CHAPTER 7

SYSTEM ANALYSIS

INTRODUCTION

The purpose of Chapter 7 is to evaluate whether the District's system is in compliance with the existing and proposed water quality regulations and facility capacity regulations. The existing facilities ability to meet the projected water system demands will be analyzed in accordance with the water quality and facility standards outlined in Chapter 2. Deficiencies identified in the analysis are considered in the development of the District's Capital Improvement Plan (CIP) in Chapter 10.

WATER QUALITY ANALYSIS

SPU provides the District with high-quality, treated drinking water. In 2001, SPU constructed a new Tolt Filtration Treatment Facility to improve the water quality of the system. Improvements to the Cedar River Treatment Facility were completed in 2004. Both SPU treatment facilities include chlorine and fluoride addition. Lime and carbon dioxide (at the Cedar Treatment Facility only) are also added to adjust the pH for corrosion control. Both facilities use ozonation for disinfection. Further description of the water quality and treatment systems for both the Tolt and Cedar River is presented in Chapter 4.

The following sections provide a discussion of the water-quality monitoring conducted by the District as well as the coordination with SPU for regional water quality monitoring programs.

BACTERIOLOGICAL

The District is part of SPU's Regional Monitoring Plan. In accordance with the District's agreement with SPU, all routine bacteriological sampling is conducted by SPU at eight sampling stations located throughout the District. A minimum of 63 samples per month were taken within the District, in accordance with WAC 246-290-300 but the number increased to 90 in January 2016. As part of the Regional Monitoring Plan, SPU was only required to take 70 percent of the samples normally required for a region with the District's population but the January 2016 will increase that requirement to 100 percent. The District is responsible for collecting any repeat samples. More than 750 bacteriological samples are taken every year and there have been seven exceedances since the last plan was approved in 2009. In these seven cases, repeat samples were taken and did not reveal any coliform presence. A copy of the District's Coliform Monitoring Plan is included in Appendix J.

The District has been in compliance with WAC regulations for sampling and follow-up actions, and no acute or non-acute maximum contaminant level (MCL) violations have occurred within the last 7 years.

RESIDUAL DISINFECTANT

The District's residual disinfectant monitoring is done in three ways. First, residual testing is done by SPU simultaneously with the District's coliform monitoring. Second, the District continuously monitors chlorine residual at each District reservoir via the District's SCADA system. According to the 2013 SPU monitoring reports, the average chlorine residual varies between 0 and 1.7 mg/L, with an average of 0.85 mg/L.

DISINFECTION BYPRODUCTS

The District collects 8 samples for both Total Trihalomethane (TTHM) and Halo-Acetic Acids (HAA5) each quarter. Of the 64 samples per year, there have been no exceedances since the previous Plan.

The District is in compliance with all TTHM and HAA5 monitoring requirements.

LEAD AND COPPER

SPU's source and distribution water contains no significant amount of lead and copper. Household plumbing, however, is often made of copper, and household plumbing systems can include components containing lead, such as lead-tin solder and leaded-brass fixtures, that can leach lead and copper into the water. Both SPU and the District reported no lead or copper exceedances in 2013.

WATER QUALITY REPORTING

The District issues an *Annual Water Quality Report* to all customers. This report provides a description of the drinking water source, a discussion on water quality, results of recent water quality testing, and references to additional water quality information. A copy of the 2014 report is included in Appendix E.

WATER RIGHTS ANALYSIS

The District currently obtains all of its water from SPU which has a Water Right Claim on the Cedar River and a Certificate of Water Right on the Tolt River issue.

The District, as a member of the Snohomish River Regional Water Authority (RWA), holds a water right certificate for the Snohomish River but is currently not withdrawing water under this water right. Chapter 4 provides additional discussion regarding RWA and water rights.

FACILITY ANALYSIS

The following sections provide a facility analysis based on the ability of the system to meet the existing and projected water system demands.

SOURCE OF SUPPLY

A fixed block wholesale contract between the District and SPU signed in 2005 provides the District with 8.55 mgd of supply through 2062. SPU provides all treated water supply to the District through six connections to the Tolt Pipelines and one connection to the TESSL pipeline. SPU has source meters that monitor flows at each connection point, and the District also monitors flows from SPU with eleven master meters.

The District is charged for 8.55 mgd of usage even if the actual withdrawal is less than that amount. The SPU contract does not prohibit the District from withdrawing high instantaneous flows. However, SPU does impose contractual peak season and peak month penalties. During the peak season, defined as June 1 through September 30 of the same calendar year, the District is limited to an average supply rate of 11.97 mgd. During the peak month, defined as the 30-day period with the largest District usage, the District is limited to an average supply rate of 14.96 mgd. The peak season and peak month limitations do not physically limit the District from flows above the identified levels, but financial penalties are imposed for usage beyond the supply rates.

Source of Supply Analysis

Projected water usage is identified in Chapter 5. Table 7-1 provides a comparison of the District's projected average day, peak season, and maximum month demands to the flows identified in the SPU contract.

TABLE 7-1

Source of Supply Analysis

Year	2014	2020	2024	2034	Buildout
District Average Day Demand (mgd)	5.58	6.10	6.45	7.20	8.51
SPU Contractual Supply (mgd)	8.55	8.55	8.55	8.55	8.55
ADD Surplus (mgd)	**2.97**	**2.45**	**2.10**	**1.35**	**0.04**
District Maximum Day Demand (mgd)	11.15	12.21	12.91	14.39	17.03
SPU Peak Day Supply (mgd)	11.97	11.97	11.97	11.97	11.97
MDD Surplus (mgd)	**0.82**	**-0.24**	**-0.94**	**-2.42**	**-5.06**
Peak Season Average Day Demand (mgd)	7.24	7.93	8.40	9.36	11.07
SPU Peak Season Supply (mgd)	11.97	11.97	11.97	11.97	11.97
Peak Season Surplus (mgd)	**4.73**	**4.04**	**3.57**	**2.61**	**0.90**
Maximum Month Average Day Demand (mgd)	11.15	12.21	12.91	14.39	17.03
SPU Peak Month Supply(mgd)	14.96	14.96	14.96	14.96	14.96
Maximum Month Surplus (mgd)	**3.81**	**2.75**	**2.05**	**0.57**	**-2.07**

The District's demands projected through the 20-year planning period are within the limits of the SPU supply contract. However, the maximum month average day demands exceeds the SPU supply contract flows at the buildout scenario (all land fully developed). Additional demand can be served beyond the limits; however, financial penalties will be imposed by SPU.

Source Reliability

The SPU regional supply system provides a high level of reliability and redundancy. Figure 4-1 provides an overview of the SPU regional supply system. SPU has two major sources, the Tolt Treatment Facility and Cedar Treatment Facility, either of which can supply the District if the other is out of service.

SPU installed several isolation valves on the Tolt Pipelines that allow portions of the pipeline to be isolated for repairs. These valves allow the remaining portion of the pipeline to continue service. If the Tolt Pipeline is out of service east of the District, SPU can provide supply from the Lake Hill Pump Station located in Bellevue. If the Tolt Pipeline is out of service within the District, SPU has the ability to pump from the Mapleleaf Reservoir in Seattle to the Lake Forest Park Reservoir and supply the District from the west. SPU also installed the Tolt II Pipeline, parallel to the original Tolt Pipeline, which provides reliability, improves capacity, and improves the consistency of delivery pressure.

Alternative Sources of Supply

The District has several emergency interties with adjacent purveyors, but only three can provide supply to the District. The intertie with Lake Forest Park includes a pump that can transfer supply into the District's 530 Zone. The intertie with the Alderwood Water and Wastewater District can supply the 342 Zone by gravity through a normally closed valve. The interties with Kirkland can provide supply to the 366 zone. These sources are not used for normal supply.

STORAGE ANALYSIS

The District has eight reservoirs with a combined storage capacity totaling 29.1 MG. Chapter 4 provides an inventory of the District's storage facilities and a description of each storage site. Chapter 2 provides the standards for which the storage analysis is based.

Physical Condition

The District conducted seismic analyses of the Inglemoor Tank Farm in 2001 and the Westhill Standpipe, Kingsgate Standpipe, and Norway Hill Reservoir in 2002. Based on the recommendations of these analyses, the District performed seismic upgrades to the

Inglemoor Standpipe, Westhill Standpipe, Kingsgate Standpipe, and upgraded the Inglemoor Tank Farm site piping with restrained joint pipe and flexible expansion couplings. Other upgrades to the storage facilities included interior and exterior coating restoration, and other ancillary upgrades. Since 2005, security improvements and seismic valves were installed at the Inglemoor, Kingsgate, Westhill, and Norway reservoirs. At the Inglemoor site, Reservoirs 1, 2 and 3 were painted and seal welded on the interior in 2013 and 2014. The Inglemoor Standpipe coating has been inspected and is in need of repair/replacement in the near future. Norway Hill Reservoir coating was recently inspected and it was recommended to re-coat the interior in 5 years.

Storage Area Demand Allocation

The District's reservoirs provide storage to four areas: Inglemoor, Lake Forest Park (LFP), Westhill, and Norway/Kingsgate. Each of these storage areas provides storage for multiple pressure zones through pressure-reducing valves and booster stations. Two pressure zones, the 342 and 366 zones, are supplied by multiple storage areas during normal operating conditions. The demand for each storage zone was based on the projected populations and demands discussed in Chapter 5. Each pressure zone was given a population and demand based on the expected growth within that zone. Since some pressure zones can be served by multiple storage facilities, system demands for the 342 Zone are split equally between the Inglemoor and LFP storage areas, and system demands for the 366 Zone are divided equally into the Inglemoor and Norway/Kingsgate storage areas. Table 7-2 provides the average day, maximum day, and peak hour demands allocated to each storage area.

TABLE 7-2

Demand Allocation by Storage Area

Storage Area	Lake Forest Park	Westhill	Inglemoor	Norway Hill /Kingsgate	Total
Average Day Demand, ADD(1) (mgd)					
2014	0.99	0.32	2.98	1.29	5.58
2020	1.10	0.35	3.22	1.43	6.10
2024	1.16	0.38	3.38	1.53	6.45
2034	1.32	0.43	3.77	1.68	7.20
Buildout	1.56	0.51	4.45	1.99	8.51
Maximum Day Demand, MDD(2) (mgd)					
2014	1.99	0.63	5.96	2.58	11.15
2020	2.19	0.71	6.44	2.87	12.21
2024	2.33	0.76	6.76	3.06	12.91
2034	2.63	0.87	7.53	3.36	14.39
Buildout	3.11	1.03	8.91	3.98	17.03

TABLE 7-2 – (continued)

Demand Allocation by Storage Area

Storage Area	Lake Forest Park	Westhill	Inglemoor	Norway Hill /Kingsgate	Total
Peak Hour Demand, PHD(3) (gpm)					
2014	2,760	880	8,270	3,580	15,490
2020	3,040	980	8,940	3,980	16,940
2024	3,240	1,050	9,390	4,260	17,940
2034	3,660	1,210	10,460	4,670	20,000
Buildout	4,320	1,430	12,370	5,530	23,650

(1) Total system demands are provided in Table 5-16.
(2) Based on a MDD/ADD peaking factor of 2 discussed after Table 5-6.
(3) Based on a PHD/MDD peaking factor of 2 discussed after Table 5-7.

Storage Requirements

The Washington State Department of Health (DOH) Water System Design Manual (Design Manual) provides guidance on sizing reservoirs “to ensure water system adequacy, reliability, and compatibility with existing and future facilities.” The Design Manual identifies the following components of reservoir storage volume that must be considered:

- Operational Storage (OS)
- Equalizing Storage (ES)
- Standby Storage (SB)
- Fire Suppression Storage (FSS)
- Dead Storage (DS)

In addition, the District is contractually obligated to provide the City of Bothell with 1 MG of storage in the Norway Hill Reservoir or up to 1 mgd supply. Since this was not evaluated in the source of supply analysis, it is included here. The following sections define each of the storage components, provide a methodology for determining each storage component, and identify the District’s storage components for the current, 6-year, 20-year, and buildout scenarios.

Operational Storage

Operational storage is the volume of the reservoir that supplies the water system under normal operating conditions while the sources are not in operation. The District operates its reservoirs in a “draw and fill” mode so that the sources turn on and off at predetermined set points. The operational storage for each reservoir is the volume within the reservoir between the “source on” level and the overflow level. Table 7-3 provides the levels corresponding to the master meter set points and the operational storage in each reservoir.

TABLE 7-3

Operational Storage

Storage Facility	Overflow Height (ft)	Source Off Level (ft)	Source On Level[1] (ft)	Operational Storage (ft)	Operational Storage (MG)
Lake Forest Park	30	28[2]	26[2]	4	0.60
Inglemoor Reservoirs	39	37[3]	35[3]	4	1.30
Inglemoor Standpipe	103	100[4]	97[4]	13	0.37
Westhill	121	120[5]	109[5]	4	0.11
Kingsgate	94	94[6]	92[6]	12[7]	0.38
Norway Hill	29	28[8]	22[6]	4	0.67
Total					**3.43**

(1) Operational settings as of September 2014.
(2) Supplied by Master Meter 7.
(3) Supplied by Master Meter 5B.
(4) Supplied by Master Meter 4, Inglemoor Booster Station, and Norway Hill Booster Station.
(5) Supplied by Master Meter 5A.
(6) Supplied by Master Meters 1, 2, and 3.
(7) Larger Operational storage is used during the months of August-September which is included for this analysis.
(8) Supplied by Master Meter 3.

Equalizing Storage

Equalizing storage must be provided as part of the total storage for the system to provide water during periods of peak demand that cannot be met by the source production capacity. The volume of equalizing storage required depends on the peak hour system demands, duration of the peak demand period, and source production rate. The Design Manual recommends calculating equalizing storage using the following equation:

$$ES = (PHD - Q_S)*(150 \text{ minutes})$$

Where: ES = Equalizing storage (gallons)
PHD = Peak hour demand (gpm)
Q_S = Source capacity (gpm)

Table 7-4 provides the peak hour demand, source capacity, and equalizing storage volume for each storage area.

The Inglemoor Tank Farm is typically supplied by Master Meter 5B, which either flows through the turbine into the ground level reservoirs, or directly into the 601 zone through a 16-inch Cla-Val. It can also be supplied from Master Meter 4 and the Norway Hill

Booster Station which flow directly into the standpipe bypassing the ground level reservoirs. Since flow is typically supplied through Master Meter 5B into the ground level reservoirs, that will be evaluated as the source capacity.

TABLE 7-4

Equalizing Storage

Storage Area	Lake Forest Park	Westhill	Inglemoor	Norway Hill/ Kingsgate
Peak Hour Demand (PHD) (gpm)				
2014	2,760	880	8,270	3,580
2020	3,040	980	8,940	3,980
2024	3,240	1,050	9,390	4,260
2034	3,660	1,210	10,460	4,670
Buildout	4,320	1,430	12,370	5,530
Source Capacity (gpm)	2,500(1)	1,000(2)	5,000(3)	5,500(4)
Equalizing Storage (MG)				
2014	0.04	0.00	0.49	0.00
2020	0.08	0.00	0.59	0.00
2024	0.11	0.01	0.66	0.00
2034	0.17	0.03	0.82	0.00
Buildout	0.27	0.06	1.11	0.00

(1) The Lake Forest Park Reservoir is supplied by Master Meter 7 (2,500 gpm).
(2) The Westhill Standpipe is supplied by Master Meter 5A (1,000 gpm).
(3) The Inglemoor area is supplied by Master Meter 5B (5,000 gpm).
(4) The Norway/Kingsgate area is supplied by Master Meters 1 (1,500 gpm), 2 (1,500 gpm) and 3 (2,500 gpm).

Fire Suppression Storage

Water systems must be capable of delivering fire flows in accordance with the adopted fire flow requirements. The required fire suppression storage is the product of the fire flow rate and duration. The maximum adopted fire flow requirement for the District is 1.2 MG (5,000 gpm for 4 hours) and is located in the 342 Zone. Table 7-5 provides a summary of the maximum fire flow requirements by storage area. For Lake Forest Park, the highest fire flow is 1,500 gpm but the water model indicated a higher flow of 2,250 gpm was coming from the reservoirs to aid in fire suppression in the 342 Zone

TABLE 7-5

Fire Suppression Storage

Storage Area	Lake Forest Park	Westhill	Inglemoor	Norway Hill/ Kingsgate
Fire Flow Rate (gpm)	2,250(1)	3,000(2)	4,000	6,500(3)
Fire Flow Duration (minutes)	240	180	240	120
Fire Suppression Storage (MG)	0.54	0.54	0.96	0.78

(1) The largest fire flow provided only by the Lake Forest Park Reservoir is 1,500 gpm, but the reservoir also contributes storage to high fire flow areas of the 342 Zone.
(2) Two structures in the City of Bothell require 3,000-gpm fire flow.
(3) Includes 2,500-gpm and 1,500-gpm fire flows provided to the Evergreen Hospital Medical Center and 2,500 gpm provided to another fire in the area.

Standby Storage

Standby storage provides reliability for the system should sources fail or unusual conditions create higher than anticipated system demands. The District is supplied exclusively by SPU, which is considered a single source for purposes of calculating standby storage volumes. Therefore, the standby storage volume is calculated based on two times the average day demand. The total required standby storage is provided in Table 7-6.

$$SB = (2\text{ days})(ADD)(N)$$

Where: SB = Standby storage (gallons)
ADD = Average day demand for the design year (gpd/ERU)
N = Number of ERUs

TABLE 7-6

Standby Storage

Year	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
2014	1.99	0.63	5.96	2.58
2020	2.19	0.71	6.44	2.87
2024	2.33	0.76	6.76	3.06
2034	2.63	0.87	7.53	3.36
Buildout	3.11	1.03	8.91	3.98

Contractual Storage

The District and City of Bothell have an agreement stating that the City is “entitled to the permanent use of up to one million gallons” in the Norway Hill Reservoir. For purposes of this analysis the full capacity less 1 MG of the Norway Hill Reservoir is considered to be available for the District's use.

Dead Storage

Dead storage is the volume of the reservoir that cannot be utilized because minimum system pressures would be below the 20 psi minimum during a fire flow event or 30 psi during peak hour demand. Dead storage is a component of the District's three standpipes, the Inglemoor Standpipe, Westhill Standpipe, and Kingsgate Standpipe. The water stored in the Lake Forest Park Reservoir is pumped into the system; therefore, the full capacity of the reservoir can be considered usable storage. Similarly, the Inglemoor Booster Station allows the full capacity of the 537 Inglemoor Reservoirs to be considered usable storage. However, there is dead storage in the Inglemoor Standpipe below a level of 43 feet. This storage can be used by closing a valve, and pumping from the standpipe to the 601 Zone through the Inglemoor Booster Station. For purposes of this analysis, the storage volume below 43 feet is considered dead storage because manual action is required to utilize the full reservoir volume. The Westhill and Kingsgate Standpipes have dead storage below the water levels of 62 and 38 feet, respectively. The base elevation of the Norway Hill reservoir is such that the full capacity of the reservoir can be used to supply all of its customers while maintaining 33 psi. Table 7-7 provides a summary of the dead storage analysis.

TABLE 7-7

Dead Storage

Storage Facility	Base Elevation(1),(2) (ft)	Highest Service Elevation(1),(3) (ft)	Minimum HGL(1)(4) (ft)	Dead Storage (ft)	Dead Storage (MG)
Inglemoor Standpipe	498	495	541	43(5)	1.24(5)
Inglemoor Reservoirs	498	N/A(6)	498	0	0.00
Westhill	259	275	321	62	1.64
Norway Hill	422	344	390	0	0.00
Kingsgate	352	344	390	38	1.19
Lake Forest Park	501	418	464	0	0.00
Total					**4.07**

(1) Datum is NAVD 1988.
(2) Base elevation is the elevation of the bottom of the reservoir floor.
(3) Highest service elevation is the elevation of the highest customer served by gravity from the reservoir.
(4) Minimum HGL is the minimum hydraulic grade necessary to provide 20 psi to the highest service elevation.
(5) The dead storage in the Inglemoor Standpipe can be eliminated by pumping through Inglemoor Booster Station directly to the 601 Zone.
(6) No customers are served directly from the Inglemoor Reservoirs.

Storage Capacity Analysis Summary

Table 7-8 summarizes the available storage capacity for each storage area.

TABLE 7-8

Summary of Available Storage

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
Reservoir Volume	4.51	3.01	13.70	7.98
Contractual Storage	0.00	0.00	0.00	(1.00)
Dead Storage	0.00	(1.64)	(1.24)	(1.19)
Available Storage	**4.51**	**1.37**	**12.46**	**5.79**

Tables 7-9, 7-10, 7-11, 7-12 and 7-13 summarize the storage capacity analysis for each storage area for the 2014, 2020, 2024, 2034 and buildout scenarios, respectively.

TABLE 7-9

2014 Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
2014				
Operational Storage	0.60	0.11	1.47	1.05
Equalizing Storage	0.04	0.00	0.49	0.00
Fire Suppression Storage	0.54	0.54	0.96	0.78
Standby Storage	1.99	0.63	5.96	2.58
Total Required Storage	**3.17**	**1.28**	**8.88**	**4.40**
Available Storage	4.51	1.37	12.46	5.79
Surplus/(Deficit)	**1.35**	**0.09**	**3.57**	**1.38**

TABLE 7-10

2020 Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
6-Year				
Operational Storage	0.60	0.11	1.47	1.05
Equalizing Storage	0.08	0.00	0.59	0.00
Fire Suppression Storage	0.54	0.54	0.96	0.78
Standby Storage	2.19	0.71	6.44	2.87
Total Required Storage	**3.41**	**1.35**	**9.47**	**4.70**
Available Storage	4.51	1.37	12.46	5.79
Surplus/(Deficit)	**1.10**	**0.02**	**2.99**	**1.09**

TABLE 7-11

2024 Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
10-Year				
Operational Storage	0.60	0.11	1.47	1.05
Equalizing Storage	0.11	0.01	0.66	0.00
Fire Suppression Storage	0.54	0.54	0.96	0.78
Standby Storage	2.33	0.76	6.76	3.06
Total Required Storage	**3.58**	**1.41**	**9.85**	**4.89**
Available Storage	4.51	1.37	12.46	5.79
Surplus/(Deficit)	**0.93**	**-0.04**	**2.60**	**0.90**

TABLE 7-12

2034 Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
20-Year				
Operational Storage	0.60	0.11	1.47	1.05
Equalizing Storage	0.17	0.03	0.82	0.00
Fire Suppression Storage	0.54	0.54	0.96	0.78
Standby Storage	2.63	0.87	7.53	3.36
Total Required Storage	**3.95**	**1.55**	**10.79**	**5.19**
Available Storage	4.51	1.37	12.46	5.79
Surplus/(Deficit)	**0.56**	**-0.18**	**1.67**	**0.60**

TABLE 7-13

Buildout Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
Buildout				
Operational Storage	0.60	0.11	1.47	1.05
Equalizing Storage	0.27	0.06	1.11	0.00
Fire Suppression Storage	0.54	0.54	0.96	0.78
Standby Storage	3.11	1.03	8.91	3.98
Total Required Storage	**4.53**	**1.74**	**12.45**	**5.81**
Available Storage	4.51	1.37	12.46	5.79
Surplus/(Deficit)	**-0.02**	**-0.37**	**0.01**	**-0.02**

As indicated in Table 7-12 and 7-13, a storage deficit for the Westhill Standpipe is projected in 2024 and storage deficits for Lake Forest Park and Norway Hill/Kingsgate are projected at buildout. The storage deficits can be addressed through future improvements such as decreasing dead storage with a booster station and planned storage improvements.

BOOSTER STATIONS

The following sections provide an analysis of the District's booster stations, including their physical condition, capacity, and reliability.

Lake Forest Park

The Lake Forest Park Booster Station supplies the 640 and 530N Zones. The booster station consists of three pumps: two 25-hp pumps (550 gpm) and one 75-hp pump (1,500 gpm). The 25-hp pumps are equipped with variable frequency drive motors, and the 75-hp pump is a constant-speed motor. The combined output of the booster station is 2,600 gpm. The Lake Forest Park Booster Station is located adjacent to the Lake Forest Park Reservoir in a concrete structure. The booster station was constructed in 1987, and no major upgrades have been completed since that date.

<u>Physical Condition</u>

A booster station analysis was completed in 2013 by Gray & Osborne to assess the existing condition of the mechanical and electrical equipment and to verify operation and capacity through testing. The analysis found that the pumps were running below nameplate capacity. This could mean the pumps have a smaller impeller size than recorded or the impellers might be worn. The interior of the booster station is clean and piping, pumps, and valves are free from corrosion. Some electrical components are outdated and need to be upgraded or replaced. The generator needs to be replaced since it is longer serviceable but the underground storage tank is still in good condition and only needs a new fuel pump.

<u>Capacity and Reliability Analysis</u>

The booster station has sufficient pumping capacity to provide peak hour demands and maximum day plus fire flow demands to the 640 and 530N Zones. These two zones are anticipated to have a combined MDD of 190 gpm and a combined PHD of 370 gpm in 2034.

WAC 246-293-660(1) states that fire flows supplied by pumping must do so with the largest pump out of service. The maximum day demand plus a fire flow demand of 1,500 gpm is equal to 1,680 gpm in 2034. The booster station was designed to provide 2,050 gpm at 140 feet TDH with the largest routinely used pump out of service. The Booster Station Study found that the pumps were running below nameplate capacity but testing and modeling verified the station still has adequate capacity. Fire flows can be provided throughout the 640 and 530N pressure zones with the largest pump out of service.

The Lake Forest Park Booster Station is equipped with an onsite 125 kW generator with an automatic transfer switch to provide immediate emergency backup power. Auxiliary power is necessary because these booster pumps are the only means of supply for the 640 and 530N Zones during days when the hydraulic grade of the Tolt is below 640 feet.

Inglemoor Booster Station

The Inglemoor Booster Station supplies the Inglemoor Standpipe and effectively is the only continuously available source of supply to the 601 Zone. The booster station consists of five pumps: one 3,200 gpm turbine pump, two 75-hp pumps rated at 2,000 gpm each, and two 100-hp pumps rated at 2,500 gpm each. The turbine pump replaced two old 40-hp pumps. The 75- and 100-hp pumps are equipped with soft starts and constant-speed motors. The District utilizes the high head of the Tolt pipeline to drive the turbine as the water fills the ground level reservoirs. The same shaft drives a pump that draws from the ground level reservoirs and fills the standpipe. The combined output of the booster station is 12,200 gpm. The Inglemoor Booster Station is located adjacent to the Inglemoor Tank Farm and is housed in a CMU building constructed in 2013. This building replaced the previous booster station that was constructed in 1962 and reached the end of its useful life. The two 100-hp pumps received new motor starters, the 75-hp pumps were replaced, and the turbine pump replaced two old 40-hp pumps.

Physical Condition

The booster station structure, mechanical, and electrical equipment were recently replaced in 2013. The building is in excellent condition and no foreseeable upgrades will be necessary in the 20-year projection period.

Capacity and Reliability Analysis

The booster station currently has sufficient pumping capacity to provide peak hour demands and maximum day plus fire flow demands to the 601 Zone and zones supplied by PRVs. These zones are anticipated to have a combined MDD of 5,230 gpm and a combined PHD of 10,460 gpm in 2034. Fire flow is 4,000 gpm.

In the event that the Inglemoor Booster Station is out of service, the 601 Zone can potentially be supplied by three sources: from Master Meter 5B via the 24-inch transmission main, directly from Master Meter 4, or through the Norway Hill Booster Station. If the Tolt Pipeline HGL is greater than 601 feet, the 24-inch transmission main can flow directly into the 601 Zone at the Inglemoor Tank Farm site. Similarly, flows from Master Meter 4 can supply the 601 Zone from near the Norway Hill Reservoir site. The Tolt Pipeline HGL averaged around 710 feet in 2013, with the exception of peak demand periods.

Norway Hill

The Norway Hill Booster Station consists of two 35-hp pumps, each capable of delivering 1,000 gpm at 90 feet TDH. The booster station does not have an onsite standby generator because the booster station is not necessary to provide immediate emergency supply. A manual transfer switch and receptacle are available to connect a portable generator if necessary.

Physical Condition

The Norway Hill Booster Station is housed in a CMU building with a wood frame roof. The structure, mechanical systems, and electrical systems are all in good physical condition and are not in need of any repairs. The control panel was rebuilt in 2005 as part of the Norway Hill security improvements.

Capacity and Reliability Analysis

The Norway Hill Booster Station provides a redundant source of supply to the 601 Zone, serving as a backup to the 24-inch transmission main. The booster station pumps from the 451 Zone near the Norway Hill Reservoir through an 18-inch ductile iron transmission main. The booster station is a low priority call under normal conditions based on the Inglemoor Standpipe level.

Summary of Booster Station Capacity Analysis

Table 7-14 provides a comparison of the Inglemoor, Norway Hill, and Lake Forest Park Booster Station capacity to the demand on each booster station. The total capacity of each booster station includes the sum of the nominal capacities of the individual booster pumps. DOH recommends pumps stations are able to meet demands with the largest pump out of service. The reliable capacity in Table 7-14 is booster station capacity with the largest pump out of service. The total demand for the Inglemoor and Norway Hill Booster Stations is the larger value of the MDD plus a 4,000 gpm fire flow or the PHD. For all projected years, the PHD was the larger value. For the Lake Forest Park Booster station, the total demand is the larger value of the MDD plus 1,500 gpm fire flow or the PHD. For all years, MDD plus fire flow was the larger value.

No capacity-related deficiencies are noted at the Lake Forest Park, Inglemoor Booster Station, or Norway Hill Booster Station through 2034.

TABLE 7-14

Summary of Booster Station Capacity Analysis

Year	2014	2020	2024	2034	Buildout
Inglemoor and Norway Hill Booster Stations					
Total Capacity(1) (gpm)	14,200	14,200	14,200	14,200	14,200
Total Demand(2) (gpm)	8,270	8,940	9,390	10,460	12,370
Surplus Capacity (Deficit) (gpm)	5,930	5,260	4,810	3,740	1,830
Reliable Capacity(3) (gpm)	11,000	11,000	11,000	11,000	11,000
Total Demand(2) (gpm)	8,140	8,470	8,690	10,460	12,370
Surplus Capacity (Deficit) (gpm)	2,860	2,530	2,310	540	-1,370

TABLE 7-14 – (continued)

Summary of Booster Station Capacity Analysis

Year	2014	2020	2024	2034	Buildout
Lake Forest Park Booster Station					
Total Capacity[(1)] (gpm)	2,600	2,600	2,600	2,600	2,600
Total Demand[(4)] (gpm)	1,650	1,660	1,670	1,690	1,720
Surplus Capacity (gpm)	950	940	930	910	880
Reliable Capacity[(3)] (gpm)	2,050	2,050	2,050	2,050	2,050
Total Demand[(4)] (gpm)	1,650	1,660	1,670	1,690	1,720
Surplus Capacity (Deficit) (gpm)	400	390	380	360	330

(1) Total capacity is the sum of all booster pump capacity.
(2) Total demand is the peak hour demand for the 601 Zone and sub-zones supplied by PRVs.
(3) Reliable Capacity is the total pumping capacity with the largest routinely used pump out of service.
(4) Total demand is the maximum day demand plus a 1,500-gpm fire flow for the 640 and 530N pressure zones.

INGLEMOOR TRANSMISSION MAIN

A 24-inch concrete cylinder pipe (CCP) is the primary source of supply to the Inglemoor Tank Farm. This transmission main begins at Master Meter 5B, travels south under the Sammamish River, and terminates at the Inglemoor Tank Farm. The section of the water main under the river is 18-inch ductile iron, restrained joint pipe. As shown on Figure 3-3, this section of the Sammamish River is a seismic hazard area. A geotechnical investigation conducted in 2006 concluded that the Inglemoor Transmission Main would likely not fail or experience excessive settling during a seismic event.

The transmission main currently provides a majority of the supply to the Inglemoor Tank Farm. In the 20-year planning period, total flows are projected to increase by 25 percent through this transmission main. Because the District typically operates the Inglemoor Reservoirs on a draw and fill mode, this increase in flow will result in a longer fill period, not necessarily a need to increase the flow rate. In 2034, the projected maximum day demand for the area supplied by the Inglemoor Tank farm is 7.53 mgd, or 5,230 gpm over 24 hours.

DISTRIBUTION

The District has a reliable distribution system that has sufficient capacity to provide fire flows to almost all customers. Chapter 6 discusses the capacity of the distribution system. The 3-year average DSL rate for water in the system was 4.5 percent of total, which includes leaks in piping and under-registering service meters. This value is well below the distribution leakage standard of 10 percent set by DOH.

Distribution projects during the previous six years have focused on replacing piping that has a high risk of failure or frequent maintenance. Typically, these pipes are small diameter asbestos cement mains, thin-walled PVC mains, and cast iron mains. Table 4-3 provides an inventory of the water mains in the District's system. Since 2009, the District has replaced approximately 18,000 LF (1 percent of system) of AC, PVC, and CI water mains. The District has also installed 113,000 LF of new ductile iron water main since 2009 to serve growth.

A total of 59,000 LF of AC pipe 8 inches and larger in diameter remain in the distribution system, roughly 4 percent of all piping. The District has not experienced significant maintenance problems with the AC piping 8 inches and larger. These AC mains were installed between 1959 and 1979 and represent some of the oldest piping in the system. The design life of AC pipe is typically 50 years; therefore, these pipes theoretically have at most 15 year of useful life remaining. Since the last plan, the District has replaced over 10,000 LF of AC pipe.

Maintenance staff indicated that a majority of the District's distribution line failures have been in the PVC mains. Although this pipe was primarily installed in the late 1970s and early 1980s and theoretically should not reach the end of its design life for over 20 years, much of this pipe is thin-walled, and some has glued fittings. Pipe failures often occur where the pipe is in direct contact with large rocks or where glued fittings separate due to age.

Leak detection surveys are conducted for 1 week every year and discussed further in the Chapter 8. When leaks are identified they are corrected by maintenance staff.

The District reviewed their base maps to determine the locations of remaining non-ductile iron water mains. These mains will be the focus of future leak detection surveys and will be replaced as necessary. The District is also identifying and replacing smaller diameter spaghetti line, with 4-inch ductile iron to provide more reliable service.

SUMMARY OF SYSTEM DEFICIENCIES

The following sections provide a summary of deficiencies identified in this Chapter. These deficiencies will be addressed in the District's capital improvement plan, provided in Chapter 10.

STORAGE DEFICIENCIES

Most of the system's storage facilities are in great physical condition after having been seismically retrofitted and recoated. The Inglemoor Standpipe and Norway Hill Reservoirs were recently inspected and will need to be recoated in the next 5 years. Presently, all reservoirs have a storage surplus. In the 10-year planning period, the Westhill Standpipe storage demand will be deficient. The Westhill capacity analysis can be reviewed during the preparation of the water system plan in 6 years. The Lake Forest Park, Inglemoor, and Norway Hill/Kingsgate storage areas are projected to maintain a storage surplus until buildout, at which time Westhill, Lake Forest Park, and Kingsgate will be storage deficient. The Inglemoor storage area is projected to be at capacity at buildout.

Although storage facilities are projected to be sufficient until the 10-year planning period, an increased amount of urban development is planned in Kirkland and Kenmore. Dense urban town centers are planned for the Totem Lake, Juanita, Lakepointe, and Downtown Kenmore areas. The District anticipates construction of a new reservoir in the Totem Lake area in the 10-year planning horizon due to this increased rate of development and will reevaluate the anticipated need for additional storage when the plan is updated next.

BOOSTER STATIONS

The Lake Forest Park Booster Station has sufficient capacity to meet demands through 2034. The generator is no longer serviceable and needs to be replaced.

The Inglemoor Booster Station has sufficient capacity to meet demands through 2034. A new CMU structure and upgrades or replacement of all pumps and electrical equipment occurred in 2013. The booster station is in good condition and should not need any upgrades in the 20-year projection period.

The Norway Hill Booster Station has adequate capacity and there are no foreseeable upgrades needed within the planning period.

TRANSMISSION

The Inglemoor Transmission Main has sufficient capacity to supply the Inglemoor Tank Farm through 2034. The transmission main was constructed in 1975 and its design life is 75 years. The City is in the process of assessing the condition and capacity of the transmission main, and no capacity deficiencies or physical condition related deficiencies are identified.

DISTRIBUTION

Overall, the distribution system is in very good condition with sufficient capacity to meet demands through 2034. The capacity analysis and discussion are in Chapter 6.