EXECUTIVE SUMMARY

This report summarizes the background and findings of King County's Water Quality Assessment and Monitoring Study (Study). The Study was undertaken to explore ways to optimize water quality improvements in waterbodies where the County is planning projects to reduce the frequency of combined sewer overflows (CSO) to an average of one untreated overflow per site per year over a 20-year moving average. Reducing CSO frequency to this degree is known as CSO "control" and is required by the terms of King County's CSO consent decree and by King County's National Pollutant Discharge Elimination System (NPDES) permit issued by the Washington State Department of Ecology.

Reducing CSO Frequency: Helping Restore Healthy Waters in the Region

The early development of Seattle and surrounding areas included some remarkable engineering achievements such as linking Puget Sound and Lake Washington through the construction of the Lake Washington Ship Canal. The fast-paced development and growth also created environmental problems the region is still grappling with today.

The Water Quality Assessment and Monitoring Study addresses four questions:

1. What are the existing and projected water quality impairments in the Duwamish River, Elliott Bay, and Lake Union/Ship Canal?
2. How do County CSOs contribute to the identified impairments?
3. How do other sources contribute to the identified impairments?
4. What activities are planned through 2030 that could affect water quality in the receiving waters?

The CSO control program is addressing three questions based on Study findings:

5. How can CSO control projects and other planned or potential corrective actions be most effective in addressing the impairments?
6. How do various alternative sequences of CSO control projects integrated with other corrective actions compare in terms of cost, schedule, and effectiveness in addressing impairments?
7. What other possible ways, such as coordinating projects with Seattle and altering the design of planned CSO control projects, could make CSO control projects more effective and/or help reduce the costs to WTD and the region of completing all CSO control projects by 2030?

Water quality is one such problem. The greater Seattle area is graced with magnificent waterbodies—the Duwamish Estuary, Lakes Washington and Union, Elliott Bay, and Puget Sound—but years ago these waters were treated as open sewers. In the 1950s, residents voted to clean up Seattle area waters. The vote led to the construction of a regional wastewater system in the 1960s. Instead of emptying untreated sewage directly into the Duwamish Estuary, Elliott Bay and Puget Sound, and emptying effluent from 10 secondary treatment plants to Lake Washington, pipes now carry the sewage to regional secondary treatment plants before discharging to Puget Sound.

A large part of Seattle's sewer system was built during a time when it was common practice to combine both sanitary sewage and stormwater in the same pipes. The West Point Treatment Plant treats most of these combined sanitary and storm sewer flows. However, during heavy storms, the wastewater conveyance system is overburdened and some of the combined flow overflows at set locations and discharges to area waterbodies to prevent sewer backups into homes and businesses in the system. King County and the City of Seattle own and manage CSO discharge locations in the city; both agencies are working to reduce the CSO frequency at each location down to the state requirements of an average of no more than one untreated overflow per year over a 20-year moving average.

On July 3, 2013, the United States District Court for the Western Washington District entered a Consent Decree between the United States (the Environmental Protection Agency), the State of Washington (the Department of Ecology), and King County which requires King County to complete nine projects to control the County's 14 remaining uncontrolled CSO outfalls by 2030, As required by State law, King County updates its CSO control plan about every five years. Before each update, the County reviews the entire CSO Control Program against conditions that have changed since the last update. The most recent update occurred in September 2012, when the King County Council's passage of Ordinance 17413 approving an amendment to the County's long-term CSO control plan. The plan contains the nine projects described in the County's CSO Consent Decree, including construction of underground storage tanks, green stormwater infrastructure, and wet weather treatment facilities.

Water Quality Assessment and Monitoring Study: Designed to Guide Investments to Improve Water Quality

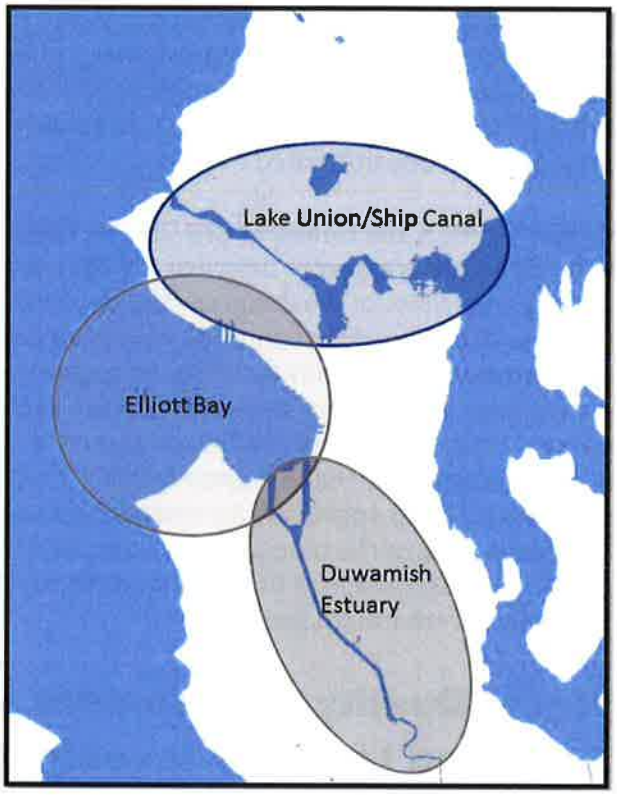
King County has a long history of monitoring water quality and using the data in decision making

Starting with the public vote to form Metro in the 1950s, water quality data has been used as a key factor when making major infrastructure and policy decisions. Metro/King County now has decades of monitoring data that allows for assessment of water quality improvements or declines over time. The breadth of data types, and the number of years the data have been collected, makes King County's monitoring programs extremely valuable for assessing overall effectiveness of environmental programs and policies.

Ordinance 17413 also calls for completion of a Water Quality Assessment and Monitoring Study ("Study") to inform the next CSO control plan update due to the Washington State Department of Ecology in 2018. Between 2015 and 2030, King County and the City of Seattle will invest over $1 billion on projects to reduce the frequency of CSOs to below the permit-required standard of an average of one untreated discharge per year per site over a 20-year moving average. The Study was commissioned to ensure the County's investments in these projects are well planned and timed.

The scope of work for the Study includes seven questions. Four questions were addressed by the assessment, and the answers are summarized below. The remaining three questions are being addressed by the CSO Control Program as part of the 2018 update.

The Study assessed past and present water quality conditions in the waterbodies where the County's remaining 14 CSOs that overflow more than an average of once per year discharge: Lake Union/Ship Canal, Elliott Bay, and the Duwamish Estuary. The assessment estimated annual contaminant loadings to these study areas from different pollutant pathways, reviewed planned projects to understand how contaminant loadings may change, and identified impairments that will remain in 2030. Nine technical reports describe different aspects of water quality in the study areas.

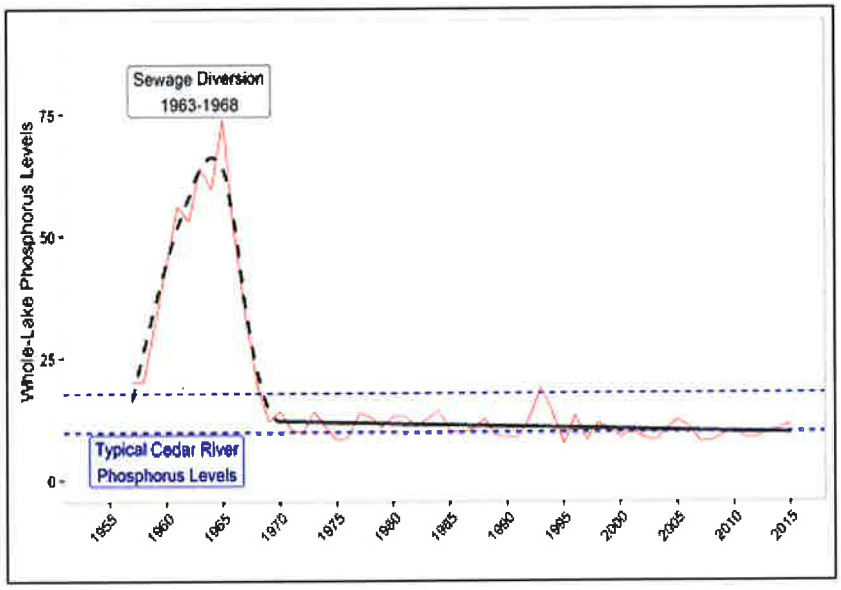


Although uncertainties remain because of insufficient data or limitations in study scope, conclusions from the Study are sufficiently robust to inform the CSO Control Program and support ongoing efforts to restore local waters.

Actions in the Past 50 Years Have Improved Water Quality in Several Ways

Investments in projects and implementation of regulations throughout the region have substantially improved water quality in Lake Washington, Lake Union/Ship Canal, Elliott Bay, and the Duwamish Estuary in the past 50 years:

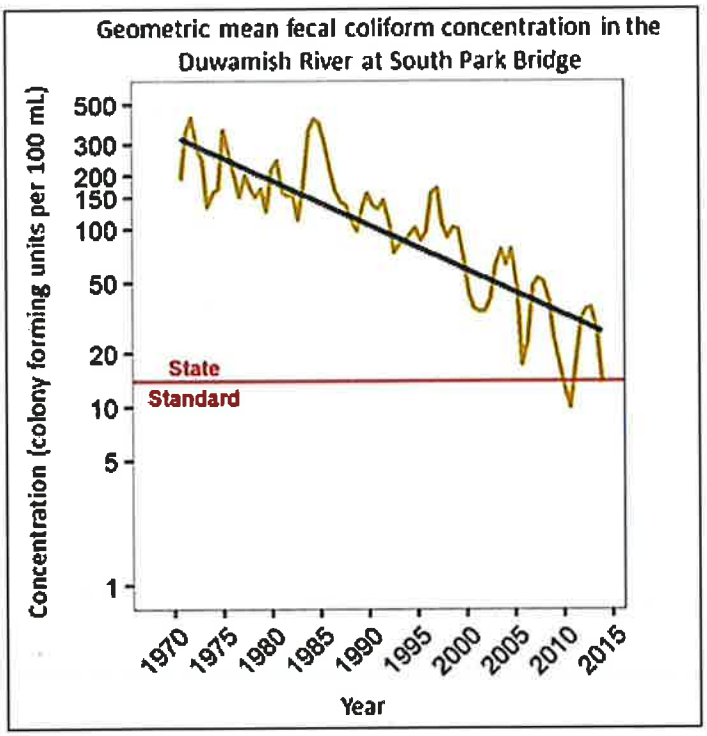
- Nutrient levels in receiving waters improved dramatically following construction of the regional wastewater system. Excess phosphorus in the Lake Washington was causing large cyanobacteria blooms, whose decay produced odors and reduced the amount of dissolved oxygen available for fish and other aquatic life. Phosphorus levels in the lake dropped to near natural levels within a few years of the diversion of treated sewage effluents to Puget Sound. There have been long-term improvements in bacteria, nutrient, and dissolved oxygen levels over the past several decades.



After the regional wastewater system was completed, phosphorus levels in Lake Washington improved dramatically and now appear to be near natural levels. (Source: University of Washington historical data, begun in the 1950s by W.T. Edmonson and provided by D.E. Schindler.)

- Pathogen levels (as indicated by fecal coliform bacteria) in the study areas have substantially dropped over the last 45 years. CSO control, stormwater management, and other improvements implemented in the watersheds have likely contributed to this success, including use of agricultural best management practices and management of on-site septic systems.
- Concentrations of sediment contaminants have declined as the result of multiple remediation activities, particularly in Elliott Bay and the Duwamish Estuary.

These improvements are even more impressive considering King County's population growth and land use changes during the same timeframe.



Bacteria levels are declining in the Lower Duwamish Waterway, even as the region's population continues to grow.

Despite Improvements, Some Aspects of Water Quality Is Still Impaired in the Three Study Areas

The Study identified the following impairments in study area waterbodies:

- Bacteria concentrations remain above Washington State standards.
- Summer surface temperatures have been warming over time especially in the Lake Union/Ship Canal.
- Periodic summer low dissolved oxygen and high salinity levels at depth in Lake Union make the area inhospitable for freshwater aquatic life.
- Multiple metals and organic chemicals in sediments do not meet state standards.

King County CSOs Contribute to Identified Impairments

An analysis of how contaminants enter the study areas done as part of the Study showed that discharges from King County's 14 CSOs that overflow more than an average of once per year contribute about 85 percent of the annual loadings of fecal coliform bacteria to the three study areas. This analysis also showed that discharges from City of Seattle's CSOs that overflow more than an average of once per year contribute about 8 percent, and other pathways combined contribute about 7 percent. King County's CSOs that discharge more than an average of once per year contribute a number of additional contaminants to the receiving waters but at substantially lower annual loads than contributions from other pathways.

Equipment Failure and Flooding at the West Point Treatment Plant on February 9, 2017, Does Not Change the Findings of this Study

King County's West Point Treatment Plant experienced an equipment shutdown early on February 9, 2017, while also receiving maximum inflows of combined wastewater and stormwater. This event caused extensive damage to the treatment plant and untreated discharges from an emergency bypass outfall that day and again on February 15 and 16. Following this incident, West Point provided primary treatment with disinfection until the secondary treatment process was restarted in late April, 2017.

Monitoring conducted to assess the impacts of the incident on water quality in Puget Sound is being conducted and will be presented separately. However, King County does not expect to see changes to long-term water quality trends in the study area or changes to the conclusions of the Water Quality Assessment and Monitoring Study because this study used decades of data and the event happened over a comparatively short period of time.

Other Pathways Contribute to Identified Impairments

The major pathways for contaminant loadings other than bacteria are as follows:

- Direct stormwater discharges to the study area waterbodies and/or flows from the upstream watersheds contribute the majority of the annual loads of nutrients, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs), and most metals. Contaminant loadings from flows from the upstream watersheds (i.e., the Green River and Lake Washington) represent the combined loadings of all sources and pathways throughout the watersheds, including stormwater discharges from upstream jurisdictions in the watersheds.
- Leaching from marine vessel antifouling paint contributes the largest known copper loads.
- Leaching from creosote-treated wood pilings contributes the largest known polycyclic aromatic hydrocarbons (PAHs) loads.

The Study reviewed contaminant loadings from a number of pathways to study area waterbodies.

Planned Actions Will Reduce Contaminant Loadings Even Further by 2030

A range of actions is likely to improve water quality in the study areas by 2030:

- **Reduction in Frequency of Untreated CSO Discharges.** Implementation of King County's CSO control plan and the City of Seattle's Integrated Plan by 2030 to reduce the frequency of untreated CSO discharges to an average of once per year at each site over a 20-year moving average, in accordance with Consent Decrees and state

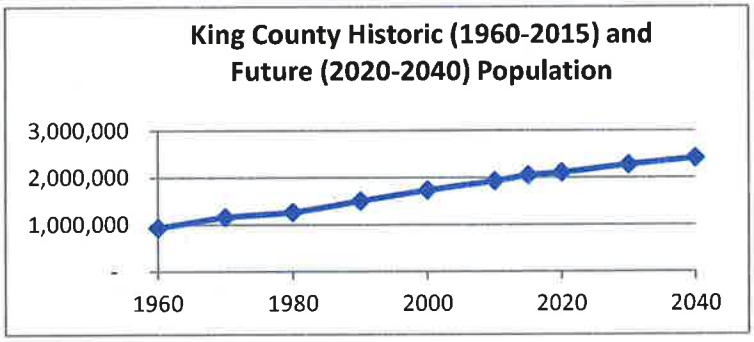
requirements, is projected to reduce annual bacteria loading to the study areas by about 80 percent.

- **Copper source control.** Implementation of Washington State's limits on the copper content in antifouling vessel paint for small recreational vessels and in automobile brake pads is projected to reduce copper loading to the study areas by 50 percent by the early 2020s.
- **Creosote-treated wood piling removal.** The planned removal of about 11,000 creosote-treated wood pilings is projected to reduce PAH loadings to Elliott Bay and the Duwamish Estuary by about one-third by 2030.
- **Contaminated sediment cleanup.** Remediation of contaminated sediment sites is projected to reduce contamination levels in the study areas. In particular, levels of PCBs, other organic chemicals, and metals in Duwamish Estuary sediments are projected to decline as the cleanup plan for the Lower Duwamish Waterway Superfund site is implemented. While some remediation projects have been identified in Lake Union/Ship Canal, less improvement is projected to occur in Lake Union/Ship Canal than in the other study areas because no cleanup strategy has been developed for a large fraction of the sediments in Lake Union/Ship Canal relative to the other study areas.
- **Stormwater management and treatment.** Improvements in stormwater management by the City of Seattle and other jurisdictions in the study areas and upstream watersheds are projected to reduce loadings of multiple contaminants. The City is planning capital projects that include construction of stormwater treatment systems. Planned projects and programs, including both operational and source control efforts, will decrease the annual loadings of all contaminants studied to some degree.
- **Behavioral changes.** The cumulative impacts of changes in behavior by area residents can substantively affect water quality, although the degree of change and impact is difficult to quantify. Examples of behaviors that can have a positive impact on water quality include preventing oil leaks through better vehicle maintenance and using nontoxic cleaning products.

Because of data and scope limitations, the Study did not estimate changes to future contaminant loadings for all known factors that affect water quality. For example, the Study did not quantify changes to contaminant loadings that may result from climate change, population growth, new and redevelopment, future strengthening of requirements of municipal stormwater National Pollutant Discharge Elimination System permits, or planned projects in the upstream watersheds. These factors are likely to have a mixed impact on water quality and, thus, are not assumed to substantially change the overall findings on changes to contaminant loadings by 2030.

Water Quality Challenges Will Remain in 2030 Unless the Region Does More

King County's population has doubled since the mid-1960s to more than 2 million people and is expected to keep growing into the foreseeable future. Maintaining and improving water quality while also accommodating growth and development are challenges that cannot be understated.



Even with compliance with National Pollutant Discharge Elimination System permits and implementation of planned projects and programs, many water quality challenges are anticipated to remain in 2030 in the study areas because:

- Freshwater surface temperatures are likely to be above state standards, a condition exacerbated by climate change, and may continue to pose risks to salmonids and other fish and wildlife.
- Even after the frequency of untreated CSO discharges is reduced at all locations to meet CSO Consent Decree and State requirements of an average of once per year over a 20-year moving average, fecal coliform bacteria levels are likely to exceed state standards in the three study areas. This conclusion is based on estimated ongoing loadings from direct stormwater discharges, untreated discharges from CSO that occur an average of once per year over a 20-year moving average, upstream watersheds, and local creeks.
- Leaching from antifouling paint on commercial and large recreational vessels is projected to remain the largest pathway for copper to enter the study areas.
- Leaching from creosote-treated wood pilings is projected to remain the largest pathway for PAHs to enter the study areas.
- PCBs, metals, and other organic chemicals in sediments are likely to remain above state standards and/or remediation goals in the study areas.
- Flows from stormwater discharges and upstream watersheds into the study areas are projected to continue to represent a substantial pathway for nutrients and a number of metals and organic chemicals.
- During the summer, elevated salinity and low dissolved oxygen conditions in the deep waters of Lake Union are likely to continue to make these waters inhospitable to freshwater species.

Recommended Next Steps for the Region

Washington State and the region have a track record of improving water quality. The data show that investments made over the last five decades have made the region's waterbodies cleaner and safer. Analyses indicate that reducing the frequency of CSOs to an average of one untreated discharge per year per site over a 20-year moving average will substantially improve bacteria levels in the study areas and that other planned water quality improvement projects and programs will greatly decrease the levels of copper and PAHs in water and the levels of metals and organic contaminants in sediments by 2030. Modest improvements are anticipated for other contaminants.

King County scientists brave the weather on the SoundGuardian research vessel to collect samples from area waterbodies.

To continue the progress being made to address current water quality impairments and to address impairments projected to remain in 2030, the assessment identifies the following actions to continue to improve water quality. Some of these actions are already in progress or planned, and others are proposed:

- **Reduce the Frequency of Untreated CSO Discharges.** King County and the City of Seattle are committed to meet CSO Consent Decree and State requirements to reduce the frequency of untreated CSO discharges to an average of once per year over a 20-year moving average at each site. Barring unforeseen circumstances, King County and the City of Seattle anticipate completing projects to meet their CSO control requirements by 2030. King County will use the Study findings, along with engineering and legal information, during development of the 2018 update to its long-term CSO control plan to evaluate possible alternative approaches for achieving this goal, explore partnerships, and assess the timing and sequencing of projects to increase water quality benefits to the region. The design, sequencing, and deadlines for the projects are set forth in King County's CSO Consent Decree and cannot be modified without the concurrence of EPA, Ecology, and the Court. King County's CSO Consent Decree and its current plan calls for constructing nine projects by 2030 to reduce the frequency of untreated CSO discharges to an average of once per site per year over a 20-year moving average.
- **Implement planned water quality improvement projects and programs.** The Study identified over 100 stormwater improvement, piling removal, remediation, and regulatory water quality improvement projects and programs that are scheduled for implementation by 2030. Additional projects are likely to be identified and funded over the next 15 years. While not sufficient to fully address all of the water quality concerns the region faces, these planned actions will improve

receiving water quality. It is essential that the region ensures that these planned actions be implemented and that municipal stormwater permit requirements continue to be strengthened over time and implemented by all jurisdictions.

- **Monitor changes and add to the body of knowledge over time.** The Study recommended several monitoring programs and research studies to track changes in water quality over time, address uncertainties identified in the Study, and track and adjust implementation of water quality improvement projects. These include:
    - Continue and expand long-term water quality monitoring programs,
    - Conduct additional monitoring and studies to fill data gaps,
    - Undertake water quality modeling for parameters that are projected to not meet water quality standards to better understand concerns,
    - Assess the effectiveness of stormwater controls and permit implementation,
    - Identify and control sources of bacteria,
    - Track climate change impacts to aid in CSO and stormwater planning, and
    - Assess the feasibility and benefits of increased stormwater management requirements for development and redevelopment.

- **Do more for water quality.** It is recommended that King County and its partners implement additional water quality improvement projects and programs to build on this region's long-standing commitment to clean water, a healthy environment, and an outstanding quality of life for its residents. These projects and programs would continue to reverse and address the impacts from past and ongoing actions, population growth, development, and climate change throughout the watersheds. Implementing them would likely require watershed-scale coordination, with participation from governments, non-governmental organizations, tribes, businesses, and residents. Example actions include:
    - Implementation of Washington State Department of Ecology's Pollutant Loading Assessment to create a tool that will help determine ways to reduce ongoing sources of pollution,
    - Construction of stormwater flow control and water quality treatment where none currently exist, and implementation of other stormwater programs beyond permit requirements, such as are being discussed by the Our Green Duwamish partnership,
    - Tree plantings along all waterways and throughout the watersheds to reduce instream temperatures,
    - New regulations to control pollution at the source,
    - Upgrades to the Ballard Locks ,
    - Removal of additional creosote-treated pilings,
    - Contaminated site remediation, both on land and in sediments, where none is currently planned,

- Expansion of the restrictions on the use of copper content of vessel antifouling paint to expand the number and variety of vessels affected,
- Coordination of public outreach and education across the region to more universally improve water quality while also meeting regulatory requirements in a more cost-effective manner,
- Implementation of the salmon recovery plans, and
- Preservation of priority open space throughout the watersheds.

Lake Washington was too polluted for swimming in the 1950s, but regional actions resulted in a cleaner Lake Washington that now attracts thousands of swimmers every summer.