheduled for completion prior to 2018.
- **ST-3 Water Station 3 1.25-MG Reservoir Replacement.** The Water Station 3 1.25-MG Reservoir is in need of replacement due to age, condition, and structural deficiencies for seismic resiliency. Leaks have developed that limit the volume of allowable storage in the reservoir. The full volume of the reservoir is needed to meet the storage requirements of the Vancouver High Zone. Project costs are estimated at $4,870,000. The project is scheduled for completion prior to 2024.
- **ST-4 Water Station 3 0.25-MG Tank Replacement.** The Water Station 3 0.25-MG Tank is identical to the Water Station 1 elevated tank and will likely require similar upgrades to improve seismic resiliency. This project allocates $970,000 for replacement with a new 0.25-MG Tank to be completed prior to 2034. Project ST-3 will confirm this project and associated costs.
- **ST-5 Water Station 5 Tank Altitude Valve.** An altitude valve is recommended for the Water Station 5 Tank in order to allow higher pumping rates from the Water Station 5 BPS. Without the altitude valve, the pump station has to be turned off when the tank is full to avoid overflows. As described in Chapter 3, additional pumping at Water Station 5 BPS is critical for maintaining pressure in the Heights High Zone under future demand conditions. Project costs for the altitude valve are estimated at $120,000 and the project is recommended prior to 2024.

- **ST-6 Water Station 6 Tank Internal Coating.** The City is planning on scheduled maintenance to prevent corrosion of the Water Station 6 Tank in 2017. Project costs for replacing the internal coating are estimated at $400,000.
- **ST-7 Water Stations 5, 6, and 7 Tanks Seismic Improvements.** The City has identified that the tanks at these water stations require structural improvements to meet seismic resiliency standards. The project cost for this work is estimated at $1.1M. Improvements are recommended for completion prior to 2020.
- **ST-8 Water Station 5 Reservoir Seismic Improvements.** Similar to Project ST-7, the City has identified that the Water Station 5 Reservoir requires structural improvements to meet seismic resiliency standards. A recent report states that full replacement would be more economical than repairs alone. Replacement of this 8-MG reservoir, including a planning study, is estimated to cost $20,570,000. Improvements are recommended for completion prior to 2024.
- **ST-9 Study for Additional Heights High Tanks.** Previous storage analyses for the City have resulted in additional storage requirements for the Heights High Zone. Additional storage could be met through excess storage in the Heights Low Zone (as recommended in this plan) or through additional storage tanks. The City has acquired two properties that could accommodate new storage facilities for the Heights High Zone. This project allocates $20,000 for additional review of the benefits of developing storage at these locations. The project is scheduled for completion prior to 2034 as additional storage would be redundant to existing storage for the zone.

8.4.4 Pumping

- **BP-1 Water Station 1 Tower BPS Replacement.** This Water Station 1 project includes replacing the two existing Tower BPSs with a single new BPS at the site. A BPS total capacity of 8,000 gpm was recommended in TM 3 – Water Station 1 Pumping Capacity Evaluation. The BPS replacement portion of the Water Station 1 improvements is anticipated to cost $2,930,000. This project is currently under design and construction is anticipated for completion by 2017.
- **BP-2 Water Station 3 BPS Replacement.** The Water Station 3 BPS is physically connected to the aging Water Station 3 1.25-MG Reservoir. Replacement of the reservoir requires replacement of the BPS. A project cost of $5,420,000 is estimated for replacing this 6,000-gpm pump station (costs are higher than for BP-1 as many associated costs for BP-1 are included in Project S-1). This project will need to occur at the same time as the reservoir replacement, which is scheduled for completion prior to 2024. Project ST-3 may result in updated recommendations and costs for this water station.
- **BP-3 Water Station 5 BPS Backup Power.** Water Station 5 BPS currently has no ability to operate during a power outage. Because this BPS is a critical facility for supplying the Heights High Zone with excess storage from the Heights Low Zone, back-up power is recommended at Pumps 1, 2, and 3 as a minimum (5,250 gpm). Project costs are

estimated at $440,000 and the project is recommended for completion prior to 2024 to meet the Heights High storage needs.

- **BP-4 45th Street BPS Replacement.** The 45th Street BPS was found deficient for providing fire flows in Chapter 3. To meet the demands of the Lincoln High Zone, a new pump station with a firm capacity of 300 gpm and total capacity of 1,500 gpm (for fire flow) is recommended. The new BPS could be located at the Water Station 3 site, thus evaluation of a new pump station is included in Project ST-3. Project costs are estimated to be $1,450,000, and the project is scheduled for completion prior to 2024.
- **BP-5 Study for St. Johns Additional Capacity.** Previous City studies have recommended additional capacity at the St. Johns BPS by adding a fourth pump. This project allocates $10,000 for additional hydraulic modeling work to confirm whether a fourth pump is recommended for future demands. Costs for a new pump are not included at this time. The project is scheduled for completion prior to 2034, as it is not required given the current demand projections.

8.4.5 Piping

- **P-1 Pipe Improvements Program.** The Pipe Improvements Program includes currently planned and recommended future pipe improvements that increase distribution capacity to accommodate future demands. The program includes all pipe projects listed in Table 8.2. Appendix 8A provides a detailed list with costs for these projects. The program is anticipated to cost approximately $39,030,000, and assumes annual project implementation.
- **P-2 Pipe Repair Program.** The Pipe Repair Program is recommended to provide an annual budget to address aging and leaking pipes, as listed in Table 8.3 above. Appendix 8A provides a detailed list with costs for these projects. The program is anticipated to cost approximately $21,900,000, and assumes annual project implementation.

8.5 CIP SUMMARY

Table 8.4 provides a summary of all recommended CIP projects listed above. As seen in the table, the total CIP estimate is anticipated to cost $179,710,000. Of the total, 41 percent is anticipated to be expended by 2020, which includes large capital expenditures at Water Station 1, as well as several major pipe improvements and repairs. It is anticipated that future Comprehensive Water Master Plan Updates will further revise the cost estimates and prioritization of projects for the long-term. Chapter 9 addresses how the City might fund the proposed CIP recommended herein.

Table 8.4 Capital Improvements Plan

		Cost Estimate	Short-Term 2015-2020	Mid-Term 2021-2024	Long-Term 2025-2034
GENERAL PROJECTS		**$33,610,000**	**$16,670,000**	**$450,000**	**$16,490,000**
G-1	SCADA System Program Improvement	$7,200,000	$7,200,000	$0	$0
G-2	Rezone Study for Vancouver Low and Vancouver High Zones	$50,000	$50,000	$0	$0
G-3	Comprehensive Water Master Plan Updates	$900,000	$0	$450,000	$450,000
G-4	O&M Program Electronic Manual	$300,000	$300,000	$0	$0
G-5	Water Shortage Response Plan	$40,000	$40,000	$0	$0
G-6	Ongoing SCADA Upgrades	$1,000,000	$0	$0	$1,000,000
G-7	Central Operations Center Remodel	$15,000,000	$0	$0	$15,000,000
G-8	Pump House Roofing	$200,000	$200,000	$0	$0
G-9	SCIP Sewer Project	$8,750,000	$8,750,000	$0	$0
G-10	Study for Heights High Hydraulic Grade Line Balance	$40,000	$0	$0	$40,000
G-11	WS 3 Master Plan	$130,000	$130,000	$0	$0
SUPPLY PROJECTS		**$34,470,000**	**$17,520,000**	**$5,400,000**	**$11,550,000**
S-1	WS 1 General Site Improvements	$14,160,000	$14,160,000	$0	$0
S-2	WS 1 Chlorination Facility Improvement	$890,000	$890,000	$0	$0
S-3	Supply Capacity Improvements Study for WS 4, 6, 8, and 15	$200,000	$200,000	$0	$0
S-4	WS 4 Well Replacement	$1,000,000	$0	$0	$1,000,000
S-5	WS 6 Well/Treatment Installation	$3,000,000	$0	$0	$3,000,000
S-6	WS 8 Replace Wells 2 & 3	$2,000,000	$0	$0	$2,000,000
S-7	WS 15 Replace Wells 1 through 4	$4,000,000	$0	$0	$4,000,000
S-8	WS 1 Replace Wells 2, 4, & 5	$3,000,000	$0	$3,000,000	$0
S-9	WS 4 Well 4 Building Replacement	$310,000	$310,000	$0	$0
S-10	Sodium Hypochlorite Generation System (all sites except WSI)	$2,150,000	$1,050,000	$1,100,000	$0
S-11	Ellsworth Well Rehabilitation	$870,000	$270,000	$300,000	$300,000
S-12	Ellsworth Greensand Replacement	$500,000	$500,000	$0	$0

Table 8.4 Capital Improvements Plan

		Cost Estimate	Short-Term 2015-2020	Mid-Term 2021-2024	Long-Term 2025-2034
S-13	Well Level Probes	$40,000	$40,000	$0	$0
S-14	WS 9 Lead and Copper Pilot Study	$100,000	$100,000	$0	$0
S-15	WS 3 Replacement of Wells 1 & 2 with One Well	$1,000,000	$0	$0	$1,000,000
S-16	WS 7 Greensand Replacement	$200,000	$0	$0	$200,000
S-17	New Treatment Regulations Compliance	$1,000,000	$0	$1,000,000	$0
S-18	Exploration for New Water Source	$50,000	$0	$0	$50,000
STORAGE PROJECTS		**$40,450,000**	**$13,900,000**	**$25,560,000**	**$990,000**
ST-1	WS 1 Reservoir Improvements	$9,900,000	$9,900,000	$0	$0
ST-2	WS 1 0.25-MG Tank Replacement	$2,500,000	$2,500,000	$0	$0
ST-3	WS 3 1.25-MG Reservoir Replacement	$4,870,000	$0	$4,870,000	$0
ST-4	WS 3 0.25-MG Tank Replacement	$970,000	$0	$0	$970,000
ST-5	WS 5 Tank - Altitude Valve Addition	$120,000	$0	$120,000	$0
ST-6	WS 6 Internal Coating	$400,000	$400,000	$0	$0
ST-7	WS 5, 6, &7 Tanks Seismic Improvements	$1,100,000	$1,100,000	$0	$0
ST-8	WS 5 Reservoir Replacement	$20,570,000	$0	$20,570,000	$0
ST-9	Study for Additional Heights High Tanks	$20,000	$0	$0	$20,000
PUMPING PROJECTS		**$10,250,000**	**$2,930,000**	**$7,310,000**	**$10,000**
BP-1	WS 1 Tower BPS Replacement	$2,930,000	$2,930,000	$0	$0
BP-2	WS 3 BPS - Replace with Reservoir	$5,420,000	$0	$5,420,000	$0
BP-3	WS 5 BPS - Adding Back-up Power	$440,000	$0	$440,000	$0
BP-4	45th Street BPS - Replace for Pump Redundancy and Fire	$1,450,000	$0	$1,450,000	$0
BP-5	Study for Adding 4th Pump to St. Johns BPS	$10,000	$0	$0	$10,000
PIPING PROJECTS		**$60,930,000**	**$21,990,000**	**$12,540,000**	**$26,400,000**
P-1	Pipe Improvement Program	$39,030,000	$16,240,000	$8,490,000	$14,300,000
P-2	Pipe Repair Program	$21,900,000	$5,750,000	$4,050,000	$12,100,000
TOTAL CIP		**$179,710,000**	**$73,010,000**	**$51,260,000**	**$55,440,000**

8.6 OTHER RECOMMENDATIONS

The system and condition analyses summarized in Chapter 3 resulted in a few recommendations for system operation to improve distribution, and some facility repairs that are too minor to be included in the CIP (and will likely be addressed by operations staff as part of regular maintenance). These include the following:

Operational:

- Pipe Condition/Hydraulic Assessment. A pipeline condition assessment was recommended to identify the cause of high head loss in the City's piping network that was discovered during model calibration. Due to the unknown nature of the cause, it is recommended that the City gain understanding of pipe condition during regularly scheduled pipe maintenance. Thus, this project is included as an operational recommendation. As part of regular pipe maintenance and repair, it is recommended that operations staff investigate the cause of high head losses through the distribution system, such as corroding pipes, closed valves, disconnected pipes, etc.
- Adjust pump controls for Water Stations 5 & 9 to meet Heights High Peak Hour Demands. Once the Water Station 5 altitude valve is installed (Project ST-6), it is recommended that controls for the Water Station 5 and 9 pumps be adjusted to increase supply to the Heights High Zone to meet future demands (as described in Chapter 3).
- Close the Bernie Street PRV. Chapter 3 describes how operating the Bernie Street PRV during a fire flow in the Vancouver Low Zone creates pressure deficiencies in the Vancouver High Zone. It is recommended that the Bernie Street PRV be closed once the transmission projects in the Vancouver Low Zone are complete (Projects T-3 and T-9 in particular).
- Fire Flow Improvement Program. Chapter 3, Table 3.15 lists several pipe projects identified to meet the new fire flow requirements provided by the Fire Marshall. As stated in Chapter 3, the new fire flow requirements are significantly larger than previous requirements for which the existing water system was designed. Implementing the fire flow improvements will take decades to complete. Rather than schedule a specific CIP program for fire flows, it is recommended that the City increase the pipe sizes as recommended for fire capacity when development or pipe repair requires pipe replacement. Therefore, project costs are expected to fall under the annual pipe repair program (P-2).

Minor Repairs:

- Water Station 4 Well 3: Address leak at base of the well.
- Water Tower 3 Riser Repair – Install band at riser bottom to fortify the corroded base that has compromised strength (new project identified during creation of the CIP).

- Water Station 7 – Address structural damage caused by fluoride corrosion.
- Water Station 8 – Use a wet-vacuum or sump pump to keep floor of chemical room dry.
- Water Towers – Address site improvements, access and security issues identified in Tower 3, 5, 6 and 7 seismic evaluation project (new project identified during creation of the CIP).
- Water Station 9: Replace BPS pump flow meters.
- Ellsworth Water Station: Replace BPS 1 flow meter.

8.6.1 Recommendations Already Completed

The following recommendations were identified in Chapters 3 and 4, but are not carried forward into the final CIP because the City has already completed the project or addressed the underlying issue:

- St. Johns BPS: install electrical components to utilize existing flow meter.
- Water Station 5: Install electrical components to allow BPS pump flow meters to function.
- Water Station 7: Repair structural damage caused by fluoride corrosion.
- Ellsworth Water Station: Repair roof of treatment building to prevent further water damage to equipment.

8.6.2 Future Update

Near the end of plan development, it was determined that one of the City's largest customers, NW Packing, will convert to the Port of Vancouver water system by 2016. This loss of a large customer could potentially impact the need for several identified capital projects. The City will complete a modeling evaluation to determine if all of the identified water main projects in the area of NW Packing are necessary following the loss of this large water customer.

Chapter 9

FINANCIAL PLAN

9.1 INTRODUCTION

The purpose of this chapter is to evaluate the financial impacts and potential funding alternatives while implementing the recommended Capital Improvements Program (CIP) provided in Chapter 8. This chapter reviews the City of Vancouver's (City's) water utility financial condition and the projected impact of the proposed capital improvements on the utility's finances and customer base. The City is planning to perform a full water rate analysis in 2015 and 2016 that will thoroughly evaluate the City's system development charges and water rates. This Chapter is not intended to replace the study, but provides options that the City can explore more thoroughly as part of the rate study. The analysis includes the following:

- A calculation of potential system development charges (SDCs) based on the recommended CIP and incorporation of the potential SDC revenue into the financial model.
- Development of a financial model incorporating the City's existing financial assets and liabilities, as well as the recommended CIP.
- A customer rate impact analysis forecasting the impact that the anticipated SDC revenue and implementation of the CIP could have on customer rates under two different scenarios. Those scenarios include (1) a no-debt scenario, relying solely on rate revenue and cash on hand to fund capital, and (2) a debt scenario, where debt issuances are available to finance the CIP.

9.1.1 SYSTEM DEVELOPMENT CHARGE

System development charges, commonly referred to as connection fees, are a method by which agencies can impose charges to offset the costs of new customers connecting to their water, wastewater, or other utility or infrastructure systems. Connection fees are governed by Revised Code of Washington (RCW) 35.92.025, which provides a legal framework for the applicability, assessment, and imposition of connection fees. There are various methods to calculate connection fees; the most appropriate method for any system is dictated by the system's specific characteristics.

Under Vancouver Municipal Code (VMC) 14.04.235, the City currently imposes a water SDC of $2,360 per meter equivalent. A 5/8-inch by 3/4-inch meter is considered one meter equivalent and as the meter size grows, the applicable system development change increases based on meter equivalency factors as determined by AWWA.

9.1.2 Statutory Requirements

A connection fee that is levied on users of a water utility is subject to the requirements of RCW 35.92.025 relating to the imposition of charges on customers of the water system of cities and towns. Agencies are authorized to charge property owners seeking to connect to the water or sewerage system of the agency as a condition to granting the right to so connect. In addition to the cost of the connection, a property owner shall bear their equitable share of the cost of such system. The equitable share may include interest charges applied from the date of construction of the system until the connection, or for a period not to exceed ten years, at a rate commensurate with the rate of interest applicable to the city or town at the time of construction or major rehabilitation of the water or sewer system, or at the time of installation of the water or sewer lines to which the property owner is seeking to connect. Furthermore, as determined by Hillis Homes v. Public Utility District No. 1 of Snohomish County and Lincoln Shiloh Association v. Mukilteo Water District, governmental utilities have been found to also have the authority to include future costs of projects that are planned to be implemented within ten years.

A key tenet in adopting these connection fees is: “growth pays for growth.” This means that the costs associated with building excess capacity to serve new customers ultimately should be borne by those new users who benefit from this available capacity.

9.1.3 Connection Fee Methodologies

Two general types of connection fees are used to recover system investments from new users: the system reimbursement approach and the improvement approach. Additionally, utilities can elect to use a combined approach that combines the reimbursement and improvement fees. While all are valid, the best approach is dictated by each system’s specific characteristics.

9.1.3.1 Reimbursement Approach

Utilities often construct infrastructure capacity to meet projected future demands. The purpose of the reimbursement approach is to recover costs that have already been incurred by the City. Existing customers have paid for this system over time through user rates and fees (through direct capital financing or retired debt). The reimbursement approach provides a mechanism to reimburse existing system users for the carrying costs of constructing system capacity that is available to be fulfilled by future users. In this sense, the reimbursement approach estimates the fraction of the existing system that will benefit future users.

There are further considerations when calculating the reimbursement fee. Given that the existing system was constructed over time, the original cost of constructing the system neither accurately reflects the current value of that system nor the cost to construct the facilities today. Consequently, original costs are escalated in order to better capture the time value of money. However, Washington law requires that an asset only be escalated for ten years at a “rate commensurate with the rate of interest applicable to the city or town at the time of construction.” The City’s 2014 fixed asset records were used as the basis for this analysis, which included original costs, acquisition dates, and estimated useful lives. General Obligation Bond interest rates[1] listed were used to represent the commensurate rate that was applied for up to ten years in order to escalate the value of the asset.

[1] Bond Buyer Index

Replacement costs alone might not be the best estimate of system value, as system assets have a finite lifespan and must be replaced and/or rehabilitated in time. The City adjusts the existing cost basis by deducting straight-line depreciation. Accumulated depreciation is determined by dividing the age of each asset by the projected useful life and reducing the asset value by that percentage. By accounting for accumulated depreciation in the reimbursement fee, the City may recover a proportionate value of capital improvements that will replace depreciated assets or will be undertaken to extend the useful lives of these assets through the future cost component of the connection fee.

The reimbursement fee should not include costs of assets that were grant-funded or donated assets and should only include those costs incurred by the City ratepayers for the development of the existing system, which includes the accumulation of fund reserves as well as expenses associated with construction in progress.

Finally, in the calculation of the reimbursement fee, the existing system value is segregated into the portions for existing customers and future users. This is achieved by dividing the total value of the entire system over all projected users by build out. As the existing customers have already paid their share of costs through prior connection fees and rates, only the future users pay their fraction of costs upon connecting to the system.

The reimbursement fee divides the value of the existing system by the total number of users by build out that are expected to benefit from the system in order to calculate the connection fee. The figure below represents the calculation of the reimbursement fee.

$$Reimbursement\ Fee = \frac{Value\ of\ the\ Existing\ System}{Total\ Expected\ Users}$$

9.1.3.2 <u>Improvement Approach</u>

The improvement approach recovers the cost in present value (FY 2014) dollars of the City's planned investments that it will undertake to serve future development. Projects included in the City's CIP have two primary purposes – (1) maintain reliability of existing infrastructure; and (2) increase system capacity. For the improvement approach, the future system value is segregated between those two purposes. The costs of each project are associated in some percentage to either or both of these purposes. This is achieved by determining the approximate portion of each asset that benefits either existing customers or future users. In the improvement approach, the current value of planned capital improvements that will serve future users through the City's defined planning horizon of fiscal year (FY) 2034 is divided by the expected number of future users through FY 2034.

The future cost basis accounts for capacity related improvements that will be constructed through FY 2034. The costs of these improvements are estimated in present value terms (FY 2014 dollars). Costs are fairly and reasonably spread over all future users by dividing the capacity related CIP value by the total number of future users that are projected to receive water service by FY 2034. The figure below represents the calculation of the improvement fee.

$$Improvement\ Fee = \frac{Capacity\ Related\ CIP}{Expected\ Future\ Users}$$

9.1.3.3 System Development Charge

The SDC combines the reimbursement and improvement fees. Current system value is divided by the total expected future customers. The costs of capacity related capital projects are divided by the expected future customers. The sum of these two components, the reimbursement component and the improvement component, represents the total SDC. The figure below represents the calculation of the SDC.

$$System\ Development\ Charge = \frac{Value\ of\ the\ Existing\ System}{Total\ Expected\ Users} + \frac{Capacity\ Related\ CIP}{Expected\ Future\ Users}$$

9.1.3.4 Recommended Approach

Based on the characteristics of the City's water system and discussion with City Staff, Carollo recommends that the SDC incorporate a reimbursement and improvement component. Vancouver's potable water system holds available capacity that has been funded by existing users, which drives the need for a reimbursement component. Additionally, the CIP is designed to expand system capacity, calling for an improvement component. The SDC establishes a nexus between the value of the existing and future system, and between the benefits of capital investments to existing customers and future users.

In order to calculate the SDC for the City, based on the equation presented above, three separate steps must be taken as follows:

1. The value of the existing system must be determined. This includes determining the value of the existing assets.
2. The value of the future system, or synonymously the capacity related CIP, and the portion allocated to future users must be determined.
3. The customer base must be determined. This includes the number of expected future users by build out and the number of total users by build out.

The following sections of the report outline the process to determine each of these steps.

9.1.4 Value of the Existing System

This section presents the value of the combined existing system and accounts for fixed assets, reserves, and a property tax credit.

9.1.4.1 Net Capital Asset Equity

Net capital asset equity represents the current value of the physical water systems funded by existing ratepayers, less accumulated depreciation. This approach accounts for the fact that system assets have been in service and no longer have their full useful life. The terms related to the calculation of net capital asset equity are defined as shown below.

1. Replacement Cost New - Current value of the existing water or sewer system. Original costs are adjusted for ten years' interest using the Municipal Bond Buyer's Index interest rate from the year of purchase.
2. Capital Costs Not Funded by Existing Ratepayers - These include developer-funded assets and are excluded from the ratepayers' equity calculation.
3. Depreciation - Represents the loss in value of the system as the useful life of that asset is exhausted.

Throughout the remainder of this report, the value of the physical system will be referred to as replacement cost new less depreciation (RCNLD).

9.1.4.1.1 *Valuation of Physical Assets*

The RCNLD represents the value of each system's physical assets. The fixed asset data was provided by the City. The RCNLD for each system was calculated based on the City's Fixed Asset Schedule (physical asset records). Table 9.1 presents the RCNLD for the City's water system.

Table 9.1 Value of the Existing Water System

	Value
Original Cost	$243,008,570
Adjusted Cost(1)	358,546,947
Less: Adjusted Depreciation(2)	(157,727,376)
Subtotal: Fixed Assets	$200,819,571
Less: Outstanding Debt Principal	(2,085,100)
Less: Developer Contributed Assets(3)	(23,602,639)
Less: Grant Funded Assets	(114,245)
Subtotal: Adjustments	$(25,801,984)
Total RCNLD	**$175,017,587**

Notes:
(1) Each asset's book value is escalated for ten years by the general obligation interest rate from the year of construction as listed in the Municipal Bond Buyer's Index.
(2) The total depreciation is the sum of the adjusted (see Note 1) accumulated depreciation of each asset.
(3) Adjusted cost less depreciation of developer funded assets.

9.1.5 Value of the Future System

9.1.5.1 Capital Projects

The value of the future system is determined by evaluating the capital investments that will add capacity to serve future users. Previous chapters in this Plan have identified the need for capital investments through FY 2034, resulting in the recommended CIP. Only the projects that provide a benefit to future users are included as a cost element in the calculation of connection fees.

The CIP project types that are included in the calculation of the connection fee include the following:

- General (G)
- Supply (S)
- Storage (ST)
- Booster (BP)
- Pipeline (P)

The future capital projects that add capacity specifically benefitting future development or upgrade the system in a manner that benefits both future and existing users are evaluated on a project-by-project basis to determine the amount that should be allocated to future users. Based on this approach, projects that are undertaken strictly to expand capacity for future users are fully allocated to future customers. Projects that upgrade the system in order to meet regulatory requirements or rehabilitate assets that have reached the end of their useful lives, are allocated to both existing and future users proportionate to capacity requirements. It is important to note that this was a high-level allocation. When the City develops a final SDC calculation, the City should revisit the allocation process. The value of the existing system assets have been reduced by depreciation in order to prevent double counting of asset values. The calculations for these allocated amounts are included in Appendix 9A.

Table 9.2 summarizes the portion of the project costs, by fund, that are allocated to future users and that are planned for the City's water system through FY 2034. All other CIP costs are allocated to existing users.

Table 9.2 Water Capital Improvement Projects – Allocation to Future Users

Fund	**Costs Allocated to Growth**
General (G)	$7,101,000
Supply (S)	15,410,000
Storage (ST)	9,987,000
Booster Pump Station (BP)	450,000
Pipeline (P)	39,030,000
Total	**$71,978,000**

9.1.6 Customer Base

As stated above, connection fees are calculated by dividing the monetary value of the existing and/or future system by the number of existing and/or future customers. The number of customers, or connections, is typically expressed as equivalent residential units.

9.1.6.1 Potable Water Equivalent Residential Units

An ERU is the measure of a customer's water consumption as a ratio to the consumption of a typical single-family residence. A commercial customer's impact is calculated based on this ratio while a single-family residence is assumed to have the consumption of exactly one ERU. The City's existing and future ERUs were developed in Chapter 2. Also in Chapter 2, three different growth scenarios were provided: Low, Medium, and High Growth. These scenarios projected new connections through FY 2034. In order to calculate the SDC, the Medium Growth scenario results were utilized. The results of this scenario are presented in Table 9.3.

Table 9.3 ERU Results

	ERUs(1)
Existing	110,496
Additional by FY 2034	35,129
Total by FY 2034	**145,625**

Notes:
(1) Presented in the Medium Growth scenario in Chapter 2.

9.1.7 Calculated System Development Charge

Based on the defined value of the existing system, the value of the future system (capacity related CIP), and the number of expected future and total users, the water SDC can be calculated as follows:

$$System\ Development\ Charge = \frac{Value\ of\ the\ Existing\ System}{Total\ Expected\ Users} + \frac{Capacity\ Related\ CIP}{Expected\ Future\ Users}$$

$$= \frac{Value\ of\ Existing\ System}{Total\ Expected\ Users} = \frac{\$175{,}017{,}587}{145{,}625} = \$1{,}202$$

$$+ \frac{Capacity\ Related\ CIP}{Expected\ Future\ Users} = \frac{\$71{,}978{,}000}{35{,}129} = \$2{,}049$$

The calculated SDC fee is shown below.

$$System\ Development\ Charges = \$1{,}202 + \$2{,}049 = \$3{,}251$$

9.1.7.1 Summary

Given the recommended CIP and proposed SDC calculation methodology, a water SDC of $3,251 per ERU was calculated. Table 9.4 shows the detailed calculation of the charge.

Table 9.4 Summary

Reimbursement Component	
Original Cost	$243,008,570
Adjusted Cost	358,546,947
Less: Adjusted Depreciation	(157,727,376)
Subtotal: Fixed Assets	$200,819,571
Less: Outstanding Debt Principal	(2,085,100)
Less: Developer Contributed Assets	(23,602,639)
Less: Grant Funded Assets	(114,245)
Subtotal: Adjustments	$(25,801,984)
Total RCNLD	**$175,017,587**
Existing ERUs	110,496
Additional Future ERUs by 2034	35,129
Total ERUs by 2034	145,625
Reimbursement Fee	**$1,202**
Improvement Component	
Total CIP Costs	**$71,978,000**
Additional Future ERUs by 2034	35,129
Improvement Fee	**$2,049**
Combined	
Total System Development Charge	**$3,251**

9.2 FINANCIAL MODEL

A financial model was prepared to evaluate the current financial condition of the City and to project impacts from the recommended CIP. Through a revenue requirements analysis, the model analyzes the main driver of revenue shortfalls as a result of the CIP and presents the potential rate increases under two scenarios.

9.2.1 Assumptions and Existing Financial Information

The City provided background financial information that serves as the basis for the financial forecast presented within this report. This information included operations and maintenance (O&M) expenditures, a debt service schedule, fixed asset records, current reserve policies and ending fund balances, other revenues, customer growth projections, and other miscellaneous financial information. Table 9.5 summarizes the City's operational budget from the last six years.

Table 9.5 2008 – 2013 Water Utility Revenues and Expenses

FY	2008	2009	2010	2011	2012	2013
Rate Payer Revenue	$21,872,511	$23,611,083	$22,000,895	$22,110,229	$23,847,940	$25,041,718
System Development Charges	$1,933,949	$1,414,154	$1,137,266	$967,860	$1,373,668	$2,589,774
Grants	$0	$66,117	$78,692	$81,613	$23,475	$74,357
Miscellaneous Revenue	$2,923,579	$6,990,593	$5,638,242	$7,435,657	$7,007,496	$6,476,195
Total Revenue	**$26,730,039**	**$32,081,947**	**$28,855,095**	**$30,595,359**	**$32,252,579**	**$34,182,044**
Expenses						
Staffing	$8,083,613	$8,956,353	$8,491,671	$9,196,450	$9,163,090	$9,530,724
Supplies $ Services	5,401,481	5,101,372	4,909,890	5,269,198	5,535,403	5,728,550
Excise and City Utility Tax (20%)	4,565,289	5,885,317	5,475,430	5,513,929	5,959,149	6,218,301
Debt Service	1,248,196	1,259,296	1,249,973	1,251,637	1,195,069	1,308,134
Interfund/ Intergov. Services	3,196,945	4,466,066	4,325,516	3,002,479	3,686,728	3,847,279
Total Expenses	**$22,495,523**	**$25,668,404**	**$24,452,480**	**$24,233,693**	**$25,539,439**	**$26,632,988**

9.2.2 Expenditures

9.2.2.1 Capital Improvement Program

The 20-year CIP runs through FY 2034. During this period, the Plan's Medium Growth scenario projects 32 percent in cumulative ERU growth. In order to address the rehabilitation requirements of the system as well as the additional demands placed on the system by this growth, approximately $180M in projects are recommended. Forty percent of the CIP costs are allocated to capacity related projects and sixty percent are allocated to rehabilitation and replacement of the existing system, as described above.

9.2.2.2 Annual Expenditures

The revenue requirement analysis uses the City's FY 2014 budget as the baseline for forecasting future revenue needs. Future expenditures are assumed to increase commensurate with cost inflation and projected cost increases associated with increases in water demands due to growth.

9.2.2.2.1 *O&M Expenditures*

O&M expenditures made by the City include personnel expenses, supplies, and services. In FY 2014, the City's annual O&M expenses are budgeted at $29.3 million. The model does not account for any additional O&M expenses resulting from the completion of new facilities.

9.2.2.2.2 *Debt Service*

The City is currently paying debt service on three outstanding bonds, the last of which will be retired in FY 2020. FY 2014 debt service payment totaled $0.6 million. Table 9.6 presents the City's outstanding debt obligations at the start of FY 2015.

Table 9.6 Outstanding Debt as of FY 2015

	Outstanding Balance	Final Maturity
2004 Water – Sewer Revenue Refunding Bonds	$409,578	2020
2005 Water – Sewer Revenue Refunding Bonds	197,112	2018
2008 Water – Sewer Revenue Refunding Bonds	1,047,150	2016
Total Debt	**$1,653,840**	**2020**

9.2.3 Funding Sources

Over the next 20 years, the CIP projects $180M in water system capital improvements, as stated in FY 2014 dollars. The City expects to fund these improvements through SDC revenues and user rate revenues. Additionally, the City may issue debt through traditional municipal bonds or loans.

9.2.3.1 System Development Charges

SDC revenue offsets the use of rate revenues as SDC revenue is the first revenue source used to fund the CIP. The financial model includes the calculated SDC proposed in Section 9.2 in order to project the financial impacts of the proposed CIP. This analysis assumes that the SDC will be escalated by 3 percent annually to reflect increases in construction costs. Using each year's SDC value in conjunction with the medium growth scenario provided by the City, projected annual SDC revenues can be calculated. Table 9.7 presents the results of this calculation. Additionally, Table 9.7 delineates between the reimbursement component and improvement component of the charge. This distinction reflects the restrictions on SDC revenue usage. The improvement component of the charge is available to fund only the capacity related projects while the reimbursement component can be allocated to fund both expansion as well as rehabilitation.

Table 9.7 System Development Charge Revenue

	FY 2015	FY 2034	Growth
Reimbursement Portion of Revenue	$1,592,650	$3,853,703	42%
Improvement Portion of Revenue	2,714,925	6,571,597	42%
Total SDC Revenue	**$4,307,575**	**$10,425,300**	**42%**

It is important to note that deviation from the realization of the Plan's growth projections will impact the projected SDC revenues and, therefore, the required rate increases.

9.2.3.2 Debt Financing

The City has significant upcoming CIP expenditures, which, if solely cash funded, could require, continued rate increases, significant use of on-hand reserves, or a combination of the two. Consequently, the City may decide to issue additional debt during the 20-year forecast period to fund CIP projects. The State has a variety of debt financing options. When debt is required, the model assumes the use of municipal bond financing by the City. Additionally, the model assumes that any future debt will require a minimum coverage ratio of 1.5 times. The coverage ratio is calculated as the ratio of net annual revenues available for debt service payments to total annual debt service requirements. Legally, the City is required to maintain a coverage factor of 1.3x. The City currently targets 2.0x, which is a sound fiscal policy considering the City's low levels of existing debt. For the purposes of evaluating an alternative where the City does issue additional debt, a bond coverage factor of 1.5x is used. This factor allows for fluctuation in revenues due to changes in demand without violating legal requirements. The application of 1.5x as the coverage factor also secures a higher coverage in order to pursue a higher rating.

9.2.3.3 User Rate Revenues

User rates are the primary revenue source for the City's water utility. The City implemented rate increases in previous years in order to fund operating expenses and capital improvements. Additionally, rate revenues have increased with the City's customer growth as it occurs. Currently, the City's annual rate revenues in the FY 2014 budget are estimated to total $25.0 million. The City recently approved five percent rate increases for FY 2015 and 2016.

9.2.3.4 Other Revenues

Other revenues collected by the City include accrued interest, transfers from other utilities, and miscellaneous revenues. The FY 2014 budgeted other revenues are $6.5 million.

9.2.3.5 Reserves

The City maintains multiple categories of reserve funds. Table 9.8 presents a summary of the projected end of FY 2014 balances for the reserve funds involved in this study.

Table 9.8 Ending Fund Balances

Fund	Fund Number	FY 2014, Projected
Water Operating Fund	445	$4,818,519
Water Emergency Fund	446	3,127,686
Water System Development Fund	447	-
Water Construction Fund	448	42,203,113
Water Debt Service Reserve Fund	NA	-

The withdrawals from and deposits into the City's funds are restricted. SDC revenues are deposited into the Water System Development Fund, Fund 447, which also can be funded through transfers from Fund 445. When possible, Fund 447 is the first source of revenue used to fund expansion related CIP projects. However, as the costs of expansion related projects in the short term exceed the annual revenue generated from the improvement component of the SDC, the City will fund any differences from Fund 448.

Revenues from the reimbursement component of the SDC are held in the Water Construction Fund, Fund 448. Fund 448 also receives deposits from future bond and loan proceeds (if the City elects to debt fund future projects). Finally, Fund 448 is assumed to require a minimum fund balance of $5 million throughout the planning period.

The reimbursement component revenues provide greater flexibility than the improvement component of the SDC and may be used to fund either reimbursement projects or expansion related projects. Due to near-term projected deficiencies in Fund 447 revenues, it is expected that the City will use Fund 448 revenues to help finance expansion related projects. In the latter years of this forecast, expansion related projects will diminish, at which time SDC improvement component revenues may be used to reimburse Fund 448. By the end of the planning period, the use of improvement component funds is assumed to approximately align with expansion related project costs.

Operating fund balances are often expressed as days of O&M costs. For the purposes of developing the financial forecast, an operating fund balance range of at minimum 100 days and at maximum 120 days was assumed.

9.2.4 Revenue Requirement Analysis

9.2.4.1 Introduction

The revenue requirement analysis determines the amount of rate revenue needed in a given year to meet a utility's expected financial obligations. At least two separate tests must be met in order for rates to be sufficient:

- Cash Flow Test: A utility must generate annual utility revenues adequate to meet general cash needs.
- Bond Coverage Test: Annual rate revenues must satisfy debt coverage obligations on the City's outstanding debt.

The cash-flow test identifies projected cash requirements in each given year. Cash requirements include operation and maintenance expenses, debt service payments, policy-driven additions to working capital, miscellaneous capital outlays, replacement funding, and rate-funded capital expenditures. These expenses are compared to total annual projected revenues. Shortfalls are then used to estimate needed rate increases.

The bond coverage test measures the ability of a utility to meet legal and policy-driven revenue obligations. The existing water/sewer bond covenants require that revenue available for debt service, operating and non-operating revenues less expenses, must exceed the annual debt payment by a ratio of 1.3x. This means that the City is legally obligated to collect rate revenues sufficient to fund annual operation and maintenance expenditures and 130 percent of its annual debt service payments. An informal higher coverage target is set by City policy at 200 percent in order to provide a minimum safeguard against temporary fluctuations in expenditures and revenues. The analysis herein was performed using a minimum 1.5x debt service coverage ratio requirement. As the legal coverage requirement is adjusted for future debt issuances, the City will need to revisit the financial model and modify the capital funding strategy as appropriate.

Revenues must be sufficient to satisfy both the cash flow and bond coverage tests. If revenues are found to be deficient through one or both of the tests, then the greater deficiency (shortfall) drives the rate increase. Due to the relative scarcity of planned debt funded CIP expenditures relative to the City's annual revenues, cash flow requirements are expected to be the primary drivers of rate increases.

9.2.4.2 Capital Financing

The 20-year CIP totals approximately $180M in 2014 dollars weighted heavily in years 2015 through 2020. As mentioned previously, SDC revenue in Funds 447 and 448 are the first sources of revenue used to fund capital expenditures. Bond proceeds, when available, are the next source of revenue. Rate revenue is the last source of revenue utilized. For this reason, variability in the projected SDC revenue will have an impact on the use of rate revenue to fund capital projects. If the projected growth and corresponding SDC revenue does not occur as anticipated, the City could experience insufficient reserve balances or could fail to meet debt coverage requirements.

9.2.4.3 Results of Revenue Requirement Analysis

The initial results of the revenue requirements analysis are shown in Table 9.9. The table includes the assumption that water rates will increase by 5 percent in FY 2015 and FY 2016 and will not be adjusted in subsequent years. The initial analysis of the impact of the recommended CIP on the City's budget revealed multiple years of negative cash flow due to a spike in rate funded capital in FY 2019 and FY 2020. Much of the CIP is weighted towards short-term implementation of projects. Therefore, in lieu of debt proceeds or significant up front rate revenue increases, the City will quickly draw down existing reserves. The rapid drawdown of the City's reserves in order to fund the CIP is due to the City's low rate revenue. In order to mitigate the impact on its reserves, the City may develop a funding strategy to finance the CIP combining debt issuances and/or rate increases over the course of the 20-year planning period.

Table 9.9 Impact of CIP with Current Funding Sources

FY	'15	'16	'17	'18	'19	'20
Planned Rate Increase	5%	5%	0%	0%	0%	0%
Rate Revenue(1)	$27.9	$29.7	$30.0	$30.4	$30.7	$31.5
Other Revenue(2)	6.6	6.7	6.8	7.0	7.1	7.2
SDC Revenue	3.7	4.4	4.5	4.6	5.3	10.1
O&M(3)	(29.9)	(31.0)	(31.8)	(32.7)	(33.6)	(34.6)
Debt	(0.6)	(0.6)	(0.1)	(0.1)	(0.1)	(0.1)
Capital Expense	(12.2)	(12.5)	(12.9)	(13.3)	(13.7)	(14.1)
Cash Flow	**($4.5)**	**($3.3)**	**($3.5)**	**($4.1)**	**($4.2)**	**$0.0**
Debt Coverage Factor	17x	18x	116x	113x	145x	145x
Reserve Total(4)	$45.9	$42.8	$39.6	$35.7	$31.8	$32.1

Notes:
(1) Includes the impact of the planned rate increases as well as of customer growth on revenue.
(2) Includes Work for Other Funds, Other Charges for Services, Interfund Rents, General Fund Support of Hydrant Maint., and Service Installation Charges among others.
(3) Includes the increase in tax expenditure due to the increase in rate revenue.
(4) Includes assumed interest earnings.

9.3 FINANCIAL PLAN

The CIP will be the most significant driver of the City's financial planning for the next 20 years. The near-term capital improvement needs make user rate increases unavoidable. The City may pursue several different funding strategies as part of a full rate and SDC study in FY 2015 and FY 2016. Using the financial model, two optional financial strategies were developed which could provide sufficient funding for operations and capital improvements while minimizing the impact to City customers. The first strategy, called Option 1, proposes only rate increases while the second strategy, called Option 2, proposes debt issuances accompanied by rate increases. Detailed descriptions of the two scenarios follow below.

9.3.1 Option 1 - Exclusive Rate Increase

In order to fund the upcoming capital projects, the first scenario calculates the rate impacts of funding the CIP exclusively through cash funding from the drawdown of reserves and rate increases, particularly in the short term followed by relatively smaller rate increases in subsequent years. Table 9.10 presents the rate increases that could satisfy the reserve requirements and fund the CIP.

In this absence of bond proceeds, the short-term need for sources of funds could be met by additional cash and rate funding. Consequently, higher rate increases may be required in the short term. Minimum rate increases of 3 percent throughout the planning period help the City maintain reasonable reserve levels and keep pace with inflation. Table 9.10 presents a comprehensive projection of revenues and revenue requirements before and after the rate adjustment under Option 1.

Table 9.11 presents the capital funding from each source that will maintain minimum fund balances while satisfying the cash flow and debt coverage tests. Table 9.11 also includes the resulting fund balances.

One issue resulting from the exclusive cash funding strategy is that as capital expenditures decrease, revenues may outstrip expenditures, resulting in excess reserves. However, these reserves could be used to fund future capital projects without increasing rates.

Table 9.10 Option 1 - Exclusive Rate Increase: Cash Flow Summary

FY	**'15**	**'16**	**'17**	**'18**	**'19**	**'20**
Revenues, $M						
Pre-Increase Rate Revenue(1)	$27.9	$29.7	$30.0	$30.4	$30.7	$31.5
Other Revenue	6.6	6.7	6.8	7.0	7.1	7.2
SDC Revenue	3.7	4.4	4.5	4.6	5.3	10.1
Debt Proceeds	-	-	-	-	-	-
Rate Adjustments						
Adopted Rate Adjustments(2)	5%	5%	-	-	-	-
Forecasted Adjustments	-	-	3%	3%	3%	3%
Increase in Annual Revenue from Forecasted Rate Adjustments	-	-	0.9	1.8	2.8	3.8
Post-Increase Revenue(3)	**$38.2**	**$40.8**	**$42.2**	**$43.8**	**$46.0**	**$52.7**
Requirements, $M						
O&M Expenditures(4)	($29.9)	($31.0)	($32.0)	($33.1)	($34.2)	($35.4)
Debt Service	(0.6)	(0.6)	(0.1)	(0.1)	(0.1)	(0.1)
Capital Expenditures(5)	(12.2)	(12.5)	(12.9)	(13.3)	(13.7)	(14.1)
Post-Increase Requirements	**($42.7)**	**($44.2)**	**($45.0)**	**($46.5)**	**($47.9)**	**($49.5)**
Post-Increase Cash Flow(6)	**($4.5)**	**($3.3)**	**($2.8)**	**($2.7)**	**($2.0)**	**$3.1**

Notes:
(1) Includes the planned 5% rate increases for two years.
(2) 5% rate increases are planned by City for FY 2015 and FY 2016.
(3) Sum includes SDC revenues.
(4) Includes the increase in tax expenditure due to the rate increases.
(5) Escalated by the Annual CIP rate of 3% to capture expected increase in construction costs.
(6) Any remaining shortfalls are funded by the appropriate reserve. Totals may not foot due to rounding.

Table 9.11 Option 1 - Exclusive Rate Increase: Funding Sources						
Source, $M	**FY '15**	**FY '16**	**FY '17**	**FY '18**	**FY '19**	**FY '20**
Fund 447	-	-	-	-	-	-
Cash Funded(1)	$12.2	$12.5	$12.9	$13.3	$13.7	$14.1
Bond Proceeds	-	-	-	-	-	-
PayGo (Rate Funded)	-	-	-	-	-	-
Accumulated Funds (Ending Balances including Interest Accumulation)						
Water Operating Fund: 445	$7.7	$7.8	$8.1	$8.2	$8.4	$8.7
Water Construction Fund: 448	35.0	31.8	29.0	26.5	24.5	27.7
Water System Development Fund: 447	0.0	0.0	0.0	0.0	0.0	0.0
Water Emergency Fund: 446	3.2	3.2	3.2	3.3	3.4	3.4
Water Debt Service Reserve Fund	0.0	0.0	0.0	0.0	0.0	0.0
Total Reserves(2)	**45.9**	**42.8**	**40.3**	**37.9**	**36.3**	**39.8**

Notes:
(1) Cash funding may include the use of Fund 448 reserves as well as additional rate funds.
(2) Includes assumed interest earnings.

9.3.2 Option 2 - Debt Issuance and Rate Increase

Much of the CIP is scheduled to be funded by FY 2020. While the City's current surplus of reserves can be drawn down to fund the CIP, the timing of the CIP does necessitate significant uses of funds. As a funding source, the City can issue bonds to pay for upcoming CIP expenditures and therefore reduce its reliance on existing reserves as illustrated in Option 1. In accordance with the previously described financial assumptions, a scenario where debt is available as a funding source has been analyzed. It is likely that debt issuances are unlikely to alleviate rate increases associated with Option 1. However, if the City's adopted SDC varies significantly from that discussed previously, or if growth in water demand doesn't occur as projected, the City may benefit from the issuance of debt, as opposed to rate increases, in order to compensate for reduced revenues.

As presented in Option 1, the City could implement inflationary rate increases of 3 percent beginning in FY 2017. It is important to note that these adjustments will likely be sufficient to satisfy the City's projected expenditures and, therefore, would require no new debt issuances.

9.3.3 Impact on User Rates

In order to provide a smooth increase in the rates without the use of debt, the City can increase rates over the next five year period in order to minimize the drawdown of reserves. Based on the analysis presented within this chapter, a 4.4 percent annualized rate increase over the 20-year planning period would be necessary to fund the recommended CIP. Appendix 9B details this financial analysis.

The City could also use debt to fund its CIP, which could minimize the drawdown of reserves and potentially postpone some future rate increases. However, by implementing inflationary annual rate adjustments the City sufficiently minimizes the drawdown of reserves. As a result, this financial analysis does not consider using debt to fund the capital improvement program.

9.3.3.1 Summary of CIP Implementation Impact

From the results presented above, the City has a few options for funding the recommended CIP. Based on the previously described set of assumptions, the implementation of the 20-year CIP could result in necessary rate increases as presented in the third and fourth rows of Appendix 9B. It is recommended that City's upcoming rate analysis consider the financial impacts and suggestions identified herein.

9.3.3.2 Staffing Requirements

Over the past ten years, the City has staffed a CIP program of approximately $6M per year (but up to $10M) with seven staff, including a department manager, two project managers, and four technical support staff. The average annual CIP budget is approximately $10M per year, with a short-term average of $15M per year. Given the larger annual CIP anticipated, the City may need to consider hiring additional staff to manage the CIP projects, particularly for the next ten years as the largest annual CIP costs are anticipated by 2024.

Chapter 10

MISCELLANEOUS DOCUMENTS

10.1 INTRODUCTION

This chapter provides documentation for compliance with the State Environmental Policy Act (SEPA), addresses key agreements related to the Water System Plan that have been discussed in previous chapters, and summarizes the required documents for submittal and approval of this Plan.

10.2 STATE ENVIRONMENTAL POLICY ACT: COMPLIANCE AND DOCUMENTS

The City of Vancouver is designated “lead agency” and thus is responsible for preparing the SEPA checklist and complying with EPA requirements. The SEPA checklist, which is presented in Appendix 10A, describes all environmental impacts related to the implementation of projects associated with improving or maintaining the water system that have previously been discussed in Chapter 8, Capital Improvements Program and Chapter 9, Financial Program. The City of Vancouver reviewed the SEPA Checklist and evaluated the proposal’s impacts. The City then issued a determination of nonsignificance (DNS). The DNS was sent to the Department of Ecology, agencies with jurisdiction, and made publicly available, and is included in Appendix 10B.

10.3 OTHER SUPPORTIVE DOCUMENTS AND AGREEMENTS

Construction and design standards previously discussed in Chapter 7, Design and Construction Standards, are presented in Appendix 7A, “City of Vancouver Engineering Services General Requirements and Details for the Design and Construction of Water, Sanitary Sewer and Surface Water Systems.”

A signed agreement confirming water utility service boundaries, discussed in Chapter 1, Description of Water System, is presented in Appendix 1B. Vancouver Municipal Code section 14.04.280 outlines water system extension policies as discussed in Chapter 1.

10.4 PLAN APPROVAL

Appendix 10C includes the DOH Water System Plan Submittal Form and Plan Content Checklist for submitting to the DOH. Appendix 10D provides the notice of public hearing and meeting minutes for the City’s approval of this Plan. Appendix 10E includes the government consistency review checklists as required. Resolutions adopting the Water System Plan are included in Appendix 10F.