Regional Wastewater Services Plan

RWSP Water Quality Report

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King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

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Executive Summary

This report describes the efforts of King County's Department of Natural Resources and Parks (DNRP) in 2002 to protect and preserve water quality in Puget Sound and the major lakes and rivers in the county. In particular, this report is concerned with those waters that benefit from, or could be impacted by, the operations of King County's wastewater treatment and conveyance system; namely, management of wastewater, discharges of treated wastewater, sanitary sewer overflows (untreated wastewater), and combined sewer overflows (untreated wastewater combined with stormwater runoff). The health of Puget Sound received extra public attention in November 2002 when the *Seattle Post-Intelligencer* ran a five-part series called "Our Troubled Sound." The articles highlighted the challenges and difficult choices involved in protecting fish, managing stormwater, and cleaning up historical pollution. It also highlighted the efforts of the many organizations working together to overcome these challenges. Many of those efforts are led by King County and are described in this report.

This report is required by King County Ordinance 13680, which adopted the Regional Wastewater Services Plan (RWSP)—a $1.8 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 an annual 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 manage water quality and monitor its waters.

State of the Waters

Three major groups of waters are described in this report: the major lakes, including Lake Washington, Lake Sammamish, and Lake Union; the rivers and streams, including the Cedar River, the Sammamish River, and the Green and Duwamish Rivers; and the marine waters of Puget Sound. These waters are shown in Figure 1 (in Chapter 1) and their status is 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 2002, with good water clarity and low concentrations of algae. Water quality was good in Lake Sammamish in 2002 with good water clarity, low concentrations of algae, and moderate concentrations of phosphorous. Excess phosphorous loading has been a historical problem in the lake, particularly in summer. Since 1998, phosphorous concentrations

[1] In 2003 dollars.

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 2002 and has fluctuated between moderate and good since 1994.

Rivers and Streams

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, as do many other state waters. 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 from the river 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, high temperature, and high fecal coliform bacteria levels 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. Sediment contamination is a significant focus of attention in the Lower Duwamish River.

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.

Water Quality Management Programs

King County has many programs in place that protect and preserve water quality. The wastewater treatment system collects wastewater from 32 cities and sewer districts serving approximately 1.4 million residents and conveys it to two regional treatment plants: the West Point Treatment Plant in Seattle and the South Treatment Plant in Renton. On average, these plants provide secondary treatment for over 182 million gallons of wastewater each day. The

[2] The 303(d) list identifies water bodies that do not meet State Water Quality Standards.

quality of treated effluent from these plants remained high in 2002, with effluent values typically much higher in quality than what is required by wastewater discharge permits.

King County also has a program to reduce the amount of combined sewer overflows (CSOs), with two large CSO projects under way at Denny Way and Henderson/Martin Luther King Jr. Way. As part of the RWSP, the County has committed to controlling all its CSO discharge locations to no more than one untreated discharge per year by 2030, as required by Washington State regulation. 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 Local Hazardous Waste Management Program. For example, last year the Industrial Waste Program, which regulates industrial wastewater discharges, collected 2,069 samples and found 23 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 methane (digester gas) for use in running plant operations, and implementing a program that provides reclaimed water for use in treatment plant operations and for customers in the service area.

Monitoring the Health of King County Waters

To protect public health and its significant investment in water quality improvements, King County regularly monitors its major lakes, beaches, streams, marine waters, and wastewater effluent. The major lakes monitoring program collects samples from 5 sites in Lake Union, 13 sites 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 five 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 assesses beaches on Lake Sammamish, Lake Washington, and Green Lake every summer. This effort, ongoing since 1996, tests for bacteria 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 source of pollutant loading to a major water body. The long-term program has sampled at 63 sites on 3 rivers and 27 streams for many years.

King County's marine monitoring program routinely evaluates nutrient, bacteria, and dissolved oxygen levels in the waters of the main basin of Puget Sound. The program also includes monitoring of 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 conducts special intensive investigations of water quality to support specific decision-making. Currently three studies are under way to understand water quality issues and needs, to project future growth impacts in County watersheds, and to characterize

northern Puget Sound for siting a marine outfall for the Brightwater Treatment Plant expected to be on line in 2010.

King County regularly monitors its wastewater effluent using process laboratories at both of its regional treatment plants and the environmental laboratory in Seattle.

2002 Results

Management and monitoring program performance in 2002 indicates that County efforts continue to make a significant contribution to protecting regional water quality and protecting public health. No needs were identified that are not already being addressed, and the wastewater system is achieving its purposes. King County residents are continuing to enjoy the excellent water quality that they value and expect.

Chapter 1 Background

In 1911, the City of Seattle completed the Fort Lawton Tunnel to discharge untreated wastewater flows off West Point (what is now Discovery Park) into Puget Sound. Early wastewater systems, which were the beginning of the current combined sewerage system in the City of Seattle, were built to collect wastewater from homes and businesses and stormwater runoff from streets.

By the 1950s, more than 25 small wastewater treatment plants were operating in the Seattle metropolitan area. Not all communities were served by treatment plants. Untreated wastewater entered Lake Washington, Lake Sammamish, Elliott Bay, the Duwamish River, the Lake Washington Ship Canal, and Puget Sound. For example, about 40 million gallons of untreated wastewater was discharged off of Discovery Park each day.

The degradation of water quality in Lake Washington resulted in beach closures, and there was concern about the future of other local waters. A grassroots citizens committee was formed that successfully sponsored state legislation allowing formation of a municipal corporation to manage the wastewater pollution problem for the Seattle metropolitan area. As a result, the Municipality of Metropolitan Seattle (Metro) was formed in 1958 to assume responsibility for cleaning up Lake Washington and establishing a regional wastewater system.

Metro developed the *Comprehensive Sewerage Plan* that became the guiding planning document for wastewater treatment services in the Lake Washington drainage basin for the next 35 years. Under that plan, Metro built regional treatment plants, closed small plants, constructed major trunk lines and the pump station needed to move the wastewater to the new plants, and eliminated 46 untreated wastewater discharge points into Lake Washington and Lake Sammamish. The plan was amended periodically, with the *1999 Regional Wastewater Services Plan* (RWSP) being the most recent significant amendment.

By the 1960s, Lake Washington's water quality had dramatically improved. The King County area became known as a national model of citizen action in cleaning up the environment. Metropolitan King County assumed Metro's functions in 1994. With the combined King County and Metro resources and expertise, the County became a regional provider of water quality protection services.

In addition to providing wastewater management services, King County performs many other activities to protect and improve water quality. These activities include monitoring water quality in lakes and streams, educating the public about water quality issues, and providing grant funds for local water quality projects. Water quality sampling and monitoring efforts began in 1962 to track cleanup progress in Lake Washington and to measure the impacts of diverting wastewater effluent from the lake to deep-water outfalls in Puget Sound. Monitoring programs and scientific studies have since remained a key element, informing County decisions on wastewater service and water quality management activities, as well as evaluating the effectiveness of those actions.

Purpose of this Report

The RWSP, King County's most recent comprehensive plan amendment, is a $1.8 billion (in 2003 dollars) capital improvement program to provide wastewater capacity for this region for the next 30 years and beyond. The plan includes the following elements:

- Siting and construction of a new Brightwater regional treatment plant in the north end of the County's service area
- Construction of many new conveyance lines and pump stations
- Implementation of 21 projects to complete combined sewer overflow (CSO) control
- Implementation of programs to investigate control of inflow and infiltration of clean water into the County system, water reuse, and new technologies to manage treatment plant solids (biosolids)

King County recognized that the RWSP needed to be flexible and adaptable to changing conditions and needs. In the Ordinance 13680 (1999) adopting the RWSP, the County required the development of an annual water quality report. The purpose of the report, as stated in the ordinance is as follows:

> [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 *2003 RWSP Water Quality Report* meets this requirement. This report, along with the 2001 and 2002 water quality reports, will be used to inform the comprehensive plan review—the *2003 RWSP Update*—that is currently under way. It describes the scientific and institutional programs supporting implementation of the RWSP and identifies any water quality needs not being met by the RWSP. Using this information, the County can determine any needed adjustments to the goals, policies, and RWSP guiding provision of wastewater services.

The remainder of this chapter describes the waters in King County. The chapters that follow describe County programs to manage and monitor water quality in the region; present the state of the waters in 2002; and outline continuing issues and needs concerning the health of county waters. The appendixes contain a glossary of technical terms used in this report and a list of Web sites that contain additional information about the programs and water bodies described in this report.

King County Waters

The wastewater service area of western King County includes major freshwater streams and lakes and the marine waters of Puget Sound. The fresh waters are grouped by watersheds designated as Water Resource Inventory Areas (WRIAs). WRIAs 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 1 shows the boundaries and the major water bodies of each WRIA.

Cedar-Sammamish Watershed (WRIA 08)

Approximately 85 percent of the Cedar-Sammamish watershed lies within King County; the remaining 15 percent is in Snohomish County. The eastern portion of the watershed lies in the Cascade Range, and the western portion occupies the Puget Sound lowland. The major lakes studied by King County in WRIA 08 are Lake Sammamish, Lake Washington, and Lake Union.

The Cedar-Sammamish watershed has been dramatically altered in the last 150 years. This transformation resulted from the following activities:

- Building of the Landsburg Diversion Dam at the turn of the century by the City of Seattle to tap into the Cedar River as its main source of water
- Construction of the Lake Washington Ship Canal and Hiram M. Chittendon Locks between 1910 and 1920, which redirected the outlet of Lake Washington from its south end at the Black River to the north through Lake Union and the Locks and dropped Lake Washington's level almost 9 feet
- Dropping of the level of Lake Sammamish as a result of the change in the level of Lake Washington
- Draining of the wetlands along much of the shoreline of Lakes Washington and Sammamish as a result of their level changes
- Channelization of the Sammamish River in the early 1920s

Lake Washington

At 21,500 acres in area 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 lake is 108 feet at its deepest point. The water bodies in the Lake Washington basin are all high quality (Class AA) waters. Some of the beneficial uses of 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.

By the late 1960s, all wastewater discharge to both Lake Washington and Lake Sammamish was ended, which removed about 75 percent of the nutrient inputs to the lakes. The subsequent water quality improvements were dramatic. Now phosphorus concentrations in Lake Washington are in large part a reflection of the amount of phosphorus entering the lake from the Cedar River. The Cedar River contributes about 57 percent of the water to the lake and has relatively low phosphorus concentrations.

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,

Insert Figure 1

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*). Over the five-year period following the cessation of wastewater discharges, water quality responded favorably showing a 50 percent reduction of phosphorus and algal concentrations and a 35 percent increase in water clarity. There remains cause for vigilance, though, as water quality often degrades with increasing development and population densification such as is occurring in this basin. Thus, in 1989 a *Lake Sammamish Management Plan* was developed based on the assumption that control of phosphorus loading into the lake would control primary productivity (algal blooms), water clarity, and dissolved oxygen. Measures to control phosphorus loading to the lake also result in many secondary benefits to the watershed, such as control of erosion and sedimentation and preservation of fish habitat, forest cover, and riparian cover.

Lake Union

Lake Union, at 580 acres in area 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, connecting lakes Washington and Union with Puget Sound. This construction allowed intrusion of salt water from the Ship Canal. This intrusion now 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, Lake Union received wastewater discharges from local wastewater collection systems, from houseboats, and from discharges from ships, industry, and businesses along the shore. The lake has been impacted by fuel spills and other discharges from ships and onshore facilities. Pollution inputs from many of these sources have decreased—untreated wastewater was intercepted for treatment in the 1980s and the remaining CSOs are being controlled. In 1994, a CSO separation project in the University Regulator basin removed a significant amount of CSOs from the lake. The project included construction of a new stormwater outfall. A study was completed to assess the impact of the stormwater discharge from the outfall, and the report is nearly complete. A joint project between King County and the City of Seattle—the Denny Way/Lake Union CSO control project—is currently in construction and will be completed in 2005. The project will control all CSOs that discharge directly into Lake Union. Remaining CSOs along the Ship Canal will be controlled as part of the County's RWSP (1999) and Seattle's *Combined Sewer Overflow Control Plan Amendment* (2001).

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 improve 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, one of the major salmon producing streams in King County, drains into the Sammamish River. However, the river continues to experience degraded fish habitat and increased flooding and erosion—impacts from development that began in the 1970s and 1980s and that continue today.

Cedar River

The Cedar River is the largest tributary to Lake Washington and drains nearly 200 square miles from the crest of the Cascade Range 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 is 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.

Streams

Many small streams exist in the Cedar-Sammamish watershed. Twenty-one streams are in areas near wastewater facilities or are considered potential sources of pollution to their downstream water bodies: Bear-Evans, Ebright, Eden, Fairweather, Forbes, Idlewood, Issaquah, Juanita, Kelsey, Lewis, Little Bear, Longfellow, Lyon, May, McAleer, North, Pine, Swamp, Thornton, Tibbets, and Yarrow.

Duwamish-Green Watershed (WRIA 09)

The Green-Duwamish River watershed begins in the Cascade Range about 30 miles northeast of Mount Rainier and flows for over 93 miles to Puget Sound at Elliott Bay in Seattle. Historically, the White, Green, and Cedar (via the Black) Rivers flowed into the Duwamish River, and the system drained an area of over 1,600 square miles. The Green-Duwamish River watershed has one of the most altered hydrological ecosystems in the Puget Sound basin. To date, 97 percent of the Duwamish estuary has been filled, 70 percent of the flows of its former watershed have been diverted out of the basin, and about 90 percent of the once extensive floodplain is no longer flooded on a regular basis. These changes resulted from the following activities:

- Dredging, channelizing, and diking of the river for navigation and flood control between 1895 and 1980
- Filling and draining of the estuary tidelands to support industry and port activities between 1900 and 1940
- Diversion of the White River from the Green River to the Puyallup River for flood control in 1911
- Diversion of water for drinking water supply by the City of Tacoma in 1913

- Diversion of the Black and Cedar Rivers from the Duwamish River to Lake Washington in 1916
- Construction of the Howard Hanson Dam for flood control in 1962

As a result of these activities, the watershed has been reduced to 556 square miles and the ecosystem has been significantly altered. The major water bodies in the overlap of the Green-Duwamish watershed and the wastewater service area include the Green River, Duwamish River, and several small streams. There are no major lakes in the watershed.

Green River

The lower Green River and its valley 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 residents. The upper Green River extends from the crest of the Cascade Range, the river’s headwaters, to the Tacoma diversion dam. The dam provides drinking water to the City of Tacoma and water for forest production for federal, state, and private landowners.

Duwamish River

The area around the Duwamish River is heavily urbanized, consisting of dense commercial and industrial development. The Duwamish River provides a passageway to the inland portions of the state, and thus has been an area of heavy industrial development. Concrete, glass, steel, and lumber factories, and construction and barge companies have all been a part of its economic fabric. Development in the Duwamish Estuary has resulted in the loss of approximately 98 percent of the estuary’s former intertidal marshes and mudflats.

Streams

Among the small streams in this watershed, five occur in areas near wastewater facilities or are considered potential sources of pollution to their downstream water bodies: Crisp, Mill, Newaukum, Soos, and Springbrook.

Puget Sound Marine Waters

Puget Sound is the southernmost of a series of glacially scoured channels, relatively protected by a single entrance 84 miles from the Pacific Ocean. It 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. The Sound consists of four major basins: the Main (Admiralty Inlet and the Central Basin), Whidbey, Southern, and Hood Canal Basins. All of the basins have different characteristics due to water circulation and underwater topography. Puget Sound is surrounded by 2,354 miles of shoreline, including beaches, bluffs, mudflats, deltas, and wetlands.

The average depth of Puget Sound is 348 ft. The Main Basin has depths greater than 919 ft and is shielded at the main entrance to the Sound by the Admiralty Inlet sill that impedes the exchange of deep waters. The Sound has near-oceanic salinity throughout most of the year and is supplemented with cold, nutrient-rich, low-oxygenated deep water upwelling off the Washington coast during the later summer and fall months. This upwelling creates a partially mixed two-layer system, with relatively fresh water flowing seaward at the surface and saline oceanic water returning landward at depth. Puget Sound has a mixed, semi-diurnal tidal cycle that is characterized by two unequal high tides and two unequal low tides each day with an average tidal exchange of 12 to 14 ft. Half of its water can be replaced with fresh ocean water in a tidal cycle. All of this helps the Sound maintain favorable water quality conditions.

Chapter 2 Water Quality Management Programs

This chapter describes King County's water quality management programs, including its regional wastewater system and its programs for controlling pollutants at their source, for cleaning up contaminated sediments near combined sewer overflow outfalls, and for recovering resources.

Regional Wastewater System

The King County wastewater system serves approximately 1.4 million residents in a 420-square-mile service area. A total of 275 miles of pipes, 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 Seattle and the South Treatment Plant in Renton—and a small treatment plant on Vashon Island (Figure 2). These three plants treat wastewater to the secondary level. In addition, King County operates two combined sewer overflow (CSO) treatment plants at Alki and Carkeek Park in Seattle. The Alki and Carkeek plants provide primary treatment of excess flows that occur in the combined sewer system during storm events.

Secondary Treatment Plants

The federal 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 Washington State Department of Ecology (Ecology) and set limits on the quality of effluent discharged from point sources such as treatment plants and industrial facilities. King County has NPDES permits for its West Point, South, and Vashon Treatment Plants. The West Point NPDES permit also includes the Alki and Carkeek CSO plants and the CSO outfalls. The NPDES permits for the Renton and West Point plants are currently administratively extended while being renewed.

The treatment process is an intensive and controlled version of the biodegradation of organic material that occurs in the natural world. 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 then 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

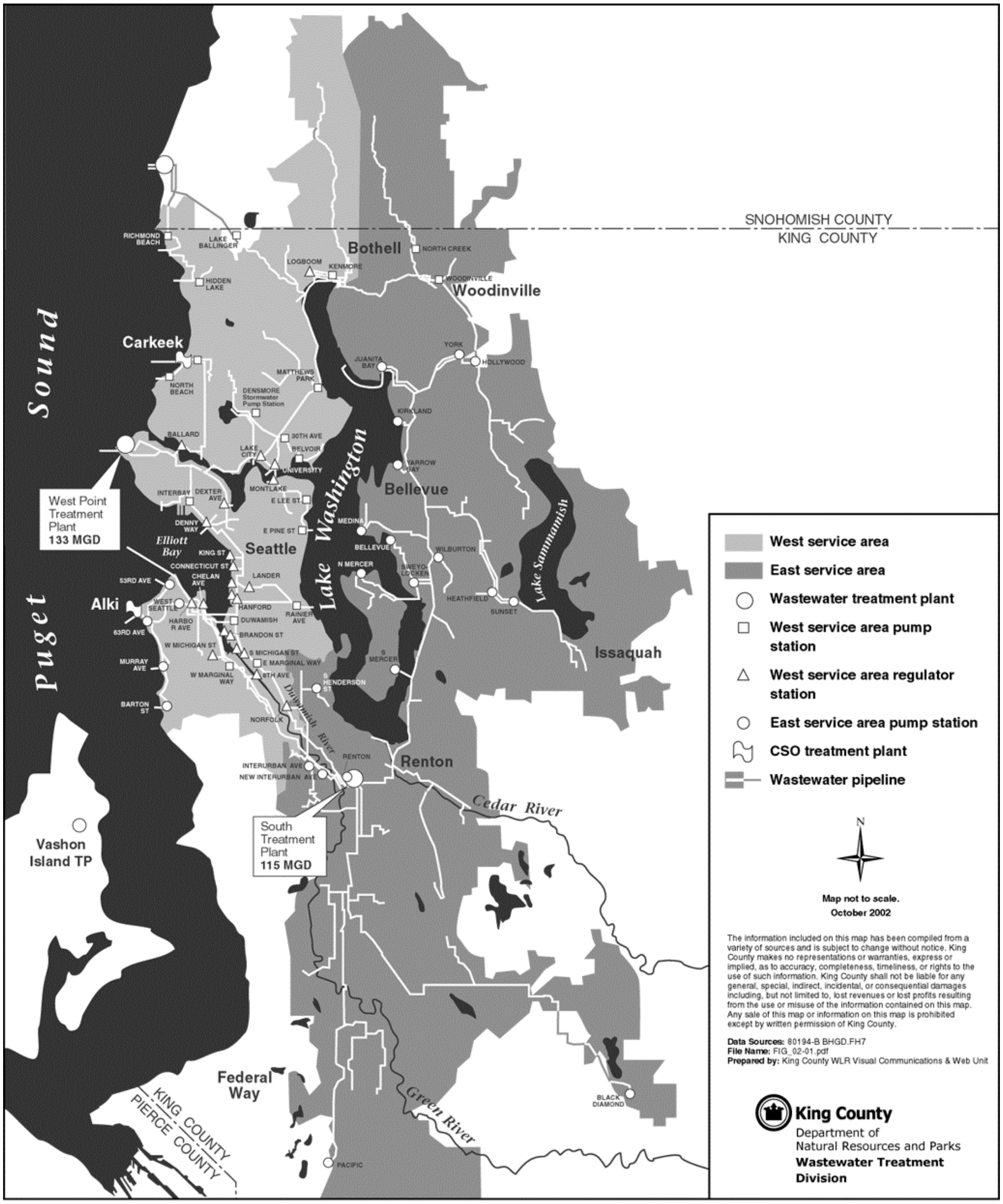

Figure 2
King County Regional Wastewater System

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 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, sometimes dechlorinated, and pumped to an 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.

Both the West Point and South Treatment Plants also produce reclaimed water, which is secondary effluent that receives additional 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 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 (MG) per year of septic tank solids from throughout the region as well as sludge from treatment facilities in neighboring areas such as Snoqualmie Valley cities and Vashon Island. The South plant is current holder of an Association of Metropolitan Sewerage Agencies (AMSA) Platinum Award for excellent operation.

The South Treatment Plant is designed to manage a monthly wet-weather average flow of 115 million gallons per day (mgd). The effluent pumping capacity at the South Treatment Plant was recently upgraded to handle a peak flow of 325 mgd. The outfall in Puget Sound discharges secondary effluent 10,000 feet from shore at a depth of 625 feet into the denser deeper water layer. The increasingly diluted effluent plume moves southward in the Sound, remaining at or below a depth of 425 feet.

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 customers located in the greater Seattle area and in southwest Snohomish County. It is the largest plant in the King County system, designed to manage an average wet-weather, non-storm flow of 133 mgd and a peak wet-weather flow 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 increasingly dilute effluent plume flows northward most of the year, out of Puget Sound. The West Point plant is current holder of the Association of Metropolitan Sewerage Agencies (AMSA) Gold Award for excellent operation.

The plant is designed to provide secondary treatment for up to 300 mgd. Capacity between the 300 mgd capacity for secondary treatment and the 440 mgd peak capacity of the plant is used to manage captured CSO. The plant provides these CSO flows with primary treatment, disinfection, and dechlorination.

Vashon 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 November 1999 when King County assumed responsibility for the plant. The plant was designed to manage a monthly average flow of 0.264 mgd and a peak flow 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.

The treatment plant has a history of numerous NPDES permit violations. Since King County assumed responsibilities for plant operations and facilities, many improvements have been made to enable the plant, though it is close to its design capacity, to operate more consistently. Improvements include removal of hydraulic restrictions in the outfall line to increase its peak-flow handling capacity, addition of a new ultraviolet disinfection process, improvement of sludge handling processes, and enhancement of the electrical and water utilities. In addition, to assure all permit limits will be met in the future, the plant will be replaced by a new higher capacity facility by 2006.

Other wastewater-related improvements were completed on Vashon Island. A new community treatment system at Buelah Park and Cove was built and began operation. This system can serve up to 75 homes at this time. In addition, King County 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 northeast side of the island. It transfers wastewater to the Vashon plant for treatment.

Treatment Plant Flows and NPDES Compliance in 2002

King County’s facilities continue to be in compliance with the terms and conditions of its NPDES permits, and so are in compliance with the Washington Water Pollution Control Law and Federal Water Pollution Control Act (The Clean Water Act).

Despite the fluctuation of flow and influent composition, the South plant’s secondary treatment process consistently produces high quality secondary effluent. In 2002, the plant managed an average flow of about 75 mgd with a daily maximum of about 98 mgd. Treatment efficiency remained high and consistent. There were no NPDES permit discharge violations at the South plant, but there were four reclaimed water violations. The average flow through the West Point Treatment Plant was about 107 mgd with a daily maximum of 206 mgd. There were no permit limit violations in 2002. At the Vashon plant, the average flow in 2002 was about 0.098 mgd with a maximum monthly average of 0.192 mgd. There were 17 NPDES permit exceptions, primarily for suspended solids and biochemical oxygen demand.

Combined Sewer Overflows

The combined sewer system carries both wastewater and stormwater. The City of Seattle is the only wastewater agency served by King County that has such a system. This combined system is primarily in the West Point service area. The other local collection systems are separated sewer systems. These separated systems carry wastewater to large King County pipelines, while "separately" directing stormwater to the nearest water body. Depictions of combined and separated sewer systems are shown in Figures 3 and 4.

During periods of heavy rainfall when flows exceed the capacity of the secondary and CSO treatment plants, untreated discharges of wastewater and stormwater from combined sewers are released via outfalls directly into marine waters, lakes, and rivers. These releases are called combined sewer overflows (CSOs). Approximately 90 percent of the CSO volume is stormwater and only 10 percent is wastewater. Figure 5 shows the locations of CSO outfalls in the King County system.

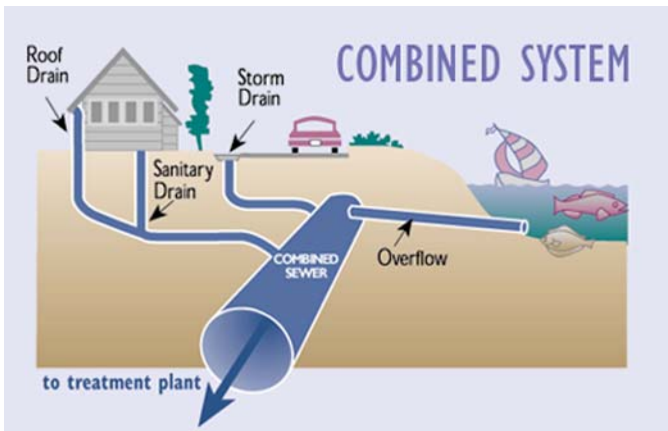

Figure 3
Typical Combined Sewer System

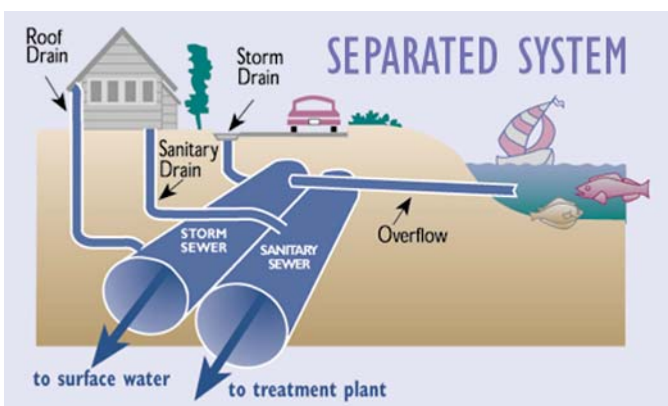

Figure 4
Typical Separated Sewer System

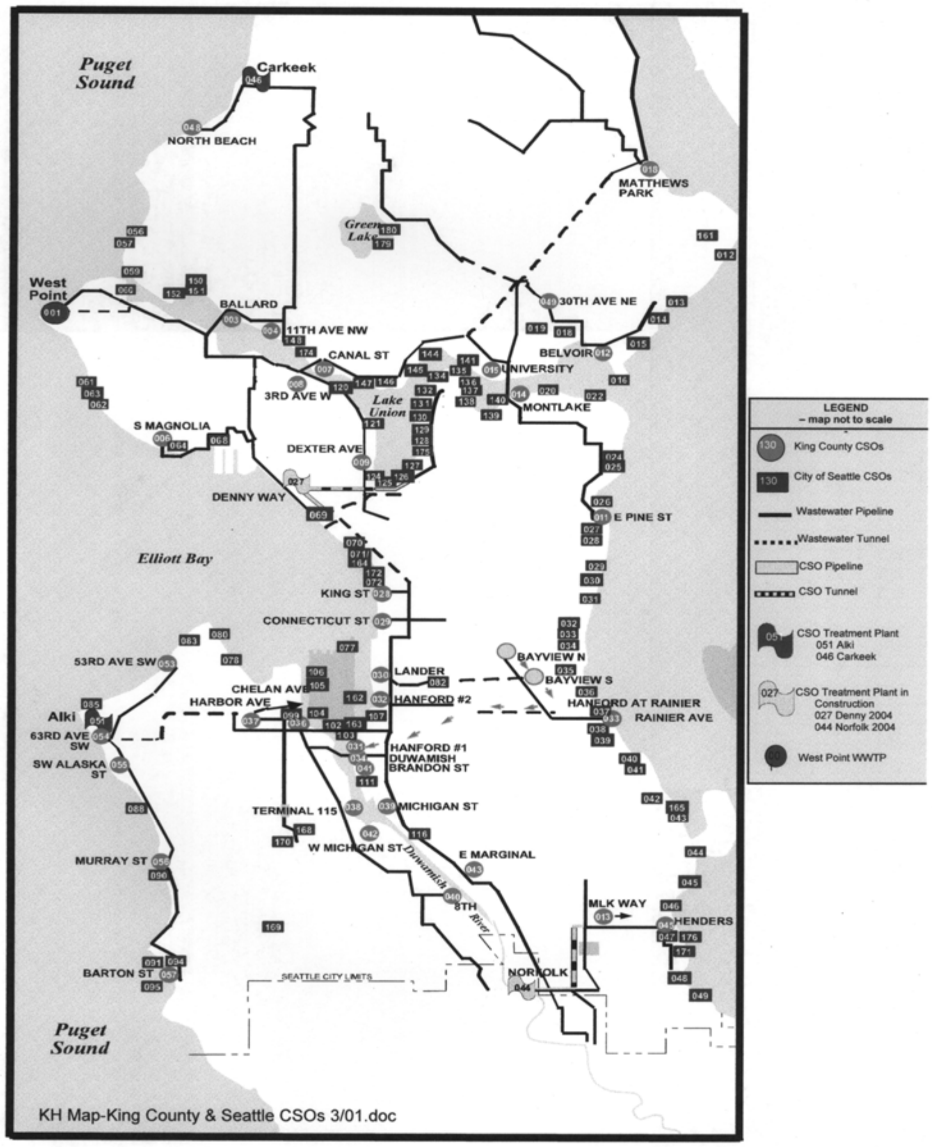

Figure 5
King County and City of Seattle Combined Sewer Overflows

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

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 usually occur between December and February during the largest, most intense storms.

Combined Sewer Overflow Activity in 2002

The goal of King County's CSO control program is to bring all CSOs into controlled status by 2030. The CSO control program, as outlined in the RWSP, is a continuation of a CSO control program started in the 1970s. The total number of CSO events (using Ecology's newer 24-hour inter-event interval definition) in 2001/2002 was 232, with total system volume of 897 MG. Of this volume, 70 MG overflowed in the West Point service area and 827 MG in the South service area. These numbers are more than a third lower than the baseline estimated in 1981 through 1983, demonstrating CSO control progress over time (Figure 6). More information about specific CSOs can be found in the *2001/02 Combined Sewer Overflow Annual Report*.

During 2002, work continued on two major CSO control projects. The Denny Way/Lake Union project will control all overflows into Lake Union and will control the County's largest CSO at Denny Way near Myrtle Edwards Park in Seattle. The Henderson/Martin Luther King/Norfolk project will control three CSOs: two CSOs into Lake Washington and one into the Duwamish River. These projects will be complete in late 2004 or early 2005.

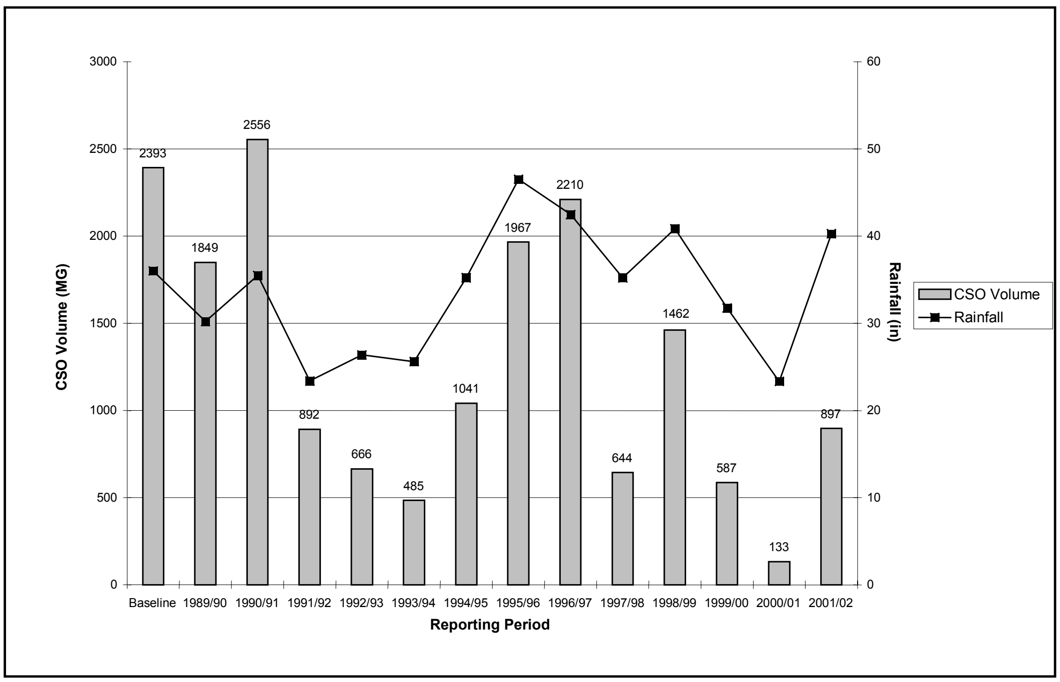

Figure 6
Combined Sewer Overflow Volumes Versus Rainfall—1989–2002

Carkeek CSO Treatment Plant

The Carkeek plant and pump 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 wastewater flows—defined by the Washington State Department of Ecology (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. Flows exceeding 8.4 mgd are stored at the Carkeek plant. Flows that exceed the storage capacity of the Carkeek plant are provided 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 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 to approximately 60 MG per year over the last five years. Because this discharge is still greater than had been planned, a study to explore the causes 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 flowmeter maximum had occurred allowing some flows to go uncounted.
- Some service area flows that had not been reaching the plant in the past were subsequently captured and brought to the plant through conveyance system improvements.
- The pump station was pumping less than its design maximum, which resulted in 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 Lake Washington Ship Canal, a new pump operating strategy has been developed that will temporarily reduce the pump rate when sensors show excess overflow is imminent along the Ship Canal. This approach is a cost-effective temporary solution until storage projects along the Ship Canal are completed under the RWSP. The approach been proposed to Ecology, as have new NPDES permit limits reflecting an updated 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 2003.

Alki CSO Treatment Plant

The Alki Treatment Plant was originally constructed to provide primary treatment to all service area flows from the Alki area in West Seattle. Similar to the approach used at the Carkeek plant, 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 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 to less than 10 MG per year on average.

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are discharges of wastewater from separated sewer systems. SSOs can flow from manholes, broken pipes, or pump stations onto city streets, into water bodies, and even as backups into basements. SSOs occur on rare occasions, typically during extreme storm events and power outages. Minimizing the discharge of untreated wastewater is fundamental to the mission of the Wastewater Treatment Division, and extensive resources have been committed to maintaining the integrity of the system and preventing SSOs. The County's Maintenance and Asset Management groups maintain a regular schedule of inspection, maintenance, and repair of facilities to prevent mechanical failures and SSOs.

Sanitary Sewer Overflow Activity in 2002

Table 1 shows that King County reported eight SSOs in 2002, which is below the annual average of 16 (based on averages over a 14-year period). One of the overflows was of primary treated and disinfected effluent, and one was of secondary treated and disinfected effluent. Three of the SSOs flowed into Puget Sound, two into Lake Washington, one into the Ship Canal, and one into Gorsuch Creek on Vashon Island. One overflow from the Cedar River Trunk was contained before reaching any water bodies. The overflows ranged in size from 500 gallons to over 2 million gallons. 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. 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.

Table 1
2002 Sanitary Sewer Overflows

Date	Location	Estimated Volume (gallons)	Duration (hours)	Discharge Type	Receiving Waters	Reason for Overflow
February 12	Carkeek Pump Station	220,000	2.75	Primary, disinfected effluent via outfall	Puget Sound	Power outage at pump station
February 23	Vashon Treatment Plant	500	0.17	Secondary, disinfected effluent	Gorsuch Creek	Chlorine contact channel construction
February 27	Fremont Siphon	250,000	84.00	Untreated wastewater	Ship Canal	Leaking gate
June 19	West Point Emergency Bypass	approx. 2 million	<96	Untreated wastewater	Puget Sound	Leak at bypass gates
November 6	South Mercer Pump Station	27,000	1.5	Untreated wastewater	Lake Washington	Power failure and dual feed line disabled
November 18	Bunker Trail Pump Station No. 2	8,800	Unknown	Untreated wastewater	Puget Sound	Main pump was airbound; backup pump failed to start
December 10	Cedar River Trunk	<30,000	48	Untreated wastewater	Ground – contained	Construction punctured the trunk
December 27	South Mercer Pump Station	125,000	1	Untreated wastewater	Lake Washington	Power outage

Planning for Future Capacity

To make sure that there is adequate time to plan, design, and build new wastewater management facilities to be ready when needed, King County must continually analyze and monitor its system. As a result of these analyses, the King County Council adopted the RWSP in 1999 to provide needed capacity through 2030. Central to the plan will be the construction of a new treatment plant—the Brightwater Treatment Plant, which will be online by 2010.

The following analyses are part of King County's ongoing planning efforts:

- Projected population growth, type, and location using Puget Sound Regional Council data
- Economic changes affecting population growth
- Trends in water use and conservation
- Estimates of the quantity of stormwater and groundwater leaking into the system via infiltration and inflow
- Actual measured flows and solids loading over time
- New wastewater sources via contracts for service or septic system hookups

This information is then modeled and compared to existing facilities to determine where and when additional capacity must be provided by new facilities. The *2003 RWSP Update Report* describes this activity in more detail.

Infiltration and Inflow

In general, the County finds that needs for additional capacity in its wastewater system are driven less by population growth and more by the intrusion of clean water through infiltration and inflow (I/I). I/I affects the hydraulic peak flow that must be managed by pipelines and plants. Measures such as water conservation have little benefit in comparison to these wet weather demands. The County is currently investigating various approaches to control I/I. However, because control alternatives are difficult to implement and have not been demonstrated to be successful, the County is not factoring reduced I/I into current planning. Should our pilot projects provide significant control of I/I, projections of needed capacity will be modified.

Water Conservation

Water conservation minimizes the loss of potable water into the wastewater stream, thus decreasing the demand for this valuable resource from fish-bearing streams and decreasing the baseflow of wastewater to the treatment plants. Water conservation projects are being implemented as a form of "demand management" under the RWSP.

Water Conservation Activities in 2002

With 2002 water conservation funding established as part of the RWSP, King County partnered with Seattle Public Utilities to conduct water audits of its major facilities. Based on the audit findings, conservation retrofit projects were prioritized, designed, and implemented. Single-pass cooling systems in the Courthouse and Administration buildings were replaced with looped systems, saving approximately 12 MG of water per year and $120,000 per year in water and wastewater costs. Restroom retrofits were also conducted at the Courthouse,

Administration, and Yesler buildings. Replacement of toilets, urinals, and faucet aerators in the buildings saved approximately 5 MG of water per year and $50,000 per year in water and wastewater costs. Total project costs were about $400,000, with Seattle Public Utilities providing over $140,000 in funding.

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 agencies to extend their service to currently unsewered areas within the regional wastewater service area. It will also require local sewer agencies to develop or update their policies to assist residents in acquiring wastewater service or require them to connect under circumstances less severe than outright system failure.

Septic Conversion Activities in 2002

The Seattle-King County Public Health Department continues to work 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.

Source Control Programs

King County operates three source control programs: Industrial Waste Program, Local Hazardous Waste Management Program, and Sediment Management Program.

The Industrial Waste and Local Hazardous Waste Management programs work to control pollutants at their source, keeping them out of the wastewater system and, in turn, out of surface waters and the environment. The two approaches complement one another, enhancing the County's ability to address pollutants from a wide variety of sources. 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 Local Hazardous Waste Management Program focuses on smaller businesses and on households in a non-regulatory manner, providing technical assistance, resources, and education under a State-mandated program. The Sediment Management Program is focused on cleaning up contaminated sediments near CSO outfalls and, in doing so, eliminating a source of pollution to the environment.

Industrial Waste Program

This section describes the Industrial Waste Program, the Lower Duwamish Waterway Source Control Project that was begun in 2002, and other activities completed through the program in 2002.

Description of the Program

The Industrial Waste Program regulates industrial wastewater discharged into the King County wastewater system. The core work of the Industrial Waste Program involves identification of conditions under which companies may discharge to the County wastewater system, and then following up with monitoring, inspections, and enforcement. The purpose of these activities is to see that industries treat wastewater before discharging it in order 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 wastewater system and its workers, and biosolids quality.

The Industrial Waste Program may regulate any industry, from largest to smallest, if the industry discharges wastewater to the wastewater system. 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 federally regulated categories. The U.S. Environmental Protection Agency (EPA) 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.

Industrial waste investigators inspect facilities before issuing discharge approvals and also inspect those with approvals to see that they are complying with regulations. Most are companies that are required to self-monitor their discharges. Industrial waste specialists take verification samples at facilities to see whether wastewater complies with regulations. When violations are found, follow-up 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.

Lower Duwamish Waterway Source Control Project

A new effort by Industrial Waste, in support of the Sediment Management Program, was initiated in 2002. The purpose of Lower Duwamish Waterway Source Control Project is to prevent, as much as possible, the recontamination of sediments in the lower Duwamish Waterway after remediation efforts are completed. The project involves inspection of wastewater and combined sewers, stormwater drainage systems, and waterfront properties in the area; enforcement of existing regulations; and identification of best management practices that businesses can use to prevent pollution. Representatives from six agencies are being trained to conduct these activities. The involvement of multiple agencies and training in a variety of different regulations will serve to reduce redundancy and costs. Each business will require only one inspection unless the inspectors find problems that need follow-up visits.

In 2002 inspections began in the Duwamish-Diagonal drainage basin, a large basin that extends east and north from the shared King County and Seattle drainage pipe at Diagonal Way. An area of sediments near this pipe is one of the early action sites to be cleaned up through the Lower Duwamish Superfund Site process. Following completion of inspections in the

Duwamish-Diagonal basin, inspectors will move to other basins draining to other early action sites where King County and Seattle Public Utilities are participating in remediation efforts.

Industrial Waste Program Activities in 2002

During 2002, the Industrial Waste Program had 138 permits and 293 discharge authorizations in effect and conducted 375 inspections.

Table 2 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 2
Number of Discharge Compliance Samples and Discharge Violations in 2002

Parameter	Compliance Monitoring	Post-Violation	Discharge Violations
Cyanide	165	0	1
Metals	501	10	14
Organics	287	1	4
BNA	35	1	0
VOA	208	1	0
Fats, Oils, and Grease (FOG)			
Total	0	0	0
Polar*	37	0	0
Non-polar	311	12	1
pH (field)**	556	5	6
Surcharge	227	0	0

*The "Polar" (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.

During 2002, Notices of Violation were issued to 21 companies for 46 violations. Several companies had multiple violations in more than one category. None of the violations caused NPDES violations at the King County treatment plants. In summary, these violations consisted of the following:

- 14 companies had 23 discharge violations.
- 8 companies had 19 permit/code violations.
- 4 companies had 4 reporting violations.

These violations resulted in the following enforcement actions:

- 11 companies were placed on compliance schedules.
- 18 companies were billed a total of $24,910 in post-violation charges.
- 5 companies were issued fines totaling $12,459.

For the Lower Duwamish Waterway Source Control Project, 2002 activities included definition of the project, negotiation of roles between six agencies, training of 30 inspectors, and inspections of the Diagonal/Duwamish drainage.

Local 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. Operated out of the County's Water and Land Resources Division, 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 oversees King County's Integrated Pest Management (IPM) Program for all County operations. Through IPM, there have been substantial reductions in total pesticide use by the County (by more than 60 percent since 2000) and proper disposal of tons of old pesticides that the County no longer needs. King County has incorporated many innovative alternative pest management approaches and is working with local cities to share experiences and resources.

These activities helped to reduce air emissions within the wastewater system caused by solvents and other hazardous air pollutants. Potentially problematic chemicals that could affect the secondary 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.

Hazardous Waste Program Activities in 2002

In 2002, the Local Hazardous Waste Management Program conducted over 3,000 onsite technical assistance visits to local businesses. The program helped local businesses reduce the generation of over 68,000 pounds of hazardous wastes and diverted over 111,000 pounds from improper disposal. These figures include significant amounts of wastewaters containing hazardous chemicals, including mercury in wastes from dental offices; silver in wastes from photo processors; and solvents, oils, and corrosive chemicals.

More than 8,100 school children were taught about hazardous chemical safety, reduction in use, safer alternatives, and connections to family health and environmental protection. Up to 1,600 additional students were taught about household hazardous waste through the 65 teachers that attended workshops and received training in the topic. Science labs in 297 local middle and high schools were assisted (over a two-year project) in safely disposing of more than 35 tons of hazardous chemicals, including many explosive or toxic substances and many chemicals that would have been discharged to the wastewater system.

Sediment Management Program

To address the potential for contaminated subaquatic sediments to pollute the environment and harm aquatic species, King County developed the *Sediment Management Plan* (SMP) in 1999 as directed in the RWSP. The plan identified and evaluated programmatic long-range remediation alternatives for consideration at seven sites near King County CSO outfalls. These

seven sites represent Ecology's currently designated contaminated sediment sites in Puget Sound and the Duwamish River for which the County has some responsibility. These sites are near the following King County CSO outfall sites: Hanford Street, Lander Street, Duwamish Siphon, Brandon Street, King Street, Denny Way, and Chelan Avenue.

Ecology is granted legal authority under Washington Administrative Code (WAC) 173-204, Sediment Management Standards, to direct the identification, screening, ranking, prioritization, and cleanup 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 cleanup. WAC 173-204 provides for the voluntary cleanup of contaminated sediments with oversight and guidance by Ecology. Alternatively, Ecology or EPA may initiate enforcement actions (including cost recovery) 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 cleanup of these seven identified sites, using the voluntary approach whenever possible and participating in State or Federal cleanup processes that have already begun. The County agreed with the City of Seattle, the Port of Seattle, and Boeing to undertake the first steps in the cleanup of the Lower Duwamish Waterway (LDW)—sharing the cost of developing the Remedial Investigation and Feasibility Study (RI/FS). The RI/FS is being done under an Administrative Order of Consent signed by the four parties, by EPA, and by Ecology.

Two of the seven sediment cleanup sites are in the East Waterway at the mouth of the Duwamish River. EPA has expanded an existing Superfund site along the east shoreline of Harbor Island to cover the entire East Waterway. This expansion has slowed the dredging efforts by the Port of Seattle under its East Waterway Harbor Improvement Project. Further, inclusion under Superfund of the two County sediment cleanup sites has delayed cleanup at the sites by at least two years. The Superfund cleanup requirements for the East waterway could also result in changes in the priority and schedule of CSO control projects if other pollutant source control measures are not adequate.

Sediment Management Program Activities in 2002

Accomplishments in 2002 under the Sediment Management Program are as follows:

- Delivered the final draft of the Phase I remedial investigation (RI) report to EPA and Ecology on the LDW, including proposal of candidate sites for early action cleanups and initiation of negotiations to conduct two cleanup actions
- Completed the initial phase of developing a near-field discharge model for CSOs identified in the SMP as necessary to gain state approval of proposed cleanup actions
- Conducted the second year of a Memorandum of Agreement with the Washington State Department of Natural Resources to develop a process for cleanup decisions on State-owned aquatic lands and a general plan of operations for cleanup site leases that will streamline all future leases
- Received the Cleanup Action Decision from Ecology authorizing the Elliot Bay/Duwamish Restoration Panel cleanup of the Duwamish/Diagonal CSO—one of the contaminated sediment sites on the State list and within the LDW Superfund site;

completed public and environmental review and 60 percent design for the action scheduled to start in winter 2003

- Initiated innovative one-stop source control help for local businesses in the LDW Superfund site by combining industrial waste, local hazardous waste, stormwater, and health department site inspection programs into one site inspection and technical assistance program (see the "Industrial Waste Program" section above)

Resource Recovery Programs

King County has long recognized that the liquids and solids leaving the wastewater treatment process are not "wastes" for disposal, but are useful resources that can be recycled to benefit the environment or replace other high-demand resources. The County currently recycles three of these resources as useful products: biosolids, methane (digester gas), and reclaimed water.

Biosolids

On average, King County produces approximately 128,000 wet tons of biosolids each year—all of which is recycled for use in forestry, compost, and agricultural applications. There are two ongoing efforts in King County's management of biosolids: the recycling program and new technology assessment. The recycling program continues to produce Class B biosolids at all treatment plants by anaerobic digestion. Class B processing relies on application of the biosolids to a controlled-access site, such as a forest or agricultural field, to complete the pathogen reduction process. The assessment of new technologies is discussed below under "Biosolids Activities in 2002."

Biosolids Activities in 2002

To ensure the appropriate use of biosolids, King County continued to monitor water quality of streams near biosolids application sites in 2002 and, as with previous years, found little effect to receiving waters from biosolids.

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 2002. Two of these technologies were selected for possible further evaluation:

- **Vertad®** uses a 400-foot-deep vertical shaft and air injection to create high pressure, aerobic conditions suitable for thermophilic aerobic digestion. A potential second phase of testing would 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. Class A biosolids have no detectable pathogens and can be used without access limitations.

In 2003, King County will initiate a project to evaluate the best technologies and implementation strategies for production of Class A biosolids at the South and West Point Treatment Plants. The project will result in a detailed implementation plan to support decision-making processes regarding the possible conversion to Class A biosolids production.

Methane (Digester Gas)

A byproduct of biosolids production is methane (digester gas). Both the West Point and South plants recover this gas, but each uses it differently. The South Plant sells the gas to Puget Sound Energy for distribution in its natural gas system; West Point uses the gas to fuel generators that produce electricity. This electricity is used to power plant operations; any excess electricity is sold to Seattle City Light.

Methane Recovery Activities in 2002

Production and use of methane continued at both plants in 2002. In addition, investigation of new uses and technologies progressed. As an outcome of that investigation, two new uses for methane will be implemented at the South plant. The first is a digester gas-fired boiler, which will provide heat for some plant facilities and operating processes. The second is a fuel cell demonstration, which will use 20 percent of the plant's gas production and will produce 1 MW of electricity. Construction of both projects should be complete by the end of 2003.

Reclaimed Water

King County began producing reclaimed water at its West Point and South Treatment Plants in the early 1990s. This water is used in plant operations and irrigation. To focus the County's efforts to reclaim more water, a five-year *Water Reuse Work Plan* was transmitted to Council in December 2000. The plan recommended two primary implementation efforts: a technology demonstration project and a satellite treatment facility.

To identify the best alternative for the satellite treatment plant, an extensive public involvement process was conducted. 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, 11 nominations representing 13 projects were received. 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 1 and 3 mgd of water for irrigation, ranked favorably on all the criteria and therefore received the highest overall ranking.

Reclaimed Water Activities in 2002

The demonstration project began operation in 2001; testing was completed in 2002. The project—located at the West Point Treatment Plant—evaluated the effectiveness, operability, and cost of seven wastewater treatment technologies.

The goal was to identify technologies that could do the following:

- Reduce the costs and potential impacts of producing highest quality (Class A) reclaimed water at small upstream satellite plants for commercial and irrigation uses
- Minimize the size of a satellite treatment plant
- Cost-effectively remove additional nutrients, pathogens, organics, and other contaminants from wastewater so as to make it suitable for discharge to fresh water to supplement surface water supplies

Several treatment technologies were combined into small-scale operational process systems to assess their ability to meet process objectives and potentially to eliminate the need for primary treatment, secondary clarification, and tertiary filtration.

After completion of the demonstration project, predesign of the Sammamish Valley Reclaimed Water Production Facility began in March 2002. The facility should be operational in August 2004.

Chapter 3
Monitoring 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. The quality of our waters has improved dramatically over the years as the result of the development of a regional wastewater collection and treatment system and our cooperative efforts to implement pollution control programs. The County's goal is to ensure that our actions are not degrading the beneficial uses of our valuable water resources. Understanding the health of our waters is the starting place for achieving this goal.

This section describes how the County measures the health of water bodies in its wastewater service area using chemical, physical, and biological indicators. It also describes how the County monitors these indicators in order to identify changes in water quality that warrant intervention and then take the necessary steps to restore and maintain the quality of county waters. Some of the monitoring programs are ongoing; some are special short-term studies.

Washington State Water Quality Standards

The primary objective of the federal Clean Water Act (CWA) is to restore and maintain the integrity of the nation's waters. This objective translates into two national goals: to eliminate the discharge of pollutants into the nation's waters and 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 distinct and identifiable sources, called point sources, such as King County's wastewater treatment plants and municipal stormwater systems. 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) put into regulation a classification-based system in which each water body is assigned to one of eight classes: four freshwater classes (Class AA, Class A, Class B, Lake Class) and four marine classes (Class AA, Class A, Class B, and Class C). Class AA is for the highest quality waters that are 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 physical, chemical, and biological Water Quality Standards supporting those uses. The standards are set at levels designed to protect all the listed beneficial uses associated with the class. Under the authority of Water Quality Standards regulations, a higher class of protection requires pollutants to be more strictly limited and can result in restriction of activities that could reduce water quality. Table 3 shows the Washington State classification system and corresponding standards.

Table 3
Washington State Classification System and Corresponding Standards for Water Bodies

Parameter	Unit	Class AA		Class A		Class B		Class C	Lake Class
		Fresh	Marine	Fresh	Marine	Fresh	Marine	Marine	Freshwater
Fecal coliform	Colonies /100 mL	Geomean ≤50; ≤10% >100	Geomean ≤14; ≤10% >43	Geomean ≤100; ≤10% >200	Geomean ≤14; ≤10% >43	Geomean ≤200; ≤10% >400	Geoman ≤100; ≤10% >200	Geomean ≤200; ≤10% >400	Geomean ≤50; ≤10% >100
Dissolved oxygen	mg/L	>9.5	>7	>8	>6	>6.5	>5	>4	No measurable decrease from natural conditions
Temperature	°C	≤16	≤13	≤18	≤16	≤21	≤19	≤22	No measurable change from natural conditions
PH	Standard units	6.5–8.5	7.0–8.5	6.5–8.5	7.0–8.5	6.5–8.5	7.0–8.5	6.5–9.0	No measurable change from natural conditions
Turbidity	NTU	≤5 over background turbidity when background turbidity is ≤50; ≤10% increase when background turbidity is >50				≤10 over background turbidity when background turbidity is ≤50; ≤20% increase when background turbidity is >50			≤5 over background conditions

When waters do not meet standards, they must be listed per the requirements of section 303(d) of the Clean Water Act, which is published every 3 to 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 the standards. This process is called a Total Maximum Daily Load (TMDL). TMDLs are described in more detail in Chapter 5 of this report.

The biological, chemical, and physical parameters used to assess a water body's health under the State's classification system are fecal coliform bacteria, dissolved oxygen, temperature, pH, and turbidity. Each parameter, or indicator of health, is described below. In December 2002, Ecology proposed several changes to the current use/class-based system and to several water quality criteria. Ecology will make final decisions in 2003 after completion of the public review process.

Fecal Coliform Bacteria

Fecal coliform bacteria live in the intestines of warm-blooded animals including humans, wildlife, and pets, and are used as an indicator of human fecal pollution. Most fecal coliform bacteria do not cause disease, but they may coexist with bacteria and viruses that may pose a public health risk. Because we cannot easily distinguish if the feces came from humans or from other warm-blooded animals, the usefulness of fecal coliform bacteria as an indicator is limited. As a result, the State standard for fecal coliform bacteria is currently under review and may be replaced by standards for Enterococcus in marine waters and *E. coli* in fresh waters.

Dissolved Oxygen

Aquatic (water-based) 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 DO are generally considered healthy ecosystems. DO averages are most important during the summer season when oxygen-depleting processes are at their peak. The DO levels at sites meeting the Class AA and Class A criteria are better than required by fish of the salmon family (salmonids). Salmon receive special consideration because they are an important cultural, recreational, and economic resource for the Northwest and are recognized as being in danger of extinction.

Temperature

Temperature is an important physical parameter for aquatic systems because it influences many of the chemical components of the water (e.g., DO concentration). Temperature also exerts a direct influence on the biological activity and growth and therefore ultimately the survival of aquatic organisms. Waters that meet Class AA and Class A criteria are at temperatures generally suitable for salmonids.

pH

The pH of water is a measure of the concentration of hydrogen ions. A pH value higher than 7 (meaning there are fewer free hydrogen ions) is considered alkaline or basic, a value of 7 is

considered neutral, and a value of less than 7 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. The state standard specifies a pH value of between 6.5 and 8.5 for Class AA and Class A waters.

Turbidity

Turbidity refers to the amount of suspended material in water. It is measured by 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. In general, higher turbidity results from human activities within the watershed (e.g., land development and construction causing loss of vegetation, increased runoff, and increased erosion). The effects of high turbidity can include diminished light penetration for plant growth and DO production, sedimentation of gravel beds used by spawning fish, and waters that are too “dirty” to enjoy.

Usually turbidity is used to evaluate the impact of a pollutant source. Two measurements are made to measure the change in turbidity from a source: one upstream of a discharge point (background levels) and another downstream. Because King County often monitors waters where there is no identifiable pollutant source the County measures only one point in a stream and then compares it to the average of all measurements for that site. Values exceeding the average by 5 NTU or more are considered substandard.

Other Water Quality Standards

Other water quality standards have been set for special uses, including chemical-specific standards for the protection of aquatic species and human health. These standards may be developed for the water or for the subaquatic sediments.

Aquatic Health Standards

Standards to protect aquatic organisms have been developed that define acceptable levels for individual chemicals. Acute standards protect aquatic organisms from immediate and severe impacts such as death or poisoning, while chronic standards protect against sub-lethal effects such as reduced growth or reproduction.

Human Health Standards

Chemical-specific standards for water or sediment are designed to prevent harm to humans as they are transmitted to humans through the food chain.

Nutrient Standards

Ammonia is the only nutrient that has a numeric water quality criterion. The Washington State ammonia standard is based on un-ionized ammonia. However, for total ammonia, as is measured by King County, the State uses the U.S. Environmental Protection Agency's (EPA's) criteria concentrations. These total ammonia criteria are based on temperature, salinity, and pH of the water. Ammonia tends to have a seasonal cycle, as do other nutrients. Higher concentrations typically occur in summer and fall and at deeper depths, corresponding to decay of organic nitrogen from phytoplankton.

Sediment Quality Standards

In the early 1990s, Washington State became the first state to implement Sediment Quality Standards for marine waters, providing a new tool to assess the cumulative impacts of chemicals on the environment. The "standard" includes chemical-specific criteria that designate what is considered healthy sediment quality, the sediment quality standard (SQS), as well as a threshold for considering sediment remediations called the Cleanup Screening Level (CSL). When these chemical criteria are exceeded, the adverse impact is verified using toxicity testing.

Non-Regulatory Water Quality Measures

Other measures have been developed over time based on the experience of water quality professionals. While these may not have the rigor of regulatory standards, they are time-honored methods to quickly assess water quality and to provide comparisons that guide the development of water quality protection efforts. Three measures are discussed in this section: the Trophic State Index, the Water Quality Index, and chlorophyll-*a* (a measure for phytoplankton blooms).

Trophic State Index

A common way to characterize the health of lakes is by the numerical Trophic State Index (TSI). With the TSI, lakes can be rated and compared according to the level of biological activity (e.g., level of nutrients, algal growth, and so forth). This index provides a standard measure to compare lake quality on a scale of 0 to 100. Each major division (10, 20, 30, and so forth) represents a doubling of algal biomass and is related to nutrients and transparency (water clarity). The summer mean values of the three most common lake parameters—Secchi depth transparency, total phosphorus, and chlorophyll-*a* concentrations—are used to develop the TSI. Average characterizations for the three TSI values—oligotrophic, mesotrophic, and eutrophic—are shown in Table 4.

Table 4
Average Summer (June-September) Trophic State Index Values

TSI Value	Classification	Characterization
< 40	Oligotrophic	Low biological productivity resulting in high water clarity, low algal levels. and low phosphorus concentrations
40–50	Mesotrophic	Moderate levels of plant and animal activity, resulting in moderate water clarity, moderate, 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 a water's clarity or transparency as measured by viewing 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 is affected by algae, soil particles, and other materials suspended in the water. The Secchi depth will decrease as these factors increase. In King County, clarity tends to be very low during periods of high algal growth (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. An excessive amount of nutrients, however, can increase the growth of aquatic plants, which subsequently decay and deplete oxygen to levels incapable of sustaining aquatic organisms. Phosphorus is the primary nutrient of concern in freshwater systems because, if present in excess amounts, it can cause nuisance algal blooms or, rarely, toxic algal blooms. Phosphorus enters water bodies via discharge of detergents, runoff containing fertilizers, or seepage from failing septic systems. Sediment can also be a source of phosphorus, releasing it into the water column when DO concentrations fall below 0.2 mg/L.

Chlorophyll

Chlorophyll is the green pigment in plants that allows them to create energy from light (photosynthesis). Chlorophyll serves as an indirect measure of the amount of 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.

Water Quality Index

The Draft Water Quality Index (WQI) was established by Ecology in 2002[3] as a means to rank the conditions of streams. The WQI integrates a series of key water quality parameters into a single number that can be used for comparison over time and between locations. King County has modified the WQI slightly to achieve a better representation of its rivers and streams.

[3] Hallock, D. 2002. *Washington's Water Quality Index.* Draft report prepared for the Washington State Department of Ecology.

The WQI is a unit-less number ranging from 10 to 100; a higher number indicates better water quality. For temperature, pH, fecal coliform bacteria, and DO, the index expresses results relative to levels required to maintain beneficial uses (based on State standards). There are no State standards for nutrient and sediment measures. Instead, they are expressed relative to expected conditions in a given ecoregion. Multiple constituents are combined and results aggregated over time to produce a single score for each sampling station. In general, stations with scores of 80 and above meet expectations for water quality and are of "low concern," stations with scores of 49 to 80 indicate "moderate concern," and stations with scores below 40 do not meet expectations and are of "high concern."

Chlorophyll-*a* (Phytoplankton Blooms)

In marine waters, chlorophyll-*a* concentration is used independently as the best available indicator of phytoplankton biomass because all marine planktonic algae contain this photosynthetic pigment. Although not an exact measurement, high chlorophyll-*a* concentrations are useful for evaluating the presence and frequency of phytoplankton blooms in the marine environment. An increased frequency of phytoplankton blooms on a yearly basis serves an indicator of possible nutrient excess and potential water quality problems.

Ongoing Monitoring Programs

Ensuring the health of county water bodies, and so the health of the people using them, is the purpose of King County's water quality efforts. The County's extensive water monitoring programs provide the high quality data from which decisions can be made to direct these efforts.

Monitoring programs are also designed to protect the significant investment in water quality improvements made by the people of King County. Though nearly all wastewater is now either treated with an onsite septic system or sent to treatment plants, water quality monitoring is still an important tool to help ensure continued wastewater system integrity and to identify any threats to the gains we have already made to improve water quality. King County regularly assesses the impact of its own operations by measuring the quality of the effluent from each of its wastewater treatment facilities, the surrounding water, and nearby beaches to ensure the facility is meeting regulatory requirements. A summary of the monitoring programs is shown in Table 5; a map of monitoring locations, also known as stations, is included as Figure 7. The table and map also include information on special studies, described later in this chapter.

King County's laboratory system supports the monitoring programs. The system includes two process laboratories—one at each treatment plant (South and West Point)—and an 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.

Additional information and data are available on the County's Web sites listed in Appendix B.

Ambient Monitoring

Ambient refers to the general condition of a water body, without singling out specific pollutant sources. Ambient sampling and flow monitoring stations are located in lakes and streams and in the Puget Sound to monitor the long-term environmental quality of these waters.

The objectives of ambient monitoring programs are as follows:

- Assess existing conditions for water bodies, determine if Washington State Water Quality Standards are met, and track progress in correction of 303(d) listed parameters
- Determine long-term water quality trends in the Lake Washington basin
- Identify successes and needs in water quality protection efforts
- Monitor the integrity of the wastewater conveyance system and track water quality parameters of interest to the Wastewater Treatment Division (WTD)
- Provide information on historical and existing conditions in support of special projects such as the WTD Habitat Conservation Plan and WRIA 08 salmon conservation planning efforts

Freshwater Ambient Monitoring

Freshwater ambient monitoring programs run by King County include the Major Lakes, Swimming Beach, and Stream Monitoring Programs.

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 inflowing 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.

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. Beginning in 1987, storm-influenced samples have been collected to increase our understanding of wet weather impacts on local water quality.

Every summer since 1996, swimming beaches on Lake Sammamish, Lake Washington, and Green Lake have been 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.

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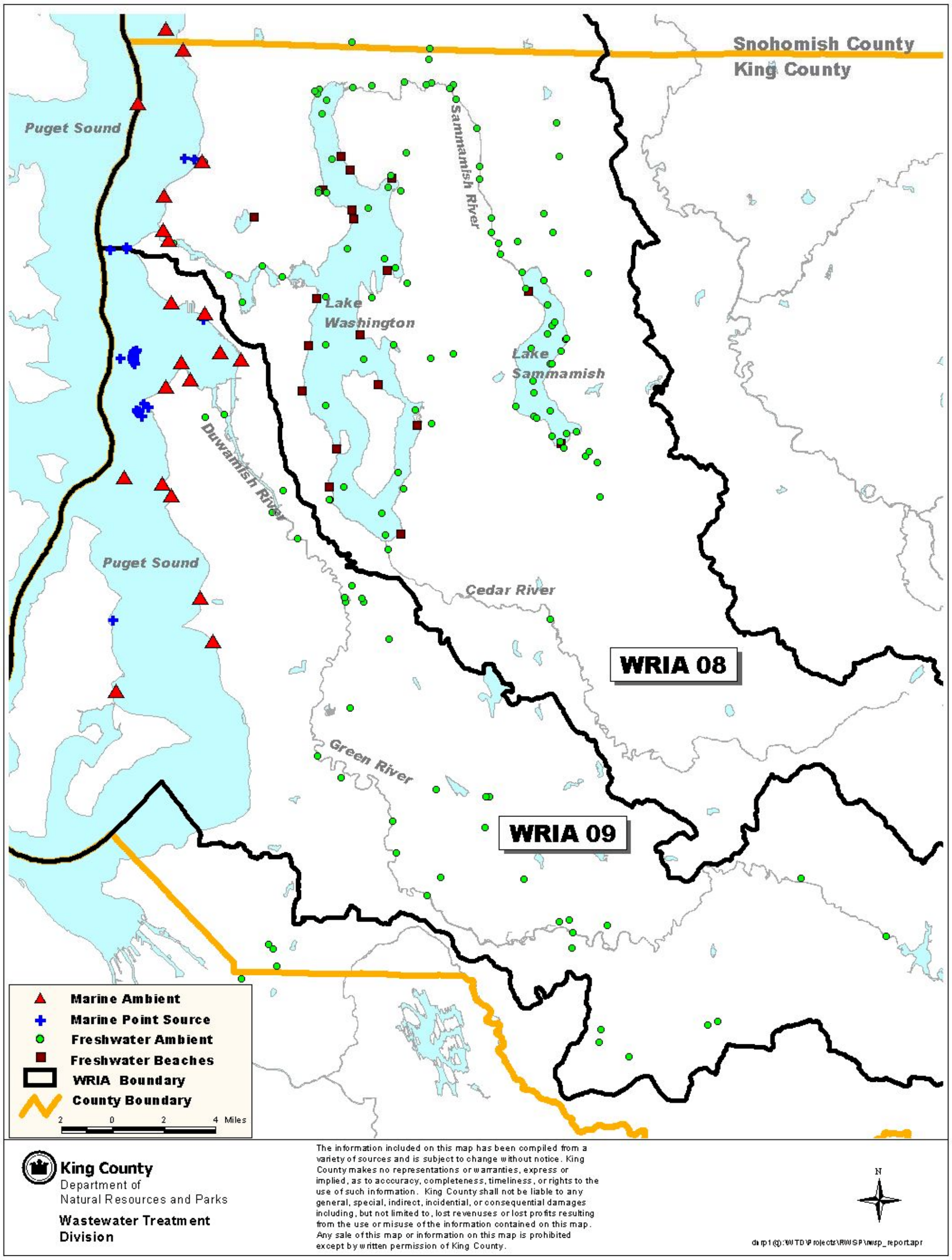

Figure 7
King County Monitoring Stations

Marine Ambient Monitoring

Marine ambient monitoring is conducted in areas free from the influence of point source discharges to provide valuable background and comparison data. The program includes water and sediment monitoring as well as shellfish and macroalgae monitoring at beaches. Water column monitoring is an important component of the marine monitoring program and is structured to detect natural seasonal variations in the water column and to identify changes influenced by human activities. Temperature and salinity influence the amount of water column stratification, which in turn can influence the amount of pollutants trapped within the water column. Sediment monitoring is included in the marine monitoring program because many pollutants tend to settle onto bottom sediments. At sufficient concentrations, these pollutants may be harmful to organisms that live in or on the sediments (benthic organisms) and may then also accumulate up through the food chain.

Benthic Macroinvertebrate Monitoring

One of the ways to assess the health of a water body is to compare the resident plants and animals to those in a similar water body that is known to be healthy. If the plants and animals are the same types and proportions and of similar number and density, it can be inferred that the studied water body is also healthy. The primary purpose of Benthic Macroinvertebrate Monitoring Program is to characterize the size and distribution of aquatic sediment-dwelling macroinvertebrate (insect) populations in King County watersheds. These data collected over time in the ambient monitoring programs will be used to detect any long-term population trends. Additional intense monitoring will attempt to determine the health of macroinvertebrates in wade-able stream sub-basins within the Cedar-Sammamish watershed (WRIA 08) and the Green-Duwamish watershed (WRIA 09) (See "Special Studies" later in this chapter.).

Benthic macroinvertebrates have been monitored under two distinct programs within the County's Water and Land Resources Division (WLRD). The wastewater related benthic monitoring program was initiated in the mid-1970s. The primary objective was to monitor streams potentially impacted by wastewater, treated effluent, and the system of pipes and pumps that make up the collection and transfer system. This program was part of the ambient water quality monitoring program that includes lakes and mainstem rivers. In the early to mid 1990s a second macroinvertebrate monitoring program began to provide data to evaluate the success of recent basin planning efforts and, when possible, to make specific recommendations for improved watershed management. These two programs were designed to address different, but closely related and complementary water quality issues. These programs are now combined within WLRD as part of a larger effort to consolidate the County's freshwater monitoring programs.

The objectives of the Freshwater Streams Benthic Macroinvertebrate Monitoring Program are as follows:

- Determine existing aquatic macroinvertebrate conditions of wade-able stream sub-basins located within WRIA 08 and WRIA 09
- Identify differences in macroinvertebrate communities in the WRIA 08 and WRIA 09 watershed sub-basins

- Collect data that can be used as a baseline tool for detecting long-term trends in benthic macroinvertebrate communities

Marine Point Source Monitoring

For over 30 years, an extensive point source monitoring program has been in effect to assess water quality around the marine outfalls for the County's wastewater treatment facilities.

Point source monitoring is now focused around the County's three secondary wastewater treatment plants, two combined sewer overflow (CSO) treatment plants, and the Denny Way CSO (the County's largest CSO). The program consists of water column and sediment monitoring, as well as shellfish and algae monitoring at beaches near the outfalls.

Point source monitoring backs up other precautions taken to assure that plant operations are not adversely impacting water quality. For example, prior to discharge, effluents are disinfected, continuously monitored for chlorine residual levels, and then analyzed for bacteria at regular intervals as verification that the treatment process is effective.

Sediment monitoring at the outfalls is required by the County's NPDES permits. Ecology and the County are working to reach agreement on a scope of work for sampling design for the next phase of sediment monitoring activities. This will be finalized in the renewed West Point NPDES permit.

Beach (intertidal) areas that are in the vicinity of the treatment facility outfalls are also monitored for a variety of parameters to assess whether discharges may be affecting beach areas. Shellfish (butter clams) and macroalgae samples are collected as part of the beach assessment.

Special Studies

When ambient monitoring suggests the early stages of degrading water quality or when decisions must be made based on scientific information, King County initiates special studies to understand the situation and to project outcomes of different actions. The information from the ongoing monitoring programs often must be supplemented with information from more intense and focused sampling and greater analytical precision. These special studies are usually intensive in scope, but limited in time. Currently, there are three major projects —the Green-Duwamish Water Quality Assessment (G-DWQA), the Sammamish-Washington Analysis and Modeling Project (SWAMP), and the Marine Outfall Siting Study (MOSS)—and several smaller projects under way. A summary of these studies is shown in Table 5; a map of sampling locations is included as Figure 7. The table and map also provide information on ongoing monitoring programs, described earlier in this chapter. The details of these complex projects can be found at the County Web sites listed in Appendix B.

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. It will provide water quality information to a variety of clients internal and external to King County DNRP by collecting water quality information, developing a watershed model, and using the model to explore resource management options. The project will also assist wastewater capital planning (including the CSO program and the Habitat Conservation Plan). Specifically, the project will accomplish the following:

- Assess existing and projected water quality conditions for selected parameters, and assess the efficacy of best management practices for achieving Washington State Water Quality Standards in the Green-Duwamish watershed
- Coordinate with Ecology in order to provide technical information for Ecology's TMDL development for stakeholders of the watershed to use to achieve the most cost effective improvement in water quality in the watershed
- Assess parameters of interest for the King County WTD
- Provide information to support the WTD's Habitat Conservation Plan (HCP) and WRIA 09 salmon conservation planning efforts, including information on water quality as a factor of decline for salmonids

The G-DWQA 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. It is scheduled to be complete in 2006.

The two main components of the G-DWQA—storm impact water quality monitoring and temperature and DO studies—are described in the following sections.

Storm Impact Water Quality Monitoring

An intensive monitoring program was developed for the G-DWQA to achieve the following objectives:

- Measure instream water quality parameter concentrations in different geographic areas of the watershed throughout the year, including mouths of major tributaries and boundary conditions of the Green River mainstem
- Measure instream water quality parameter concentrations resulting from different land use/land cover types within the stream drainage area
- Measure in-stream water quality parameter concentrations as a function of the rise, peak, and fall of the corresponding stream hydrograph to determine peak concentrations and variability within a storm-influenced flow
- Collect sufficient data to allow development and calibration of water quality models for the Green River watershed

The program was initiated in 2001 and is scheduled to continue until September 2003. Both storm-influenced and baseflow samples are being collected from 17 stations distributed

throughout the Green-Duwamish watershed. Some of these stations overlap with the ambient stations monitored in the past in order to provide historical continuity.

Temperature and Dissolved Oxygen Studies

To supplement the information collected in the freshwater ambient monitoring programs, an intense temperature and DO sampling program is being implemented under the G-DWQA. Both programs use continuously recording data loggers to characterize the daily fluctuations in temperature and DO.

Salmonid Habitat and Inventory Assessments

Stream salmonid habitat assessments were implemented by King County in 1999 to quantify the instream, riparian, and watershed conditions that contribute to high quality aquatic habitat. Stream habitat evaluation is a core element of several recently implemented regional programs. The information gathered in the assessments is used to assist in the identification of areas that require stream habitat restoration and preservation for the WRIA planning process, the Sammamish River Ecosystem Restoration Study, and other land use planning and Sensitive Area regulation. These assessments will also provide information for the HCP that is supporting siting of the new Brightwater wastewater treatment system.

The Sammamish-Washington Analysis and Modeling Project

The Sammamish-Washington Analysis and Modeling Project (SWAMP) is a coordinated water quantity and quality monitoring and modeling project that will support future water resource decisions for King County's fresh waters in the Cedar-Sammamish watershed. The overall objectives of SWAMP are as follows:

- Identify risks to aquatic life (including threatened and endangered species), wildlife, and people under existing conditions.
- Project future water body conditions and risks to aquatic life, wildlife, and people under a variety of future land use scenarios or built-out conditions under the Growth Management Act
- Provide support to resource management programs including:
  - — Salmon conservation and recovery efforts in the watershed
  - — Planning for use of reclaimed water in the watershed
  - — Ecology's Total Maximum Daily Load (TMDL) program
  - — WTD's HCP
- Provide an organized database and integrated modeling framework to address water resource issues in the watershed

The major component of this project is development of a computer model for Lake Washington, Lake Sammamish, and Lake Union and their inflowing rivers and streams. Coupled with these models will be a broader watershed model that simulates streamflow and

water quality based on historical, current, and future land use scenarios in King County watersheds. SWAMP is directly linked and coordinated with current King County water resource monitoring efforts. This project is expected to be completed in 2005.

Three components of SWAMP—the sediment study, remote underwater sampling station, and Small Streams Toxicity/Pesticide Study—are described in the following sections.

Sediment Study

As part of SWAMP, King County DNRP completed a comprehensive sediment sampling study for Lakes Sammamish, 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.

Remote Underwater Sampling Station™

In July 2000 as part of SWAMP, King County installed five robotic buoys to collect water quality data from Lake Washington and Lake Sammamish. The buoys collect water samples automatically, 24 hours a day, 365 days a year. Data are transmitted daily to King County. The data from the buoys will contribute to the development of the models discussed above.

Small Streams Toxicity/Pesticide Study

The Small Streams Toxicity/Pesticide Study is being done under SWAMP and is intended to assess the presence and biological implications of pesticides in selected small streams in the watershed. This four-year study was begun as a follow-up to recent studies that detected pesticides in regional stormwater runoff and surface waters.[4] These studies indicated that small urban and suburban streams can contain high concentrations of a wide variety of pesticides during storm runoff periods. This finding led to the hypothesis that chemicals applied to lawns and landscapes are making their way into the aquatic environment through nonpoint runoff. Many of the pesticides present in these streams do not have Water Quality Standards or guidelines, leaving a gap in our understanding of the ecological consequences of these pesticides to aquatic life in these streams. This study will fill some of that gap.

Wastewater Capital Project Monitoring

Monitoring is done in support of capital project siting and construction. Usually the monitoring involves pre-construction baseline characterization followed by post-construction monitoring to identify project effectiveness and continued integrity.

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[4] Davis, D. Washington State Pesticide Monitoring Program reports: Publications 93-e09 (1993), 96-305 (1996), 98-305 (1998), 00-03-003 (2000).

Voss, F., and Embry, S. 2000. *Pesticides detected in urban streams during rainstorms in King and Snohomish Counties, Washington, 1998.* USGS Water Resources Investigations Report 00-4098.

Voss, F., Embry, S., Ebbert, J., Davis, D., Frahm, A., and Perry, G. 1999. *Pesticides detected in urban streams during rainstorms and relations to retail sales of pesticides in King County, Washington.* USGS Fact Sheet 097-99.

Marine Outfall Siting Study

The Marine Outfall Siting Study (MOSS) monitoring program began in October 1998 to assist with siting and design of a marine outfall for the new Brightwater Treatment Plant. The sampling program includes the following major study components: oceanography, submarine geophysics, water column sampling, beach water quality sampling, sediment sampling, and biological surveys.

Oceanographic studies were performed to provide data for modeling efforts. King County will undertake modeling on three scales to support siting the new outfall: a "nearfield" model of plume behavior; a "mesoscale" model on a 1- to 20-km scale; and a "farfield" model on a Puget Sound-wide scale. The oceanographic studies included release of current meters, drift cards, drogues (underwater "sails" affixed to surface floats), and dye studies at several locations in Puget Sound for a period of 12 months. These data on currents in the Puget Sound will be used to predict effluent transport from candidate outfall sites.

Geophysical surveys were conducted to provide detailed characterization of the physical features of the seafloor and subsurface geology. Precision single- and multi-beam echosounding, side-scan sonar, subbottom profiling, and high-resolution and deep-penetration seismic reflection profiling were used.

Between 1999 and 2002, intensive offshore water column and beach water quality sampling was conducted at several locations to evaluate physical, chemical, and bacterial characteristics of Puget Sound receiving water. Sediment samples were collected the end of 2001 from various locations within the candidate outfall areas to assess sediment characteristics and any potential contaminant issues in the area. The data will be also be used to establish a sediment quality baseline against which data from post-discharge monitoring can be compared.

Between 1999 and 2002, nearshore habitat and resources were assessed in order to provide accurate maps of benthic habitats and biological resources, including submerged aquatic vegetation (eelgrass and kelp), fish, and macroinvertebrates. In addition, a survey for geoduck distribution and abundance was conducted in early 2002 to help fill the information gap for this resource in the study area.

Denny Way/Lake Union CSO Control Project: Pre-Construction Sediment Characterization Study

The Denny Way/Lake Union CSO Control Project is a joint effort between King County's WTD and Seattle Public Utilities to control City and County CSO discharges into Lake Union and the Denny Way CSO into Elliott Bay.

The project Biological Opinion, resulting from a NOAA Fisheries Section 7 consultation under the Endangered Species Act, required King County to develop a plan to monitor the benthic community surrounding the CSO outfalls. The primary goal is to determine whether implementation of the Denny Way/Lake Union CSO Control Project and future operation of the facility may cause an impact to the benthic communities in the marine environment surrounding the CSO outfalls. Baseline monitoring was completed in 2001, and results are presented in Chapter 4 of this report.

Norfolk CSO Sediment Post-Remediation Monitoring

Sediment remediation at the Norfolk CSO site was undertaken in response to a 1991 Consent Decree, which defined the terms of a natural resources damage agreement between King County and the City of Seattle and federal, state, and tribal natural resources trustees. The Norfolk CSO site was chosen by the oversight group—the Elliott Bay/Duwamish Restoration Program Panel—as one of four sites prioritized for potential sediment remediation.

Chemicals of concern at the site included mercury, 1,4-dichlorobenzene, bis (2-ethylhexyl) phthalate, and PCBs, all present at concentrations exceeding CSL chemical criteria. PCB "hot spot" concentrations at the site also exceeded Toxic Substances Control Act limits for hazardous waste disposal.

Site remediation was completed in late March 1999. Remedial activities consisted of dredging and disposal of contaminated sediment and backfilling the dredged area to original grade with clean sediment from the Duwamish River Turning Basin. Contaminated sediments were removed from the site by mechanical dredge and dewatered on shore in a containment area.

Under the site hydraulic permit, issued by the Washington State Department of Fish and Wildlife, a five-year post remediation monitoring plan is being implemented to assess possible recontamination over time. This monitoring will be completed in 2004.

Hidden Lake Pump Station and Ronald Sewer District Pump Station No. 4 Baseline Sediment Characterization Study

The Hidden Lake Pump Station and Ronald Sewer District Pump Station No. 4 Baseline Sediment Characterization Study was performed to establish a sediment quality baseline in the vicinity of King County's Hidden Lake Pump Station emergency outfall. Because this marine outfall also serves as an emergency outfall for the Ronald Sewer District's (RSD's) sanitary sewer conveyance system, this work was also performed to partially fulfill requirements of an outfall lease renewal application between the RSD and the Washington State Department of Natural Resources. Baseline sampling was completed in October 2000. Results are presented in Chapter 4 of this report.

Other Regional Water Quality Programs

Other entities within King County conduct monitoring and water quality protection programs. King County makes an effort to keep informed of this work and to negotiate joint work where interests overlap. Programs are as follows:

- Ecology runs both a sediment and water monitoring program with sites located within King County. None of King County's stations overlap with Ecology's stations. Both agencies review the other's data to gain a more comprehensive picture of water quality.
- The Washington State Department of Fish and Wildlife (WDFW) collect fish samples within King County waters and analyze them for chemical contaminants. King County reviews and uses these data as appropriate.
- The U.S. Geological Survey (USGS) performed stream monitoring for the presence or absence of pesticides. King County has built upon this program in a cooperative effort.

- The USGS conducted some water quality sampling within the Green River watershed. While these data were not sufficient alone to meet the G-DWQA project objective, they will be incorporated into the model development as appropriate.
- The University of Washington (UW) is working jointly with King County on several projects supplementing the SWAMP project. The UW School of Fisheries is working on the ecosystem dynamics component and the bioaccumulation study for the model. The UW Department of Civil and Environmental Engineering is working on the lake-dynamics and biological processes modeling efforts and the mid-trophic model.
- UW is working jointly with King County on characterization of water quality conditions in the Mill Creek/Mullen Slough basin. Water quality data in Mill Creek/Mullen Slough were identified as a data gap in the model selection report (ftp://dnr.metrokc.gov/hydrodat/GDWQA/); data collected will be used to develop models for the G-DWQA.
- King County, WDFW, Seattle Public Utilities, and the Muckleshoot Tribe are conducting chinook surveys in the main stem of the Cedar River.
- King County in partnership with the City of Kirkland is conducting habitat surveys in the Juanita Creek area.
- The Salmon Watcher Program trains volunteers to observe, count, and identify salmon in streams. King County conducts this work in partnership with Seattle, Bellevue, Redmond, Federal Way, Snohomish County, WDFW, and the Muckleshoot Tribe.
- King County Department of Transportation, Roads Services, conducts water quality and macroinvertebrate sampling at several road crossing sites within the Green-Duwamish River watershed. The sites, parameters, and methods differ from those of the G-DWQA. The G-DWQA is designed to address some of the remaining data gaps.
- The Puget Sound Ambient Monitoring Program is coordinated by the Puget Sound Water Quality Action Team and is a long-term effort to investigate environmental trends and prevent overlaps and duplication in monitoring efforts. King County participates in this program, the only local entity to do so, to ensure that there are no overlaps with other monitoring efforts.
- The Washington State Department of Health collects marine water samples for bacterial analysis (fecal coliform) in King County at two locations on Vashon Island. They also analyze shellfish tissues for Paralytic Shellfish Poisoning (PSP) at these same locations as part of a larger statewide sampling program to protect consumers of shellfish. None of the bacteria stations overlaps with King County stations, and the County does not monitor PSP.
- The National Oceanographic and Atmospheric Agency (NOAA) samples three stations in King County for chemical contaminants in mussels as part of the national Mussel Watch Program. NOAA Fisheries has sampled salmonids in the Duwamish River for evidence of chemical impairment. The County uses this information in its studies.
- The Port of Seattle monitors sediment quality at Port-owned property in King County. There is no overlap with County stations.

- The U.S. Army Corps of Engineers is required to monitor sediment quality during routine maintenance dredging, which often occurs in the Duwamish River. The County uses this information in its projects.
- The City of Seattle monitors sediment quality at some of its CSOs and storm drains. The County uses this information in marine modeling efforts.

Chapter 4 Program Results—State of King County Waters

This chapter summarizes the state of the waters within the wastewater service area of western King County. Monitoring and management performance in 2002 indicates that County efforts continue to make a significant contribution to protecting regional water quality and public health. No needs were identified that are not being addressed, and the wastewater system is achieving its purposes. King County residents are continuing to enjoy the excellent water quality that they value and expect.

Cedar-Sammamish Watershed (WRIA 08)

Water quality in the major lakes of the Cedar-Sammamish watershed—Lake Sammamish, Lake Washington, and Lake Union – continues to be good in 2002. Water quality, as described by the Trophic State Index, has fluctuated between moderate (mesotrophic) and good (oligotrophic) over the last nine years. Lakes Sammamish and Washington were considered good 60 to 70 percent of the time; Lake Union was more often of moderate quality (good 33 percent of the time). Figure 8 illustrates the variability in each lake from year to year (1994–2002). Often these year-to-year changes are the result of regional climatic differences (e.g., drought and cooler summer temperatures) and appear as similar fluctuations in the lines for all three lakes.

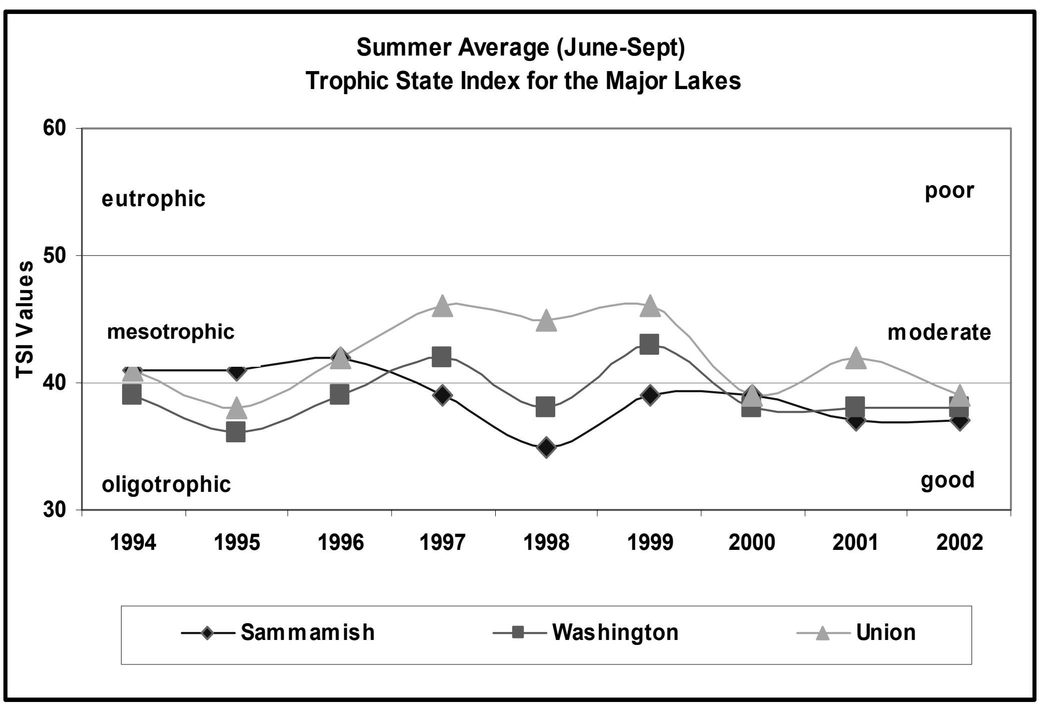

Figure 8
Average Summer Trophic State Index for Major Lakes in the Cedar-Sammamish Watershed

Lake Washington

Lake Washington can be characterized as having good water quality (oligotrophic) in 2002, as shown in Figure 9. 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. The wastewater removal goals of reduced nutrient loading and subsequent reduction in algal biomass were achieved, and improved stormwater management practices have prevented increases in nutrient enrichment that often result from the type of extensive development that has been occurring in the area.

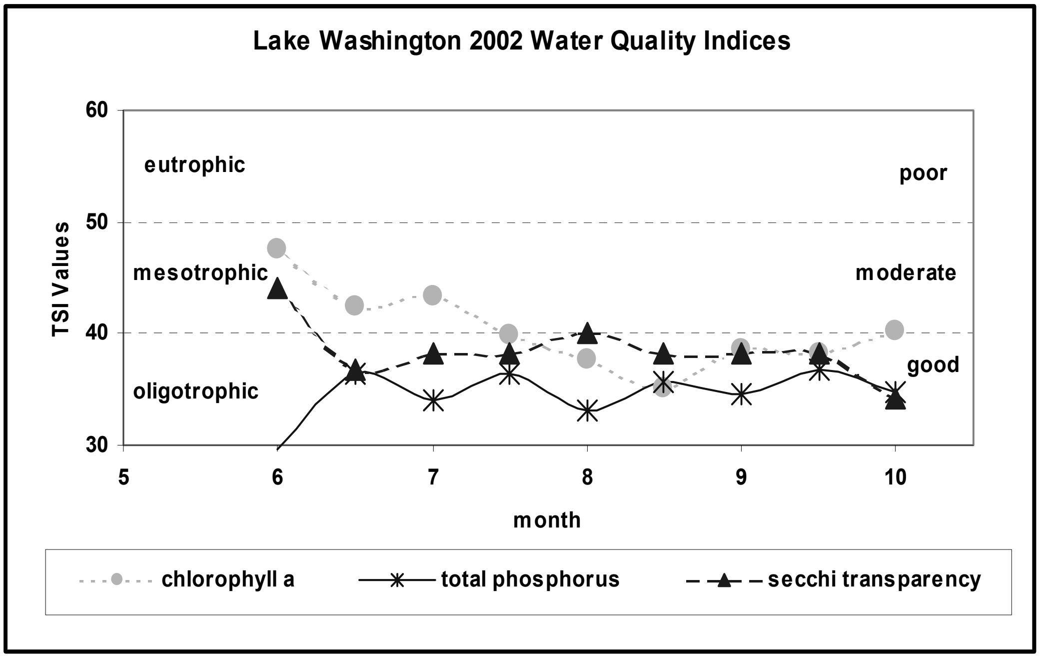

Figure 9
2002 Water Quality Indices for Lake Washington

Lake Sammamish

Water Quality

Overall water quality was good in Lake Sammamish in 2002, as shown in Figure 10. Table 6 shows that all the goals for phosphorous and clarity were met in 2002. The average summer chlorophyll-*a* was slightly higher than the goal. Algal volumes (measured as chlorophyll-*a*) were high in early spring (March and April) but declined by the summer months. Generally, conditions in the basin are good and nutrient concentrations and subsequent algal biomass have been low in Lake Sammamish since 1997.

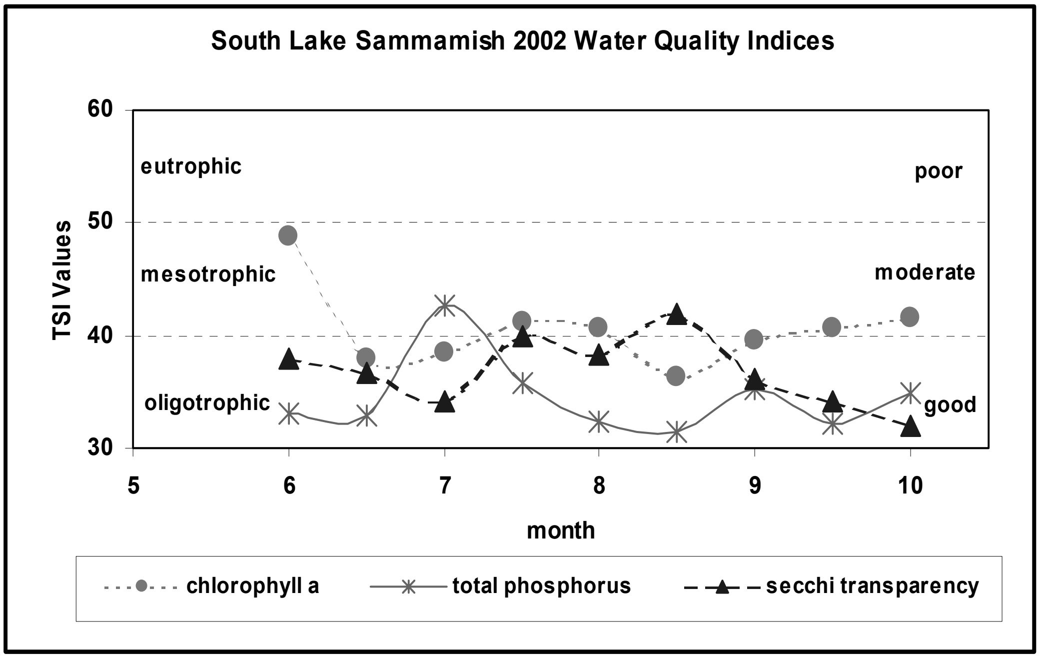

Figure 10
2002 Water Quality Indices for Lake Sammamish

Table 6
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*	22	≤ 2.8	≥ 4.0
2002 Values	13.0	3.0	5.1

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

Sediment Quality

The highest levels of sediment-associated contaminants in Lake Sammamish 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 throughout the lake; however, toxicity test results suggest that sediment-associated contaminants are creating 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). A challenge to this analysis will be to differentiate whether impacts to the structure of benthic communities occur from sediment-associated chemicals or from phosphorus loading.

Lake Union

Water Quality

Lake Union has historically been characterized as mesotrophic (moderate water quality) with fluctuations in some years to oligotrophic conditions (good water quality). Measurements taken over the summer of 2002 characterized Lake Union as having good water overall. Figure 11 shows that with the exception of a phosphorus increase in October, phosphorus and algal biomass were highest in early summer and declined as the season progressed. These lower nutrient levels and algal biomass resulted in improved water clarity as well.

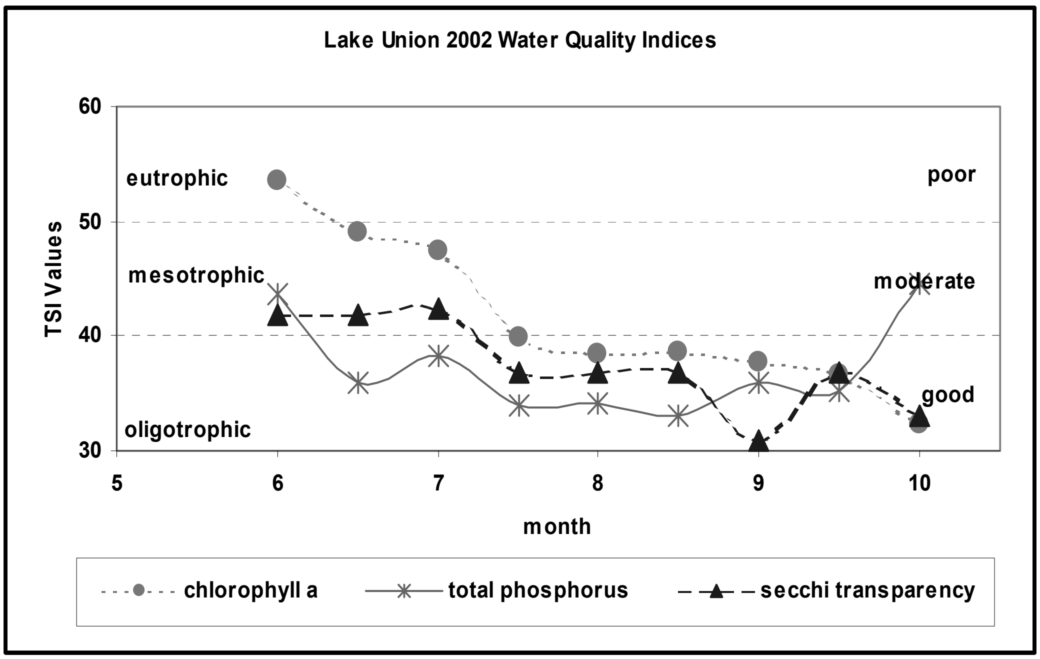

Figure 11
2002 Water Quality Indices for Lake Union

Historically, thermal stratification has caused oxygen deprivation (anoxic conditions) in the lake bottom waters. The optimal oxygen concentration for salmonids is between 6 to 8 mg/L. Dissolved oxygen (DO) concentrations become critical for fish survival at 4.25 mg/L and lethal below 2.0 mg/L. By July 15, water at depths greater than 10 meters had DO concentrations less than 5 mg/L; by August 20, DO concentrations at depths below 8 meters were less than 6 mg/L. When DO concentrations drop below 2 mg/L at the sediment interface, phosphorus that is bound with iron in the sediment dissolves and is released into the water column. This process was evident in Lake Union as the summer stratification progressed. Total phosphorus concentrations at 14 meters increased from 9µg/L on July 15 to 2,610 µg/L by December 3. While the lake remains stratified, the increased phosphorus concentrations in the bottom waters do not mix vertically and therefore do not influence the phosphorus concentrations lake-wide until the water column mixes in late fall or early winter.

Sediment Quality

Under the Sammamish-Washington Analysis and Modeling Project (SWAMP), a comprehensive sediment sampling effort in Lake Union was completed. Sampling analysis and reporting will be completed in late 2003.

Rivers and Streams

Thirty-six sites on 2 rivers and 22 streams have been sampled monthly in the Cedar-Sammamish watershed (WRIA 08) under baseflow and wet weather conditions—some for over 20 years. The two main rivers in the watershed are the Sammamish River and the Cedar River.

Sammamish River

Water Quality

The Sammamish River is listed on the Washington Department of Ecology's (Ecology's) 1998 303(d) list for exceeding standards for temperature, DO, 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. River temperatures as high as 80°F in late July have been observed, which is far above the lethal limit for salmon. High temperatures 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 resistance to disease, and even mortality in juvenile salmon.

Tracking of adult chinook in 1998 and 1999 indicated that salmon use 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 that the Sammamish River has historically been warmer than many Northwest rivers in the summer and early fall. However, the historical river channel conditions likely provided significantly more cool-water refuge for salmon than is currently available. The historical 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) through SWAMP. In addition, computer models are being developed 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 provision of a cool-water inflow source.

Water and Sediment Quality— Toxicity/Pesticide Study

To better understand the degree to which toxic 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 numbers of organisms present in

river sediments provides 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 is currently analyzing these samples; additional information will be available later this year.

Cedar River

The Cedar River is listed on Ecology's 1998 303(d) list for fecal coliform bacteria. Bacterial pollution in the Cedar River is not at as significant as the pollution 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. The WRIA 08 Technical Committee identified the following mainstem factors of decline for chinook: access and passage barriers, loss of channel complexity and connectivity, degradation of riparian conditions, altered hydrology and flow, and increased and altered sedimentation. 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*).*

Small Streams

As part of the County ambient monitoring program, 32 sites on 22 streams have been sampled monthly in WRIA 08 under baseflow and wet weather conditions.

For this report, the data from August 2001 through July 2002 were used to evaluate the water quality conditions using Ecology's new Draft Water Quality Index (WQI), modified slightly to better represent county rivers and streams. Water quality at only one site in WRIA 08, Ebright Creek, had a high enough water quality ranking to be considered a "low concern" site (Figure 12). Twenty-six sites were ranked in the "Moderate Concern" range. The following eight streams ranked of "high concern" in the WRIA 08 watershed: Forbes, Thornton, Fairweather, Lyon, Tibbetts, Kelsey, Bear-Evans, and the mouth of the Sammamish River.

Generally, water quality seems to be better in the upper reaches of streams where development is minimal. High fecal coliform bacteria counts and high total phosphorus concentrations were the primary reason for the low WQI ratings at Thornton, Fairweather, Lyon, and Kelsey Creeks. Low DO concentrations were also a contributing factor to the low WQI ratings at Bear-Evans Creek, Forbes Creek, and the mouth of the Sammamish River. High temperatures during the summer months are a concern at the mouth of the Sammamish River and Tibbets Creek. Some of these low ratings are believed attributable to agricultural activities upstream resulting in higher nutrients, higher bacteria, and disturbed riparian conditions. Waterfowl and aquatic mammals (e.g., muskrats, raccoons) feeding in the wetlands a short distance upstream of seven other streams may also contribute to fecal coliform concentrations. Other sources of fecal bacteria include failing septic systems and pet feces.

Work on the Small Streams Toxicity/Pesticide Study, an additional effort to better understand the extent to which pesticides are present in the watershed, is continuing. These data are currently being analyzed.

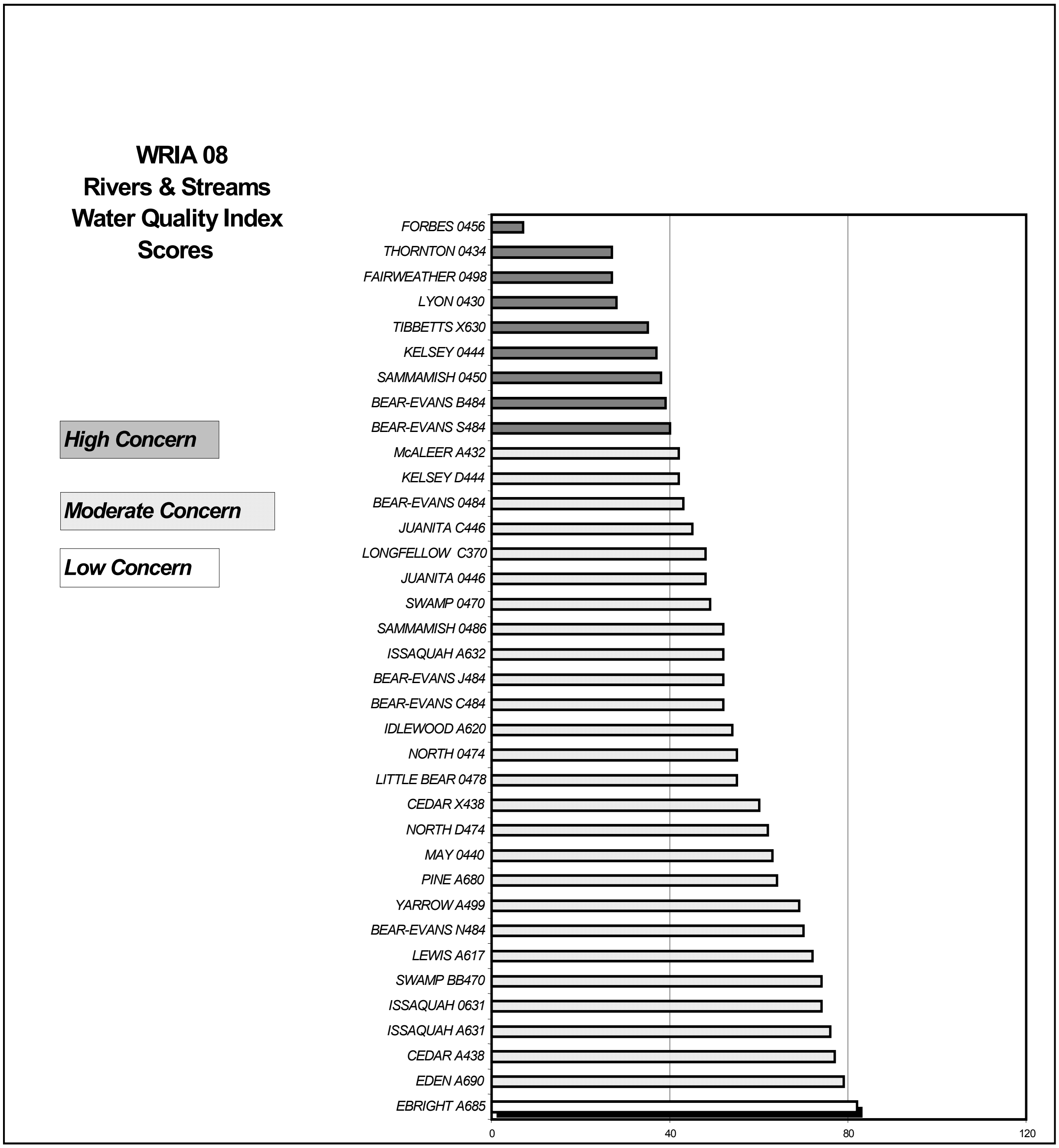

Figure 12
Water Quality Index Scores for Rivers and Streams in the Cedar-Sammamish Watershed

Duwamish-Green Watershed (WRIA 09)

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 in the watershed are listed on Ecology'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, DO, and temperature are the most common parameters listed, but there are also isolated listings for pH, metals, and ammonia.

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

Green and Duwamish Rivers

In general, the water quality is good in the Duwamish Estuary. The risks to organisms that dwell in the water column 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 into 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 in the Duwamish River is of high priority for the County.

Small Streams

In 2002, Ecology's new Draft Water Quality Index (WQI), modified slightly to better represent county rivers and streams, was used to rank the conditions of streams in the Green-Duwamish watershed (Figure 13). For this report, data from August 2001 through July 2002 were used.

In the Green-Duwamish tributaries, water quality is closely linked to the level of urbanization and intensity of land use. Soos Creek has some of the region's best water quality for urbanized small creeks and was rated of "low to moderate concern." Based on previous assessments, Crisp Creek, one of the least developed tributaries, was determined to have good overall water quality. But it was rated of "moderate concern" using the WQI and has high storm flow fecal coliform bacteria counts, high total suspended solids, and unusually high ammonia concentrations. Newaukum Creek, which has extensive agricultural land use, was also rated of "moderate concern" because of occasional depressions in DO levels, high turbidity, and high bacteria counts. Mill and Springbrook (Black River) Creeks are the most heavily urbanized of the tributaries listed here and exhibit the most degraded water quality conditions. Mill Creek, which is rated of "moderate concern," has low DO concentrations, high nutrient concentrations, and high bacteria counts. Springbrook Creek has the worst WQI rating of any stream in the King County ambient monitoring program and suffers from low DO concentrations, high temperatures, and high nutrients. High turbidity at Newaukum and Springbrook Creeks likely results from suspended organisms such as iron-reducing bacteria that seem to be present year-round.

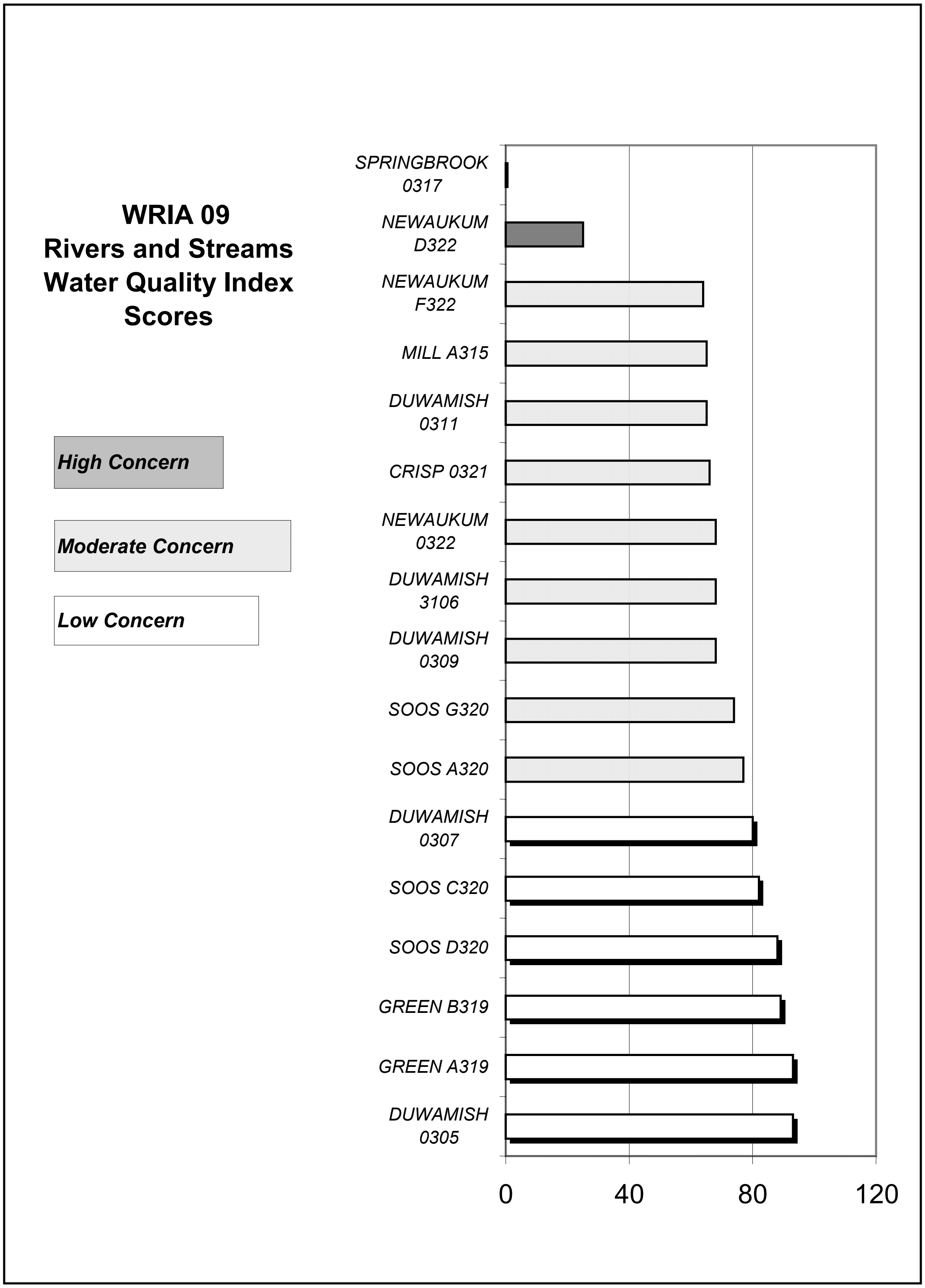

Figure 13
Water Quality Index Scores for Rivers and Streams in the Green-Duwamish Watershed

Puget Sound Marine Waters

Only locations sampled in Puget Sound since the adoption of the RWSP in 1999 are discussed because stations change with changing program goals over time. Sampling locations prior to 1999 may be found in the appropriate yearly *Water Quality Status Report for Marine Waters* produced by Water and Land Resources Division.

Water Quality at Ambient and Outfall Locations

Dissolved Oxygen

DO concentrations between late winter and summer are usually above 7.0 mg/L at all depths and locations sampled and are always above 5.0 mg/L, the level where potential problems could occur. Concentrations below 7.0 mg/L naturally occur in the late summer and fall as a result of a seasonal influx of deep oceanic water, which contains low amounts of DO. Figure 14 shows the seasonal variation seen in DO concentrations for the past six years and the concentrations at ambient and outfall sites. Some surface DO concentrations are above 14.0 mg/L but are not shown in Figure 14 in order to show more detail for the most measured concentrations. Lower DO concentrations at the outfall sites compared to the ambient sites are not seen, even at deep depths where oxygen concentrations tend to be the lowest. Of the 3,865 DO values measured over the past 10 years, only 25 have been below 5.0 mg/L. Persistent levels below 5.0 mg/L have never been observed.

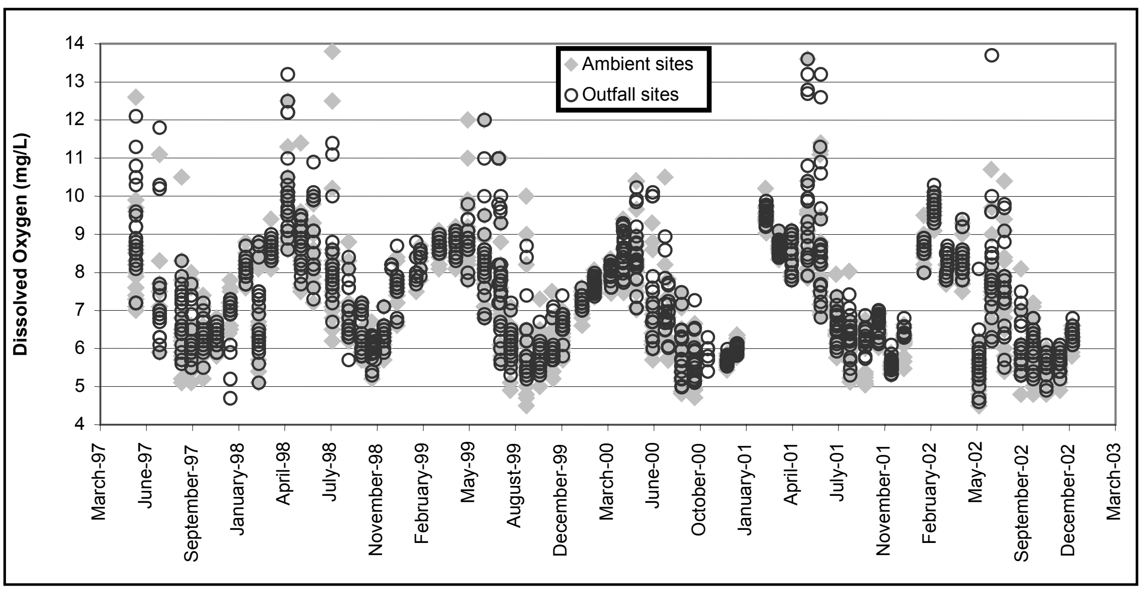

Figure 14
Dissolved Oxygen Concentrations at Ambient and Outfall Sites in Puget Sound 1997-2003

Fecal Coliform Bacteria

Routine fecal coliform testing measures the amount of bacteria present but does not distinguish whether the bacteria is from a human or animal source. Source tracing requires specialized sampling and analysis techniques that must be performed at the University of Washington or another specialized laboratory.

With the exception of stations located in inner Elliott Bay, all offshore water column stations have met fecal coliform standards over the past several years (Figures 15 and 16). The stations in Elliott Bay receive higher freshwater input than other sites because of their proximity to the Duwamish River and because of the discharge of runoff from storm drains along the waterfront. All values at the wastewater treatment plant and CSO outfalls were well below standards, with the exception of the site located at the former Denny Way CSO outfall along the waterfront. Bacteria levels at the Denny Way CSO met the geometric mean standard but did not meet the peak standard. This sampling location was moved in 2003 to reflect the relocation of the discharge to a new outfall as part of the Denny Way/Lake Union CSO Control Project.

Fecal coliform levels in water samples from beaches are influenced by freshwater and stormwater runoff and by waterfowl that congregate in these areas. As a result, a number of stations exceeded standards during high rainfall months and at sites close to streams and other freshwater sources. Stations that are in areas with restricted water movement also tend to exceed standards more frequently than do areas with ample mixing. Sites located near the Lake Washington Ship Canal, Fauntleroy Cove, Tramp Harbor, Golden Gardens, Carkeek Park, and Piper's Creek have consistently failed standards for the last several years. All of these stations are located near a freshwater source or in an embayment.

Fecal coliform bacteria levels at beaches in the vicinity of the West Point Treatment Plant outfall have met the geometric mean standard for the last three years but generally do not meet the peak standard. Bacteria at beaches in the vicinity of the Alki CSO outfall, which rarely discharges, have consistently failed both standards. The reason for this failure is not clear. Further investigation is required to determine the bacteria source. The beach closest inshore of the Carkeek CSO outfall also consistently failed both standards. This is likely due to bacteria levels from Piper's Creek. Two stations have been sampled in the Carkeek Park area for several years: one located at the beach close to the outflow of Piper's Creek and the other in Piper's Creek upstream of the CSO treatment plant. Additional sampling at Carkeek Park began in 2000 for the MOSS project at a beach station located at Carkeek Park but outside the influence of Piper's Creek. Bacteria levels at this new station were consistently low and passed both fecal coliform standards, indicating that the bacteria at the other beach station is likely due to bacteria from Piper's Creek. A source tracking study conducted in 1991 at Piper's Creek found mainly animal sources, including cats and ducks.

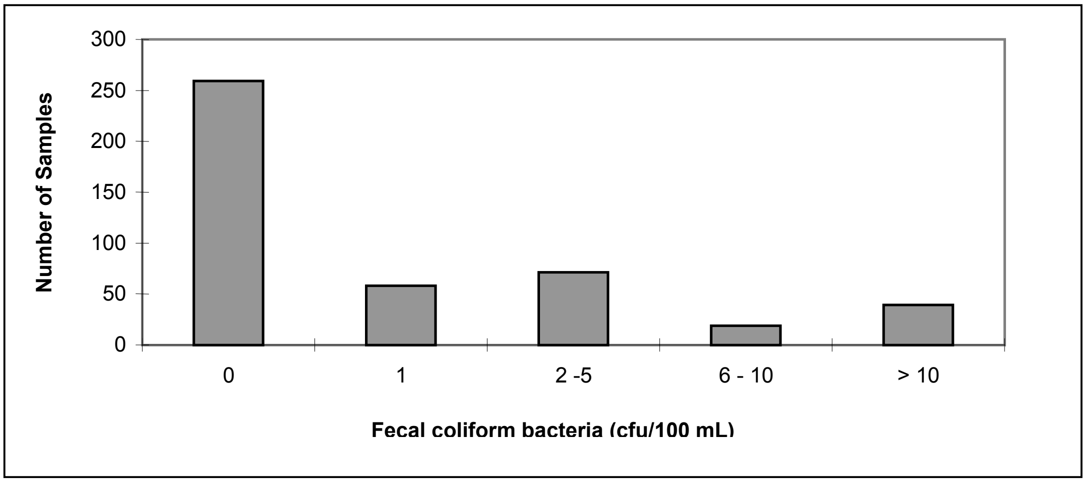

Figure 15
Fecal Coliform Counts Versus Number of Samples for Puget Sound Waters—1998–2002

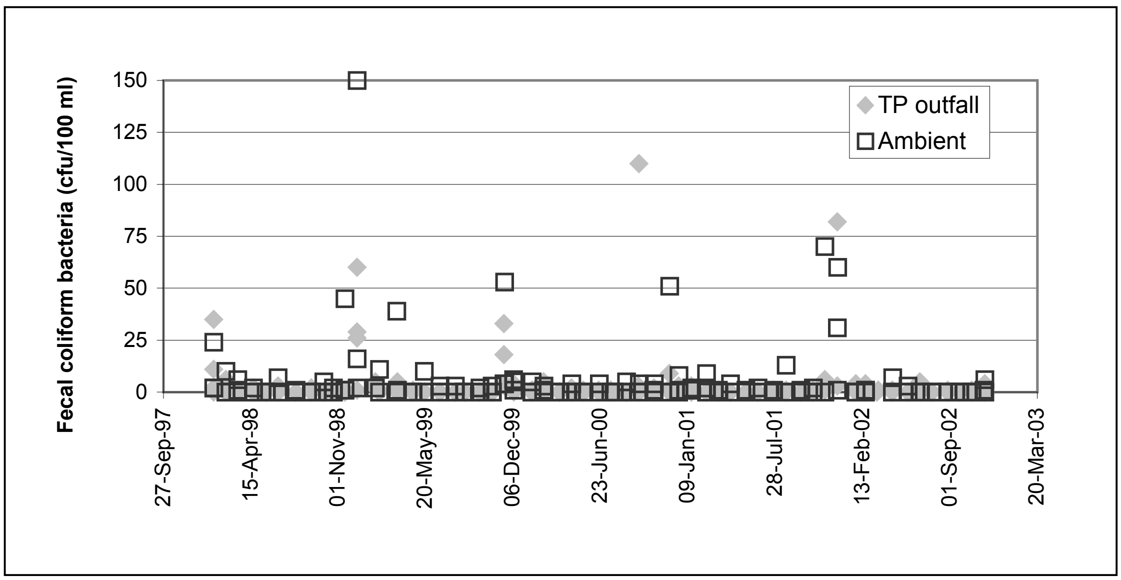

Figure 16
Fecal Coliform Counts for Ambient and Outfall Sites in Puget Sound—1998–2002

Nutrients

Nutrients, including nitrogen (in the form of ammonia, nitrate, nitrite), phosphorus, and silica are ubiquitous in the marine environment. Nitrate is the primary form of inorganic nitrogen in seawater. Nitrate concentrations are usually higher in the winter months when phytoplankton growth is the lowest and freshwater flows are the highest. Nitrate values are typically lower in the shallower parts of the water column where marine plants are taking up the nitrate for photosynthesis. Nitrate concentrations at beach stations were similar to offshore stations; the

same seasonal trend was observed at beach stations. Nitrate concentrations at outfall stations were similar to values measured at the ambient stations.

All ammonia concentrations measured for offshore and beach stations over the last several years were well below the 1.6 mg/L chronic criterion. In the past several years, the highest ammonia concentrations have been measured at the West Point and South Treatment Plant outfall stations, generally at the predicted trapping depth and deepest depth for each site. But as stated above, these ammonia concentrations were well below the criterion. Figure 17 shows typical ammonia profiles for two ambient stations and the two main wastewater treatment plant outfall stations. These data were collected in 2001 but are typical for other years monitored.

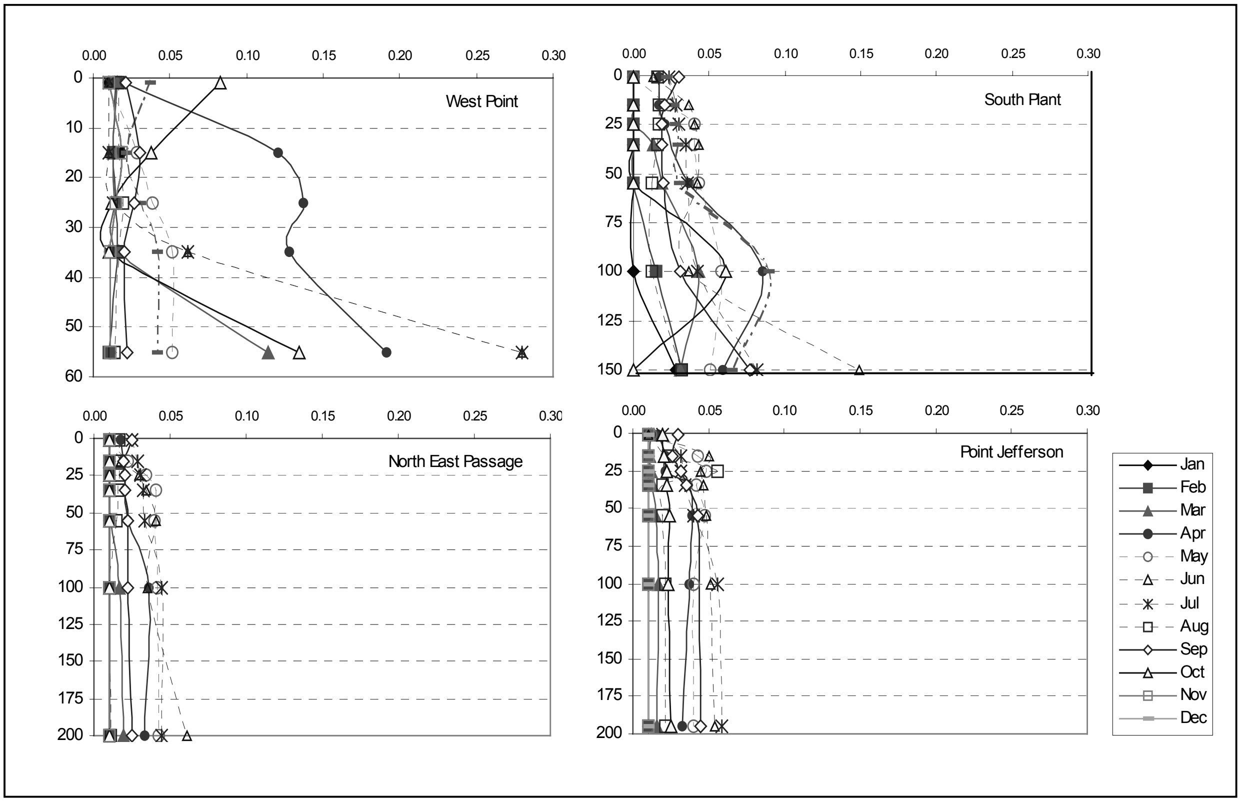

Figure 17
2001 Ammonia Profiles for Ambient and Outfall Sites in Puget Sound

Phytoplankton Blooms

Phytoplankton blooms, measured as chlorophyll-*a*, in the Central Basin of Puget Sound exhibit seasonal trends, with blooms usually occurring between April and July of each year. In recent years, blooms have followed this same trend. Figure 18 shows the frequency of phytoplankton blooms for several sampling locations. Each symbol indicates a bloom. Phytoplankton bloom frequency reflects annual variability at all sites. Frequency at treatment plant outfall locations were comparable to those at ambient stations.

Location	Number of Phytoplankton Blooms as Indicated by Chlorophyll-a Levels			
	1999	2000	2001	2002
Point Wells	●●◆◆	●●◆◆◆	◆◆◆	●●●◆◆
Point Jefferson	●●◆◆	◆◆◆◆◆	●●◆◆◆	●◆◆◆◆
Carkeek CSO outfall	●◆◆	●●◆	●◆◆	●◆◆◆
West Point outfall	●◆◆◆	●●◆◆◆	●◆◆	●●◆◆◆
Elliott Bay	●◆	●◆◆◆	●◆◆	●●●●◆
South Plant outfall	●●◆	●●◆◆◆	●●◆◆	●●●●◆◆
Alki CSO outfall	●◆◆	●●◆◆	●●●◆	●●●●◆
North East Passage	◆	●●◆◆	●◆◆	●●◆◆◆
Vashon outfall	--	--	●◆◆◆	●●●◆◆

● Concentration >5 ug/L
◆ Concentration >10 ug/L

Figure 18
Phytoplankton Blooms in Central Basin of Puget Sound—1999–2002

Chemicals

Between 1999 and 2000, monthly water column samples were collected from eight offshore stations as a component of the MOSS project. Trace metal analysis showed little variability between stations and months, and all met applicable water quality criteria. No chlorinated pesticides and herbicides, PCBs, or organophosphorus pesticides were detected in any sample. Twenty semivolatile compounds were detected; most were phthalates and polynuclear aromatic hydrocarbons (PAHs).

MOSS beach sampling was done between 2000 and 2001. As of 2002, preliminary evaluation indicates that there are large variations in individual metal concentrations, although they easily met applicable water quality criteria. No difference in metal concentrations in waters at the West Point and South Plant outfalls was seen when compared to other sites sampled. No chlorinated pesticides and herbicides, PCBs, or organophosphorus pesticides were detected in any beach waters. There were 21 semivolatile compounds detected; most were phthalates and PAHs, the same compounds that were detected in offshore waters.

Sediment Quality

Treatment Plant Outfalls

Point source program sediment samples were collected around the South Treatment Plant outfall and the Alki CSO Treatment Plant outfall in late October 1999 and early November 2001. These samples were analyzed for conventional, metal, and organic chemistry parameters.

as required by King County's wastewater NPDES permit. Concentrations of detected metals met all Washington State Sediment Quality Standards (SQS) chemical criteria. A concentration gradient with respect to distance away from the outfall pipe was not evident for any metal at either of the outfall sites. Seventeen organic compounds, out of 98 analyzed, were detected in outfall sediment samples. The majority of the detected compounds were PAHs. Concentrations of detected organic compounds met all SQS chemical criteria.

Benthic community analysis was conducted at six stations around the South Treatment Plant outfall in 1999 and 2001. Diversity indices and total species numbers were typical for sediments composed mostly of silt and clay, such as those around the South Treatment Plant outfall. Numerically dominant species found at all stations are those typically seen in other areas with similar sediment grain sizes and are indicative of deep-water fine sediments. Diversity indices, species abundance, and dominant species did not indicate a gradient with respect to distance away from the outfall pipe. Chemical and biological results for the most recent monitoring (1999 and 2001) were similar to past results and indicate no increasing trend in contaminant concentrations.

Point source program sediment samples were collected from 14 stations around the West Point Treatment Plant outfall and 6 stations around the Carkeek CSO Treatment Plant outfall in October 2000. These samples were analyzed for conventional, metal, and organic chemistry parameters, as required by King County's wastewater NPDES permit. Concentrations of detected metals met all SQS chemical criteria. A concentration gradient with respect to distance away from the outfall pipe was not evident for any metal at either of the outfall sites. Twenty-four organic compounds, out of 98 analyzed, were detected in outfall sediment samples. The majority of the detected compounds were PAHs. Concentrations of detected organic compounds at both outfalls met all SQS chemical criteria.

Two PAH compounds exceeded SQS criteria at one West Point outfall station sampled in 1998, but met criteria in 2000. Because of the chemistry results in 1998, toxicity testing was conducted with sediments from two stations in 1998. Results exceeded the SMS Biological Effects Criterion for an acute toxicity test at both stations. Although there were no chemical exceedences at any sediment monitoring station in 2002, an agreement was reached with Ecology to perform two acute and one chronic toxicity test on sediments from the two stations that have exceeded standards in the past. Toxicity tests showed no toxicity for one acute test but exceeded the SMS Severe Biological Effects Criterion for the other acute test at both stations. Both stations also exceeded the SMS Biological Effects Criterion for the chronic test. However, benthic community sampling in 2000 at the West Point outfall showed no impairment of biological species assemblages. Because of the confounding chemical, biological, and toxicity testing results from the sampling events in 1998 and 2002, it was decided to postpone the 2002 sampling at West Point until a new sampling design could be planned in consultation Ecology. A draft Scope of Work has been developed for sampling around the West Point outfall.

Point source program sediments around the existing Vashon Treatment Plant outfall were sampled in late 1999 in order to obtain baseline sediment quality information following addition of the Vashon Treatment Plant to the County's jurisdiction. No previous sediment data existed for this area. Concentrations of detected metals met all SQS chemical criteria and a concentration gradient with respect to distance away from the outfall pipe was not evident for

any metal. Three organic compounds, out of 98 analyzed, were detected in sediment samples. Concentrations of detected organic compounds met all SQS chemical criteria. Sediments around the outfall have a high percentage of sand due to the shallow depth. Results from Vashon outfall sediment sample analysis are similar to other areas of the Sound that contain sandy sediments. Additional sediment sampling at the Vashon outfall is not expected to occur until a new location for the outfall has been determined.

Ambient Locations

Ambient sediments were sampled in 2000 and again in 2002 at several locations outside the influence of the treatment plant outfalls. Sediments were analyzed for conventional, metal, and organic chemistry parameters. With the exception of sediments collected in inner Elliott Bay along the Seattle waterfront, results were similar to those obtained for treatment plant outfall sediments. Mercury concentrations at a site located along the waterfront failed the SMS criterion for mercury. This area routinely fails the mercury standard, most likely because of historical contamination along the waterfront.

MOSS Area

Analytical results from the MOSS Baseline Sediment Characterization Study chemical testing and analysis of the benthic community indicated the following characteristics of sediments in the candidate Brightwater marine outfall diffuser zones:

- Concentrations of trace metals and organic compounds meet all regulatory and guidance criteria.
- The benthic communities in the deep diffuser zones are homogenous, dominated to a great extent by a single species of small clam, *Macoma carlottensis*. These results are comparable with data from other areas in Puget Sound with similar depths and physical sediment characteristics.
- The benthic community in the shallower diffuser zone is very diverse. A large number of species were found.

Denny Way CSO

Samples from the Denny Way CSO were collected in April 2001 for chemical and benthic community analysis that was completed for this report. Sediments in the vicinity of the planned Denny Way CSO outfalls were characterized as follows:

- Mercury concentrations exceeding the SQS chemical criterion at 5 of 19 stations and exceeding the cleanup screening level (CSL) chemical criterion at 4 of 19 stations
- Benzyl butyl phthalate concentrations exceeding the SQS chemical criterion at 9 of 16 stations
- Bis (2-ethylhexyl) phthalate concentrations exceeding the SQS chemical criterion at 4 of 19 stations and exceeding the CSL chemical criterion at 3 of 19 stations
- Total PCB concentrations exceeding the SQS chemical criterion at 10 of 16 stations
- Total DDT concentrations exceeding the Puget Sound Dredge Disposal Analysis (PSDDA) screening level chemical criterion at 9 of 16 stations

- A nearshore area that is a sandy to sandy-gravelly low-organic carbon environment that is dominated by annelid species, some of them pollution tolerant
- Most of the remainder of the site dominated by molluscan species, most often *Parvilucina tenuisculpta*, a small bivalve

Data from this study indicate that sediment quality and the benthic community in the area around the existing Denny Way/Lake Union CSO Control Project have most likely been impacted by historical discharges from the existing CSO outfall and possibly from other sources. Data from this and previous studies will be used to establish a sediment quality baseline, against which results from future monitoring efforts may be compared after construction and operation of the outfalls and after sediment remediation efforts have been implemented.

Norfolk CSO

Remediation of the Norfolk CSO site was completed in 1999. Sediment samples collected in April 2002 represented the third year of the post-remediation monitoring program. Results raised the following issues:

- **Boeing Storm Drain Channel (Station NFK503).** The total PCB concentration in the 0- to 10-cm depth stratum exceeds the SQS and is 47 percent of the CSL. The total PCB concentration in the 0- to 2-cm depth stratum is 83 percent of the SQS chemical criterion. This is a significant decrease from total PCB concentrations detected during April 2001 monitoring.
- **Upriver Reference (Station NFK504).** Bis (2-ethylhexyl) phthalate was detected in the sample collected from the 0- to 2-cm depth stratum at a concentration that exceeded the SQS and that was 81 percent of the CSL. The bis (2-ethylhexyl) phthalate concentration detected in the sample collected from the 0- to 10-cm depth stratum equaled the SQS. If the concentration of bis (2-ethylhexyl) phthalate increases above the CSL, bioassay testing will be added to the monitoring program to further evaluate possible sediment toxicity to benthic organisms.

Hidden Lake Pump Station/Ronald Sewer District Emergency Outfall

Results became available in 2002 for the baseline sediment characterization at the emergency outfall for the Hidden Lake Pump Station and Ronald Sewer District Pump Station No. 4. The results indicate that sediment quality does not appear to have been negatively impacted by operation of this outfall, nor does there appear to be a chemical gradient around the outfall for any constituent analyzed. Concentrations of detected metals and organic compounds met all SQS chemical criteria, and the benthic communities near the outfall were similar to ambient conditions. When construction is completed, additional monitoring will be done to identify if changes have occurred as a result of this project.

Chapter 5
Developing Issues and Needs

In the coming year, King County will face some unique challenges and some new opportunities for change. Creating a balance in water needs and water resources for fish and people will be an ongoing focus.

Endangered Species Act

Since 2000, King County has been engaged in three efforts related to the Endangered Species Act (ESA): preparation of a proposal concerning compliance with the ESA 4(d) rule, review of its practices for compliance with the chinook 4(d) rule, and preparation of a Habitat Conservation Plan (HCP).

In 2000, NOAA Fisheries (formerly National Marine Fisheries Service, or NMFS) adopted a draft protective rule under section 4(d) of ESA prohibiting the "take" of salmon and steelhead species previously listed as threatened under ESA. In July 2001, the County submitted to NOAA Fisheries a proposal to include its discharges that are within NPDES permit limits and its discharges from controlled CSOs as a "limitation" on take, to be included for chinook salmon under the ESA 4(d) rule. A limitation means that if activities are conducted according to their description in the 4(d) rule, they are not considered to "take" or seriously harm the species population.

Following the adoption of the rule, King County began a review of its activities to determine how the Wastewater Treatment Division (WTD) 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. Affected areas of our business include construction practices and uses of property near water bodies.

For treatment plant discharges, NOAA stated in the 4(d) rule that it would work with permitting authorities (Washington State Department of Ecology) to ensure that permitted discharges do not violate the ESA. The County is, therefore, concentrating its efforts on working with NOAA Fisheries and the U.S. Fish and Wildlife Service to develop a Habitat Conservation Plan to gain certainty regarding what we must do to develop projects that comply with the ESA. In 2002, the County completed four "issue papers" for the HCP covering operations and maintenance, discharge of secondarily treated effluent, construction of pipes and facilities, and the Brightwater Wastewater Treatment System. In addition, the County produced technical memoranda on bioaccumulation, the sea surface microlayer, endocrine disrupters, and the benthic communities around its outfalls. These documents will form the basis for the draft HCP. Throughout 2002, regularly scheduled negotiation and discussion sessions were held with NOAA Fisheries, the USFWS, and the Tribes. A draft HCP and Draft EIS are expected in September 2003. Over the following 12 months, staff will develop the required final HCP environmental documents and implementation agreements that will lead to the issuance of the Incidental Take Permit in summer 2004.

Watershed Resource Inventory Area (WRIA) Planning

Watershed planning activities under precedent-setting interlocal agreements (ILAs) continued in 2002—the second year of these activities. ILAs involve cost sharing by more than 45 jurisdictions in support of the salmon conservation planning effort as well as a new management construct. As the result of the success and accomplishments of the first two years, all jurisdictions have agreed to continue funding for 2003 work.

Both WRIAs 08 and 09 completed their Near-Term Action Agendas (NTAAs) in 2002. Early in the year, draft versions were released for public review. The Steering Committee of each WRIA subsequently revised and finalized its NTAA. The resulting NTAAs provide recommendations about actions that can be voluntarily taken in the short term—the next two to four years—that are feasible and are known to help salmon and salmon habitat. Each NTAA was tailored to meet the specific conditions of its WRIA. The recommendations of the NTAAs were based on the scientific information gathered in the Reconnaissance Assessments completed previously. Given the similarities across many recommendations, however, and the fact that implementation is voluntary, the differing approaches are not expected to present implementation difficulties for the County.

With the NTAAs providing direction for the short term, the planning effort turned in the latter part of the year to detailed scoping for the comprehensive Salmon Conservation Plans (also termed Habitat Plans). These plans will describe long-term habitat conservation and recovery actions in the WRIA 08 and 09 watersheds, taking an ecological approach but concentrating on the needs of the ESA-listed species of chinook salmon and bull trout. Development of elements of the plans also began in 2002 and will continue into 2003-2004. Areas of initial work include modeling of the watershed and its responses to management changes, analysis of historical conditions, and analysis of land use.

Of equal importance, work on the Strategic Assessments got under way in 2002, with much work expected to be completed in 2003. The Strategic Assessments will provide the technical foundation for the conservation plans as well as baseline information needed for adaptive management. The Strategic Assessments 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.

Many of the questions that need to be answered in regard to the WRIAs are identical to those that the County's WTD must address in various projects. While the scientific needs of the WRIA have been greater (for instance, in terms of geographic extent) than the specific needs of WTD, supporting the success of WRIA planning will ensure a sound framework for reasonable RWSP ESA requirements from the federal government.

Anti-Degradation Regulations

In December 2002, the Washington State Department of Ecology (Ecology) proposed revisions to its surface Water Quality Standards and procedures. Ecology is considering modifying its

permit renewal processes to include stricter evaluations of projects that may lower, or degrade, water quality in state water bodies. This new anti-degradation procedure could potentially inhibit the siting of new discharges into water bodies with especially high water quality or those already impaired by a parameter (for example, temperature or dissolved oxygen) if it contributes to the reduction of a beneficial use (swimming, fish spawning, and so forth). King County's future wastewater projects will be subject to this new procedure if implemented.

Total Maximum Daily Loads

Defined by the U.S. Environmental Protection Agency (EPA), 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 Water Quality Standards, the Clean Water Act requires that a TMDL and a pollutant allocation be done for that water body. The EPA or 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. New federal rules for performing TMDL analysis were scheduled to go into effect in October 2001, but have since been rescinded. New EPA rules are expected to be proposed some time in 2003, but under the current federal rules, many King County water bodies already listed by the state as having impaired water quality must have TMDLs prepared as soon as possible. As a result, King County will need to give increased attention to water quality data collection and modeling so that TMDL calculations done by Ecology will be based on good science and will be as accurate and complete as possible.

In 2001, King County completed a joint project with the Ecology to begin work on TMDLs for certain county water bodies. In particular, a model sediment TMDL was developed and approved by EPA in its first application to a site in Bellingham Bay. This model should eventually be applied to the Lower Duwamish Waterway and other County remediation sites.

Endocrine Disrupting Chemicals

Chemicals that mimic hormones in animals (fish, birds, people) may sometimes result in changes in how an animal's endocrine or reproductive systems works. These chemicals have been called suspected endocrine disrupting chemicals (EDCs) or 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 suspected endocrine disrupting substances that may be present in treated municipal wastewater. This document, entitled *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. King County is also undertaking some initial sampling of its surface waters during 2003 to determine if there are measurable suspected EDCs present.

Sediments

Source control of upland properties is needed to ensure that sediment cleanup sites are not recontaminated. In the Lower Duwamish Waterway and Harbor Island/East Waterway Superfund sites, the size of the industrial area makes source control particularly challenging. If the County is not successful, imposed solutions may be to increase the control levels of CSO discharges beyond current requirements. That could mean accelerating planned CSO control projects or requiring more costly storage or treatment projects than currently planned—either could have significant consequences for the RWSP capital program. The effectiveness of source control efforts, therefore, is very important. A new intensive integrated cross-agency source control effort is being implemented in the Diagonal/Duwamish basin. Coordination of four separate programs to help businesses identify and control pollutant sources will now occur at one time through one contact with each business. In the next few years, the County will determine if this approach will be successful. For more information on this program, see the "Industrial Waste Program" section in Chapter 2 of this report.

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 wastewater pollution in water and as an indicator of the human health risk.

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

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 a tribal government.

Nonpoint Source: An input of pollutants into a water body from unidentifiable sources, such as agriculture, the atmosphere, and 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 freshwater systems as it can cause nuisance algal blooms if present in excess amounts.

Phytoplankton: Marine plants, mostly small to microscopic in size, that 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 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 . 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 levels 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/
http://dnr.metrokc.gov/wtd/henderson-cso/

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