Appendix O

The Health of Our Waters, Water Quality Monitoring Results for 2006

Contents

This appendix presents a summary of the quality of King County's marine water and freshwater bodies in 2006. 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 2006 Water Quality

Monitoring activities in 2006 found that in general, the quality of marine and fresh waters in King County is good.

With the exception of one site in Elliott Bay, all offshore marine monitoring locations in Puget Sound—both ambient and outfall sites—met fecal coliform bacteria standards in 2006. The percentage of nearshore marine sites (beaches) that met the standards has nearly doubled since 1998.[1] The two nearshore sites of highest concern are near freshwater sources—the mouth of the Lake Washington Ship Canal and a storm drain at Alki Point South. 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 three 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 stations, 92 percent of Lake Washington stations, and 80 percent of Lake Union stations met the exceptionally high fecal coliform standard used for lake water. These percentages represent a slight decrease for Lake Washington from 2005 percentages because of higher bacteria levels at one station.

Bacterial counts in 2006 at all swimming beaches monitored in Lake Washington, Lake Sammamish, and Green Lake were within acceptable ranges and did not warrant swimming beach closures. Bacteria levels were low in Green Lake for the second year in a row. Lakes Washington and Sammamish remained fairly consistent, with slight variability from year to year. In terms of overall water quality, as measured by the Trophic State Index, Lakes Sammamish, Washington, and Union were ranked as moderate in 2006.

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 the 2005–2006 water year, water quality at 35 of the 56 sites (63 percent) were rated either low or moderate concern, while 21 sites (38 percent) were rated high concern. A comparison of 2006 data with historical data for 17 streams in King County suggest that increased urbanization has resulted in faster surface runoff and peak streamflow rise and fall than have previously occurred in these streams. These conditions can lead to flooding, channel erosion, and disturbance to organisms.

[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.

Monitoring Programs

To protect public health and its significant investment in water quality improvements, King County regularly monitors wastewater treatment plant effluent, marine waters, beaches, major lakes, and streams (Table O–1). The biological, chemical, and physical parameters used to assess a water body's health under Washington State 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 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.

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.

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.

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.

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 56 sites on four rivers and twenty-eight streams for many years.

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.

Web-Based Monitoring Data

In 2006, King County's regional data management program continued to upgrade the methods used to store and disseminate monitoring data. This program is intended to allow the public 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 additional tables and graphs of monitoring results as they become available each month. These pages continue to allow for direct data download from the Web. Page locations 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.

The Streamflow monitoring page was upgraded to improve data presentation and data download ability. This page is found at http://dnrp.metrokc.gov/wlr/waterres/hydrology/.

Table O–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 Shellfish: lipids and metals	Water samples collected at multiple depths, ranging from 1 to 200 m Sediments and shellfish	Water samples*:* monthly Shellfish: annually; sediments: bi-annually	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 bottom at one station in center of lake and from the surface around various locations around the shoreline	Biweekly during the growing season; monthly during the rest of the year	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	To characterize and identify trends in water quality	Ongoing

BMP = best management practices; BOD = biochemical oxygen demand; DNR = Washington State Department of Natural Resources; DO = dissolved oxygen; Ecology = Washington State Department of Ecology; HPA = Hydraulic Permit Approval; SAP = sampling and analysis plan; TMDL = total maximum daily load; TOC = total organic carbon; TSS = total suspended solids.

Table O–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	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	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	Annually	To establish a baseline for identifying long-term trends	Ongoing
Wastewater Treatment Plant Outfall Monitoring						
Marine wastewater plant outfall water column and beach monitoring	Puget Sound water column at treatment plant outfalls; water and shellfish at beaches near outfalls	Water samples: temperature, salinity, clarity, DO, nutrients, chlorophyll, and bacteria Shellfish: lipids and metals	Water samples at outfalls collected at multiple depths, ranging from 1 to 200 m Shellfish	Water samples: monthly Shellfish: annually	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	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 Ecology	Sediment samples at outfalls once per permit cycle (about every 5 years)	NPDES permit requirement	Ongoing

BMP = best management practices; BOD = biochemical oxygen demand; DNR = Washington State Department of Natural Resources; DO = dissolved oxygen; Ecology = Washington State Department of Ecology; HPA = Hydraulic Permit Approval; SAP = sampling and analysis plan; TMDL = total maximum daily load; TOC = total organic carbon; TSS = total suspended solids.

Table O–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	1999-–2003	To develop a computer model of the watershed	Completed in 2006
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	To assess sampling program adequacy based on potential for chemicals to pose risks to aquatic life, wildlife, or human health	Completed 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	To develop models, evaluate BMPs, prepare risk assessments	Completed 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	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		To estimate chemical loading to surface waters	Completed in 2006

BMP = best management practices; BOD = biochemical oxygen demand; DNR = Washington State Department of Natural Resources; DO = dissolved oxygen; Ecology = Washington State Department of Ecology; HPA = Hydraulic Permit Approval; SAP = sampling and analysis plan; TMDL = total maximum daily load; TOC = total organic carbon; TSS = total suspended solids.

Table O–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	To evaluate conditions and to support modeling and WRIA planning	Completed in 2003; temperature report issued in 2004; DO report completed in 2006
Microbial Source-Tracking Study	Green River and its tributaries	Land uses and bacterial sources associated with bacterial populations		Intensive	To assist in setting and measuring TMDLs	Completed in 2004; report completed in 2006
Brightwater Outfall Studies	Water, sediment, and eelgrass for the Brightwater outfall site Upland soils at outfall Portal 19	Water quality: temperature, salinity, DO, nutrients, and fluoresence Sediments: benthic community and chemistry	Water column samples and continuous buoy readings Surface sediments Eelgrass survey	Annual	Regulatory—to meet HPA and DNR outfall lease requirements	Through 2014
Brightwater Construction NPDES Stormwater Monitoring	Stormwater and surface water	Stormwater quality	Various	Intensive	To meet NPDES Construction Stormwater permit	Through 2010
Denny Way/Lake Union pre-remediation sediment monitoring	Sediment near the Denny Way and Lake Union CSOs	Benthic communities, sediment chemistry	Sediment samples per approved SAP	Variable	Regulatory—under a NOAA Fisheries Section 7 ESA consultation	Through 2021
Diagonal/Duwamish post-remediation sediment monitoring	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	Annual	Regulatory—under an EPA/Ecology Consent Order	Through 2013

BMP = best management practices; BOD = biochemical oxygen demand; DNR = Washington State Department of Natural Resources; DO = dissolved oxygen; Ecology = Washington State Department of Ecology; HPA = Hydraulic Permit Approval; SAP = sampling and analysis plan; TMDL = total maximum daily load; TOC = total organic carbon; TSS = total suspended solids.

Marine Waters

This section describes the results of marine monitoring activities in 2006. The discussion includes fecal coliform bacteria levels and overall water quality rankings (water quality index). It also includes a discussion of additional sediment sampling and analysis conducted at the West Point Treatment Plant outfall in support of NPDES permit requirements.

Monitoring Locations

Figures O–1 and O–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 standards are a geometric mean standard of 14 colony forming units (cfu)/100 mL and a peak standard of no more than 10 percent of the samples used to calculate the geometric mean to exceed 43 cfu/100 mL. All 15 ambient and outfall sites met the fecal coliform standards in 2006, with the exception of one ambient site along the Seattle waterfront. Bacteria levels tend to be higher in Elliott Bay than at other sites because of freshwater input from the Duwamish River and stormwater outfalls. The two sites in Elliott Bay that are offshore of the waterfront met the standards, while the site just offshore of the seawall, which receives greater freshwater input, failed both the geometric mean and peak standards.

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.

In 2006, 15 Puget Sound beach sites were monitored monthly for fecal coliform bacteria. The results show that 8 of the 15 sites met both the geometric mean and peak standards, 5 sites met the geometric mean standard but not the peak standard, and 2 sites met neither standard (Figure O–3). The greatest determination of compliance with bacteria standards tends to be proximity to a freshwater source. The two sites that failed both standards in 2006 are near freshwater sources: a storm drain in the south Alki area and the mouth of the Lake Washington Ship Canal. These sites also failed these standards in the previous few years. All beaches in the vicinity of an outfall met fecal coliform standards in 2006. The percentage of Puget Sound beach sites meeting fecal coliform standards in 2006 has almost doubled since 1998. Fluctuations in water quality over time are most likely caused by annual variability in amount and intensity of rainfall. For example, 1996 through 1999 were substantially wetter than average years and may have caused the higher fecal coliform levels in 1998 and 1999.

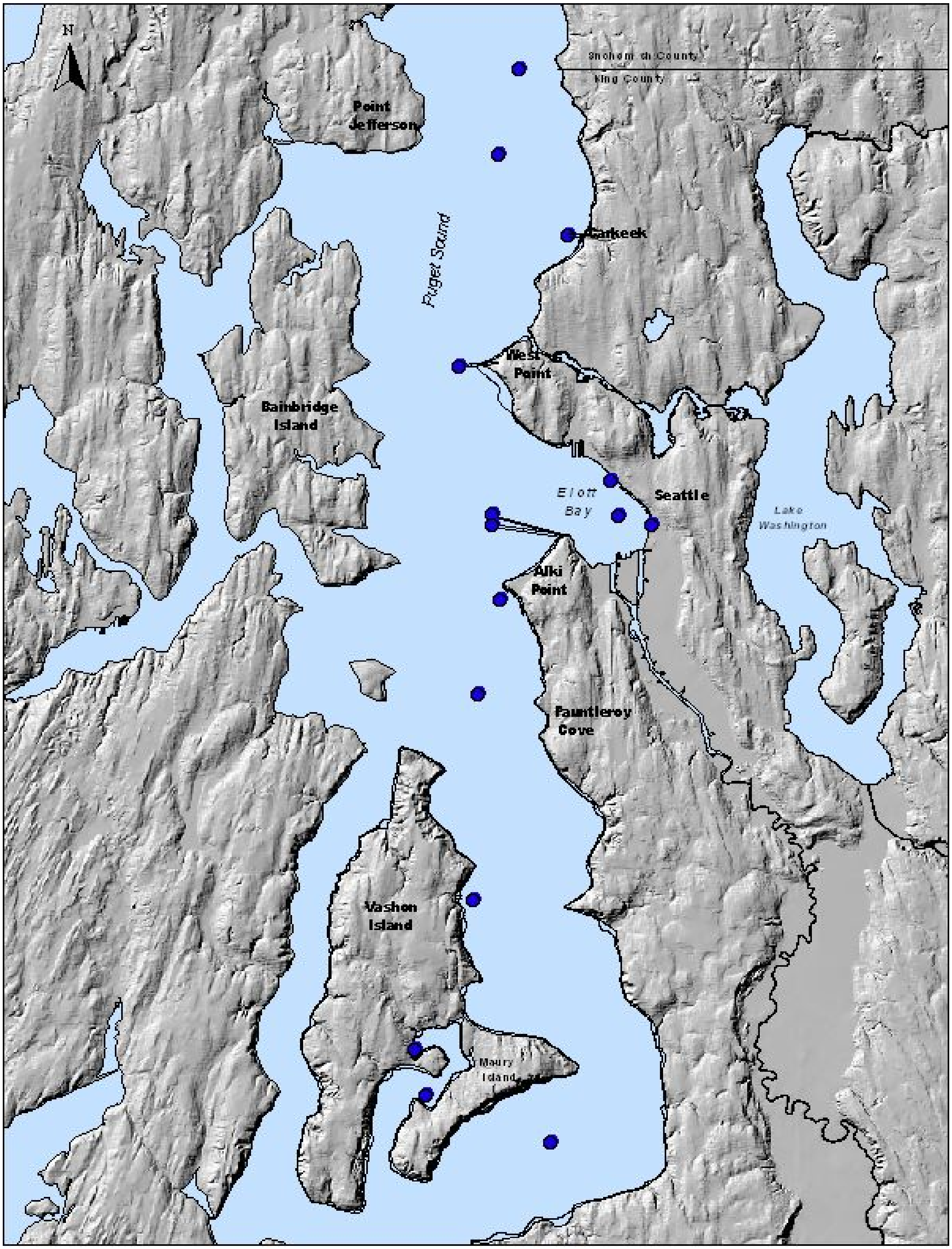

Figure O–1. Offshore Ambient and Outfall Monitoring Locations in Puget Sound

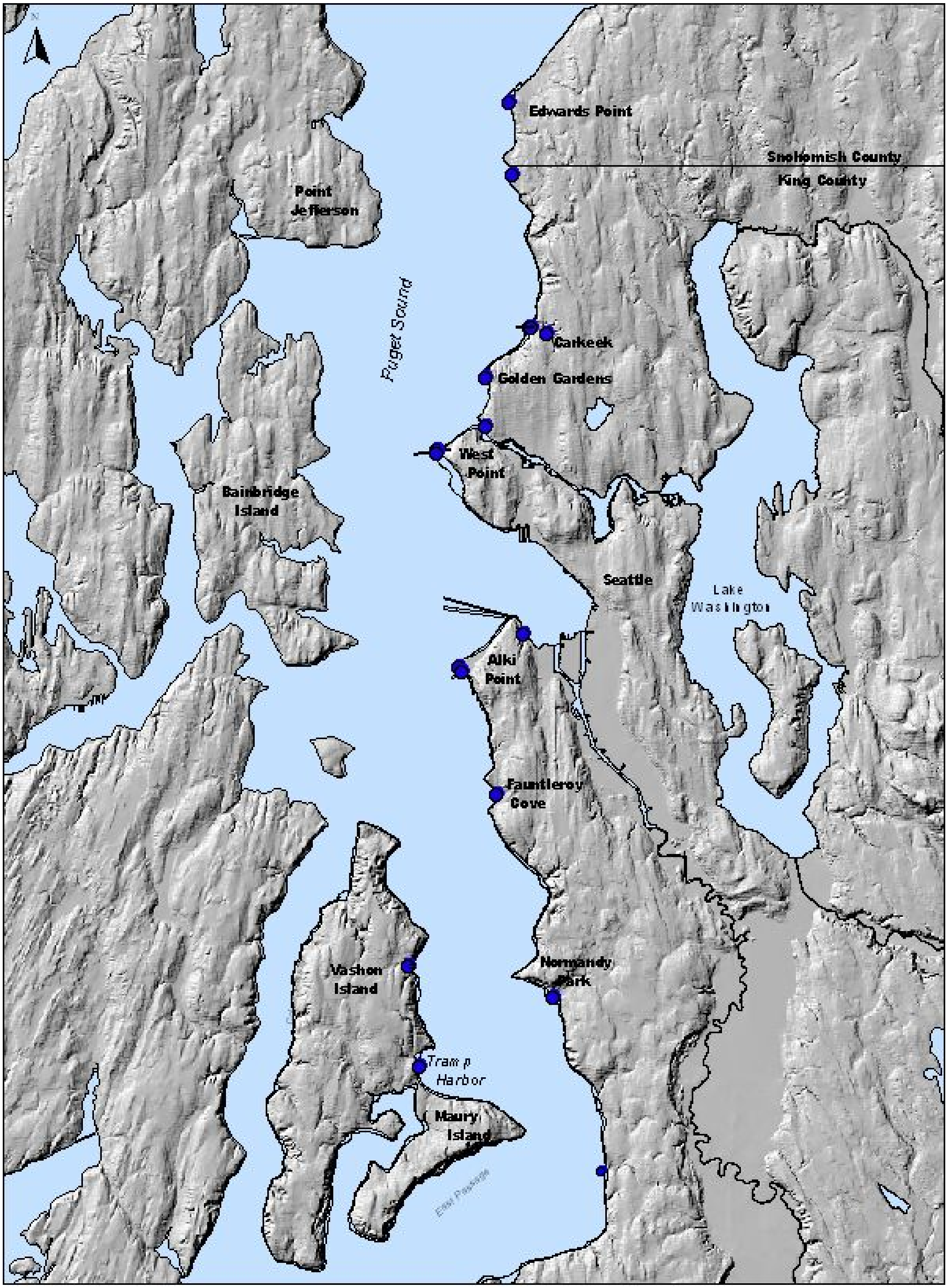

Figure O–2. Nearshore (Beach) Ambient and Outfall Monitoring Locations in Puget Sound

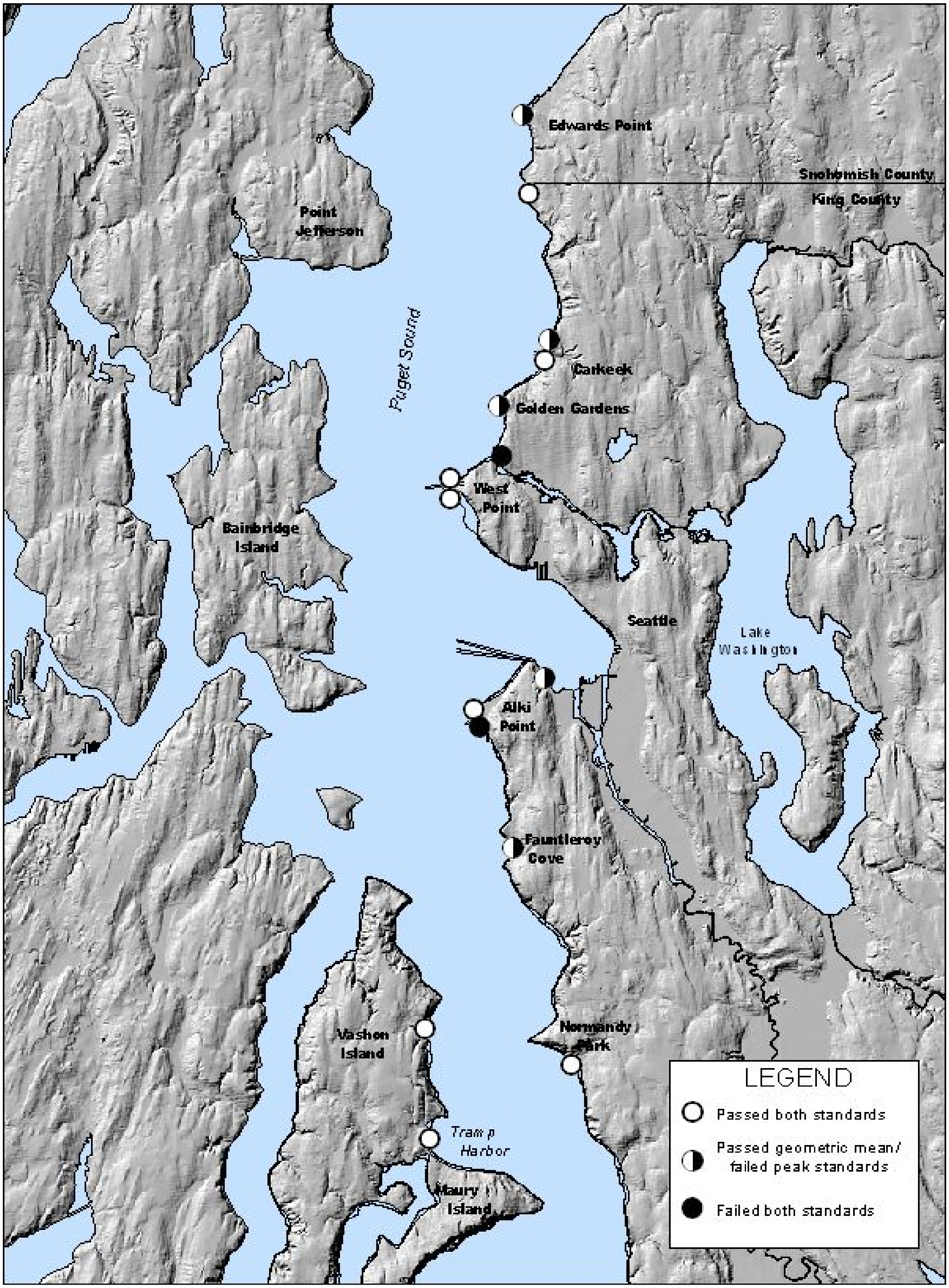

Figure O–3. Pass-Fail Status of Puget Sound Beach Monitoring Sites for Fecal Coliform Bacteria Standards, 2006

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 2006 findings indicate that the water quality at all of the ambient and outfall offshore stations is at a level of low concern. Although five stations located throughout the Central Basin experienced strong-intermittent stratification, low DO levels were not observed. No stations experienced persistent stratification in 2006.[2] Figure O–4 shows the percentage of the 12 offshore stations categorized as moderate or high concern between 1999 through 2006. 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 three years.

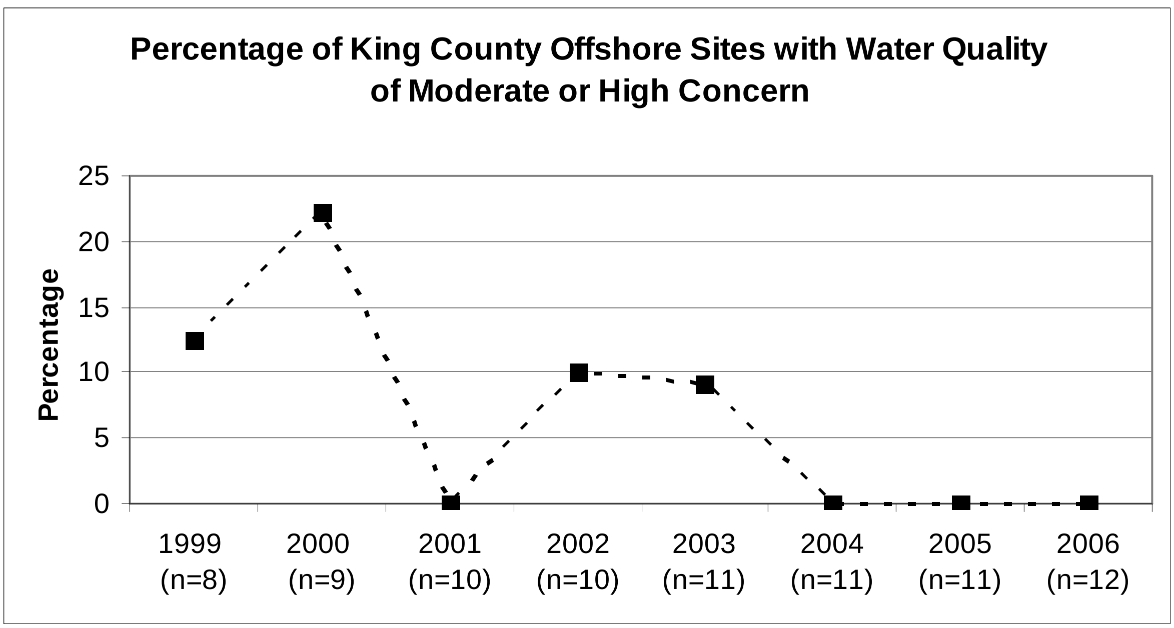

Figure O–4. Percentage of King County Offshore Stations with Moderate or High Concern Rankings Based on Water Quality Index, 1999–2006

Sediment Quality near West Point Outfall

In 2006, King County collected sediment samples in the vicinity of the West Point Treatment Plant marine outfall to meet NPDES permit requirements. Nineteen surface sediment samples were collected in September 2006 for analysis of chemical parameters including sediment

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[2] Areas where persistent stratification occurs may be susceptible to nutrient loading and low DO problems.

conventionals, metals, and trace organics. A subset of these samples were submitted for toxicity testing and benthic community analysis. All analyses have been completed and the data are currently being evaluated and prepared for reporting.

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

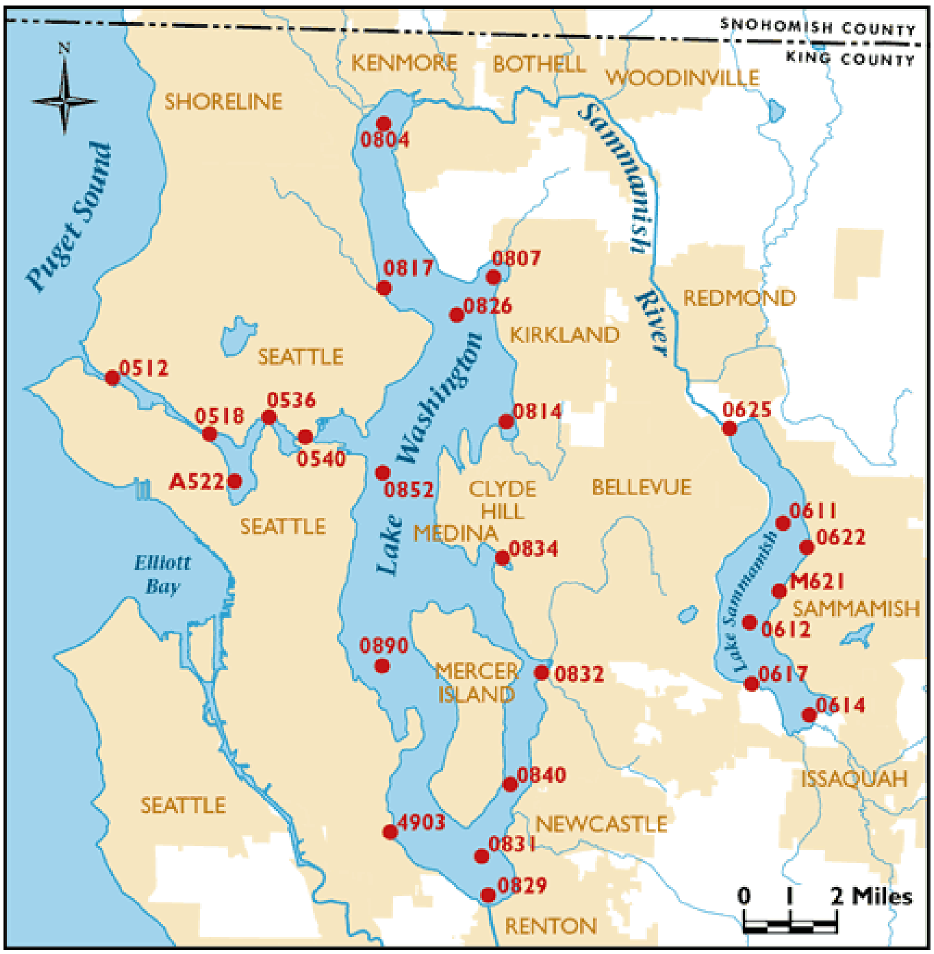

Figure O–5. Ambient Monitoring Locations in Lakes Washington, Sammamish, and Union (including the Ship Canal)

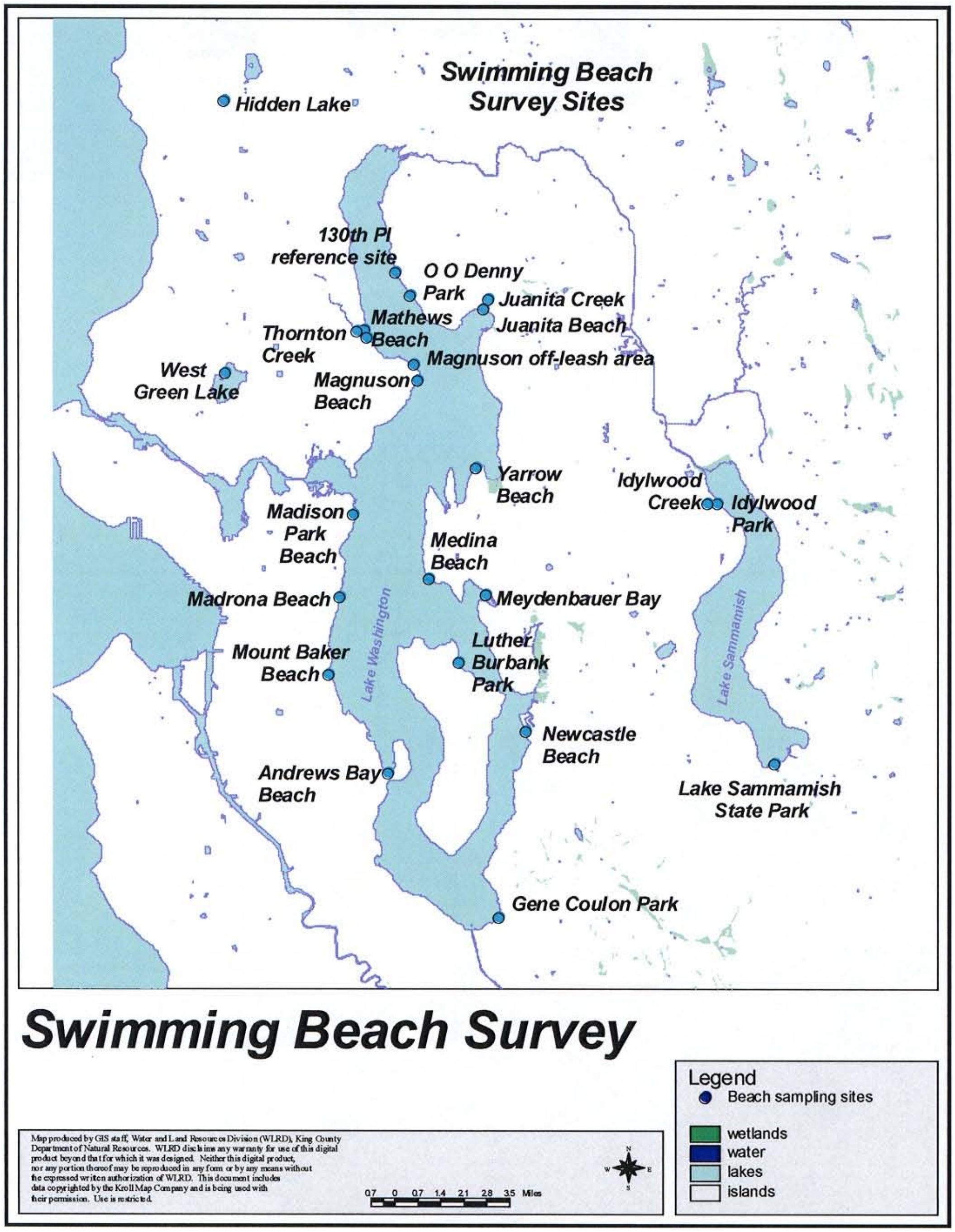

Figure O–6. Swimming Beach Monitoring Locations in Lake Washington, Lake Sammamish, and Green Lake

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

The lake standard for fecal coliform bacteria addresses human health 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. The indicator is based on data from routine monitoring at these sites and does not include sampling done in conjunction with emergency overflow events.

Even though this measure uses a standard that is exceptionally difficult to attain, 100 percent of the Lake Sammamish stations, 92 percent of the Lake Washington stations, and 80 percent of the Lake Union stations achieved this standard in 2006 (Figure O–7). Lake Washington showed a decrease of 8 percent from 2005 because of higher bacteria at one station (4903).

In 2006, roughly half of the samples that had higher fecal coliform levels were the result of unusual storm conditions with the highest bacteria concentrations collected in November directly after record-breaking rainfalls hit the region. Lower percentages in Lake Union are due to the influence of CSO and stormwater outfalls into the lake.

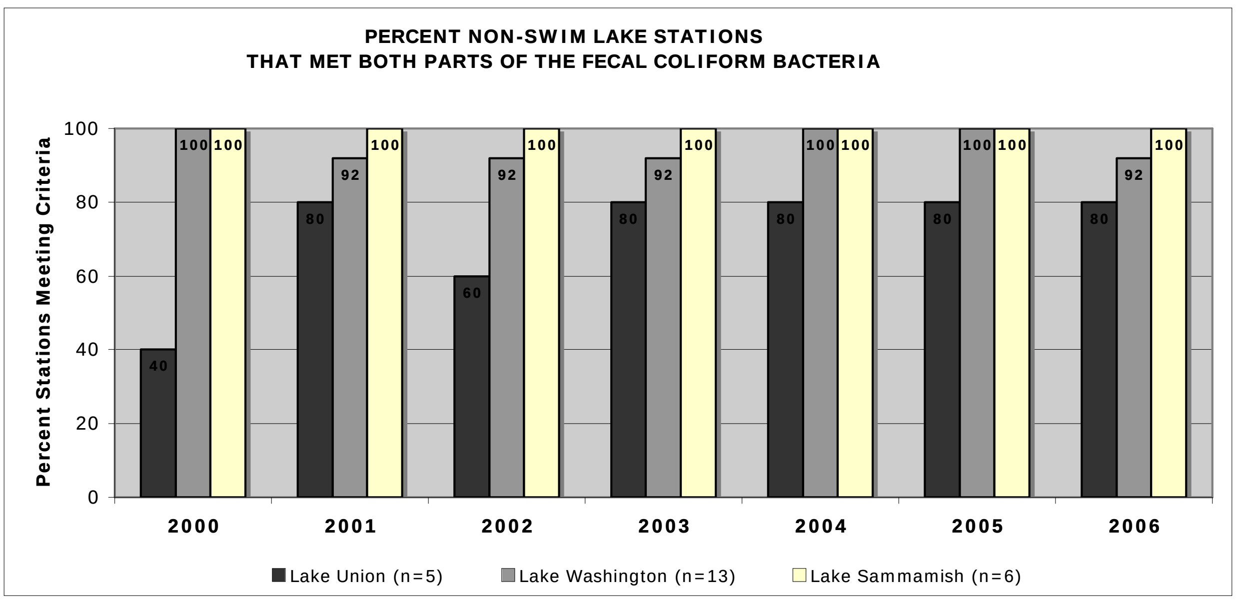

Figure O–7. Percentage of Ambient Stations in Lakes Washington, Sammamish, and Union that Met the Fecal Coliform Bacteria Standard, 2000–2006

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.

Bacterial counts for all beaches monitored in all three lakes were within acceptable ranges and did not warrant swimming beach closures. All samples collected at Green Lake met the fecal coliform standard for the third year in a row (Figure O–8). Between 1998 and 2006, levels at swimming beaches in Lakes Sammamish and Washington remained fairly consistent, with slight variability from year to year (Figures O–9 and O–10). In Lake Sammamish, 89 percent of the samples collected in 2006 met the standard, down slightly from 2005 (90 percent). In Lake Washington, 88 percent of the samples met the standard, the same percentage as in 2005.

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. 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.

Water quality in these lakes varies annually, depending on watershed inputs, weather, and biological interactions. The 1994–2006 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 O–11). In the past eight years, Lake Union typically has fallen in the moderate range, Lake Washington in the low range, and Lake Sammamish in both ranges.

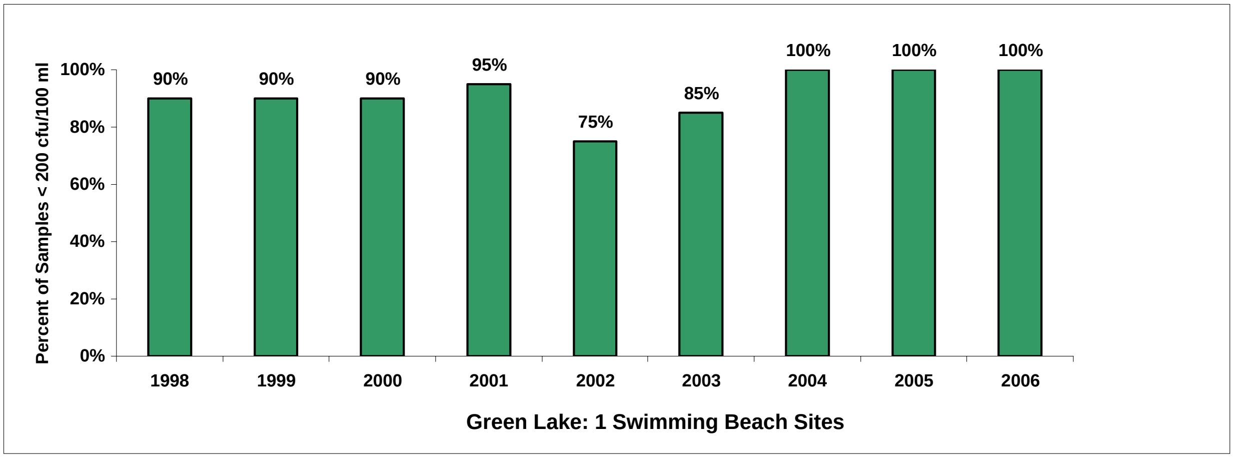

Figure O–8. Percentage of Samples that Met the Fecal Coliform Bacteria Standard at Green Lake Swimming Beaches, 1998–2006

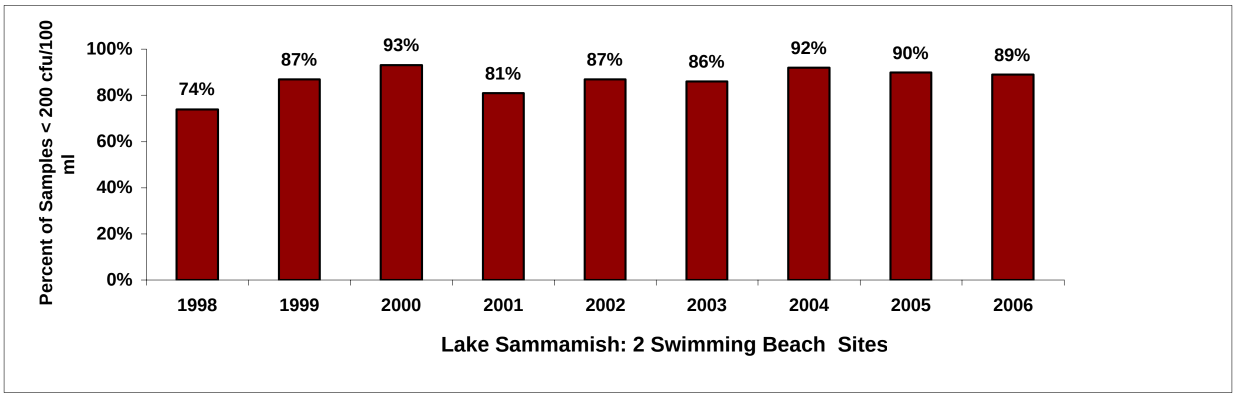

Figure O–9. Percentage of Samples that Met the Fecal Coliform Bacteria Standard at Lake Sammamish Swimming Beaches, 1998–2006

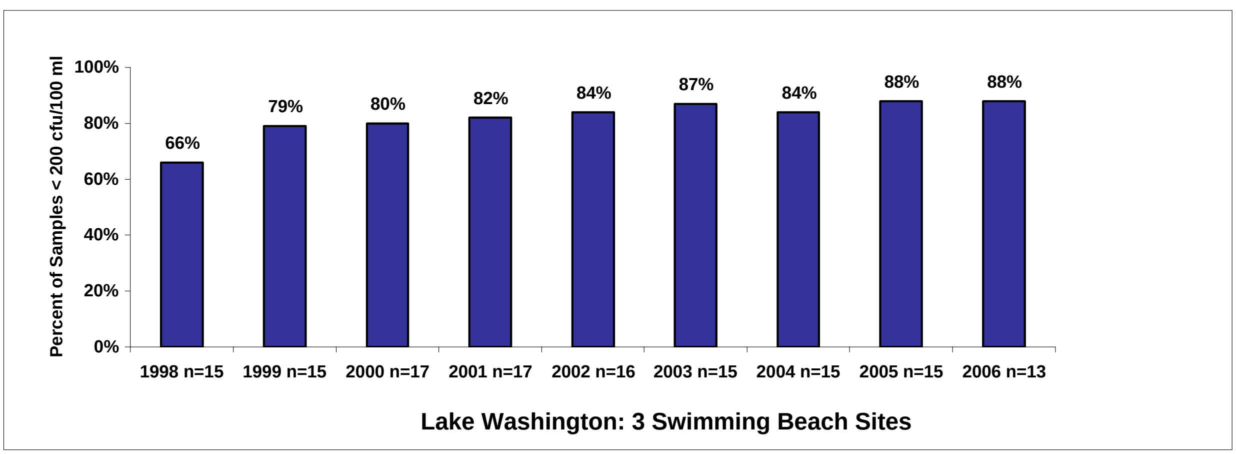

Figure O–10. Percentage of Samples that Met the Fecal Coliform Bacteria Standard at Lake Washington Swimming Beaches, 1998–2006

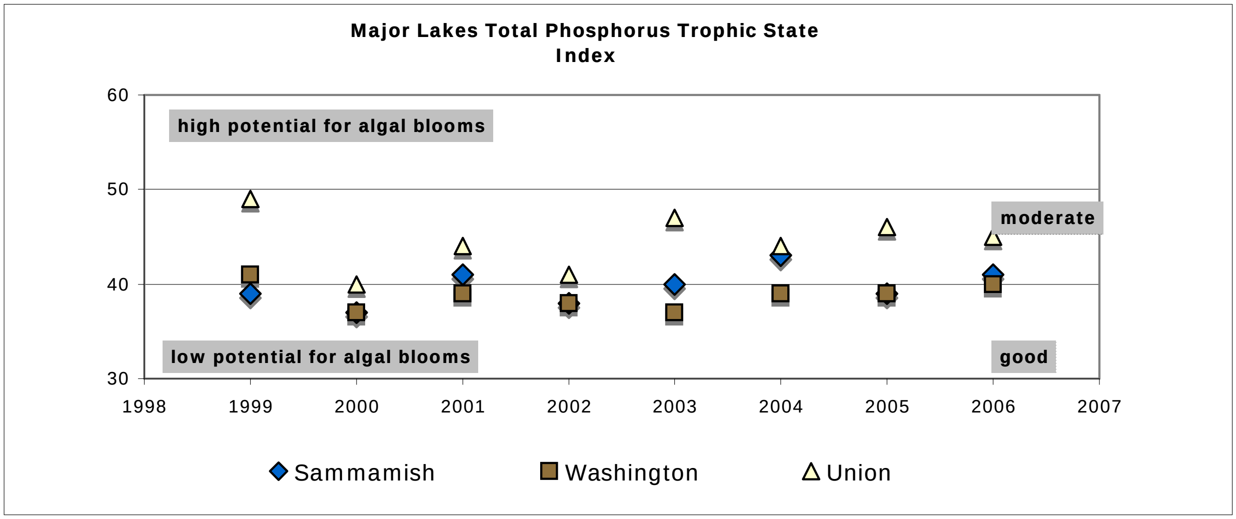

Figure O–11. Overall Water Quality in Lakes Washington, Sammamish, and Union Based on Trophic State Index, 1999–2006

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.[3] 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 O–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.

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

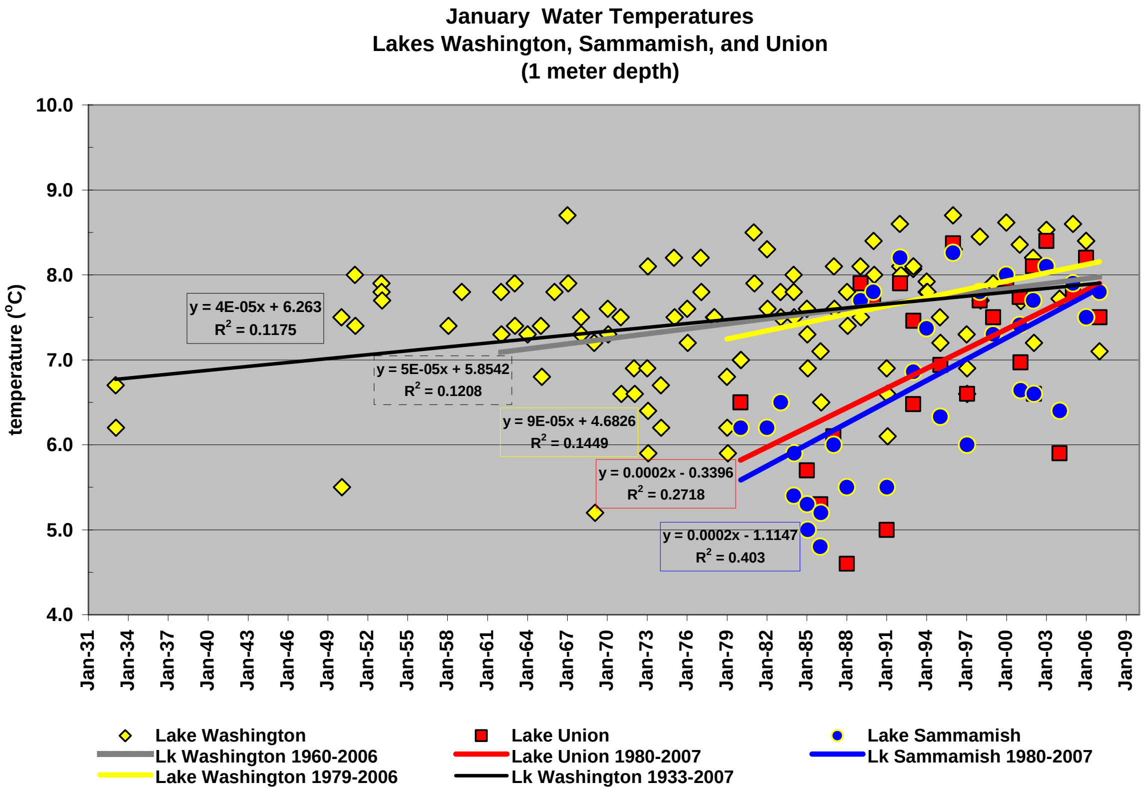

Figure O–12. January Water Temperatures in Lakes Washington, Sammamish, and Union, 1933-2007

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 Water Resource Inventory Areas (WRIAs) 8 and 9 (Cedar-Sammamish and Duwamish-Green watersheds) have been sampled monthly, some for over 30 years, for numerous water quality parameters, including those used to determine the Water Quality Index (Figure O–13).

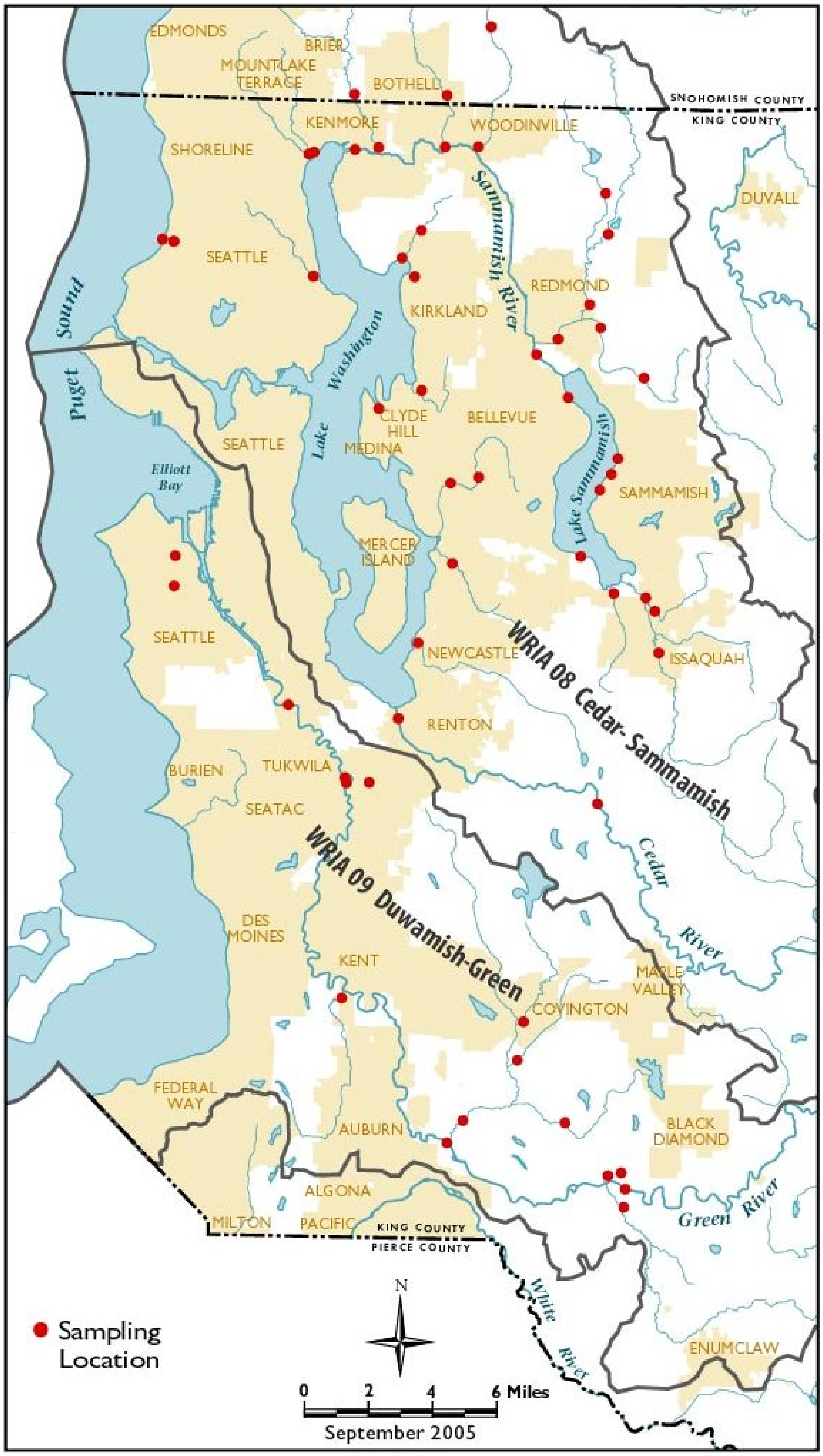

Figure O–13. River and Stream Monitoring Locations

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, results are aggregated over time to produce a single score, and a rating of low, moderate, or high concern is assigned 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 35 of the 56 sampled sites (63 percent) during the 2005–2006 water year were considered good to moderate water quality, with either low concern or moderate concern ratings, while 21 sites (37 percent) were rated high concern because of serious water quality concerns (Figure O–14).

In WRIA 9, four of the sixteen sites were rated of low concern, ten sites were of moderate concern, and two sites were of high concern (Figure O–15). Of the forty sites in the WRIA 8, one site rated of low concern, nineteen sites were of moderate concern, and twenty were of high concern (Figure O–16). Overall, high-concern ratings at all high-concern sites were, at least in part, a result of excessive nutrients (nitrogen and/or phosphorus). In addition, high bacteria levels at four sites and low DO concentrations at six sites contributed to the overall high-concern ratings. None of the high-concern sites were the result of high temperatures.

While cumulative rainfall in 2006 was average compared to historical values, the summer (mid-June to mid-Sept) was the second driest on record. This dry summer was followed by record-breaking precipitation in November and severe windstorms in December. Flooding and high stormwater flows contribute to poor water quality in a variety of ways.

Fecal coliform bacteria enters the aquatic environment from household or farm animals, wildlife, stormwater runoff, untreated wastewater effluent, wastewater overflows, and failing septic systems. Poor livestock management practices and failing septic systems can be a potential source of bacteria in agricultural and in suburban areas. Wildlife and stagnant water conditions in wetlands can lead to elevated bacteria counts. Elevated phosphorus concentrations are often linked to similar sources as bacteria because high phosphorus concentrations are found in fecal material. Elevated phosphorus concentrations are also linked to areas undergoing development.

Low DO concentrations can be associated with low flows, high temperatures (colder water holds more oxygen), and high levels of organic matter (bacteria use up oxygen in the process of decomposition).

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 vegetation and soil, more surface runoff occurs. 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 17 stream sites, including 4 sites monitored by the U.S. Geological Survey, were measured and their flashiness calculated during the 2006 water year (October 2005–September 2006) (Figure O–17). The "flashiness index" is based on the reciprocal of the fraction of days during the year that the flow rises above the annual mean daily flow ($1/T_{Qmean}$). The stream flashiness index was also calculated for previous years using historical data. The number of streams where data were available varies from one stream in 1941 to twenty-one streams in 2001. The median of the flashiness index scores across all streams measured in King County has increased between 1945 and 2006 (Figure O–18). These data suggest that increased urbanization in King County has resulted in faster surface runoff and peak streamflow rise and fall (increased flashiness) than previously occurred for at least some streams.

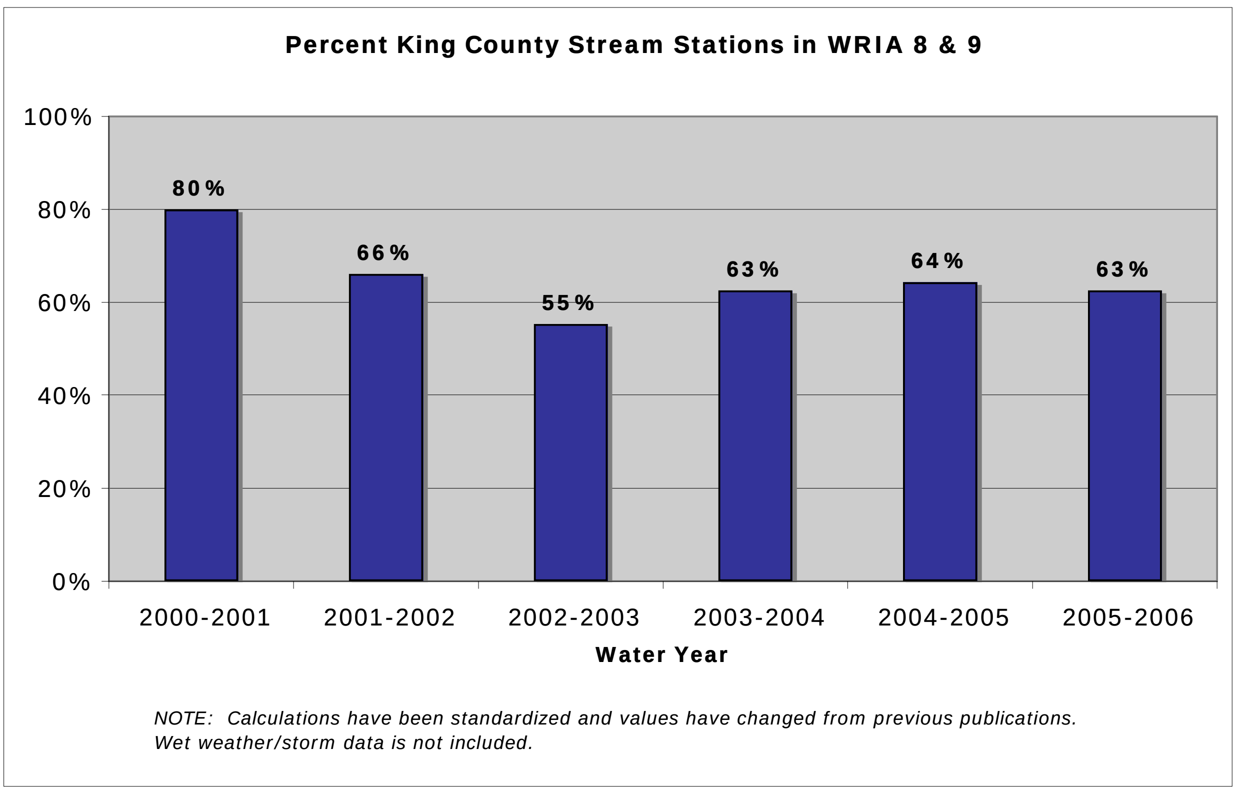

Figure O–14. Percentage of Streams in WRIAs 8 and 9 with Low or Moderate Concerns Based on Water Quality Index, 2000–2006

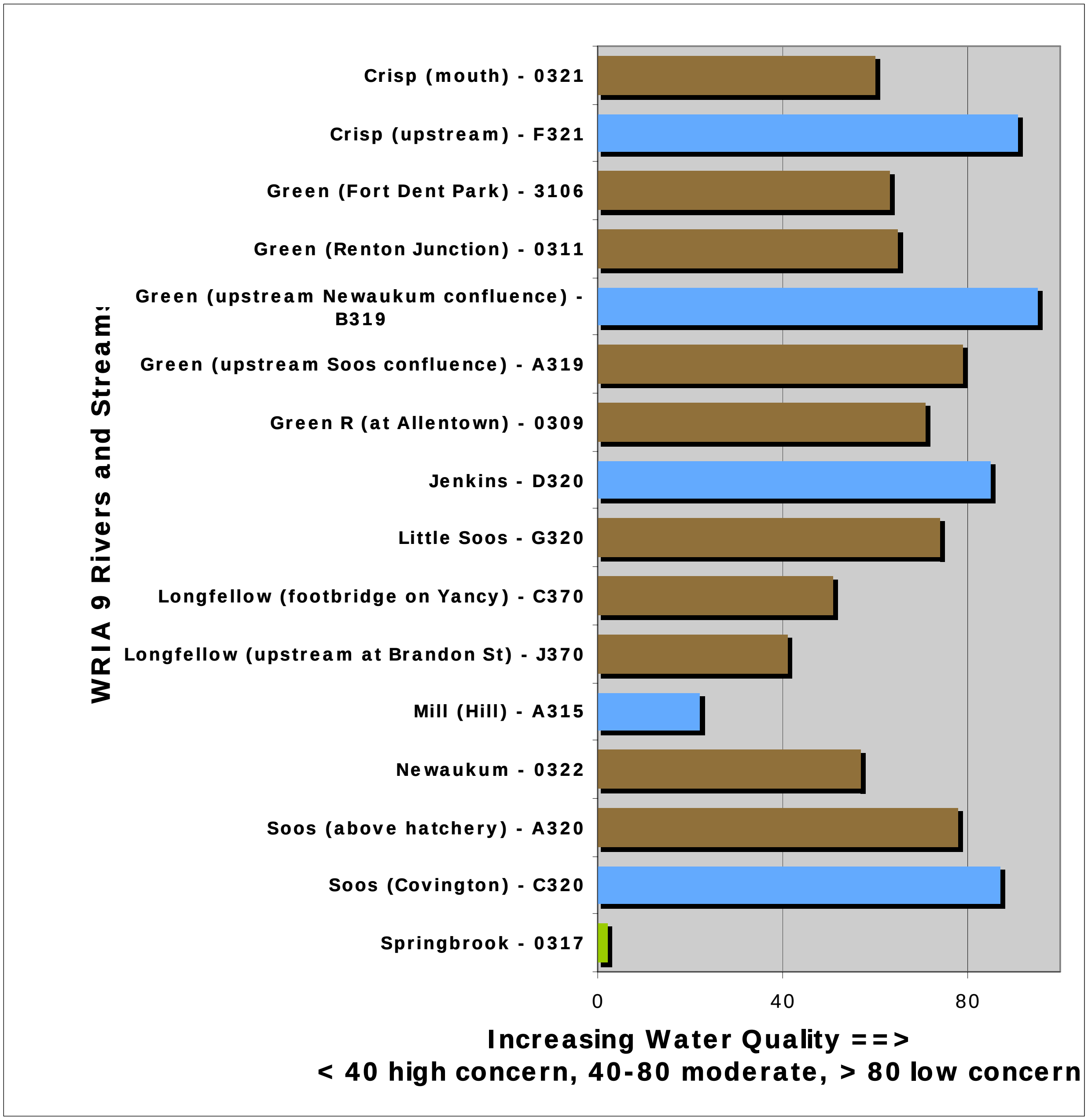

Figure O–15. Water Quality Index Rankings for Rivers and Streams in WRIA 9, 2005–2006

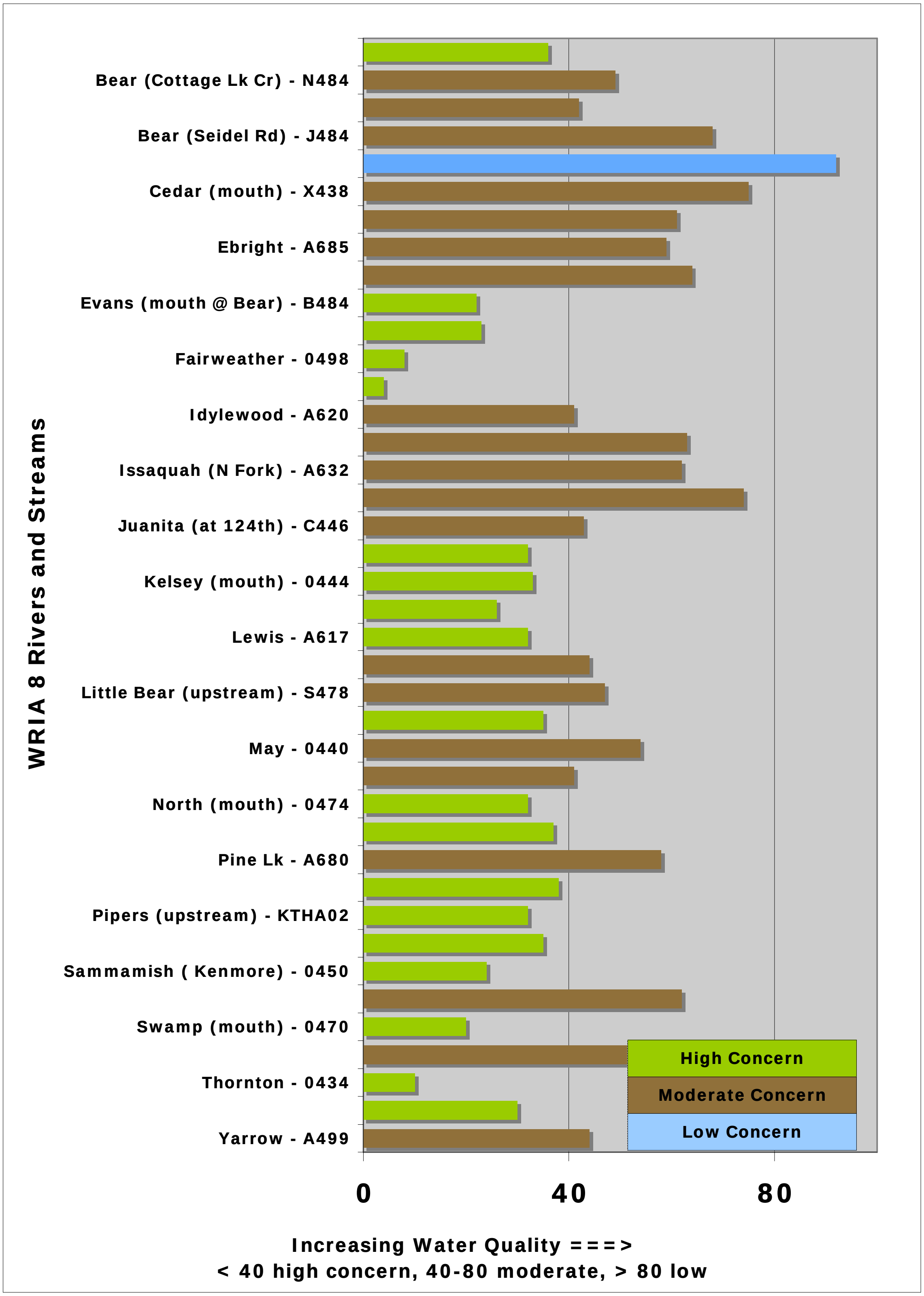

Figure O–16. Water Quality Index Rankings for Rivers and Streams in WRIA 8, 2005–2006

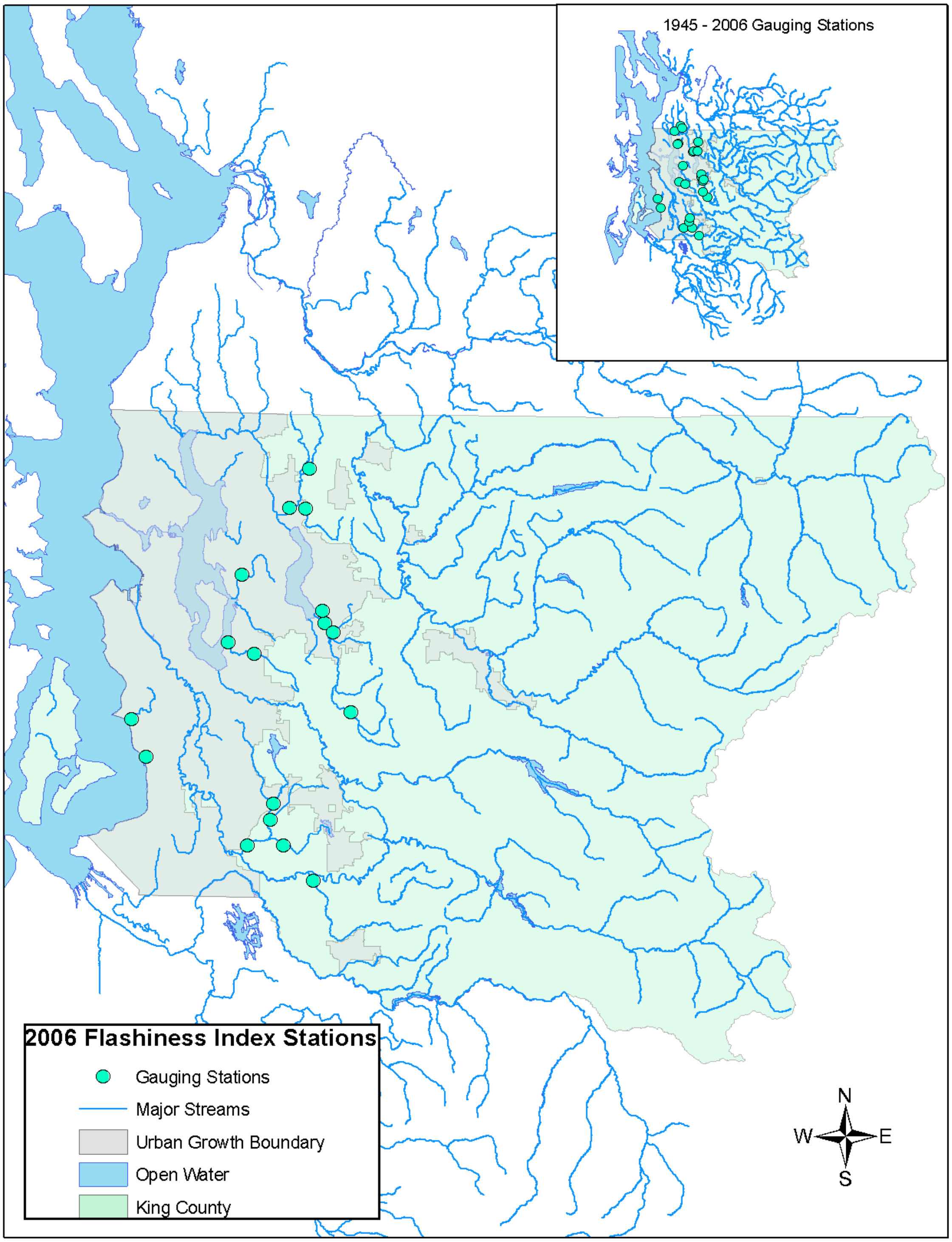

Figure O–17. Hydrologic Monitoring Stations Used to Calculate the Stream Flashiness Index, 1945–2006

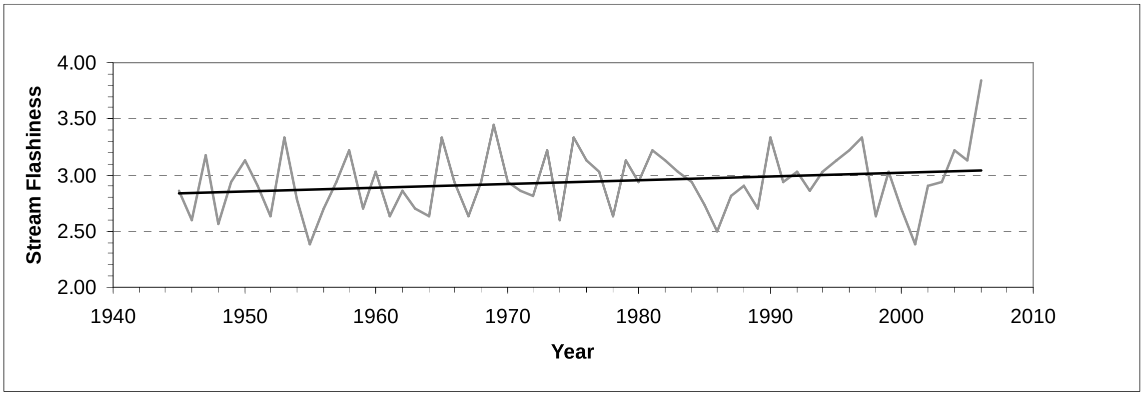

Figure O–18. Median Stream Flashiness Index per Year, 1945–2006