Appendix D

The Health of Our Waters, Water Quality Monitoring Results for 2005

Contents

Summary of 2005 Water Quality D-1
Monitoring Programs D-2
Treatment Plant Effluent D-2
Ongoing Freshwater Monitoring D-2
Ongoing Marine Monitoring D-3
Other Monitoring D-3
Web-Based Monitoring Data D-3
Marine Water D-9
Monitoring Locations D-9
Fecal Coliform Bacteria D-9
Overall Quality—Marine Offshore Water Quality Index D-13
Shoreline Armoring D-14
Major Lakes D-14
Monitoring Locations D-14
Fecal Coliform Bacteria—Ambient Mid-Lake (Open-Water) and Nearshore D-17
Fecal Coliform Bacteria—Swimming Beaches D-17
Overall Quality in Major Lakes—Trophic State Index D-18
Water Temperature—Effects of Climate Change D-21
Rivers and Streams D-22
Monitoring Locations D-22
Overall Quality—Water Quality Index D-24
Normative Streamflows D-24

This appendix presents a summary of the quality of King County's marine water and freshwater bodies in 2005. The summary is followed by more detailed information on water quality monitoring locations, procedures, and results. The information satisfies the RWSP reporting policies that call for inclusion of yearly water quality monitoring results as a part of the RWSP annual report.

Summary of 2005 Water Quality

Monitoring activities in 2005 found that in general, the quality of marine and fresh waters in King County is good.

As in the previous five years, all offshore marine monitoring locations in Puget Sound—both ambient and outfall sites—met the fecal coliform bacteria standard in 2005. The percentage of nearshore marine sites (beaches) that met the standards has nearly doubled since 1998.[1] The three nearshore sites of highest concern—Pipers Creek Mouth, Shilshole Bay, and Alki Point South—are near freshwater sources with high fecal coliform counts. The overall quality of marine water, as indicated by the water quality index, is good. The percentage of monitoring locations ranked as moderate or high concern has declined to zero in the past two years, from a peak of 22 percent in 2000.

The quality of major lakes in King County, as indicated by fecal coliform bacteria levels, is also good. For non-beach areas, 100 percent of Lake Sammamish samples, 97 percent of Lake Washington samples, and 86 percent of Lake Union samples taken in 2005 met the exceptionally high fecal coliform standard used for lake water. These percentages represent a slight increase for Lakes Sammamish and Washington and a slight decrease for Lake Union. The completion of two major combined sewer overflow control projects in 2005 will likely reduce levels in Lake Union.

At lake swimming beaches, fecal coliform levels were also acceptable. All samples collected at Green Lake met the fecal coliform standard for the second year in a row. In Lake Sammamish, 89 percent of the samples collected in 2005 met the standards, down slightly from 2004 (91 percent). In Lake Washington, 85 percent of the samples met the standards, up from 79 percent in 2004. Four beaches at Lake Washington were temporarily closed because of high fecal coliform levels. These levels were primarily the result of inflowing streams or waterfowl. In terms of overall water quality, as measured by the Trophic State Index, Lakes Sammamish, Washington, and Union were ranked as good or moderate.

Given the large population and the growing urbanization in King County, overall stream water quality, as measured by the Water Quality Index for rivers and streams, is fairly good. In 2005, water quality at 36 of the 56 sites, or 64 percent, was considered either low or moderate concern, while 20 sites (or 36 percent) were rated high concern. Urbanization is impacting the normal patterns of streamflow. For 10 streams, "flashiness" was compared between actual data and a

[1] About 75 percent of the marine beach sites met the geometric mean standard and about 50 percent met the peak standard for fecal coliform bacteria.

watershed model simulation under fully forested conditions over a period of 50 years. Seven of the ten streams were flashier (higher peak flows and less annual flow) than if they had existed in forested conditions.

Monitoring Programs

To protect public health and its significant investment in water quality improvements, King County regularly monitors major lakes, beaches, streams, marine waters, and wastewater effluent (Table D-1). The biological, chemical, and physical parameters used to assess a water body's health under Washington State's Water Quality Standards are fecal coliform bacteria, dissolved oxygen, temperature, pH, ammonia, turbidity, and a variety of chemical compounds. King County also uses other indicators in addition to these parameters.

Treatment Plant Effluent

King County's three regional wastewater treatment plants continue to be in compliance with the terms and conditions of their NPDES permits, and so are in compliance with the Washington State Water Pollution Control Law, the Federal Water Pollution Control Act, and the Federal Clean Water Act.

The county regularly samples wastewater effluent from the plants and analyzes these samples at process laboratories at the plants and at its environmental laboratory in Seattle.

Ongoing Freshwater Monitoring

The major lakes monitoring program collects samples from 25 open-water sites in Lake Union and the Ship Canal, Lake Washington, and Lake Sammamish. Sampled parameters include temperature, dissolved oxygen, pH, conductivity, clarity (Secchi Transparency), phosphorus, nitrogen, and fecal coliform bacteria.

The swimming beach monitoring program assesses 21 beaches on Lake Sammamish, Lake Washington, and Green Lake every summer. This effort, ongoing since 1996, tests for fecal coliform bacteria as an indicator of risk to human health.

Some water quality indicators…

Fecal coliform bacteria. The presence of fecal indicator bacteria indicates that the water has been contaminated with the fecal material of humans, birds, or other warm-blooded animals. One type of fecal indicator bacteria, fecal coliforms, may enter the aquatic environment from domestic animals, wildlife, stormwater runoff, wastewater discharges, and failing septic systems. Although these bacteria are usually not harmful, they often occur with other disease-causing bacteria and their presence indicates the potential for pathogens to be present and to pose a risk to human health.

Dissolved oxygen. Aquatic plants and animals require a certain amount of dissolved oxygen (DO) for respiration and basic metabolic processes. Waters that contain high amounts of DO are generally considered healthy ecosystems. DO concentrations are most important during the summer season when oxygen-depleting processes are at their peak.

Temperature. Temperature influences many of the chemical components of the water, including DO concentration. Temperature also exerts a direct influence on the biological activity and growth and, therefore, the survival of aquatic organisms. Temperature levels in waters that bear salmonids are also very important.

The stream monitoring program targets rivers and streams that cross sewer trunk lines and those that are considered a potential source of pollutant loading to a major water body. This long-term program has sampled at 54 sites on four rivers and twenty-eight streams for many years.

Ongoing Marine Monitoring

King County's marine monitoring program routinely evaluates nutrient, fecal coliform bacteria, dissolved oxygen, and stratification levels at offshore locations in the main basin of Puget Sound. Samples are collected near treatment plant and combined sewer overflow (CSO) outfalls to assess potential effects to water quality from wastewater discharges. Additional samples are collected at ambient locations to better understand regional water quality and to provide data needed to identify trends that might show impacts from long-term cumulative pollution.

Ongoing marine monitoring also includes fecal coliform bacteria monitoring of water at Puget Sound beaches near outfalls and at ambient locations and sediment quality monitoring near outfalls and at ambient locations.

Other Monitoring

In addition to ongoing water and sediment quality monitoring, the county conducts special intensive investigations. Currently, studies are under way to understand water quality issues and needs, to project future growth impacts, and to identify any needed improvements to salmon habitat in the two primary watersheds in King County. Other studies are under way to support decision-making, siting, and construction of wastewater capital projects.

In 2005, analysis was conducted of data collected in 2004 on shoreline armoring along Puget Sound in King County. The amount and locations of shoreline armoring, such as seawalls and bulkheads, are generally considered to be indicators of the condition of marine shorelines.

Web-Based Monitoring Data

In 2005, King County’s regional data management program completed substantial upgrades to the methods used to store and disseminate monitoring data. The public now has the ability to directly download substantial amounts of data from the Web, instead of requesting data from county staff.

The Swimming Beach monitoring page was upgraded to provide tables, graphs, and maps of monitoring results as they become available each week and to provide the most current information on beach closures. The Swimming Beach page is found at http://dnr.metrokc.gov/wlr/waterres/swimbeach/default.aspx.

The Large Lakes, Streams, and Marine Monitoring pages were upgraded to provide tables and graphs of the monitoring results as they become available each month and to allow for direct data download from the Web. Locations for these pages are as follows:

- Large Lakes Monitoring page: http://dnr.metrokc.gov/wlr/waterres/lakes/index.htm
- Streams Monitoring page: http://dnr.metrokc.gov/wlr/waterres/streamsdata/
- Marine Monitoring page: http://dnr.metrokc.gov/wlr/waterres/marine/Index.htm.

Table D-1. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Ambient Monitoring						
Marine monitoring	Water and sediments in areas of Puget Sound away from outfalls and CSOs; shellfish and algae from Puget Sound beaches	Water samples: temperature, salinity, clarity, DO, nutrients, chlorophyll, and bacteria Beach sediment: grain size, solids, TOC, metals, and organic compounds Shellfish: lipids, bacteria, metals, and organic compounds Macroalgae samples: metals	Water samples collected at multiple depths, ranging from 1 to 200 m Sediments, shellfish, and algae: from single sites	Water samples: monthly Beach sediment: annually Shellfish & macroalgae: annually	Voluntary—to assess potential effects to water quality from nonpoint pollution sources and to compare quality against point source data	Ongoing
Major lakes monitoring	Cedar-Sammamish Watershed (WRIA 08) only: Lakes Washington, Sammamish, and Union	Temperature, DO, pH, conductivity, clarity, phosphorus, nitrogen, and fecal coliform; micorcystin is measured at select stations	Samples collected every 5 m from 1 m below the surface to near the lake center bottom and around the shoreline	Biweekly during the growing season; monthly during the rest of the year	Voluntary—to monitor the integrity of the wastewater conveyance system and the condition of lakes	Ongoing
Small lakes monitoring	Volunteers monitor 51 small lakes in King County	Precipitation, lake level, temperature, Secchi depth, phosphorus, nitrogen, chlorophyll-a, phytoplankton	Single-point and vertical profiles	Rainfall & lake level: daily Temperature & Secchi depth: weekly Other parameters: every 2 weeks April to October	Voluntary—to characterize and identify trends in water quality	Ongoing

BOD = biochemical oxygen demand; DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; SAP = sampling and analysis plan.

Table D-1. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Rivers and streams monitoring	Rivers and streams of both watersheds; emphasis on those that cross wastewater conveyance lines or that could be a source of pollution	Baseflow and storm samples: turbidity, TSS, pH, temperature, conductivity, DO, nutrients, ammonia, bacteria Storm samples: trace metals Sediment quality at selected stations	Various	Monthly sampling under baseflow conditions Three to six times per year at mouth of streams under storm conditions	Voluntary—to monitor the integrity of the wastewater conveyance system and the condition of streams and rivers	Ongoing
Swimming beach monitoring	Cedar-Sammamish Watershed: Lake Washington, Lake Sammamish, and Green Lake	Bacteria	Water samples at swimming beaches	Summer	Voluntary—to evaluate human health risks and necessity for beach closures	Ongoing
Benthic macroinvertebrate monitoring	Wade-able stream sub-basins	Size and distribution of aquatic macroinvertebrate populations	Samples colllected with a Surber stream bottom sampler	Yearly	Voluntary—to establish a baseline for identifying long-term trends	Ongoing
Wastewater Plant Outfall Monitoring						
Marine wastewater plant outfall water column and beach monitoring	Water in Puget Sound near treatment plant outfalls; sediment, shellfish and algae at beaches near outfalls	Same parameters as in the marine ambient monitoring program	Water samples at outfalls: collected at multiple depths, ranging from 1 to 150 m	Water samples: monthly Beach sediment: annually Shellfish & macroalgae: annually	Voluntary—to assess potential effects to water quality from wastewater discharges	Ongoing
Marine NPDES sediment monitoring	Sediments in Puget Sound near treatment plant outfalls and the Denny Way CSO	Sediment samples at outfalls: grain size, solids, sulfides, ammonia-nitrogen, oil & grease, TOC, metals, organic compounds, and (at South and West Point plants) benthic infauna	Sediment samples in a grid pattern as defined in the SAP approved by Ecoloogy	Sediment samples at outfalls once per permit cycle	NPDES permit requirement	Ongoing

BOD = biochemical oxygen demand; DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; SAP = sampling and analysis plan.

Table D-1. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Special Studies						
Sammamish-Washington Analysis and Modeling Project (SWAMP)	Water and sediments in major lakes—and their inflowing streams	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Various		Voluntary—to develop a computer model of the watershed	Complete in 2006
Sediment Study	Lakes Washington, Sammamish, and Union	Toxic chemicals & benthic community structure	Grab samples	Lake Sammamish in 1999; Lake Washington in 2000; Lake Union in 2001	Voluntary—to develop a baseline characterization	Completed in 2001; report issued in 2004
Ecological and Human Health Risk Assessment	Water bodies in Cedar-Sammamish watershed	Existing water, sediment, and tissue data	Various, using a tiered approach	Using existing data from other sampling efforts	Voluntary—to assess ecological and human health risk associated with exposure to chemicals of concern	Complete in 2006
Green-Duwamish Water Quality Assessment (G-DWQA)	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Broad spectrum of water quantity and quality, biological, and physical parameters	Various	Intensive	Voluntary—to develop models, evaluate BMPs, prepare risk assessments	Complete in 2006
Storm Impact Water Quality Monitoring	Water in Green and Duwamish Rivers—and their inflowing rivers and streams—under storm flow conditions	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Various	Intensive	Voluntary—to evaluate conditions and to support modeling and WRIA planning	Completed in 2003; report issued in 2004
Loadings Calculations	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Broad spectrum of water quantity and quality, sediment quality, biological, and physical parameters	Estimates based on water quality data and on literature reviews for land use classifications		Voluntary	Complete in 2006

BOD = biochemical oxygen demand; DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; SAP = sampling and analysis plan.

Table D-1. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Temperature and DO Studies	Water in Green and Duwamish Rivers—and their inflowing rivers and streams	Daily fluctuations in temperature and DO, especially in the summer	Continuously recording data loggers	Intensive	Voluntary—to evaluate conditions and to support modeling and WRIA planning	Completed in 2003; temperature report issued in 2004; DO report to be issued in 2006
Microbial Source-Tracking Study	Green River and its tributaries	Land uses and bacterial sources associated with bacterial populations		Intensive	Voluntary—to assist in setting and measuring TMDLs	Completed in 2004; report will be issued in 2006
Brightwater Outfall Studies (wastewater capital project)	Water, sediment, & eelgrass for the proposed Brightwater outfall site Upland soils at outfall Portal 19	Water quality: temperature, salinity, DO, nutrients, and fluoresence Sediments: borings for chemicals Upland soils: total petroleum hydrocarbons, lead, and volatiles	Water column samples and continuous buoy readings Borings Soil samples Eel grass diver survey	Intensive	Voluntary--to support the design of the Brightwater outfall	Complete in 2010
Brightwater Surface Water Characterization (wastewater capital project)	Water samples of surface runoff from proposed treatment plant site and Little Bear Creek upstream and downstream of site.	Temperature, pH, DO, specific conductance, alkalinity, BOD, total dissolved solids,TSS, and turbidity	Auto-samplers	Intensive	Voluntary—to support permitting of the Brightwater plant	Completed in 2004; draft report was issued in 2005
Norfolk post-remediation sediment monitoring (wastewater capital project)	Sediment near the Norfolk CSO on the Duwamish River	Chemicals	Sediment samples per approved SAP	Intensive	Regulatory—under a 1991 Consent Decree	Completed in 2004

BOD = biochemical oxygen demand; DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; SAP = sampling and analysis plan.

Table D-1. Summary of King County Water Quality Monitoring Programs

Program	Media and Locations	Parameters	Methods	Sampling Frequency	Program Purpose	Duration
Denny Way/Lake Union pre-remediation sediment monitoring (wastewater capital project)	Sediment near the Denny Way and Lake Union CSOs	Benthic communities	Sediment samples per approved SAP	Intensive	Regulatory—under a NOAA Fisheries Section 7 ESA consultation	Completed in 2004
Diagonal/Duwamish post-remediation sediment monitoring (wastewater capital project)	Sediments near the Seattle Diagonal storm drain (includes City and county CSO) and the county's Duwamish CSO	Sediment chemistry, turbidity, cap surveys	Sediment samples per approved SAP	Intensive	Regulatory—under an EPA/Ecology Order	Through 2013

BOD = biochemical oxygen demand; DO = dissolved oxygen; TOC = total organic carbon; TSS = total suspended solids; SAP = sampling and analysis plan.

Marine Water

This section describes the results of marine monitoring activities in 2005. The discussion focuses on fecal coliform bacteria levels and on overall water quality as measured by the water quality index. It ends with a description of shoreline armoring along the Puget Sound shoreline.

Monitoring Locations

Figures D-1 and D-2 show ambient and outfall monitoring locations in Puget Sound. Ambient sites are chosen to reflect general environmental conditions. Outfall monitoring sites are located at King County wastewater treatment plant and CSO outfalls. Both offshore and nearshore (beach) areas are monitored.

Fecal Coliform Bacteria

Offshore Ambient and Outfall Locations

Levels of fecal coliform bacteria at offshore Puget Sound locations are measured to gauge the risk posed to human health from recreational uses of these waters. For marine surface waters, the current fecal coliform standard is a geometric mean of 14 colony forming units (cfu)/100 mL. All ambient and outfall sites met the fecal coliform standard in 2005; and in the five previous years. Bacteria levels tend to be higher in Elliott Bay than at other sites because of quantity of freshwater that carries fecal coliform to the bay.

Nearshore (Beach) Ambient and Outfall Locations

Fecal coliform bacteria levels in Puget Sound beach locations are measured to assess the health effects from direct contact with marine waters during activities such as swimming, wading, SCUBA diving, and surfing. To meet the state standard, the geometric mean of samples collected should not exceed 14 cfu/100 mL and not more than 10 percent of the samples used to calculate the geometric mean should exceed 43 cfu/100 mL (the peak standard).

In 2005, 17 Puget Sound beach sites were monitored monthly for fecal coliform bacteria. The results indicate that 9 of the 17 sites meet both the geometric mean and peak standards and are at a low level of concern, 5 sites meet the geometric mean standard but not the peak standard, and 3 sites do not meet either standard. The three sites of highest concern—Pipers Creek Mouth, Shilshole Bay, and Alki Point South—are near freshwater sources or storm drains with high fecal coliform counts. Specialized sampling conducted at Alki Point South in 2005 to determine the possible source of the bacteria indicate that a freshwater flow is the likely cause. The number of fecal coliform exceedances at beaches near outfalls was similar to beaches without a known point source nearby.

The percentage of Puget Sound beach sites meeting fecal coliform standards in 2005 has almost doubled since 1998 (Figure D-3). The fluctuation in water quality over time is most likely caused by annual variability in amount and intensity of rainfall. For example, 1996 through 1999 were substantially wetter than average years, which is the likely explanation for higher fecal coliform levels in 1998 and 1999.

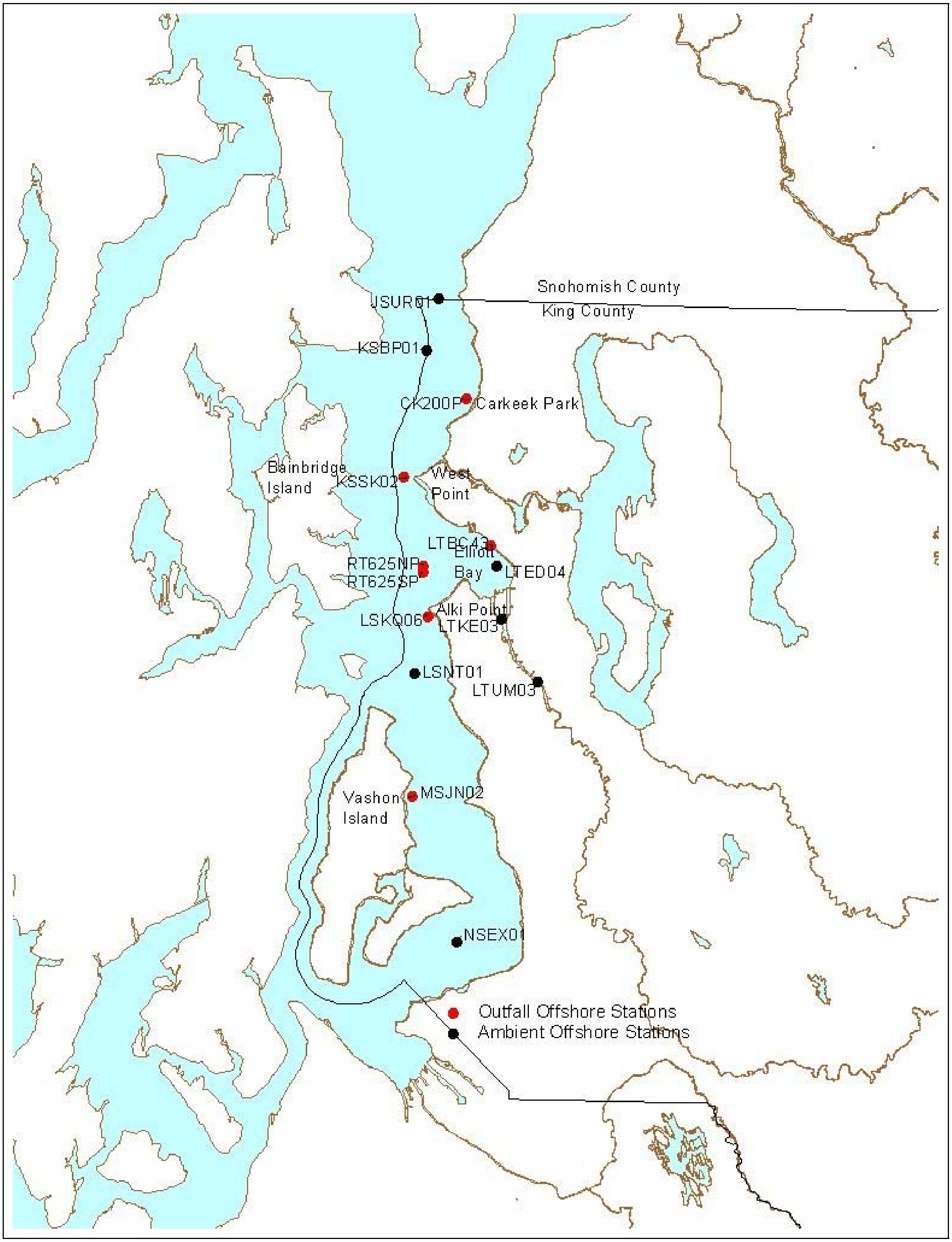

Figure D-1. Offshore Ambient and Outfall Monitoring Locations in Puget Sound

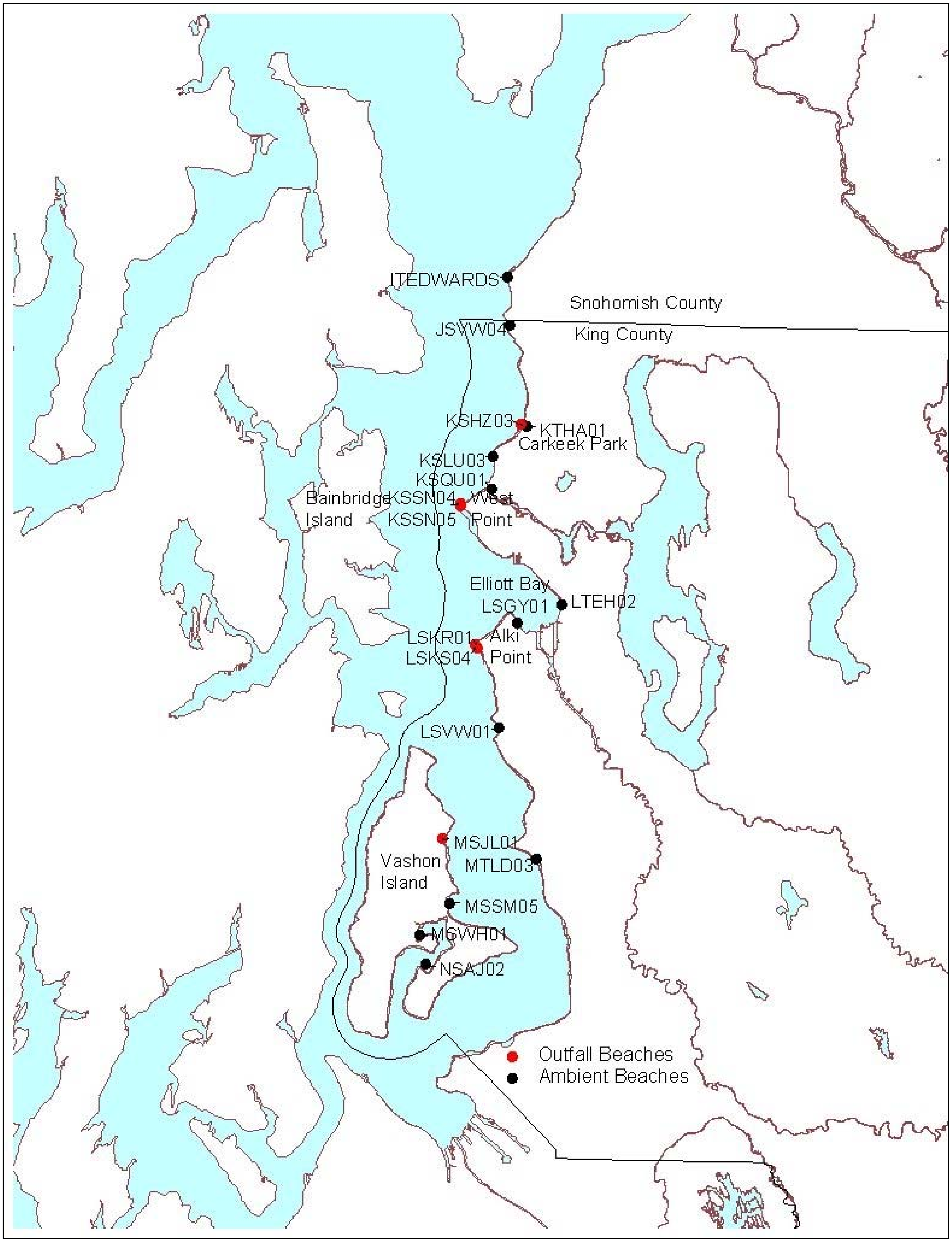

Figure D-2. Nearshore (Beach) Ambient and Outfall Monitoring Locations in Puget Sound

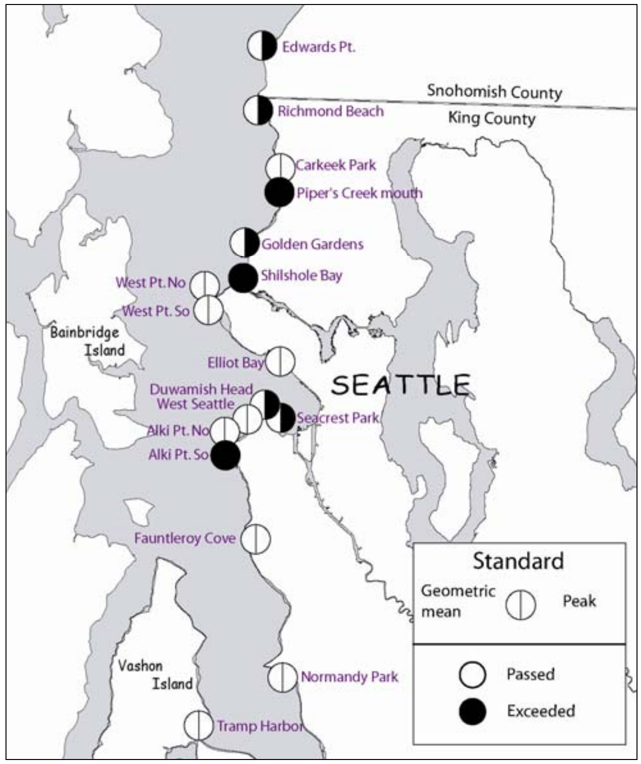

Figure D-3. Pass-Fail Status of Puget Sound Beach Monitoring Sites for Fecal Coliform Bacteria Standards, 2005

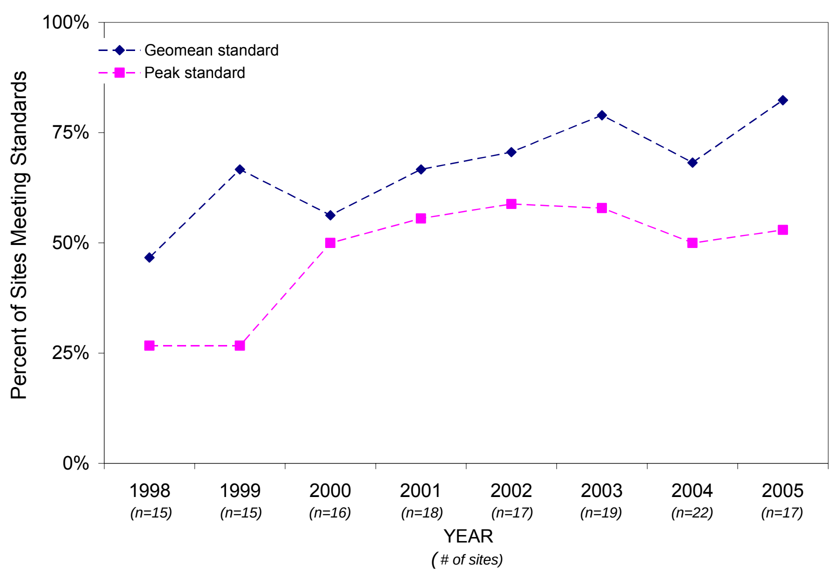

Figure D-4. Percentage of Puget Sound Beach Monitoring Sites that Met Fecal Coliform Bacteria Standards, 1998-2005

Overall Quality—Marine Offshore Water Quality Index

King County uses a modified version of the water quality index developed by the Washington State Department of Ecology to assess overall quality of offshore marine water. The determination is based on four indicators: dissolved oxygen (DO), dissolved inorganic nitrogen (DIN), ammonia, and stratification strength and persistence. Each location is categorized as low, moderate, or high concern.

The 2005 findings indicate that the water quality at all of the ambient and outfall offshore stations is at a level of low concern. Although the ambient station in Elliott Bay experienced strong-intermittent stratification, low DO levels were not observed. Areas where strong or persistent stratification occurs, however, should be regarded as areas where significant nutrient loading could lower DO concentrations. DO concentrations below the threshold (5 mg/L for two consecutive months) were observed at the ambient station located in the East Passage of Puget Sound. These concentrations occurred in the fall as a result of the natural seasonal influx of low oxygenated Pacific Ocean water into the deep main basin of Puget Sound.

Figure D-4 shows the percentage of the 8 to 11 offshore stations categorized as moderate or high concern in 1999 through 2005. The percentage of stations of moderate or high concern reached a maximum in 2000 (22 percent) and has declined to zero percent for the past two years.

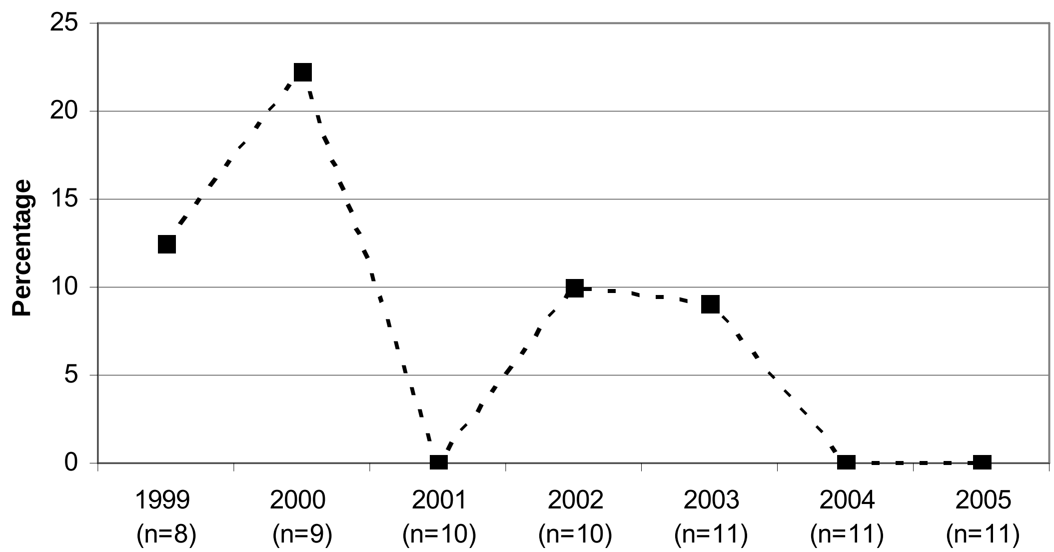

Figure D-4. Percentage of King County Offshore Stations with Moderate or High Concern Rankings Based on Water Quality Index, 1999-2005

Shoreline Armoring

Shoreline armoring is a general indicator of the condition of marine shorelines. Data on shoreline armoring along Puget Sound in King County were collected in 2004. This is the first time that comprehensive armoring data have been available for the area. The study characterized marine shorelines by whether they were armored and by their historical and current role in the sediment transport process.

What is shoreline armoring?

Shoreline armoring can be hard protective structures such as vertical seawalls, revetments (facings of stone placed on a bank or bluff to protect a slope), riprap (permanent cover of rock used to stabilize streambanks), and bulkheads.

Table D-2. Percentages of Unarmored Shoreline in King County

Jurisdiction	% Unarmored
City of Federal Way	51.81%
Unincorporated KC (Vashon)	51.25%
City of Normandy Park	43.55%
City of Shoreline	19.56%
City of Des Moines	15.87%
City of Burien	13.53%
City of Seattle	12.03%

The spatial distribution of shoreline armoring reveals a striking contrast between the mainland shoreline and the Vashon and Maury Island shorelines (Table D-2). The islands have less modified shoreline and more natural habitat than along most of the mainland. As expected, the City of Seattle was the most armored. Somewhat unexpected was the trend toward decreasing amounts of armoring moving south along the mainland shoreline, particularly given Federal Way's proximity to the City of Tacoma.

The data show that many of the beach-feeding sediment sources are trapped behind armoring.

Major Lakes

This section describes the results of fecal coliform bacteria sampling in ambient and swimming beach locations in the major lakes in King County. It also describes overall water quality in these lakes based on calculation of their Trophic State Index.

Monitoring Locations

Figure D-5 shows the 25 ambient sampling locations in Lakes Washington, Sammamish, and Union and in the Ship Canal. Figure D-6 shows the 21 swimming beach sampling locations in Lake Washington, Lake Sammamish, and Green Lake.

Figure D-5. Ambient Monitoring Locations in Lakes Washington, Sammamish, and Union (including the Ship Canal)

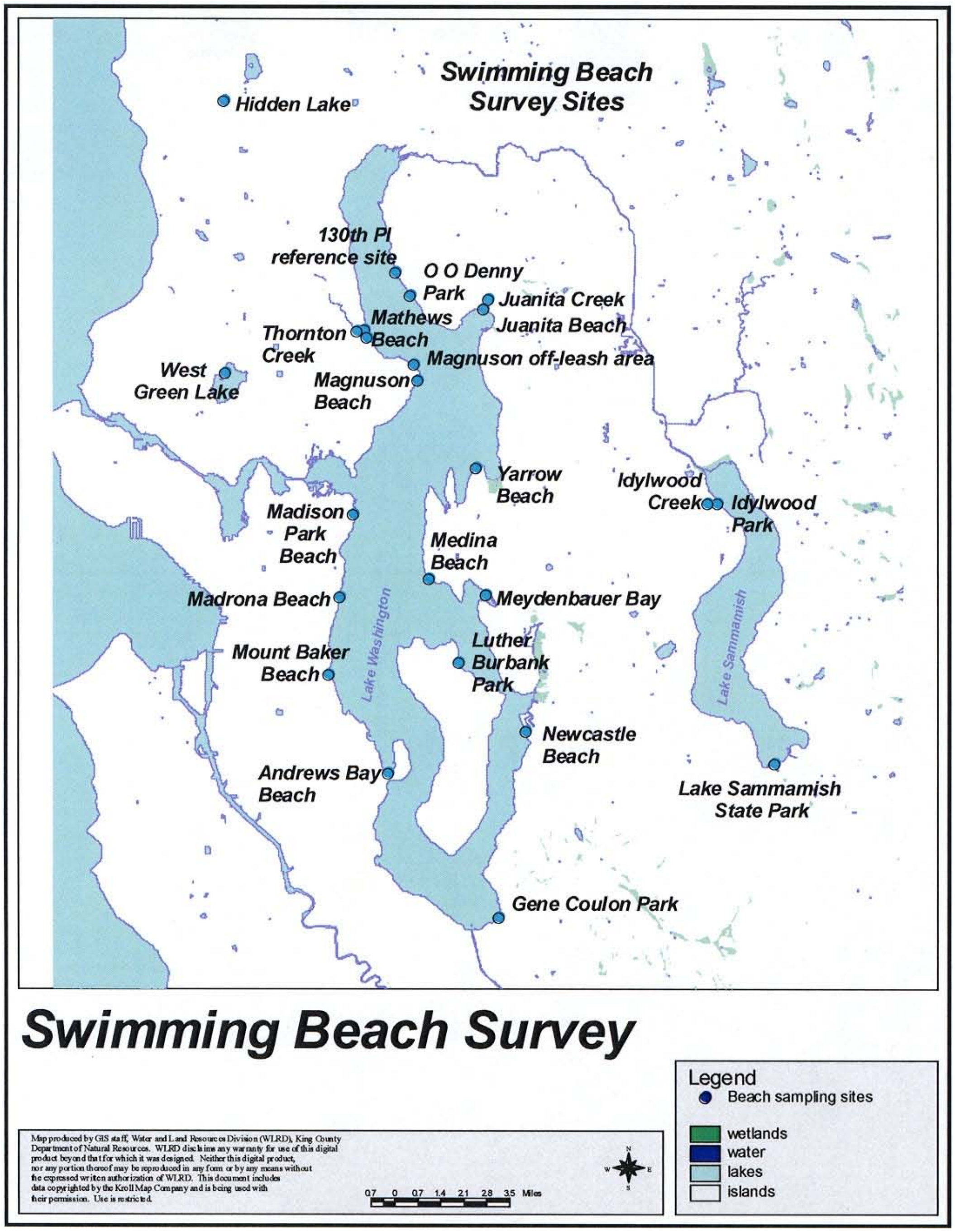

Figure D-6. Swimming Beach Monitoring Locations in Lake Washington, Lake Sammamish, and Green Lake

Fecal Coliform Bacteria—Ambient Mid-Lake (Open-Water) and Nearshore

The lake standard for fecal coliform bacteria addresses human risk resulting from direct contact with the water during activities such as swimming and wading. The standard is a geometric mean value of less than 50 colonies/100 mL with no more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 100 colonies/100 mL (WAC 173-201A). Sites used for this indicator are located in both mid-lake (open water) and nearshore locations.

Even though this measure uses an exceptionally high standard, 100 percent of the Lake Sammamish samples and 97 percent of the Lake Washington samples achieved this standard in 2005 (Figure D-7). Fewer samples in Lake Union met this standard (86 percent), most likely resulting from the influence of numerous CSO and stormwater outfalls in the lake. Two major projects to reduce flows from CSOs were completed after the unusually high precipitation that occurred during the spring of 2005. These projects are expected to reduce fecal coliform levels in Lake Washington and Lake Union, as well as in Elliott Bay.

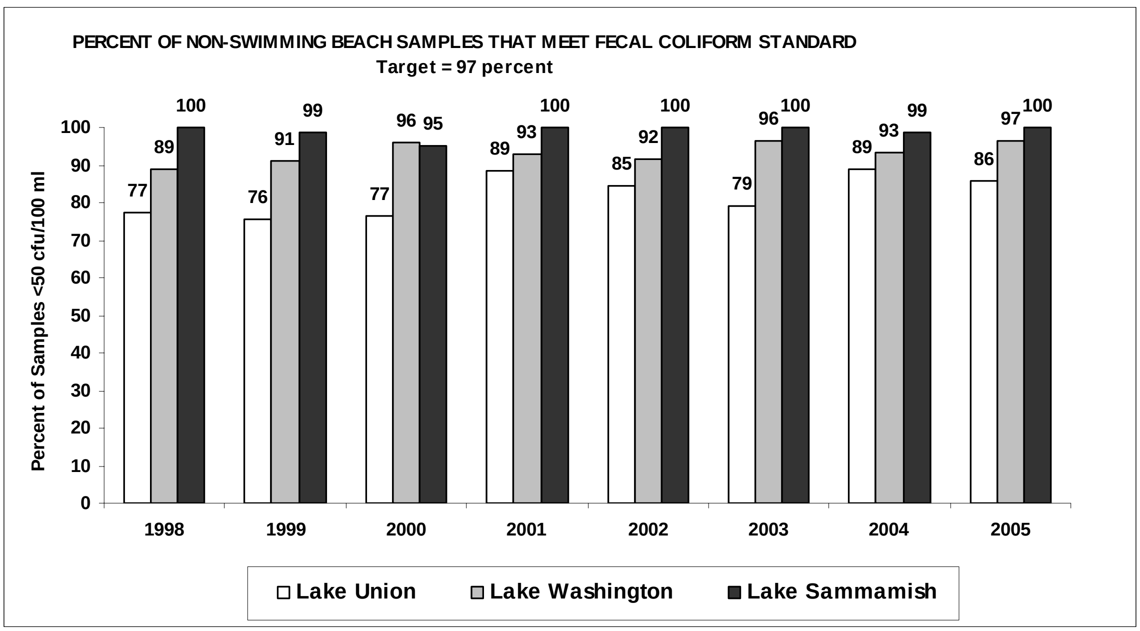

Figure D-7. Percentage of Ambient Samples in Lakes Washington, Sammamish, and Union that Met the Fecal Coliform Bacteria Standard, 1998–2005

Fecal Coliform Bacteria—Swimming Beaches

King County’s standard for acceptable fecal coliform bacteria levels in swimming beaches is less than 200 colonies/100 mL in any sample. Public Health-Seattle & King County and the Washington State Department of Health currently use this standard, which is called the Ten State Standard.

All samples collected at Green Lake met the fecal coliform standard for the second year in a row (Figure D-8).

Levels at swimming beaches in Lakes Sammamish and Washington remained fairly consistent with slight variability from year to year (Figures D-9 and D-10). In Lake Sammamish, 89 percent of the samples collected in 2005 met the standards, down slightly from 2004 (91 percent). In Lake Washington, 85 percent of the samples met the standards, up from 79 percent in 2004. A greater number of bacterial exceedances occurred at the swimming beaches than at the ambient monitoring sites in these two lakes.

Bacterial counts for all beaches monitored in Lake Sammamish were within acceptable ranges and did not warrant swimming beach closures. Four Lake Washington swimming beaches were closed in July 2005: Matthews, Newcastle, Juanita, and Gene Coulton Beaches. Matthews Beach was closed because of high-bacteria stormwater inflow from Thornton Creek and was reopened after the streamflow diminished. Waterfowl were suspected as sources of bacteria in the Newcastle and Juanita Beach closures. The most likely source of the bacteria at Gene Coulon Beach was waterfowl. There were no sewer line breaks, spills, or leaks; nor is there an adjacent stream that contributes high counts of bacteria into the swimming area.

Overall Quality in Major Lakes—Trophic State Index

Overall water quality in Lakes Washington, Sammamish, and Union is determined by measuring the summer total phosphorus concentrations and converting them to the Trophic State Index (TSI-TP). The Trophic State Index relates phosphorus to the amount of algae that the lake can support. The potential for nuisance algal blooms is considered low if the TSI-TP is less than 40, moderate if less than 50, and high if greater than 50.

Water quality in these lakes varies annually, depending on watershed inputs, weather, and biological interactions. The 1994–2005 results for these three lakes show the values fluctuating across the low-to-moderate threshold, indicating that the water quality varies from good to moderate (Figure D-11). In the past five years, Lake Union typically has fallen in the moderate range, Lake Washington in the low range, and Sammamish in both ranges.

High algae productivity often relates to poor water quality. Although such high productivity may not reduce beneficial uses in all cases, depending on the natural condition of the lake, a trend toward increased TSI-TP could indicate changes in the watershed.

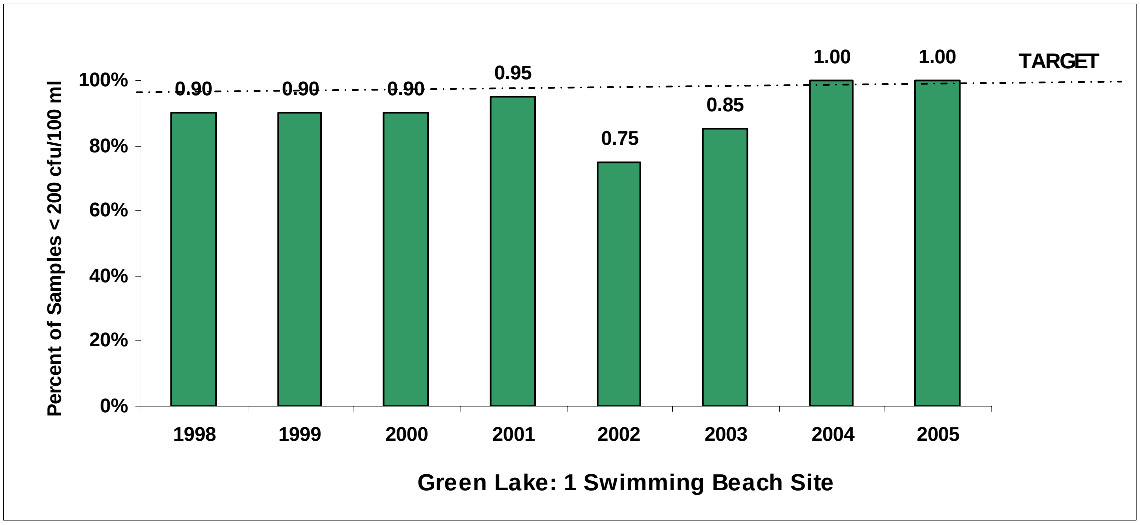

Figure D-8. Percentage of Samples that Met the Fecal Coliform Bacteria Standard at Green Lake Swimming Beaches, 1998–2005

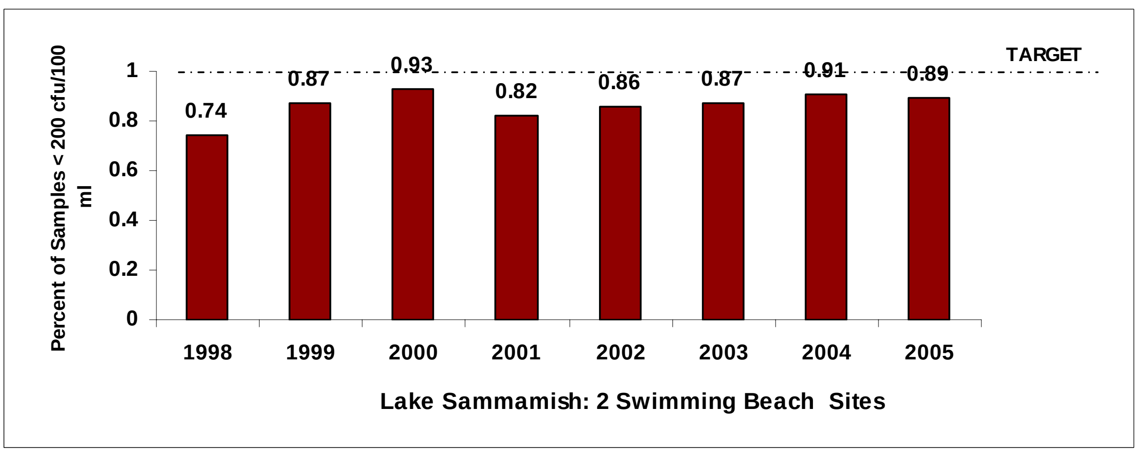

Figure D-9. Percentage of Samples that Met the Fecal Coliform Bacteria Standard at Lake Sammamish Swimming Beaches, 1998–2005

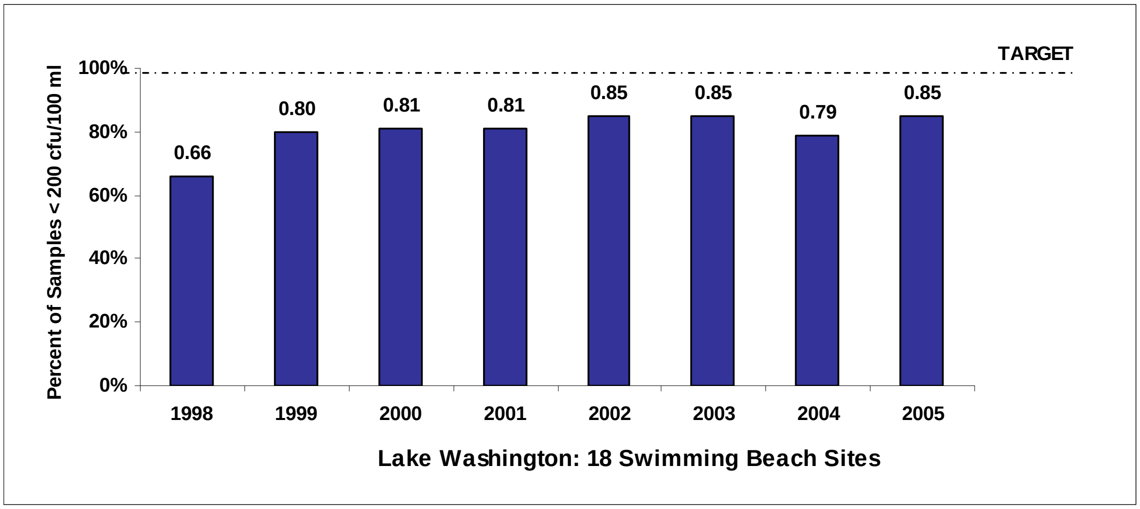

Figure D-10. Percentage of Samples that Met the Fecal Coliform Bacteria Standard at Lake Washington Swimming Beaches, 1998–2005

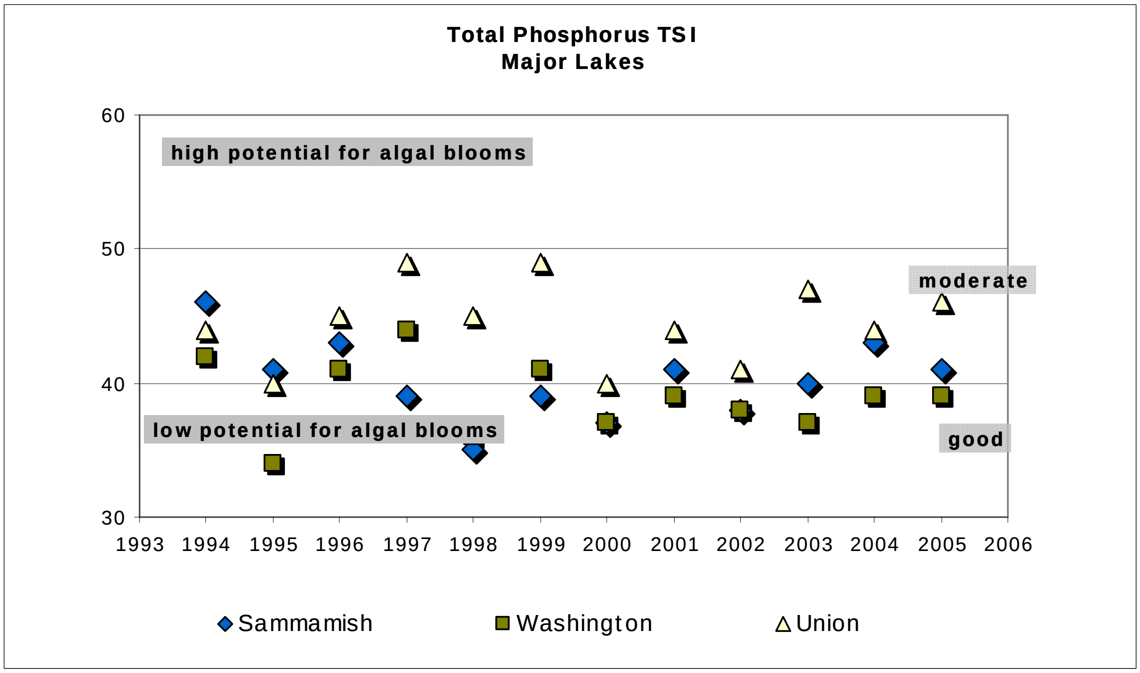

Figure D-11. Overall Water Quality in Lakes Washington, Sammamish, and Union Based on Trophic State Index, 1994–2005

Water Temperature—Effects of Climate Change

Global climate change is having an impact on our local weather patterns and subsequently on county aquatic resources. On average, ambient air temperatures in the Pacific Northwest have increased over the twentieth century by roughly 1.5ºF.[2] Air temperatures in the region are expected to continue to increase by another 2 to 9ºF over the next 80 years.

Warmer temperatures have reduced the snow pack levels in Washington and, thus, the timing and quantity of flows in regional rivers and streams. Higher air temperatures and changes in wind patterns also increase lake temperatures through surface heat exchange processes. January water temperatures are taken at a 1-meter depth from the mid-lake monitoring stations in Lakes Washington, Sammamish, and Union (Figure D-12). Because the lakes are well mixed during January, temperatures at the surface reflect the temperatures throughout the water column.

The University of Washington has measured temperatures in Lake Washington since 1960. King County (then Metro) began monitoring temperatures in Lakes Washington, Sammamish, and Union in 1979. Additional Lake Washington data were collected in 1913 and 1933. Lake temperatures vary annually, depending on seasonal weather conditions (wind, precipitation, cloudiness, ambient air temperatures). Overall, winter water temperatures have increased about 0.25^{o}C (0.45^{o}F) per decade since 1960 in Lake Washington and about 1^{o}C (1.8 ^{o}F) per decade since 1979 in Lakes Sammamish and Union. The smaller increase in Lake Washington is likely due to its larger volume, which is roughly 8 times greater than Lake Sammamish and 118 times greater than Lake Union.

[2] http://www.cses.washington.edu/cig/pnwc/pnwc.shtml

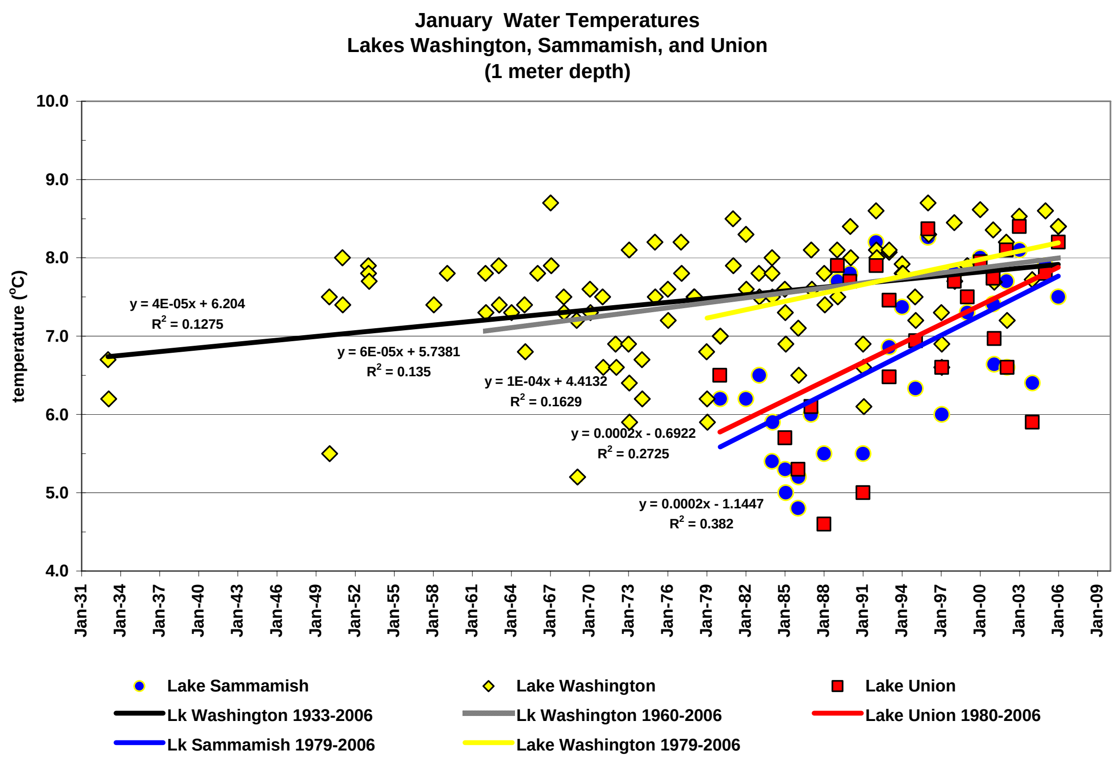

Figure D-12. January Water Temperatures in Lakes Washington, Sammamish, and Union, 1931–2006

Rivers and Streams

This section describes the quality of water in King County rivers and streams in terms of overall water quality (Water Quality Index) and normative streamflows.

Monitoring Locations

Fifty-six sites in rivers and streams in the Lake Washington and Green-Duwamish drainage basins were sampled monthly from 2001 through 2005 for numerous water quality parameters, including those used to determine the Water Quality Index (Figure D-13).

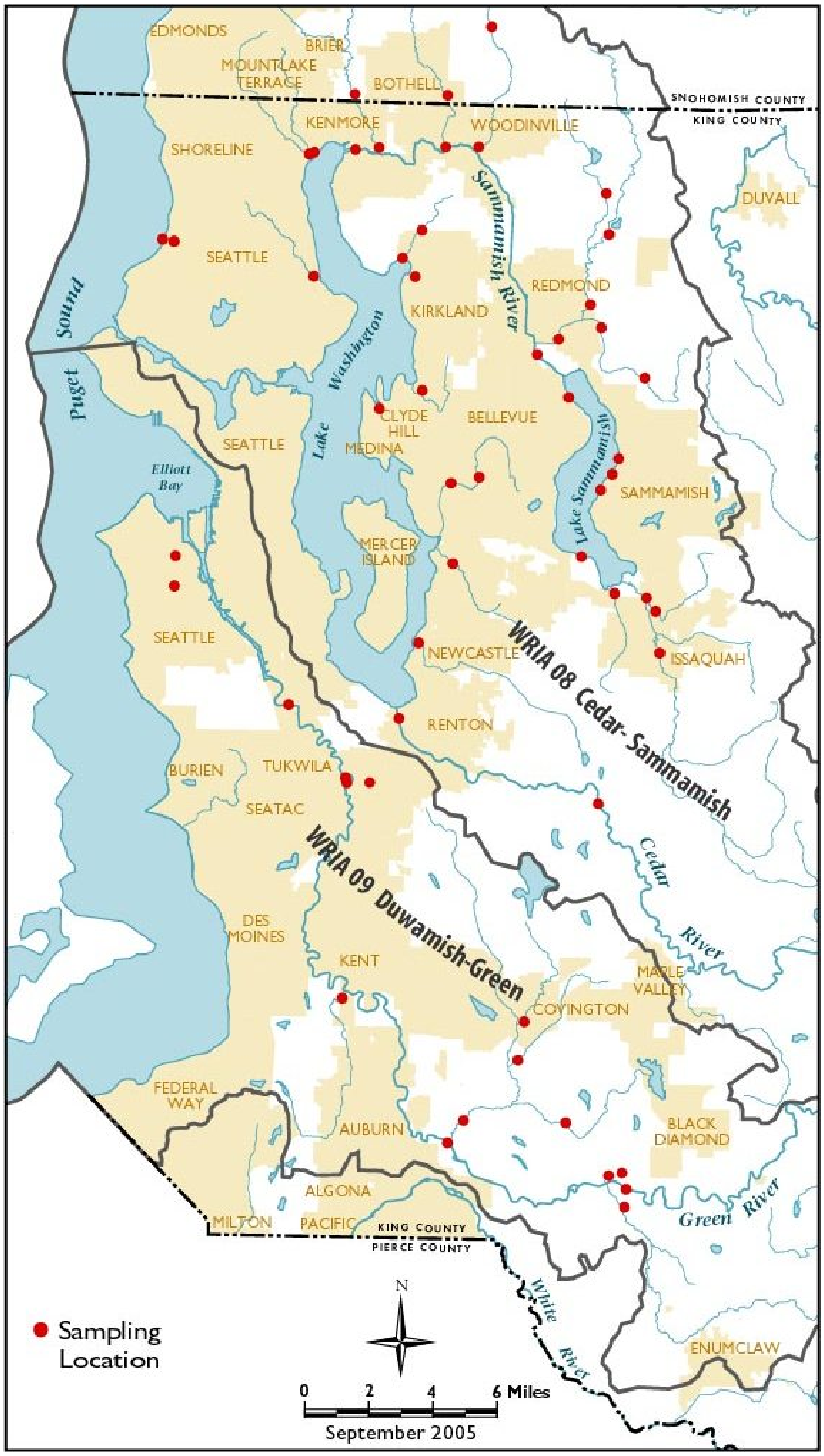

Figure D-13. River and Stream Monitoring Locations

Overall Quality—Water Quality Index

The Water Quality Index (WQI) for rivers and streams attempts to integrate a series of key water quality indicators into a single number that can be used for comparison over time and among locations. The WQI is based on a version proposed by the Washington State Department of Ecology and originally derived from the Oregon Water Quality Index. The WQI is a number ranging from 10 to 100—the higher the number, the better the water quality. For temperature, pH, fecal coliform bacteria, and dissolved oxygen (DO), the index expresses results relative to state standards required to maintain beneficial uses. For nutrient and sediment measures, where the state standards are not specific, results are expressed relative to expected conditions in a given eco-region. Multiple constituents are combined and results aggregated over time to produce a single score for each sampling station.

Given a population of almost two million residents and the intense urbanization of the area, overall stream water quality in King County is fairly good. Water quality at 36 of the 56 sites, or 64 percent, was considered either low or moderate concern, while 20 sites (or 36 percent) were rated high concern. In Water Resource Inventory Area (WRIA) 9—the Green-Duwamish basin, 6 of the 16 sites were rated as low concern, 8 sites as moderate concern, and 2 sites as high concern (Figures D-14 and D-15). Of the 40 sites in WRIA 8 (Lake Washington basin), no sites were rated as low concern, 22 sites as moderate concern, and 18 as high concern (Figures D-16 and D17). High concern ratings were caused at least in part by excessive nutrients (phosphorus) at all 20 sites, high bacteria levels at 17 sites, low DO concentrations at 12 sites, and high temperatures at 5 sites.

Because high phosphorus concentrations are found in fecal material, elevated phosphorus concentrations are often linked to the same sources that cause higher bacteria levels. Phosphorus is also released from the sediment when DO concentrations are low. In addition, elevated phosphorus concentrations are linked to areas with high volumes of stormwater runoff and areas undergoing development.

Pets and failing septic systems are the most likely sources of bacteria in the urban areas. Poor livestock management practices can be a potential source of bacteria in agricultural areas. In wetland areas, wildlife and stagnant water conditions can lead to elevated bacteria counts.

Low DO concentrations can be associated with low flows, high temperatures, and high levels of organic matter. Low flows and high temperatures were a particular problem during late summer 2005. There were extended dry periods, and the cumulative rainfall was relatively low compared to historical values. Finally, lower instream flows exacerbate every measurement in the WQI.

Normative Streamflows

In urban areas, streams respond more quickly to rainfall with higher peak flows rising and falling more rapidly than under forested conditions. Because less rainfall is being absorbed by the vegetation and soil, there is more surface runoff. Higher, more rapid and frequent pulses of runoff (“flashiness”) lead to flooding and channel erosion. From a biological perspective, streams with more frequent peak flows are disturbed more often. Organisms that survive in these conditions are those that have adapted to more frequent and severe disturbances.

Flows from 16 stream sites were measured and their flashiness calculated during the 2005 water year (October 2004–September 2005). For 10 streams, flashiness was compared between actual data and a watershed model simulation under fully forested conditions over a period of 50 years.[3] Seven of the ten streams were flashier (higher peak flows and less annual flow) than if they had existed in forested conditions (Figure D-18). Over the past 36 years, average stream flashiness has been higher than would be expected under fully forested conditions, indicating an overall increase in flashiness at several monitoring locations in the county (Figure D-19).

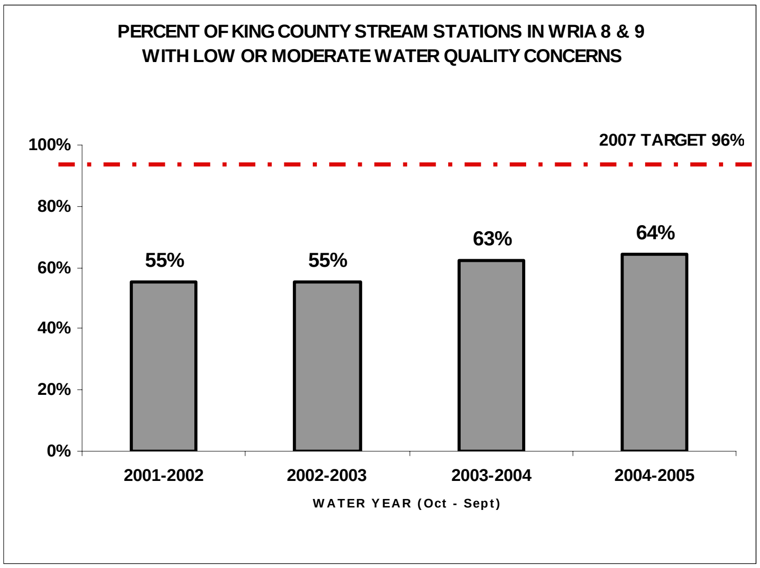

Figure D-14. Percentage of Streams in WRIAs 8 and 9 with Low or Moderate Water Quality Concerns Based on Water Quality Index, 2001–2005

[3] Flashiness is defined as the fraction of days during the year that flow rises above the annual mean daily flow.

Figure D-15. Water Quality Index Rankings for Rivers and Streams in WRIA 9, 2004–2005

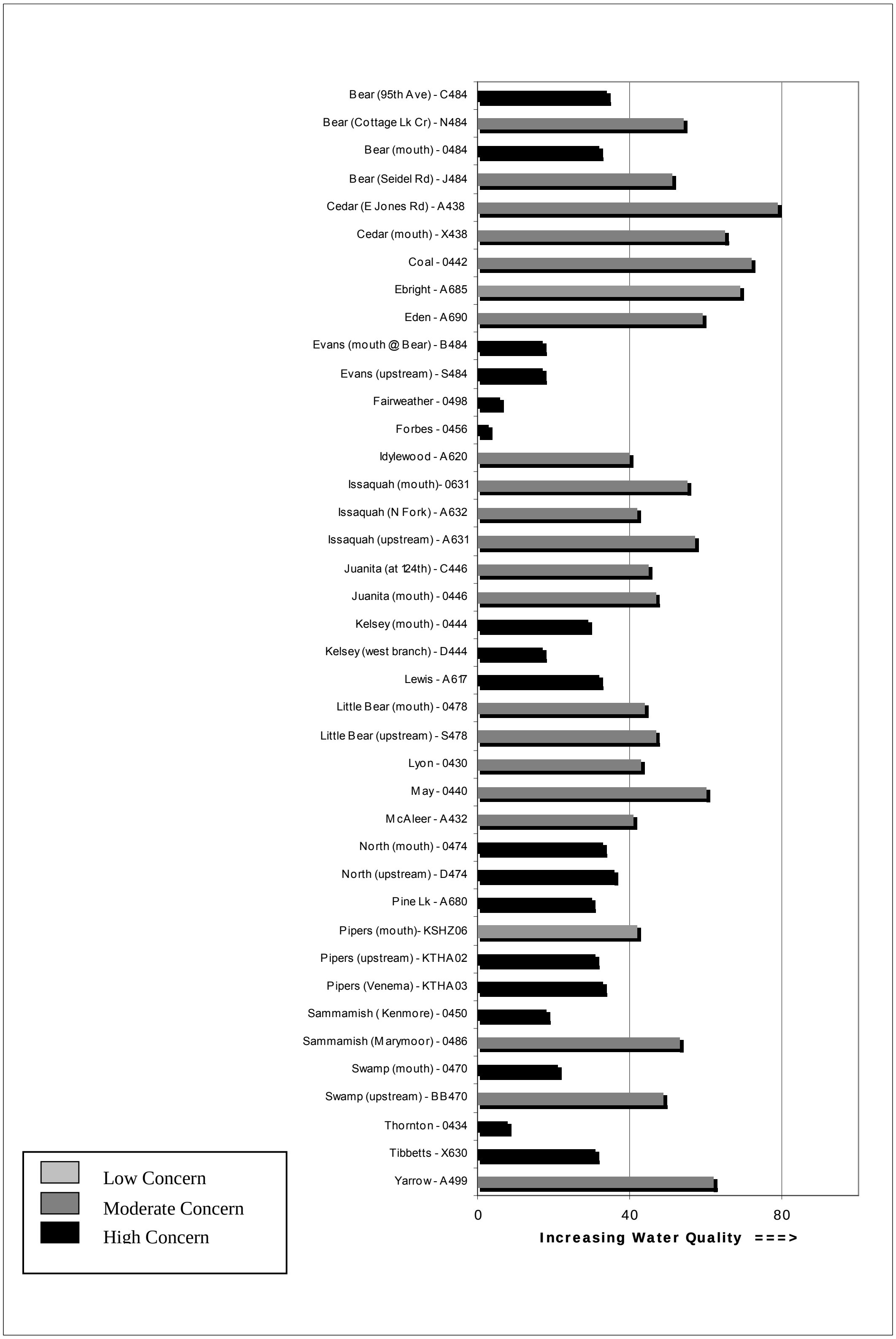

Figure D-16. Water Quality Index Rankings for Rivers and Streams in WRIA 8, 2004–2005

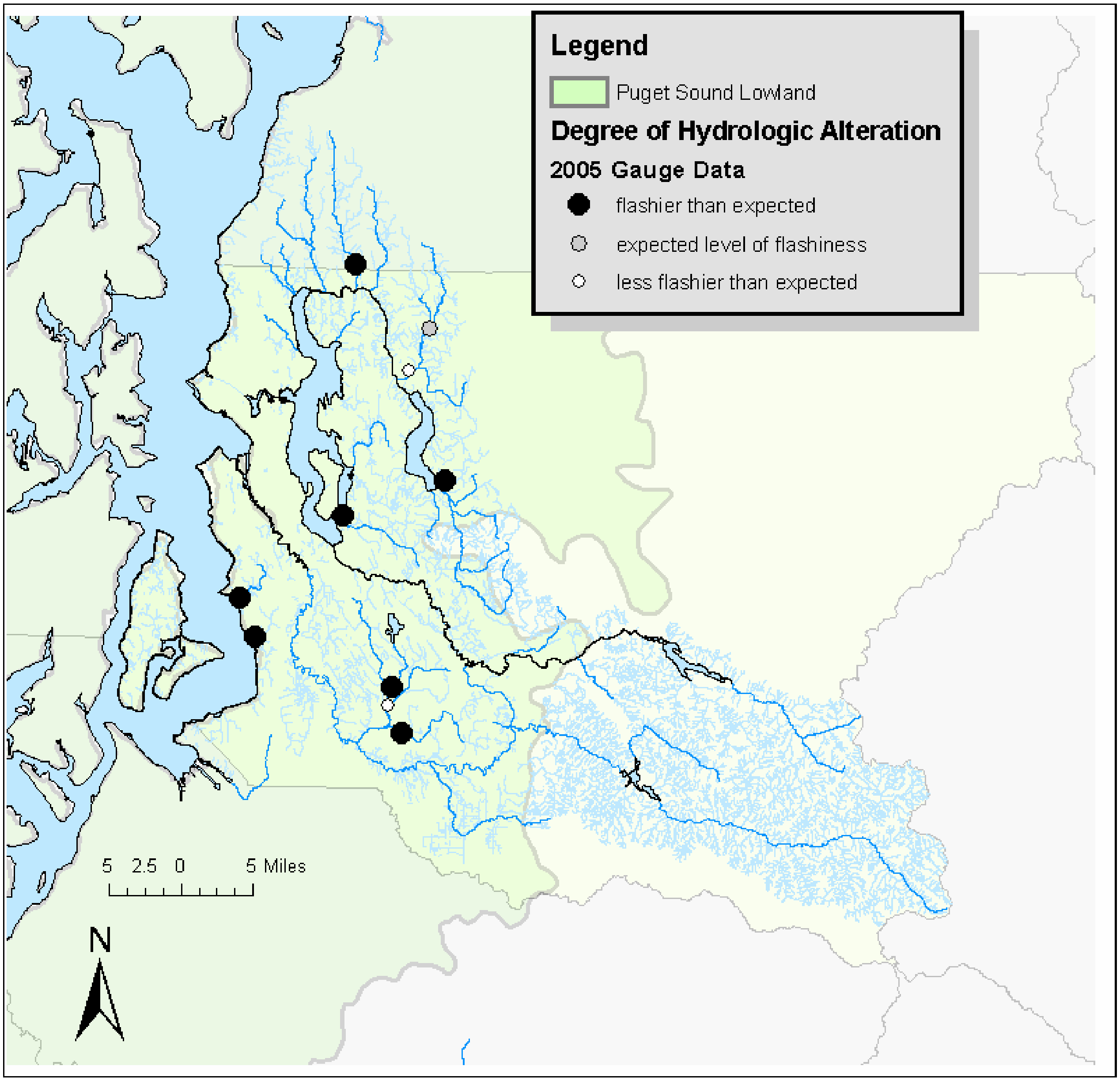

Figure D-17. Comparison of 2005 Stream Flashiness to Modeled Simulation of Flashiness in a Fully Forested Watershed

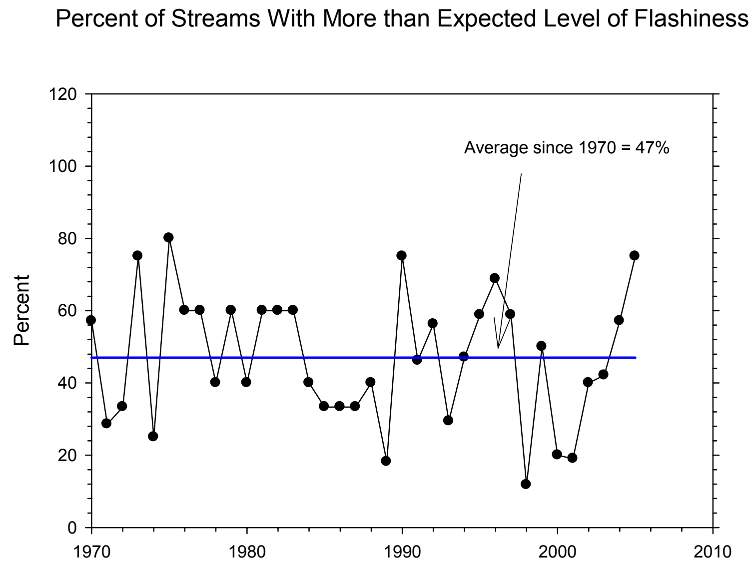

Figure D-18. Percentage of Times Stream Flashiness Was Greater Than Flashiness in Fully Forested Model Simulation, 1970–2005