

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 the ability of the existing facilities to meet the projected water system demands 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).

WATER QUALITY ANALYSIS

SPU provides the District with high-quality, treated drinking water. In 2001, SPU constructed a new Tolt 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 soda ash are also added to adjust the pH for corrosion control. Both water supplies have low alkalinity and are very soft. This makes them more corrosive to plumbing materials. Organic levels are slightly higher in the Tolt than the Cedar, causing higher DBP formation in the Tolt supply. However, the Tolt Treatment Facility has demonstrated success at maintaining low DBP levels.

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. SPU currently takes a minimum of 43 samples per month within the District, in accordance with WAC 246-290-300. As part of the Regional Monitoring Plan, SPU is only required to take 70 percent of the samples normally required for a region with the District's population. The District is responsible for collecting any repeat samples. Between 2000 and 2005, 3,682 bacteriological samples were taken, and three had a detectable coliform concentration. Repeat samples were taken and did not reveal any coliform presence. A copy of the District's Coliform Monitoring Plan is included in Appendix I.

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 5 years. In January 2005, there was a minor coliform monitoring violation when SPU did not collect enough samples. The District sent out public notification of this.

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 monitors chlorine residual at the Lake Forest Park, Norway Hill, and Inglemoor Booster Stations via the District's SCADA system. Finally, each reservoir is checked once per month by District staff to ensure that adequate chlorine residual is being maintained. According to the SPU monitoring reports, the average monthly chlorine residual varies between 0.6 and 1.0 mg/L, with an average of 0.8 mg/L.

DISINFECTION BYPRODUCTS

The District conducted trihalomethane testing on 17 samples collected between 2000 and 2003. All samples were collected after the Tolt Treatment Facility came online in 2000. All but one sample had TTHM levels below the 80 mg/L MCL. The only sample to exceed the MCL occurred shortly after the Tolt Treatment Facility came online and was corrected by adjustments in the treatment system. Eleven samples indicated TTHM levels below 40 mg/L.

SPU collected four HAA5 samples from the District between November 2000 and December 2001. All sample HAA5 concentrations were found to be less than 40 µg/L, which is less than the running annual average MCL of 60 µg/L.

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 system can include components containing lead, such as lead-tin solder and leaded-brass fixtures, that can leach lead and copper into the water. As a result of exceeding the regulatory action level for lead in 1992 and 1997, SPU negotiated a compliance agreement with DOH in 1997. SPU has since met the requirements of the compliance agreement through construction of the Tolt Treatment Facility, covering of two reservoirs on the Tolt system, and changes in disinfection treatment at the two reservoirs. Between 2001 and 2004, SPU conducted additional testing to optimize treatment. In 2003 and 2004, two rounds of lead and copper tap monitoring showed that SPU's water system was in compliance with the regulatory limits. In the fall of 2004, the compliance agreement was terminated.

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 2006 report is included in Appendix H.

WATER RIGHTS ANALYSIS

The District currently obtains all of its water supply from SPU under a Water Right Claim on the Cedar River and a Certificate of Water Right on the Tolt River issued to SPU.

The District, as a member of 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 ten master meters.

The SPU contract does not prohibit the District from withdrawing high instantaneous flows. However, SPU does impose contractual peak season and peak month limitations. 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 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 recently 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.

Alternative Sources of Supply

The District has several emergency interties with adjacent purveyors, but only two can provide supply to the District. The intertie with Water District No. 83 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 PRV. These sources are not used for normal supply.

Physical Condition of Master Meters

In 2005, the District inspected all master meter facilities and identified the condition of each facility in the *Master Meter Operations and Maintenance Manual*. The manual provides an inventory of each master meter facility, including meter type and size, valving, and vault type. A list of recommended improvements related to the condition of each master meter is included in the manual.

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 peak month demands to the flows identified in the SPU contract.

TABLE 7-1

Source of Supply Analysis

Year	2006	2012	2026	Buildout
District Average Day Demand	5.86	6.06	6.55	9.63
<u>SPU Contractual Supply</u>	<u>8.55</u>	<u>8.55</u>	<u>8.55</u>	<u>8.55</u>
ADD Surplus (Deficit)	2.69	2.49	2.00	(1.08)
Peak Month Demand	8.91	9.21	9.96	14.64
<u>SPU Peak Month Supply</u>	<u>14.96</u>	<u>14.96</u>	<u>14.96</u>	<u>14.96</u>
Peak Month Surplus	6.05	5.75	5.00	0.32
Peak Season Demand	7.56	7.82	8.45	12.42
<u>SPU Peak Season Supply</u>	<u>11.97</u>	<u>11.97</u>	<u>11.97</u>	<u>11.97</u>
Peak Season Surplus (Deficit)	4.41	4.15	3.52	(0.45)

The District's demands projected through the 20-year planning period are within the limits of the SPU supply contract. However, the average day and peak season demands exceed the SPU supply contract flows at the buildout scenario (all land fully developed). The District can serve 40,208 ERUs with the SPU supply without triggering a peak demand surcharge. Additional ERUs can be served beyond this limit; however, financial penalties will be imposed by SPU.

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 upgrades to these reservoirs between 2002 and 2005. Upgrades to the storage facilities included seismic improvements, site piping replacement, interior and exterior coatings, and other ancillary upgrades.

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. For purposes of the storage analysis, 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)					
2006	1.25	0.30	3.00	1.31	5.86
2012	1.30	0.32	3.10	1.34	6.06
2026	1.40	0.36	3.27	1.52	6.55
Buildout	2.06	0.51	4.88	2.18	9.63
Maximum Day Demand, MDD⁽¹⁾ (mgd)					
2006	2.51	0.60	6.00	2.62	11.72
2012	2.60	0.64	6.19	2.69	12.12
2026	2.79	0.73	6.55	3.04	13.10
Buildout	4.12	1.02	9.76	4.36	19.26
Peak Hour Demand, PHD⁽¹⁾ (gpm)					
2006	3,500	800	8,300	3,700	16,300
2012	3,600	900	8,600	3,700	16,800
2026	3,900	1,000	9,100	4,200	18,200
Buildout	5,700	1,400	13,600	6,100	26,800

(1) Total system demands are provided in Table 5-16.

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. 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)	(MG)
Lake Forest Park	29	28 ⁽²⁾	22 ⁽²⁾	7	1.05
Inglemoor Reservoirs	39	37 ⁽³⁾	31 ⁽³⁾	8	2.20
Inglemoor Standpipe	103	100 ⁽⁴⁾	97 ⁽⁴⁾	6	0.17
Westhill	121	120 ⁽⁵⁾	109 ⁽⁵⁾	12	0.32
Kingsgate	94	94 ⁽⁶⁾	92 ⁽⁶⁾	2	0.06
Norway Hill	29	28 ⁽⁶⁾	22 ⁽⁶⁾	7	1.17
Total					4.98

- (1) Operational settings as of June 2006.
- (2) Supplied by Master Meter No. 7.
- (3) Supplied by Master Meter No. 5B.
- (4) Supplied by Master Meter No. 4, Inglemoor Booster Station, and Norway Hill Booster Station.
- (5) Supplied by Master Meter No. 5A.
- (6) Supplied by Master Meters No. 1, 2 and 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.

TABLE 7-4
Equalizing Storage

Storage Area	Lake Forest Park	Westhill	Inglemoor	Norway Hill/Kingsgate
Peak Hour Demand (PHD) (gpm)				
2006	3,500	800	8,300	3,700
2012	3,600	900	8,600	3,700
2026	3,900	1,000	9,100	4,200
Buildout	5,700	1,400	13,600	6,100
Source Capacity (gpm)	2,500 ⁽¹⁾	1,000 ⁽²⁾	3,300 ⁽³⁾	5,500 ⁽⁴⁾
Equalizing Storage (MG)				
2006	0.15	0.00	0.75	0.00
2012	0.17	0.00	0.80	0.00
2026	0.21	0.00	0.87	0.00
Buildout	0.48	0.06	1.55	0.09

- (1) The Lake Forest Park Reservoir is supplied by Master Meter No. 7 (2,500 gpm).
- (2) The Westhill standpipe is supplied by Master Meter No. 5A (1,000 gpm).
- (3) The Inglemoor area is supplied by Master Meters No. 4 (300 gpm) and 5B (3,000 gpm).
- (4) The Norway/Kingsgate area is supplied by Master Meters No. 1 (1,500 gpm), No. 2 (1,500 gpm), and No. 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 1.5 MG (5,000 gpm for 5 hours) and is located in the 342 Zone. For purposes of this analysis, the 1.5 MG is split between the Inglemoor, Lake Forest Park, and Westhill storage areas. Table 7-5 provides a summary of the maximum fire flow requirements by storage area.

TABLE 7-5

Fire Suppression Storage

Storage Area	Lake Forest Park	Westhill	Inglemoor	Norway Hill/Kingsgate
Fire Flow Rate (gpm)	3,000	3,000	3,000	3,000
Fire Flow Duration (minutes)	180	180	300	180
Fire Suppression Storage (MG)	0.54	0.54	0.90	0.54
Notes	(1)	(2)	—	—

- (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.

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.

TABLE 7-6

Standby Storage

Year	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/Kingsgate (MG)
2006	2.51	0.60	6.00	2.62
2012	2.60	0.64	6.19	2.69
2026	2.79	0.73	6.55	3.04
Buildout	4.12	1.02	9.76	4.36

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. 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) ⁽⁵⁾	(MG) ⁽⁵⁾
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	1.20
Lake Forest Park	501	418	464	0	0.00
Total					4.08

- (1) Datum is NGVD 1929.
- (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. Figure 7-1 provides a schematic illustration of the storage components.

TABLE 7-8

Summary of Available Storage

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/Kingsgate (MG)
Reservoir Volume	4.40	3.20	13.70	7.80
Contractual Storage	0.00	0.00	0.00	(1.00)
<u>Dead Storage</u>	<u>0.00</u>	<u>(1.64)</u>	<u>(1.24)</u>	<u>(1.20)</u>
Available Storage	4.40	1.56	12.46	5.60

Tables 7-9, 7-10, 7-11, and 7-12 summarize the storage capacity analysis for each storage area for the 2006, 2012, 2026, and buildout scenarios, respectively.

TABLE 7-9

2006 Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/Kingsgate (MG)
2006				
Operational Storage	1.05	0.32	2.37	1.24
Equalizing Storage	0.15	0.00	0.75	0.00
Fire Suppression Storage	0.54	0.54	0.90	0.54
<u>Standby Storage</u>	<u>2.51</u>	<u>0.60</u>	<u>6.00</u>	<u>2.62</u>
Total Required Storage	4.25	1.46	10.02	4.40
<u>Available Storage</u>	<u>4.40</u>	<u>1.56</u>	<u>12.46</u>	<u>5.60</u>
Surplus/(Deficit)	0.15	0.10	2.44	1.20

TABLE 7-10

2012 Storage Capacity Analysis

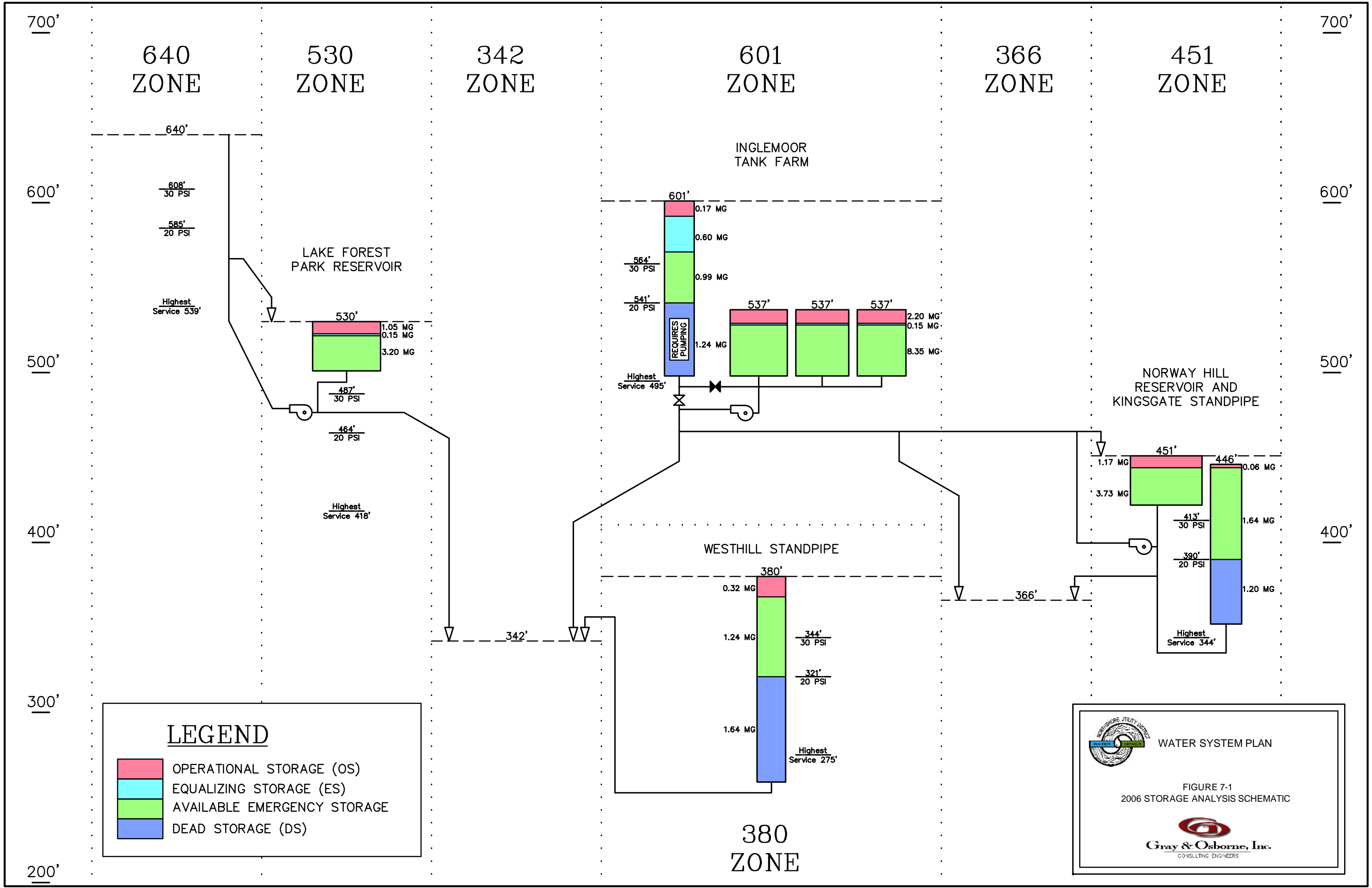
Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
2012				
Operational Storage	1.05	0.32	2.37	1.24
Equalizing Storage	0.17	0.00	0.80	0.00
Fire Suppression Storage	0.54	0.54	0.90	0.54
<u>Standby Storage</u>	<u>2.60</u>	<u>0.64</u>	<u>6.19</u>	<u>2.69</u>
Total Required Storage	4.36	1.50	10.26	4.47
<u>Available Storage</u>	<u>4.40</u>	<u>1.56</u>	<u>12.46</u>	<u>5.60</u>
Surplus/(Deficit)	0.04	0.06	2.20	1.13

TABLE 7-11

2026 Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/ Kingsgate (MG)
2026				
Operational Storage	1.05	0.32	2.37	1.24
Equalizing Storage	0.21	0.00	0.87	0.00
Fire Suppression Storage	0.54	0.54	0.90	0.54
<u>Standby Storage</u>	<u>2.79</u>	<u>0.73</u>	<u>6.55</u>	<u>3.04</u>
Total Required Storage	4.59	1.59	10.69	4.82
<u>Available Storage</u>	<u>4.40</u>	<u>1.56</u>	<u>12.46</u>	<u>5.60</u>
Surplus/(Deficit)	(0.19)	(0.03)	1.77	0.78

M:\NSHORE\06401\FIGURES\FIG 7-1 RESERVOIRS (COLOR).DWG, FIG 7-1, 3/26/2009 11:11:31 AM, PDF-XCHANGE FOR ACROPLOT PRO, BY: P. MARSHALL



LEGEND

- OPERATIONAL STORAGE (OS)
- EQUALIZING STORAGE (ES)
- AVAILABLE EMERGENCY STORAGE
- DEAD STORAGE (DS)


WATER SYSTEM PLAN
 FIGURE 7-1
 2006 STORAGE ANALYSIS SCHEMATIC

 Gray & Osborne, Inc.
 CONSULTING ENGINEERS

TABLE 7-12

Buildout Storage Capacity Analysis

Storage Component	Lake Forest Park (MG)	Westhill (MG)	Inglemoor (MG)	Norway Hill/Kingsgate (MG)
Buildout				
Operational Storage	1.05	0.32	2.37	1.24
Equalizing Storage	0.48	0.06	1.55	0.09
Fire Suppression Storage	0.54	0.54	0.90	0.54
<u>Standby Storage</u>	<u>4.12</u>	<u>1.02</u>	<u>9.76</u>	<u>4.36</u>
Total Required Storage	6.19	1.94	14.58	6.23
<u>Available Storage</u>	<u>4.40</u>	<u>1.56</u>	<u>12.46</u>	<u>5.60</u>
Surplus/(Deficit)	(1.79)	(0.38)	(2.12)	(0.63)

As indicated in Tables 7-11 and 7-12, a storage deficit is projected in 2026 and at buildout. The 2026 deficit can be eliminated by transferring storage from the Inglemoor and Norway Hill/Kingsgate Zones into the Lake Forest Park and Westhill Zones. The storage deficit at buildout is not projected to occur until well after the 20-year planning period and is not an immediate concern.

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 30 hp pumps and one 75-hp pump. The 30 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.

Physical Condition

The interior of the booster station is clean and piping, pumps, and valves are free from corrosion. The generator has historically performed well when needed.

Capacity and Reliability Analysis

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 250 gpm and a combined PHD of 500 gpm in 2026. A project is included in the capital improvement plan that will supply the 530N Zone directly from the Lake Forest Park Reservoir and therefore free up additional capacity for the booster station.

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 1,000 gpm is equal to 1,250 gpm in 2026. The booster station can provide 1,250 gpm at 128 ft TDH with the largest pump out of service. Assuming an inlet head of 510 ft (Lake Forest Park depleted of OS, ES, and FSS), the pump discharge head is 638 feet, or roughly the normal HGL of the pressure zone. 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 six pumps: two 40-hp pumps, two 75-hp pumps, and two 100-hp pumps. All pumps are equipped with constant-speed motors. The combined output of the booster station is 11,000 gpm. The Inglemoor Booster Station is located adjacent to the Inglemoor Tank Farm and is housed in a prefabricated aluminum building constructed in 1962. In 1985, the two 100 hp pumps were installed in the booster station. In 2003, District replaced all piping between the reservoirs and the booster station.

Physical Condition

The electrical systems in the booster station have reached the end of their design life and are due to be replaced. The manual transfer switch will be replaced with an automatic transfer switch. The existing building does not provide sufficient sound-dampening for the standby generator and will also be replaced. As part of these improvements, the District is evaluating the required capacity for the booster station and the most efficient configuration of pump in terms of capacity, power requirements, and reliability.

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 4,550 gpm and a combined PHD of 9,100 gpm in 2026.

The Inglemoor Booster Station has a 270 kW generator that can provide power to two 40-hp pumps and one 75-hp pump for a combined capacity of 4,000 gpm. Under typical circumstances, only the first three pumps operate. This generator currently has a manual transfer switch, although an automatic transfer switch is currently being designed for the booster station.

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 No. 5 via the 24-inch transmission main, directly from Master Meter No. 4, or through the Norway Hill Booster Station. If the Tolt Pipeline HGL is greater than 601, the 24-inch transmission main can flow directly into the 601 Zone at the Inglemoor Tank Farm site. Similarly, flows from Master Meter No. 4 can supply the 601 Zone from near the Norway Hill Reservoir site. The Tolt Pipeline HGL is normally greater than 601 feet, with the exception of peak demand periods (see Figure 4-5).

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 does not operate under normal conditions except to exercise the pumps and motors.

Summary of Booster Station Capacity Analysis

Table 7-13 provides a comparison of the Inglemoor 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

No capacity-related deficiencies are noted at the Lake Forest Park, Inglemoor Booster Station, or Norway Hill Booster Station through 2026.

TABLE 7-13

Summary of Booster Station Capacity Analysis

Year	2006	2012	2026	Buildout
Inglemoor and Norway Hill Booster Stations				
Total Capacity ⁽¹⁾ (gpm)	13,000	13,000	13,000	13,000
Total Demand ⁽²⁾ (gpm)	<u>8,300</u>	<u>8,600</u>	<u>9,100</u>	<u>13,600</u>
Surplus Capacity (Deficit) (gpm)	4,700	4,400	3,900	(600)
Reliable Capacity ⁽³⁾ (gpm)	10,500	10,500	10,500	10,500
Total Demand ⁽²⁾ (gpm)	<u>8,300</u>	<u>8,600</u>	<u>9,100</u>	<u>13,600</u>
Surplus Capacity (Deficit) (gpm)	2,200	1,900	1,400	(3,100)
Lake Forest Park Booster Station				
Total Capacity ⁽¹⁾ (gpm)	2,600	2,600	2,600	2,600
Total Demand ⁽³⁾ (gpm)	<u>1,230</u>	<u>1,240</u>	<u>1,250</u>	<u>1,380</u>
Surplus Capacity (gpm)	1,370	860	850	720
Reliable Capacity ⁽³⁾ (gpm)	1,250	1,250	1,250	1,250
Total Demand ⁽³⁾ (gpm)	<u>1,230</u>	<u>1,240</u>	<u>1,250</u>	<u>1,380</u>
Surplus Capacity (Deficit) (gpm)	20	10	0	(130)

- (1) Total capacity is the sum of all booster pump capacity.
- (2) Total demand is the greater of the maximum day demand plus a 5,000-gpm fire flow or the peak hour demand for the 601 Zone and sub-zones supplied by PRVs.
- (3) Total demand is the maximum day demand plus a 1,000-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 No. 5, 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 10 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 2026, the projected maximum day demand for the area supplied by the Inglemoor Tank farm is 6.55 mgd, or 4,550 gpm over 24 hours.

DISTRIBUTION

The District has a reliable distribution system that has sufficient capacity to provide fire flows to all customers. Chapter 6 discusses the capacity of the distribution system. Between 2000 and 2005, the rate of lost and unaccounted for water in the system was 3.3 percent of total, which includes leaks in piping and under-registering service meters. This value of lost and unaccounted for water 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 1999, the District has replaced over 13,000 lf (one percent of system) of AC, PVC, and CI water main.

A total of 71,000 LF of AC pipe 8 inches and larger in diameter remain in the distribution system, roughly five 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 between 3 and 23 years of useful life remaining.

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 were conducted in 2000 and 2005 on a total of 28 miles of water main. The targeted water mains were those constructed of AC, thin-walled PVC, and CI piping. A total of six leaks totaling 7.25 gpm were identified, including three hydrants that were not seated properly. All identified leaks were 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.

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

All of the system's storage facilities are in excellent physical condition after having been seismically retrofitted over the previous several years. Presently, all reservoirs have a storage surplus. In the 20-year planning period, the storage surplus in the Westhill and Lake Forest Park storage areas is depleted. However, the Inglemoor and Norway Hill/Kingsgate storage areas are projected to maintain a storage surplus through the planning period, which can be transferred to the other storage areas and is sufficient to eliminate the storage deficiencies in the other storage areas.

BOOSTER STATIONS

The Lake Forest Park Booster Station has sufficient capacity to meet demands through 2026. No deficiencies are identified with the booster station.

The Inglemoor Booster Station has sufficient capacity to meet demands through 2026. Non-capacity related improvements are necessary due to the condition and age of the facility. A new super-structure is needed to replace the existing building and to provide additional sound-dampening to the surrounding neighborhood. Installation of an automatic transfer switch is also necessary to improve the level of reliability during a primary power failure. Electrical and mechanical components of the station need to be replaced and upgraded. The District plans to investigate new pumping arrangements and capacities to reduce the number of pumps and booster station footprint.

The Norway Hill Booster Station has adequate capacity for its currently intended use. However, the District plans to increase the capacity of the booster station to provide a reliable and redundant supply to the 601 Zone in case the Inglemoor Transmission Main experiences a failure.

TRANSMISSION

The Inglemoor Transmission Main has sufficient capacity to supply the Inglemoor Tank Farm through 2026. The transmission main was constructed in 1975 and its design life is

75 years. 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 2026. The District has recognized that cast iron, small-diameter asbestos cement, and thin-walled PVC water mains have historically been failure-prone or maintenance-intensive. Much of these pipe types have been replaced during the previous 10 years, and the District plans to continue to replace these water mains to minimize risk of future failures and to maintain the low rate of lost and unaccounted for water.