Regional Wastewater Services Plan

Water Quality Report

March 2002

King County

Department of
Natural Resources and Parks
Wastewater Treatment Division

Contents

Visit the Regional Wastewater Services Plant Web site at
http://dnr.metrokc.gov/wtd/rwsp/rwsp.htm

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Executive Summary

This report describes the efforts of King County's Department of Natural Resources and Parks (DNRP) in 2001 to protect and preserve water quality in Puget Sound and the major lakes and rivers. In particular, this report is concerned with those waters that could be impacted by the operations of King County's wastewater treatment and conveyance system; namely, discharges of treated or partially treated wastewater, sanitary sewer overflows (untreated wastewater), and combined sewer overflows (untreated wastewater combined with stormwater runoff).

This report is required by Ordinance 13680, which adopted the Regional Wastewater Services Plan (RWSP)—a $1.7 billion[1] capital improvement program to provide wastewater capacity for this region for the next 30 years and beyond. Ordinance 13680 identified the need for a water quality report to "ensure that the RWSP reflects current conditions and addresses water pollution abatement, water quality monitoring results, water conservation and water reclamation, Endangered Species Act compliance, septic system conversions to the regional sewer system, biosolids management, wastewater public health problems, and compliance with other agency regulations and agreements."

This Executive Summary provides an overview of the information provided in this report, beginning with a summary of the state of waters in King County and continuing with a description of the county's programs to monitor our waters and manage water quality. The next section of the report describes how we measure the health of our water bodies using chemical, biological, and physical indicators and comparing them against established criteria. The report then describes our programs to monitor and manage water quality in this regional. The final section identifies upcoming issues that will present some unique challenges—as well as opportunities for change—for King County, such as how the Endangered Species Act may impact our already water quality-focused wastewater treatment processes and monitoring programs. The appendixes contain a glossary of technical terms used in this report as well as a list of Web sites you can visit to learn more about the programs and water bodies described in this report.

State of the Waters

There are three major groups of waters described in this report: the major lakes, including Lake Washington, Lake Sammamish, and Lake Union; the major rivers, including the Cedar River, the Sammamish River, and the Green River; and the marine waters of Puget Sound. These waters are shown if Figure 1 and summarized below.

Major Lakes

Water quality in the major lakes, as described by their biological productivity, has ranged between moderate to exceptionally good during the last several years. Lake Washington had good water quality in 2001, with good water clarity and low concentrations of algae. Water

[1] In 2001 dollars

quality was very good in Lake Sammamish in 2001 with good water clarity, low concentrations of algae, and moderate concentrations of phosphorous. Excess phosphorous loading has been an historical problem in the lake, particularly in summer. Since 1998, phosphorous concentrations have been well below the goal of 22 ug/L (mean annual volume weighted total phosphorous) as determined in the 1989 Lake Sammamish Management Plan. However, lakes Washington and Sammamish remain vulnerable to water quality degradation by urbanization and land use activities such as construction, development, forestry, and farming. Lake Union's water quality was moderate in 2001 and has fluctuated between moderate and good since 1994.

Major Rivers

Water quality in the Cedar River is typically very high. The Cedar River was listed on the Washington State Department of Ecology's 1998 303(d) list[2] for exceeding the fecal coliform standard. Much of the Cedar River watershed is forested, which is the major contributor to the continued high water quality in the river. Diversion of flows for drinking water is a major issue for the Cedar River.

The Sammamish River is listed on the 1998 303(d) list for exceeding standards for temperature, dissolved oxygen, pH, and fecal coliform. High river temperatures typically occur in the summer and early fall when chinook and sockeye salmon are returning to spawn in tributaries. In general, elevated temperature is considered the most serious water quality problem limiting beneficial uses in the river.

Water quality in the Green River and its tributaries varies widely depending on location in the watershed, level of urbanization, and human activities. Numerous streams throughout the Green-Duwamish watershed are listed on the 303(d) list, including portions of the Duwamish River and lower Green River. Low dissolved oxygen and fecal coliform bacteria are concerns in the Green River watershed, and there has been a trend toward increasing water temperatures in tributaries in the urbanized part of the watershed.

Puget Sound

The marine waters of Puget Sound within King County are in excellent condition overall and do not show evidence of persistent bacterial, nutrient, or toxicant pollution. Offshore waters have consistently shown high levels of dissolved oxygen and low fecal coliform bacteria over the last several years. There were some pollution problems in the nearshore environment, however, with localized areas failing water quality standards for fecal coliform bacteria—particularly in areas near freshwater sources or in areas of poor tidal flushing. Another localized problem is sediment contamination, which is evident primarily in Elliott Bay.

[2] The 303(d) list identifies water bodies that do not meet state water quality standards.

Water Quality Monitoring Programs

To protect its significant investment in water quality improvements, King County continuously monitors its major lakes, beaches, streams, marine waters, and wastewater effluent. The major lakes monitoring program collects samples monthly, with samples collected every two weeks during the growing season from 5 sites in Lake Union, 13 sties in Lake Washington, and 7 sites in Lake Sammamish. Sampled parameters include temperature, dissolved oxygen, pH, conductivity, clarity, phosphorus, nitrogen, and fecal coliform bacteria. In addition, the county installed 5 robotic buoys to collect water quality data from Lake Washington and Lake Sammamish. The buoys continuously measure temperature, pH, dissolved oxygen, and chlorophyll *a.*

The swimming beach monitoring program monitors swimming beaches on Lake Sammamish, Lake Washington, and Green Lake every summer. This effort, ongoing since 1996, collects bacteria samples to determine if there are risks to human health. The stream monitoring program targets locations in streams and rivers where they cross sewer trunk lines or if they are considered a potential or significant source of pollutant loading to a major water body. The long-term program has collected monthly samples under baseflow conditions at 63 sites on 3 rivers and 27 streams for many years. Storm samples have been collected at the mouths of major streams three to six times annually since 1987.

King County's marine monitoring program routinely evaluates nutrient, bacteria, and dissolved oxygen levels in the waters of the main basin of Puget Sound as well as monitoring sediment quality near outfalls and at ambient locations. The goals of the ambient monitoring program are to better understand regional water quality and to provide data needed to identify trends that might show impacts from long-term cumulative pollution. In addition, the county is conducting a detailed investigation of water quality in northern Puget Sound termed the Marine Outfall Siting Study (MOSS). This study will help evaluate potential sites for the marine outfall that will serve the Brightwater Treatment Plant expected on line in 2010.

King County continuously monitors its wastewater effluent using process laboratories at both of its regional treatment plants and at the environmental laboratory in Seattle. The process laboratories perform conventional chemistry and microbiology analyses in support of plant process optimization and state permit requirements. The environmental laboratory also supports meeting our state permits, analyzing wastewater effluent quarterly for 13 priority pollutant metals (such as mercury) and testing for organic compounds such as PCBs and 75 other organic priority pollutants semi-annually. In addition to the chemical testing, the environmental laboratory tests the wastewater effluent for toxicity to freshwater and marine organisms.

Water Quality Management Programs

King County has many programs in place that help protect and preserve water quality. The wastewater treatment system collects wastewater from 34 cities and sewer districts serving approximately 1.3 million residents and conveys it to two regional treatment plants: the West Point Treatment Plant in Seattle's Discovery Park and the South Treatment Plant in Renton. On average, these plants provide secondary treatment for over 300 million gallons of sewage each day. The quality of treated effluent from these plants remained high in 2001, with effluent limits typically much higher quality than what is required by our state permits.

King County also has a program to reduce the amount of combined sewer overflows, with two large CSO projects underway at Denny Way and Henderson/Martin Luther King Jr. Way. As part of the Regional Wastewater Services Plan, the county has committed to controlling all its CSO discharge locations to one event per year by 2030. In addition, two source control programs are working to prevent pollutants from even reaching our treatment plants and the environment—the Industrial Waste Program and the Hazardous Waste Management Program. For example, last year the Industrial Waste Program, which regulates industrial wastewater discharges, collected 2,617 samples and found 231 violations of discharge regulations. All violations were followed up with some form of enforcement action. The county also recovers its resources where possible, recycling 100 percent of its biosolids from the wastewater treatment process, recovering digester gas (methane) for use in running plant operations, and implementing a program that provides reclaimed water for customers in the service area.

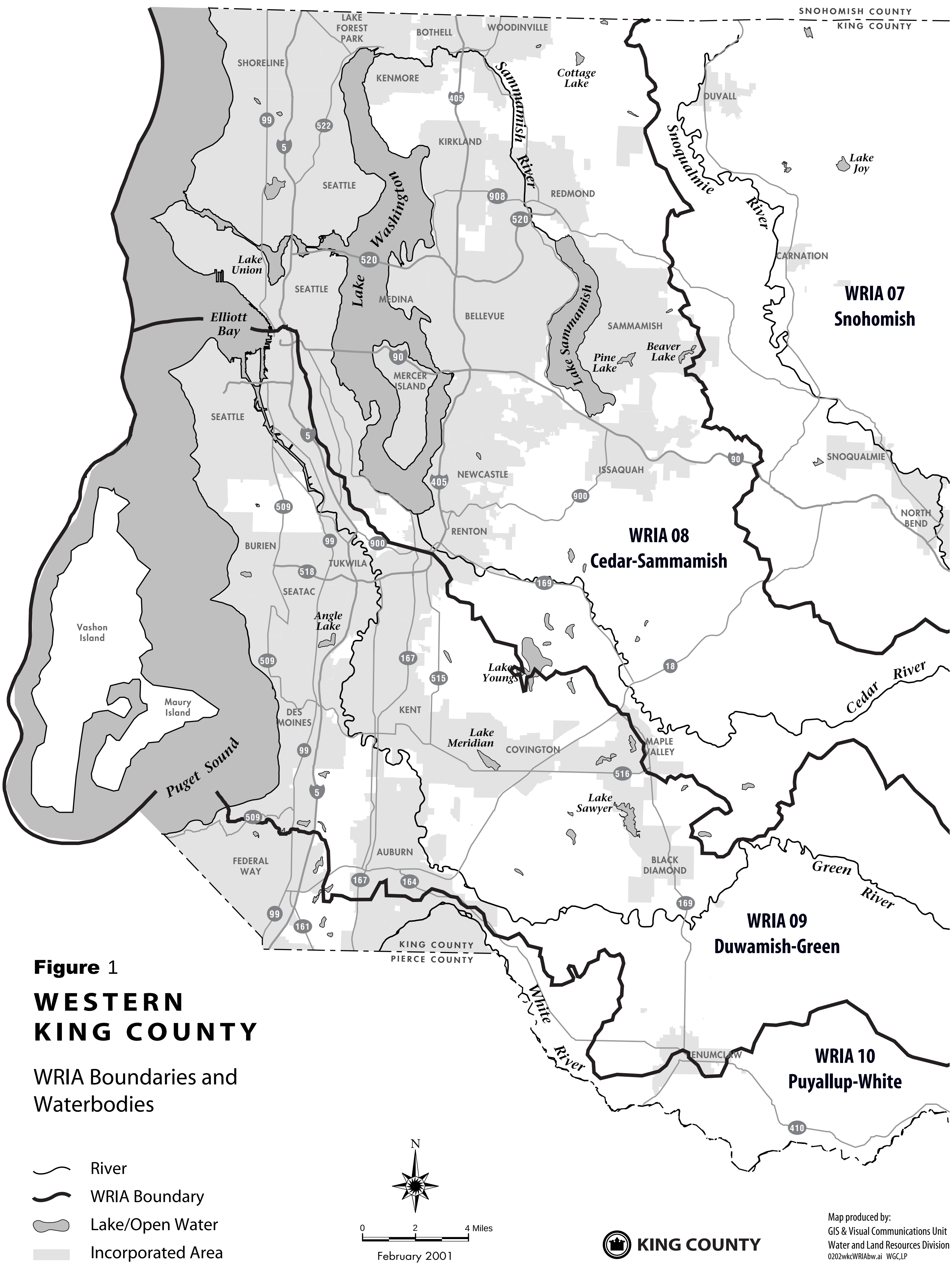

Figure 1

WESTERN KING COUNTY

WRIA Boundaries and Waterbodies

February 2001

Map produced by:
GIS & Visual Communications Unit
Water and Land Resources Division
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Understanding the Health of King County Waters

In the Puget Sound region, water is an integral part of our surroundings, economy, and way of life. King County acts as a steward of these waters and is committed to keeping them clean. Today, the quality of our waters has improved dramatically as a result of the development of a regional wastewater collection and treatment system and our cooperative efforts to implement the pollution control programs established by the Clean Water Act (CWA) in 1987. Our goal is to ensure that our actions are not degrading the beneficial uses of our valuable water resources, and understanding the health of our waters is the basis for achieving this goal.

This section describes how we measure the health of water bodies in the King County wastewater service area using chemical, physical, and biological indicators. We monitor these indicators and compare them against criteria established by the Washington State under the Clean Water Act (Water Quality Standards). We also compare indicators against accepted scientific criteria; for example, we evaluate the health of lakes by their trophic state, a measure of biological productivity.

Washington State Water Quality Standards

The primary objective of the Clean Water Act is to restore and maintain the integrity of the nation's waters, which translates into two national goals. One goal is to eliminate the discharge of pollutants into the nation's waters, and the other goal is to achieve fishable and swimmable waters. The first goal is met through the National Pollutant Discharge Elimination System (NPDES) permit program, which sets limits on pollutants discharged from point sources such as King County's wastewater treatment plants. The second goal is met by setting specific water quality criteria for water bodies and developing pollution control programs to meet them.

To meet the second CWA goal, the Washington State Department of Ecology (Ecology) developed a classification-based system in which each water body is assigned to one of seven classes: Class AA, Class A, Class B, Class C, Lake Class, Marine Class AA, and Marine Class A. Class AA is for the highest quality waters and it is clean enough to support all beneficial uses. Each class has a specific set of beneficial uses that must be protected (e.g., swimming, fishing, aquatic life habitat, and domestic water supply) and a specific set of water quality criteria limiting the amount of pollution allowed. The criteria are set at levels designed to protect all the listed beneficial uses associated with the class. A higher class of protection requires pollutants to be more strictly limited. Table 1 shows the classification of water bodies in King County and the corresponding criteria.

Table 1
Water Quality Criteria used in the Freshwater and Marine Monitoring Programs

Class	Fecal coliform bacteria	Dissolved Oxygen	Temperature	pH
Lake	Geometric mean value shall not exceed 50 org/100 mL, with not more than 10 percent of the samples exceeding 100 org/100 mL.	No measurable change from natural conditions	No measurable change from natural conditions	No measurable change from natural conditions
AA	Geometric mean value shall not exceed 50 colonies/100mL, with not more than 10 percent of the samples exceeding 100 colonies/100 mL	Shall exceed 9.5 mg/L	Shall not exceed 16° C	Shall be between 6.5 and 8.5
A	Geometric mean value shall not exceed 100 colonies/100 mL, with not more than 10 percent of the samples exceeding 200 colonies/100 mL.	Shall exceed 8.0 mg/L	Shall not exceed 18° C	Shall be between 6.5 and 8.5
B	Geometric mean value shall not exceed 200 org/100 mL, with not more than 10 percent of the samples exceeding 400 org/100 mL.	Shall exceed 6.5 mg/L	Shall not exceed 21 ° C	Shall be between 6.5 and 8.5
Marine AA	Geometric mean value shall not exceed 14 colonies/100 mL, with not more than 10 percent of the samples exceeding 43 colonies/100 mL.	Shall exceed 7.0 mg/L	Shall not exceed 13° C	Shall be between 7.0 and 8.5
Marine A	Geometric mean value shall not exceed 14 colonies/100 mL, with not more than 10 percent of the samples exceeding 43 colonies/100 mL.	Shall exceed 6.0 mg/L	Shall not exceed 16° C	Shall be between 7.0 and 8.5

Source: Washington State Department of Ecology and WAC 173-201a, 11/25/92

Marine AA includes all Puget Sound waters within King County exclusive of Elliott Bay

Marine A includes the waters of Elliott Bay

When waters do not meet standards, they must be listed per the requirements of the Clean Water Act, section 303(d), which is published every 3–5 years. Once listed, the water body must be studied and controls must be put into place that will correct conditions so that it meets standards. Controls often involve dividing the pollutant load into allocations that the water body can assimilate and still meet standards. This process is called a Total Maximum Daily Load, or TMDL. TMDLs are described in more detail in the final section of this report.

The criteria used to assess a water body's health under the state's classification system include a mix of biological, chemical, and physical parameters. They are fecal coliform bacteria, dissolved oxygen, temperature, pH, and turbidity. Each parameter, or indicator of health, is described below.

Fecal Coliform Bacteria

Fecal coliform bacteria live in the intestines of warm-blooded animals and are used as an indicator of fecal pollution. Wildlife, pets, livestock, and humans are all potential sources of fecal coliform bacteria, and this inclusiveness diminishes the effectiveness of using these bacteria as indicators of human sewage pollution. Most fecal coliform bacteria do not cause disease but they coexist with bacteria that do pose a public health risk, such as *Enterococcus* and *E. coli*. The higher the fecal bacteria count the higher the probability of *Enterococcus* and *E. coli* being present as well). While the presence of fecal coliform bacteria indicates fecal contamination, we can not distinguish if the feces comes from humans or from other warm-blooded animals. Because human sewage is the real public health issue, the state standard for fecal coliform bacteria is currently under review by the Washington State Department of Ecology and may be replaced by standards for *Enterococcus* or *E. coli*.

Dissolved Oxygen

Aquatic plants and animals require a certain amount of dissolved oxygen (DO) in the water for respiration and basic metabolic processes. Waters that contain high amounts of dissolved oxygen are generally considered healthy ecosystems. The concentration of dissolved oxygen is also important in determining the amount of habitat available for different types of aquatic organisms. Dissolved oxygen averages are most important during the summer season. The DO levels at sites meeting the Class AA and Class A criteria are more than required by salmonids.

Temperature

Temperature is an important physical parameter for aquatic systems as it influences many of the chemical components of the water (e.g., dissolved oxygen concentration). Temperature also exerts a major influence on biological activity and growth and therefore ultimately the survival of aquatic organisms. The temperature averages for June through September are important since the worst conditions for fish would occur then. Waters that meet Class AA and Class A criteria are suitable for salmonids.

pH

The pH of water is a measure of the concentration of hydrogen ions. A value higher than seven (meaning there are fewer free hydrogen ions) is considered basic, a value of seven is considered neutral, and a pH value of less than seven is considered acidic. The pH of water determines the solubility and biological availability of chemical constituents such as heavy metals and nutrients. Metals tend to be more toxic at lower pH values because they are more soluble. Likewise, at lower pH values nutrients are also in soluble form and are therefore more readily taken up by aquatic plants. For example, if nutrients enter a water body in the form of organic matter that first needs to be broken down before it can be utilized for growth by plants, pH becomes important, as it will affect the rate of decomposition.

State criterion is that pH shall be between 6.5 and 8.5 pH units for Class AA and Class A waters. At pH levels above 8.5, low levels of ionized ammonia can become toxic and at levels below 6.5, metals can become more toxic.

Turbidity

Turbidity is a measure of the amount of light scattered in a water sample and is reported in Nephelometric Turbidity Units (NTU). The more material in the water, the greater the light scattering and the higher the NTU reading. The state Class AA turbidity criterion is used primarily for assessing the impact of point discharges. In general, it is human activities within the watershed that usually result in higher turbidity (e.g., land development and construction causing loss of vegetation, increased runoff, and increased erosion).

Usually, when using turbidity to evaluate the impact of a pollutant source, two measurements are made: one upstream of a discharge point (background levels) and another downstream. The Class AA criteria states, “downstream turbidity shall not be more than 5 NTU higher than the upstream measurement if the background is 50 NTU or less.” In the King County Stream Monitoring Program, measurements are made at only one point in a stream and are typically less than 50 NTU in baseline measurements. Therefore, to evaluate potential turbidity problems at each site, individual measurements are compared to the average of all measurements for that site. Values exceeding the average by 5 NTU or more are considered substandard.

Trophic State Index

Another way we measure the health of waters is using the numerical Trophic State Index (TSI) developed by Robert Carlson in 1977. Using this index, lakes can be characterized and compared according to the level of biological activity. This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, etc.) represents a doubling of algal biomass and is related to nutrients and transparency (water clarity). This index is calculated from the summer mean values of the three most common lake parameters: Secchi depth transparency, total phosphorus, and chlorophyll *a* concentrations. Average characterizations for the three TSI values are shown in Table 2.

Table 2
Average Summer (June-Sept) Trophic State Index Value

TSI Value	Classification	Characterization
< 40	Oligotrophic	Low biological productivity resulting in high water clarity, low algal levels and phosphorus concentrations.
40 – 50	Mesotrophic	Moderate levels of plant and animal activity, resulting in moderate water clarity, algal levels and low phosphorus concentrations.
> 50	Eutrophic	High biological productivity resulting in low water clarity, high algal levels and high phosphorus concentrations.

Secchi Depth Transparency

Secchi Depth Transparency is a measure of how clear or transparent water is as measured by a Secchi disk—an 8-inch disk with alternating black and white quadrants. The disk is lowered into the water until the observer can no longer see it. This depth of disappearance, called the Secchi depth, is a measure of the water's transparency. Transparency can be affected by algae, soil particles, and other materials suspended in the water, and the Secchi depth will decrease as these factors increase. In King County, clarity tends to very low during periods of high primary productivity (spring and summer) and very high during the winter.

Phosphorus

A certain amount of nutrients such as nitrogen, phosphorus, and silica are necessary for plant and animal growth, but an excessive amount may lead to poor water quality conditions. While excess nutrients do not cause immediate harm to organisms living in the water column, they can increase the growth of marine plants, which subsequently decay and deplete oxygen to levels incapable of sustaining aquatic organisms. Phosphorus is the primary nutrient of concern in freshwater systems as it can cause nuisance algal blooms if present in excess amounts. Sediment bound phosphorus is released into the water column when oxygen concentrations fall below 0.2 mg/L.

Chlorophyll

Chlorophyll is the green pigment in plants that allows them to create energy from light (photosynthesis). By measuring chlorophyll, you indirectly measure the amount of photosynthesizing plants/algae in the water column. Chlorophyll *a* is a measure of the portion of the pigment that is still actively photosynthesizing at the time of sampling.

Other Indicators of Health

In addition to the indicators that are used to measure if a water body is complying with water quality standards and the Trophic State Index, King County looks at other indicators of water body health as part of its monitoring programs. For example, The point source monitoring program required by the county's NPDES permit (such as those around the West Point Wastewater Treatment Plant outfall) are analyzed for nutrients, water clarity, salinity, and sediments, as well as metals and organics in shellfish tissues. The Small Streams Toxicity/Pesticide Study assesses toxicity in urban streams under both storm and baseflow conditions by collecting and evaluating metals and pesticides. The marine monitoring program collects information on pesticides, metals, semi-volatile organics, and PCBs in the water column, sediment, algae, and shellfish. These programs and their results are described in the following sections of this report.

human health, wildlife, and aquatic life, including threatened and endangered species such as chinook salmon and bull trout. Potential risks and water quality conditions will be assessed for both current and future conditions. The SWAMP is directly linked and coordinated with current King County water resource monitoring efforts.

Remote Underwater Sampling Station™

King County installed five robotic buoys to collect water quality data from Lake Washington and Lake Sammamish in July 2000. The buoys collect water samples automatically, 24 hours a day, 365 days a year. Data are transmitted daily to King County and is available online at http://www.metrokc.gov/lakedata. The data from the buoys will contribute to the development of the models of Lake Washington, Lake Sammamish, the Sammamish River, and the Lake Washington Ship Canal. In addition to buoy data, the models will include input from rivers/streams, surface runoff, groundwater, and precipitation.

Beach and Stream Monitoring

There are four components of King County's beach and stream monitoring program: swimming beach monitoring, stream monitoring, the Small Streams Toxicity/Pesticide Study, and the Green-Duwamish Watershed Water Quality Assessment. Each component is summarized as follows.

Swimming Beach Monitoring

Every summer since 1996, swimming beaches on Lakes Sammamish, Washington, and Green were surveyed to determine levels of bacterial pollution. King County evaluates relative human health risks and necessity for beach closures in cooperation with the Seattle-King County Public Health Department and local parks departments. Prior to this survey, there was limited local data on bacterial levels at these swimming beaches on these lakes. In addition to this beach monitoring, King County collects substantial amounts of bacterial data for Lake Sammamish and Lake Washington as part of the Lake Assessment long-term monitoring program. These data are collected to monitor the integrity of the sewage collection and transfer system.

Stream Monitoring

Streams and rivers in the King County service area are monitored if they cross sewer trunk lines or if they are considered a potential or significant source of pollutant loading to a major water body. Monthly baseflow samples have been collected along some of the tributaries flowing into Lake Washington and Lake Sammamish since 1979. Sixty-three sites on three rivers and twenty-seven streams have been sampled monthly under baseflow conditions for the parameters of turbidity, pH, summer temperature, summer dissolved oxygen, fecal coliform bacteria, *E. coli* bacteria, and *Enterococcus* bacteria. Beginning in 1987, storm samples have

been collected three to six times annually at sites located at the mouth of streams. Storm samples are analyzed for the same parameters as baseflow samples plus trace metals.

Small Streams Toxicity/Pesticide Study

The Small Streams Toxicity/Pesticide Study is an assessment of toxicity in urban streams under both storm and baseflow conditions. It is also an effort to collect and evaluate information on potential toxins, primarily pesticides, and metals. The 2001 effort was the third year of this multi-year study and is part of King County's Sammamish Washington Analysis and Modeling Project.

The United States Geological Survey and the Washington Department of Ecology have been studying the ambient distribution of pesticides in the Puget Sound Region for much of this decade under the National Water Quality Assessment Program (NAWQA). Much of this work has involved storm sampling to monitor current trends in nonpoint pollution. Their initial findings focused subsequent efforts on small urban/suburban streams. In 1999, King County initiated the Small Streams Toxicity Study as a follow-up to those earlier studies to investigate the incidence, prevalence, and possible cause of toxicity in small urban streams. King County collaborated with the USGS and Ecology to test for toxicity, pesticides, and metals in three small suburban streams and a reference stream.

Green-Duwamish Watershed Water Quality Assessment

The primary goal of this project is to develop analytical tools for evaluating current and future water quality issues in the Green-Duwamish watershed and to provide water quality information to a variety of clients internal and external to King County DNRP. The Green-Duwamish Watershed Water Quality Assessment will assist wastewater capital planning (including the CSO program and habitat conservation planning), WRIA 09 salmon conservation planning, and the Department of Ecology's TMDL program by collecting water quality information, developing a watershed model, and using the model to explore resource management options. Specifically, the project will:

- assess existing and future water quality conditions for selected parameters, and best management practices for achieving Washington State water quality standards in the Green-Duwamish watershed
- assess the 303(d) listed parameters of concern for the King County Wastewater Treatment Division (e.g., parameters that could influence future CSO permit requirements: fecal coliform/*Enterococcus*/*E.coli,* and metals), including the identification of sources of bacteria and metals throughout the watershed

- provide information to support the Wastewater Treatment Division's Habitat Conservation Plan and WRIA 09 salmon conservation planning efforts, including information on water quality as a factor of decline for salmonids
- coordinate with the Department of Ecology in order to provide technical information for Ecology's TMDL development for stakeholders of the watershed to use to achieve the greatest improvement in water quality in the watershed given a finite amount of money

The Green-Duwamish Water Quality Assessment will involve water quality and hydrologic monitoring, land use/land cover modeling, water quality and quantity modeling, best management practice evaluation, and ecological and human health risk assessment.

Marine Monitoring

King County monitors marine water and sediment quality in Puget Sound within King County borders to assess and preserve the unique and diverse marine environments found in this region. King County's marine monitoring programs are designed to assess potential effects to water quality from both county facility point sources and from regional nonpoint sources of pollution. Point source pollution is characterized by its entry into the aquatic environment from a specific source, such as an outfall pipe from an industrial or municipal facility. King County has implemented an extensive point source monitoring program for over 20 years in order to assess water quality around the county's wastewater treatment facilities, marine outfalls, and nearby beaches, ensuring that the facilities are causing no adverse effects. Nonpoint source pollution enters the aquatic environment from any source that is not a point source and includes runoff from streams, stormwater, and groundwater.

King County's marine monitoring program (separated into point source and ambient monitoring) is structured to assess potential effects from both types of pollution in both nearshore and offshore environments and also to assess ambient (or background) water quality conditions. Observing conditions in areas away from point sources provides essential water quality data. King County's goals for the ambient monitoring program are to better understand regional water quality and to provide data needed to identify trends that might show impacts from long-term cumulative pollution.

Water Monitoring Programs

Ensuring the health of county water bodies, as well as the health of the people using them, is the purpose of King County's extensive water monitoring programs. King County is continuously assessing the quality of the effluent at each of its wastewater treatment facilities, the receiving water around each outfall, and the waters at nearby beaches to ensure the facility is meeting the goals of the Clean Water Act and other regulatory requirements. In addition, and with the help of expert staff and outstanding volunteers, King County monitors the quality of a large number of its water bodies, including environmental indicators (the aquatic life in the water bodies) such as amphibians, stream bugs, and fish. This section describes four King County programs to monitor its major lakes, beaches and streams, marine waters, and the effluent from King County's wastewater treatment facilities.

Major Lakes Monitoring

The Major Lakes Monitoring Program is designed to protect the significant investment in water quality improvements made by the people of King County. Though nearly all sewage is either treated with an on-site septic system or sent to treatment plants, water quality monitoring is still important to help ensure the continued system integrity and to identify any threats to the gains we have already made in water quality. Sampling and flow monitoring sites are distributed around the lakes and streams to monitor the long-term environmental quality of these waters.

Samples are collected monthly except during the growing season, when samples are collected every two weeks. There are 5 sampling sites in Lake Union, 13 sites in Lake Washington, and 7 sites in Lake Sammamish. Samples are collected every 5 meters from 1-meter depth to just above the lake bottom. Each of the lakes has one or more sampling stations located in its deep central basin where the influence of the shoreline is muted by the mixing action of wind and waves. Changes observed over time at these sites reflect broad large-scale or landscape-scale changes in the watershed and the lake. Other sampling stations are distributed around the shoreline of the lake, primarily off the mouths of influent streams. Changes in water quality at these stations are more directly influenced by shoreline activities and by the quality and quantity of inflowing stream water. Each site is sampled for temperature, DO, pH, conductivity, clarity, phosphorus, nitrogen, and fecal coliform bacteria.

The Sammamish Washington Analysis and Modeling Project (SWAMP)

The SWAMP is a coordinated water quantity and quality monitoring and modeling project that will support water resource decisions regarding King County's fresh waters. A major component of this project is to configure a computer model for Lake Washington, Lake Sammamish, and Lake Union and their influent rivers and streams. Coupled with these models will be a watershed model that simulates stream flow and water quality based on historic, current, and future land use scenarios in King County watersheds. Using data from the monitoring program and modeling effort, the county will assess and evaluate potential risks to

Results from both monitoring programs are provided and discussed in an annual report entitled *Water Quality Status Report for Marine Waters* that is available in several formats and may also be downloaded from the county's marine monitoring Web site at the following address: http://dnr.metrokc.gov/topics/marine/MARtopic.htm

Marine Outfall Siting Study (MOSS)

King County is planning to build a regional wastewater treatment plant that will discharge treated effluent through a marine outfall into Puget Sound waters. The county initiated an extensive field sampling program in October 1998 to help identify suitable sites for the outfall.

The field sampling program includes four major study components: physical oceanography, submarine geophysics, nearshore water quality and habitat, and water column profiling. Physical oceanography studies include the use of current meters, drift cards, drogues, and fluorescent dye releases to assess water movement in the area. Submarine geophysical studies include the use of state-of-the-art technologies such as sidescan sonar, high-resolution seismic reflection, and precision bathymetric mapping to locate areas suitable for the outfall pipe. Preliminary geophysical studies and physical oceanography studies have been completed. Detailed, site-specific geophysical and physical oceanography studies will be conducted throughout 2002. Nearshore water quality studies (which are almost complete) include analyses for microbiological, conventional, trace metal and trace organic parameters. Preliminary nearshore habitat studies have been completed, which included vegetation and substrate mapping with sidescan sonar and videography. Detailed habitat studies will be conducted from spring 2002 until 2003. Water column profiling studies have also been completed and included analyses for microbiological, conventional, trace metal, and trace organic parameters as well as assessing primary productivity.

Wastewater Treatment Plant Effluent Monitoring and Modeling

Water, sediment, shellfish, and algae are collected for the point source monitoring program, including point source stations required by the county's NPDES permit (such as those around the West Point Wastewater Treatment Plant outfall) and those that are in close proximity to treatment plant discharges (such as beach stations near the West Point Treatment Plant outfall). Waters are analyzed for bacteria, nutrients, dissolved oxygen, clarity, chlorophyll, temperature, and salinity. Sediments are analyzed for physical parameters (such as grain size and total solids), metals, and organic pollutants. Shellfish tissues (butter clams) are analyzed at selected sites and analyzed for bacteria and pollutants (metals and organics). Algae tissues are analyzed for metals.

Effluent Monitoring

The King County laboratory system includes two process laboratories, one at each treatment plant (South and West Point), and the environmental laboratory located centrally in metropolitan Seattle. The process laboratories perform conventional chemistry and microbiology analyses in support of plant process optimization and NPDES requirements. The process laboratories also provide support to capital projects such as effluent reuse and the advanced wastewater technology (AWT) program.

The environmental laboratory provides support for NPDES permit requirements, the biosolids source control program, the CSO control program, the lakes monitoring program, and the streams monitoring program. The NPDES permits for the West Point and South Treatment Plants require a series of tests throughout the year to meet compliance. These include quarterly analysis of the effluent for 13 priority pollutant metals (such as mercury) and semi-annual testing for organic compounds such as PCBs and 75 other organic priority pollutants. In addition to the chemical testing, the permit requires that the effluent be tested for toxicity to freshwater and marine organisms. These tests are done at the beginning and end of a permit cycle but may require additional testing if toxicity is found in the effluent. The toxicity testing consists of subjecting various freshwater and marine organisms to the treated effluent (before chlorination) and determining if the effluent has a measurable effect on the organisms. All the results for the chemical and biological testing are reported to plant personnel who include this information in the reports required by the NPDES permit.

Water Quality Management Programs

As part of its stewardship of the waters, King County has several water quality management programs that help protect and preserve water quality. In the late 1950s, the concerns of Puget Sound residents over wastewater pollution in Lake Washington led to the formation of the Municipality of Metropolitan Seattle (Metro), which assumed responsibility for cleaning up the lake and establishing a regional sewerage system. By the late 1960s, Metro's wastewater system had dramatically improved water quality in Lake Washington. Today, under the responsibility of King County, the regional wastewater system continues to protect and preserve public health and the water resources in the Puget Sound region. Recently, King County began implementing the Regional Wastewater Services Plan—a 30-year capital improvement plan to ensure that public health and water quality are protected and preserved for our future generations.

The County's regional wastewater system is described in more detail below, including a summary of how we comply with state and federal regulations, how we control our combined sewer overflows, and how we respond to sanitary sewer overflows. This section also describes water quality management programs to control pollutants at their source (the Hazardous Waste Management Program and Industrial Waste Program) and to clean up contaminated sediments near combined sewer overflow outfalls. We also describe our resource recovery efforts such as the Biosolids Program and the Water Reuse Program, which recycle byproducts of the wastewater treatment process.

Wastewater Treatment System

The King County wastewater treatment system serves approximately 1.3 million residents in a 420-square-mile service area. A total of 275 miles of pipe, 42 pump stations, and 19 regulator stations move wastewater from homes and businesses served by local agencies to two large regional treatment plants: the West Point Treatment Plant in Discovery Park and the South Treatment Plant in Renton. In addition, King County operates two combined sewer overflow treatment facilities at Alki and Carkeek Park and a small treatment plant on Vashon Island. The wastewater facilities are shown on Figure 2.

Wastewater Treatment Process

Raw wastewater coming into the plants undergoes a series of treatment processes. The first is preliminary treatment, which screens out large items such as sticks, cans, and rags and settles out heavy suspended material such as sand and grit. The next process is primary treatment. Here, wastewater flows through large settling tanks (primary sedimentation tanks) that allow up to 60 percent of suspended material to settle out. This treated water, called primary effluent, is then directed to the secondary aeration tanks. Whereas primary treatment relies on settling to remove coarse suspended material, secondary treatment uses aerobic bacteria to consume and digest the fine organic material in solution. The bacteria are called "aerobic" because they need

air to survive. In the secondary treatment process, oxygen is bubbled into large aeration tanks where bacteria consume the dissolved organic material. After time, this mix of bacteria and primary effluent, called "mixed liquor," moves into large tanks (secondary clarifiers) that allow the bacteria and other fine material to settle out, removing 90 percent or more of pollutants. This highly treated water, called secondary effluent, is then disinfected with chlorine and pumped to a outfall that diffuses it deep in Puget Sound.

Solids are generated at each point in the treatment process. The heavier sand and grit collected from the preliminary treatment process are disposed of in a landfill. Solids collected from the primary sedimentation tanks and secondary clarifiers (termed sludge) are thickened by a dewatering process to 10 to 20 percent of their original volume and conveyed to large aboveground digesters. Here, anaerobic bacteria (bacteria that need no oxygen) digest the sludge for three to four weeks, producing a byproduct called biosolids—a nutrient-rich, organic material used as compost or fertilizer in agriculture and forestry. Another byproduct of the solids digestion process is methane gas, or digester gas, which is either sold to utilities or used to run generators to power plant operations.

Both regional treatment plants also produce reclaimed water, which is secondary effluent that receives more treatment using sand filters or other processes to produce non-potable water for irrigation, industrial processes, and in-plant use at the treatment plants.

South Treatment Plant

The South Treatment Plant, located on Monster Road in Renton, treats wastewater flows from about 600,000 customers in the lower Green River basin, suburban cities east of Lake Washington, and Seattle's Rainier Valley. The plant provides secondary treatment of wastewater and treats about 20 million gallons per year of septic tank solids from throughout the region as well as sludge from neighboring treatment facilities such as Snoqualmie Valley cities and the Vashon Treatment Plant. The plant produces biosolids for land application, reclaimed water for reuse, and digester gas for sale to a local utility.

The South Treatment Plant has a monthly wet-weather average capacity of 115 million gallons per day (mgd). The pumping capacity at the South Treatment Plant was recently upgraded to handle a maximum peak flow of 300 mgd. The outfall in Puget Sound discharges secondary effluent 10,000 feet from shore at a depth of 625 feet into the denser lower water layer and moves southward in the Sound. The effluent plume remains at or below a depth of 425 feet in the vicinity of the outfall.

Despite the fluctuation of flow and influent composition, the plant's secondary treatment process consistently produces high quality secondary effluent. In 2001, the average flow through the South Treatment Plant was about 70 mgd with a maximum average flow of about 96 mgd. Treatment efficiency in 2001 remained high and consistent. There were no NPDES permit exceptions at the South Plant in 2001.

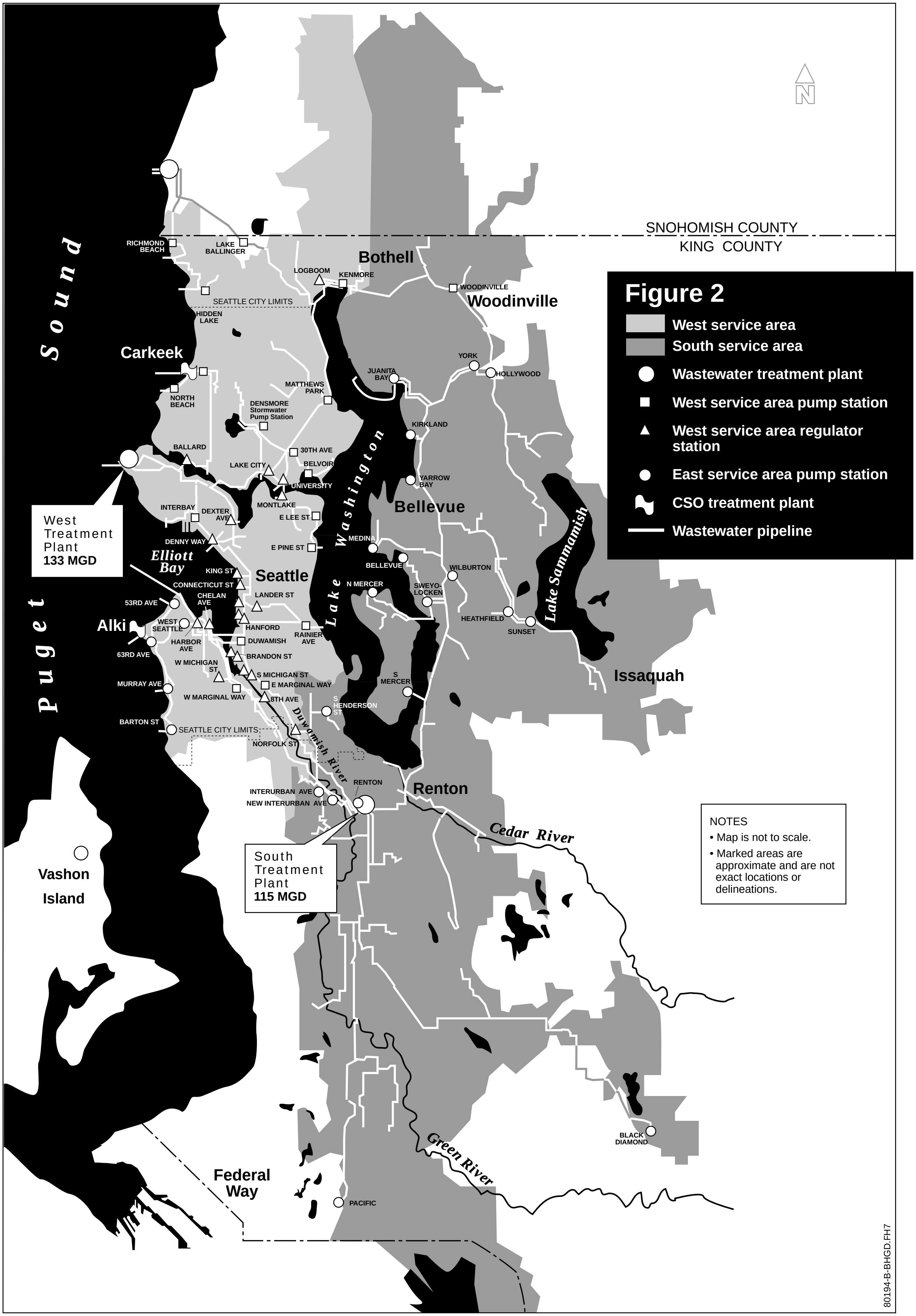


Figure 2
West service area
South service area
Wastewater treatment plant
West service area pump station
West service area regulator station
East service area pump station
CSO treatment plant
Wastewater pipeline
NOTES
• Map is not to scale.
• Marked areas are approximate and are not exact locations or delineations.
SNOHOMISH COUNTY
KING COUNTY
Puget Sound
Bothell
Woodinville
Carkeek
Bellevue
Seattle
Elliott Bay
Alki
Issaquah
Renton
Vashon Island
Federal Way
Lake Washington
Lake Sammamish
Duwamish River
Cedar River
Green River
West Treatment Plant
133 MGD
South Treatment Plant
115 MGD
RICHMOND BEACH
LAKE BALLINGER
LOGBOOM
KENMORE
WOODINVILLE
SEATTLE CITY LIMITS
HIDDEN LAKE
YORK
HOLLYWOOD
JUANITA BAY
MATTHEWS PARK
NORTH BEACH
DENSMORE Stormwater Pump Station
KIRKLAND
BALLARD
30TH AVE
LAKE CITY
BELVOIR
UNIVERSITY
YARROW BAY
INTERBAY
MONTLAKE
DEXTER AVE
E LEE ST
DENNY WAY
E PINE ST
MEDINA
BELLEVUE
WILBURTON
KING ST
CONNECTICUT ST
CHELAN AVE
LANDER ST
N MERCER
SWEYOLOCKEN
53RD AVE
HEATHFIELD
SUNSET
WEST SEATTLE
HANFORD
RAINIER AVE
HARBOR AVE
DUWAMISH
63RD AVE
BRANDON ST
W MICHIGAN ST
S MICHIGAN ST
S MERCER
MURRAY AVE
E MARGINAL WAY
W MARGINAL WAY
8TH AVE
S HENDERSON ST
BARTON ST
NORFOLK ST
RENTON
INTERURBAN AVE
NEW INTERURBAN AVE
BLACK DIAMOND
PACIFIC
N
80194-B-BHGD.FH7

West Point Treatment Plant

The West Point Treatment Plant, located on the shore of Puget Sound in Discovery Park, provides secondary treatment for wastewater from about 700,000 customers located in the greater Seattle area and in southwest Snohomish County. It is the largest plant in the King County system, with an average wet-weather, non-storm capacity of 133 mgd and a peak wet-weather capacity of 440 mgd. After treatment, the secondary effluent is discharged through an outfall to Puget Sound. The outfall discharges 3,600 feet from shore at a depth of 240 feet. The effluent plume remains at or below a depth of 88 feet near the outfall and, most of the year, flows northward out of Puget Sound. Like the South Treatment Plant, the West Point Treatment Plant produces biosolids for land application, reclaimed water for reuse, and digester gas that is used to run generators, producing electricity that is used for plant processes and also sold to Seattle City Light.

The peak capacity of the plant is 440 mgd. However, the NPDES permit requires that the plant provide secondary treatment for up to 300 mgd. Flows greater than 300 mgd are considered to be combined sewer overflows and the plant is required to provide these flows with primary treatment, disinfection and dechlorination. In 2001 the average flow through the West Point Treatment Plant was about 118 mgd with a maximum monthly average of 217 mgd.

Vashon Wastewater Treatment Plant

The Vashon Treatment Plant is located just northeast of the unincorporated Town of Vashon. This secondary treatment plant was constructed in 1975 and operated by the Vashon Sewer District until 1999 when King County assumed responsibility for the plant. The plant was designed with a maximum monthly average capacity of 0.264 mgd and a peak wet-weather capacity of approximately 1.0 mgd. After secondary treatment and disinfection, the effluent is discharged through an outfall to Puget Sound. The outfall discharges 1,300 feet offshore of the eastern shoreline of the island at a depth of 41 feet. At the Vashon facility, the average flow in 2001 was about 0.10 mgd with a maximum monthly average of 0.18 mgd. These flows were fairly low due to the extended drought conditions. However, the total amount of solid materials that the plant processed in 2001 was almost at the level of the plant’s design capacity.

The treatment plant’s history has been marked by numerous NPDES permit violations. In 2001, there were 28 NPDES permit exceptions, primarily for suspended solids and biochemical oxygen demand. Most of these exceptions did not occur until the last quarter when high storm flows washed solids from the treatment facilities. King County assumed responsibilities for plant operations and facilities in November 1999 and is upgrading the facility to improve operations as described above. One improvement was to remove hydraulic restrictions in the outfall line to increase its peak-flow handling capacity. We are also making interim improvements such as adding a new ultraviolet disinfection process, improving the sludge process, and enhancing the electrical and water utilities in 2002. In addition, significant improvements to the plant will be completed by 2005, including additional secondary treatment facilities.

Other wastewater-related improvements were made on Vashon Island in 2001. One was to start operation of the new community treatment system at Buelah Park and Cove. This system can serve up to 75 homes at this time. In addition, we also began operation of the Bunker Trail vacuum collection system and conveyance system. This system includes one new vacuum station and four new pump stations and has the capability to serve up to 18 residences and businesses near the Washington State Ferry Landing on the NE side of the island.

Regulatory Compliance

The Clean Water Act states that all wastewater collection and treatment facilities that discharge effluent into surface waters are required to have a National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are issued by the state Department of Ecology and set limits on the quality of effluent discharged from point sources such as treatment plants and industrial facilities. For example, the NPDES permit for the South Treatment Plant allows an average of 30 mg/L of total suspended solids to be discharged from the plant each day (though we typically discharge less than half of that, removing about 95 percent of suspended solids overall). Other permitted effluent limits include biological oxygen demand, fecal coliform, pH, and residual chlorine. These limits protect water quality and ensure that beneficial uses are retained in the receiving waters.

King County has NPDES permits for its three treatment plants (the West Point Treatment Plant, the South Treatment Plant, and the Vashon Treatment Plant). The county also has NPDES permits for its combined sewer overflow (CSO) treatment facilities (Alki and Carkeek) and for the outfalls that discharge combined sewage directly into Puget Sound, the Duwamish waterway, Elliott Bay, the Lake Union/Ship Canal, and Lake Washington. The NPDES permits for these facilities are current and in compliance with the Washington Water Pollution Control Law and Federal Water Pollution Control Act (The Clean Water Act).

Combined Sewer Overflow Control

CSOs are untreated discharges of sewage and stormwater released directly into marine waters, lakes, and rivers during periods of heavy rainfall. CSOs occur from combined sewer systems that were designed to carry both sanitary sewage and stormwater drainage. These are typically found in older cities. The City of Seattle is the only sewerage agency served by King County that has a combined sewer system. A separated sewer system, now the standard, is designed to carry sewage to a treatment plant while directing stormwater to the nearest water body. Depictions of combined and separated sewer systems are shown in Figures 3 and 4.

Figure 3
Illustration of a Typical Combined Sewer System

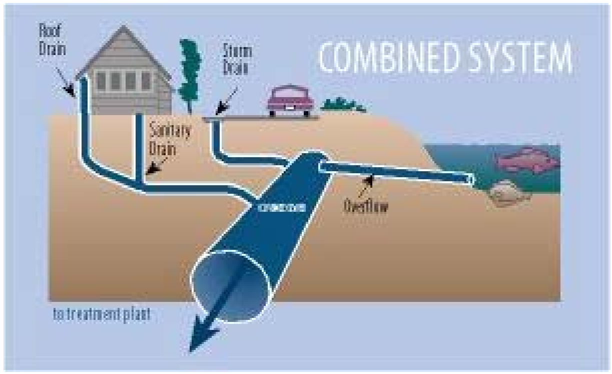
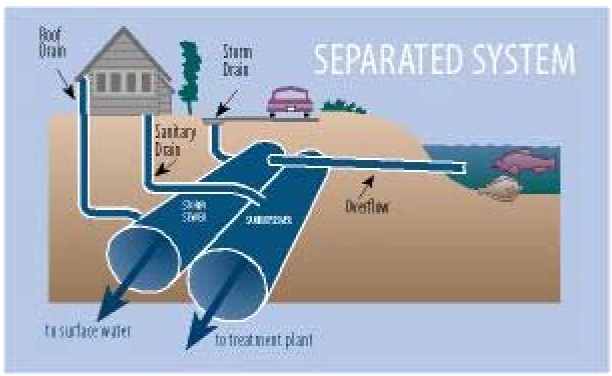


Figure 4
Illustration of a typical Separated Sewer System



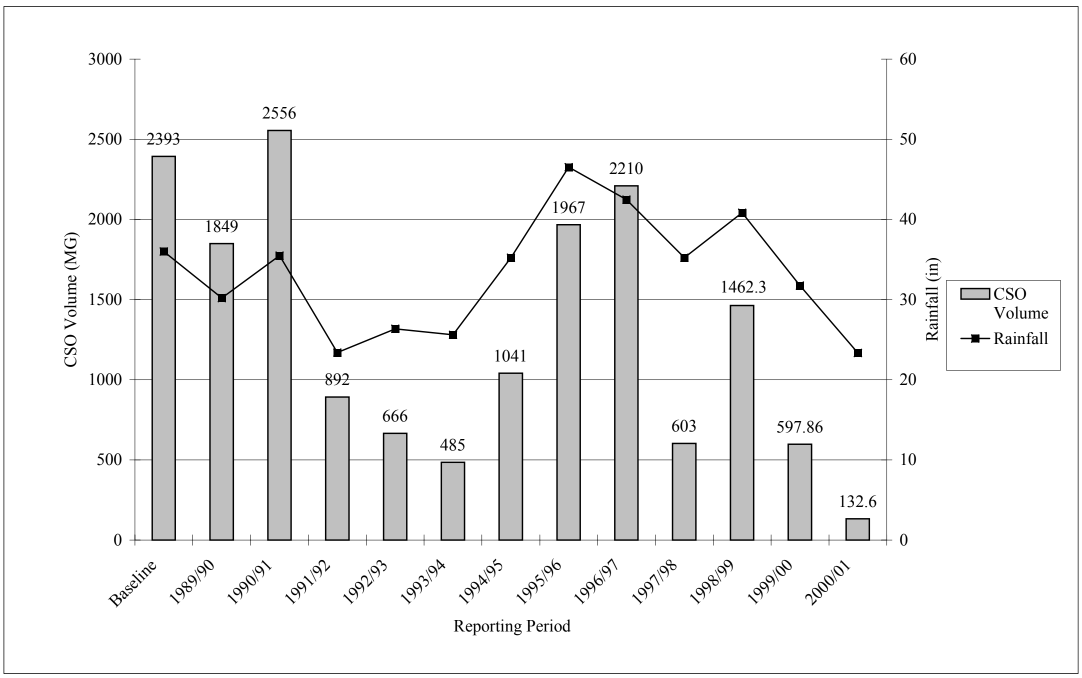
King County's conveyance system is designed to carry both combined and separated sewage. The combined system is entirely within the West Point service, with about one-third of the system being fully combined (including street and roof drains) and one-third being partially combined (only roof drains); the remaining one-third is separated. When flow volumes remain within the capacity of the sewage system they are pumped or transported via gravity through the interceptors to the West Point Treatment Plant for secondary treatment prior to discharge. However, the sewage system was not designed to transport and/or store all of the water that enters the system during large storms. To handle storm capacity, pressure relief points, called CSOs, were provided to allow the excess flows to discharge into local water bodies, rather than damaging conveyance facilities or backing up into homes and streets. Approximately 90 percent of the CSO volume is stormwater and only 10 percent is wastewater.

CSO sites that meet the Washington State standard of "an average of no more than one untreated discharge per year per outfall" are referred to as "controlled." Those that do not meet the standards are referred to as "uncontrolled." Uncontrolled CSOs occur year-round, mostly between September and March; single-event discharges from controlled CSOs will usually occur between December and February when larger, more intense storms occur.

King County's CSO control program, as outlined in the RWSP, is a continuation of a CSO control program that has been going on for many years. At present, the total volume of King County's untreated CSO discharges is equal to only about two percent of the total volume of all wastewater discharges in the system. Of this, about 1.3 percent is discharged to marine waters and about 0.7 percent is discharged to fresh water in the Duwamish River, Lake Washington, or the Ship Canal.

The total number of CSO events in 2000/2001 was 131, with total system volume of 133 million gallons (MG). Of this, 8 MG overflowed in the northern service area and 125 MG in the southern service area. These numbers are significantly lower than baseline studies done in 1981 – 83 and can be attributed primarily to the unusually dry year (23 inches of rainfall compared to an average of 37), but also to CSO control progress (Figure 5). More information about specific CSOs can be found in the *2000/01 Combined Sewer Overflow Report*.

Figure 5
CSO Volumes vs. Rainfall Compared to Previous Years



Two large CSO control projects are currently underway. The Denny Way CSO Control Project will control discharges into Lake Union and Elliott Bay using a large treatment/storage tunnel built under Queen Ann hill. It will store most of the CSO for transport to West Point and will treat the rest, reducing untreated discharges from approximately 50 per year to one per year.

The other project is similar in concept. The Henderson/Martin Luther King Jr. Way/Norfolk CSO Control Project will store most of the CSO from the Henderson and Martin Luther King CSOs that currently discharge to Lake Washington, and the Norfolk CSO that discharges to the Duwamish River, and treat the excess for discharge through the Norfolk outfall. This will achieve the desired outcome of one untreated event per year at all three locations. We expect to complete both projects by the end of 2005.

Alki and Carkeek CSO Treatment Plants

The Alki and Carkeek CSO treatment plants provide primary treatment of excess flows that occur in the combined sewer system during storm events. The Carkeek plant and pumping station were originally constructed to provide primary treatment to all service area flows reaching the plant. In 1994 new pipelines were completed to transfer base sanitary flows—defined by the Department of Ecology as 2.25 times the service area's average wet weather flow (AWWF) or up to 8.4 mgd—to the West Point Treatment Plant for secondary treatment and discharge. Flows exceeding 8.4 mgd are provided CSO treatment equivalent to primary treatment, disinfection, and discharge to Puget Sound at the Carkeek plant. The Carkeek outfall discharges 2,100 feet offshore at a depth of about 200 feet; the effluent plume normally remains at or below a depth of 100 feet. The transfer of flows from Carkeek to the West Point Treatment Plant since 1994 has reduced the amount of primary effluent discharged from the Carkeek Treatment Plant from approximately 1,351 million gallons per year to under 100 million gallons per year on average. A project to determine the cause of higher-than-expected flows to the plant in previous years has been completed. It was concluded that the transfer of base sanitary flows had been under-designed as a result of the following:

- rainfall during the model calibration for the design had been unusually low
- flows above the plant flow meter maximum had occurred allowing some flow uncounted
- some service area flows had not been reaching the plant but were subsequently captured and brought to the plant through conveyance system improvements
- the pump station was pumping less than its design maximum conveying more flow to the Carkeek Plant than intended

A new AWWF has been calculated indicating that the transfer to West Point will need to be increased to 9.2 mgd. Since this transfer must not worsen CSOs along the Ship Canal, a new pump operating strategy has been developed which will temporarily reduce the pump rate when sensors show overflow is eminent along the Ship Canal. This approach will save considerable money compared to the more typical approach of providing storage. This has been proposed to Ecology, as have new NPDES permit limits reflecting the new understanding of the flow dynamics of the Carkeek service area. These proposals are currently under review. The pump station upgrades and programming will be completed by the end of 2002.

The Alki Treatment Plant was originally constructed to provide primary treatment to all service area flows from the Alki area. Similar to the approach used at Carkeek, the West Seattle Tunnel was constructed in 1998 to transfer base combined sewage flows—up to 18.9 mgd—from Alki via the Elliott Bay Interceptor to the West Point Treatment Plant for secondary treatment. Flows in excess of 18.9 mgd are provided CSO treatment equivalent to primary treatment, disinfection and discharge to Puget Sound at the Alki plant. The Alki outfall discharges 1,900 feet offshore at a depth of 143 feet. The transfer of flows from Alki to the West Point Treatment Plant since 1998 has reduced the amount of primary effluent discharged from the Alki Treatment Plant from approximately 2,500 million gallons per year to less than 10 million gallons on average.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are discharges of raw wastewater (as opposed to diluted wastewater from combined sewers) from municipal sanitary sewer systems. Sanitary sewer overflows can release untreated sewage from manholes, broken pipes, or pump stations onto city streets, into streams, lakes, or Puget Sound, and even into basements.

Overflows from the separate sanitary conveyance system occur on rare occasions, typically during extreme storm events and power outages. Minimizing the discharge of untreated wastewater is paramount to the mission of the Wastewater Treatment Division. Extensive resources are committed to maintaining the integrity of the system and preventing SSOs.

Table 3 shows that King County reported twelve SSOs in 2001, which is below the annual average of 16 (based on averages over a 14-year period). Seven of the overflows were raw sewage—the largest of which occurred at a break in the local system operated by the City of Seattle. Three were of primary treated and disinfected effluent, and two were secondary treated disinfected effluent. Five overflowed into Puget Sound, two into the Duwamish/Elliott Bay, and one each into the Sammamish River, Juanita Creek, Kelsey Creek, and Gorsuch Creek; one seeped into the soil. The overflows ranged in magnitude from a one thousand gallons to over two million gallons.

In all cases, the county's overflow response procedures were implemented. These procedures include posting the area, sampling, and public notification as appropriate for the nature of the overflow. While there is some short-term risk to public health and the environment from SSOs, there are no long-term effects from this volume of release.

Table 3
2001 Sanitary Sewer Overflows

Date	Location	Estimated Volume (gallons)	Duration (hours)	Discharge type	Receiving Waters	Reason for Overflow
January 5	Heathfield PS	1,000-3,000	0.02	Raw sewage	Lake Sammamish	Hydraulic check valve failure
February 16	Carkeek PS	70,000	0.33	Primary, disinfected effluent via outfall	Puget Sound	Power outage at pump station[1]
April 1	Carkeek PS	1,060,000	8.66	Primary, disinfected effluent	Puget Sound	Power outage at pump station[1]
April 10	ETS Manhole at 10700 27th Ave. S	0.1 gal per hour	unknown	Secondary, disinfected effluent	Absorbed by soil	Seepage through faulty air bleed structure
June 29	King Street Regulator Station	1,000	6.00	Raw sewage	Elliott Bay	Faulty sensor sent a false "high level" signal triggering the overflow
August 19	Juanita Bay PS	25,000	1.50	Raw sewage	Juanita Creek	Road construction had disturbed a 1" pressure tap on the forcemain
October 1	Wilburton Siphon	1,500	0.20	Raw sewage	Kelsey Creek	Pipe plug knocked out while contractors were working on site
September 29 – October 4	Carkeek Park Basin	2,000,000-2,400,000	96.00	Raw sewage	Puget Sound	Break in an abandoned (capped) section of City of Seattle pipe
October 4	Murray PS	10,000	2.00	Raw sewage	Puget Sound	Power outage at pump station
October 30	West Point Treatment Plant	1,200,000	0.80	Primary blended w/ secondary effluent	Puget Sound	Failed electrical controller allowed CSO gate to open
November 27	W. Michigan St. Regulator	80,000	8.00	Raw sewage	Duwamish Waterway	Overflow caused by blockage in pipe
December 13	Vashon TP	9,000	2.00	Secondary effluent	Gorsuch Creek	High flows from a storm exceeded hydraulic capacity of the plant

1 a permanent emergency generator will be on site in April 2002

Septic Conversions

The King County Comprehensive Plan establishes a goal of having the entire Urban Growth Area (UGA) sewered by the year 2020. The King County Wastewater Treatment Division uses this goal as a planning assumption for determining future wastewater capacity for its wastewater service area. Accordingly, by 2020, King County's wastewater system will have sufficient capacity to accommodate the entire population within the wastewater service area. In practice, achieving the Comprehensive Plan goal will require local sewer providers to extend their service to currently unsewered areas with the regional wastewater service area. It will also require local sewer providers to develop or update their policies to provide residents assistance in acquiring sanitary sewer service or require them to connect under circumstances less severe than outright system failure.

The Seattle-King County Public Health Department is coordinating with the King County Department of Natural Resources and Parks to develop a database of property owners who are currently on septic tanks. These owners will receive information about maintaining their systems per Title 13 of the King County Board of Health.

At the present time, property owners with septic systems are not required to connect to the sanitary system even if it is available on their street. However, they are required to hook up to the sanitary system if it is available and (1) their septic system fails, or (2) their septic system needs to be enlarged to accommodate a home remodel.

Pollution Source Control

In addition to its wastewater treatment facilities and monitoring effort, King County has several water quality management programs that help protect and preserve water quality. Two of the programs—Hazardous Waste Management and Industrial Waste—work to control pollutants at their source, keeping them out of surface waters or the sewer system and the environment. The Sediment Management Program is focused on cleaning up contaminated sediments near combined sewer overflow outfalls. In addition, the Biosolids Program and the Water Reuse Program recycle byproducts of the wastewater treatment process. For example, King County recycles 100 percent of its biosolids for use as fertilizer or soil amendments for agriculture and forestry. Each program is described in more detail as follows.

Hazardous Waste Management Program

King County participates in a regional program that addresses hazardous wastes from small businesses and households. This program, called the Local Hazardous Waste Management Program, is a consortium of agencies in King County (Water and Land Resources and Solid Waste divisions), the City of Seattle (Public Utilities), the Seattle-King County Public Health Department, and the Suburban Cities Association. The program provides technical assistance, reimbursement, and recognition to businesses that generate small quantities of hazardous waste. It also provides collection services for household hazardous wastes as well as public education aimed at proper handling and reduction in use of hazardous household products.

The Local Hazardous Waste Management Program works closely with King County's Industrial Waste Program. Both programs address source control of pollutants and other problem chemicals that enter the county's wastewater treatment system and local waters. Generally speaking, the Industrial Waste Program focuses on larger businesses in a regulatory manner, issuing permits and discharge authorizations under a federally mandated pretreatment program. The Hazardous Waste Management Program focuses on smaller businesses as well as households in a non-regulatory approach, providing technical assistance, resources and education under a state-mandated program. The two approaches complement one another, enhancing the county's ability to address pollutants from a wide variety of sources.

In the year 2001, the Hazardous Waste Management Program conducted over 3,500 on-site technical assistance visits to local businesses. The program helped local businesses stop discharging over 6,800 gallons of hazardous-chemical-bearing wastewater, including silver-contaminated wastes from photo processors, solvents, oils, and corrosive chemicals. Over 2,500 pounds of solvent-contaminated materials were also diverted from municipal landfills.

In schools, more than 7,400 school children were taught about hazardous chemical safety, reduction in use, safer alternatives, and connections to family health and environmental protection. Up to 1,500 additional students were taught about household hazardous waste through the 60 teachers that attended workshops and received training in the topic. The science labs of 83 local middle and high schools were assisted in safely disposing of 21,684 pounds (586 drums) of hazardous chemicals, including many explosive or toxic substances.

The Hazardous Waste Management Program helped develop an Integrated Pest Management (IPM) Program for use throughout King County's departments and operations. Through IPM, there was a 50 percent reduction in total pesticide use by the county from 1999 to 2000, during which time we properly disposed of 2,800 pounds of old pesticides and incorporated many other innovative alternative pest management approaches.

These activities helped to reduce air emissions within the sewerage (collection) system and treatment plants caused by solvents and other hazardous air pollutants. Potentially problematic chemicals that could affect the secondary biological treatment processes have been reduced. By reducing hazardous waste, heavy metals and organics that accumulate in the solids are reduced, making biosolids products more useable and more acceptable to customers and the public. The program ultimately reduces the discharge of heavy metals and organic chemicals in plant effluents into Puget Sound.

Industrial Waste Program

The Industrial Waste Program regulates industrial wastewater discharged into the King County sewerage system. The core work of the Industrial Waste Program includes issuing discharge approvals to companies, then following up with monitoring, inspections and enforcement. The purpose is to see that industries treat wastewater before discharging it to control harmful substances such as metals, oils, acids, flammables, organic compounds, gases or solids. This program protects surface water quality, the environment, public health, the sewerage system, its workers, and the quality of biosolids.

The Industrial Waste Program may regulate any industry, from largest to smallest, if it discharges wastewater to the sewer. To do this, the Industrial Waste Program issues two main kinds of discharge approvals: permits and discharge authorizations. Permits are issued to significant industrial users. These industries discharge more than 25,000 gallons per day and/or are in federal categories. The U.S. Environmental Protection Agency requires at least 20 categories of industries to get permits, whatever their size or quantity of wastewater. Permits have more comprehensive requirements than discharge authorizations and require a company to self-monitor its discharge. During 2001, the Industrial Waste Program had 147 permits and 282 discharge authorizations in effect.

Industrial waste investigators inspect facilities before issuing discharge approvals and also inspect those with approvals to see that they are complying with regulations. In 2001, investigators made 375 inspections. Industrial waste specialists take samples at facilities to see whether wastewater complies with regulations. In 2001 our specialists collected 2,617 compliance samples and found 231 discharge violations. The Industrial Waste Program also requires most companies to self-monitor their discharges. Data for 2001 are not available at this writing but are expected to be similar to 2000 when companies reported that they had made 22,384 analyses of self-monitored samples. After violations are found, inspections and sampling are done to determine that violating conditions have been eliminated.

The Industrial Waste Program issues a notice of violation when a company discharges more contaminants or volume than allowed, violates conditions of its discharge approval, or fails to submit required reports. For enforcement, the Industrial Waste Program uses tools such as compliance schedules, fines, charges for monitoring and inspections, and cost recovery for damages.

Table 4 gives perspective on Industrial Waste enforcement activities, showing the number of compliance samples collected versus the number of violations detected. Following the table is a brief summary of the enforcement actions that were taken.

Table 4
Number and Type of Compliance Samples Collected in 2001

Parameter	Compliance Monitoring	Post-Violation	Number of Discharge Violations
Cyanide	214	0	3
Metals	534	13	10
Organics	287	1	4
Fats, Oils, and Grease (FOG)			
Animal-vegetable	20*	0	0
Petroleum based	386	0	2
Ph (Field)**	622	18	211
Surcharge	522	0	0

*The animal-vegetable FOG analyses are for the visual free floating FOG test, not laboratory analyses.

**The number of pH samples is somewhat misleading because it shows only discrete pH samples collected and analyzed in the field. The number does not include readings from continuous pH measurement, where the majority of pH violations were detected.

Summary of Enforcement Activities

During 2001, 29 companies were issued notices of violation for 255 violations.

- 15 companies had 231 discharge violations
- 9 companies had 14 permit/code violations
- 8 companies had 10 reporting violations

Of these violations:

- 13 companies were placed on compliance schedules
- 19 companies were billed a total of $22,060 for post violation charges
- 4 companies were issued fines totaling $13,712

None of the violations identified by King County or by self-monitoring caused NPDES exceptions at King County treatment facilities.

Sediment Management Program

King County developed a draft Sediment Management Plan (SMP) as directed in the RWSP. The plan identified and evaluated programmatic long-range remediation alternatives for consideration at seven identified sediment clean-up sites near King County CSO outfalls. These seven sites represent the currently designated contaminated sediment sites in Puget Sound for which the county has responsibility. These sites are near the following King County CSO outfall sites: Hanford Street, Lander Street, Duwamish Pump Station, Brandon Street, King Street, Denny Way and Chelan Avenue.

The state Department of Ecology is granted legal authority under Washington Administrative Code (WAC) 173-204, Sediment Management Standards, to direct the identification, screening, ranking, prioritization, and clean-up of contaminated sediment sites in the state. Once a site is ranked and placed on the contaminated sites list, it may then be considered for clean-up. WAC 173-204 provides for the voluntary clean-up of contaminated sediments with oversight and guidance by the Department of Ecology. Alternatively, the Department of Ecology or the U.S. Environmental Protection Agency may initiate enforcement actions (including cost recovery) at some time in the future under the Washington Model Toxics Control Act (MTCA) or the federal Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), also known as Superfund.

The county is moving ahead with the clean-up of these seven identified sites using the voluntary approach whenever possible and participating in state or federal clean-up processes where they have begun. The County agreed with the City of Seattle, the Port of Seattle, and Boeing to undertake the first steps in the clean-up of the Duwamish Waterway—sharing the cost of developing the Remedial Investigation and Feasibility Study (RI/FS). Under an Administrative Order of Consent signed by the four parties, the U.S. Environmental Protection Agency and state Department of Ecology to conduct the RI/FS, the first four scheduled deliverables (roughly half of the work on the Phase I Remedial Investigation) were completed.

King County had other accomplishments in 2001 under the Sediment Management Program:

- began developing a discharge model for CSOs identified in the SMP as necessary to gain state approval of proposed clean-up actions
- conducted the first year of a memorandum of agreement with the state Department of Natural Resources (WADNR) to develop a decision process for clean-up decisions on state-owned aquatic lands and a general plan of operations for clean-up site leases
- selected the preferred alternative for the Elliot Bay/Duwamish Restoration Panel clean-up of the Duwamish/Diagonal CSO—one of the contaminated sediment sites on the state list and within the Lower Duwamish Waterway Superfund site
- continued negotiations with Port of Seattle on the county share of costs for contaminated dredged material disposal costs in the combined East Waterway Harbor Improvement/Harbor Island Superfund Cleanup Project

Biosolids Program

There are two ongoing efforts under the biosolids program. One is to continue producing "Class B" biosolids at all treatment plants. On average, King County produces approximately 135,000 wet tons of biosolids produced each year—all of which is recycled for use in forestry and agricultural applications. The other effort is to evaluate new technologies for biosolids processing, as described below.

King County has completed initial assessments of four biosolids processing technologies that have the potential to improve biosolids quality, increase the efficiency of existing digesters, reduce truck traffic, and otherwise minimize the potential impacts of solids processing at our wastewater treatment facilities. Four technologies were reviewed during 2001 and two were selected for further evaluation.

Vertad® utilizes a 400-foot-deep vertical shaft and air injection to create high pressure, aerobic conditions suitable for thermophilic aerobic digestion. A second phase of testing will assess the technology when operated in conjunction with anaerobic digestion to obtain the benefits of both systems.

Thermophilic/mesophilic digestion uses a temperature-phased anaerobic process to increase the efficiency of the digestion process and reduce the required digestion volume. It also has the potential to produce a class A biosolids product with the addition of appropriate high temperature storage capacity. This technology is currently being considered for use at both the South and West Point Treatment Plants.

King County continued to monitor water quality of streams near biosolids application sites in 2001 and, as with previous years' monitoring, found little effect to receiving waters from biosolids. As part of the ESA 4(d) rule review, the county provided documentation to the National Marine Fisheries Service (NMFS) on the biosolids forestry program, including results of water quality monitoring and beneficial effects on soils and vegetation. In 2000, the NMFS concluded that the program poses no risk to chinook salmon and, in fact, results in an environmental benefit.

Water Reuse Program

The goal of the county's Water Reuse Program is to use reclaimed water to meet the water resource needs of this region's residents and environment. The five-year Water Reuse Work Plan was transmitted to Council in December 2000 and two primary implementation efforts are underway: the technology demonstration project and the satellite treatment facility.

King County DNR began operating a water reuse technology demonstration facility at the West Point Treatment Plant in June 2001. The nine-month project will evaluate the effectiveness, operability, and cost of seven wastewater treatment technologies. The goal of this program is to identify technologies that could:

- minimize the size of a satellite treatment facility
- reduce the costs and potential impacts of producing "Class A" reclaimed water at small, upstream "satellite" plants for commercial and irrigation uses
- cost-effectively remove nutrients, pathogens, organics, and other contaminants from wastewater as necessary to make reclaimed water suitable for discharge to freshwater to supplement surface water supplies

The demonstration facility combines several treatment technologies into small-scale operational process systems to assess their ability to meet process objectives and potentially to eliminate the need for a primary treatment process, secondary clarification, and tertiary filtration. Testing will be completed in March 2002.

The King County Department of Natural Resources and Parks is also evaluating this region's need for a satellite treatment facility and its ability to support. In 1997, the Water Reuse Policy Development Task Force adopted a needs statement suggesting that "recycling and reusing highly treated wastewater effluent should be investigated as a significant new source of water." The county worked with a Stakeholder Task Force to solicit and rank nominations from public and private parties interested in partnering to implement water reuse demonstration projects. In all, we received 11 nominations representing 13 projects.

Each of these projects was ranked based on a set of criteria developed jointly with the Stakeholder Task Force. The criteria evaluated factors such as cost per unit of reclaimed water, regulatory issues, community impacts and support, and integration with other County projects. The Sammamish Valley Reclaimed Water Production Facility, which will produce between one- and three-million gallons per day of water for irrigation, ranked favorably on all the criteria and therefore received the highest overall ranking. Accordingly, this project was selected for implementation. Predesign of the facility began in March 2002 and the project is expected to move into the design phase in November 2002. The facility should be operational in June 2005.

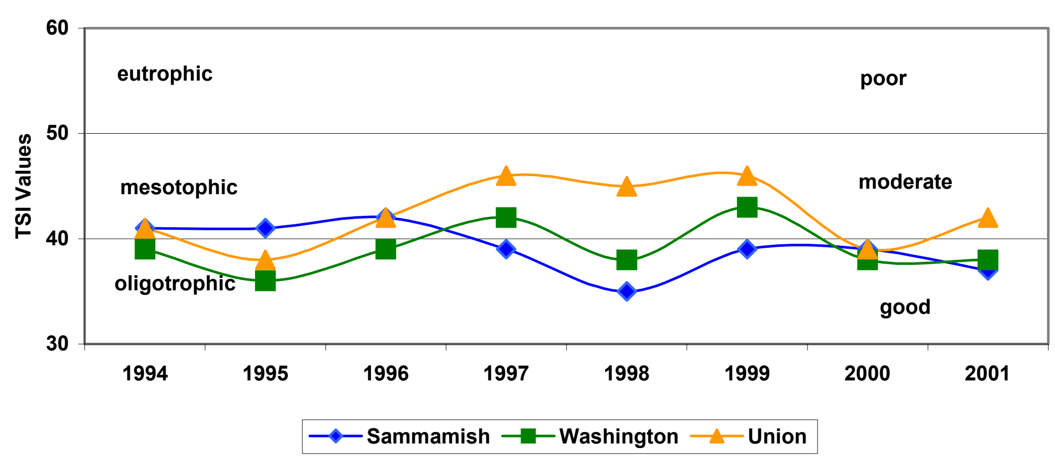
King County Program Results – State of the Waters

This section of the report summarizes the state of waters within the wastewater service area of western King County, including major freshwater streams and lakes and the marine waters of Puget Sound. The fresh waters are grouped by watershed designations termed Water Resource Inventory Areas (WRIAs), which were established by the State of Washington for the purpose of resource planning and management within a watershed's boundary. WRIA 08 is the Cedar-Sammamish watershed and WRIA 09 is the Duwamish-Green watershed. These two watersheds make up the majority of King County's wastewater service area. Figure 6 shows the boundaries of each WRIA and the major water bodies within each one.

Cedar-Sammamish Watershed (WRIA 08)

The major lakes studied by King County in WRIA 08 are Lake Sammamish, Lake Washington, and Lake Union. As shown in Figure 7, water quality as described by trophic state has been oligotrophic (good) in Lake Sammamish for the last five years. Water quality in Lake Washington has also been good since 1994, with the exceptions of 1997 and 1999 when the water was mesotrophic, or moderate quality. Lake Union has historically been characterized as having moderate water quality, with 1995 and 2000 being the best years. Figure 7 also illustrates the variability in each lake from year to year. Sometimes these year-to-year changes are the result of regional climatic differences (e.g., drought and cooler summer temperatures) and would show up as similar fluctuations in the lines for all three lakes.

Figure 7
Summer Average (June-Sept)
Trophic State Index for the Major Lakes



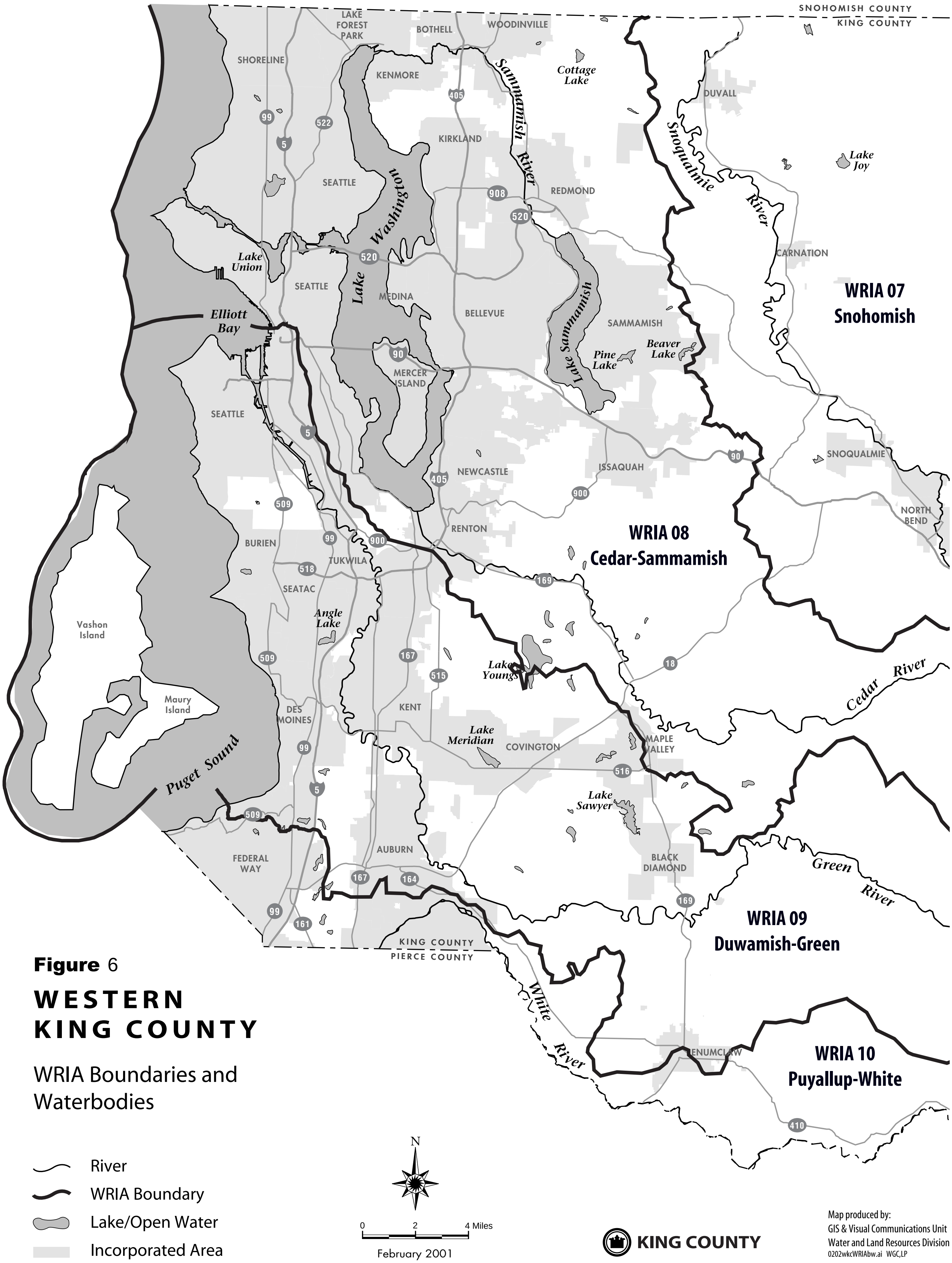


Figure 6

WESTERN KING COUNTY

WRIA Boundaries and Waterbodies

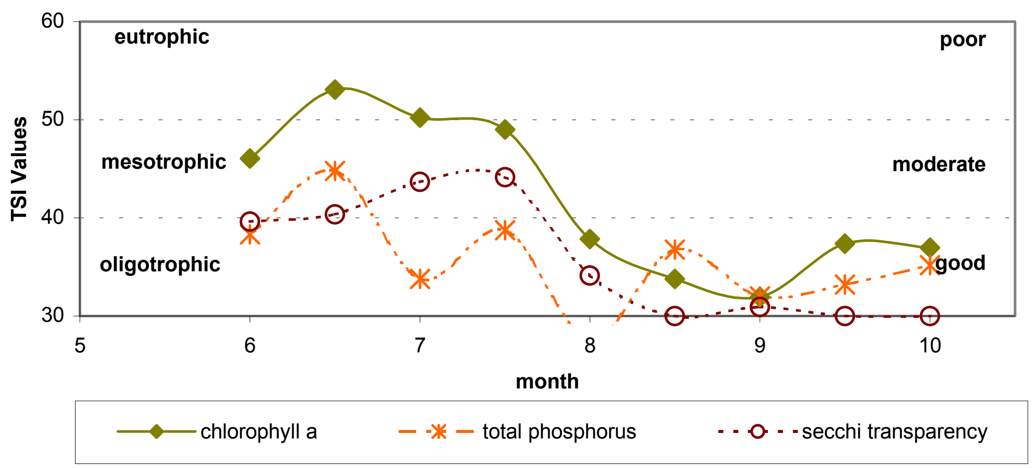
Lake Washington

At 21,500 acres and 13 miles long, Lake Washington is the largest of the three major lakes in King County and the second largest natural lake in the State of Washington. The average depth of the lake is 108 feet at its deepest point. The water bodies in the Lake Washington Basin are all Class AA waters." Some of the beneficial uses Lake Washington include fish rearing, spawning, and harvesting; wildlife habitat; swimming (primary contact recreation), and boating (secondary contact recreation). Lake Washington is the prime rearing habitat for juvenile salmon spawned in the Cedar and Sammamish rivers and supports a number of resident fisheries. In the 1960s, sewage was diverted from both Lake Washington and Lake Sammamish, which removed about 75 percent of the nutrient inputs to the lakes. The subsequent water quality improvements were dramatic.

General Conditions

Based upon the Trophic State Index, Lake Washington can be characterized as having good water quality (oligotrophic) in 2001, as shown in Figure 8. Water clarity was good (measured as Secchi transparency), phosphorus values were low, and algal levels (measured as chlorophyll *a*) were moderate to low, except in late June and early July.

Figure 8
Lake Washington 2001 Water Quality Indices



Lake Sammamish

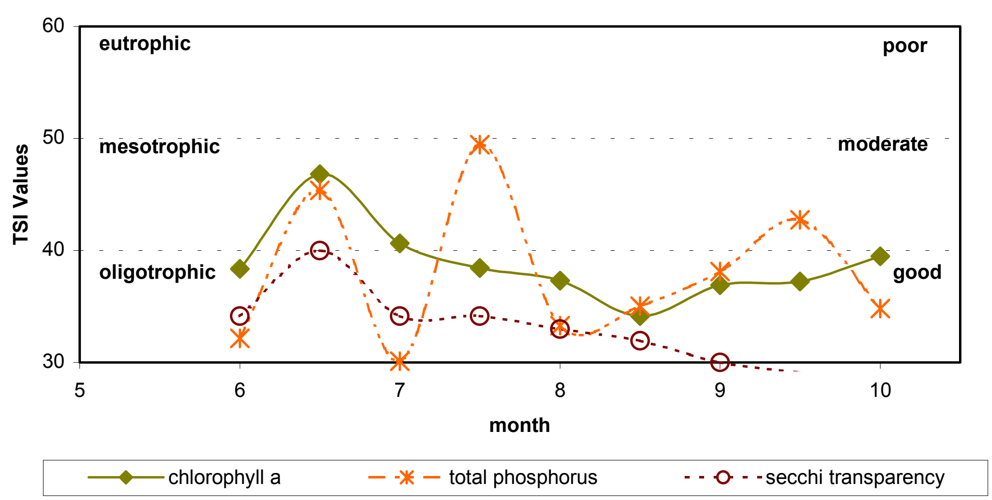
Lake Sammamish is the sixth largest lake in Washington and the second largest in King County. It is a major lake for recreational users such as fishermen, boaters, water skiers, swimmers, and picnickers. It also provides rearing and migratory habitat for multiple salmon species and is home to a variety of warm water fish, birds and other wildlife. The water bodies in the Sammamish Basin are all Class AA, with beneficial uses including fish rearing, spawning, and harvesting; wildlife habitat; swimming (primary contact recreation); and boating (secondary contact recreation).

Lake Sammamish has historically suffered from excess phosphorus loading with frequent late summer algal blooms and a dominance of the aquatic plant Eurasian milfoil (*Myriophylum spicatum*). In 1968 all municipal wastewater that was being discharged into the lake was diverted from it. Over a 5-year period, water quality responded favorably showing a 50 percent reduction of phosphorus and algal concentrations and a 35 percent increase in water.

General Conditions

Figure 9 shows that overall water quality has been good in Lake Sammamish in 2001 with good water clarity (measured as Secchi transparency), low algal concentrations (measured as chlorophyll *a*), and moderate to low phosphorus concentrations. There was a bit more fluctuation in the month-to-month water quality indicators than in previous years. Total phosphorus concentrations were almost twice as high in mid-June, mid-July, and mid-September, compared to the other months. Algal volumes (measured as chlorophyll *a*) were also high in mid-June.

Figure 9
Lake Sammamish 2001 Water Quality Indices



Generally, conditions in the basin are good compared to the state Water Quality Standards, but there is cause for vigilance as water quality often degrades with the increasing development and population density such as is occurring in this basin.

Phosphorous and Water Clarity

Water quality goals for Lake Sammamish, as described in the 1989 Lake Sammamish Management Plan, are based on the assumption that control of phosphorus loading into the lake will control primary productivity (algal blooms), water clarity, and dissolved oxygen. Measures to control phosphorus loading to the lake also results in many secondary benefits to the watershed, such as control of erosion and sedimentation and preservation of fish habitat, forest cover, and riparian cover. A goal of 22 ug/L mean annual volume-weighted total phosphorus (VWTP) is used to meet the summer chlorophyll *a* goal of 2.8 mg/m^3. Concentrations of chlorophyll *a* of less than or equal to 2.8 mg/ m^3 have historically resulted in summer average water clarity of greater than or equal to 4.0 meters. Table 5 shows that the goals for phosphorous, chlorophyll *a*, and clarity were all met in 2001.

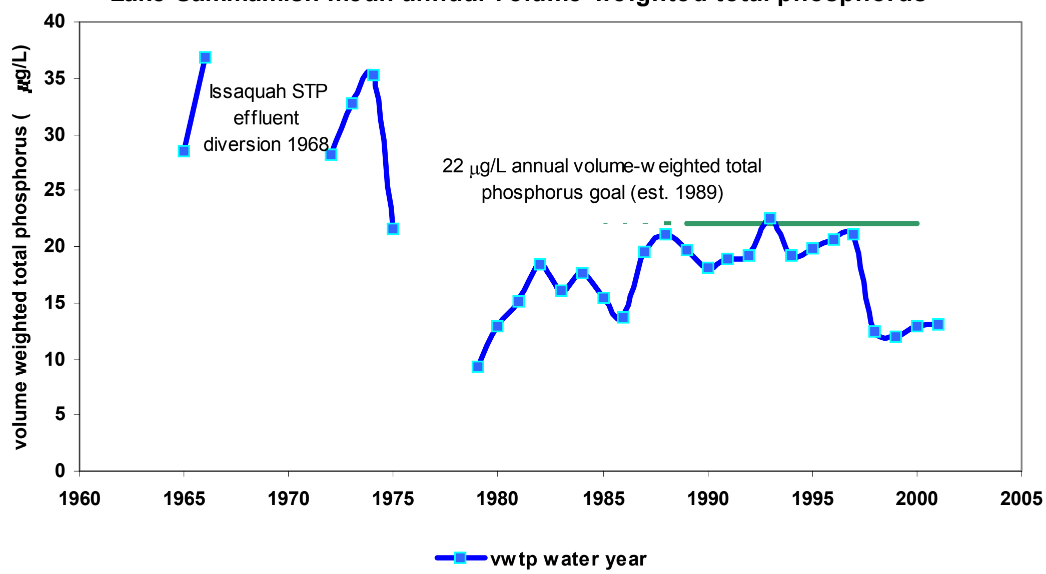
Table 5
Water Quality Goals and Values for Lake Sammamish*

	Mean Annual Volume Weighted Total Phosphorus (ug/L)	Summer Chlorophyll *a* (mg/m^3)	Summer Secchi Depth (meters)
Goals (est. 1989)	22	≤ 2.8	≥ 4.0
2001 Values	13.0	2.5	6.5

*As defined in the Lake Sammamish Management Plan in 1989.

Figure 10 illustrates the annual volume-weighted total phosphorus in Lake Sammamish since the early 1960's. Phosphorus concentrations have, with a few exceptions, remained well below the goal of 22 ug/L (mean annual volume weighted total phosphorus) as determined in the Lake Sammamish Management Plan.

Figure 10
Lake Sammamish mean annual volume-weighted total phosphorus



Sediment Study

King County DNRP recently completed a comprehensive sediment quality evaluation of Lake Sammamish and also completed the sediment sampling portion of the evaluation for lakes Washington and Union. There were four primary objectives of the study: (1) conduct a baseline sediment quality evaluation including both chemical and biological testing; (2) evaluate the relative distribution of potential contaminants of concern; (3) evaluate sediment toxicity; and (4) evaluate benthic community structure and compare these data with sediment toxicity testing. This project is part of a much larger effort Sammamish-Washington Assessment and Modeling Project that will provide a comprehensive evaluation of current and future water and sediment quality in the Greater Lake Washington watershed.

In general, the highest levels of sediment-associated contaminants were found in the vicinity of stormwater discharges and at deep lake locations. A number of metals and organic compounds were found to exceed the sediment guidelines through out the lake; however, toxicity test results suggest sediment associated contaminants are having adverse impacts in only a few areas.

Benthic data are currently being analyzed and will be compared to both the toxicity and chemistry data (e.g., sediment triad analysis). Because the lake is also organically enriched due to relatively high phosphorus loading, a challenge to this analysis will be to determine to what extent the benthic community structure is adversely impacted by sediment-associated chemicals.

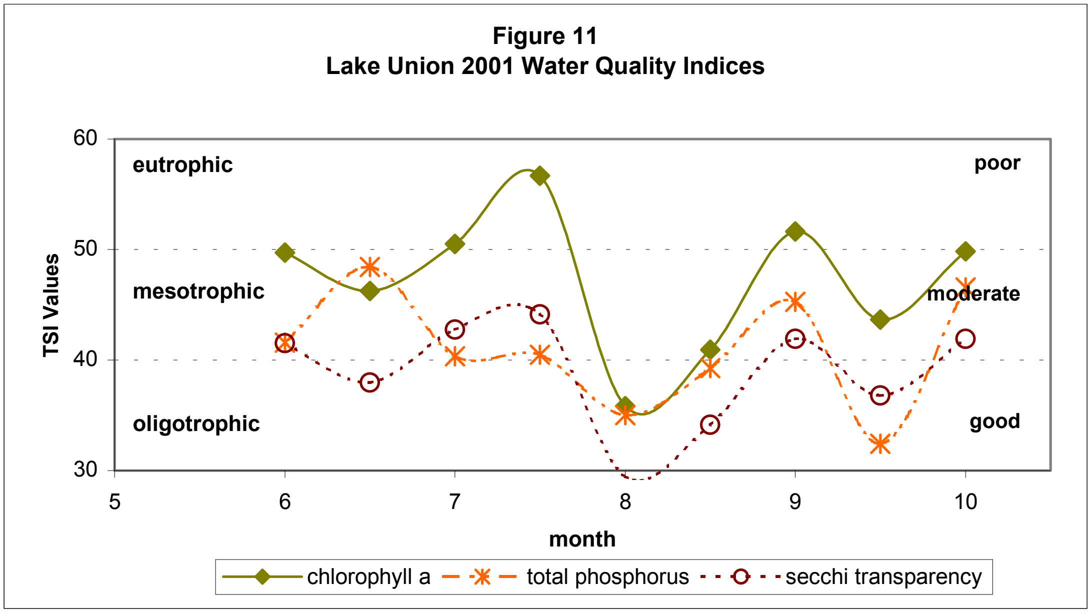
Lake Union

Lake Union, at 580 acres and averaging 34 feet deep, differs significantly from the other two major lakes in the county because its hydrology was modified when the Fremont and Montlake cuts and the Hiram M. Chittenden Locks were constructed in 1911, allowing intrusion of salt water from the Ship Canal. This intrusion results in strongly stratified lake conditions: the more dense saline bottom water becomes devoid of oxygen early in the summer as bacteria consume the organically rich sediments at the bottom of the lake, limiting the amount of habitat available to fish. The lake and canal systems are the only migration route for the salmonids in the Lake Washington, Cedar River, and Lake Sammamish drainages.

In the past, the lake has received sanitary discharges from land as well as from houseboats and from discharges from ships, industry, and businesses along the shore. The lake was impacted by fuel spills and other discharges from ships and onshore facilities. Pollution inputs from many of these sources have decreased—raw sewage was intercepted for treatment in the 1980s and the remaining combined sewer overflows (CSOs) are being controlled. A program was begun in the late 1970s to controls CSOs, and in 1994 a CSO separation project in the University Regulator basin removed a significant amount of CSOs from the lake, leaving a new stormwater outfall. A study is nearing completion to assess the impact of the stormwater discharge from the outfall. Currently, a joint project between King County and the City of Seattle—the Denny way/Lake Union CSO control project—will be completed in 2005, controlling all CSOs that discharge directly into Lake Union. Remaining CSOs along the Ship Canal will be controlled as part of the county's Regional Wastewater Services Plan (1998) and Seattle's Combined Sewer Overflow Control Plan Amendment (2001).

General Conditions

Lake Union has historically been characterized as mesotrophic (moderate water quality) with fluctuations in some years to oligotrophic conditions (good water quality). Measurements of water clarity (Secchi transparency), algae (chlorophyll *a*), and phosphorus taken in the summer of 2001 characterize Lake Union overall as having moderate water quality. Figure 11 shows that all three parameters were variable throughout the summer sampling season. Water quality was very good in early August when algal levels were low, phosphorus concentrations were low, and water clarity was very high.



The water quality of Lake Union in the summer of 2001 was generally characterized overall as being oligotrophic, or good. While the lake did stratify in the summer of 2001, dissolved oxygen concentrations at the 10-meter depth remained near or above 6 mg/L. Subsequently, phosphorus bound with the lake sediments was not released and concentrations of this nutrient at depth were lower relative to other years. The amount of phosphorous released from sediment is a factor of the amount of dissolved oxygen present: when oxygen is present, dissolved phosphorous precipitates out with iron; however, when no oxygen is present, iron dissolves and releases the bound phosphorous.

Sammamish River

Long, straight, and open describes the Sammamish River, which since the late 1800s has been dredged, realigned, and stripped of much of its forest cover. The river was channeled and dredged in the early 1960s for flood control and land use. Existing native vegetation was also removed from its banks, although recent recovery efforts are beginning to make a difference toward improving the condition of the riparian area. Generally, conditions in the Sammamish River are good compared to the state Water Quality Standards and, as in most streams and rivers, water quality seems to be better in the upper reaches where development is minimal. The Bear-Evans Creek system drains into the Sammamish River and is one of the major salmon producing streams in King County. However, the river continues to experience degraded fish habitat and increased flooding and erosion—impacts from development that began in the 70s and 80s that continue today.

General Conditions

The Sammamish River is listed on the Washington Department of Ecology's 1998 303(d) list for exceeding standards for temperature, dissolved oxygen, pH, and fecal coliform. High river temperatures typically occur in the summer and early fall when chinook and sockeye salmon are returning to spawn in tributaries. In general, elevated temperature is considered the most serious water quality problem limiting beneficial uses in the river. Most of the sites met Class AA standard and a few met the Class A standard. The Kenmore site on the Sammamish River and Fairweather Creek only met the Class B standard, and the Marymoor site on the Sammamish River only met the Class C standard.

River temperature as high as 80°F in late July have been observed, which is above the lethal limit for salmon. High temperature can affect reproductive health and survival of all adult fish entering the River. Elevated but sub-lethal temperatures common in June and July can also cause feeding alterations, decreased disease resistance, and even mortality in juvenile salmon.

Tracking of adult chinook in 1998 and 1999 indicated that salmon utilize every deep area in the River during migration, likely in an attempt to find cooler water conditions. The most serious temperature problems are located where the river is fed by the warm surface waters of Lake Sammamish. The relationship between the lake and river suggests the Sammamish River has historically been warmer than many northwest rivers in the summer and early fall. However, the historic river channel conditions likely provided significantly more cool-water refuge for salmon than is currently available. The historic channel meandered through a vast wetland complex that dominated much of the corridor, providing greater shade cover, more pools, and greater connection with groundwater and tributaries, all of which contributed to maintaining cooler river temperatures.

To better understand the issue of increased temperature in the Sammamish River, the county has been evaluating the conditions that influence the overall temperature in the river (e.g., riparian vegetation conditions, groundwater, and influence of tributary flow). In addition, we are using computer models to help identify which potential restoration options would have the greatest influence on decreasing temperature in the River; for example, increased shading, increased groundwater inflow, or providing a cool water inflow source. This effort is currently underway by King County technical DNRP and additional information will be available later this year.

Another potentially significant water quality concern for the fresh waters within WRIA 08 is the presence of pesticides and herbicides and other contaminants in the water column and river sediment. Sampling and analysis for these chemicals has occurred in selected tributaries within the watershed. The limited data collected to date suggest that elevated levels of commonly used pesticides are present and may have an impact on resident aquatic organisms. However, many of these chemicals do not have established water quality standards or do not have standards that were established with regard to their potential effects on salmon. Some of these chemicals may interfere with the ability of salmon to reproduce or to find their home streams for spawning.

To better understand the degree to which these chemicals are present, King County conducted an evaluation of sediment and water quality in the Sammamish River in late 2001. Water and sediment samples were collected for analysis of a variety of chemicals such as pesticides, metals, conventional parameters, and nutrients. In addition to chemical analysis, the county is evaluating sediment samples to determine the overall health of the populations of aquatic organisms living in the riverbed. Evaluating the types and number of organisms present in river sediments provides us with additional information on the overall ecological health of the river. Samples were collected from locations throughout the 13-mile length of the river. Sampling sites were located below major tributaries and in the vicinity of potential pollution sources. King County DNRP is currently analyzing these samples and additional information will be available later this year.

An additional effort to better understand the extent to which pesticides are present in the watershed is being conducted through the Small Stream Toxicity Study. Select urban streams within the greater Lake Washington watershed have been sampled for the presence of pesticides and metals, and toxicity testing has been conducted to better understand the potential impacts these chemicals may have on aquatic life. In late 2001, samples were collected from four areas in the Sammamish River. These data are currently being analyzed. Through the SWAMP (see section on Major Lakes Monitoring) and related salmon recovery planning efforts, King County continues to evaluate the presence and potential effects of these chemicals in the river.

Small Streams

Parameters of concern for the small streams in WRIA 08 include turbidity, pH, temperature, dissolved oxygen, and bacteria. Overall, turbidity is not a major problem but elevated turbidity does seem to be related to construction in most cases. The elevated turbidity at the mouths of several creeks, including Coal, Little Bear, Juanita, Fairweather, McAleer, Thornton and Issaquah, was linked to soil-disturbing activities. The elevated average at the mouth of the Cedar River was due to extreme values following a landslide in mid-February 2001.

The geometric mean levels of pH at all sites met state criterion, and most of the sites met Class AA standard for temperature and a few met the Class A standard. In addition, most sites met the Class AA or Class A criteria for dissolved oxygen, with a few meeting only the Class B criterion and one meeting the Class C criterion. The sites not meeting the Class AA or A criteria tended to be on streams that had relatively low gradients; consequently, the aeration of the water was minimal.

Forty-five percent of the WRIA 08 sites met the Class AA or A criteria for fecal coliform bacteria. About twenty-five percent of the sites had levels exceeding the Class B criteria of 200 organisms/100ml. The distribution of the *E. coli* bacteria average concentrations was very similar to those for the fecal coliform bacteria. None of the King County stream sites met the *Enterococcus* criteria for either the “Extraordinary” or “Excellent” stream conditions. Six sites in WRIA 08 met the “Good” criterion. Those were the upstream sites on the Cedar River, Sammamish River, Evans Creek, Swamp Creek, North Creek and the mouth of Tibbetts Creek.

Cedar River

The Cedar River is the largest tributary to Lake Washington and drains nearly 200 square miles from the crest of the Cascade Mountains to the lake at the City of Renton. The upper two-thirds of the basin is owned and managed by the City of Seattle and supplies drinking water to two-thirds of Seattle and its regional customers. The upper watershed is closed to the public and managed under the Cedar River Habitat Conservation Plan. The lower portion of the river is primarily forested or rural, except near the mouth where the river passes through the City of Renton.

General Conditions

The Cedar River is listed on the Washington Department of Ecology's 1998 303(d) list for fecal coliform. Bacterial pollution in the Cedar River is not at as significant levels as is observed in the more urbanized portions of WRIA 08. The lower main stem of the Cedar River and major tributaries provide the majority of the spawning habitat for chinook, sockeye, and steelhead, as well as significant spawning and rearing habitat for coho and cutthroat trout. Details of the factors of decline and proposed action alternatives are collated in the *Lake Washington/Cedar/Sammamish Watershed (WRIA 08) Near Term Action Agenda for Salmon Habitat Conservation (*February 2002*).*

The WRIA 08 Technical Committee identified mainstem factors of decline for chinook as access and passage barriers, loss of channel complexity and connectivity, degradation of riparian conditions, altered hydrology and flow, and increased and altered sedimentation.

On February 28, 2001, the Nisqually Earthquake activated movement of glacial deposit earth material, estimated at 50,000 cubic yards, along the right bank of the Cedar River at River Mile 5.0 near Renton. The earth material completely demolished 600 feet of King County's Punnett-Briggs Revetment, a public flood erosion control facility. The debris and sediments also filled approximately 600 feet of the Cedar River channel completely blocking the flow of water. Flows reentered the river through a previously constructed salmon spawning channel adjacent to the earth movement for a distance of 125 feet, causing considerable erosion. Erosion damages to the side channel and adjacent access roadway are ongoing and a small portion of the main slide mass still obstructs flow at the connection to the side channel opening.

Duwamish-Green Watershed (WRIA 09)

The lower Green River, its valley, and the Duwamish waterway are urbanized, consisting of dense commercial and industrial development as well as some of the fastest growing suburban communities in King County. Most of this area is incorporated, including the cities of Seattle, Tukwila, Renton, Kent and Auburn. Much of the commercial and residential development in the valley depends on a levee and dike system to contain the river. The middle Green River watershed includes rich farmlands and forestlands, as well as the cities of Covington, Maple Valley, Black Diamond, and Enumclaw, several state and county parks, and a salmon hatchery. The area is increasingly important as an affordable area for suburban and rural residences and hobby farms, is one of the largest remaining agricultural communities in King County, and provides extensive recreational opportunities for watershed and county residents. The upper Green River extends from the crest of the Cascade Mountains, the Green’s headwaters, to the Tacoma diversion dam. It provides drinking water to the City of Tacoma and forest production for federal, state and private landowners.

General Conditions

An assessment of the current water quality conditions in the Green-Duwamish watershed was compiled in 2000 from water quality reports and from analysis of water quality data collected between 1996 and 1999. Numerous streams throughout the watershed are listed on the state’s 1998 303(d) list of water bodies that do not meet water quality standards. These include portions of the Duwamish River, lower Green River, Springbrook Creek, Mill Creek, Mullen Slough, Soos Creek and Newaukum Creek. Fecal coliform bacteria, dissolved oxygen, and temperature are the most common parameters listed, but there are also isolated listings for pH, metals, and ammonia.

Fecal coliform bacteria exceed standards most commonly during storm conditions in all of the water bodies listed above. Dissolved oxygen and temperature typically exceed standards during warmer summer conditions when stream flows are lower. They are mostly a problem in the tributaries, but are also occasionally a concern in the Green River mainstem.

Water quality in the Green River and its tributaries varies widely depending on location in the watershed, level of urbanization, and human activities. The upper Green River watershed is mostly forested, has been minimally altered by human activities, and thus generally has the best water quality. The middle Green River is dominated by agricultural land, mixed forest, and rural residential development, and still exhibits fairly good water quality conditions, but exceeds state standards for fecal coliform bacteria, temperature and dissolved oxygen. The lower Green River and Duwamish River are the most urbanized and industrialized portions of the watershed and have the most degraded water quality conditions with impairments by metals, fecal coliform bacteria, dissolved oxygen, and pH.

In the tributaries assessed, water quality is also closely linked to the level of urbanization and intensity of land use. Crisp Creek has the best overall water quality and is the least developed of the tributaries assessed. Newaukum Creek, which has extensive agricultural land use, generally has good water quality but suffers from occasional depressions in dissolved oxygen levels. Soos Creek has some of the region's best water quality of the smaller creeks in the urban portion of King County. Mill and Springbrook (Black River) creeks are the most heavily urbanized of the tributaries evaluated in this report and exhibit the most degraded water quality conditions.

Water quality conditions in the lower Green and Duwamish River have improved from the poor water quality conditions that existed in the 1960s and earlier. This is a result of the reduction of municipal and industrial discharges, including relocation of the wastewater treatment plant outfall to Puget Sound. Even with these improvements, there are still problems with fecal coliform bacteria and other pollutants as noted above.

There has been a trend towards increasing water temperatures in most tributaries in the urban and urbanizing areas of the region over the past 20 years, probably attributable to urbanization and development, a concern for adult chinook migration up the Green River. Dissolved oxygen levels are one of the most significant issues for salmonids in the basin. High levels of dissolved oxygen are necessary for life processes including spawning, egg incubation, and rearing.

In general the water quality is good in the Duwamish estuary. The risks to water column dwelling organisms are minimal; however, there are potential risks to benthic (sediment-dwelling) organisms from several chemicals in the sediments. Risks to the benthic organisms can potentially translate to risks to salmonids via food-chain transfer, reduction in immune system functioning, or reduction in available food. This is an example of why sediment remediation is of high priority for the county in the Duwamish River.

Small Streams

As with the Cedar-Sammamish watershed, the parameters of concern for the small streams in the Duwamish-Green watershed include turbidity, pH, temperature, dissolved oxygen, and bacteria. In this watershed, turbidity was related to construction in most cases. However, the high turbidity at Newaukum and Springbrook creeks was probably caused by suspended organisms such as iron-reducing bacteria, which seem to be present year-round.

The geometric mean levels of pH at all sites met state criterion, and most of the sites met Class AA standard for temperature and a few met the Class A standard. Additionally, most sites met the Class AA or Class A criteria for dissolved oxygen, while a few sites met only the Class B. The sites not meeting the Class AA or A criteria tended to be on streams that had relatively low gradients; consequently, the aeration of the water was minimal.

Fifty-eight percent of the WRIA 09 sites met the Class AA or A criteria for fecal coliform bacteria. Roughly twenty-five percent of the sites had levels exceeding the Class B criteria of 200 organisms/100ml. The distribution of the *E. coli* bacteria average concentrations was very similar to those for the fecal coliform bacteria. None of the King County stream sites met the *Enterococcus* criteria for either the "Extraordinary," or "Excellent" stream conditions, or even the lowest criterion for streams classified as "Good."

Puget Sound

Puget Sound is a large estuary where fresh water draining from more than 10,000 streams and rivers mixes with salt water entering from the Pacific Ocean through Admiralty Inlet and Deception Pass. Although Puget Sound is an estuary, it has near-oceanic salinity throughout most of the year. It is characterized by deep underwater valleys and ridges and has an average depth of 204 feet. Surrounded by 2,354 miles of shoreline, Puget Sound is a mosaic of beaches, bluffs, deltas, mudflats, and wetlands. Much of the Puget Sound economy—tourism, fishing, maritime industry, and timber harvesting—is derived from its incredible environment. However, natural resource consumption and rapid growth and development are also placing increasing pressure on the Puget Sound environment.

General Conditions

The marine waters of Puget Sound within King County are generally in excellent condition overall and do not show evidence of persistent bacterial, nutrient, or toxicant pollution problems. Offshore waters have consistently shown high levels of dissolved oxygen and low fecal coliform bacteria over the last several years. There are, however, certain areas that show localized environmental degradation in terms of bacterial and other pollutant contamination, as seen with other heavily urbanized watersheds. It is the nearshore environment where these problems tend to occur due to the proximity of freshwater input from both stormwater and riverine input as well as reduced tidal mixing. While some beaches show very good water quality, monitoring results for bacteria at several beaches have consistently failed water quality standards over the last several years. As noted above, these beaches are located near a freshwater source or are in areas with poor tidal flushing, such as an embayment. Another localized problem is sediment contamination, which is evident primarily in Elliott Bay. Each of these factors affecting water quality is discussed in more detail below.

Nutrients

The marine waters of Puget Sound include nutrients such as nitrogen (ammonia and nitrate), phosphorus, and silica. Typically, nutrient levels that cause water quality problems in Puget Sound are seen in nearshore areas in the vicinity of stormwater or septic system runoff, which contain high concentrations of nutrients, or in areas of restricted circulation. King County measures ammonia, nitrate, nitrite, phosphorus, and silica. Recent water column monitoring for nitrate, the primary form of inorganic nitrogen in seawater, shows that this nutrient was most abundant in the winter from November to February. A representative example of the seasonal distribution of nitrate in the water column is given in Figure 12.

Figure 12
Seasonal Distribution of Nitrate in the Puget Sound Water Column (mg/L)

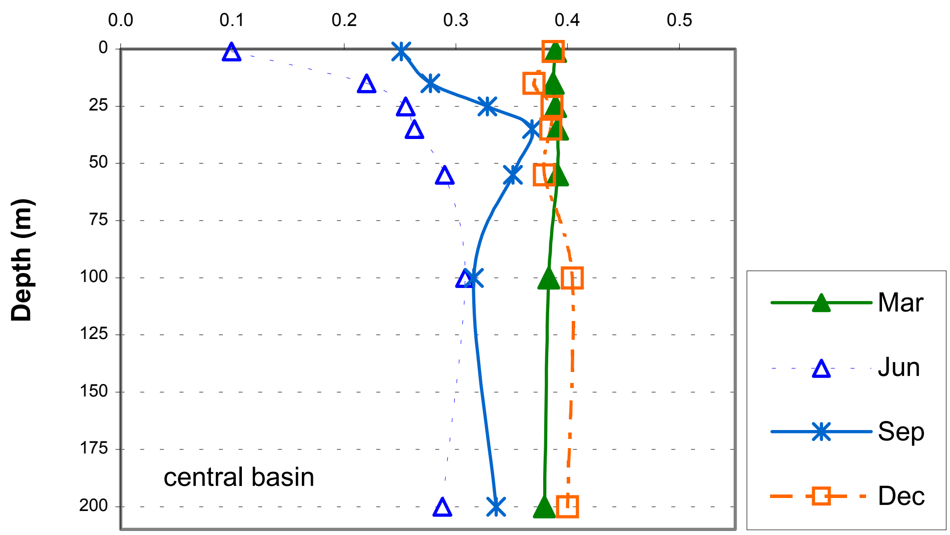


Figure 12 suggests that surface nitrate is the highest in winter when nitrate is not being taken up by marine plants and when freshwater runoff is the highest. Surface concentrations are depleted during times when large phytoplankton (microscopic plants) blooms occur in the Sound, primarily during spring and summer. Results from recent water column monitoring are similar to results obtained in previous years and do not show an increasing trend in nitrate concentrations. Nitrate levels at beach stations showed similar seasonal patterns to those sampled in the water column stations, but the beach stations levels showed higher maximum values on nitrate.

Recent monitoring of ammonia levels has shown them to be consistent over the past several years. Higher ammonia concentrations during the summer months are common as ammonia is generated from the decay of organic nitrogen (both natural plant die-off and from zooplankton grazing on phytoplankton). Ammonia is the only nutrient for which Washington State has a criterion for marine surface waters. No values measured exceeded the 1.6-mg/L chronic ammonia criterion.

Nutrients in King County waters follow seasonal patterns and have been consistent for several years. Nutrient levels in King County waters are lower than levels measured in some other areas of Puget Sound, where potential nutrient-related water quality degradation may occur. King County is currently conducting a detailed nutrient study to estimate the effects an increase of nutrients will have on water quality.

Dissolved Oxygen

Generally, a high amount of dissolved oxygen in waters is considered an indicator of a healthy ecosystem. Dissolved oxygen concentrations in Puget Sound are routinely above the level at which potential problems could occur (almost all values were 5.0 mg/L or above); however, naturally low levels of oxygen occur when deep oceanic water from the Pacific Ocean enters Puget Sound in winter. Figure 13 shows a frequency plot of dissolved oxygen values measured in 1999 and 2000. Values are typical of other years monitored. As evident, the majority of all values measured were above 5.0 mg/L.

Figure 13
Dissolved Oxygen in Puget Sound (all depths)

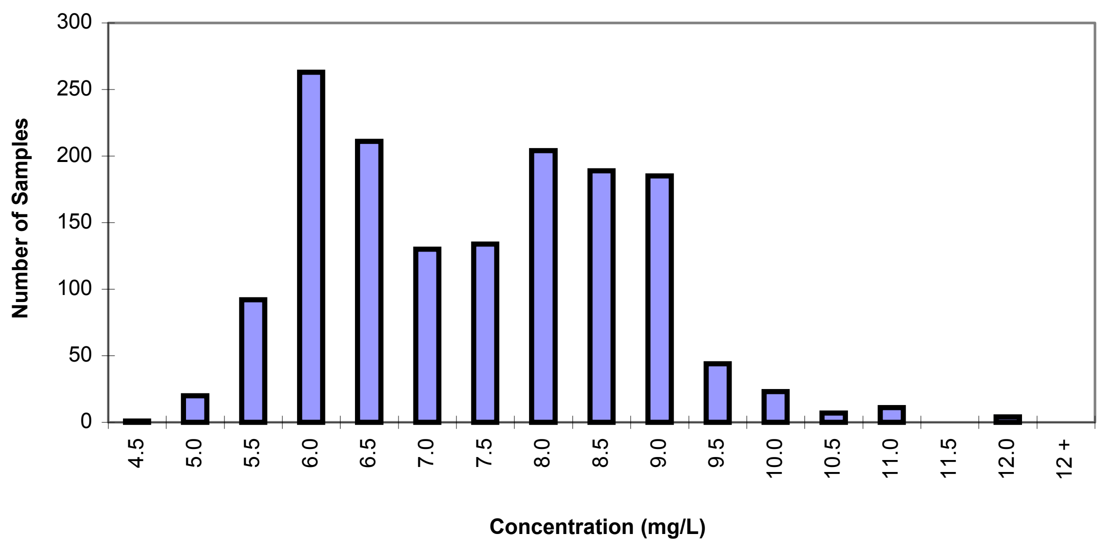


Figure 13 shows that there are occasions when specific locations exhibit low dissolved oxygen (less than 5.0 mg/L but above 4.5 mg/L) occur. This generally happens once a year because of an influx into Puget Sound of deep oceanic water, which contains naturally occurring low amounts of oxygen. These lower oxygen levels are not low enough to kill marine organisms. Dissolved oxygen levels as a whole at King County sites indicate sufficient oxygen to support marine life.

Bacteria

Fecal coliform bacteria are flushed into Puget Sound during storm events in the stormwater runoff and combined sewer overflows. Another possible source of the bacteria is from the feces of waterfowl and marine mammals that congregate on the beaches. As a result, the highest fecal coliform levels occur during high rainfall months in waters close to streams and other freshwater sources. Fecal coliform levels at certain beaches have routinely failed Washington State standards for the last several years. These sites tend to be in areas that have reduced mixing (such as Tramp Harbor and Faunteloy Cove) and retain freshwater inputs for a long period of time or are near fresh water sources (such as Carkeek Park). In contrast, certain beaches such as Seacrest Park, Alki Point, and off Duwamish Head, routinely have the lowest bacteria levels and consistently meet standards.

Figure 14 shows the stations monitored and results for fecal coliform bacteria in 1999 and 2000. King County has monitored bacteria (both fecal coliform and *Enterococcus*) in the water column and at beaches for over 20 years. Monitoring results from the last five years show that water column stations consistently meet Washington State Class AA marine surface water standards for fecal coliform bacteria, including those stations near the county's wastewater treatment plant outfalls. However, stations near a fresh water source or in certain nearshore areas regularly fail standards.

Sediment

King County monitors marine sediments from various offshore and beach stations as part of the ambient and point source monitoring programs. Point source stations are located around the county's wastewater treatment plant outfalls. Pollutants in sediments at sites within King County generally meet Washington State Sediment Management Standards with the exception of areas located along the Seattle waterfront in inner Elliott Bay. This area routinely fails standards for mercury and certain compounds that are present in petroleum products and wood preservatives. There are occasional failures at other locations sampled, but the highest levels are found within Elliott Bay.

Benthic communities are sampled at the South Treatment Plant and the West Point Treatment Plant outfalls, and results from recent monitoring show them to be healthy for their respective conditions (sandy sediment at West Point and silty sediment at the South Plant).

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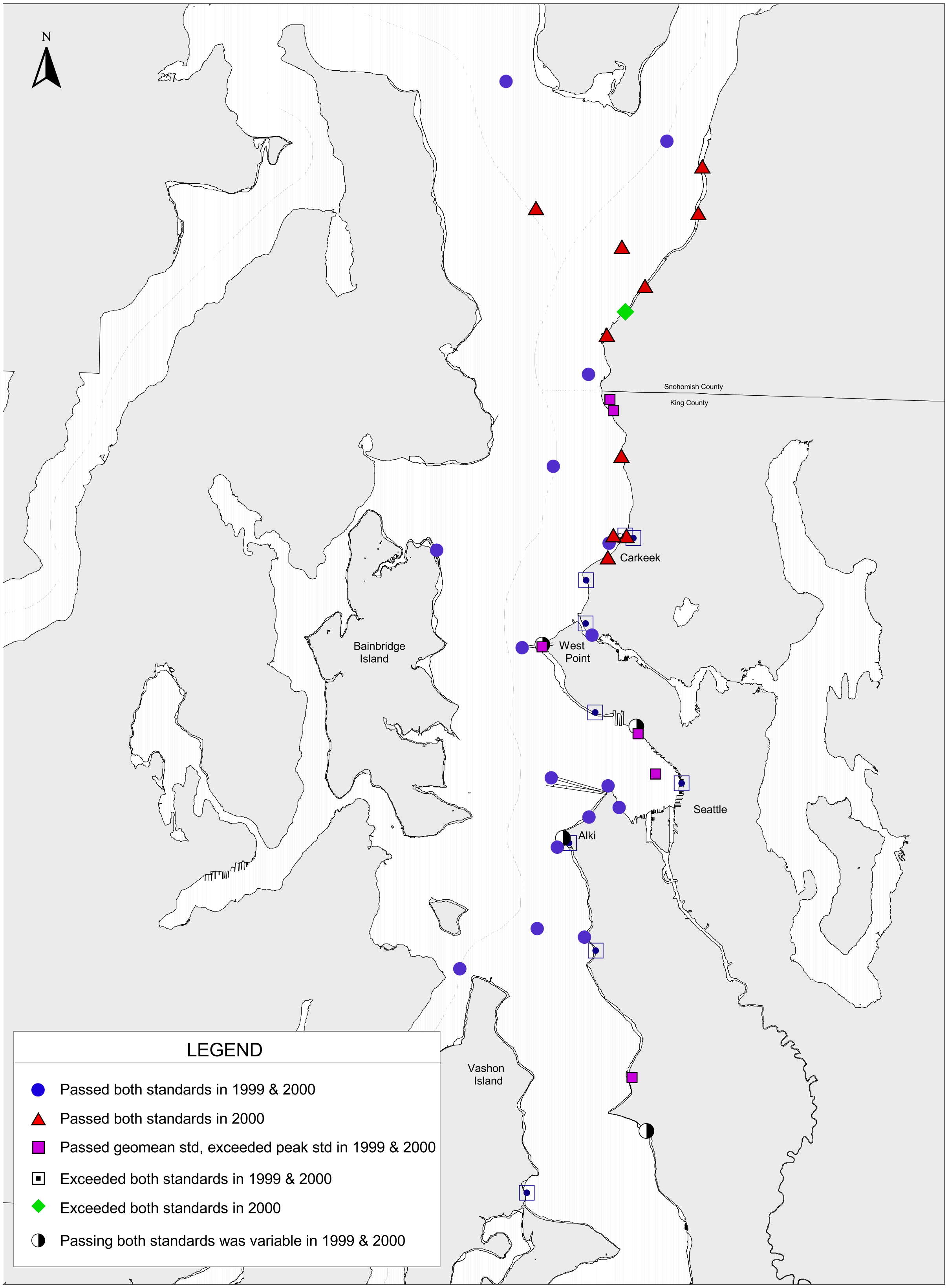

Figure 14 Fecal Coliform - comparison with water quality standards 2000/2001

Developing Issues & Needs

In the coming year, King County will face some unique challenges, as well as be presented with some new opportunities for change. Creating a balance in water needs and water resources for fish and people will be an ongoing focus for the county. The listing of chinook salmon under the ESA will impact every aspect of our already water quality-focused wastewater treatment processes and monitoring.

Endangered Species Act (ESA)

In 2000, King County worked with the NMFS to develop a "limitation" on take, to be included in the 4(d) rule for chinook salmon. A limitation means that if activities are conducted according to their description in the 4(d) rule, they are not considered a "take." For example, discharges from King County's secondary treatment plants, if done according to stipulations in the 4(d) rule, would not be considered a take of protected species. King County's proposal is to include discharges within NPDES permit limits and CSOs controlled to an average of no more than one untreated event per year in the limitation. We expect to complete discussions with NMFS in the first half of 2002.

The chinook 4(d) rule, which became effective January 8, 2001, addresses many activities conducted by the county's Wastewater Treatment Division; for example, development within 200 feet of water bodies, construction of sewer lines in streets, and control of stormwater from facility sites. In 2000 the county began a review of its activities to determine how the Wastewater Treatment Division should modify its practices to stay within the parameters set out in the 4(d) rule. The intent is to meet the spirit of the ESA even in cases where there is no permitting agency to enforce the ESA.

The Habitat Conservation Plan continued development in 2001. The county completed the Water Quality Effect process that examined potential impacts of secondary discharge on listed species and four issue papers that examined different activities within Wastewater Treatment Division. This information was given to NMFS and the US Fish and Wildlife Service (Services) for review and will lead to the drafting of the HCP. Throughout 2001, several negotiation and discussion sessions were held with the Services as well meeting with our stakeholder groups that included MWPAAC, environmental groups, government agencies and other interested parties.

In 2002 we have planned out a complete schedule of technical and formal negotiations with the Services and interested Tribes that will conclude with a draft agreement by mid-2002. Over the following 18 months, staff will develop the required draft and final environmental documents and implementation agreements that will lead to the issuance of a Incidental Take Permit in early 2004.

Watershed Resource Inventory Area (WRIA) Planning

In 2001 the interlocal agreements (ILA) were in place and work began on development of work products under the ILA model. This model involves cost sharing by more than 45 jurisdictions in support of the salmon conservation planning effort as well as a new management construct. Due to the success of the first year, all jurisdictions have agreed to continue funding for 2002 work.

The Draft WRIA 08 Reconnaissance Report was published in March 2001, which includes known, probable, and possible factors of decline organized by sub-basin. Also, the Reconnaissance Assessment was updated and expanded as a Limiting Factors Report. The first draft of the Near Term Action Agenda (NTAA) was completed in December 2001. The NTAA outlines early, voluntary steps that can ameliorate some of the factors that are negatively affecting salmon and salmon habitat; public review of the NTAA will continue through the first quarter of 2002. Detailed scoping for the Salmon Conservation Plan—a long-term habitat conservation and recovery actions in the WRIA 09 watershed—will take place in 2002. Work on the Strategic Assessment will also be underway with completion projected for 2003. The Strategic Assessment will provide technical foundation for the conservation plan as well as baseline information needed for adaptive management, involving research concerning the health of chinook salmon and bull trout. The Strategic Assessment will result in a more complete understanding of problems and opportunities in the watershed related to salmon and salmon habitat conservation and recovery, with a focus on ESA-listed species

The draft Near Term Action Agenda for WRIA 09 was completed at the end of 2001 and is based on findings in the WRIA 09 Reconnaissance Report. As with the other NTAAs, it contains doable actions that can be taken in the next 2 – 3 years while more detailed conservation planning work is underway. In 2002, the NTAA will be completed and the Strategic Assessment will be underway. Detailed scoping for the Comprehensive Salmon Conservation Plan will also begin in 2002 with completion projected for 2004.

Anti-Degradation Regulations

The state Department of Ecology is expected to propose revisions to their surface water quality standards and procedures. They will be considering modifying their permit renewal processes to include more strict evaluations of whether projects lower water quality in water bodies throughout the state and protect clean water. The new anti-degradation criteria procedure could potentially block new discharges into water bodies with especially high quality or those already impaired by a parameter (for example, temperature or DO) a new discharge might further impair. King County's future wastewater projects will be subject to this new procedure if implemented by the state Department of Ecology.

Total Maximum Daily Loads

According to the U.S. Environmental Protection Agency, a total maximum daily load (TMDL) is a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. When a water body fails to meet quality standards the Clean Water Act requires that a TMDL and a pollutant allocation be done for that water body. The U.S. Environmental Protection Agency or the state Department of Ecology makes allocations of that pollutant to its sources, such as storm runoff or industrial discharges.

Any water bodies consistently identified by the state as not meeting water quality standards must have a TMDL prepared and implemented in the next ten years. New federal rules for performing TMDL analysis will go into effect in October 2001. These new rules and the great number of King County water bodies listed by the state will require additional attention to water quality data collection and modeling so that TMDL calculations done by the state Department of Ecology are as accurate and complete as possible.

In 2001 King County completed a joint project with the state Department of Ecology to begin work on TMDLs for certain county water bodies. In particular, a model sediment TMDL has been developed and approved by the U.S. EPA. in its first application to a site in Bellingham Bay. This model should next be applied to the Lower Duwamish Waterway.

Endocrine Disrupters

Chemicals that mimic hormones in animals (fish, birds, people) may sometimes result in changes in how an animal's endocrine system works. These chemicals have been termed "endocrine disrupters." Some of these chemicals may be found in treated municipal wastewater. King County has assembled a document to provide a review of the scientific literature on potentially endocrine disrupting substances potentially present in treated municipal wastewater. The document, titled *Endocrine Disrupters in Secondary Treated Effluent: Toxicological Effects in Aquatic Species*, discusses endocrine disrupting chemicals, their toxicological effects on aquatic species, and the current state of endocrine disrupter research.

Sediments

The U.S. Environmental Protection Agency is considering expanding the Superfund site designation along the east shoreline of Harbor Island to cover the entire East Waterway. This would mean the dredging scheduled to be done under the East Waterway Harbor Improvement Project would become a CERCLA clean-up action through the Superfund. The County would become involved because of CSO discharges at the site. This could result in changes in the priority and schedule of CSO control projects to address source control issues and changes in the schedule to coordinate clean-up actions.

Appendix A – Glossary

Algae: Plants that grow in surface waters in relative proportion to the amount of light, nutrients and attachment sites available. Algae are food for fish and other aquatic organisms.

Benthos: The communities of aquatic life that dwell in or on the bottom of sediments of a water body.

Biochemical Oxygen Demand (BOD): The amount of dissolved oxygen required to meet the metabolic needs of microorganisms in water, wastewater and effluents.

Biosolids: The organic solids separated from raw wastewater or produced by the wastewater treatment process. Biosolids contain large amounts of organic matter.

Chlorophyll: The green pigment in plants that allows them to create energy from light (photosynthesis). By measuring chlorophyll, one indirectly measures the amount of photosynthesizing plants, or algae, in the water column. Chlorophyll α is a measure of the portion of the pigment that is still actively photosynthesizing at the time of sampling.

Combined Sewer Overflow (CSO): An overflow of combined wastewater and stormwater. CSOs occur when stormwater from heavy rains exceed the capacity of the wastewater collection system.

Dissolved Oxygen (DO): The oxygen that is freely available in water. Certain amounts are necessary for life processes of aquatic animals. The oxygen is supplied by the photosynthesis of plants and by aeration. Oxygen is consumed by animals, plants, and bacteria that decompose dead organic matter and some chemicals.

Effluent: Treated or untreated water or wastewater flowing out of a treatment facility, sewer or industrial outfall. Generally refers to discharges into surface waters.

Eutrophic: The trophic state of lakes with high concentrations of nutrients and algae and with low transparency or clarity.

Eutrophication: The natural physical, chemical and biological changes that take place as nutrients, organic matter and sediment are added to a lake. When accelerated by human-caused influences, this process is called cultural eutrophication.

Fecal Coliforms: The intestinal bacteria from warm-blooded animals that are routinely used as an indicator of sewage pollution in water and as an indicator of the human health risk.

Influent: Water, wastewater or other liquid flowing into a treatment facility.

Lake Classification: Lakes are typically compared according to the level of biological activity or **trophic state**. A lake with high concentrations of nutrients and algae and with low transparency or clarity is considered **eutrophic**. Lakes with low concentrations of nutrients and algae and high transparencies are considered **oligotrophic**. Lakes that are intermediate between eutrophic and oligotrophic are considered **mesotrophic**.

Mesotrophic: The trophic state of lakes that have moderate concentrations of nutrients and algae between those found in eutrophic and oligotrophic lakes.

National Pollutant Discharge Elimination System (NPDES): NPDES comes from Section 402 of the Clean Water Act. It prohibits the discharge of pollutants into navigable waters of the United States unless a special permit is issued by the U.S. Environmental Protection Agency, a state, or tribal government.

Nonpoint Source: An input of pollutants into a water body from unidentifiable sources, such as agriculture, the atmosphere, stormwater or groundwater runoff.

Nutrient: An inorganic or organic compound essential for growth of organisms.

Oligotrophic: The trophic state of lakes with low concentrations of nutrients and algae and high transparency.

Phosphorus: The primary nutrient of concern in fresh water systems as it can cause nuisance algal blooms if present in excess amounts.

Phytoplankton: Marine plants, mostly small to microscopic in size, which are suspended in the water column and drift with the currents.

Point Source: An input of pollutants into a water body from discrete sources, such as municipal or industrial outfalls.

Productivity: The rate at which organic matter is formed that is averaged over a defined period of time.

Mg/L: Milligrams per liter. Used in describing the amount of a substance in a given volume of liquid. Equal to parts per million (ppm).

Secchi Depth: The measure of lake water clarity and is used primarily as an indicator of algal abundance. Clarity is affected by algae, soil particles and other materials suspended in the water.

Thermal Stratification: Layering of lake water caused by differences in water density. During summer months, deep lakes divide into three layers: the epilimnion (uppermost, warmest layer), hypolimnion (lower, cooler layer) and metalimnion (middle layer).

Trophic State Index (TSI): One of the most common lake indices used to characterize water quality is the numerical trophic state index developed by Robert Carlson in 1977. This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, etc.) represents a doubling of algal biomass and is related to nutrient and transparency.

Water Column: The area of water contained between the surface and the bottom of a water body.

Appendix B – Web sites

Water Monitoring Programs

King County Environmental Laboratory
http://dnr.metrokc.gov/wlr/envlab/index.htm

King County Lakes Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/lakes/

King County Beach Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/lakes/bacteria.htm

King County Streams Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/streams/creekindex.htm
http://dnr.metrokc.gov/wlr/waterres/Bugs/index.htm

King County Marine Monitoring Program
http://dnr.metrokc.gov/wlr/waterres/marine/marine.htm

Water Quality Management Programs

Wastewater Treatment Division
http://dnr.metrokc.gov/wtd/

King County's CSO Control Program
http://dnr.metrokc.gov/wtd/cso/index.htm
http://dnr.metrokc.gov/wlr/waterres/wqa/wqpage.htm
http://dnr.metrokc.gov/wtd/dennyway/

City of Seattle's CSO Control Program
http://www.ci.seattle.wa.us/util/CSOPlan/default.htm

King County Hazardous Waste Program
http://www.metrokc.gov/hazwaste/house/

King County Industrial Waste Program
http://dnr.metrokc.gov/wlr/indwaste/index.htm

King County Integrated Pesticide Management Program
http://www.metrokc.gov/hazwaste/ipm/

King County Sediment Management Program
http://dnr.metrokc.gov/wlr/waterres/norfolk/norfolk.htm

King County Biosolids Program
http://dnr.metrokc.gov/WTD/biosolids/index.htm

King County Water Reuse Program
http://dnr.metrokc.gov/wtd/reuse/index.htm

State of Waters

Cedar Watershed
http://dnr.metrokc.gov/wlr/watersheds/cedar-lkwa.htm

Lake Washington
http://dnr.metrokc.gov/wlr/waterres/lakes/biolake.htm
http://dnr.metrokc.gov/wlr/waterres/lakes/Wash.HTM

Sammamish basin
http://dnr.metrokc.gov/wlr/watersheds/samm.htm
http://dnr.metrokc.gov/wlr/waterres/lakes/SAMM.htm

Lake Union
http://dnr.metrokc.gov/wlr/waterres/lakes/UNION.HTM

Green watershed
http://dnr.metrokc.gov/wlr/watersheds/green.htm

Puget Sound watershed
http://dnr.metrokc.gov/wlr/watersheds/puget.htm

King County salmon recovery activities
http://dnr.metrokc.gov/topics/salmon/SALtopic.htm
http://dnr.metrokc.gov/Wrias/9/index.htm
http://dnr.metrokc.gov/Wrias/8/index.htm