CHAPTER 5

WASTEWATER CHARACTERIZATION

INTRODUCTION

Water usage characterization is an important aspect of wastewater system planning. Wastewater flows can be estimated based on potable water consumption during winter months, when irrigation uses are minimal. By evaluating the historical trends in the amount of water purchased and consumed, peaking factors, and the customer population, it is possible to provide forecasts of future demands on the wastewater system. This is necessary to assess the capacity of the District's existing facilities and to design future wastewater system facilities.

Adequate design of the District's wastewater conveyance facilities requires a determination of the quantity of wastewater from various contributing sources. The District's wastewater is predominantly domestic in origin, with lesser amounts contributed by commercial and industrial businesses, as well as by institutional facilities, such as schools, parks, hospitals, and government offices. Infiltration and inflow (I/I) contributions result from groundwater and surface water entering the collection system during periods of rainfall or as a result of high groundwater levels.

In this chapter, information from previous reports, water use records, transportation analysis zone (TAZ) data, flow meter data, and lift station pump run time readings are used to estimate unit flow quantities for critical parameters related to population, land use, and overall land area within the existing service area. Future flows for the entire service area are estimated based on buildout population and area and on the unit flow rates developed in this chapter.

WASTEWATER CHARACTERIZATION FLOW

In order to assess the capacity of the District's existing facilities and design future wastewater facilities, it is necessary to determine the unit quantities for each of the major components that constitute the total volume of wastewater flows. The parameters to be identified are domestic and nonresidential (commercial, industrial, and institutional) wastewater flows, peaking characteristics, infiltration, and inflow. The following section presents a brief description of these parameters and typical values cited in regulatory guidelines, previous reports, and literature.

The domestic wastewater unit is generally expressed as gallons per capita per day (gpcd), the nonresidential in gallons per employee per day (gpcd), and I/I quantities in gallons per acre per day (gpad). Peaking characteristics are described in terms of peaking factors and diurnal curves.

PER CAPITA DOMESTIC FLOW

Domestic wastewater is generated as a result of regular household activities and comprises waste discharge from showers, toilets, food preparation, washing machines, and washbasins. Per capita use rates are derived and applied to population projections to determine basin-wide generation rates. The *1990 Wastewater Comprehensive Plan* used 85 gpcd, and the *2000 Wastewater Comprehensive Plan* used 74 gpcd.

COMMERCIAL AND INDUSTRIAL FLOW

Nonresidential customers can be, but are not limited to, commercial, industrial, institutional, or municipal users. Use rates can vary widely depending on the type of user and can change significantly as development occurs. For these reasons, it is appropriate to develop a unit flow parameter based on acreage or number of employees. The *1990 Wastewater Comprehensive Plan* used 3,600 gpad for Community Business and Heavy Manufacturing and 1,800 gpad for General Commercial and Light Manufacturing. The *2000 Wastewater Comprehensive Plan* did not distinguish between heavy and light manufacturing, rather a nonresidential flow of 600 gpad was used, based on winter water consumption data and trends. The Puget Sound Regional Council (PSRC) projected the number of employees per TAZ, providing a reasonable basis for projecting the non-residential flow based on the projected number of employees.

INFILTRATION AND INFLOW

Infiltration is groundwater that enters the sewer system through pipe joints and cracks and is related to rainfall on a seasonal basis. Inflow enters the system through manhole lids, storm drain connections, and illegal roof connections, and is affected by rain on a more immediate time scale. In general, infiltration is represented by the wet season average I/I rate, while the peak I/I rate represents the base I/I flow in conjunction with peak inflow. The *1990 Wastewater Comprehensive Plan* used 1,100 gpad for residential and 300 gpad for nonresidential I/I. The *2000 Wastewater Comprehensive Plan* used a design I/I value of 1,100 gpad for both residential and nonresidential I/I.

PEAKING FACTORS AND DIURNAL CURVES

Since wastewater flow rates vary throughout the 24-hour day and seasonally, a collection system should be designed to convey the peak flows expected. A peaking factor is the peak hourly flow divided by the average daily flow. The peaking factor may be developed based on observed data or historical values taken from similar systems. A peaking factor is used to convert average daily flow directly to peak hourly flow. A factor of 2.9 is cited in the literature (Metcalf & Eddy, 4th Edition, 2003) for basins comparable in size to that of the District. Ecology recommends a minimum peaking factor of 2.5.

A diurnal curve represents the variable rate of wastewater flow throughout the day. For example, a service area may contribute 144,000 gallons of wastewater per day, which represents an average of 100 gallons per minute (gpm). At 3:00 a.m., however, the flow could be nearly zero, since most residents are asleep and not using household facilities. At 8:00 a.m. the flow may be as high as 250 gpm. A diurnal curve attempts to account for this by quantifying the flow rates at regular intervals instead of one daily average rate. The highest point on the diurnal curve divided by the average daily flow represents the peaking factor.

Traditionally, a peaking factor has been used to ensure that collection system facilities are designed with adequate capacity to convey the maximum instantaneous flow expected. There are several factors that should be considered to accurately describe actual peak flow conditions.

First, the diurnal characteristic of wastewater flow is related to land use. For example, the peak flows from a residential area are usually experienced between 6:00 a.m. and 8:00 a.m., and between 7:00 p.m. and 9:00 p.m. Peak flows from a commercial area, however, usually occur between 9:00 a.m. and 4:00 p.m. The capacity of a pipe may be erroneously identified as insufficient if peak flows from all contributing sources are assumed to occur simultaneously, when in fact the peaks occur at different times.

Second, peaking factors vary with the size of the basin. This is due to two factors. As the size of the basin increases, the variability of the hydraulic travel time from the initial point of discharge to downstream points of the collection system also increases. This means that the peak flows from each individual user reach downstream points in the system at different times, which tends to decrease the observed peaking factor. Also, as the size of the basin increases, there tends to be a greater variability of use patterns. For example, in larger cities, many people may begin work earlier (or later) when traffic conditions are better, which tends to distribute flow over a longer period of time.

WASTEWATER PRODUCTION

Winter water use records of the District's sewer rate payers are used to estimate residential and commercial wastewater production rates and peaking factors. To negate the effect of irrigation water use (water that generally does not enter the wastewater system), water consumption records during the winter period are used to estimate the amount of water, which generally is discharged to the wastewater system. The District's sewer service customer base is composed of residential, commercial, and industrial connections.

SEWER SERVICE CONNECTIONS

The total number of sewer service billed accounts within the District at the end of 2005 was 20,258. This number is taken to be the number of sewer service connections for establishing the wastewater production within the District. The number of connections is discussed by customer type and location within various municipalities in the following sections.

Service Connections by Customer Class

The District classifies its customers based on various rate codes. Water usage has been divided into the following customer types: single-family residential, multi-family residential with individual water meters, multi-family residential with multiple units per meter, and non residential. Single-family residential (SFR) is defined as single units with individual water service meters. Multi-family residential (MFR) with individual meters consists of condominiums with individual service meters. MFR with multiple units per meter consist of residential meters that serve apartment complexes, condominiums, and mobile homes. Non residential customers include commercial and industrial connections.

Table 5-1 provides a summary of the connections for the various types of customers for 2000 to 2005. Ninety-one percent of the sewer service connections are for single-family residential homes.

TABLE 5-1

Sewer Service Connections by Customer Class (2000-2005) (1)

Year	Single-Family Residential Connections	Multi-Family Residential		Non-Residential Connections	Total Connections
		Individual Meters Connections	Multiple Units per Meter Connections		
2000	15,254	15	1,027	605	16,901
2001	16,933	15	1,062	609	18,619
2002	17,235	15	1,094	621	18,965
2003	17,991	15	1,107	634	19,747
2004	18,285	19	1,115	640	20,059
2005	18,468	19	1,128	643	20,258

Source: Northshore Utility District Billing Records.
(1) Based on billing records for the winter months (from November through February).

Service Connections by Municipality within District

The District provides sewer service to a number of different municipalities within its sewer service boundary. The percent of sewer service connections within the District for the cities of Bothell, Kenmore, Kirkland, Lake Forest Park, and Woodinville, and for Unincorporated King County are based on the District's billing records. Table 5-2 provides an estimate of the number of sewer service connections in each municipality that the District serves.

TABLE 5-2

Percent of Sewer Service Connections per Municipal Entity (2005)

Municipality	Percent of Sewer Service Connections
Bothell	1%
Kenmore	27%
Unincorporated King County	57%
Kirkland	9%
Lake Forest Park	4%
Woodinville	2%
Total	**100%**

Source: Northshore Utility District Billing Records.

RESIDENTIAL WASTEWATER PRODUCTION

Table 5-3 identifies the total residential winter water consumption, total number of residential connections (on individual meters only), and the average daily winter water consumption per capita. The information is based on District water use records for the District's sewer system connections. The numbers of District water system and sewer system connections are different because the District's service areas are different for water and sewer and because there are areas within the District's sewer service area that are on septic systems. The winter water use per capita can provide a good estimation of the average wastewater production per capita.

SFR users account for 91 percent of the residential connections. Determination of the average residential winter water use rate is therefore one of the most critical elements in the analysis of the wastewater collection system. In general, customers living in SFR use slightly more water than those living in MFR; however, determination of multi-family use is difficult because many meters at multi-family dwellings serve more than one household. Therefore, only records for SFR connections and MFR with individual connections are used to determine residential use rates.

Based on customer billing records, average winter water use (approximately November through February) for SFR connections and MFR with individual connections for 2000 through 2005 totaled 3.1 million gallons per day (mgd). The 2000 Census estimated the average number of people per household by municipal jurisdiction and zoning classification. The average person per household was determined by averaging the persons per household for the different zoning classifications (presented in Table 3-6). Assuming an average household size of 2.5 residents per household, per capita winter water consumption is approximately 71 gpcd.

Generally, all of the potable water that is consumed is not discharged as wastewater; however, the winter water usage provides a conservative estimate of the average wastewater produced. Furthermore, an estimated wastewater produced of 71 gpcd is within the recommended range of 54 to 81 gpcd for two to three person households (Metcalf & Eddy 4th Edition, 2003).

TABLE 5-3

Historical Per Capita Residential Winter Water Consumption

Year	Average Residential Winter Water Use (mgd)	Number of Connections(1)	Average Number of People per Household(2)	Average Daily Winter Water Consumption Per Capita (gpcd)
2000	2.7	15,269	2.5	70
2001	3.0	16,948	2.5	71
2002	3.2	17,250	2.5	73
2003	3.3	18,006	2.5	74
2004	3.2	18,304	2.5	69
2005	3.1	18,487	2.5	67
Average	**3.1**	**17,377**	**2.5**	**71**

Source: Northshore Utility District Billing Records.

(1) Based on residential water system connections for SFR and MFR with individual meters; does not include commercial accounts. The number of connections for water and sewer are not equal because the service areas are not congruent.

(2) Based on Washington State OFM 2000 census data.

COMMERCIAL AND INDUSTRIAL WASTEWATER PRODUCTION

Nonresidential water users accounted for 3 percent of the total number of sewer connections and 11 percent of the total winter water consumption in 2000 through 2005. Table 5-4 presents the nonresidential winter water consumption expressed as gallons per employee per day (gpcd) for the years 2000 through 2005. An average of 21,386 employees used an average of 0.55 mgd of water during the winter months (approximately November through February) from 2000 through 2005.

Based on the information presented in Table 5-4, the employee per capita wastewater flow is approximately 26 gpcd. The Department of Ecology's *Criteria for Sewage Works Design* suggests a range of 7 to 15 gallons per employee per day of wastewater produced for various commercial businesses. The value calculated for the District is slightly higher than the suggested range, but is more conservative with regard to the projection of future wastewater system flows.

TABLE 5-4

Nonresidential Winter Water Consumption

Year	Average Non-Residential Winter Water Use (mgd)	Number of Employees	Average Daily Winter Water Consumption per Employee (gpcd)
2000	0.56	20,636	27
2001	0.55	20,930	26
2002	0.55	21,229	26
2003	0.55	21,532	25
2004	0.55	21,839	25
2005	0.55	22,151	25
Average	**0.55**	**21,386**	**26**

Source: Northshore Utility District Billing Records.

KING COUNTY DEPARTMENT OF NATURAL RESOURCES INFLOW AND INFILTRATION STUDY AND DISTRICT FLOW MONITORING RESULTS

KING COUNTY DEPARTMENT OF NATURAL RESOURCES STANDARDS

KCDNR has established an allowable standard for I/I of 1,100 gpad. The value of 1,100 gpad dates back to the Metropolitan Seattle Sewerage and Drainage Survey completed by Brown and Caldwell in 1958, which established an infiltration value of 500 gpad and an inflow value of 600 gpad, and has served as the standard for the area ever since. This standard was used to develop the District's 2000 *Wastewater System Comprehensive Plan*.

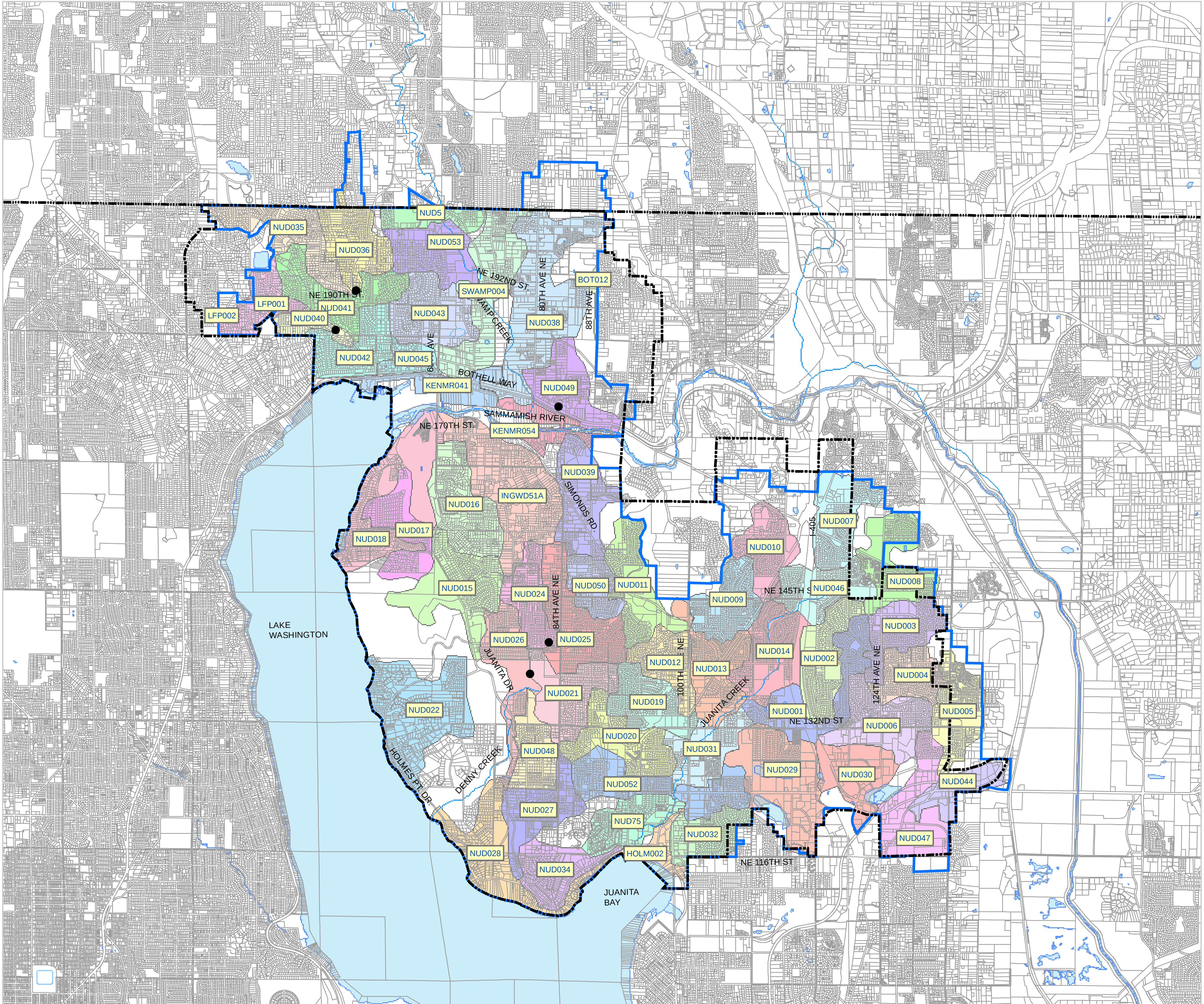
KING COUNTY DEPARTMENT OF NATURAL RESOURCES I/I STUDY

KCDNR conducted an I/I Study in 2001/2002 by providing flow monitoring of 774 mini basins throughout the entire KCDNR service area. Fifty-seven of the mini basins monitored are within the District sewer service area boundary. The study established peak I/I as the peak flow over a 30-minute period and a baseline I/I flow based on an average dry day flow. Although the standard is measured in gallons per acre per day, the standard is not based on a daily peak flow but a 30-minute interval. The I/I values reported in the KCDNR 2001/2002 Wet Weather Flow Monitoring Study were normalized based on the sewered area of the mini basin. The sewered area does not include parks and athletic fields. Figure 5-1 maps the mini basins within the District. Table 5-5 presents the KCDNR results with the estimated I/I value for each of the mini basins within the District in the I/I Study. The peak I/I rates were recalculated based on the total area of the basin.

KCDNR determined the net dry day flow for each mini basin by subtracting the average dry day flow of upstream basins from the gross dry day flow from each mini basin. A mini basin with no upstream meters has a net dry day flow equal to the gross dry day flow. Uncertainty in the flow measurement and peak I/I rate increases as the number of meters upstream from the basin increases. A list of the upstream meters for each mini basin within the District is presented in Appendix G.

Over 85 percent of the total mini basins monitored by KCDNR exceed a 30-minute peak I/I of 1,100 gpad. Of the 774 mini basins monitored by KCDNR, 700 mini basins had significant results that were used to compare the relative peak I/I rates as presented in Figure 5-2. Figure 5-2 presents a distribution of the total number of mini basins that exceed a given peak I/I rate. The District average peak I/I rate based on the sewered area is 3,231 gpad. The average peak I/I measured for all mini basins monitored throughout King County is 4,774 gpad (based on the sewered area).

For the Plan, the mini basins established by KCDNR have been reconfigured to follow parcel lines and the District sewer service area boundary; Figure 5-3 presents the reconfigured I/I mini basins. Some areas of the District were not monitored by KCDNR; mini basins have been created for these areas. The KCDNR I/I values were renormalized to the *total* area of the basin. The renormalized I/I values have then been applied to the reconfigured basins. In some cases, the sub basin overlaps two KCDNR mini basins; in these cases an average I/I value from the corresponding KCDNR mini basins is used. The peak I/I rates based on the total area of each basin within the District are included in Table 5-5. It is necessary to use a peak I/I rate based on total area for the purposes of the model exercise. To remain consistent with KCDNR, the most reasonable use of the KCDNR data is to use an I/I rate based on the total area of the basin.



LEGEND:

- CORPORATE BOUNDARY
- SEWER SERVICE STUDY AREA BOUNDARY
- COUNTY LINE
- NUD 009 KCDNR FLOW MONITORING LOCATIONS
- DISTRICT FLOW MONITORING LOCATIONS

SOURCE: KING COUNTY GIS

NORTHSHORE UTILITY DISTRICT WATER SEWER

WASTEWATER SYSTEM PLAN

FIGURE 5-1
KCDNR I/I FLOW MONITORING LOCATIONS

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TABLE 5-5

KCDNR 2001/2002 I/I Flow Monitoring Results

Basin	Peak I/I Rate(1) Sewered Area (gpad)	Peak I/I Rate(1),(2) Total Area (gpad)
BOT004	1,126	4,227
INGWD51A	3,135	1,301
KENMR041	NA(3)	4,637
KENMR054	NA(3)	5,585
LFP001	3,096	1,478
NUD001	2,615	1,882
NUD002	1,532	1,214
NUD003	2,308	2,182
NUD004	4,141	3,922
NUD005	1,703	1,382
NUD006	1,164	1,040
NUD007	3,035	2,455
NUD008	1,942	1,274
NUD009	1,842	1,720
NUD010	4,501	3,441
NUD011	1,889	1,205
NUD012	3,652	3,268
NUD013	5,603	4,373
NUD014	4,337	2,975
NUD015	2,602	1,589
NUD016	688	618
NUD017	1,887	1,328
NUD018	1,946	937
NUD019	1,927	1,594
NUD020	1,714	1,322
NUD021	3,985	2,643
NUD022	1,199	706
NUD024	2,860	2,476
NUD025	2,922	2,632
NUD026	4,865	3,027
NUD027	1,534	809
NUD028	8,010	3,894

TABLE 5-5 – (continued)

KCDNR 2001/2002 I/I Flow Monitoring Results

Basin	Peak I/I Rate(1) Sewered Area (gpad)	Peak I/I Rate(1),(2) Total Area (gpad)
NUD029	1,776	1,393
NUD030	3,143	2,226
NUD031	5,049	4,190
NUD032	1,871	1,785
NUD034	2,884	2,152
NUD035	1,185	997
NUD036	4,717	4,058
NUD038	6,025	2,156
NUD039	1,526	834
NUD040	5,028	4,378
NUD041	2,572	2,257
NUD042	5,137	5,043
NUD043	4,642	3,845
NUD044	1,809	1,671
NUD045	1,650	1,565
NUD046	5,517	3,330
NUD047	854	738
NUD048	2,572	1,673
NUD049	3,787	2,219
NUD050	2,073	1,503
NUD052	6,762	5,141
NUD053	10,415	4,623
NUD5	10,415	5,279
NUD75	6,762	3,666
SWAMP004	NA(2)	2,654
BASIN_1	NA(3)	0
BASIN_2	NA(3)	0
BASIN_3	NA(3)	706
BASIN_4	NA(3)	706
BASIN_5	NA(3)	706
BASIN_6	NA(3)	1,565
NUD006/NUD001	NA(3)	1,461
NUD013/NUD031	NA(3)	4,281

TABLE 5-5 – (continued)

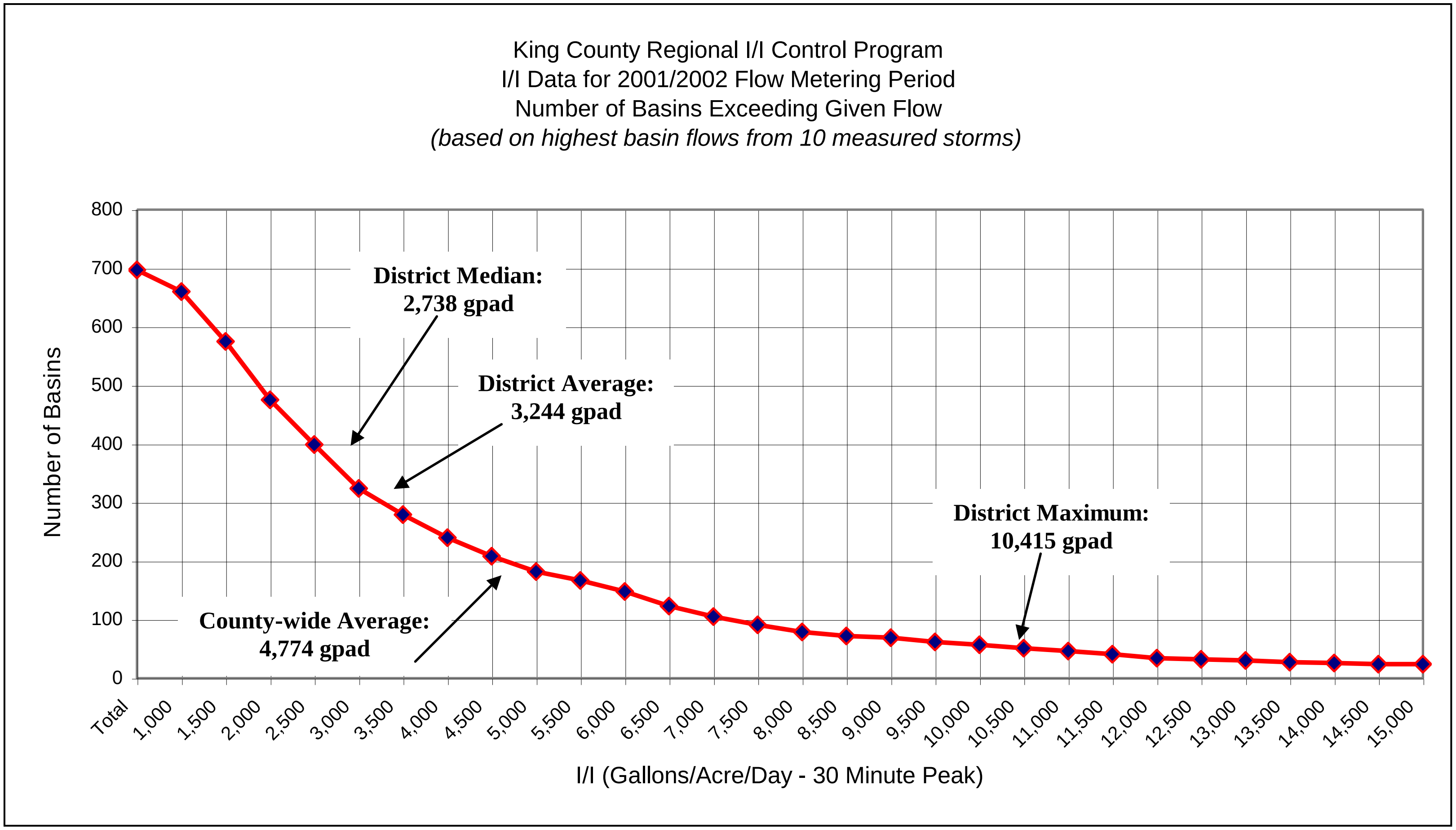
KCDNR 2001/2002 I/I Flow Monitoring Results

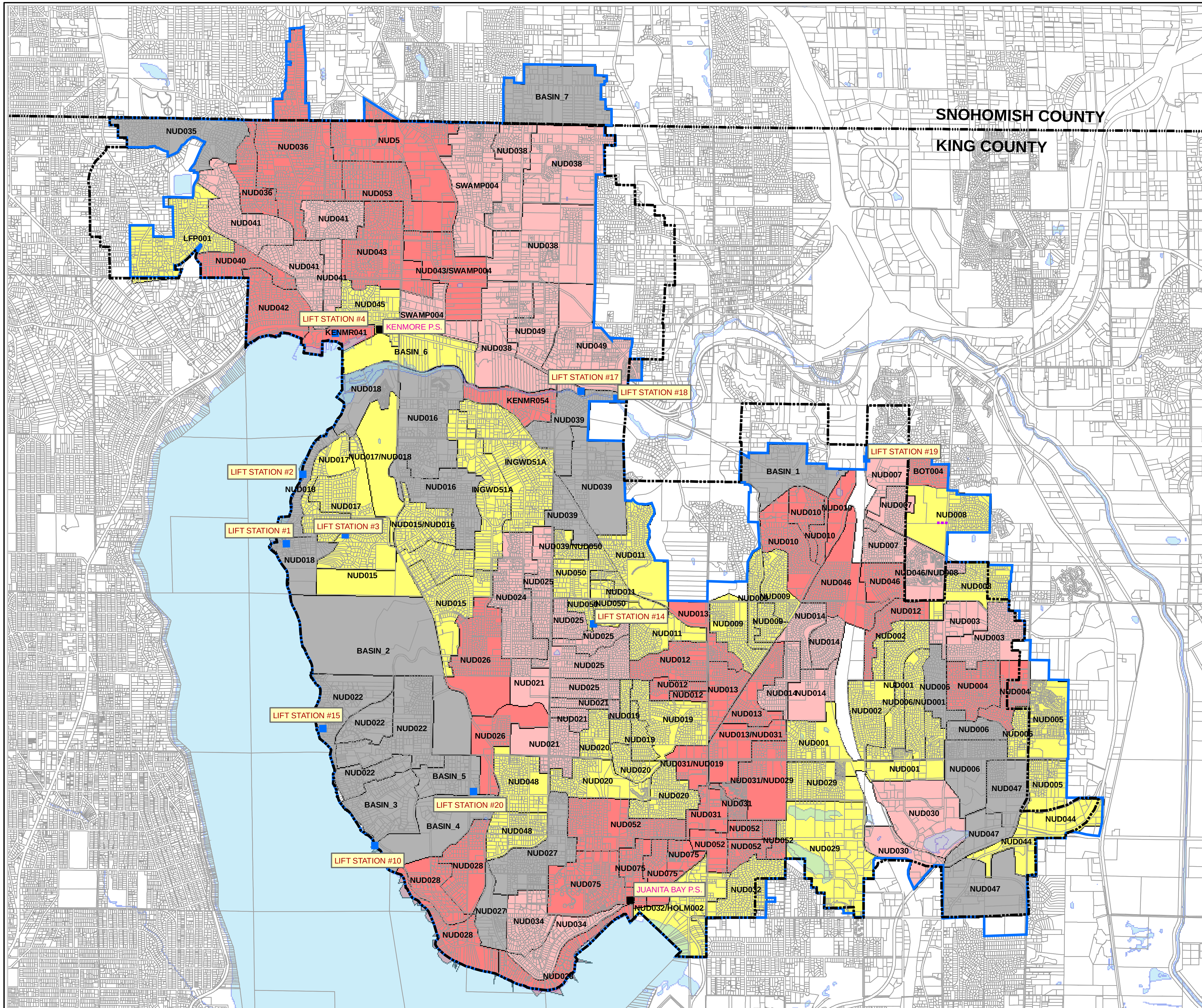
Basin	Peak I/I Rate[1] Sewered Area (gpad)	Peak I/I Rate[1],[2] Total Area (gpad)
NUD015/NUD016	NA[3]	1,103
NUD017/NUD018	NA[3]	1,132
NUD031/NUD019	NA[3]	2,892
NUD031/NUD029	NA[3]	2,792
NUD032/HOLM002	NA[3]	1,785
NUD039/NUD050	NA[3]	1,168
NUD043/SWAMP004	NA[3]	3,845
NUD046/NUD008	NA[3]	2,502
Average	**3,231[4]**	**2,265[4]**
Median	**2,738**	**NA[5]**
Maximum	**10,415**	**NA[5]**

Source: King County Department of Natural Resources
(1) Based on a 30-minute peak I/I rate.
(2) Basin areas are reconfigured along parcel lines and to include the entire area of the District; the I/I rate is based on the total area of the basin.
(3) Results not available.
(4) Area weighted average.
(5) Not applicable.

FIGURE 5-2

KCDNR I/I Flow Monitoring Results 700 Mini Basins within King County
Relative Flow Monitoring Results for 57 Mini Basins within Northshore Utility District





N

0 1,600 3,200 6,400 Feet

LEGEND:

- CORPORATE BOUNDARY
- SEWER SERVICE STUDY AREA BOUNDARY
- COUNTY LINE
- PRIVATE FORCE MAIN
- LIFT STATIONS
- KCDNR LIFT STATIONS

KCDNR ESTABLISHED I/I RATE BASED ON THE TOTAL AREA:

- PEAK I/I RATE<1100 gpad
- 2,000>PEAK I/I RATE>1100 gpad
- 3,000>PEAK I/I RATE>2000 gpad
- PEAK I/I RATE>3000 gpad

SOURCE: NORTHSHORE UTILITY DISTRICT

NORTHSHORE UTILITY DISTRICT WATER SEWER

WASTEWATER SYSTEM PLAN

FIGURE 5-3
I/I BASINS

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DISTRICT I/I FLOW MONITORING STUDY

In 2004, the District conducted flow monitoring in five basins to confirm that the KCDNR I/I quantities are representative of the basins. Figure 5-1 identifies the flow monitoring locations. Table 5-6 provides a summary of the District's flow monitoring results for the five basins.

TABLE 5-6

District Flow Monitoring Results

Basin	Basin Area (Acre)	Upstream Area (Acre)	Base Flow (gpm)	District Measured Peak Flow (gpm)	District I/I Rate(1) (gpad)
NUD 024	128	0	61	136	842
NUD 026	158	178	102	428	1,397
NUD 036	160	50	150	383	1,593
NUD 040	55	0	6	56	1,315
NUD 049	164	0	70	202	1,156

(1) Based on a 30-minute peak rate.

Table 5-7 summarizes information from the KCDNR I/I study and the District I/I flow monitoring study to provide a comparison between the flow monitoring performed by the District and the monitoring performed by KCDNR.

TABLE 5-7

Flow Monitoring Comparison

Basin	Basin Area (Acre)	KCDNR I/I Rate(1) (gpad) (Total Area)	District I/I Rate(1) (gpad)
NUD 024	128	2,476	842
NUD 026	158	3,027	1,397
NUD 036	160	4,058	1,593
NUD 040	55	4,378	1,315
NUD 049	164	2,219	1,156

(1) Based on a 30-minute peak rate.

As illustrated in Table 5-7, there are differences in the District's estimated I/I rate and the KCDNR I/I rate. Differences can exist due to the calculation of basin areas, placement of flow meters, variability in wet weather, and a misrepresentation of upstream conditions. For example, flow meters with a lift station upstream will receive slugs of flows that are not necessarily representative of the basins they serve. Lift stations serving small basins can have disproportionate flow rates from the basins they serve, resulting in large downstream spikes in flow that could register as a 30-minute peak and may overstate I/I when projecting the flow to a 24-hour peak.

Furthermore, in 2004 and 2005 the District conducted visual inspections of manholes, smoke testing, and television inspections to address problem areas identified by the KCDNR flow monitoring study. The smoke tests found two illegal connections (of a total of 111 connections) in basin NUD 040 and two illegal connections (from a total of 180 connections) in basin NUD 053. The identified illegal connections have since been corrected. The results of the manhole inspections, smoke testing, and television inspections are summarized in Appendix H. Manhole inspections in Basin NUD 040 did not identify significant infiltration; however, the TV inspection indicated several areas within Basin NUD 040 with severe infiltration problems. Manhole investigations were also conducted in Basin NUD 049; the inspections showed significant signs of infiltration and Basin NUD 049 has been recommended for rehabilitation by the District as a result of the District's visual manhole inspections and flow monitoring of the basin.

The lift station run time data presented in Table 4-2 is consistent with KCDNR and the District I/I flow monitoring studies for Basin NUD 049. Lift Station No. 17, which serves flows from Basin NUD 049, operates approximately 114 percent more on an average day during wet weather periods than during dry weather periods. In addition, KCDNR flow monitoring results for Basin NUD 050 are consistent with the lift station run time data. A peak I/I of approximately 2,631 gpad was measured for Basin NUD 050 and summarizing lift station run time data during wet weather and dry weather shows a difference in run time of 119 percent.

Although the magnitude of the results vary between flow monitoring conditions and inspection results, the District plans to continue to proactively investigate and correct significant problems due to I/I, which should result in a reduction of I/I over time.

WASTEWATER PRODUCTION PEAK FACTOR

The wastewater production peak hour factor was determined from District flow monitoring data. The peak factor will vary depending on the size of the basin and the number of connections the basin serves. Five basins were monitored as part of the District's I/I study. The peak factor was determined for each of these basins based on the measured average and peak flows from April 14, 2004 through April 27, 2004, and is presented in Table 5-8. The flow was measured and recorded every 15 minutes. The flow during the month of April has an I/I component; however, for the purposes of determining the approximate peak hour factor the I/I component during the time period of study, April 14, 2004 through April 27, 2004, is assumed relatively constant. The peak hour factors determined for the individual basins from flow monitoring results are relatively consistent with the recommended value of 2.5. Therefore, the peak hour factor determined for Basin NUD 040 is very high which is explained by the small size of the basin. A peak hour factor of 2.5 is used in the hydraulic model, which also agrees with the Department of Ecology's criteria.

TABLE 5-8

Peak Hour Factor for Basins NUD 024, NUD 026, NUD 036, NUD 040, and NUD 049

Basin Identification Number	NUD 024	NUD 026	NUD 036	NUD 040	NUD 049
Basin Area (acres)	128	158	210	55	164
Upstream Basin Area (acres)	0	178 (1)	50	0	0
Total Number of Connections in Basin	402	296	428	121	130
Residential Connections	402	294	428	120	119
Commercial Connections	0	2	0	1	11
Average Daily Flow Rate (2) (gpm)	41	181	150	0.28	53
Max Daily Flow Rate (2) (gpm)	111	428	382	8.3	93
Peak Hour Factor	2.7	2.4	2.6	29	1.8

(1) Basin NUD 021 flows into basin NUD 026. Basin NUD 025 (223 acres) is upstream from Basin NUD 021 and Basins NUD 023 (100 acres) and NUD 024 (128 acres) are upstream from Basin NUD 025.

(2) Results from April 14, 2004 through April 27, 2004.

WASTEWATER FLOW PROJECTION

Based on the data presented in the previous sections, flow parameters for the District have been determined for the purposes of estimating future flows. A summary of the data is presented in Table 5-9. For the purposes of estimating future flows, the values shown in Table 5-9 are used to identify projected flows. The KCDNR established wastewater production per residential customer equivalent is 187 gpd. The wastewater produced by commercial and residential accounts is used to quantify the number of equivalent residential units (ERUs) served by the District sewer system.

For use in the hydraulic model, a diurnal curve has been created using a peak flow of 2.5 times the average flow. This allows the use of a diurnal curve in the modeling and also satisfies Ecology criteria regarding peaking factors.

WASTEWATER PRODUCTION AND ERU PROJECTIONS

The results shown in Tables 5-10, 5-11, 5-12, and 5-13 are estimates of the projected wastewater production and ERUs for 2005, 2012, and 2026, and at buildout. The results are derived by applying the design criteria shown in Table 5-9 to the populations from Table 3-5 and buildout populations shown in Table 3-7. In order to estimate the expected wastewater contribution from various parts of the system, the sewer area is divided into smaller collection basins based on topography and the existing facilities. In Chapter 6, projected flows for individual basins and intermediate time periods have been determined using a more detailed hydraulic computer model.

TABLE 5-9

Summary of Wastewater Flow Design Criteria

	Design Value
KCDNR Residential Customer Equivalent Wastewater Production (gpd)	187
Residential Per Capita Flow Rate (gpcd)	71
Non residential Flow Rate (gpcd)	26
Baseline Infiltration and Inflow (gpad)	200[1]
Peak Infiltration and Inflow (gpad)	2,265[2]
Decreased Infiltration and Inflow (gpad)	1,100
Peaking Factor	2.5

(1) A value of 148 was estimated from KCDNR 2001/2002 I/I Flow Monitoring results based on the total area of the basin; the value was rounded up to 200 to provide a conservative estimate.
(2) Estimated District average based on KCDNR 2001/2002 I/I Flow Monitoring and the total area of reconfigured basins.

TABLE 5-10

Domestic ERUs and Wastewater Production

Year	ERUs[1]	Population	Average Flow[2] (mgd)	Peak Flow[3] (mgd)
2005	26,262	69,168	4.91	12.3
2012	27,115	71,415	5.07	12.7
2026	28,884	76,074	5.40	13.5
Buildout	47,411	124,871	8.87	22.2

(1) Based on 187 gpd.
(2) Based on 71 gpcd.
(3) Based on a peak factor of 2.5.

TABLE 5-11

Commercial ERUs and Wastewater Production

Year	ERUs(1)	Number of Employees	Average Flow(2) (mgd)	Peak Flow(3) (mgd)
2005	3,080	22,151	0.58	1.44
2012	3,417	24,576	0.64	1.60
2026	4,214	30,312	0.79	1.97
Buildout	4,438	31,921	0.83	2.07

(1) Based on 187 gpd.
(2) Based on 26 gpcd.
(3) Based on a peak factor of 2.5.

TABLE 5-12

Inflow and Infiltration

Year	Total Acreage	Average Flow(1) (mgd)	Peak Flow(2) (mgd)	Peak Flow with Decreased I/I(3) (mgd)
2005	11,280	2.3	36.4	NA
2012	11,280	2.3	36.4	12.4
2026	11,280	2.3	36.4	12.4
Buildout	11,280	2.3	36.4	12.4

(1) Based on 200 gpad.
(2) Based on 2,265 gpad.
(3) Based on a peak I/I rate of 1,100 gpad.

TABLE 5-13

District ERUs and Wastewater Production(1)

Year	ERUs(2)	Average Flow (mgd)	Peak Flow (mgd)	Peak Flow with Decreased I/I(3) (mgd)
2005	29,341	7.74	50.1	NA
2012	30,532	7.97	50.6	26.7
2026	33,098	8.45	51.8	27.9
Buildout	51,849	12.0	60.6	36.6

(1) Includes domestic, commercial, and I/I.
(2) Based on 187 gpad.
(3) Based on a peak I/I rate of 1,100 gpad.

POTENTIAL FOR WATER REUSE

INTRODUCTION

This section presents a brief analysis of the potential for reuse within the District boundary. Use of reclaimed water is an alternative to wastewater treatment plant effluent disposal. The production and beneficial use of reclaimed water is the development of a new usable water supply. In addition to minimizing the environmental impacts of wastewater disposal, water reuse can address problems associated with diminishing potable water supplies and acquiring new water rights. In the state of Washington, any type of direct beneficial reuse of municipal wastewater is defined as water reuse or reclamation. *Water Reuse and Reclamation Standards* have been issued jointly by the Departments of Health and Ecology.

KCDNR is planning to produce Class A reclaimed water at the Brightwater Wastewater Treatment Facility (WWTF). Class A reclaimed water treatment will consist of a side stream off the membrane bioreactor and disinfection; the reclaimed water will be treated separately from the WWTF effluent to be disposed of via the outfall to Puget Sound. A dedicated 27-inch pipeline from the WWTF site in Snohomish County will convey up to 21 mgd of reclaimed water (*Brightwater Facility Plan*, May 2005). The reclaimed water will be conveyed to three main distribution points via:

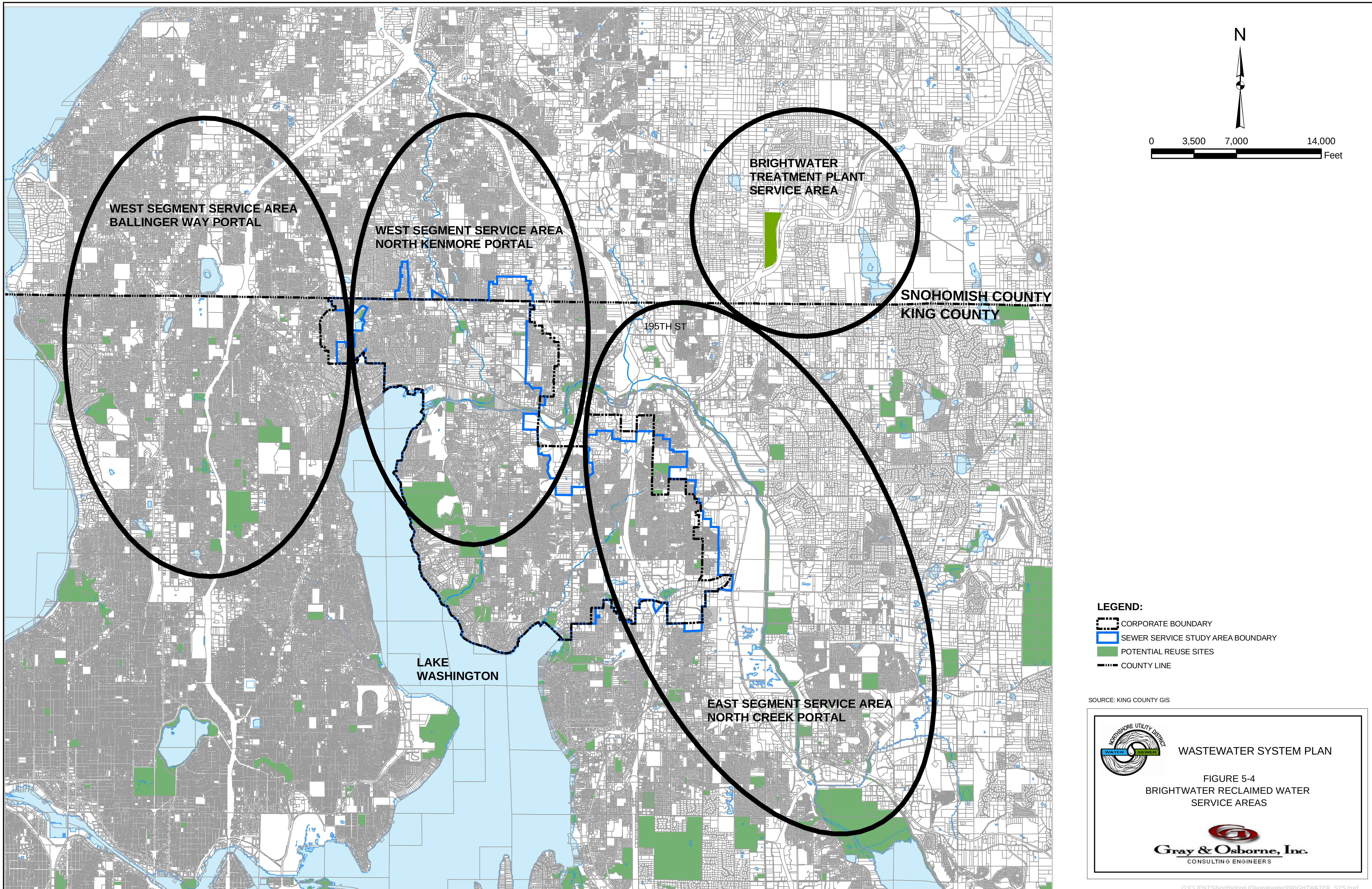
- A 27-inch pipeline from the Brightwater WWTF site to the North Creek Portal.
- A 20-inch pipeline from the Northcreek Portal to the North Kenmore Portal.
- Two 14-inch pipelines from the North Kenmore Portal to the Ballinger Way Portal.

The reclaimed water service areas are displayed on Figure 5-4; the pipeline alignment and distribution portals are displayed on Figure 5-5. At each of these portals, the reclaimed water will be brought to the surface for distribution.

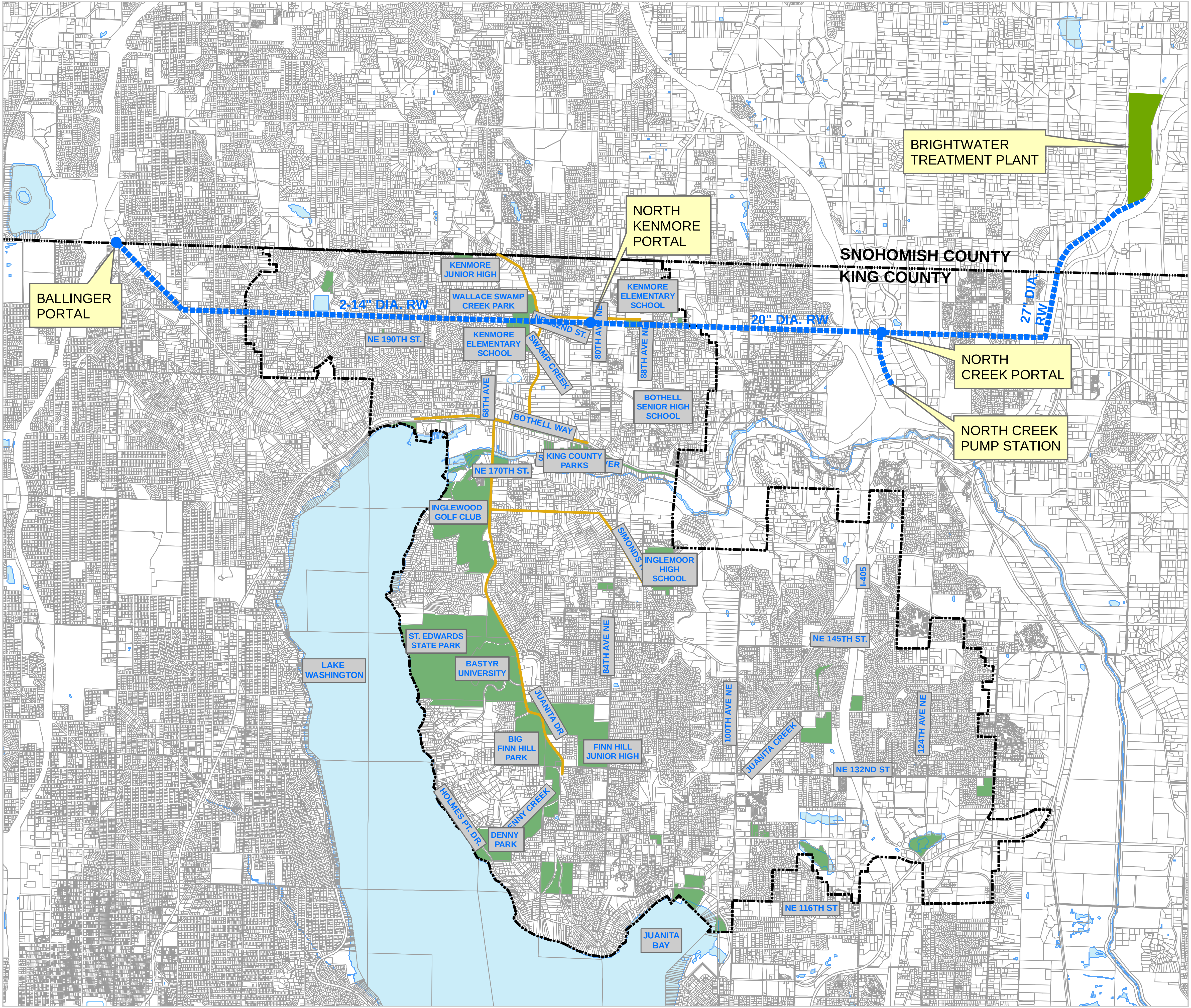
PERMITTED USES OF RECLAIMED MUNICIPAL WASTEWATER

Allowable water reuse methods of Class A reclaimed water include:

- Irrigation of Non-Food Crops
- Spray Irrigation of Food Crops
- Surface Irrigation
    - Food crops where there is no reclaimed water contact with edible portion of crop
    - Root crops
    - Orchards and vineyards



WEST SEGMENT SERVICE AREA
BALLINGER WAY PORTAL
WEST SEGMENT SERVICE AREA
NORTH KENMORE PORTAL
BRIGHTWATER
TREATMENT PLANT
SERVICE AREA
SNOHOMISH COUNTY
KING COUNTY
195TH ST
LAKE
WASHINGTON
EAST SEGMENT SERVICE AREA
NORTH CREEK PORTAL
N
0
3,500
7,000
14,000
Feet
LEGEND:
CORPORATE BOUNDARY
SEWER SERVICE STUDY AREA BOUNDARY
POTENTIAL REUSE SITES
COUNTY LINE
SOURCE: KING COUNTY GIS
NORTHSHORE UTILITY DISTRICT
WATER
SEWER
WASTEWATER SYSTEM PLAN
FIGURE 5-4
BRIGHTWATER RECLAIMED WATER
SERVICE AREAS
Gray & Osborne, Inc.
CONSULTING ENGINEERS



N

0 2,000 4,000 8,000 Feet

LEGEND:

- CORPORATE BOUNDARY
- POTENTIAL REUSE SITES
- RECLAIMED WATER DISTRIBUTION SYSTEM
- COUNTY LINE
- TUNNEL WITH RECLAIMED WATER (RW) PIPELINE

SOURCE: KING COUNTY GIS

NORTHSHORE UTILITY DISTRICT WATER SEWER

WASTEWATER SYSTEM PLAN

FIGURE 5-5
POTENTIAL SITES FOR WATER REUSE

Gray & Osborne, Inc.
CONSULTING ENGINEERS

O:\CLIENTS\NorthshoreUD\wastewater\WATER REUSE.mxd

  - Food crops that undergo physical or chemical processing sufficient to destroy all pathogenic agents
- Landscape Irrigation
  - Restricted access areas (e.g., cemeteries, freeway landscaping)
  - Open access areas (e.g., golf courses, parks, playgrounds, etc.)
- Impoundments
  - Landscape impoundments
  - Restricted recreational impoundments
  - Non-restricted recreational impoundments
- Fish Hatchery Basins
- Decorative Fountains
- Flushing of Sanitary Sewers
- Street Cleaning
  - Street sweeping, brush dampening
  - Street washing, spray
  - Washing of corporation yards, lots, and sidewalks
- Dust Control (Dampening Unpaved Roads, Other Surfaces)
- Dampening of Soil for Compaction (Construction, Landfills, etc.)
- Water Jetting for Consolidation of Backfill Around Pipelines
- Fire Fighting and Protection
  - Dumping from aircraft
  - Hydrants or sprinkler systems in buildings
- Toilet and Urinal Flushing
- Washing Aggregate and Making Concrete
- Industrial Boiler Feed
- Industrial Cooling
- Industrial Process

Most of these methods provide limited potential for use in the District due to the relatively small quantities and seasonal nature of the reuse method. Two reuse methods that offer the potential for 100 percent reuse on a year-round basis are groundwater recharge and stream flow augmentation. A more detailed discussion of groundwater recharge and stream flow augmentation is provided.

Groundwater Recharge

Groundwater recharge using reclaimed water is permitted under the water reuse standards. Three categories of groundwater recharge are covered in the water reuse standards:

- Direct injection to a drinking water aquifer
- Direct injection to a non-drinking water aquifer
- Surface percolation

Since the District does not rely on groundwater as a source of supply, direct injection of reclaimed water to a drinking water aquifer is not discussed in detail. Direct injection of reclaimed water to a non-drinking water aquifer must be Class A reclaimed water treatment standards as well as the following additional criteria:

> $BOD_5 \leq 5$ mg/L
> TSS ≤ 5 mg/L
> Any additional criteria deemed necessary by DOH or Ecology

Groundwater recharge using surface percolation must be at least Class A reclaimed water. In addition to secondary treatment to provide oxidized wastewater, the process must include a "step to reduce nitrogen prior to final discharge to groundwater." Treatment of the Class A reclaimed water will be done at the Brightwater WWTF site in Snohomish County. Reclaimed water treatment consists of advanced secondary treatment with a membrane bioreactor, which combines activated sludge secondary treatment and a microfiltration membrane. The MBR system is designed for complete nitrification.

Streamflow Augmentation

For small streams where fish habitat has been degraded due to low instream flows, stream flow augmentation is an alternative that is allowed under the water reuse regulations and standards. This reuse method still requires an NPDES permit and adherence to the surface water quality standards (WAC 173-201A). However, the key difference between stream flow augmentation and surface water disposal is that a determination of beneficial use has been established based on a need to increase flows to the stream. To make this determination requires concurrence from WDFW that the need exists for additional instream flows.

Other Uses

The water reuse standards allow for a number of other uses that are not discussed in detail here. However, the general basis for the reuse criteria is that when unlimited public access to the reclaimed water is involved, the criteria requires Class A reclaimed water. The use of reclaimed water for agricultural purposes is allowed under the water reuse standards including food crops, as proper setback distances are employed. These setback distances are discussed in the next section.

REUSE AREA REQUIREMENTS

The water reuse standards establish criteria for siting and identifying water reclamation projects and their facilities. Water reclamation storage facilities, valves, and piping must be clearly labeled, and no cross-connections between potable water and reclaimed water lines are allowed. A key area requirement for a water reclamation project is setback distance. Table 5-14 summarizes setback requirements for water reclamation facilities.

TABLE 5-14

Setback Distances for Class A Reclaimed Water in the State of Washington

Reclaimed Water Use/Facility	Distance (Feet)
Minimum Distance to Potable Water Well:	
Spray or Surface Irrigation	50
Unlined Storage Pond or Impoundment	500
Lined Storage Pond or Impoundment	100
Pipeline	50
Minimum Distance between Irrigation Area and Public Areas	0

BRIGHTWATER WWTF AND RECLAIMED WATER PLAN

King County Department of Natural Resources (KCDNR) has identified general areas in King County that may be suitable for the potential use of reclaimed water. Thus far, however, contracts have not been established between the distributor and the end user, and the reclaimed water facility is still in the planning stages. KCDNR has primarily identified areas with high irrigation needs that could potentially use reclaimed water to substitute for potable quality water supply, including schools, athletic fields, public parks, and golf courses.

The District has identified potential users within the District consistent with the areas KCDNR has identified; identified areas within the District are labeled on Figure 5-5, and the proximity of the distribution portals can be seen on the figure. KCDNR has divided the potential reclaimed water service area into an East Segment and two West Segments served by the different distribution portals. The potential reclaimed water service areas are identified on Figure 5-4. The District primarily lies within the West Segment and would be served by the North Kenmore Portal.

The peak day reclaimed water demand for the total potential reclaimed water service area within King County is projected to be 21 mgd. Table 5-15 presents the projected peak day reclaimed water demand for the east and west segments and corresponding portal service areas.

TABLE 5-15

KCDNR Projected Peak Day Reclaimed Water Demand

East Segment	
Influent Pump Station	0.8 mgd
North Creek Portal Service Area	8.2 mgd
West Segment	
North Kenmore Portal Service Area	4.5 mgd
Ballinger Way Portal Service Area	7.5 mgd
Total East and West Segment	**21 mgd**

Source: *Brightwater Facility Plan*, Appendix J, May 2005.

The potential peak day demand for the North Kenmore Portal Service Area identified by KCDNR is 4.5 mgd. The North Kenmore Portal Service Area is planned to be served by a reclaimed water pump station at the Brightwater WWTF; the reclaimed water pump station is scheduled for implementation in Phase 2. Initial demands for the East Segment will be met by gravity flow from the Brightwater WWTF to the customers. The phased gravity and pump flow approach outlined by KCDNR in the *Brightwater Facilities Plan* (May 2005) is presented in Table 5-16.

TABLE 5-16

Reclaimed Water System Capacity

	Service Area	Capacity (mgd)
Gravity Flow	Initial East Segment	5.0-7.0(1)
Phase 1	Future East Segment	9.0
Phase 2	Future East Segment, and North Kenmore Portal Service Area	13.5
Phase 3	Future East Segment, North Kenmore, and Ballinger Way Portal Service Areas	21.5

Source: *Brightwater Facility Plan*, Appendix J, May 2005.
(1) Initial system capacity depends on final pipeline routing and size.

POTENTIAL FOR IRRIGATION WATER REUSE

Reclaimed water could be used for irrigation and landscape purposes. The District has an annual average rainfall of approximately 38 inches. Due to the significant amount of rainfall during winter months, reclaimed water could be used for irrigation only during the summer. Many of the parks within the District are heavily treed and are not irrigated; however, there are several athletic and play fields at schools and the public parks. The public areas that irrigate and could potentially use reclaimed water identified by the District are indicated on Figure 5-5. Privately owned business that potentially could use reclaimed water have also been identified based on photos. Bastyr University and the Inglewood Golf Club are identified as areas that could potentially use reclaimed water for irrigation purposes. However, Inglewood Golf Club currently has the right to draw water from Lake Washington to meet irrigation demands, and have expressed no interest at this time in purchasing reclaimed water. GMN Farms, located west of Bothell High School, has also been identified from photos; although, based on water billing records, GMN Farms is not a significant commercial water user. The peak day reclaimed water usage rates for irrigation demands are presented in Table 5-17. The peak day reclaimed water usage rate for irrigation purposes assumes a typical irrigation rate of 14 inches per year, irrigation for four months per year, and a peak day factor of two.

TABLE 5-17

Potential Uses for Reclaimed Water

Irrigation/Landscaping Use(1)	**Area (acre)**	**Annual Usage (MG/year)**	**Peak Day (gpd)**
Public Parks	43	16.2	133,000
Public Schools	33	12.5	103,000
Private Businesses(2)	84	31.9	262,000
Industrial Use		**Annual Usage (MG/year)**	**Peak Day (gpd)**
Glacier Concrete Northwest(3)		0.08	715
Jetting of Sewer Lines	**Length (lf)**	**Annual Usage (MG/year)**	**Peak Day (gpd)**
	360,000	1.4(4)	5,700(5)
Total Potential Reclaimed Water Usage		**62**	**504,000**

(1) Based on a typical irrigation rate of 14 inches per year over the period of 4 months (from mid May to mid September).
(2) Includes Bastyr University and Inglewood Golf Club.
(3) Based on water billing records.
(4) Assumes 30 percent of the District's sewers (360,000 lineal feet) are flushed per year at a rate of 4,000 gallons per 1,000 lineal feet.
(5) Assumes 180 lineal feet per hour are flushed for eight hours a day using 4,000 gallons of reclaimed water per 1,000 lineal feet of sanitary sewer.

POTENTIAL FOR INDUSTRIAL WATER REUSE

In addition to irrigation, industries within the District that might have a use for reclaimed water have been investigated. These include the significant industrial water users of the District.

The Glacier Northwest Ready-Mix Concrete Plant in Kenmore is one of the few significant industrial water users within the District with the potential to use reclaimed water. The Glacier Northwest Kenmore facility currently reuses all the water they produce, and collects and treats storm water to meet nearly all their water demands. However, during the summer months, when the demand for concrete is high, Glacier Northwest must purchase water from the District to augment the amount it collects from storm water (minimal). In May and June of 2005, the Glacier Northwest Kenmore facility purchased an average of 711 gpd. In July and August of 2005 Glacier Northwest purchased an average water use of 664 gpd.

Water billing records report a total of approximately 85,000 gallons were billed to the Glacier Northwest Kenmore facility for the period from May through August. Notably, the summer water use for 2005 was a maximum for the years 1998 through 2005. Excluding May 2005 through October 2005 (when the water use rate was very large), the average water consumption rate over the remaining time period from January 2000 through March 2005 was approximately 6 gpd. Apparently, in 2005 there was a very large demand for concrete. If this demand continues to increase, or remains similar to that in 2005, and the total costs of reuse water treatment and delivery are determined cost-effective and acceptable, the Glacier Northwest Kenmore facility could be a future candidate for water reuse. A peak day reclaimed water demand is presented in Table 5-17. The value is based on the summer water use (May through August) for 2005.

JETTING OF SANITARY SEWER LINES

One possible application of reclaimed water by the District could be to jet (clean) the sanitary sewer lines. The District's current rate of sanitary sewer flushing is 180 lineal feet per hour. Assuming 250 working days per year and an 8-hour work day, the District could flush approximately 30 percent (360,000 lineal feet) of the total sanitary sewer system per year. At a typical flushing rate of 4,000 gallons per 1,000 lineal feet of sewers, a total of 1.4 million gallons of water per year is required for sanitary sewer flushing. The peak day reclaimed water demand for sanitary sewer flushing is 5,700 gpd. However, without a reclaimed water distribution system in place throughout the District, and the significant costs required to develop such a distribution system for sewer flushing alone, reclaimed water use for this use does not appear cost-effective at this time.

FEASIBILITY OF RECLAIMED WATER

Should the District decide to develop a reclaimed water distribution system derived from the Brightwater WWTP, the reclaimed water could be accessed at the North Kenmore Portal. A distribution system from the North Kenmore Portal to the potential reclaimed water customers is displayed in Figure 5-5. The distribution system outlined in Figure 5-5 totals 43,700 lineal feet. Assuming all 8-inch piping, a reclaimed water distribution system would cost approximately $6,555,000 based on a unit cost of $150 per lineal foot ($90/LF piping + $40/LF surface restoration + $20/LF overhead). This cost does not include permitting and engineering costs. Additional operation and maintenance costs would also be incurred.

As noted earlier in this plan and in the foregoing analysis, the District has determined at this time that Brightwater reclaimed water is not a cost-effective alternate water source for its potable and non-potable water customers, nor is it a feasible option for District sewer flushing. The District's existing contract with SPU provides sufficient potable water supply to meet existing and future demands, in addition to constituting a significant financial investment by the District and its ratepayers. Consequently the District does not currently have sufficient need or cost-justification to develop and manage a reclaimed water distribution system. The District will, however, continue to evaluate the feasibility of reclaimed water for its customers pursuant to its Water System planning requirements, SPU's water supply situation, and as new information regarding its costs, demands, and potential customer uses evolves over time.