SAMMAMISH PLATEAU WATER

KING COUNTY **WASHINGTON**

NORTH DIVERSION INTERIM IMPROVEMENT EVALUATION

G&O #15490
SEPTEMBER 2016

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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EXECUTIVE SUMMARY

PURPOSE

The Sammamish Plateau Water & Sewer District (District) approved its Wastewater Comprehensive Plan in 2013 (2013 Plan). The 2013 Plan recommended that the North Diversion sewer interceptor be constructed and in service by 2018 in order to accommodate the District's planned growth and demands. Since then, King County Wastewater Treatment Division (KCWTD) has estimated that the earliest the North Diversion could be in service is 2026. The purpose of this analysis is to fine-tune the assumptions made in the 2013 Plan with a specific emphasis on analysis of the basins impacted by the future North Diversion, to identify potential interim improvements that can delay the District's need for the North Diversion until its completion, and to identify additional capital projects that could expand the service area of the North Diversion to other basins within the District.

KING COUNTY

King County's schedule for constructing the North Diversion has the District concerned about managing its short-term growth. Prioritization of this project by King County will raise the County's level of service to the District to a status commensurate with other King County partners. The District currently has one connection to the King County Conveyance System, whereas most other agencies – some with fewer customers, smaller service areas, or both – have multiple connections. District planning for many years has included the North Diversion, and the existing District facilities were not designed for long term use by the District's northern service area. Until the North Diversion is constructed, the District will continue to have limited options for service; service that is significantly less than the established standard of one King County connection per 1,000 acres.

The District would like to be recognized for its efforts to reduce inflow and infiltration (I/I). As good stewards of their own system, it has allowed King County to postpone the North Diversion. The District would like to urge King County to reciprocate this diligence when working through their process to develop the North Diversion to help the District to avoid stranded capital investments that do not serve the District's long-term needs.

DISTRICT GROWTH

Growth projections, domestic flow, and I/I in the 2013 Plan were revisited and refined to obtain a more accurate representation of expected growth within the District for the next 10 years. In general, the number of connections has grown and will grow (according to projections) more than the data presented in the 2013 Plan. In particular, development within the City of Sammamish's Town Center is underway. At the same time, per capita domestic water consumption has been reduced. I/I rates have been revised upwards

based on data from a storm monitored in 2015 that had greater intensity than the peak storm evaluated in the 2013 Plan.

MODEL RESULTS

The hydraulic model was reconfigured to include the new information (i.e., population, domestic flow, and I/I rates) obtained by the District and from a field test performed to calibrate the model. The model results are consistent with the results shown in the 2013 Plan and the areas of concern in the 2013 Plan still remain. As such, the most critical areas to evaluate for interim improvements include the corridor along East Lake Sammamish Parkway and the North and Central Lake Lift Stations.

Based on the District's forecasts and the updated hydraulic model, the existing facilities lack capacity to meet the anticipated growth and subsequent flows from the Inglewood Lift Station tributary basins over the next 10 years. As a result, the District will need to evaluate options (i.e., modification, system improvements, etc.) in order to accommodate this growth during the interim period before the North Diversion is in place.

INTERIM IMPROVEMENTS

Interim improvements were evaluated for accommodating future growth in the District. These include:

1. Evaluate the hydraulics at North Lake and Central Lake Lift Stations to identify potential mechanical improvements to increase capacity.

2. Install variable frequency drive (VFD) motor starters at Inglewood Lift Station.

3. Increase storage at the North Lake Lift Station.

4. Increase storage at the Central Lake Lift Station.

5. Increase pumping capacity and force main diameter at the Central Lake Lift Station.

These improvements were assessed based on short-term capacity improvement, cost, and long-term value. Improvements that are not necessary in the long term are considered "stranded investments." Stranded investments are those projects and investments in infrastructure that would be unnecessary after the North Diversion is in service. The goal when evaluating interim improvement options is to minimize stranded investments in favor of long-term more cost-effective solutions whenever possible.

SUMMARY

The District is developing faster than estimated in the 2013 Plan, and because King County is not anticipating construction of the North Diversion until 2026, the District must now evaluate different system improvement options in order to meet the demands for the next 10 years. We recommend the District implement the proposed interim improvements in the order they are presented in Table E-1. This list is prioritized by cost and future need, and attempts to limit stranded investments. These costs are summarized in Table E-1 and the locations are shown on Figure 7.

TABLE E-1

Summary of Interim Improvement Costs

No.	Location	Improvement	Cost	Stranded Investment
1	North and Central Lake Lift Stations	Pump 2 Hydraulic Study	$15,000	$0
2	Inglewood Lift Station	Install VFDs	$235,000	$0
3	North Lake Lift Station	Increase Wet Well Storage	$350,000	$0
4	Central Lake Lift Station	Increase Wet Well Storage	$350,000	$350,000
5	Central Lake Lift Station	Upgrade Force Main and Pumps	$1,400,000	$1,400,000
Total			**$2,350,000**	**$1,750,000**

INTRODUCTION AND PURPOSE

The Sammamish Plateau Water & Sewer District (District) contracted with Gray & Osborne to revisit the analysis and discussion included in Chapter 4 of the *2013 Wastewater Comprehensive Plan* (2013 Plan). The 2013 Plan indicated that the North Diversion sewer interceptor was required to be in service by 2018 in order to accommodate the District's planned growth and demands. Since then, King County Wastewater Treatment Division (KCWTD) has estimated that the earliest the North Diversion could be in service is 2026. The purpose of this analysis is to fine-tune the assumptions made in the 2013 Plan to refine the needs for the District's northern sewer basins, and to identify potential interim improvements that can delay the District's need for the North Diversion.

The purpose of this document is to identify the improvements required for the continued addition of sewer connections in the Inglewood Lift Station basins by evaluating the following:

- Refine the assumptions used in the 2013 Plan in greater detail, including domestic flow projections and inflow and infiltration (I/I) assumptions for the impacted basins;
- Identify potential interim and temporary improvements that can be made to allow continued growth in the Inglewood Lift Station basins until the North Diversion is in service, and identify the triggers or thresholds of when these interim improvements would need to be implemented; and
- Evaluate additional basins for future redirection to the North Diversion (North Diversion Added Basins).

BACKGROUND

In 2011, the District contracted with Gray & Osborne for the update of its Wastewater Comprehensive Plan/General Sewer Plan, which was completed in 2013 and approved in 2014, herein identified as the 2013 Plan. This work defined existing and future sewer flows for the District, including domestic and I/I flows. The 2013 Plan also put a significant amount of emphasis on identifying improvements required for basins in the northern portion of the District, specifically the Inglewood, North Lake Sammamish, and Central Lake Sammamish basins. The North Lake and Central Lake Lift Stations are nearing their pumping capacities. These stations currently pump to the District's South Interceptor system on an interim basis until KCWTD constructs the North Diversion Interceptor, where the Inglewood Lift Station has been designed to pump. According to the assumptions presented in the 2013 Plan, the North Diversion needs to be in service by 2018 or else the District risks capacity problems downstream of the Inglewood Lift Station. To improve reliability, the District installed a third pump in both the North Lake and Central Lake Lift Stations in 2015. Since the 2013 Plan was published, KCWTD has

indicated that the earliest the North Diversion could be in service is approximately 2026. The North Diversion Sewer Basins are shown on Figure 1.

DOMESTIC FLOW EVALUATION

Table 1 summarizes the District's average winter water consumption over a 7-year period from 2005 to 2011, as shown in the 2013 Plan (Table 2-14), using Residential Customer Equivalents (RCEs).

TABLE 1

2005 to 2011 District Sewer RCE Summary (2013 Plan, Table 2-14)
Single-Family Residential – All District Basins

Year	Sewer RCE[(1)] (gpd/RCE)
2005	161
2006	160
2007	161
2008	156
2009	155
2010	153
2011	149
Average	**155**

(1) Winter water consumption based on District billing from November through February.

According to Table 1, the average sewer RCE from 2005 to 2011 was 155 gpd/RCE. As shown in the table, sewer RCEs have been trending downward over the years as households are consuming less water (e.g., improved fixtures, plumbing code modifications, water conservation education). Consequently, the District wanted to update Table 1 with the most recent available data to determine if the sewer RCE continued to reduce. Table 2 provides a summary of the average winter water consumption from 2011 to 2014 for the North Diversion sewer basins. Table 3 provides a summary of the average winter water consumption from 2011 to 2014 for only the Inglewood sewer basin and its tributaries.

N

0 1,200 2,400 4,800 Feet

1 inch = 2,400 feet

LAKE SAMMAMISH

NORTH LAKE SAMMAMISH

CENTRAL LAKE SAMMAMISH

TIBURON

INGLEWOOD EAST

NORTHEAST PLATEAU

BEAVER DAM

NORTH SUNNYHILLS

SOUTH PINE LAKE

YELLOW LAKE

PINE LAKE

BEAVER LAKE

North Lk Samm LS

Central Lk Samm LS

Pine Lk Glen LS

Pine Lk Hts LS

First Branch LS

Redford Hudson LS

Todd's Landing LS

Inglewood LS

Camden Park LS

Beaver Dam LS

The Greens LS

Beaver Lk Estates LS

NE 24TH ST

NE INGLEWOOD HILL RD

NE 8TH ST

SE 8TH ST

SE 20TH ST

SE 24TH ST

SE 32ND ST

SE KLAHANIE BLVD

SAMMAMISH PKWY NE

EAST LAKE SAMMAMISH PKWY NE

WEST LAKE SAMMAMISH PKWY NE

SAHALEE WAY NE

NE REDMOND FALL CITY RD

NE AMES LAKE RD

LOUIS THOMPSON RD NE

216TH AVE NE

228TH AVE NE

244TH AVE NE

E MAIN DR

218TH AVE SE

212TH AVE SE

228TH AVE SE

244TH AVE SE

LEGEND:

- EXISTING LIFT STATION
- LOW PRESSURE FORCE MAIN
- FORCEMAINS & TIGHTLINES

GRAVITY MAINS:

- ≤ 8"
- > 8"
- DISTRICT FUTURE SEWER SERVICE BOUNDARY
- WATER
- PARCELS - KING COUNTY GIS

DATA SOURCE: KING COUNTY AND SAMMAMISH PLATEAU WATER & SEWER DISTRICT

SAMMAMISH PLATEAU WATER & SEWER DISTRICT

NORTH DIVERSION INTERIM IMPROVEMENTS EVALUATION
FIGURE 1
NORTH DIVERSION SEWER BASINS

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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TABLE 2

Single-Family Residential – North Diversion Basins(1)

Year (winter)	Sewer ERU	Connections	Total Winter Use (cf)	Total Winter Use (gal)	Gallons/Day (120 days)	Sewer RCE(2) (gpd/ Connection)
2011	2,397.5	2,342	6,060,730	45,340,321	377,836	161.3
2012	2,482.0	2,425	5,912,743	44,233,230	368,610	152.0
2013	2,583.0	2,523	6,109,382	45,704,287	380,869	151.0
2014	2,613.0	2,556	6,135,772	45,901,710	382,514	149.7
Average						**153.5**

(1) All sewer basins in the North Diversion: Beaver Dam, Northeast Plateau, Inglewood East, North Lake Sammamish, and Central Lake Sammamish.

(2) Based on single-family residential customers. Does not include multifamily and non-residential customers.

TABLE 3

Single-Family Residential – Inglewood Tributary Basins(1)

Year (winter)	Sewer ERU	Connections	Total Winter Use (cf)	Total Winter Use (gal)	Gallons/Day (120 days)	Sewer RCE(2) (gpd/ Connection)
2011	1,610.5	1,606	3,933,237	29,424,546	245,205	152.7
2012	1,621.5	1,617	3,882,743	29,046,800	242,057	149.7
2013	1,654.5	1,650	3,933,376	29,425,586	245,213	148.6
2014	1,648.5	1,644	3,915,242	29,289,925	244,083	148.5
Average						**149.9**

(1) Basins include: Beaver Dam, Northeast Plateau, and Inglewood East.

(2) Based on single-family residential customers. Does not include multifamily and non-residential customers.

In addition to determining a new average sewer RCE, we compared old connections to new connections. This information will refine the assumptions in the 2013 Plan, will be used to update the hydraulic model, and will provide a more accurate representation of sewer demands for new connections just placed into service. Table 4 is a further breakdown of Table 3 and shows the 2012 to 2013 winter water consumption for single-family connections in each of the North Diversion Sewer Basins.

TABLE 4

New Single-Family Residential Connections (2012 to 2013)[1]

Basin Name[2]	Sewer ERUs	Connections	Total Winter Use (cf)	Total Winter Use (gal)	Gallons/Day (120 days)	Sewer RCE[4] (gpd/ connection)
Beaver Dam	3.0	3	6,700	50,123	418	139.2
Central Lake Sammamish	2.0	2	3,000	22,443	187	93.5
Inglewood East[3]	48.5	47	75,000	561,075	4,676	99.5
North Lake Sammamish	125.0	125	281,900	2,108,894	17,574	140.6
Northeast Plateau	29.0	29	67,200	502,723	4,189	144.5
Total	**207.5**	**206**	**433,800**	**3,245,257**	**27,044**	**131.3**

(1) The average Residential Customer Equivalent (RCE) from the Comp. Plan was 155 gallons/connection.

(2) No new service connections from the Tiburon Sewer Basin were included in the data set.

(3) One SF connection has 2.5 ERUs which indicates the property has a 1-inch meter. The District follows AWWA standards thus calculating ERUs based on the diameter of the water service, which explains the difference between "Water ERUs" and "Connections" for the Inglewood East basin.

(4) Based on single-family residential customers. Does not include multifamily and non-residential customers.

Based on the information provided in Tables 2, 3 and 4, the winter water consumption appears to be reducing over time. In the 2013 Plan, the District used 155 gpd/RCE, the previous 5-year average for winter water consumption, for modeling sewer flows for existing and future flows. Using the District's new connection data, the 5-year average is approximately 150 gpd/RCE. To acknowledge the reduction in water consumption for newer customers the District plans to use 155 gpd/RCE for existing connections, as of December 2015, and 150 gpd/RCE for all new connections after December 2015.

GROWTH PROJECTIONS

In January 2016, the District provided Gray and Osborne with revised, meter-based ERUs expected for sewer customers between 2015 and 2020. These new values will be used to update the domestic flows and the inflow and infiltration for the same time period, including 2026; the year the North Diversion is planned to be in service. It appears the new projections are slightly higher than those in Table 2-9 in the 2013 Plan. (For example, the 2013 Plan estimated a total of 16,892 meter-based ERUs in 2022, whereas the revised values project 16,988 meter-based ERUs in 2020 resulting in more meter-based ERUs in a shorter time period.) This indicates that the District is currently growing marginally faster than the rates provided in the 2013 Plan.

TABLE 5

Updated Sewer ERU Projections

District Sewer Basin	2012 Area (acre)	Buildout Area (acre)	Revised Data[1]							2013 Plan Data[2]	
			2015	2016	2017	2018	2019	2020	2026	2032	Buildout
Beaver Dam	428	466	780.0	780.0	780.0	780.0	780.0	780.0	875.5	971.0	1,244.0
Central Lake Sammamish	90	482	255.0	255.0	264.0	264.0	267.0	267.0	370.5	474.0	715.0
Freegard	389	737	1,384.0	1,429.0	1,462.0	1,462.0	1,462.0	1,478.0	1,675.0	1,872.0	2,510.0
Inglewood East	404	918	1,863.0	1,873.0	2,039.0	2,039.0	2,087.0	2,092.0	2,646.0	3,200.0	4,607.0
Laughing Jacobs	427	606	1,774.5	1,880.5	1,909.5	2,035.5	2,042.5	2,042.5	2,060.0	2,077.0	2,309.0
Mallard Bay	63	350	351.5	351.5	351.5	351.5	351.5	351.5	410.0	468.0	581.0
North Lake Sammamish	318	1,529	1,033.5	1,047.5	1,163.5	1,166.5	1,268.0	1,314.0	1,741.5	2,169.0	3,616.0
North Sunnyhills	318	1,311	1,489.5	1,495.0	1,661.0	1,681.0	1,727.0	1,821.5	2,192.0	2,563.0	3,788.0
Northeast Plateau	45	608	140.0	202.0	345.0	404.0	439.0	465.0	600.5	736.0	1,207.0
South Pine Lake	461	669	1,458.5	1,458.5	1,512.5	1,555.5	1,573.5	1,576.5	1,677.0	1,778.0	2,166.0
Tiburon	0	262	40.0	40.0	40.0	40.0	40.0	40.0	179.0	318.0	635.0
Trossachs	468	826	1,491.5	1,521.5	1,521.5	1,521.5	1,521.5	1,521.5	1,589.0	1,640.0	1,795.0
Yellow Lake	638	960	3,224.5	3,225.5	3,225.5	3,225.5	3,238.5	3,238.5	3,363.0	3,487.0	3,871.0
Total	**4,049**	**9,724**	**15,285.5**	**15,559.0**	**16,275.0**	**16,526.0**	**16,797.5**	**16,988.0**	**19,379.0**	**21,753.0**	**29,044.0**

(1) District provided revised meter-based ERUs for the years from 2015 to 2020, inclusive.

(2) Meter-based ERUs for 2032 and buildout are the same as the 2013 Plan.

INFILTRATION AND INFLOW

The revised projections in Table 5 were then converted to sewer RCEs using the average RCE/ERU Ratio of 0.88 RCE/ERU that was derived in Table 2-15 in the 2013 Plan and used to develop updated domestic and I/I flows. The updated domestic and I/I flows for 2015, 2020, and 2026 are provided in Table 6. Flows were derived for 2026 because that is the assumed date the North Diversion will be constructed.

In addition to the updated water consumption data, the District also provided new flow meter data for each of the lift stations in the North Diversion area to determine if I/I has reduced, increased, or remained approximately the same relative to the rates established in the 2013 Plan. The sewer basins reevaluated include Beaver Dam, Central Lake Sammamish, Inglewood East, North Lake Sammamish, and Northeast Plateau. The results, as shown in Table 6, suggest that I/I has reduced in Beaver Dam and increased in Central Lake Sammamish, Inglewood East, North Lake Sammamish, and Northeast Plateau. (It should be noted that the December 2015 rain event selected for this report was a record rainfall event and had more precipitation than the rainfall event used for the 2013 Plan.)

TABLE 6

Updated Sewer Flow Projections[(1)]

District Sewer Basin	2015 Sewer Flows				2020 Sewer Flows				2026 Sewer Flows[(2)]			
	Sewer RCEs	Peak Hour Domestic Flow (gpd)	Peak Hour I/I Flow (gpd)	Peak Hour Incl. I/I (gpd)	Sewer RCEs	Peak Hour Domestic Flow (gpd)	I/I Flow (gpd)	Peak Hour Incl. I/I (gpd)	Sewer RCEs	Peak Hour Domestic Flow (gpd)	Peak Hour I/I Flow (gpd)	Peak Hour Incl. I/I (gpd)
Beaver Dam	686	177,675	62,608	240,283	686	177,675	118,106	295,781	770	198,727	185,996	384,723
Central Lake Sammamish	224	88,694	36,540	125,234	235	92,733	68,702	161,436	326	127,571	120,239	247,811
Freegard	1,218	317,146	240,285	557,431	1,301	337,992	295,932	633,923	1,474	381,679	370,900	752,579
Inglewood East	1,639	421,828	147,517	569,345	1,841	472,006	219,458	691,465	2,329	593,399	322,107	915,506
Laughing Jacobs	1,562	517,969	416,304	934,273	1,797	593,674	445,611	1,039,285	1,813	598,547	483,464	1,082,011
Mallard Bay	309	122,259	23,688	145,947	309	122,259	46,366	168,625	361	141,866	83,525	225,391
North Lake Sammamish	910	359,472	168,206	527,678	1,156	453,888	279,520	733,409	1,533	597,785	447,906	1,045,691
North Sunnyhills	1,311	485,571	310,845	796,416	1,603	590,310	427,587	1,017,898	1,929	707,275	580,600	1,287,875
Northeast Plateau	123	31,890	21,141	53,031	409	103,533	55,143	158,677	528	133,403	116,786	250,189
South Pine Lake	1,284	555,041	387,324	942,365	1,387	598,498	426,647	1,025,145	1,476	635,602	476,854	1,112,457
Tiburon	35	13,913	8,178	22,091	35	13,913	23,378	37,291	158	60,700	50,036	110,736
Trossachs	1,313	398,744	503,415	902,159	1,339	406,505	553,022	959,527	1,391	421,834	615,055	1,036,889
Yellow Lake	2,838	862,051	673,254	1,535,305	2,850	865,673	720,573	1,586,245	2,959	897,819	778,962	1,676,780
Total	**13,452**	**4,352,253**	**2,999,305**	**7,351,557**	**14,948**	**4,828,660**	**3,680,046**	**8,508,706**	**17,047**	**5,496,206**	**4,632,430**	**10,128,636**

(1) See Figure 7 for a map of the District's sewer system.

(2) District provided revised Sewer RCEs for 2015 to 2020, inclusive. Sewer RCEs and related data for 2026 were interpolated from the updated 2020 data and the forecast data in the 2013 Plan.

HYDRAULIC MODEL

Using the flows provided in Table 6, a hydraulic analysis was performed utilizing the InfoSewer modeling program provided by Innovyze. The development of the hydraulic model was based upon the previous model used for the 2013 Plan. The model was done as an Extended Period Simulation (EPS) model as opposed to a steady state model in order to account for attenuating flows throughout the District. The output from this model is used to evaluate the capacity of the existing collection system and to identify improvements that will be required to handle wastewater flows over the next 10 years.

Flow attenuation is a weakening of intensity over a long distance. This is in contrast to plug flow, where intensity is not reduced or dispersed. In the case of the Inglewood Lift Station, the short bursts of high flow rate (2,700 gpm for a period of less than two minutes) spread out and lose intensity as sewer travels to the North Lake Lift Station, resulting in a steady flow rate at the North Lake Lift Station, rather than the noticeable surges one would expect to occur. This attenuation of flow is critical when evaluating the actual impacts of the Inglewood Lift Station on downstream facilities and is discussed in greater detail in subsequent sections.

Three scenarios of projected flows were modeled for the purpose of analyzing the District's gravity mains in the near term. The first scenario includes a hydraulic model that was developed for 2015, which represents the existing sewer collection system. This approach was used to identify any existing pipeline deficiencies. The remaining two scenarios included modeling the anticipated years 2020 and 2026 flows so as to analyze the effect of projected growth over the next decade.

The flows described in Table 6 were assigned to each manhole per the Thiessen Polygon method. Each parcel has been analyzed to determine the nearest manhole to the centroid of that parcel using these Thiessen polygons. It is assumed that the nearest manhole to the centroid of each parcel will act as the recipient of domestic or commercial wastewater flows from that parcel.

InfoSewer then applied individual diurnal peaking curves to these average domestic flows. There were a total of nine peaking curves that were applied throughout the model. The areas where these peaking curves were applied to within the model were based on the flow monitoring locations described within the 2013 Plan.

MODEL CALIBRATION

Gray & Osborne and the District conducted a Field Test on June 15, 2016. The intent of the Field Test was to measure actual flows at various times and locations between Inglewood Lift Station and North Lake Lift Station and compare them to the hydraulic model. Attenuation appears to be the main reason North Lake Lift Station is not overwhelmed by Inglewood Lift Station flows because the capacity of Inglewood Lift

Station (2,600 gpm) is significantly greater than North Lake Lift Station (1,100 for one pump and 1,438 gpm for two pumps).

The District installed a flow monitor in a manhole upstream of North Lake Lift Station that recorded sewer flows at 15-second intervals during the field test. The field test took place between 11:00 a.m. and 12:00 p.m. Green dye was poured into the discharge manhole where the force main of the Inglewood Lift Station discharges into to help visually determine: (1) how long it takes the Inglewood Lift Station flows to reach the North Lake Lift Station; and (2) the duration those flows are present. The large pumps at Inglewood were turned on at 11:00 a.m. and pumped for 1 minute 50 seconds at approximately 2,600 gpm amounting to 4,800 gallons. Based on visual inspection, the green dye was detected 40 minutes after the pumps at Inglewood were turned on and dissipated after 12 minutes. During this time, the flows ranged from 250 gpm to 530 gpm. In summary, the same flow at the discharge manhole that lasts for 1 minute 50 seconds, it takes 40 minutes to reach the North Lake Lift Station, and lasts for 12 minutes. This indicates significant attenuation occurs.

The attenuation witnessed during the field test was more than the results shown in the hydraulic model. The hydraulic model shows flows ranging from 200 gpm to 800 gpm, whereas the flow monitor ranged from 250 gpm to 550 gpm during the same time period. The model results are provided on Figure 2.

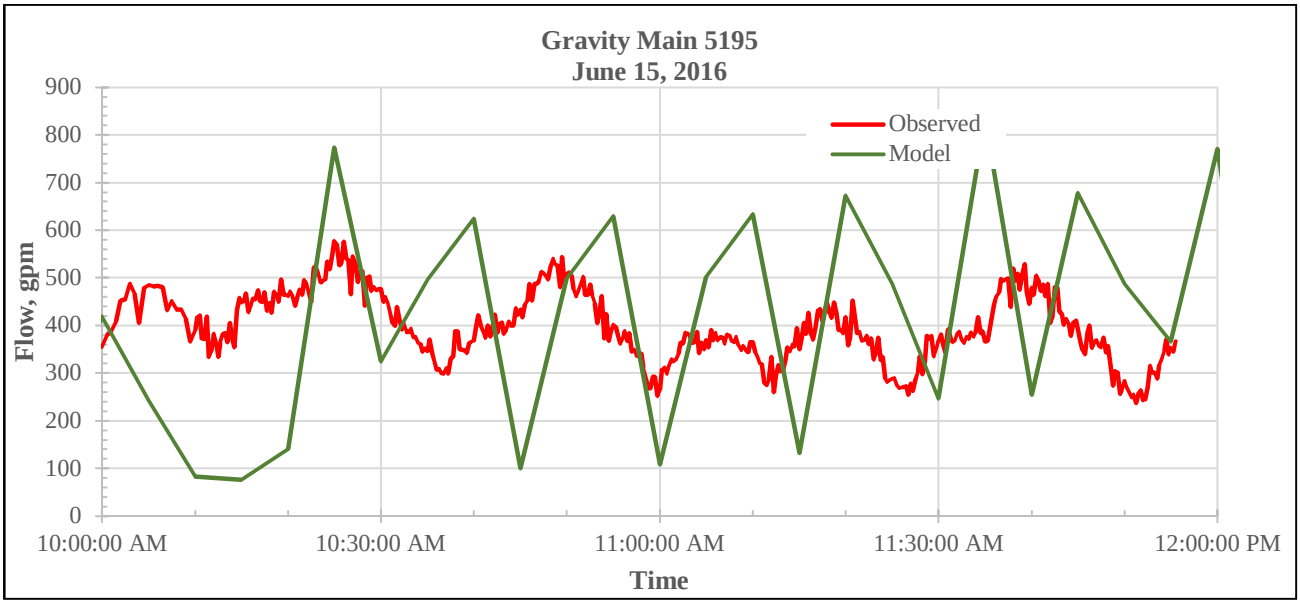

FIGURE 2

Model Results Upstream of North Lake Lift Station

Although the model results do not perfectly match the field test, it does show that attenuation is a major factor in reducing the flows at North Lake. And, because the

attenuation appears to be much greater in the field, we expect that using the model results would be relatively conservative for the present and for planning purposes in the future.

MODELING RESULTS

The hydraulic model determines pipeline capacity deficiencies by comparing design capacity with total projected flow in isolated, individual pipe segments. A deficiency resulting in the model is defined as a surcharged pipe or a pipe experiencing flow above the crown of the pipe during peak conditions. This evaluation, however, is not complete until a surcharge analysis is prepared. A surcharge analysis considers both upstream and downstream conditions to establish a hydraulic grade line over the manholes modeled within InfoSewer. A surcharged pipeline can be a priority due to the potential for backups into residential or commercial services.

Deficiencies identified within years 2015, 2020, and 2026 scenarios are summarized in Table 7 and on Figures 3 and 4. As seen in Table 7, a total of six segments in the North Diversion study area are shown to have insufficient pipeline capacity throughout out all three scenarios (2015, 2020, and 2026). The model demonstrated that an increase in the number of surcharged pipes throughout the course of the next 10 years is not anticipated. No new surcharged pipes are expected to be seen; only the problems that may exist today. However, in analyzing the model results, it should be noted that a minor amount of surcharging was seen within the model and that this surcharging may be found to be acceptable by the District if the amount is negligible. The District should also consider whether these pipes are truly an issue within the field today so as to ground truth the results of the model.

LAKE
SAMMAMISH

Pipe 5199: 20" Diam.
(Pipe full, No surcharge upstream)

North Lk Samm LS

N

0 250 500 1,000
Feet

LEGEND:

- LIFT STATIONS
- SEWER MANHOLE
- FORCEMAINS
- SEWER GRAVITY LINES
- DISTRICT BOUNDARY
- PARCELS - KING COUNTY GIS

SOURCE: KING COUNTY AND SAMMAMISH PLATEAU WATER & SEWER DISTRICT

SAMMAMISH PLATEAU
WATER & SEWER DISTRICT

NORTH DIVERSION INTERIM
IMPROVEMENTS EVALUATION
2015 - 2026 SYSTEM DEFICIENCIES
FIGURE 3

Gray & Osborne, Inc.

M:\SammPlat\15490 North Diversion Interim Improvements Evaluation\Figures\Fig 3 deficient pipes.mxd

Pipe 4667: 15" Diam.
(0.2' surcharge upstream)

Pipe 5237: 15" Diam.
(0.1' surcharge upstream)

Pipe 5243: 15" Diam.
(0.2' surcharge upstream)

Pipes 5256 and 369: 15" Diam.
(0.1' surcharge upstream)

Central Lk Samm LS

LAKE
SAMMAMISH

East Lake Sammamish Pl SE
East Lake Sammamish Trl
SE 23rd St
SE 23rd Pl
202nd Ave SE
SE 24th St
201st Ave SE
Private Rd
SE 25th St
SE 26th St
SE 24th Pl
196th Ave SE
SE 25th Pl
SE 28th Pl
194th Pl SE
SE 27th Pl
200th Ave SE
194th Ave SE
SE 24th Way
SE 29th St
SE 30th St
202nd Pl SE
197th Ave SE
198th Ave SE
199th Ave SE
SE 31st Pl
East Lk Sammamish Sh Ln SE
SE 32nd St
SE 33rd St
East Lake Sammamish Pkwy SE

N

0 250 500 1,000 Feet

LEGEND:

- LIFT STATIONS
- FORCEMAINS
- SEWER MANHOLE
- SEWER GRAVITY LINES
- DISTRICT BOUNDARY
- PARCELS - KING COUNTY GIS

SOURCE: KING COUNTY AND SAMMAMISH PLATEAU WATER & SEWER DISTRICT

SAMMAMISH PLATEAU
WATER & SEWER DISTRICT

NORTH DIVERSION INTERIM
IMPROVEMENTS EVALUATION
2015 - 2026 SYSTEM DEFICIENCIES
FIGURE 4

Gray & Osborne, Inc.

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TABLE 7

Model Results and Deficiencies for Years 2015, 2020, and 2026

Model Pipe ID	OID_PK No.	Basin	Location	Diam. (in.)	2015 Peak Flow (gpm)	2020 Peak Flow (gpm)	2026 Peak Flow (gpm)	Pipe Capacity (gpm)	Max Upstream Surcharge (ft)	Model Observation
4667	4079	Central Lake Sammamish	East Lake Sammamish Place SE	15	1,444	1,446	1,448	1,309	0.2	Surcharge likely due to downstream (Pipe 5237)
5237	1545	Central Lake Sammamish	East Lake Sammamish Pkwy/SE 25th Street	15	1,445	1,447	1,449	1,397	0.1	Slope could be slightly increased
5243	1550	Central Lake Sammamish	East Lake Sammamish Pkwy	15	1,462	1,469	1,476	1,066	0.2	Minimal slope
5266	2018	Central Lake Sammamish	Central Lake Sammamish Lift Station	15	1,505	1,538	1,565	439	0.1	Due to capacity limitation at Central LS
369	306	Central Lake Sammamish	Central Lake Sammamish Lift Station	15	1,505	1,538	1,565	1,217	0.0	Due to capacity limitation at Central LS
5199	2913	North Lake Sammamish	East Lake Sammamish Pkwy	20	877	1,288	1,658	198	0.0	Flat pipe

LIFT STATION CAPACITY ANALYSIS

The following sections detail the existing capacity of the impacted lift stations and identify required capacities based on results from the hydraulic model.

NORTH LAKE LIFT STATION

Currently all flows from the Inglewood Lift Station discharge into the North Lake Sammamish (North Lake) Sewer Basin and flow into and then pumped by the North Lake Lift Station to the Central Lake Sewer Basin.

In 2015, the District installed a third pump at North Lake and Central Lake Lift Stations for redundancy and to mitigate risk should the second pump not turn on when flows at the station are greater than the single-pump capacity. Drawdown tests performed by Gray & Osborne in 2015 indicate a two-pump capacity of 1,438 gpm at the North Lake Lift Station.

The Inglewood Lift Station alone has a greater capacity than the North Lake Lift Station; Inglewood, when operating the large pumps, pumps sewage at 2,585 gpm, while the capacity of North Lake Lift Station (with two pumps operating) is 1,438 gpm. One of the reasons the North Lake Lift Station is able to function without flooding is because of the distance between discharge location for the Inglewood Lift Station force main and the North Lake Lift Station wet well. This distance and the short pumping durations at the Inglewood Lift Station allow the pumped flows from Inglewood Lift Station to attenuate before reaching the North Lake Lift Station. This has been demonstrated in the hydraulic model and confirmed in the field.

Significant growth identified in both the Inglewood tributary basins and the North Lake basin raises concerns that longer run times of the Inglewood Lift Station will be required, exceeding the capacity of the North Lake Lift Station.

If the North Diversion is installed in the near future, sewer flows from Inglewood Lift Station would be diverted and no longer conveyed to the North Lake Lift Station. This would reduce flows conveyed to the North Lake Lift Station. As a result, construction of the North Diversion will delay required capacity improvements to the North Lake Lift Station until beyond the 2032 planning period.

CENTRAL LAKE LIFT STATION

All flows from the North Lake Lift Station discharge into the Central Lake Sewer Basin and flow into and are then pumped by the Central Lake Lift Station to KCDNR via the twin 20-inch, gravity tightlines along East Lake Sammamish Parkway. Drawdown tests performed by Gray & Osborne in 2015 indicate a two-pump capacity of 1,393 gpm at the Central Lake Lift Station.

Central Lake Lift Station has less pumping capacity than North Lake Lift Station and therefore less capacity than Inglewood Lift Station. This can be a problem during storm and high flow events because the longer the pumps operate at North Lake Lift Station the more likely it is that the incoming flow to Central Lake Lift Station will exceed its capacity.

INGLEWOOD LIFT STATION

No drawdown tests were performed at the Inglewood Lift Station because the District has not modified the pumps since the publishing of the 2013 Plan. Based on the 2013 Plan, the Inglewood Lift Station capacity is estimated as 778 gpm for each of the two small pumps and 2,585 gpm for each of the large pumps.

The Inglewood Lift Station was designed for total buildout and eventual construction of the North Diversion. However because the flows were less when the station was originally built and the existing downstream facilities do not have capacity for the normal use of the large (2,600 gpm) pumps, the design included small pumps for interim use and large pumps to scour the force main and then used full time once the incoming flows demand the larger pumps.

The District normally operates the large pumps for 22 hours and the small pumps for 2 hours each day. According to the 2013 Plan, as recent as 2013 the large pumps were only engaged to prevent solids deposition in the force main. However, because the small pumps are unable to adequately scour the force main, the District has increased its use of the large pumps. The large pump operating time is limited to less than 3 minutes because they would overwhelm the downstream facilities if they operated longer. Downstream concerns include surcharging manholes and pipelines along East Lake Sammamish Parkway, and sending more flow than the capacity of the North Lake Sammamish Lift Station. This is a long-term concern for the District and it will be addressed in subsequent sections.

LIFT STATION MODEL RESULTS

Gray & Osborne visited the District in August 2015 to perform drawdown tests on the North Lake Lift Station and Central Lake Lift Station because the District installed third pumps (since the 2013 Plan) to improve redundancy. The drawdown results for the North Lake and Central Lake Sammamish Lift Stations are provided in Table 8. The capacities provided in Table 8 represent two pumps operating simultaneously.

TABLE 8

North Lake Lift Station and Central Lake Lift Station Capacity Requirements

Lift Station	Capacity[1] (gpm)	Peak Incoming Flow – Current Operations[3] (gpm)		
		2015	2020	2026
Inglewood	1,100/2,600	918	1,086	1,232
North Lake[2]	1,438	1,057	1,563	1,968
Central Lake	1,393	1,504	1,538	1,565

(1) Incoming flow was not closed off during the tests. As such, flows were estimated beforehand and then added to the drawdown test capacity.
(2) Pump 2 was not tested. The capacity of Pump 2 was estimated to be approximately half of Pumps 1 and 3 and the District was planning to replace it in the near future.
(3) Hydraulic model results at each lift station under current operations.

As illustrated in Table 8, the peak incoming flow into the North Lake Lift Station will still be exceeded in approximately 2019. Although the District has attempted to reduce I/I and better identify future domestic sewer flows, these efforts cannot be relied upon to reduce flows in any significant way. Our analysis indicates that the District will still need to provide capital improvements in the near future to increase capacity on an interim basis until the North Diversion is constructed.

The following sections identify improvements designed to allow growth and development in the North Lake, Inglewood East, and tributary basins to continue, while avoiding significant capital improvements that would not serve the District once the North Diversion is in service.

POTENTIAL CAPITAL IMPROVEMENT OPTIONS

The following is a list of options the District could explore in order to maintain sewer services and accommodate the expected growth in the near future and prior to the construction of the North Diversion.

1. Evaluate the Hydraulics at North Lake and Central Lake Lift Stations to Identify Potential Mechanical Improvements to Increase Capacity

   District staff has indicated that Pump 2 at both North and Central Lift Stations has a lower pumping capacity than the other two pumps. Both lift stations have three pumps. For instance, at North Lake Lift Station Pumps 1 and 3 each have a capacity of approximately 1,100 gpm while Pump 2 has a capacity of 800 gpm. This relative capacity difference between Pump 2 and the two pumps is similar for Central Lift Station also.

   District staff has investigated the typical causes of pump capacity reduction, such as worn or unbalanced impellers and determined that these are not the cause. Since North Lake and Central Lake Lift Stations have similar mechanical layouts

in the dry pit, it is suspected that the capacity reduction is caused by some issue related to the mechanical configuration of the lift station. The District should evaluate the piping configuration to determine why Pump 2 has a reduced capacity. This may include evaluating the piping configuration and headloss in both the suction and force main header piping.

2. Inglewood Lift Station – Install Variable Frequency Drives

Currently the Inglewood Lift Station operates as fully "on" or "off" with soft-start motor starters. The pumps quickly achieve full speed and operate at full speed for the duration of the wet well drawdown or the maximum pumping time of 3 minutes, whichever is reached first. This leads to short runtimes, causing degradation, inefficient use of the pumps, more energy consumption, and increased potential to overwhelm downstream facilities as demand increases. To reduce these impacts the District could install VFD motor starters on the large pumps. The pumps would have the same peak capacity but would also be able to operate at lower speeds. (The lowest recommended capacity for the large pumps would be approximately 2,050 gpm. This would provide the minimum scouring velocity of 2.5 fps in the force main.) As a result, during each pumping cycle Inglewood Lift Station would pump a lower flow rate to North Lake Lift Station. This reduces the demand at North Lake Lift Station and postpones the need for significant upgrades to the North Lake Lift Station until after the North Diversion is constructed. The resulting incoming flows at the North Lake and Central Lake Lift Stations, should VFDs be installed at Inglewood Lift Station, are provided in the last column in Table 9.

TABLE 9

North Lake Lift Station and Central Lake Lift Station Model Results Summary

Lift Station	Capacity[1] (gpm)	Peak Incoming Flow – Current Operations[3] (gpm)				Peak Incoming Flow – Inglewood VFDs[4] (gpm)	
		2015	2020	2026	2032	2026	2032
Inglewood	1,100/2,600	918	1,079	1,340	1,631	1,340	1,631
North Lake[2]	1,438	1,376	1,614	2,103	2,844	1,908	2,765
Central Lake	1,393	1,507	1,538	1,604	1,683	1,605	1,683

(1) Incoming flow was not closed off during the tests. As such, flows were estimated beforehand and then added to the drawdown test capacity.
(2) Pump 2 was not tested. The capacity of Pump 2 was estimated to be approximately half of Pumps 1 and 3 and the District was planning to replace it in the near future.
(3) Hydraulic model results at each lift station under current operations.
(4) Hydraulic model results at each lift station should the District install VFDs at Inglewood Lift Station.

According to the modeling results, VFDs at the Inglewood Lift Station operating at 2,050 gpm would prevent overflows at the North Lake Lift Station with at its existing capacity. This is accomplished by storage within its existing wet well. However, continuous pumping at North Lake would result in overflows at the Central Lake Lift Station under this condition. Additional wet well storage improvements at both the North Lake and Central Lake Lift Stations to prevent overflows during the 10-year peak hour events are discussed in the following section.

Year 2026 flows at the North Lake Lift Station with VFDs installed at Inglewood Lift Station are shown on Figure 5.

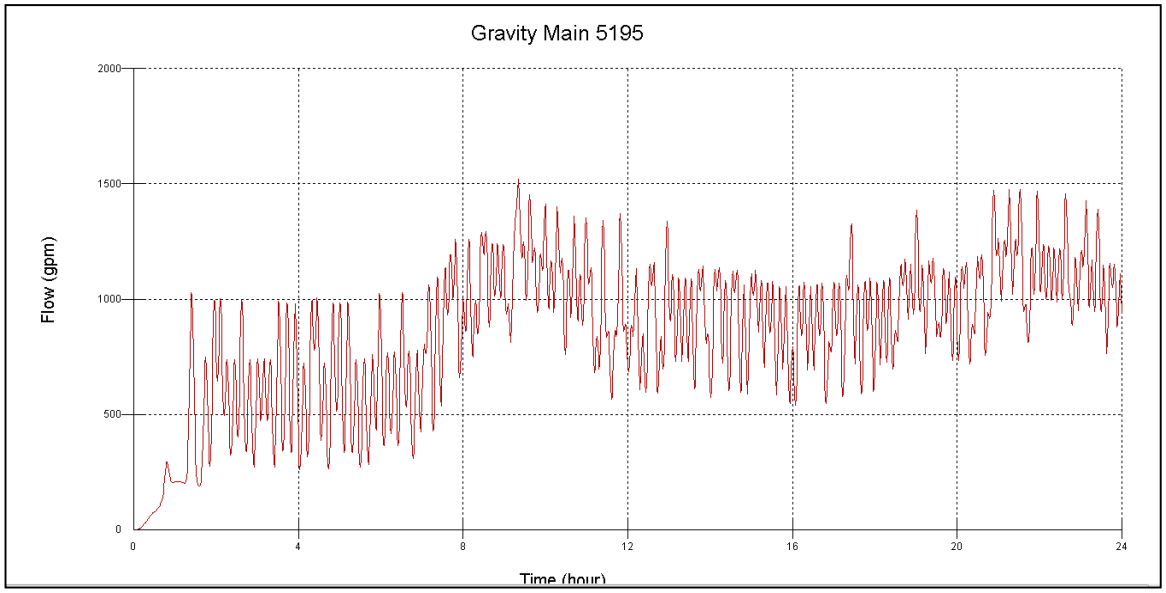


FIGURE 5

2026 Flows at North Lake Lift Station with VFDs at Inglewood Lift Station

3. North Lake Lift Station – Increase Wet Well Storage

The North Lake Lift Station is designed to pump flows from the North Lake Sammamish Sewer Basin. It currently does not have adequate capacity to pump flows from the Inglewood Lift Station and its tributary sewer basins, Tiburon Sewer Basin, and the North Lake Sammamish Sewer Basin through 2026, when the North Diversion is scheduled to be in service.

However, based on the hydraulic model results shown in Table 9, the peak incoming flows in 2026 at the lift station are reduced to 1,614 gpm when the capacity at the Inglewood Lift Station is reduced to 2,050 gpm through the use of VFDs. Although 1,614 gpm is greater than its current capacity, it is significantly

less than the peak incoming flow without reducing the capacity at the Inglewood Lift Station. It should be noted that these flows are peak "hourly" rates, and therefore, should technically only occur for 1 hour. Therefore, for that one hour the North Lake Lift Station would have a deficit of 179 gpm (1,614 gpm minus 1,438 gpm), or approximately 10,740 gallons per hour. Additional overflow storage at the North Lake Lift Station would provide temporary relief from excess flows at the lift station and allow the pumps time to catch up with incoming flows.

For example, a 12-foot-diameter overflow wet well can store approximately 845 gallons of sewage per foot of active storage. Approximately 13 feet of active storage depth would be required to store 1 hour of the 2026 peak flow deficit.

4. Central Lake Lift Station – Increase Wet Well Storage

If the North Diversion is delayed, the Central Lake Lift Station will require capacity upgrades.

As stated previously, the Central Lake Lift Station has less pumping capacity than North Lake Lift Station, which has less pumping capacity than the Inglewood Lift Station. Over time, and as the District grows in population, these upstream lift stations will be pumping more flow more frequently and for longer durations. Under current operations the Central Lake Lift Station is not able to maintain the flows pumped from North Lake Lift Station in addition to the flows from the Central Lake Sammamish Sewer Basin during peak flow events (typically during a storm).

Similar to the North Lake Lift Station, the District should consider adding wet well capacity to the Central Lake Lift Station. This would provide equalization during peak storm events and allow the lift station to function without increasing the pumping capacity. Currently, the Central Lake Lift Station has a 2026 capacity deficit of 175 gpm (from Table 9), or a peak hour deficit of 10,500 gallons. Similar to the North Lake Lift Station, approximately 13 feet of active storage in a 12-foot-diameter wet well would be required to store 1 hour of the 2026 peak hour flow.

5. Central Lake Lift Station – Upgrade Force Main and Pumps

Upgrading the pumping capacity at the Central Lake Lift Station may be required to meet the District's interim needs. Currently, the existing force main serving the Central Lake Lift Station limits the District's ability to increase the pumping capacity of the lift station. There is approximately 1,200 linear feet of existing 8-inch-diameter force main that limits the station to its current capacity. Any pumping capacity increase at Central Lake Lift Station will require the installation of a new 12-inch-diameter force main or a parallel 8-inch force main, prior to significantly increasing pumping capacity.

Once the force main has been upsized, the District can perform mechanical and electrical upgrades to the Central Lake Lift Station to increase its pumping capacity to meet the interim needs of the system.

Installing larger pumps and increasing the force main capacity are projects that would provide the District with the capacity it needs to manage the increased growth and subsequent flows for the interim period. However, the existing capacity of the Central Lake Lift Station and force main are sufficient to meet the ultimate needs of the Central Lake Sammamish basin, and so increasing the capacity of this station would only serve the interim needs of the District and would represent a stranded investment. Given the higher costs of these improvements and that they are stranded investments, this has been listed as a lower priority project.

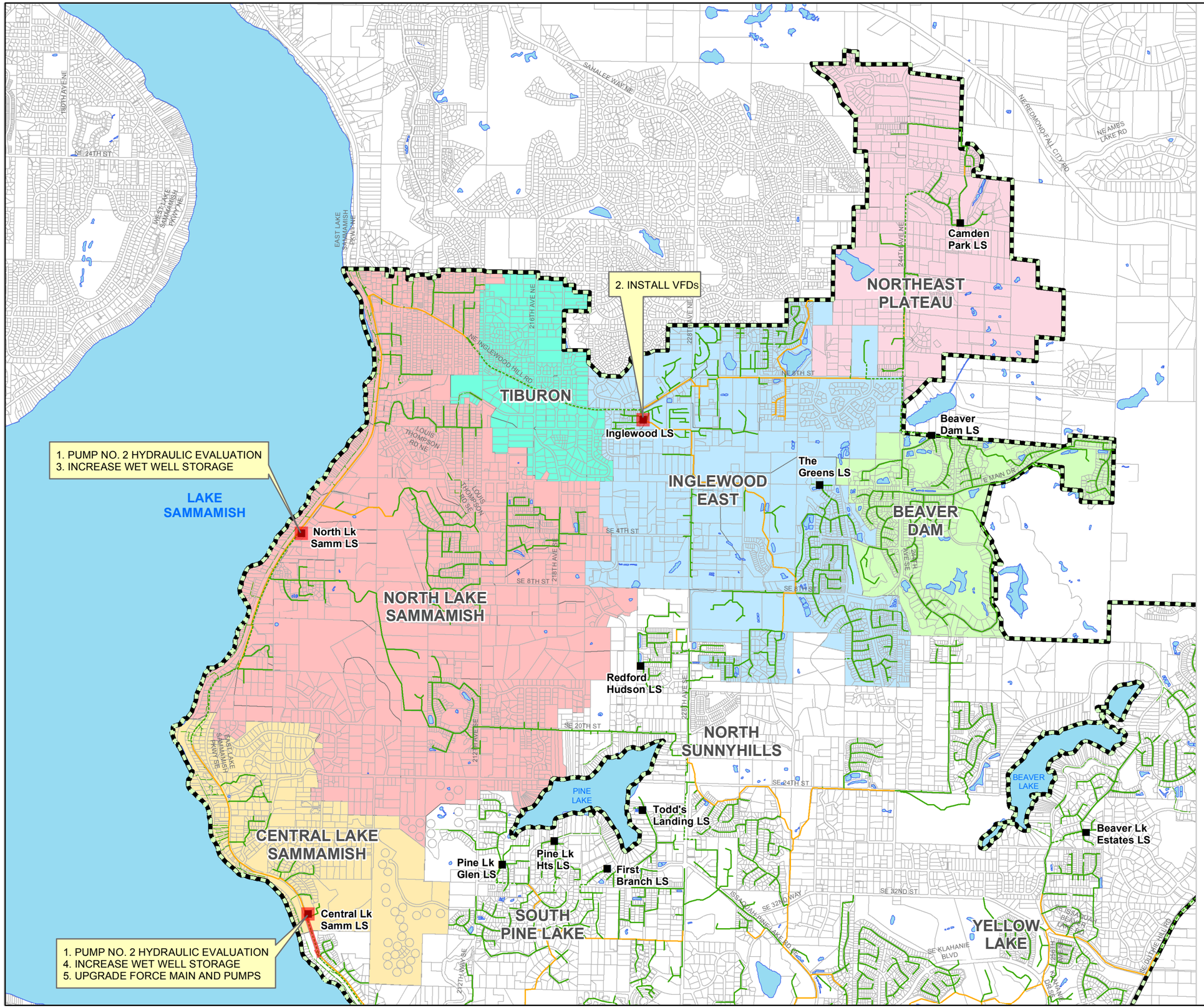
Costs for improvements are summarized in Table 10 in the Summary section. Full cost estimates are provided in Appendix A. Figure 6 illustrates the locations of the proposed interim improvement projects.

NORTH DIVERSION ADDED BASINS

Initially, the North Diversion evaluation focused on the Beaver Dam, Northeast Plateau, Inglewood East, Tiburon, and North Lake Sammamish Sewer Basins. However, during meetings with the District, KCWTD showed interest in including flows from the Mallard Bay, Central Lake Sammamish Sewer Basins, and the Sewer Basins that flow to the Control Structure. These flows account for approximately 85 percent of the total flows from the District.

The hydraulic model was used to determine the size of pipeline that could be installed from the Control Structure in order to convey sewage to the northwest boundary of the District's service area near the intersection of NE Inglewood Hill Road and East Lake Sammamish Parkway. This location is a proxy for determining the feasibility of conveying flows from the Control Structure to the North Diversion. Based on the results, a 24-inch gravity tightline would have adequate capacity to convey not only the flows from the Control Structure but also the flows from the Central Lake, North Lake, and Mallard Bay Lift Stations. Figure 7 provides an illustration of the 24-inch pipeline connecting the Control Structure to the NE Inglewood Hill Road via East Lake Sammamish Parkway.

A tightline from the Control Structure to the North Diversion would also provide King County operational flexibility to send flows from a significant portion of the District to either to the south or north. This operational flexibility and redundancy is consistent with other projects King County has completed in recent years.


N
0 1,200 2,400 4,800
Feet
1 inch = 2,400 feet
1. PUMP NO. 2 HYDRAULIC EVALUATION
3. INCREASE WET WELL STORAGE
2. INSTALL VFDs
1. PUMP NO. 2 HYDRAULIC EVALUATION
4. INCREASE WET WELL STORAGE
5. UPGRADE FORCE MAIN AND PUMPS
LAKE SAMMAMISH
TIBURON
NORTHEAST PLATEAU
INGLEWOOD EAST
BEAVER DAM
NORTH LAKE SAMMAMISH
NORTH SUNNYHILLS
CENTRAL LAKE SAMMAMISH
SOUTH PINE LAKE
YELLOW LAKE
PINE LAKE
BEAVER LAKE
Camden Park LS
Inglewood LS
Beaver Dam LS
The Greens LS
North Lk Samm LS
Redford Hudson LS
Todd's Landing LS
Pine Lk Hts LS
Pine Lk Glen LS
First Branch LS
Central Lk Samm LS
Beaver Lk Estates LS
NE 24TH ST
SAHALEE WAY NE
NE REDMOND-FALL CITY RD
NE AMES LAKE RD
NE INGLEWOOD HILL RD
NE 8TH ST
SE 4TH ST
SE 8TH ST
SE 20TH ST
SE 24TH ST
SE 32ND ST
SE KLAHANIE BLVD
E MAIN DR
SE ISSAQUAH BEAVER LAKE RD
SE ISSAQUAH-FALL CITY RD
ISSAQUAH-PINE LAKE RD
SE 32ND WAY
EAST LAKE SAMMAMISH PKWY NE
WEST LAKE SAMMAMISH PKWY NE
EAST LAKE SAMMAMISH PKWY SE
180TH AVE NE
216TH AVE NE
228TH AVE NE
244TH AVE NE
218TH AVE SE
228TH AVE SE
212TH AVE SE
212TH WAY SE
LOUIS THOMPSON RD NE
LOUIS THOMPSON RD SE
LEGEND:
PROPOSED INTERIM IMPROVEMENT PROJECT
EXISTING LIFT STATION
LOW PRESSURE FORCE MAIN
FORCEMAINS & TIGHTLINES
GRAVITY MAINS:
≤ 8"
> 8"
DISTRICT FUTURE SEWER SERVICE BOUNDARY
WATER
PARCELS - KING COUNTY GIS
DATA SOURCE: KING COUNTY AND SAMMAMISH PLATEAU WATER & SEWER DISTRICT
SAMMAMISH PLATEAU
WATER & SEWER DISTRICT
NORTH DIVERSION INTERIM
IMPROVEMENTS EVALUATION
FIGURE 6
INTERIM IMPROVEMENTS
Gray & Osborne, Inc.
CONSULTING ENGINEERS
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TO TERMINUS
(DISTRICT BOUNDARY)

CONTROL STRUCTURE
TIGHTLINE (24-INCH)

LAKE
SAMMAMISH

North Lk
Samm LS

Central Lk
Samm LS

Alexander's LS

Mallard
Bay LS

CONTROL
STRUCTURE

Freegard LS

Redford
Hudson LS

Inglewood LS

Camden
Park LS

Beaver
Dam LS

The
Greens LS

Todd's
Landing LS

Pine Lk
Glen LS

Pine Lk
Hts LS

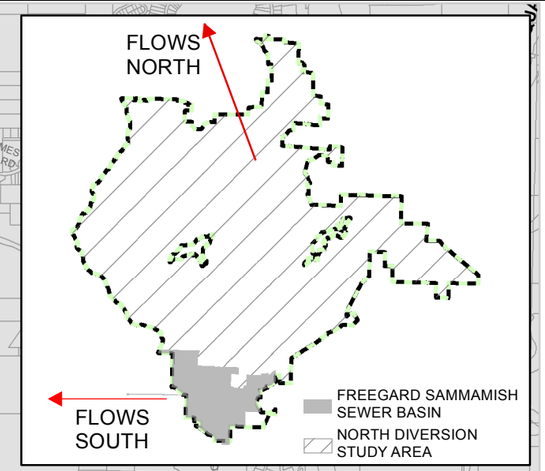
First
Branch LS

Beaver Lk
Estates LS

Trossachs LS

Aldarra LS

Aldarra
Club LS



N

0 1,750 3,500 7,000 Feet

SCALE 1" = 3,500'

LEGEND:

- EXISTING LIFT STATION
- CONTROL STRUCTURE TIGHTLINE
- CONTROL STRUCTURE
- LOW PRESSURE FORCE MAIN
- FORCEMAINS & TIGHTLINES

GRAVITY MAINS:

- ≤ 8"
- > 8"
- DISTRICT FUTURE SEWER SERVICE BOUNDARY
- WATER
- PARCELS - KING COUNTY GIS
- Beaver Dam
- Central Lake Sammamish
- Freegard
- Inglewood East
- Laughing Jacobs
- Mallard Bay
- North Lake Sammamish
- North Sunnyhills
- Northeast Plateau
- South Pine Lake
- Tiburon
- Trossachs
- Yellow Lake

DATA SOURCE: KING COUNTY AND SAMMAMISH PLATEAU WATER & SEWER DISTRICT

SAMMAMISH PLATEAU
WATER & SEWER DISTRICT

WASTEWATER COMPREHENSIVE PLAN
FIGURE 7
CONTROL STRUCTURE CONVEYANCE

Gray & Osborne, Inc.

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King County will need to determine the best possible route and means of conveying flows via the North Diversion. Although a gravity tightline has typically been discussed as the best means, a regional lift station would be feasible, and may provide more flexibility in the proposed route to the north. For example, a regional lift station, located at the current North Lake Lift Station site could serve to convey flows from the Control Structure, North Lake Sammamish gravity basin, and the Inglewood Lift Station. Further, if a tightline from the Control Structure is constructed, the Central Lake and Mallard Bay Lift Stations are located along its logical route.

SUMMARY

The results from this evaluation are similar to those provided in the 2013 Plan. The District is continuing to grow in the northern portion of its service area and the resulting sewer flows are causing some concerns about short- and long-term planning for collection system upgrades. The uncertainty about the North Diversion is also a contributor and is a major part of the District's decision-making process for providing service to its growing population.

RECOMMENDED IMPROVEMENTS

The following are recommended interim improvements to be completed by the District:

1. Perform an evaluation at the North Lake and Central Lake Lift Stations to determine the cause for capacity reduction at Pump 2 and perform recommended improvements.

2. Upgrade Inglewood Lift Station with variable frequency drives on the 2,600 gpm pumps. Program pumps to run at 2,050 gpm to achieve a minimum 2.5 fps in the 18-inch force main.

3. Add surge wet well storage to the North Lake Lift Station to provide emergency overflow storage during peak wet weather flows.

4. Add surge wet well storage to Central Lake Lift Station to provide emergency overflow storage during peak wet weather flows. This would be a stranded investment.

5. Install 1,200 linear feet of 12-inch force main (or 8-inch parallel force main) at Central Lake Lift Station and replace pumps at Central Lake Lift Station to increase pumping capacity. This would be a stranded investment.

A summary of the interim improvement costs is provided in Table 10. A project timeline is provided as Figure 8.

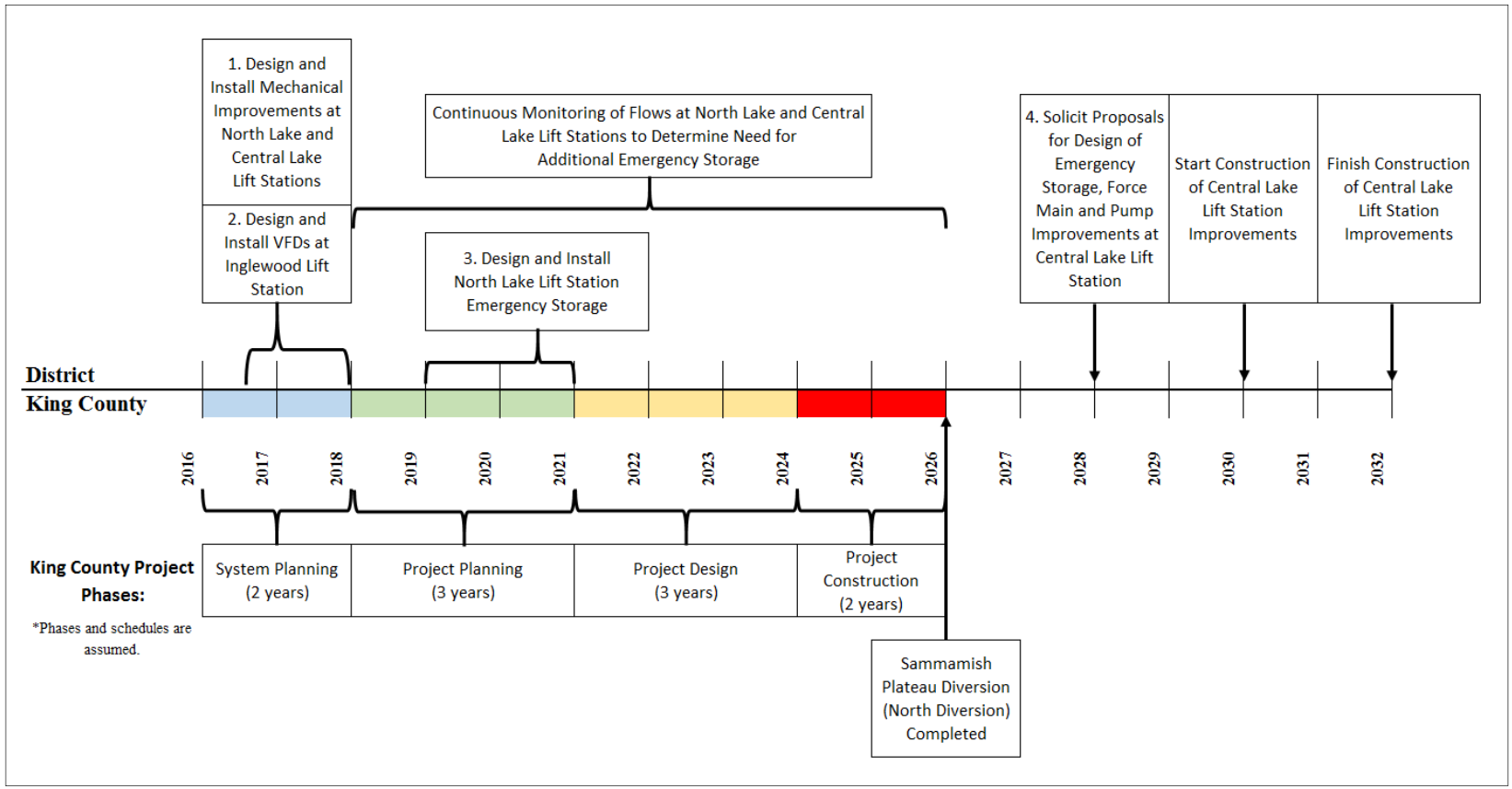
TABLE 10

Summary of Interim Improvement Costs

No.	Location	Improvement	Cost	Stranded Investment
1	North and Central Lake Lift Stations	Pump 2 Hydraulic Study	$15,000	$0
2	Inglewood Lift Station	Install VFDs	$235,000	$0
3	North Lake Lift Station	Increase Wet Well Storage	$350,000	$0
4	Central Lake Lift Station	Increase Wet Well Storage	$350,000	$350,000
5	Central Lake Lift Station	Upgrade Force Main and Pumps	$1,400,000	$1,400,000
Total			**$2,350,000**	**$1,750,000**

FIGURE 8

Timeline for North Diversion Interim Improvements



APPENDIX A

COST ESTIMATES

SAMMAMISH PLATEAU WATER AND SEWER DISTRICT
PRELIMINARY CONSTRUCTION COST ESTIMATE
VARIABLE FREQUENCY DRIVE REPLACEMENT AT INGLEWOOD LIFT STATION
August 8, 2016

NO	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1	Miscellaneous Electrical	1	LS	$ 9,000	$ 9,000
2	Electrical Demolition	1	LS	$ 1,500	$ 1,500
3	60 HP VFD Starters	1	LS	$ 70,000	$ 70,000
4	SCADA Modifications	1	LS	$ 55,000	$ 55,000

Subtotal:	$	135,500
Washington State Sales Tax (9.5%):	$	12,900
Contingency (20.0%):	$	27,100
TOTAL ESTIMATED CONSTRUCTION COST:	**$**	**175,500**
Design and Engineering, Construction Management, and Administration 30%:	$	52,700
TOTAL ESTIMATED PROJECT COST:	**$**	**228,200**

SAMMAMISH PLATEAU WATER AND SEWER DISTRICT
PRELIMINARY CONSTRUCTION COST ESTIMATE
NORTH LAKE LIFT STATION STORAGE
August 8, 2016

NO	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 25,000	$ 25,000
2	Trench Excavation and Safety Systems	1	LS	$ 5,000	$ 5,000
3	Erosion Control	1	LS	$ 3,000	$ 3,000
4	Dewatering	1	LS	$ 15,000	$ 15,000
5	Storage Tank, 12 FT. DIAM.	1	LS	$ 120,000	$ 120,000
6	Site Modifications	1	LS	$ 15,000	$ 15,000
7	Unsuitable Excavation	10	CY	$ 50	$ 500
8	Foundation Gravel	30	TN	$ 50	$ 1,500
9	Gravel Backfill	20	TN	$ 25	$ 500
10	Crushed Surfacing	30	TN	$ 25	$ 750
11	HMA	10	TN	$ 150	$ 1,500
12	Site Piping	1	LS	$ 2,500	$ 2,500
13	Site Restoration	1	LS	$ 6,000	$ 6,000

Subtotal:	$	196,300
Washington State Sales Tax (9.5%):	$	18,700
Contingency (20.0%):	$	39,300
TOTAL ESTIMATED CONSTRUCTION COST:	**$**	**254,300**
Design and Engineering, Construction Management, and Administration 30%:	$	76,300
TOTAL ESTIMATED PROJECT COST:	**$**	**330,600**

SAMMAMISH PLATEAU WATER AND SEWER DISTRICT
PRELIMINARY CONSTRUCTION COST ESTIMATE
CENTRAL LAKE LIFT STATION STORAGE
August 8, 2016

NO	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 25,000	$ 25,000
2	Trench Excavation and Safety Systems	1	LS	$ 5,000	$ 5,000
3	Erosion Control	1	LS	$ 3,000	$ 3,000
4	Dewatering	1	LS	$ 15,000	$ 15,000
5	Storage Tank, 12 FT. DIAM.	1	LS	$ 120,000	$ 120,000
6	Site Modifications	1	LS	$ 15,000	$ 15,000
7	Unsuitable Excavation	10	CY	$ 50	$ 500
8	Foundation Gravel	30	TN	$ 50	$ 1,500
9	Gravel Backfill	20	TN	$ 25	$ 500
10	Crushed Surfacing	30	TN	$ 25	$ 750
11	HMA	10	TN	$ 150	$ 1,500
12	Site Piping	1	LS	$ 2,500	$ 2,500
13	Site Restoration	1	LS	$ 6,000	$ 6,000

Subtotal:	$	196,300
Washington State Sales Tax (9.5%):	$	18,700
Contingency (20.0%):	$	39,300
TOTAL ESTIMATED CONSTRUCTION COST:	**$**	**254,300**
Design and Engineering, Construction Management, and Administration 30%:	$	76,300
TOTAL ESTIMATED PROJECT COST:	**$**	**330,600**

SAMMAMISH PLATEAU WATER AND SEWER DISTRICT
PRELIMINARY CONSTRUCTION COST ESTIMATE
CENTRAL LAKE FORCE MAIN AND PUMP REPLACEMENT
August 8, 2016

NO	ITEM	QUANTITY		UNIT PRICE	AMOUNT
1	Mobilization and Demobilization	1	LS	$ 70,000	$ 70,000
2	Erosion Control	1	LS	$ 4,000	$ 4,000
3	Trench Ecavation and Safety Sytems	1	LS	$ 5,000	$ 5,000
4	SPCC Plan	1	LS	$ 1,000	$ 1,000
5	Survey	1	LS	$ 6,400	$ 6,400
6	Project Temporary Traffic Control	1	LS	$ 12,000	$ 16,000
7	Locate Existing Utilites	1	LS	$ 2,000	$ 2,000
8	Sawcutting Concrete Panels	2,400	LF	$ 8	$ 19,200
9	Removal of Structure and Obstruction	1	LS	$ 6,000	$ 6,000
10	Pump Replacement	1	LS	$ 150,000	$ 150,000
11	Temporary Bypass Pumping	1	LS	$ 6,500	$ 6,500
12	Crushed Surfacing Top Course	330	TN	$ 30	$ 9,900
13	HMA Trench Repair	280	TN	$ 130	$ 36,400
14	Temporary HMA	70	TN	$ 130	$ 9,100
15	Gravel Backfill	920	TN	$ 45	$ 41,400
16	Removal of Unsuitable Material	10	CY	$ 100	$ 1,000
17	Cast In Place Concrete	370	CY	$ 400.00	$ 148,000
18	DI Pipe for Sewer (Force Main), 12-in.	1,190	LF	$ 180	$ 214,200
19	Additional Fittings	1,500	LB	$ 4	$ 6,000
20	PLC Programming	1	LS	$ 25,000	$ 25,000
21	Site Restoration	1	LS	$ 20,000	$ 20,000

Subtotal:	$	797,100
Washington State Sales Tax (9.5%):	$	76,000
Contingency (20.0%):	$	159,500
TOTAL ESTIMATED CONSTRUCTION COST:	**$**	**1,032,600**
Design and Engineering, Construction Management, and Administration 30%:	$	309,800
TOTAL ESTIMATED PROJECT COST:	**$**	**1,342,400**

APPENDIX B

REVISED SEWER RCE FOR 2020 AND 2026

TABLE B-1

Updated 2015 Peak Hour Flow Including Inflow and Infiltration

District Sewer Basin	2015 Area[(1)] (acre)	Meter-based ERUs	Sewer RCEs [(2)]	Average Daily Flow[(3)] (gpd)	Peaking Factor	Peak Hour Domestic Flow[(4)] (gpd)	Existing I/I Flow Rate[(5)] (gpad)	Existing I/I Flow (gpd)	Peak Hour Incl. I/I (gpd)	Peak Hour Incl. I/I (gpm)
Beaver Dam	431	780.0	686.4	106,392	1.67	177,675	145	62,608	240,283	167
Central Lake Sammamish	119	255.0	224.4	34,782	2.55	88,694	307	36,540	125,234	87
Freegard	415	1,384.0	1,217.9	188,778	1.68	317,146	579	240,285	557,431	387
Inglewood East	442	1,863.0	1,639.4	254,113	1.66	421,828	334	147,517	569,345	395
Laughing Jacobs	441	1,774.5	1,561.6	242,042	2.14	517,969	944	416,304	934,273	649
Mallard Bay	84	351.5	309.3	47,945	2.55	122,259	282	23,688	145,947	101
North Lake Sammamish	407	1,033.5	909.5	140,969	2.55	359,472	413	168,206	527,678	366
North Sunnyhills	391	1,489.5	1,310.8	203,168	2.39	485,571	795	310,845	796,416	553
Northeast Plateau	87	140.0	123.2	19,096	1.67	31,890	243	21,141	53,031	37
South Pine Lake	477	1,458.5	1,283.5	198,939	2.79	555,041	812	387,324	942,365	654
Tiburon	29	40.0	35.2	5,456	2.55	13,913	282	8,178	22,091	15
Trossachs	495	1,491.5	1,312.5	203,441	1.96	398,744	1,017	503,415	902,159	626
Yellow Lake	662	3,224.5	2,837.6	439,822	1.96	862,051	1,017	673,254	1,535,305	1,066
Total	**4,480**	**15,285.5**	**13,451.2**	**2,084,942**	**2.16**	**4,352,253**	**552**	**2,999,305**	**7,351,557**	**5,105**

(1) Determined by linear interpolation of the 2012 and Buildout Area values provided in Table 5.
(2) Meter-based ERUs multiplied by 0.88 (average RCE/ERU ratio) established in Table 2-15 of the 2013 Plan.
(3) Sewer RCE multiplied by 155 gpd/RCE.
(4) Average Daily Flow multiplied by Peaking Factor.
(5) Table 2-25 in 2013 Plan. Values for the Basins of concern (Beaver Dam, Central Lake Sammamish, Inglewood East, and North Lake Sammamish) were updated using flow meter data at District lift stations in December 2015.

TABLE B-2

Updated 2026 Peak Hour Flow Including Inflow and Infiltration

District Sewer Basin	2026 Area (acre)	Meter-based ERUs	Sewer RCEs	Average Daily Flow (gpd)	Peaking Factor	Peak Hour Domestic Flow (gpd)	I/I Flow Rate (gpad)	I/I Flow (gpd)	Peak Hour Incl. I/I (gpd)	Peak Hour Incl. I/I (gpm)
Beaver Dam	441	875.5	770.4	115,566	1.67	192,995	422	185,996	378,991	263
Central Lake Sammamish	224	370.5	326.0	48,906	2.55	124,710	537	120,239	244,950	170
Freegard	508	1675.0	1,474.0	221,100	1.68	371,448	730	370,900	742,348	516
Inglewood East	580	2646.0	2,328.5	349,272	1.66	579,792	556	322,107	901,898	626
Laughing Jacobs	489	2059.8	1,812.6	271,887	2.14	581,838	989	483,464	1,065,302	740
Mallard Bay	161	409.8	360.6	54,087	2.55	137,922	519	83,525	221,447	154
North Lake Sammamish	732	1741.5	1,532.5	229,878	2.55	586,189	612	447,906	1,034,095	718
North Sunnyhills	657	2192.3	1,929.2	289,377	2.39	691,611	883	580,600	1,272,211	883
Northeast Plateau	238	600.5	528.4	79,266	1.67	132,374	491	116,786	249,161	173
South Pine Lake	533	1677.3	1,476.0	221,397	2.79	617,698	895	476,854	1,094,552	760
Tiburon	96	179.0	157.5	23,628	2.55	60,251	519	50,036	110,287	77
Trossachs	591	1580.8	1,391.1	208,659	1.96	408,972	1041	615,055	1,024,026	711
Yellow Lake	748	3362.8	2,959.2	443,883	1.96	870,011	1041	778,962	1,648,972	1,145
Total	**5,998**	**19,370.5**	**17,046.0**	**2,556,906**	**2.16**	**5,355,811**	**710**	**4,632,430**	**9,988,241**	**6,936**

(1) Determined by linear interpolation of the 2012 and Buildout Area values provided in Table 5.
(2) Meter-based ERUs multiplied by 0.88 (average RCE/ERU ratio) established in Table 2-15 of the 2013 Plan.
(3) Sewer RCE multiplied by 155 gpd/RCE.
(4) Average Daily Flow multiplied by Peaking Factor.
(5) Determined by linear interpolation between 2015 (in Table 6) and Buildout. Buildout is assumed to take place in 2053. The assumed maximum I/I rate is 1,100 gpad.