King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Fact Sheet
King County Wastewater Flow Projections

Purpose

Comments on the November 2002 *Brightwater Draft Environmental Impact Statement* challenged the underlying population and flow projections identified in the Regional Wastewater Services Plan, asserting that a new treatment plant may not be needed at the target date of 2010 adopted by King County. After reviewing these comments, we found many misunderstandings and misconceptions about how King County projects wastewater flows and capacity needs for the wastewater service area. The purpose of this fact sheet is to summarize the process used by King County to project wastewater flows, including an overview of how population forecasts are used; how base wastewater flow, average wet weather flow, and peak flow are determined; how wastewater flow factors are determined; and how this information is modeled hydraulically and used to design a wastewater system, including treatment and conveyance components

Population and Employment Forecasts

Population and employment forecasts are used to estimate the wastewater flow that is expected to be conveyed and treated by facilities in the wastewater service area through 2030 and at saturation in 2050. Population and employment forecasts and their effect on wastewater flows are crucial to determining which facilities will reach capacity and when. King County relies on population and employment information developed by the Puget Sound Regional Council (PSRC) through 2020. For the decades 2030, 2040, and 2050, King County projects population and employment based on a trend analysis of the earlier decades. This is done to evaluate the sizing of phased facilities because the expected life of these facilities extends beyond the PSRC projections and the ultimate design must be considered in the initial design.

Puget Sound Regional Council Population and Employment Forecasts

In the early 1990s, PSRC developed population and employment forecasts through 2020 for four counties near Puget Sound within the Urban Growth Area. These forecasts, which were adopted by the PSRC in 1995, were based on the 1990 census data. During the mid-1990s King County used the PSRC data through 2020 and developed forecasts for the years 2021 through 2050 by plotting population data using an exponential growth function. These forecasts were the basis of flow estimates presented in the 1997 *Draft Regional Wastewater Services Plan.* Based on comments received on the *Draft RWSP,* King County modified its approach and the projections. The effect of the revision, which employed a linear trend function, was to lower the population forecasts by approximately 9 percent in 2030. A detailed description of this approach is given in a March 1998 technical memorandum titled *Population Forecasts, Flow and Loading Projections Methodology Comparison* by HDR Engineering, Inc.

The population forecasts modified in 1998 were the ones used to estimate flows and capacity needs for the Regional Wastewater Services Plan. The PSRC revises their projections from time to time and King County has examined them to determine if there were any significant changes. So far, there have not been any significant differences in the overall numbers.

The PSRC has recently published new projections that are based on the 2000 census. King County takes the population and employment numbers from its service area, which includes residential, commercial, and industrial population, and adjusts the numbers to reflect sewered and unsewered areas over time. King County assumes that all areas within the urban growth boundary will be sewered per the Growth Management Act and local comprehensive plans. At present there are many customers in the wastewater service area that may receive public water service but are not served by sewers; for example, much of the rapidly growing Sammamish Plateau is currently unsewered, but in time it will all be sewered. King County's wastewater projections assume the entire wastewater service area will be sewered by 2020. This is a significant factor that is often overlooked by analysts reviewing King County's flow projections.

When the sewered population is factored into the recently available 2002 PSRC Forecast Analysis Zone (FAZ) information, we get the projections listed in Table 1. The table compares King County's 1998 sewered population and employment forecasts with the 2002 PSRC forecasts adjusted for sewered population.

Table 1

Comparison of Population and Employment Forecasts

Decade	Sewered population: 1998 King County projections	Sewered population: 2002 PSRC FAZ for King County's service area
1990	2,053,746	1,981,643
2000	2,385,578	2,380,283
2010	2,756,598	2,688,001
2020	3,129,189	3,179,354
2030	3,438,937	3,354,826
Percent change 1990 – 2030	67	69

* With sewered populations considered

Table 1 shows that King County's 1998 projections of sewered population grows by 67 percent from 1990 to 2030 compared to 69 percent for the same period using the 2002 PSRC data adjusted for sewered population in the King County service area. The difference in overall change between forecasts over the 40-year period is insignificant with respect to the County's flow projections.

Design Parameters for Wastewater Systems

Wastewater conveyance and treatment systems are designed using a number of different parameters aimed at ensuring that the effluent discharged from the treatment plants meets the federal and state standards for secondary treatment. These parameters also ensure that standards are met for preventing sanitary overflows in separated systems and for limiting permitted overflows in combined systems. The treatment plants are sized according to a number of different conditions that vary largely due to weather-related factors and treatment plant processes.

Treatment Plant Sizing

If treatment plants were sized to treat peak flows to the most stringent secondary effluent limits, the plants would be much larger and more expensive than those in operation today. Instead, jurisdictions such as King County negotiate a series of parameters and standards for the treatment plants that recognize and allow for a particular range of operating conditions under both dry and wet weather conditions for both the hydraulic and solids handling requirements. These parameters include flow rates for average wet weather, average dry weather, maximum monthly, weekly, daily and hourly flow rates, as well as varying BOD and TSS concentrations and loadings based upon dry and wet weather. These parameters drive the designs of each of the processes to ensure there is adequate treatment under varying flow and weather conditions.

Historically, King County (formerly Metro) used average wet weather flow (AWWF) as a summary parameter to evaluate how we're meeting capacity limits at the treatment plants, even though there are several parameters that must be monitored and tracked. In the 1980s, the South Plant expansion was triggered based upon reaching the average wet weather flow parameter. AWWF continues to be one of the design parameters that is used to summarize a range of parameters that track plant capacity.

Current NPDES permits require that King County submit a plan and schedule for maintaining capacity to achieve permit limits when the plant reaches 85 percent of any one of the design criteria for three consecutive months or when the projected capacity increases would reach design capacity within five years, whichever occurs first. The design criteria include average flow for the maximum month, influent BOD loading for the maximum month, or influent TSS loading for the maximum month. King County has already met the threshold at both the South Treatment Plant and West Point. Accordingly, King County submitted the Regional Wastewater Services Plan to comply with this permit condition. The Washington State Department of Ecology (Ecology) approved this plan and is monitoring its implementation.

Designs for West Point and the South Plant are different because West Point includes a combined system and handles some storm flows that do not have to meet secondary treatment requirements. West Point is able to blend primary treated flows with secondary flows during wet weather events. At present, the South Plant is allowed a smaller amount of blending. The permits and standards for each of the treatment plants have been established through a design review process and negotiation with Ecology. For example, West Point is required to have secondary capacity to treat 2.25 times its AWWF; the South Plant is required to treat 1.8 times its AWWF. The Orange Book (Washington State's sewage design manual) provides guidance for designing treatment plants to meet the federal and state secondary treatment requirements, but each of King County's treatment plants and subsequent upgrades has had unique design factors that have been approved by Ecology. Design factors must not only address wastewater quantity but also quality of the discharge.

Conveyance System Sizing

The sizing of the conveyance system is based almost solely on being able to transport peak flows. For the County's conveyance system, King County proposed and Ecology accepted the use of a 20-year design storm to handle peak hydraulic flows in the separated system. The conveyance system is usually built to handle this peak flow at full build out unless there is a way to phase the conveyance. Some portions of the treatment plant are amenable to phasing so they are usually built in increments to handle the hydraulic peak as the region grows.

Base Sanitary Flow

Base sanitary flow is wastewater flow generated from households and commercial and industrial businesses. Base sanitary flow projections are combined with infiltration and inflow (I/I) components to estimate dry weather and wet weather flows. Wet weather flows and waste loadings are compared with the design capacities of wastewater facilities to determine when facilities will exceed their capacities, thus predicting system constraints over the planning period.

Methodology for Base Flow

To develop base sanitary flow projections, King County combined the population and employment forecasts by service basin with King County sewered area maps to estimate the percent of the population served by sewer. Per capita unit wastewater flow factors were then applied to the sewered population estimates to generate base sanitary flow forecasts. Base sanitary flows were generated using a spreadsheet model developed as part of the Regional Wastewater Services Plan. The model forecasts population, employment, and base sanitary flows by sewer basin using the PSRC population and employment forecasts as input.

Unit Flow Factors

Once sewered population by service basin is estimated, a per capita unit flow factor was applied to determine base sanitary flows. There are three unit flow factors used to estimate the base sanitary flows.

- Residential: 60 gallons of wastewater per capita per day (gpcd)
- Commercial: 35 gallons of wastewater per employee per day (gped)
- Industrial: 75 gallons of wastewater per employee per day

The residential flow factor of 60 gpcd has been used historically by King County and former Metro to develop both the South and West Point systems. The industrial and commercial flow factors of 75 and 35 gped, respectively, were derived based on permitted flow for industrial users, and on modeling and measured flows at the plants for commercial users. Using measured flows along with King County's hydraulic model and the assumption that residential flows equal 60 gpcd, the relationship between industrial and commercial flow factors was established.

To determine if the unit flow factors were reasonable, King County compared the base sanitary flow estimates with dry weather flows measured from each treatment plant for 1990. Dry weather flows include base sanitary flow plus dry weather infiltration and inflow (I/I). **The estimated flows derived from population and sewered area compared closely with the measured flows.**

When King County developed the Regional Wastewater Services Plan, alternative unit flow factors were examined by modeling wastewater unit flow factor changes as a result of water conservation, pricing, and the plumbing and building codes. The County's analysis of the varying flow factors indicated that the base sanitary flows could decrease from 10 to 18 percent using a moderate to aggressive water conservation program. While this sounds significant, it is important to understand that base flow is not a major factor in the timing and sizing of a treatment plant or of its associated conveyance system. Base flow represents less than 20 percent of the peak 20-year storm flow, which is King County's design standard. The potential conservation measures resulted in peak flow reductions in 2020 from 2 to 4 percent. Peak flows at 2030 are projected to be 608 mgd in the separated portion of the system. This will not change the timing or size of any facilities currently planned. Based on this analysis, and the fact that water conservation benefits are uncertain because they are not mandatory, the flow factors were not adjusted to include reliance on water conservation.

The City of Seattle recently suggested that industrial and commercial flow factors are significantly lower than those used by King County. Seattle's flow factors are based upon what we believed to be the results of water conservation efforts over the last decade that could reduce the need for additional sewer capacity in the future. Residential consumption predicted by Seattle remains similar to the King County flow factor so there is no adjustment warranted for residential. Seattle's proposed flow factor for 54 gpcd is similar to the 10 percent base flow reduction analysis discussed above. The corresponding 2 percent reduction in peak flow is small enough that it is not recognized within the accuracy of the actual monitoring. Additionally this potential reduction of 2 percent the peak is not enough to risk underbuilding any wastewater facilities unless they can be cost effectively phased. Flow information from the County's treatment plants indicates that water conservation is not having a significant effect on wastewater flows. This is probably because much of the conservation taking place is in outdoor water use, such as reduced lawn watering or car washing, which is water that usually does not reach the sewer system. The volumes of the potential commercial sector reductions are so small that we cannot see them in the volumes handled by the wastewater system.

King County agrees that there is a reduction of water use in the industrial sector, though more work needs to be done to refine the industrial flow factor However, it is important to note that any reductions in estimated industrial flow will occur primarily in the southern portions of the service area and will not benefit the north service area where we are reaching hydraulic capacity most quickly. Even so, our estimates show that, using a 50 gped flow factor, we would only see a 4 mgd reduction in base flows and average wet weather flows systemwide.

While King County is interested in further evaluating these factors, the projected water conservation benefits do not warrant any adjustment in treatment or conveyance sizing.

Average Wet Weather Flow, Peak Flow, and Solids Loading

Methodology for Average Wet Weather Flow

King County derives AWWF for the base planning year of 1990 by measuring flow at the treatment plants over several years and adjusting these flows using rainfall data to reflect an average wet period during historical conditions. This approach is unique to King County but has been approved by the Washington State Department of Ecology. The South Treatment Plant service area collection system is a separated system, and its AWWF definition is the average of all flows during the months of November through April (6 months). For the West Point collection system, which has combined systems, the AWWF is defined as the average of all non-storm flows during the months of November through April. The projections for AWWF for the entire system are shown in Figure 1.

Figure 1
Estimated Flows and Capacity Needs

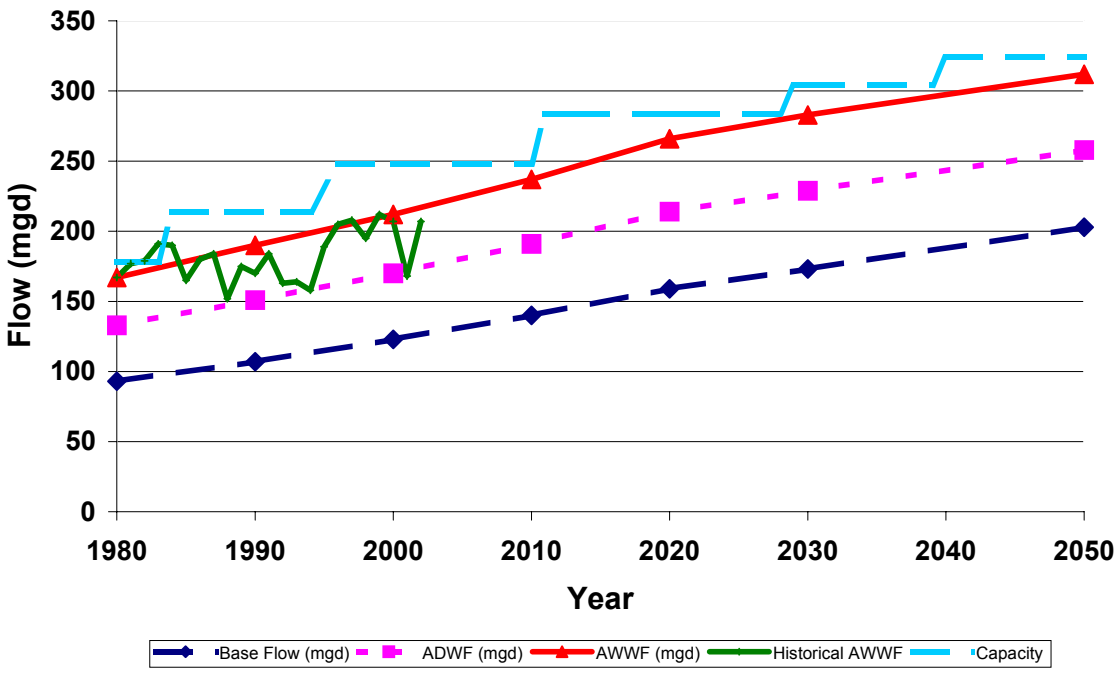

Figure 1 shows the historical AWWF compared to the projected AWWF for the King County system. One observation from the figure is that the measured flow is well below the projected flow for the years 1987–88, 1992–94, and 2000–01. This is because these years are generally described as drought years in the Puget Sound region. In years when the rainfall has been about normal or above normal (1981–82, 1984, 1986–87, 1997, and 1991), the measured AWWF at the treatment plants is very close to the projected AWWF. Figure 1 also shows that in 2013 the projected AWWF will reach the system capacity of 248 mgd. In terms of the individual treatment plants, the West Point Plant will have some capacity beyond 2010, and the South Treatment Plant may reach capacity before 2010, as shown in Figures 2 and 3, respectively.

Figure 2
West Point Average Wet Weather Flows and Capacity

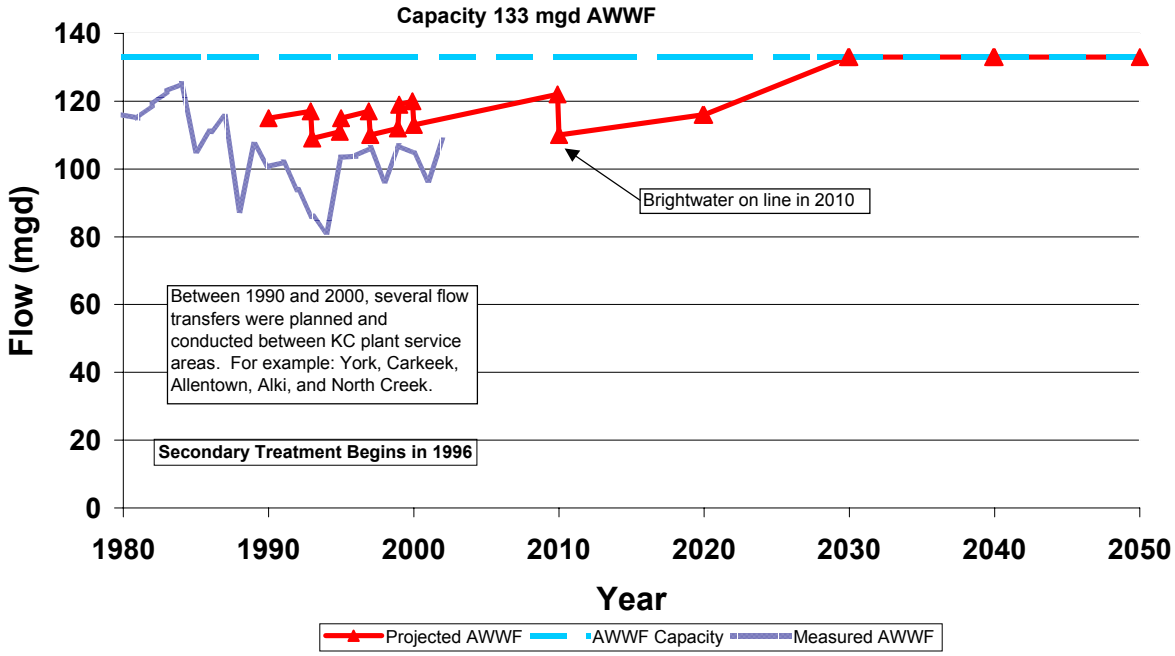

Figure 2 shows that while West Point does have additional capacity beyond 2010, there is insufficient conveyance capacity to get the flows to West Point because of limitations in the Kenmore Interceptor as well as insufficient digester capacity to handle the additional solids.

Figure 3
South Plant Average Wet Weather Flows and Capacity

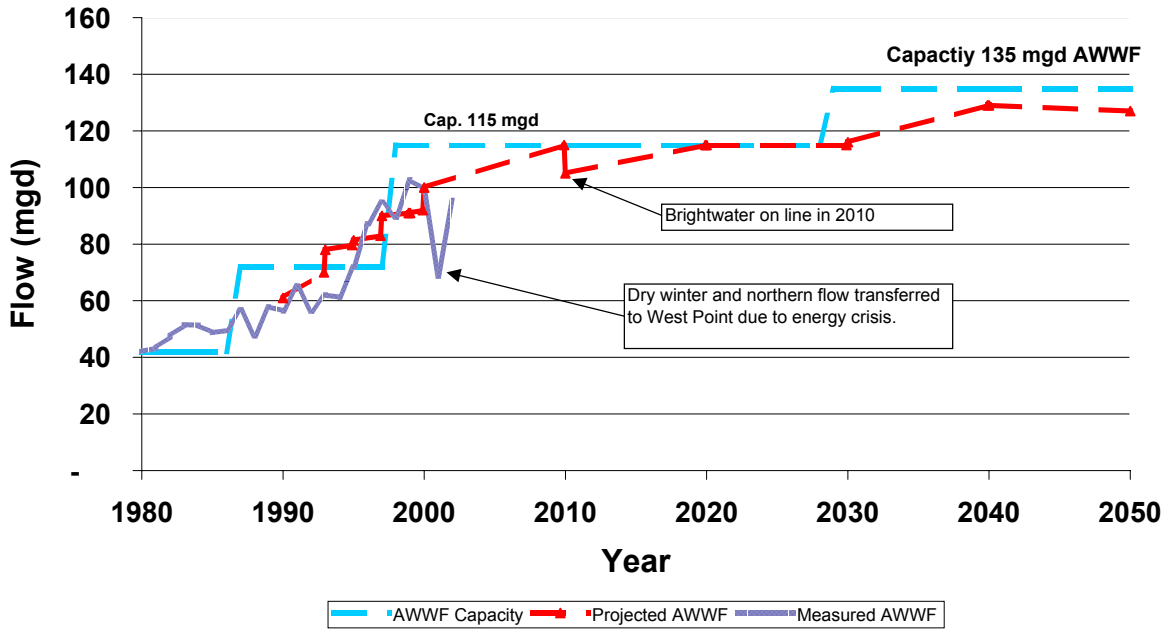

Figure 3 shows that the measured AWWF at the South Treatment Plant has increased rapidly during the 1990s toward the plant's capacity of 115 mgd in 2010. And apart from a dry year and flow transfers in 2001, the measured flows were on track to reach the plant's capacity even sooner.

Methodology for Peak Flow

Peak flows were projected starting with 1990 as the base year using King County's hydrologic and hydraulic routing models. The models use various inputs in addition to base sanitary flow estimates and sewered area estimates, and the model was calibrated for 12 sub-areas making up the entire service area. The model simulates flow, including I/I, during dry weather and storm events. Forty-three years of rainfall data was also run through the model to estimate 20-year peak flow in each sub-basin. Future peak flows are projected using population, sewered area, existing I/I responses, and a degradation factor for increases in I/I.

The north service area continues to be a major constriction in the system. Based on model results done in 1998, King County estimates that the Kenmore Interceptor (a.k.a. Lake Line) and upstream storage and flow transfers to Edmonds will reach capacity no later than 2010. This assumption is supported by recent checks against the model, comparing our 1998 modeled peak flows for basins discharging to the Lake Line for the year 2000 against updated flows modeled using actual rainfall data from the 2001–2002 wet season. The results shown in Table 2 confirm that our original estimates are still valid.

Table 2
Comparison of Previous and Current Flow Estimates to the Kenmore Interceptor

Basin	Original Year 2000 20-year Peak (mgd)[a]	Updated Year 2000 20-year Peak (mgd)[b]
Swamp Creek – Snohomish County	9.6	7.1
Swamp Creek – King County	1.7	1.7
Kenmore Section 5 plus Bothell	5.8	8.8
Inglewood	2.6	3.6
Lake Forest Park – Snohomish & King Co.	5.4	5.4
Lyon Creek – Snohomish Co.	0.7	1.7
McAleer & Lyon	6.2	6.2
Lake Ballinger Pump Station	16	14
Total	**48**	**48.5**

[a] Modeled flow in 1998
[b] Modeled flow using measured rainfall from the 2001–2002 wet season

Methodology for Solids loading

Estimates for solids are developed by applying unit loading factors to the population and employment forecasts. Biological oxygen demand and total suspended solids are measured daily so there is regular data to be used to estimate future solids loading. Actual solids volumes that leave the plants as biosolids are also measured and used to "back calculate" in-plant facility needs.

Solids handling is also a critical factor in determining the timing for new treatment plant facilities. Current projections show that the South Plant will reach its solids handling capacity at 2010 and West Point is already at or near its solids capacity. During the RWSP we expected West Point to have enough solids capacity to last through 2030 and match its hydraulic capacity at 133 mgd AWWF. Problems with the digester and solids handling facilities are leading us to believe that we have matched the capacity now. Evaluations are being done now to determine if minor modifications will enable the capacity to last through 2010 when Brightwater is on line.

Summary

All indicators used to project conveyance and treatment plant capacity indicate that King County is running out of capacity.

- We will exceed capacity in the north end conveyance and storage no later than 2010.
- We may be out of capacity at the South Plant sooner than 2010
- We are already at the limit of capacity in solids handling for West Point

In late 1999 the King County Council adopted a plan to build a new treatment plant in the north end by 2010. This decision occurred after lengthy debate over whether to maximize the existing two-plant system by expanding West Point and the South Plant in 2010. The consequences of delaying new capacity or downsizing our facilities based on uncertain projections or inadequate temporary facilities are unacceptable for public health, the environment, and the economy. Replacing or delaying new facilities by constructing interim storage facilities or alternative technologies for solids have very short-term benefits compared to their costs.