7 | WATER SYSTEM ANALYSIS

INTRODUCTION

This chapter presents the analysis of the City of Woodland's (City) existing water system. Individual water system components were analyzed to determine their ability to meet policies and design criteria under existing and future water demand conditions. The policies and design criteria are presented in **Chapter 5**, and the water demands are presented in **Chapter 4**. A description of the water system facilities and current operation is presented in **Chapter 2**. The last section of this chapter presents the existing and projected system capacity analyses that were performed to determine the maximum number of equivalent residential units (ERUs) that can be served by the City's water system.

PRESSURE ZONES

The ideal static pressure of water supplied to customers is between 40 and 80 pounds per square inch (psi). Pressures within a water distribution system are commonly as high as 120 psi, requiring pressure reducing valves (PRVs) on individual service lines to reduce the pressure to 80 psi or less.

Table 7-1 lists the City's two pressure zones, the highest and lowest elevation served in each zone, and the minimum and maximum distribution system pressures within each zone based on maximum static water conditions (full reservoirs with no demand) under existing conditions. While this table presents the results of the pressure evaluations based on the adequacy of the pressure zones (under static conditions), the hydraulic analysis section later in this chapter presents the results of the pressure evaluation based on the adequacy of the water mains (under dynamic conditions). The 261 Zone will be created when construction of the new Scott Hill BPS is completed in 2020. For the purposes of the analyses contained in this WSP, the 261 Zone and the Scott Hill BPS were assumed to be operational under the existing system analyses.

Table 7-1

Minimum and Maximum Distribution System Static Pressures

	Highest Elevation Served		Lowest Elevation Served	
Pressure Zone	**Elevation (feet)**	**Static Pressure (psi)**	**Elevation (feet)**	**Static Pressure (psi)**
Existing System				
179 Zone	73	46	10	73
261 Zone[1]	160	44	80	78

1 = The Scott Hill Pressure Zone and Scott Hill Booster Pump Station are under construction at the time this Water System Plan was being written.

SOURCE CAPACITY EVALUATION

This section evaluates the capability of the City's existing source to determine if it has sufficient capacity to meet the overall demands of the water service area based on existing and future water demands. The section that follows will address the evaluation of the individual facilities to determine if they have sufficient capacity to meet the existing and future demands of the water system. This section also identifies facility deficiencies that are not related to the capacity of the sources.

Analysis Criteria

Source facilities must be capable of adequately and reliably supplying high-quality water to the system. In addition, source facilities must provide a sufficient quantity of water at pressures that meet the requirements of Washington Administrative Code (WAC) 246-290-230. The evaluation of the capacity of the water source in this section is based on the criteria that it provides supply to the system at a rate that is equal to or greater than the maximum day demand (MDD) of the system.

Source Capacity Analysis Results

The capability of the City's active source to meet both existing and future demand requirements, based on its existing pumping and treatment capacity, is presented in **Table 7-2**. The demands used in the evaluation for 2030 and 2040 are future demand projections without reductions from water use efficiency efforts, as shown in **Table 4-10** of **Chapter 4**. Therefore, if additional reductions in water use are achieved through water use efficiency (WUE) efforts, the total source capacity required in the future will be less than that shown in **Table 7-2**.

Table 7-2

Water Source Capacity Evaluation

Description	Existing 2020	Projected 2030 (+10 years)	2040 (+20 years)
Required Supply (gpm)			
Maximum Day Demand	**1,189**	**1,551**	**1,943**
Available Source Capacity (gpm)			
Ranney Well - Pump 1	1,050	1,050	1,050
Ranney Well - Pump 2	1,050	1,050	1,050
Ranney Well - Pump 3	1,050	1,050	1,050
Firm Capacity	**2,100**	**2,100**	**2,100**
Surplus or Deficient Source Capacity (gpm)			
Surplus or Deficiency	**911**	**549**	**157**

The results of this analysis indicate that the City has approximately 911 gallons per minute (gpm) of surplus source capacity to meet existing (year 2020) demands and will have a source capacity surplus of approximately 549 gpm by 2030, decreasing to 157 gpm at the end of the 20-year planning period. These estimates assume that only two pumps can be run at the City's Ranney Well simultaneously and the WTP capacity is also 2,100 gpm. All three Ranney Well pumps can be run simultaneously; however, running all three pumps simultaneously leads to excess iron in the raw water from the Ranney Well.

Facility Deficiencies

Ranney Well

The City's Ranney Well was upgraded in 2014 to increase its output capacity to greater than 2,100 gpm to get closer to the City's water rights of 2,800 gpm. The Ranney Well Source project included an upgrade to the well's intake laterals; the Ranney Well now has a total of six operating laterals. Another upgrade included the installation of a third pump at the pump house, as well as the installation of an emergency backup generator. With these upgrades completed, the City's Ranney Well has no other deficiencies that need to be addressed.

WATER SUPPLY FACILITIES EVALUATION

This section evaluates the existing supply facilities to determine if they have sufficient capacity to provide water supply at a rate that meets the existing and future demands of each of the zones they supply. **Figures 2-1** and **2-2** in **Chapter 2** display the pressure zones described within this section. This section also identifies deficiencies that are not related to the capacity of the supply facilities.

Analysis Criteria

The evaluation to determine if supply facilities have adequate capacity is based on one of two criteria, as follows: 1) if the pressure zone that the facility provides supply into has water storage, then the amount of supply required is equal to the MDD of the zone; or 2) if the pressure zone that the facility provides supply into does not have water storage, then the amount of supply required is equal to the MDD plus the maximum fire flow requirement of the zone. Where fire flow is supplied by pumping, it must be assumed for the analyses that the largest pump supplying the pressure zone is out of service (i.e. firm capacity) per the DOH WSDM Section 8.1.3. Calculations were performed for each pressure zone based on these criteria, with a description of the results provided for each pressure zone in the following sections.

The evaluation to determine if a surface water treatment plant has adequate filtration redundancy is based on *Washington Administrative Code (WAC) 246-290-678 Reliability for filtered systems*.

Supply Analysis Results

179 Zone

The City's 179 Zone contains Reservoirs No. 2 and No. 3; therefore, it is subject to the MDD requirement in the 179 Zone. Because the 261 Zone is supplied directly from the 179 Zone, the maximum day demand of the 261 Zone also is included in the required supply. The 179 Zone is supplied directly by the City's Water Treatment Plant (WTP), which has a total supply capacity of approximately 2,100 gpm. As shown in **Table 7-3**, the 179 Zone is expected to have a surplus supply capacity of approximately 157 gpm at the end of the 20-year planning period.

Table 7-3

179 Zone Supply Capacity Evaluation

	Existing	Projected	
Description	**2020**	**2030 (+10 years)**	**2040 (+20 years)**
Required Supply (gpm)			
Maximum Day Demand[1]	**1,189**	**1,551**	**1,943**
Available Source Capacity (gpm)			
Water Treatment Plant Capacity	2,100	2,100	2,100
Total Source Capacity	**2,100**	**2,100**	**2,100**
Surplus or Deficient Source Capacity (gpm)			
Surplus or Deficiency	**911**	**549**	**157**

1 = Includes the MDD of the 179 Zone and the 270 Zone, which are supplied from the City's WTP.

261 Zone

Table 7-4 presents the supply capacity evaluation for the 261 Zone. Peak hour demands estimated in the *Scott Hill Booster Station Predesign Report* (Gray & Osborne Inc., 2019) for the 261 Zone were used, along with peaking factors presented in **Table 4-7** in **Chapter 4**, to determine the MDD of the 261 Zone shown in **Table 7-4**. Because the 261 Zone is a closed zone, the required supply capacity also includes the fire flow demand of the zone. The fire flow requirement is based on the City's assessment for the Scott Hill Park and Sports Complex.

The results of the existing 261 Zone supply capacity evaluation indicate that the Scott Hill BPS does not have sufficient redundancy in fire flow capacity. The BPS was designed prior to the firm capacity requirement for closed zone pump stations. As described in **Chapter 9**, additional redundancy in the fire flow pumping capability of the BPS is recommended to be installed by the end of the 20-year planning period. If future extensions in the zone are made to areas that require the City's planning-level fire flow requirement of 1,000 gpm, rather than the 750 gpm requirement for the Scott Hill Park and Sports Complex, additional pumping capacity will be needed.

Table 7-4
261 Zone Supply Capacity Evaluation

Description	Existing 2020	Projected 2030 (+10 years)	Projected 2040 (+20 years)
Required Supply (gpm)			
Maximum Day Demand[1]	108	141	176
261 Zone Fire Flow Demand[2]	750	750	750
Total Required Supply	**1,038**	**1,126**	**1,220**
Available Source Capacity (gpm)			
Scott Hill BPS - Pump 1	100	100	100
Scott Hill BPS - Pump 2	100	100	100
Scott Hill BPS - Pump 3	100	100	100
Scott Hill BPS - Pump 4	1,000	1,000	1,000
Scott Hill BPS - Pump 5 (Proposed)	-	-	1,000
SHBPS Firm Capacity	**300**	**300**	**1,300**
Surplus or Deficient Source Capacity (gpm)			
Surplus or Deficiency	**-738**	**-826**	**80**

1 = The estimated total domestic and irrigation PHD of 180 gpm from the *Scott Hill Booster Station Predesign Report* , prepared by Gray & Osborne Inc. was used, along with the peaking factors in **Chapter 4** to determine the MDD of the 261 Zone.
2 = Fire flow demand for the 261 Zone is based on the City's assessment for Scott Hill Park.

Facility Deficiencies

Water Treatment Plant

The capacity of the City's WTP is based on a 700 gpm rated capacity for each of the three existing filtration trains. Three filtration trains in operation may be required to meet projected MDD before 2030. When three filtration trains are in operation, there is no redundant filtration train. It is recommended that the City begin evaluating and planning for improvements to expand the existing WTP with a fourth filtration train matching the existing filtration trains. The capacity of each filtration train should be confirmed to determine if a maximum filtration rate of 6 gpm/square foot can be achieved, allowing each filtration train to be operated up to approximately 800 gpm. Improvements to address the future filtration redundancy deficiency are recommended in CIPs F6 and F7, which are described in **Chapter 9**.

The WTP was put into service in 1999; therefore, some major equipment has reached its expected service life and should be replaced within the 20-year planning period. The service life of filter media varies dependent on several factors including operating conditions. In general, the expected service life of filter media similar to what is installed at the WTP is 15 years. The filter media in the original two filters, which were installed when the WTP was constructed, is beyond the expected service life and the full media profile should be replaced. The third filter was installed in 2007 to increase the capacity of the WTP. The filter media in this filter is nearing the expected service life and replacement of the full media profile should be planned. As described in **Chapter 9**, filter restoration and media replacement improvements are recommended in CIPs F2-F4 to resolve the deficiency.

Additional major equipment replacement will be needed between 2030 and 2040 due to expected service life being exceeded. This equipment includes the filtration backwash air scour blowers, some of the chemical storage tanks, and the WTP's water booster pump station. The blowers are original to the WTP. Some chemical storage tanks were replaced in 2019; however, other older tanks remain. As described in **Chapter 9**, major equipment replacements are recommended in CIP F8 to resolve the deficiencies.

Scott Hill Booster Pump Station

The Scott Hill BPS lacks redundancy with only one high flow pump installed in the booster pump station, WAC 246-293-660 states that "New booster pumps stations in an area governed by the Public Water System Coordination Act, must be able to meet fire flow with the largest capacity booster pump out of service."

STORAGE FACILITIES

This section evaluates the City's existing water storage tanks to determine if they have sufficient capacity to meet the existing and future storage requirements of the system. This section also identifies facility deficiencies that are not related to the capacity of the water tanks.

Analysis Criteria

Water storage typically is made up of the following components: operational storage; equalizing storage; standby storage; fire flow storage; and dead storage. Each storage component serves a different purpose and will vary from system to system. A definition of each storage component and the criteria used to evaluate the capacity of the City's storage tanks is provided as follows.

Operational Storage – Volume of the reservoir used to supply the water system under normal conditions when the source or sources of supply are not delivering water to the system (i.e., sources are in the off mode). Operational storage is essentially the average amount of drawdown in the reservoir during normal operating conditions, which represents a volume of storage that most likely will not be available for equalizing storage, fire flow storage, or standby storage. The operational storage is based on the amount of storage between the fill, or pump starting setpoint level, and the overflow elevation of the tank.

Equalizing Storage – Volume of the reservoir used to supply the water system under peak demand conditions when the system demand exceeds the total rate of supply of the sources. The Washington State Department of Health (DOH) requires that equalizing storage be stored above an elevation that will provide a minimum pressure of 30 psi at all service connections throughout the system under PHD conditions. Because the City's supply sources primarily operate on a "call on demand" basis to fill the reservoirs, the equalizing storage requirements are determined using the standard DOH formula that considers the difference between the system PHD and the combined capacity of the supply sources:

$$\mathbf{ES = (PHD - Q_S)(150\ minutes)}\text{, but in no case less than zero}$$

Where:

ES = Equalizing Storage, in gallons

PHD = Peak Hour Demand, in gpm

Q_S = Sum of all installed and active sources, except emergency supply, in gpm.

If the capacities of the sources that supply each zone are sufficient to meet the peak hour demands of their zones, the equalizing storage requirement for that supply area is zero.

Standby Storage – Volume of the reservoir used to supply the water system under emergency conditions when supply facilities are out of service due to equipment failures, power outages, loss of supply, transmission main breaks, and any other situation that disrupts the supply source. DOH requires that standby storage be stored above an elevation that will provide a minimum pressure of 20 psi at all service connections throughout the system. The criteria for determining the standby storage requirements for the City's system is based on the DOH recommendation that standby storage equal one day of maximum day demands. This volume may be reduced for pressure zones with multiple sources of supply that each have permanent backup power that starts automatically. The calculated volume is sufficient to supply the system for a 24-hour period when the primary supply facility is out of service and the system is experiencing maximum day demands:

$$\mathbf{SB = (1\ day)[(ERU_{MDD})(N) - (1\ day)(Q_S\text{-}Q_L)]}$$

Where:

SB = Standby Storage, in gallons

ERU_{MDD} = Maximum Day Demand per ERU, in gallons per day (gpd) per ERU

N = Number of ERUs based on ERU_{MDD} value.

Q_S = Sum of all installed and continuously available sources with permanent backup power that starts automatically, except emergency supply, in gpd

Q_L = The capacity of the largest continuously available source with permanent backup power that starts automatically available to the system, in gpd.

DOH recommends that the minimum standby storage volume be no less than 200 gallons per ERU.

Fire Flow Storage – Volume of the reservoir used to supply water to the system at the maximum rate and duration required to extinguish a fire at the building with the highest fire flow requirement. The magnitude of the fire flow storage is the product of the fire flow rate and duration of the system's maximum fire flow requirement established by the local fire authority. DOH requires that fire flow storage be stored above an elevation that will provide a minimum pressure of 20 psi at all points throughout the distribution system under MDD conditions.

Dead Storage – Volume of the reservoir that cannot be used because it is stored at an elevation that does not provide system pressures that meet the minimum pressure requirements established by DOH without pumping. This unusable storage occupies the lower portion of most ground-level reservoirs. Water that is stored below an elevation that cannot provide a minimum pressure of 20 psi is considered dead storage for the analyses that follow.

Storage Analysis Results

As shown in **Table 7-5**, the system has an existing maximum storage capacity of approximately 1.6 million gallons (MG) provided by the two 179 Zone reservoirs. The 179 Zone contains several high elevation services near the 179 Zone reservoirs and the City's WTP that require individual booster pumps to meet DOH's minimum requirement of 30 psi service pressure during PHD conditions. However, these high elevation services will be moved into the 261 Zone and served by the Scott Hill Booster Pump Station when it's construction is completed in 2020. For the purposes of the existing system storage analyses, these high service elevations were included in the 261 Zone, resulting in no dead storage in the system.

Table 7-5

Storage Capacity Evaluation with No Additional Storage

Description	Existing 2020	Projected 2030 (+10 years)	Projected 2040 (+20 years)
Available/Usable Storage (MG)			
Maximum Existing Storage Capacity	1.60	1.60	1.60
Dead (Non-Usable) Storage	0.00	0.00	0.00
Total Available Storage	**1.60**	**1.60**	**1.60**
Required Storage (MG)			
Operational Storage	0.57	0.57	0.57
Equalizing Storage	0.00	0.07	0.17
Standby Storage	0.93	1.21	1.52
Fire Flow Storage	0.24	0.24	0.24
Total Required Storage	**1.74**	**2.09**	**2.49**
Surplus or Deficient Storage (MG)			
Surplus or Deficient Amount	**(0.14)**	**(0.49)**	**(0.89)**

The existing system operations currently require 0.57 MG of operational storage. This volume is based on the operational band of the WTP pumps that fill Reservoirs No. 2 and 3. The operational band is 6.7 feet in both reservoirs; however, the band can be altered using the Programmable Logic Controllers (PLC) at the Water Treatment Plant as needed.

The system will require 0.17 MG of equalizing storage by 2040 as shown in **Table 7-5**. This is due to the PHD exceeding the Water Treatment Plant supply capacity in before 2030.

With the upgrades completed at the Ranney Well source, the City believes that there is adequate supply redundancy to consider the system as having multiple sources with emergency backup power. This allows the standby storage volume to be calculated as one day of maximum day demand minus the sum of all sources with the largest source out of service; the resultant standby storage requirement would be less than the DOH recommended minimum of 200 gallons per ERU. Therefore, the required standby storage volume is equal to the minimum recommended standby storage volume of 200 gallons per ERU for all years shown in **Table 7-5**.

The required fire flow storage of 0.24 MG is based on the largest planning-level fire flow requirement of 2,000 gpm for 2 hours, which represents the industrial land use group.

As shown in **Table 7-5**, the system currently has a storage deficiency of approximately 0.14 MG; with the projected deficiency at the end of the planning period (2040) increasing to 0.89 MG. As described in **Chapter 9**, the City plans to construct a new 1.0 MG 179 Zone Reservoir in 2021 and 2022 (Capital Improvement Plan (CIP) F1) to resolve the storage deficiency for the 20-year planning period.

Table 7-6 illustrates the existing 2020 deficiency and the projected surplus storage once Reservoir No. 4 is constructed and operational. As shown in **Table 7-6**, the system will have a surplus storage of 0.11 MG at the end of the planning period.

Table 7-6

Storage Capacity Evaluation with Additional Storage

Description	Existing 2020	Projected 2030 [1] (+10 years)	2040 (+20 years)
Available/Usable Storage (MG)			
Maximum Existing Storage Capacity	1.60	1.60	1.60
Maximum Storage Capacity of Future 179 Zone Reservoir	0.00	1.00	1.00
Dead (Non-Usable) Storage	0.00	0.00	0.00
Total Available Storage	**1.60**	**2.60**	**2.60**
Required Storage (MG)			
Operational Storage	0.57	0.57	0.57
Equalizing Storage	0.00	0.07	0.17
Standby Storage	0.93	1.21	1.52
Fire Flow Storage	0.24	0.24	0.24
Total Required Storage	**1.74**	**2.09**	**2.49**
Surplus or Deficient Storage (MG)			
Surplus or Deficient Amount	**(0.14)**	**0.51**	**0.11**

1 = The future 1.0 MG Reservoir No. 4 is planned to be constructed and operational in 2022.

Facility Deficiencies

Reservoir No. 3 is generally in good condition. Leakage has been observed from Reservoir No. 2 and is currently being repaired.

DISTRIBUTION AND TRANSMISSION SYSTEM

This section evaluates the City's existing distribution and transmission system (i.e., water mains) to determine if they are sized adequately and looped to provide the necessary flow rates and pressures to meet the existing and future requirements of the system. This section also identifies deficiencies that are not related to the capacity of the water mains.

Analysis Criteria

Distribution and transmission mains must be capable of adequately and reliably conveying water throughout the system at acceptable flow rates and pressures. The criteria used to evaluate the City's distribution and transmission system are the state-mandated requirements for Group A water systems contained in WAC 246-290-230 – Distribution Systems. The pressure analysis criteria state that the distribution system "…shall be designed with the capacity to deliver the design PHD quantity of water at 30 psi (210 kPa) under PHD flow conditions measured at all existing and proposed service water meters…" It also states that if fire flow is to be provided, "… the distribution system shall also provide MDD plus the required fire flow at a pressure of at least 20 psi (140 kPa) at all points throughout the distribution system…"

Hydraulic analyses of the existing system were performed under existing PHD conditions to evaluate its current pressure capabilities and identify existing system deficiencies. The existing system also was analyzed under existing MDD conditions to evaluate the current fire flow capabilities and identify additional existing system deficiencies. Additional hydraulic analyses were then performed with the same hydraulic model under future PHD and MDD conditions and with the proposed improvements to demonstrate that the identified improvements will eliminate the deficiencies and meet the requirements far into the future. The following is a description of the hydraulic model, the operational conditions, and facility settings used in the analyses.

Hydraulic Model

Description

A computer-based hydraulic model of the existing water system was updated to the CONNECT edition of the WaterGEMS® program (developed by Bentley Systems, Inc.). All water mains in the City's water system, including dead-end mains, were included in the model and were based on GIS water system mapping and as-built records provided by the City. Junction node elevations were assigned based on 2-foot-interval contour data obtained from Cowlitz County. A hydraulic model node diagram that provides a graphical representation of the hydraulic model of the water system is contained in **Appendix M**.

Demand Data

The demand distribution from the City's previous hydraulic model was utilized for the hydraulic analyses performed for this Water System Plan (WSP). Allocating demands to a water system's hydraulic model is a time intensive task that did not fit the schedule for this WSP, due to the time constraints set by DOH as shown in **Appendix O**. However, the demands of the top ten known highest water users as shown in **Chapter 4** were allocated to the existing demand distribution. Estimated demands from the *Scott Hill Booster Station Predesign Report* associated with the new 261 Zone were allocated to the existing demand distribution in the hydraulic model. The demand data received from the City was then used to uniformly scale the existing demands in the hydraulic model to the 2018 average day demand (ADD). The 2018 ADD was then scaled to the projected 2020 MDD and PHD, and the peaking factors calculated in **Chapter 4** were used to analyze the system under PHD and MDD conditions.

The hydraulic model of the proposed system contains 10-year demand levels that are projected for the year 2030, and 20-year demand levels that are projected for the year 2040.

Facilities

The hydraulic model of the existing system contains all active existing system facilities, including the Scott Hill BPS that will be online in 2020. For the proposed system analyses in the years 2030 and 2040, the hydraulic model contains all active existing system facilities and proposed system improvements identified in **Chapter 9** for the 10- and 20-year planning periods, respectively.

The facility settings for the pressure analyses correspond to a PHD event in the water system. The Ranney Well source was being operated at its firm pumping capacity for all years during a peak period. The Scott Hill BPS was being operated at its normal pumping capacity for all years during a peak period. The reservoir levels were modeled to reflect full utilization of operational and equalizing storage. The operational conditions for the pressure analyses are summarized in **Table 7-7**.

Table 7-7
Hydraulic Analyses Operational Conditions

	PHD Pressure Analyses			**Fire Flow Analyses**		
Description	**2020**	**2030 (+10 years)**	**2040 (+20 years)**	**2020**	**2030 (+10 years)**	**2040 (+20 years)**
Demand	2020 PHD	2030 PHD	2040 PHD	2020 MDD	2030 MDD	2040 MDD
Storage Facilities HGL (feet)						
Reservoir No. 2	170.94	171.67	167.72	161.21	161.90	157.95
Reservoir No. 3	170.94	171.67	167.72	161.21	161.90	157.95
Reservoir No. 4	-	171.67	167.72	-	161.90	157.95
Supply Facilities Status						
Ranney Well - Pump 1	ON	ON	ON	ON	ON	ON
Ranney Well - Pump 2	ON	ON	ON	ON	ON	ON
Ranney Well - Pump 3	OFF	OFF	OFF	OFF	OFF	OFF
BPS Facilities Status						
Scott Hill BPS - Pump 1	ON	ON	ON	ON	ON	ON
Scott Hill BPS - Pump 2	ON	ON	ON	OFF	OFF	OFF
Scott Hill BPS - Pump 3	OFF	OFF	OFF	OFF	OFF	OFF
Scott Hill BPS - Pump 4[1]	OFF	OFF	OFF	ON	ON	ON

1 = Pump 4 in the SHBPS is a fire flow pump; therefore, it is not active during PHD scenarios.

Separate fire flow analyses were performed on the system to size distribution system improvements and calculate fire flow availability. The hydraulic model for the fire flow analyses contained settings that correspond to MDD events. The Ranney Well was operated at its firm pumping capacity as it was for the PHD analysis. The Scott Hill BPS was operated at its full pumping capacity to provide domestic service and fire flow to the 261 Zone. Reservoir levels were modeled to reflect full utilization of operation, equalizing, and fire flow storage based on the maximum planning-level fire flow requirement. **Table 7-7** summarizes the operational conditions for the fire flow analyses for the existing and future planning periods.

Calibration

Hydraulic model calibration is the process of adjusting hydraulic model data so the model closely reflects actual system pressures and flows under similar demand and operating conditions. Initial Darcy-Weisbach roughness coefficients were entered into the model based on computed estimates of the coefficients from available pipe age and material data. For example, assuming that the internal surface of water pipes becomes rougher as it gets older, older water mains were assigned higher roughness coefficients than newer water mains.

Hydrant flow tests were not able to be performed for the calibration of the hydraulic model used for this WSP's system analyses. The hydraulic model was not calibrated due to the effects of COVID-19 on the City staff's availability and public health and safety guidelines in place during the WSP effort.

Hydraulic Analysis Results

Hydraulic analyses were performed to determine the capability of the system to meet the pressure and flow requirements identified in **Chapter 5** and contained in WAC 246-290-230.

Existing System Pressure Analyses

The first set of analyses was performed to determine the pressure throughout the system under existing (i.e., 2020) PHD conditions. The results of this analysis were used to identify locations of low and high pressures. To satisfy the minimum pressure requirements, the pressure at all water service locations must be at least 30 psi during PHD conditions. In addition, the system should not have widespread areas with high pressures, generally considered to be more than 120 psi.

A summary of the resultant pressures throughout the distribution system from this analysis is shown on **Figure 7-1**. As shown in the figure, existing system pressures under PHD conditions range from 40 psi to 90 psi. Therefore, the system meets minimum pressure requirements and guidelines for maximum system pressure.

Existing System Fire Flow Analyses

The second set of analyses was performed to determine the capability of the existing water system to provide fire flow throughout the system under MDD conditions. A separate fire flow analysis was performed for each node in the model where fire flow is provided to determine the available fire flow at a minimum residual pressure of 20 psi at all points throughout the distribution system and a maximum allowable water main velocity of 10 feet per second (fps). Approximately 428 fire flow analyses were performed to comprehensively evaluate the water system. For each node analyzed, the resulting fire flow was compared to its general planning-level fire flow requirement, which was assigned according to its land use classification.

As is typical of most water systems, the City's distribution system was constructed to meet fire flow requirements that were in place at the time of construction. Land use classification changes and/or increases in fire flow requirements over time may create deficiencies. A summary of the results of the analyses for representative system nodes is shown on **Figure 7-2**. As shown in the figure, some areas of the distribution system do not currently meet planning-level fire flow requirements. Some nodes, such as those on small diameter or dead-end water main may not represent actual fire hydrant locations. These locations therefore are not required to carry fire flow and should not be considered deficient in meeting the planning-level fire flow requirement.

Future System Pressure and Fire Flow Analyses

Figure 7-**3** shows the pressure throughout the system under PHD conditions at the end of the 20-year planning period with all improvements completed. As shown on **Figure 7-3**, all service connections will be provided a pressure of at least 30 psi under PHD conditions when all improvements are completed.

Figure 7-4 shows the available fire flow throughout the water system at the end of the 20-year planning period with all improvements completed. As shown on **Figure 7-4**, with completion of all improvements, the minimum planning-level fire flow or greater will be available at all locations where fire flow is provided at the end of the 20-year planning period.

Deficiencies

There are no pressure deficiencies in the City's distribution system. Previously there were high elevation services that were served by individual booster pumps, but now that the Scott Hill BPS has been constructed, the high elevation services will be served by the 261 Zone, resulting in customer pressures under PHD conditions of 30 psi or greater throughout the water system.

While some areas of the system can currently provide planning-level fire flow while maintaining pressures above 20 psi and velocities below 10 fps, many areas of the system are not capable of providing planning-level fire flow within these parameters. Operating the system with high water velocities can potentially damage the system due to the high surge pressures that commonly occur with high water velocities, and allowing system pressures to drop below 20 psi can lead to unacceptably low service pressures and the possibility of backflow into the distribution system. Water main and other improvements identified in **Chapter 9** have been sized to maintain system pressures above 20 psi and to prevent water velocities from exceeding 10 fps.

The material used in all new water main installations shall comply with each project's detailed plans and specifications in accordance with the City's Construction Standards and Specifications, which are contained in **Appendix H**.

SYSTEM CAPACITY

This section evaluates the capacity of the City's existing and future water system components (supply, treatment, storage, transmission, and water rights) to determine the maximum number of ERUs it can serve. Once established, system capacity becomes useful in determining how much capacity is available in the water system to support new customers that apply for water service through the building permit process. The system capacity information, together with the projected growth of the system expressed in ERUs as shown in **Chart 4-4** of **Chapter 4**, also provides the City with a schedule of when additional system capacity is needed.

Analysis Criteria

The capacity of the City's system was determined from the limiting capacity of the water rights, source, treatment, transmission, and storage facilities. The annual water rights capacity evaluation was based on the existing annual water rights, as summarized in **Chapter 6**, and the system's average day consumption per ERU (ERU_{ADD}). The instantaneous water rights capacity evaluation was based on the existing instantaneous water rights, as summarized in **Chapter 6**, and the system's maximum day demand per ERU (ERU_{MDD}). The source capacity analysis was based on the total capacity of the Ranney Wells and the system's ERU_{MDD}. The treatment capacity analysis was based on the total capacity of the WTP and the system's ERU_{MDD}. The transmission capacity analysis was based on the total capacity of the transmission main from the Ranney Wells to the WTP and the system's ERU_{MDD}.

The storage capacity analysis was based on the storage capacity for equalizing and standby storage and the computed storage requirement per ERU. Operational and fire flow storage capacity were excluded from the storage analysis because these components generally are not directly determined by water demand or ERUs. For the analyses, a reserve amount equivalent to the operational and fire flow storage requirements was deducted from the total available storage capacity to determine the storage capacity available for equalizing and standby storage. This storage capacity available for equalizing and standby storage was divided by the existing number of ERUs presented in **Chapter 4** to determine the storage requirement per ERU. The Equalizing & Standby Storage Requirement per ERU shown in **Tables 7-8** and **7-9** does not equal 200 gallons. This is due to the additional demands of the Bridge Road Water System being added individually to ADD, MDD, and PHD values, instead of being added to the ADD and then scaled to MDD and PHD. As mentioned in **Chapter 4**, this was due to 50 gpm being the maximum allowable withdrawal rate by the Bridge Road Water System at any given time.

The ERU-based demand data was derived from the average day demand of the system and demand peaking factors from **Chapter 4**.

Capacity Analysis Results

A summary of the results of the existing and projected system capacity analysis with no additional storage is shown in **Table 7-8.**

Table 7-8
System Capacity Analysis with No Additional Storage

Description	Existing 2020	Projected 2030 (+10 years)	Projected 2040 (+20 years)
Demands Per ERU Basis			
ERU_{ADD} (gpd/ERU_{ADD})	173	173	173
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Peak Hour Demand per ERU (gpd)[1]	613	613	613
Source Capacity - Annual Water Rights			
Water Rights Capacity - Annual Average Based (gpd)	1,951,533	1,951,533	1,951,533
ERU_{ADD} (gpd/ERU_{ADD})	173	173	173
Water Rights Annual Average Based Source Capacity (ERUs)	**11,262**	**11,262**	**11,262**
Source Capacity - Instantaneous Water Rights			
Water Rights Capacity - Instantaneous Based (gpd)	4,032,000	4,032,000	4,032,000
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Day Based Source Capacity (ERUs)	**10,963**	**10,963**	**10,963**
Source Capacity - Maximum Day Based			
Source Capacity - Maximum Day Based (gpd)	3,024,000	3,024,000	3,024,000
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Day Based Source Treatment Capacity (ERUs)	**8,222**	**8,222**	**8,222**
Treatment Capacity - Maximum Day Based			
Source Treatment Capacity - Maximum Day Based (gpd)	3,024,000	3,024,000	3,024,000
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Day Based Source Treatment Capacity (ERUs)	**8,222**	**8,222**	**8,222**
Storage Capacity			
Maximum Equalizing & Standby Storage Capacity (gal)	795,297	795,297	795,297
Equalizing & Standby Storage Requirement per ERU (gal)	200	204	216
Maximum Storage Capacity (ERUs)	**3,976**	**3,902**	**3,689**
Transmission Capacity (10 fps)			
Transmission Capacity (gpd)	7,332,200	7,332,200	7,332,200
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Transmission Capacity (ERUs)	**19,936**	**19,936**	**19,936**
Maximum System Capacity			
Maximum System Capacity (ERUs)	**3,976**	**3,902**	**3,689**
Limiting Facility	**Storage**	**Storage**	**Storage**
Unused Available System Capacity			
Maximum System Capacity (ERUs)	3,976	3,902	3,689
Projected ERUs	4,657	6,293	7,826
Unused Available System Capacity (ERUs)	**(680)**	**(2,391)**	**(4,137)**

(1) Includes distribution system leakage.

The results of the existing system capacity analysis indicate that the limiting capacity of the system is storage, which currently can support up to a maximum of approximately 3,976 ERUs. The existing water system has a deficiency of approximately 680 ERUs. All other water system components have sufficient capacity to support existing water system customers.

The 10-year projected system capacity analysis, as shown in **Table 7-9** and **Chart 7-1**, includes the construction of additional storage by 2022 (CIP F1 in **Chapter 9**) to address the projected storage deficiency of 0.89 MG by 2040. The results of the 2030 system capacity analysis indicate that the proposed improvements will increase the system capacity to approximately 8,222 ERUs based on the limiting components of the City’s source and treatment capacities. The 2030 water system will have a capacity surplus of approximately 1,929 ERUs.

The 20-year projected system capacity analysis with additional storage capacity is shown in **Table 7-9** and **Chart 7-1**. The results of the 2040 system capacity analysis indicate that the system capacity will remain approximately 8,222 ERUs based on the limiting components of the City’s source and treatment capacities. The 2040 water system will have a capacity surplus of approximately 397 ERUs.

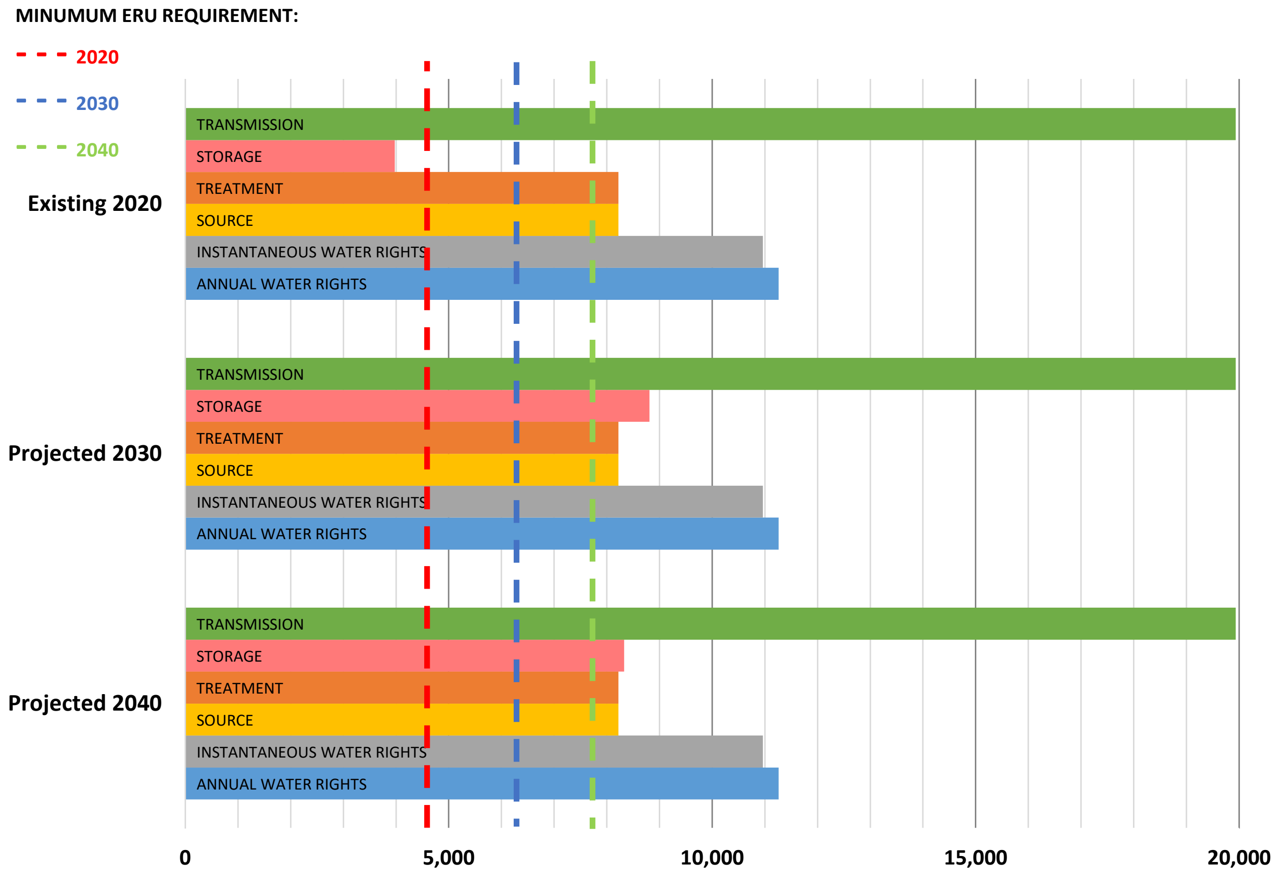
Table 7-9
System Capacity Analysis with Additional Storage

Description	Existing 2020	Projected 2030 (+10 years)	Projected 2040 (+20 years)
Demands Per ERU Basis			
ERU_{ADD} (gpd/ERU_{ADD})	173	173	173
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Peak Hour Demand per ERU (gpd)[1]	613	613	613
Source Capacity - Annual Water Rights			
Water Rights Capacity - Annual Average Based (gpd)	1,951,533	1,951,533	1,951,533
ERU_{ADD} (gpd/ERU_{ADD})	173	173	173
Water Rights Annual Average Based Source Capacity (ERUs)	**11,262**	**11,262**	**11,262**
Source Capacity - Instantaneous Water Rights			
Water Rights Capacity - Instantaneous Based (gpd)	4,032,000	4,032,000	4,032,000
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Day Based Source Capacity (ERUs)	**10,963**	**10,963**	**10,963**
Source Capacity - Maximum Day Based			
Source Capacity - Maximum Day Based (gpd)	3,024,000	3,024,000	3,024,000
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Day Based Source Treatment Capacity (ERUs)	**8,222**	**8,222**	**8,222**
Treatment Capacity - Maximum Day Based			
Source Treatment Capacity - Maximum Day Based (gpd)	3,024,000	3,024,000	3,024,000
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Day Based Source Treatment Capacity (ERUs)	**8,222**	**8,222**	**8,222**
Storage Capacity			
Maximum Equalizing & Standby Storage Capacity (gal)	795,297	1,795,281	1,795,281
Equalizing & Standby Storage Requirement per ERU (gal)	200	204	216
Maximum Storage Capacity (ERUs)	**3,976**	**8,808**	**8,327**
Transmission Capacity (10 fps)			
Transmission Capacity (gpd)	7,332,200	7,332,200	7,332,200
ERU_{MDD} (gpd/ERU_{MDD})	368	368	368
Maximum Transmission Capacity (ERUs)	**19,936**	**19,936**	**19,936**
Maximum System Capacity			
Maximum System Capacity (ERUs)	**3,976**	**8,222**	**8,222**
Limiting Facility	**Storage**	**Source/Treatment**	**Source/Treatment**
Unused Available System Capacity			
Maximum System Capacity (ERUs)	3,976	8,222	8,222
Projected ERUs	4,657	6,293	7,826
Unused Available System Capacity (ERUs)	**(680)**	**1,929**	**397**

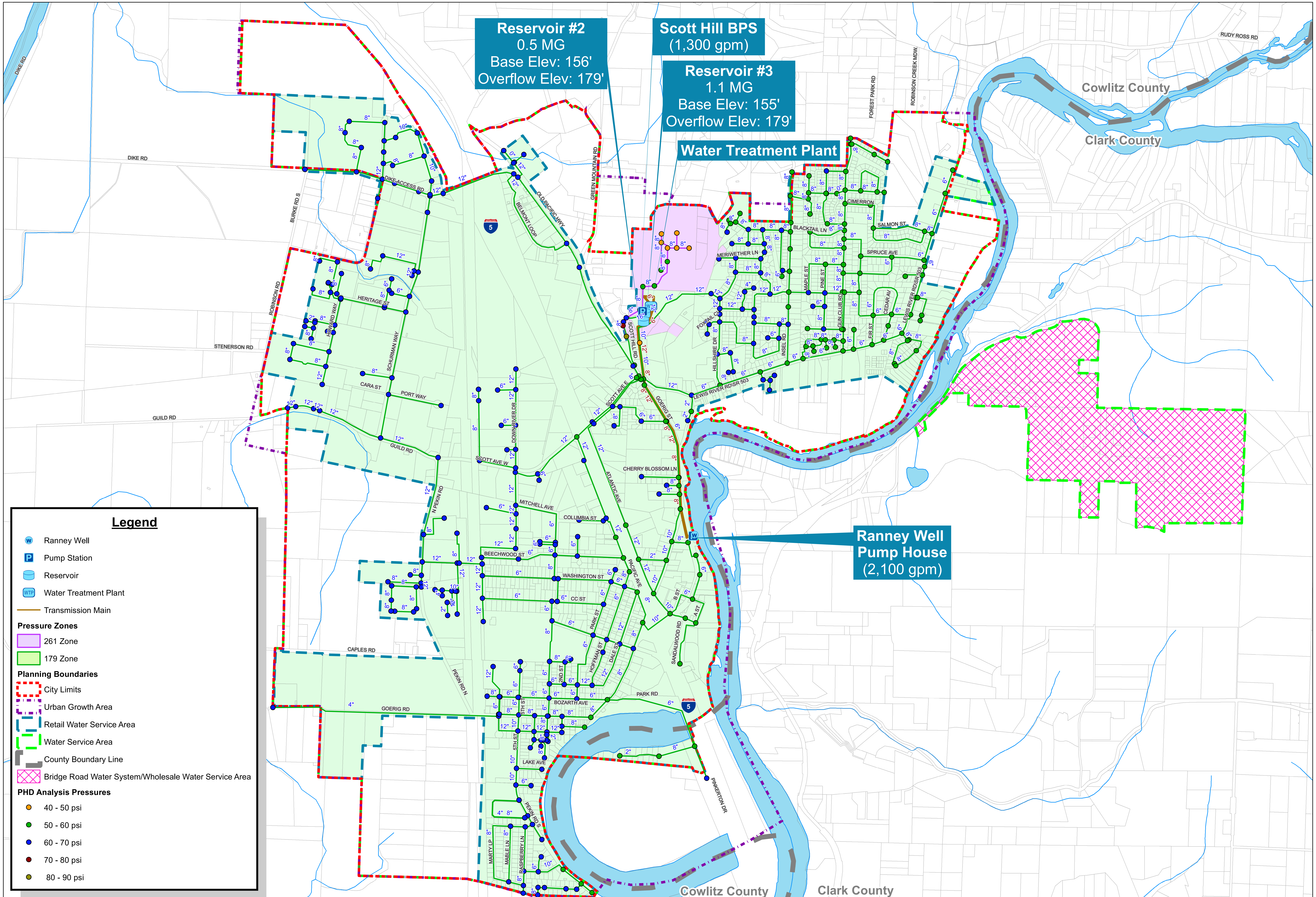
(1) Includes distribution system leakage.

Chart 7-1

System Capacity Analysis



Projected storage capacity assumes storage improvements have been completed.



This map is a graphic representation derived from the City of Woodland Geographic Information System. It was designed and intended for City of Woodland staff use only; it is not guaranteed to survey accuracy. This map is based on the best information available on the date shown on this map.

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Vicinity Map

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 7-1
Existing PHD Analysis Pressures

City of Woodland Water System Plan

COORDINATE SYSTEM: NAD 1983 STATEPLANE WASHINGTON SOUTH FIPS 4602 FEET

PLOT DATE: NOV 13, 2020 BY: SPERKINS

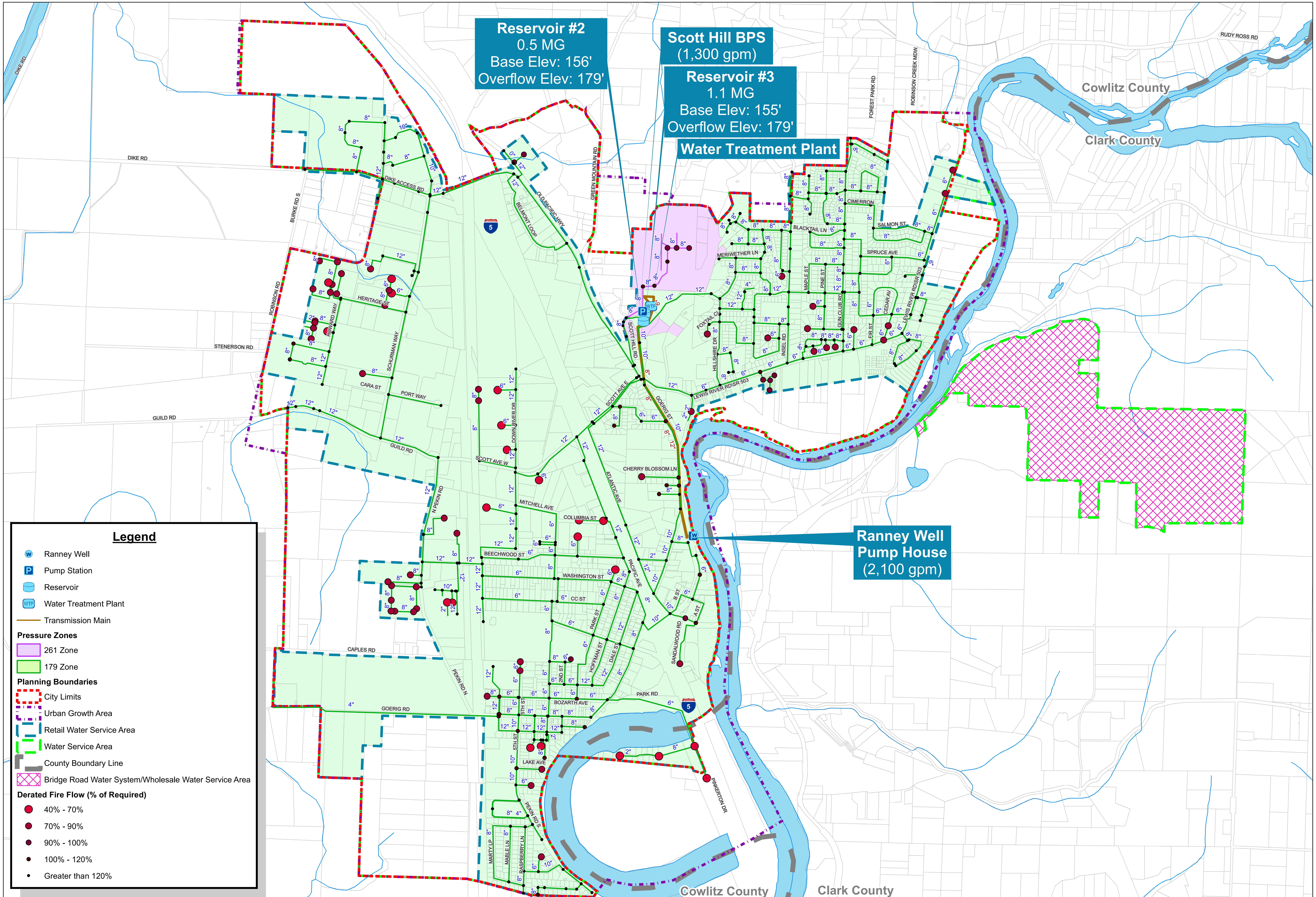
C:\DWG\COPY_OF_WSP-FIG_7-1_EX_HIGH_AND_LOW_PRESSURES.MXD

1 inch = 800 feet

0 400 800 1,600 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

NORTH



This map is a graphic representation derived from the City of Woodland Geographic Information System. It was designed and intended for City of Woodland staff use only; it is not guaranteed to survey accuracy. This map is based on the best information available on the date shown on this map.

Vicinity Map

COORDINATE SYSTEM: NAD 1983 STATEPLANE WASHINGTON SOUTH FIPS 4602 FEET

PLOT DATE: OCT 9, 2020 BY: DBRIGHT

J:\DATA\WOOD\119-141\GIS\WSP-FIG_7-2_EX_FF.MXD

Figure 7-2
Existing Derated Fire Flow

City of Woodland Water System Plan

1 inch = 800 feet

0 400 800 1,600 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

NORTH

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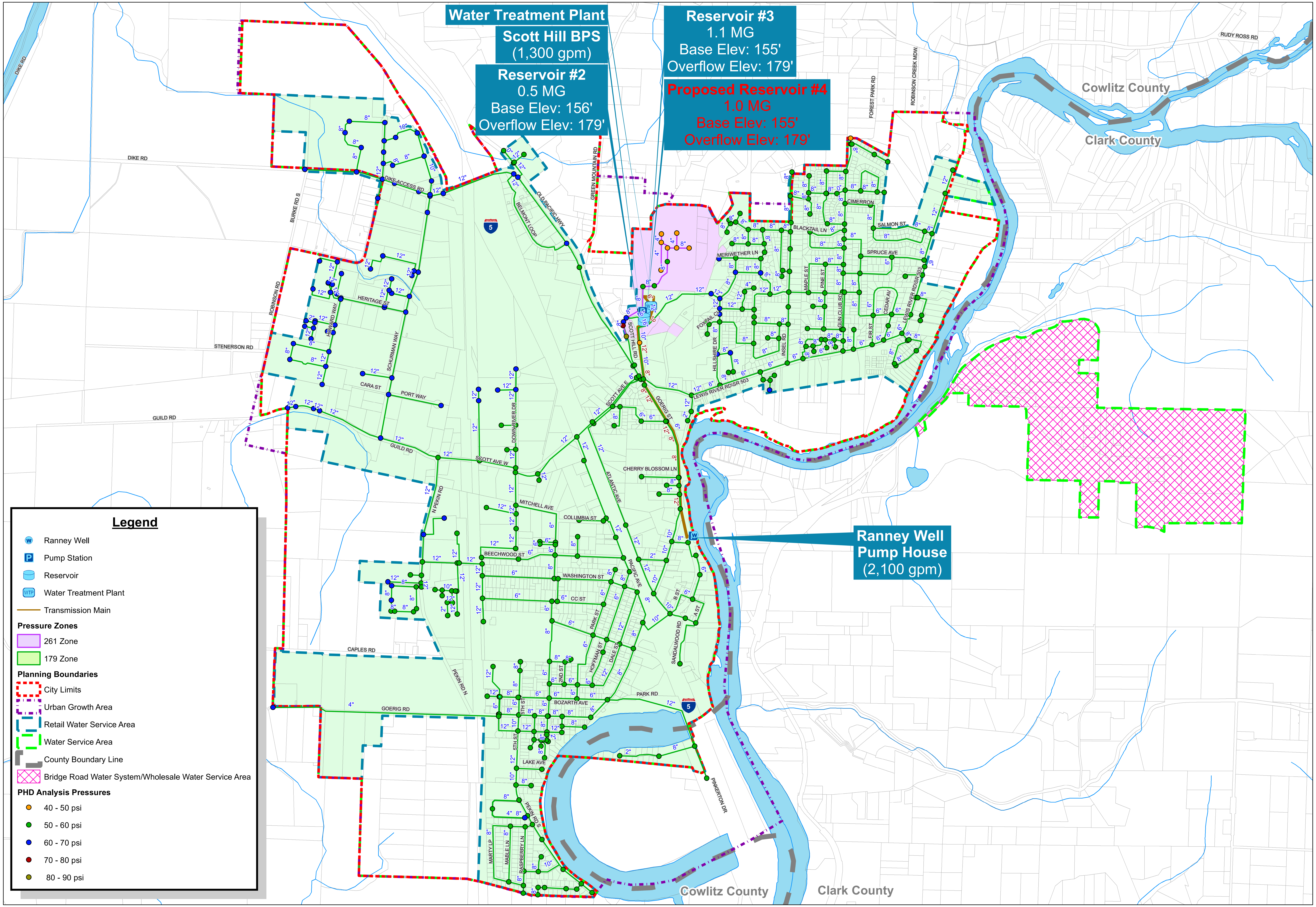
Vicinity Map

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 7-3
2040 Low and High Pressure Areas
City of Woodland Water System Plan

COORDINATE SYSTEM: NAD 1983 STATEPLANE WASHINGTON SOUTH FIPS 4602 FEET PLOT DATE: OCT 9, 2020 BY: DBRIGHT J:\DATA\WOOD\119-141\GIS\WSP-FIG_7-3_20_YEAR_PHD_PRESSURE.MXD



1 inch = 800 feet

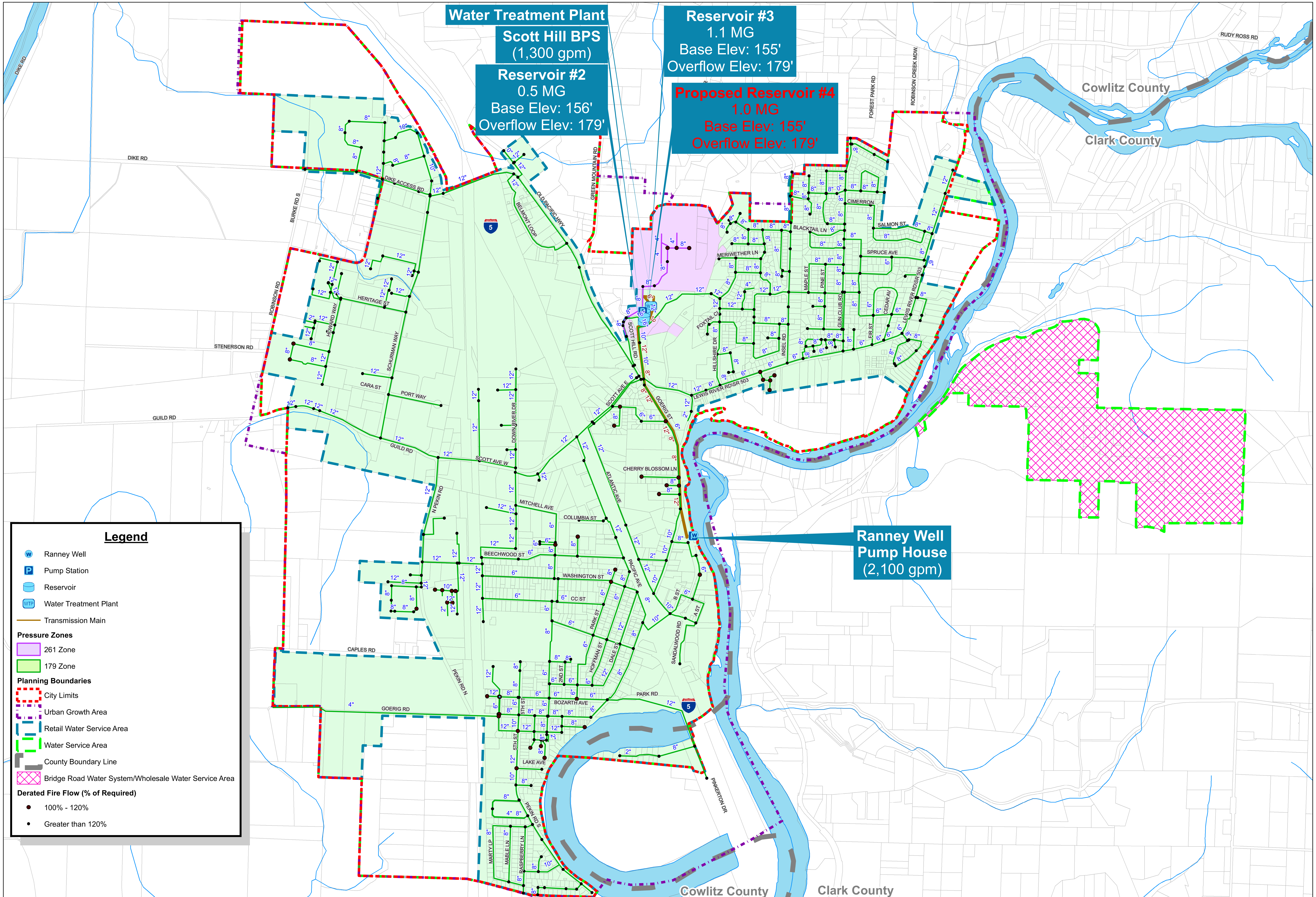
0 400 800 1,600 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

City of WOODLAND WASHINGTON

RH2

NORTH



Vicinity Map

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 7-4
2040 Derated Fire Flow

City of Woodland Water System Plan

COORDINATE SYSTEM: NAD 1983 STATEPLANE WASHINGTON SOUTH FIPS 4602 FEET

PLOT DATE: OCT 9, 2020

BY: DBRIGHT

J:\DATA\WOOD\119-141\GIS\WSP-FIG_7-4_20_YEAR_FF.MXD

City of WOODLAND WASHINGTON

1 inch = 800 feet

0 400 800 1,600 Feet

DRAWING IS FULL SCALE WHEN BAR MEASURES 2"

RH2

NORTH