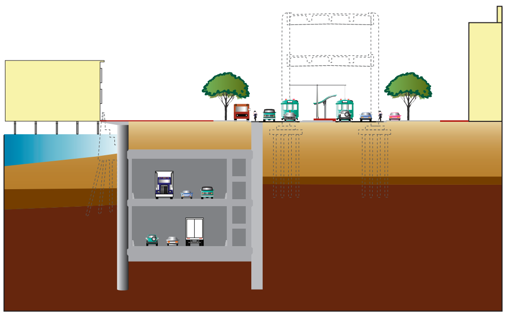
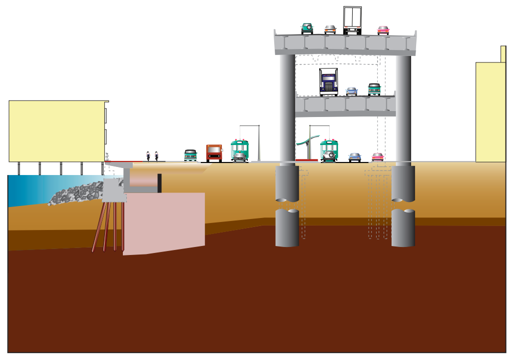
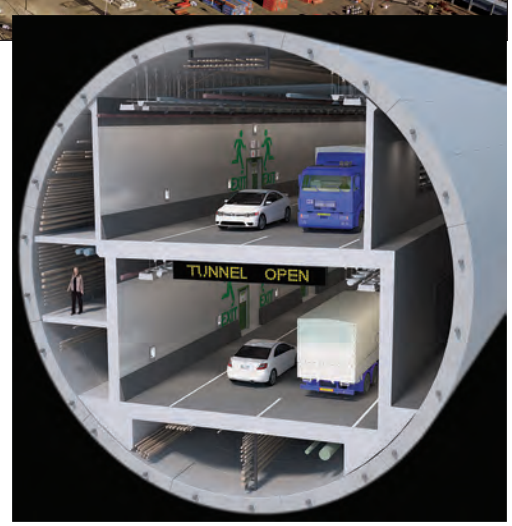
ALASKAN WAY VIADUCT REPLACEMENT PROJECT
Final Environmental Impact Statement

APPENDIX O Surface Water Discipline Report







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U.S. Department of Transportation
Federal Highway Administration

Washington State Department of Transportation

City of Seattle

JULY 2011

Alaskan Way Viaduct Replacement Project
Final EIS
Surface Water Discipline Report

The Alaskan Way Viaduct Replacement Project is a joint effort between the Federal Highway Administration (FHWA), the Washington State Department of Transportation (WSDOT), and the City of Seattle. To conduct this project, WSDOT contracted with:

Parsons Brinckerhoff
999 Third Avenue, Suite 3200
Seattle, WA 98104

In association with:
Coughlin Porter Lundeen, Inc.
EnviroIssues, Inc.
GHD, Inc.
HDR Engineering, Inc.
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LIST OF ATTACHMENTS

LIST OF EXHIBITS

ACRONYMS AND ABBREVIATIONS

BMP	best management practice
City	City of Seattle
County	King County
CSL	cleanup screening level (Washington State)
EBI	Elliott Bay Interceptor
Ecology	Washington State Department of Ecology
EIS	Environmental Impact Statement
FHWA	Federal Highway Administration
GSI	green stormwater infrastructure
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
NPGIS	non-pollution-generating impervious surface
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
PGIS	pollution-generating impervious surface
Program	Alaskan Way Viaduct and Seawall Replacement Program
project	Alaskan Way Viaduct Replacement Project
SMC	Seattle Municipal Code
SODO	South of Downtown
SPU	Seattle Public Utilities
SQS	sediment quality standard
SR	State Route
TBM	tunnel boring machine
TIA	total impervious area
TMDL	total maximum daily load
TSS	total suspended solids
WAC	Washington Administrative Code
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WWTP	wastewater treatment plant

Chapter 1 INTRODUCTION AND SUMMARY

1.1 Introduction

This discipline report was prepared in support of the Final Environmental Impact Statement (EIS) for the Alaskan Way Viaduct Replacement Project (project). The Final EIS and all of the supporting discipline reports evaluate the Viaduct Closed (No Build Alternative) in addition to the three build alternatives: the Bored Tunnel Alternative (preferred), the Cut-and-Cover Tunnel Alternative, and the Elevated Structure Alternative. The designs for the Cut-and-Cover Tunnel and the Elevated Structure Alternatives have been updated since the 2006 Supplemental Draft EIS to reflect that the section of the viaduct between S. Holgate Street and S. King Street is being replaced by a separate project and the alignment at S. Washington Street is no longer in Elliott Bay. All three build alternatives are evaluated with tolls and without tolls.

The Federal Highway Administration (FHWA) is the lead federal agency for this project, primarily responsible for compliance with the National Environmental Policy Act (NEPA) and other federal regulations, as well as distributing federal funding. Per the NEPA process, FHWA was responsible for selecting the preferred alternative. FHWA has based its decision on the information evaluated during the environmental review process, including information contained in the 2010 Supplemental Draft EIS (WSDOT et al. 2010) and previous evaluations in 2004 and 2006. After issuance of the Final EIS, FHWA will issue its NEPA decision, called the Record of Decision (ROD).

The 2004 Draft EIS (WSDOT et al. 2004) evaluated five Build Alternatives and a No Build Alternative. In December 2004, the project proponents identified the Cut-and-Cover Tunnel Alternative as the preferred alternative and carried the Rebuild Alternative forward for analysis as well. The 2006 Supplemental Draft EIS (WSDOT et al. 2006) analyzed two alternatives—a refined Cut-and-Cover Tunnel Alternative and a modified rebuild alternative called the Elevated Structure Alternative. After continued public and agency debate, Governor Gregoire called for an advisory vote to be held in Seattle. The March 2007 ballot included an elevated structure alternative (differing in design from the current Elevated Structure Alternative) and a surface tunnel hybrid alternative. The citizens voted down both alternatives.

After the 2007 election, the lead agencies committed to a collaborative process (referred to as the Partnership Process) to find a solution to replace the viaduct along Seattle's central waterfront. In January 2009, Governor Gregoire, King County Executive Sims, and Seattle Mayor Nickels announced that the agencies had reached a consensus and recommended replacing the aging viaduct with a bored tunnel, which is being evaluated in this Final EIS as the preferred alternative.

1.2 Summary of Alternatives

The Alaskan Way Viaduct Replacement Project is one of several independent projects developed to improve safety and mobility along State Route (SR) 99 and the Seattle waterfront from the South of Downtown (SODO) area to Seattle Center. Collectively, these individual projects are referred to as the Alaskan Way Viaduct and Seawall Replacement Program (the Program). See Exhibit 1-1.

Exhibit 1-1. Other Projects Included in the Alaskan Way Viaduct and Seawall Replacement Program

Project	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Independent Projects That Complement the Bored Tunnel Alternative			
Elliott Bay Seawall Project	X	Included in alternative	Included in alternative
Alaskan Way Surface Street Improvements	X	Included in alternative	Included in alternative
Alaskan Way Promenade/Public Space	X	Included in alternative	Included in alternative
First Avenue Streetcar Evaluation	X	Included in alternative	Included in alternative
Elliott/Western Connector	X	Function provided[1]	Function provided[1]
Transit enhancements	X	Not proposed[2]	Not proposed[2]
Projects That Complement All Build Alternatives			
S. Holgate Street to S. King Street Viaduct Replacement Project	X	X	X
Mercer West Project	X	X	X
Transportation Improvements to Minimize Traffic Effects During Construction	X	X	X
SR 99 Yesler Way Vicinity Foundation Stabilization	X	X	X
S. Massachusetts Street to Railroad Way S. Electrical Line Relocation Project	X	X	X

1. These specific improvements are not proposed with the Cut-and-Cover Tunnel and Elevated Structure Alternatives; however, these alternatives provide a functionally similar connection with ramps to and from SR 99 at Elliott and Western Avenues.
2. Similar improvements included with the Bored Tunnel Alternative could be proposed with this alternative.

The alternatives analyzed in this discipline report and in the Final EIS have been evaluated both quantitatively and qualitatively. Detailed descriptions of each alternative are presented in Appendix B, Alternatives Description and Construction Methods Discipline Report. All three build alternatives are being considered as non-tolled facilities, but they are also evaluated as tolled facilities in Chapter 7.

Each of the alternatives is summarized in the following subsections.

1.2.1 Viaduct Closed (No Build Alternative)

Two scenarios were evaluated as part of the Viaduct Closed (No Build Alternative):

- Scenario 1 – Unplanned closure of the Alaskan Way Viaduct for some structural deficiency, weakness, or damage due to a smaller earthquake event.
- Scenario 2 – Catastrophic failure and collapse of the viaduct.

1.2.2 Bored Tunnel Alternative

The Bored Tunnel Alternative (preferred alternative) includes replacing SR 99 with a bored tunnel and associated improvements, such as relocating utilities located on or under the Alaskan Way Viaduct or protecting in place the utilities along the bored tunnel alignment. Other project elements would be removing the viaduct, decommissioning the Battery Street Tunnel, and making improvements to the surface streets in the south and north portal areas of the bored tunnel.

Improvements in the south portal area include full northbound and southbound access to and from SR 99 between S. Royal Brougham Way and S. Dearborn Street. Alaskan Way S. would be reconfigured with three lanes in each direction. Alaskan Way S. would have one new intersection with a new east-west cross street at S. Dearborn Street. The cross street would have sidewalks on both sides.

Improvements in the north portal area would include restoring Aurora Avenue and providing full northbound and southbound access to and from SR 99 near Republican Street. Aurora Avenue would be restored to grade level between Denny Way and Harrison Street; John, Thomas, and Harrison Streets would be connected as cross streets. This rebuilt section of Aurora Avenue would connect to the new SR 99 alignment via Harrison Street. Mercer Street would be widened for two-way traffic from Fifth Avenue N. to Dexter Avenue N. Broad Street would be closed and filled in between Taylor Avenue N. and Ninth Avenue N. Also, a new roadway would be built to extend Sixth Avenue N. in a curved formation between Harrison and Mercer Streets. The new roadway would have a signalized intersection at the ramp that connects to the southbound on-ramp to the tunnel. Broad Street would be closed and filled between Fifth Avenue N. and Ninth Avenue N.

1.2.3 Cut-and-Cover Tunnel Alternative

A six-lane stacked tunnel would replace the existing Alaskan Way Viaduct between S. King Street and Pine Street. Although stacked throughout the central waterfront section, the tunnel would be side-by-side at both portals. The tunnel alignment would transition from a stacked configuration to a side-by-side roadway between Spring and Union Streets and would continue in this configuration up to the Battery Street Tunnel. The existing Elliott Bay Seawall would be replaced by the westernmost wall of the cut-and-cover tunnel between S. Jackson and Broad Streets.

The cut-and-cover tunnel would extend above grade between Union and Pike Streets. South of the Pike Street Hillclimb, SR 99 would cross over the BNSF Railway rail tracks on a side-by-side aerial roadway covered by a lid structure. The top of the lid would connect to the Pike Place Market Hillclimb at Western Avenue.

Near Lenora Street, SR 99 would transition to a retained cut extending up to the south portal of the Battery Street Tunnel. The Battery Street Tunnel would be lowered to match the roadway passing under Elliott and Western Avenues and widened to increase sight distance at the portals. The on- and off-ramps at Elliott and Western Avenues would be rebuilt for maintenance access only. The Battery Street Tunnel would be upgraded with safety improvements, which would include new fire suppression systems, updated ventilation, seismic retrofitting, and access and egress structures.

From the north portal of the Battery Street Tunnel up to about Mercer Street, SR 99 would be in a retained (lowered) cut. Mercer Street would continue to cross under SR 99 as it does today, but it would be widened and converted from a one-way to a two-way street, with three lanes in each direction and a center turn lane. Broad Street would be closed and filled between Fifth Avenue N. and Ninth Avenue N.

The primary elements of the Cut-and-Cover Tunnel Alternative described further in this report include the south portal area, the central tunnel section, the Battery Street Tunnel improvements, and the improvements to surface streets and to Aurora Avenue from the north portal of the Battery Street Tunnel to Aloha Street. This north section includes a lowered Aurora Avenue to make improvements such as several streets being reconnected over Aurora Avenue.

1.2.4 Elevated Structure Alternative

The Elevated Structure Alternative would replace the existing Alaskan Way Viaduct generally within the same right-of-way. The Elliott Bay Seawall would be rebuilt from S. Jackson Street to Broad Street.

Beginning near S. King Street, the at-grade SR 99 would rise and become a stacked aerial structure along the central waterfront. The northbound on-ramp and southbound off-ramp connections could be made from S. Royal Brougham Way and S. Dearborn Street, respectively, to complete the full access interchange in the stadium area. Other roadway improvements would include a new Alaskan Way aerial overpass of the BNSF railroad tail track, a new East Frontage Road between S. Dearborn Street and Alaskan Way S., and a multi-use bicycle and pedestrian path that would run along the east and west sides of the reconfigured Alaskan Way S.

In the central section of Seattle's downtown, the Elevated Structure Alternative would replace the existing viaduct with a stacked aerial structure along the central waterfront. The SR 99 roadway would carry three lanes in each direction, with wider lanes and shoulders than the existing viaduct.

The existing ramps at Columbia and Seneca Streets would be rebuilt and connected to a new drop lane. This extra lane would improve safety for drivers accessing downtown Seattle on the midtown ramps. Drivers could access downtown Seattle using these reconstructed ramps in either direction. SR 99 would cross over Elliott and Western Avenues to connect to the Battery Street Tunnel.

The Battery Street Tunnel would be upgraded with safety improvements, which would include new fire suppression systems, updated ventilation, seismic retrofitting, and access and egress structures.

Aurora Avenue would be lowered in a side-by-side retained cut roadway from the north portal of the Battery Street Tunnel to just south of Mercer Street and would be at-grade between Mercer and Aloha Streets. Ramps to and from Denny Way would provide access to and from SR 99 similar to today. The street grid would be connected over Aurora Avenue N. with two new bridges at Thomas and Harrison Streets. Mercer Street would be widened and converted to a two-way street. It would continue to cross under Aurora Avenue as it does today.

1.3 Stormwater Management Approach

1.3.1 Common to All Alternatives

The stormwater management approach would be similar for the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives. The approach would be a combination of strategies to provide water quality treatment for stormwater runoff before it is discharged into Elliott Bay, Lake Union, or Puget Sound. The general stormwater management approach that applies to all three build alternatives is summarized below, whereas the stormwater management strategies specific to each alternative are described in the following subsections.

The stormwater management approach would maintain existing drainage patterns and sub-basin boundaries wherever possible. Some sub-basin boundaries might be altered slightly to accommodate piping configurations, but the goal of the design would be to maintain approximately the same surface area contributing to each type of collection area (low-flow diversion, separated storm, and combined sewer). Existing drainage patterns would be maintained for all off-site stormwater (stormwater generated outside the study area) to convey it in pipes that pass through the study area.

Water quality treatment would be provided for all project-related runoff in one of two ways:

1. Stormwater from the project area that discharges to the combined sewer system would continue to receive water quality treatment at the West Point wastewater treatment plant (WWTP), similar to existing conditions.
2. Stormwater runoff from the proposed pollution-generating impervious surface (PGIS) that is not routed to the combined sewer system would be treated with water quality best management practices (BMPs) selected from the Seattle *Stormwater Manual* (City of Seattle 2009a) and/or the Washington State Department of Transportation (WSDOT) *Highway Runoff Manual* (WSDOT 2008) before discharge to Elliott Bay or Lake Union.

In accordance with the requirements of the Seattle Stormwater Code and the Seattle *Stormwater Manual* (City of Seattle 2009a), peak flow control would be added for runoff discharging to the combined sewer system through the use of detention BMPs. In the southern portion of the study area, flow control would not be provided, because modeling has shown that detention would not reduce the potential frequency and/or volume of overflows from the combined sewer system. Therefore, the City of Seattle (City) has granted an exception from the peak flow control requirements for the southern portion of the study area (City of Seattle 2009b).

Small, isolated areas within the project area have been identified that may not accommodate detention BMPs due to physical constraints such as land availability or interference with underground utilities. If detention cannot be provided in these areas, the project team would coordinate closely with the City to determine if an adjustment to the peak flow control requirements would be appropriate. Instead of requiring on-site flow control facilities in these areas, the City may grant approval for "alternative compliance." In that situation, the project would voluntarily contribute funds (equivalent to the estimated cost of an on-site facility) toward the construction of one or more off-site flow control facilities that would reduce the potential frequency and/or volume of overflows from the combined sewer system (City of Seattle 2009a).

For each build alternative, existing storm drainage utility lines would generally be removed and/or abandoned in place, and new storm drainage utility lines would be installed. Details of the analysis of the storm drainage and combined sewer utility systems for the proposed action are presented in Appendix K, Public Services and Utilities Discipline Report.

1.3.2 Viaduct Closed (No Build Alternative)

Under Scenario 1 of the Viaduct Closed (No Build Alternative), a sudden structural deficiency, weakness, or minor earthquake would result in an unplanned closure of the existing viaduct. It is assumed that the storm drainage system on and underneath the viaduct would likely be damaged and would require repair or replacement in kind. It is assumed that the existing viaduct would no longer be classified as pollution generating under this scenario.

Under Scenario 2, a major collapse of the existing viaduct would result in a dramatic disruption of the stormwater conveyance systems. Recovery measures would be necessary to repair and replace the stormwater management system in the vicinity.

1.3.3 Bored Tunnel Alternative

The bored tunnel would discharge drainage flows from several different sources; therefore, stormwater management would be provided for the tunnel itself. Some stormwater is expected to enter the bored tunnel in each portal area. In addition, drainage flows would be generated within the bored tunnel from several non-stormwater sources, including testing and operation of the emergency fire suppression system, tunnel washing, and groundwater seepage. All of this water would drain to sumps in the tunnel, which would provide significant detention (several acre-feet, depending on pump design). Eventually, the collected drainage would be pumped back to one or both portals for discharge. The exact tunnel drainage discharge rates and point(s) of discharge will be determined as the design progresses, in consultation with the receiving utility owner (either the City or King County [County]). This consultation will occur in the course of the King County Industrial Wastewater Discharge Permit process.

This analysis assumes that if the viaduct is removed, the existing drainage system for the viaduct structure also would be removed, and the remaining drainage systems in affected areas would be protected or replaced in kind. Stormwater flow control and water quality facilities in this area would be those that exist under current conditions.

In the north portal area, the area that currently discharges to the Broad separated storm drainage sub-basin would discharge to the Dexter combined sewer sub-basin after Broad Street is closed and backfilled between Taylor Avenue N. and Ninth Avenue N. To offset the additional discharge to the Dexter combined sewer sub-basin, runoff from Sixth Avenue N. that is currently collected by the Dexter sub-basin would be redirected to the Broad sub-basin.

1.3.4 Cut-and-Cover Tunnel Alternative

For the Cut-and-Cover Tunnel Alternative, it is assumed that the area of the reconstructed surface streets above the new tunnel would be similar to the area of the tunnel footprint. Along with the tunnel portal areas, runoff from these surface streets would be provided with water quality treatment through the general stormwater management approach described in Section 1.3.1.

Stormwater management for the Cut-and-Cover Tunnel Alternative in the central portion of the study area would include an exception to the approach of matching the contributing area of proposed sub-basins to the area of the existing sub-basin. Along the waterfront, several outfalls convey drainage from individual catch basins located in the west gutter line of the Alaskan Way surface street. Based on design and construction feasibility for water quality treatment, these individual catch basin basins would be eliminated and added to an adjacent sub-basin or sub-basins.

1.3.5 Elevated Structure Alternative

The Elevated Structure Alternative would provide water quality treatment for the new elevated roadway as well as for reconstructed surface streets. Water quality treatment for these areas would be provided through the general stormwater management approach described in Section 1.3.1. Also, similar to the stormwater management approach for the Cut-and-Cover Tunnel Alternative (Section 1.3.4), the individual sub-basins collecting runoff from the Alaskan Way surface street would be eliminated and added to an adjacent sub-basin or sub-basins.

1.4 Summary of Surface Water Analysis

This section provides an overview of the surface water analysis conducted for the project. It summarizes the potential water quality effects and benefits of the project alternatives and the mitigation measures that can be implemented to minimize the potential water quality effects.

Chapter 2 describes the methods used to conduct the surface water analysis detailed in this report.

Chapter 3 describes the studies and coordination efforts that contributed to this report.

Chapter 4 describes the current surface water conditions within the affected environment, including the sub-basins that receive runoff from the project area; the existing systems for managing stormwater and sewer flows within the project area; the receiving waters of central Puget Sound, Elliott Bay, and Lake Union; and the condition of nearshore sediments adjacent to project area outfalls.

Chapter 5 describes the potential operational effects of the Viaduct Closed (No Build Alternative) and the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives on surface water conditions in the project area, as compared to the current conditions detailed in Chapter 4, along with proposed mitigation for the expected adverse effects of the project.

Chapter 6 describes the potential effects of construction of the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives on surface water conditions and management systems in the project area, along with proposed mitigation measures for the expected short-term adverse effects.

Chapter 7 discusses tolling.

Chapter 8 lists the references used to prepare this report.

Attachment A describes the analysis conducted to evaluate changes in pollutant load carried by runoff from the study area established for the analysis of project-related effects on surface water.

The following subsections summarize the key findings of this report.

1.4.1 Study Area

The study area for the surface water analysis (Exhibits 1-2 and 1-3) is based on the combined footprint of each alternative and includes combined sewer service areas and stormwater drainage sub-basins within that footprint. The study area also includes associated outfall locations, receiving waters, and nearshore sediment in the vicinity of project-related outfalls. The study area covers approximately 99 acres that drain to 13 major sub-basins. Chapter 4 describes these sub-basins and the current surface water conditions within the study area in greater detail.

1.4.2 Affected Environment

The land within the study area has been developed for more than 100 years and consists predominantly of impervious surfaces. Most of the stormwater runoff from the study area currently discharges to the combined sewer system, which discharges to Puget Sound through the West Point WWTP. Sometimes, during heavy rains, stormwater in the combined sewer system discharges directly to Elliott Bay or Lake Union without treatment as a combined sewer overflow. Also, untreated runoff from smaller portions of the study area discharges directly to Elliott Bay and Lake Union on a regular basis. Elliott Bay and Lake Union have been identified by the Washington State Department of Ecology (Ecology) as exceeding certain water quality criteria. Sediment quality within the study area receiving waters is discussed in detail in Section 4.4. The pipes within all of the drainage systems discussed are owned and maintained by private entities, the County, or Seattle Public Utilities

(SPU). A detailed description of the conveyance system within the study area and the associated receiving waters is provided in Chapter 4.

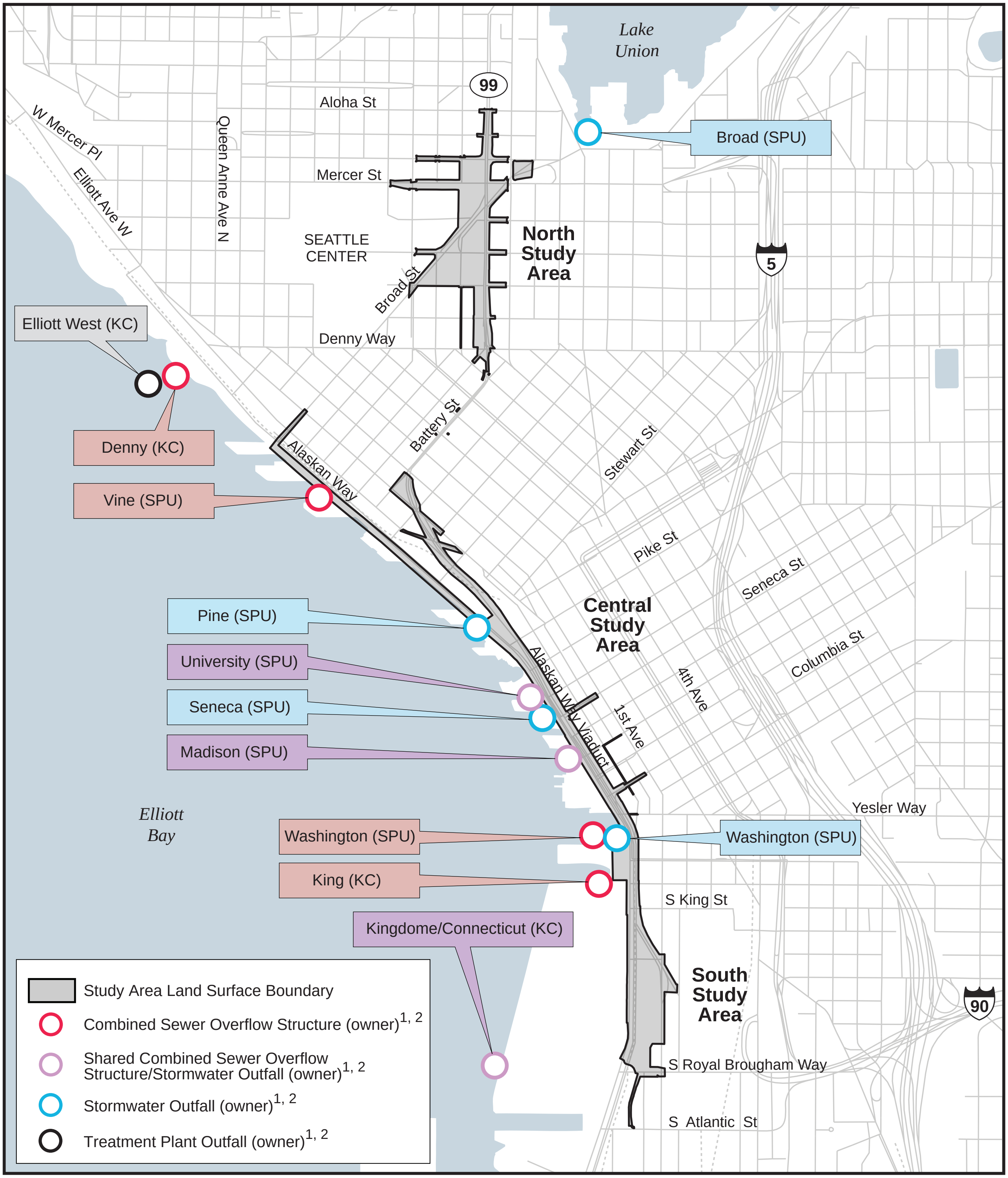
1.4.3 Operational Effects, Mitigation, and Benefits

In general, runoff from streets and highways, particularly in urban environments, contains pollutants that can affect the water quality of the receiving water body. Studies conducted on runoff in the Seattle area indicate that highways are a measurable source of suspended solids, metals (zinc and copper), and other pollutants (Driscoll et al. 1990). Pollutant loads contained in stormwater runoff vary depending on the amount and type of PGIS, traffic volumes and average speed, duration and intensity of a storm event, and several other factors. Pollutant loads reaching the receiving water can be reduced through the use of water quality BMPs.

Annual pollutant loads in stormwater under existing conditions, the Viaduct Closed (No Build Alternative), and each of the build alternatives were analyzed and compared. The results of this analysis indicate that pollutant loads would be reduced relative to existing conditions on average by approximately 14 percent under the Viaduct Closed (No Build Alternative), 31 percent by both the Bored Tunnel and Cut-and-Cover Tunnel Alternatives, and 30 percent by the Elevated Structure Alternative. The major differences in pollutant load between existing conditions and the four alternatives are the result of decreased amounts of PGIS. The proposed use of water quality BMPs results in the additional reduction in pollutant load for the three build alternatives. Chapter 5 describes the potential operational effects and proposed mitigation.

1.4.4 Construction Effects and Mitigation

The construction-related effects of the build alternatives would be temporary. They would generally result from staging, material transport, earthwork, soil stockpiling, storm drainage and/or combined sewer utility work, and dewatering. In-water construction activity, such as work for removal of the existing seawall, seawall replacement, outfall reconstruction, and pier modifications would be required for both the Cut-and-Cover Tunnel Alternative and the Elevated Structure Alternative. Construction-related pollutants could increase turbidity, decrease the available oxygen in the water, and increase pH. Construction-related effects on surface water would be minimized or prevented by the development and implementation of management plans and the selection and implementation of appropriate construction BMPs. A description of potential construction-related effects and proposed mitigation is presented in Chapter 6.



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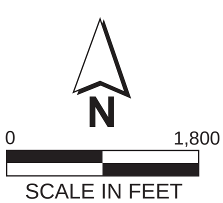
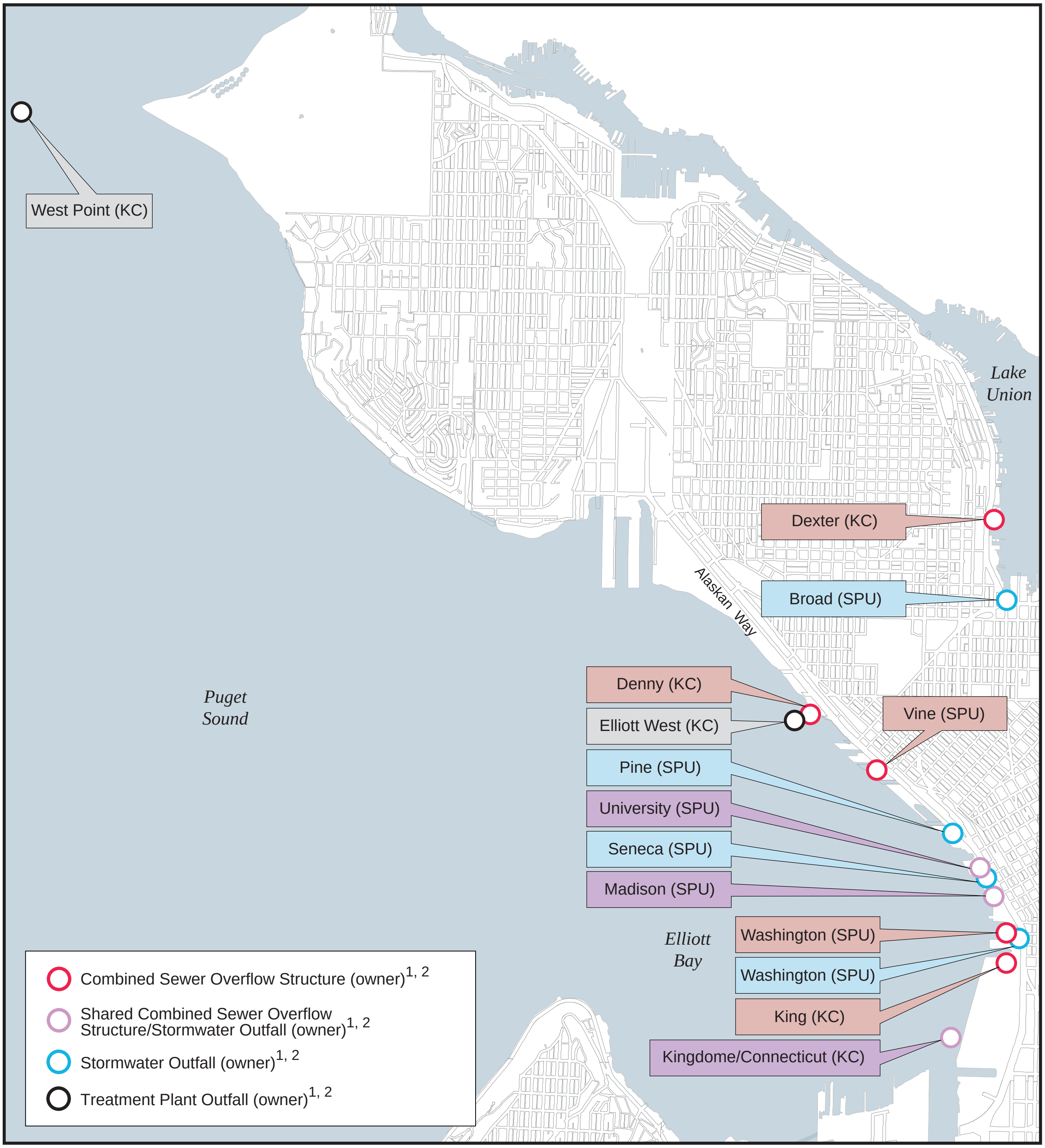


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 1-2
Surface Water Study Area - Land Surface Area



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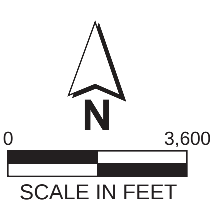


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 1-3
Surface Water Study Area - Outfall Locations

Chapter 2 METHODOLOGY

This chapter outlines the procedures and data used to:

1. Define the study area
2. Develop the stormwater management approach
3. Evaluate potential environmental effects of the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives, and the Viaduct Closed (No Build Alternative)
4. Analyze potential effects from construction-related runoff
5. Identify possible mitigation measures for avoiding or minimizing adverse environmental effects or enhancing environmental quality during construction and operation.

2.1 Defining the Study Area

The study area for the surface water analysis (Exhibits 1-2 and 1-3) is based on the combined footprints of the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives. The study area includes combined sewer service areas and stormwater drainage sub-basins within the project area. The study area also includes outfall locations, receiving waters, and nearshore sediment in the vicinity of project-related outfalls. The study area was determined by reviewing existing stormwater utility drawings, technical reports for the vicinity of the project area, drainage flow paths from the project area, and locations of outfalls that discharge to surface receiving waters. The study area was divided into three geographic areas:

- The southern portion of the study area extends from S. Royal Brougham Way to approximately S. King Street. It includes the Royal Brougham South, Royal Brougham North, and King Sub-basins and associated outfall structures and receiving waters.
- The central portion of the study area extends from approximately S. King Street through the Battery Street Tunnel. It includes the Washington, Madison, Seneca, University, Pike, Pine, Vine, and Western Diversion Sub-basins and associated outfall structures and receiving waters.
- The northern portion of the study area extends from just south of Denny Way north to Aloha Street. It includes the Dexter and Broad Sub-basins and associated outfall structures and receiving waters.

The following project elements would occur within the study area:

- Removal of the existing Alaskan Way Viaduct structure
- Replacement of SR 99 through the existing viaduct corridor with a bored tunnel, a cut-and-cover tunnel, or an elevated structure

- Relocation of utilities located on or under the existing viaduct
- Modifications to the surface streets in the southern and northern portions of the study area
- Modifications to the surface streets in the central portion of the study area, for the Cut-and-Cover Tunnel and Elevated Structure Alternatives only
- Modifications to the Battery Street Tunnel, for the Cut-and-Cover Tunnel and Elevated Structure Alternatives only
- Decommissioning of the Battery Street Tunnel, for the Bored Tunnel Alternative only
- Removal and replacement of the Elliott Bay Seawall, for the Cut-and-Cover Tunnel and Elevated Structure Alternatives only

2.2 Applicable Regulations and Guidelines

Water quality and sediment standards for fresh and marine waters in Washington State are established in Washington Administrative Code (WAC), Chapters 173-201A and 173-204, respectively (WAC 173-201A and 173-204). The discharge of stormwater into municipal sewer systems is regulated by WAC 173-336-100. King County Ordinance Regional Wastewater Services Plan is implemented according to the requirements of King County Code, Chapter 28.86. In addition, several agencies have laws, statutes, local ordinances, and guidelines that further address stormwater management. Exhibit 2-1 summarizes the stormwater management requirements and guidelines reviewed as part of the evaluation of surface water in the study area.

Exhibit 2-1. Summary of Requirements and Guidance Documents

Agency	Requirements/Guidance Documents
U.S. Environmental Protection Agency	Clean Water Act[1]
Washington State Department of Ecology	TMDLs and 303(d) lists (Ecology 2009) *Stormwater Management Manual for Western Washington* (Ecology 2005)
Washington State Department of Transportation	2010 *Environmental Procedures Manual* (WSDOT 2010) *Highway Runoff Manual* (WSDOT 2008)[2]
King County	*King County, Washington, Surface Water Design Manual* (King County 2009a)[1]
City of Seattle	Stormwater Code (SMC Chapters 22.800–22.808) and supporting *Stormwater Manual* (City of Seattle 2009a)[1]; Shoreline Master Program (SMC Chapter 23.60), and Environmentally Critical Areas Ordinance (SMC Chapter 25.09)

Notes: SMC = Seattle Municipal Code; TMDL = total maximum daily load

[1]. In Washington State, the administration of some portions of the Clean Water Act has been delegated to the Department of Ecology.

[2]. The Department of Ecology has determined that these manuals meet minimum design requirements and BMPs equivalent to those in the Department of Ecology's *Stormwater Management Manual for Western Washington* (Ecology 2005).

2.3 Data Sources

Water quality reports, sediment quality data, surface water management plans, and sub-basin and utility maps collected for previous phases of the Program were reviewed, in addition to newly acquired information, as applicable. Information collected for this review included maps and qualitative descriptions of utilities and outfalls from WSDOT, the City, and the County. Also reviewed was information on the frequency and volume of discharges to surface receiving waters from the combined sewer system. For the evaluation of temporary construction-related effects, groundwater information collected for Appendix P, Earth Discipline Report, was reviewed in terms of the quality and quantity of dewatering water.

The following agencies provided information to assist in the preparation of this report.

City of Seattle

- Detailed maps of the existing storm drainage and combined sewer system, including sub-basin boundaries
- Combined sewer overflow reduction plan documents
- Shoreline Master Program documents relating to nearshore sediment

Washington State Department of Ecology

- Section 303(d) List of Threatened and Impaired Water Bodies
- Nearshore sediment quality data, studies, and management plans

King County

- Detailed maps of the existing combined sewer system, including sub-basin boundaries
- Frequency and volumes of combined sewer overflow events
- Combined sewer overflow control plan documentation
- Nearshore sediment quality information

A description of the City's and County's existing storm drain, low-flow diversion, and combined sewer systems was developed from the following sources:

- Drainage maps of the existing storm drain and combined sewer networks, including stormwater drainage sub-basins, combined sewer service areas, existing BMPs, and outfall locations and sizes
- Water quality data collected as part of the National Pollutant Discharge Elimination System (NPDES) municipal stormwater program or data from other previous studies
- Frequency and volumes of combined sewer overflow events, based on previous studies

2.4 Analysis of Existing Conditions

The term "existing conditions" as it pertains to the affected environment refers to the period just before construction of the project, which is expected to begin in 2011. Existing conditions in the study area that could potentially be affected by the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives are discussed in Chapter 4. The surface water analysis focused on the natural environment (Puget Sound, Elliott Bay, and Lake Union) and the existing stormwater and combined sewer system.

Existing conditions in terms of the quality of surface water and nearshore sediment in Puget Sound, Elliott Bay, and Lake Union were characterized using studies conducted by various entities, including the City, the County, and Ecology. Floodplain boundaries were not addressed in the existing conditions analysis, because there are no floodplains associated with Elliott Bay or Lake Union (FEMA 1995a, 1995b). WSDOT has also confirmed that there are no streams, wetlands, or drinking wells in the study area, so these elements have not been evaluated. The condition of the existing shoreline is discussed in Appendix N, Wildlife, Fish, and Vegetation Discipline Report.

Sediment quality in the study area was evaluated by:

1. Reviewing Ecology's Environmental Information Management (EIM) database (formerly SEDQUAL; Ecology 2006)
2. Reviewing Ecology's 303(d) contaminated sediment listings (Ecology 2009)
3. Reviewing previous studies of areas along Puget Sound, Elliott Bay, and Lake Union
4. Collecting additional sediment samples in areas of data gaps in Elliott Bay (Parametrix 2007)

2.5 Development of Stormwater Management Approach

The stormwater management approach for the project was developed by the project design team and project partners to meet regulatory requirements through evaluation of engineering objectives, feasibility issues, and geographic considerations along the corridor. Several documents, including project design reports and preliminary design plans were reviewed to understand the stormwater management approach for the project (see Section 3.1).

2.6 Analysis of Environmental Effects

2.6.1 Operational Effects Analysis

Potential operational effects were analyzed under existing conditions; Viaduct Closed (No Build Alternative); and the Bored Tunnel, Cut-and-Cover Tunnel, and

Elevated Structure Alternatives. Potential operational effects on hydrology, surface water quality, and nearshore sediments were evaluated.

Potential effects on hydrology were evaluated by comparing land use changes under each alternative to existing conditions. In addition, potential effects on the volume and frequency of flows under each alternative were evaluated considering that the proposed design would meet City flow control requirements for discharges to storm drain and combined sewer systems.

Potential operational effects of the project alternatives on water quality were evaluated by generating a quantitative pollutant load analysis using the WSDOT Method 1, based on the guidance in the 2010 *Environmental Procedures Manual* (WSDOT 2010a) and outlined in *Quantitative Procedures for Surface Water Impact Assessments* (WSDOT 2009).

Potential effects on nearshore sediments due to the change in pollutant loading were qualitatively evaluated for Elliott Bay, Lake Union, and Puget Sound (for areas draining stormwater to the combined sewer outfall at the West Point WWTP), assuming that changes in annual pollutant load affect changes in sediment quality. The operational effects, mitigation, and benefits of the project are discussed in Chapter 5.

2.6.2 Construction Effects Analysis

The following methods were used to qualitatively evaluate the potential for temporary construction effects from the Bored Tunnel Alternative:

- Identification of all locations where (1) the work area may be exposed to precipitation and/or run-on, (2) work would occur in or over the water (if applicable), and (3) work would require dewatering
- Use of existing third-party data to identify possible pollutants of concern for surface water
- Use of groundwater data from Appendix P, Earth Discipline Report, to identify pollutants of concern that may be encountered during dewatering activities
- Use of groundwater dewatering volume estimates from the design team and Appendix P, Earth Discipline Report, to identify potential erosion and/or sediment transport during disposal of dewatering water
- Evaluation of potential unavoidable effects, if applicable, despite the use of proposed construction BMPs
- Evaluation of potential concurrent construction effects from other projects in the vicinity

The timeframe for construction-related (temporary) effects is as follows:

- Bored Tunnel Alternative (preferred): 5.4 years
- Cut-and-Cover Tunnel Alternative: 8.75 years
- Elevated Structure Alternative: 10 years

The findings of the construction effects analysis and a discussion of potential mitigation are included in Chapter 6.

Chapter 3 STUDIES AND COORDINATION

This report was prepared using information obtained from various sources, including the following:

- City of Seattle
- WSDOT
- King County
- Ecology
- Project design team

3.1 Studies

The following studies served as the foundation and provided background information for the preparation of this report:

- *2008 Washington State's Water Quality Assessment [303(d)]* (Ecology 2009)
- *Alaskan Way Viaduct and Seawall Replacement Project Drainage and Wastewater Tiles* (City of Seattle 2009c)
- *Bored Tunnel Corridor Final Conceptual Hydraulic Report* (CH2M Hill 2010)
- *Combined Sewer Overflow Control Program 2009 Annual Report* (King County 2010)
- *Combined Sewer Overflow Control Program 2008 Annual Report* (King County 2009b)
- *Combined Sewer Overflow Control Program 2007–2008 Annual Report* (King County 2008)
- *Combined Sewer System Analysis Study* (HDR 2007)
- *CSO and Stormwater Outfall Basis of Design* (Cosmopolitan Engineering Group, Inc. 2007)
- The Environmental Information Management Database (Ecology 2006)
- *Geotechnical and Environmental Data and Dewatering Feasibility Draft Report, Central Section* (Shannon & Wilson 2007)
- *SR 99 Bored Tunnel Alternative: Final Staging, Sequencing, Constructability, and Construction Impacts Study* (Parsons Brinckerhoff 2009)
- *Tunnel West Wall Constructability Workshop Construction Advisory Panel Report* (Parsons 2006)

Information about specific drainage sub-basin boundaries within the study area was taken from the *Bored Tunnel Corridor Final Conceptual Hydraulic Report* (CH2M Hill 2010), *Combined Sewer System Analysis Study* (HDR 2007), *Alaskan Way Viaduct and*

Seawall Replacement Project Drainage and Wastewater Tiles (City of Seattle 2009c), and updated information provided by the design team.

3.2 Coordination

Several meetings were held with WSDOT, the City, and design team members throughout the preparation of this report to establish project design conditions and assumptions to use in the evaluation of project-related effects on water resources in the study area. The City also provided geographic information system (GIS) data necessary to document and map the existing combined sewer and stormwater drainage systems.

Chapter 4 AFFECTED ENVIRONMENT

This chapter describes both the natural and built environments that could potentially be affected by the construction and operation of the proposed Bored Tunnel, Cut-and-Cover Tunnel, or Elevated Structure Alternatives. Specifically, it describes the drainage patterns, water quality, and nearshore sediment quality of the surface water and associated water bodies that receive runoff from the study area as they would likely exist during the project baseline year of 2015. It also identifies locations where the natural environment may be more susceptible to temporary or long-term effects.

4.1 Overview of Existing Conditions

The study area (Exhibit 1-2) covers approximately 99 acres, has been developed for more than 100 years, and consists of predominantly impervious surface. The study area consists of portions of the drainage basins located within the project area and the associated surface water outfalls and receiving waters (Exhibit 1-3). The additional portions of the larger drainage basins outside the project area are not included in the study area.

The study area is part of the highly developed downtown urban corridor extending to the south along the Elliott Bay waterfront and to the northeast toward Lake Union. Development and associated activities have degraded the quality of surface water and nearshore sediments of the study area receiving waters, including Puget Sound, Elliott Bay, and Lake Union. Sources of surface water pollutants in the study area include industrial facility discharges, combined sewer overflows, spills, and urban storm drains, which include roadway runoff (Ecology 1995). Studies conducted on runoff in the Seattle area indicate that highways are a measurable source of suspended solids, metals (zinc and copper), and other pollutants (Driscoll et al. 1990). Pollutants that have been found in receiving water sediments in the study area include total solids, fecal coliform bacteria, copper, zinc, mercury, lead, petroleum hydrocarbons, polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs) (Ecology 2006, 2009; Parametrix 2007).

4.2 Drainage System

Historically, a conveyance system was built in Seattle to collect both sanitary sewage and stormwater in a single pipe and convey it to a discharge location. In the early 1960s, the Municipality of Metropolitan Seattle (Metro, now part of King County) was formed under the Comprehensive Sewer Plan, and work began to reduce the annual volume of untreated sanitary and combined sewage discharge to surface waters in King County. Metro completed a variety of projects (including treatment plants, interceptor pipes, regulators, and separation projects) to reduce combined sewer overflows. As part of this program, the City and Metro constructed several projects within the study area that have reduced the frequency and volume of combined sewer overflows (Metro 1988a). The goal of these projects and others outlined in the *1988 Combined Sewer Overflow Control Plan* was to reduce the total frequency and volume of combined sewer overflow discharge (Metro 1988a). Both the City and the County have continued their efforts, and each maintains combined sewer overflow reduction programs today.

Under existing conditions, most stormwater runoff from the study area drains to 13 major sub-basins (Exhibits 4-1 through 4-3) and discharges to Puget Sound via the West Point WWTP or to Elliott Bay through either the separated or low-flow diversion storm drainage system or as part of a combined sewer system overflow. A small portion of the study area discharges to Lake Union through a separated storm drainage system. The pipes within these drainage systems are owned and maintained by private entities, the County, or SPU. An overview of the relationships between the drainage sub-basins, conveyance systems, outfall structures, and receiving waters in the study area is presented in Exhibit 4-4.

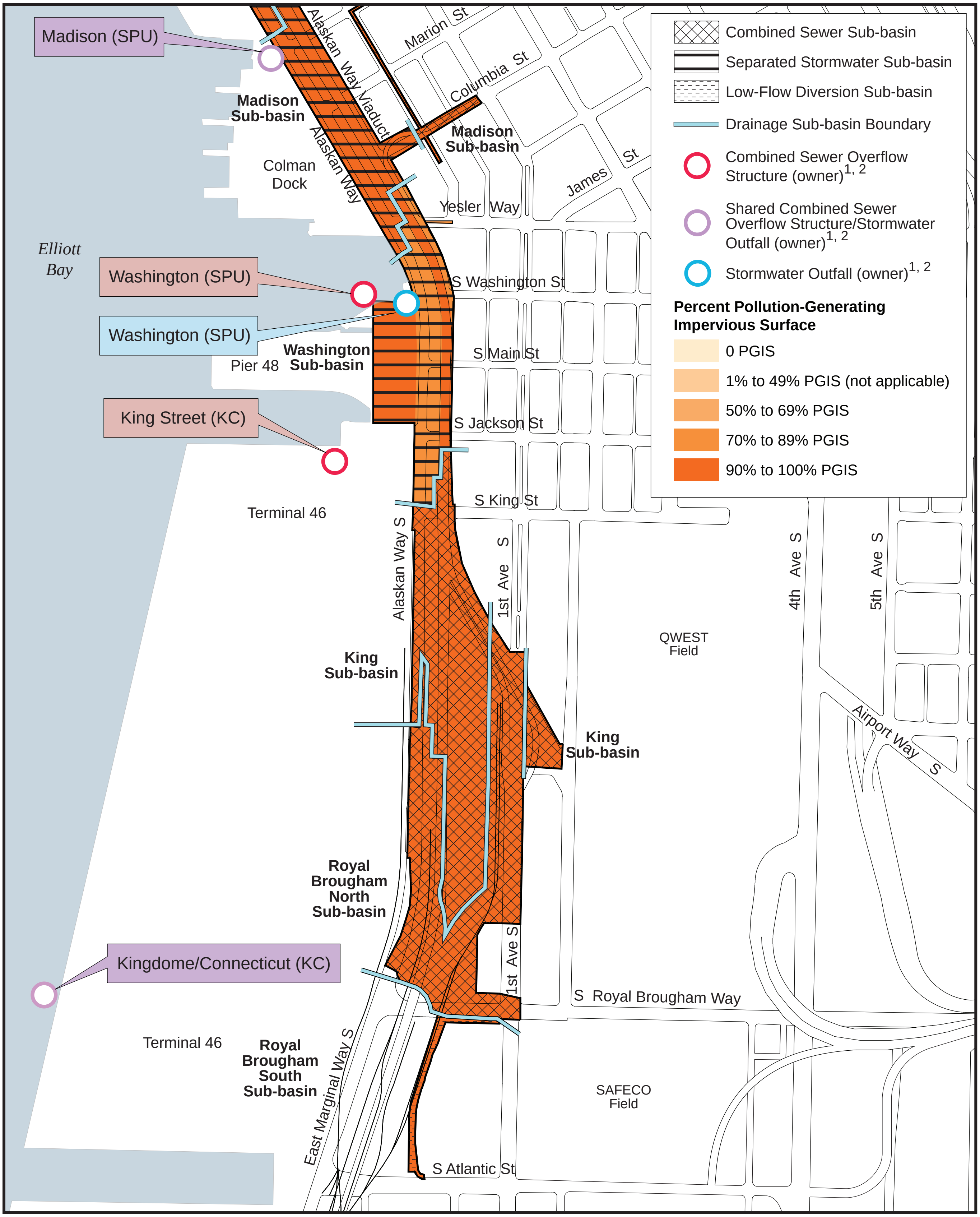
There are currently three main types of drainage systems within the study area: separated storm drainage system, low-flow diversion drainage system, and combined sewer system. These systems are described in the following subsections.

4.2.1 Separated Storm Drainage System

The separated storm drainage system typically collects stormwater from the study area and conveys it to stormwater outfalls, where it is discharged without treatment to either Elliott Bay or Lake Union. Some of the sub-basins drain stormwater to shared stormwater outfalls/combined sewer overflow structures but are independent of the larger combined sewer system.

4.2.2 Low-Flow Diversion Drainage System

The low-flow diversion system regulates the flow of stormwater into the combined sewer system with a gate operated by the County. During heavy rains, if the water surface elevation in the combined sewer system reaches a set point, the County closes the gate. At this point, stormwater is discharged to Elliott Bay without treatment.



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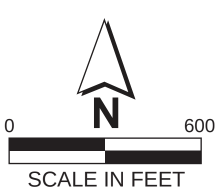
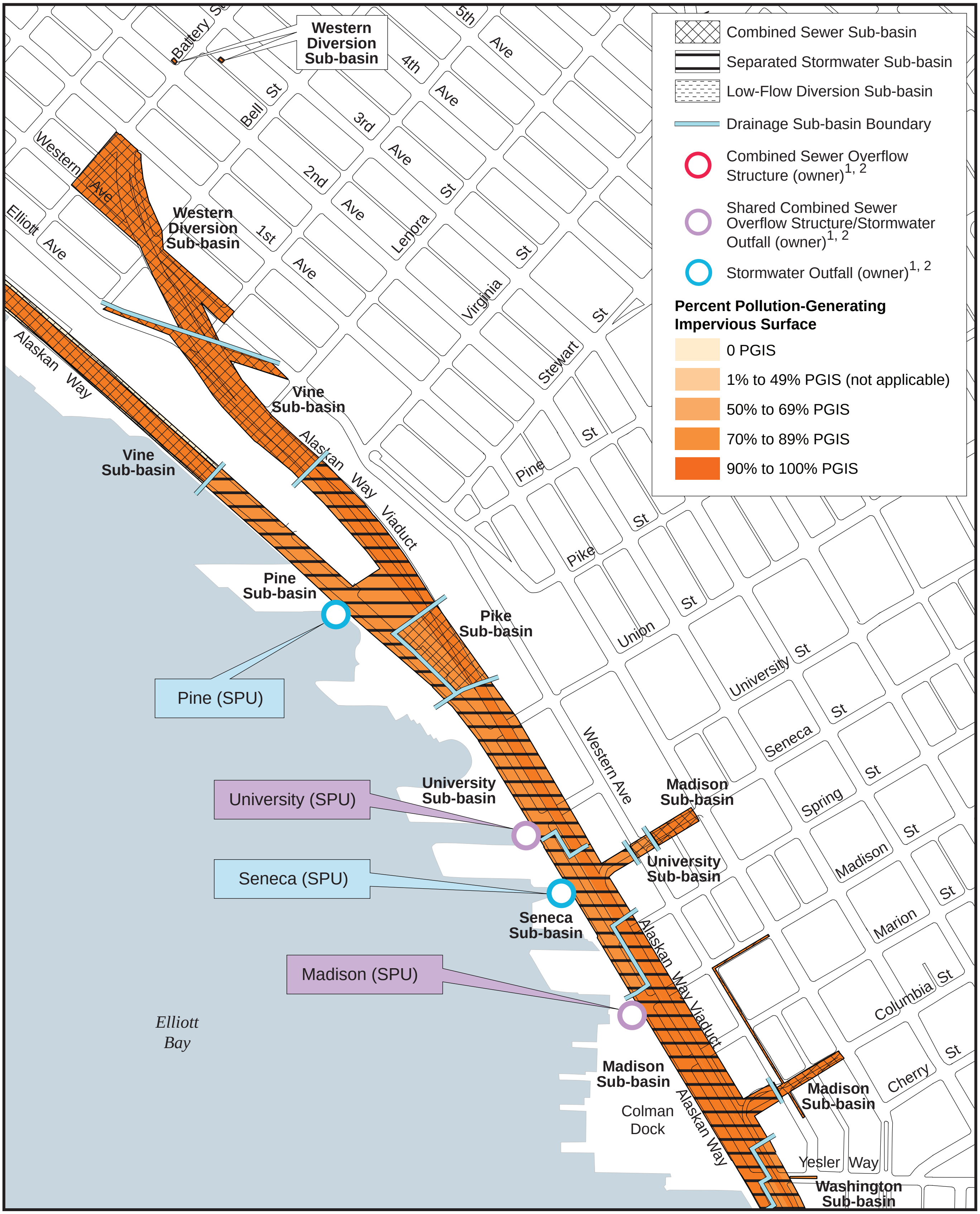


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 4-1
Existing Drainage Configuration - South



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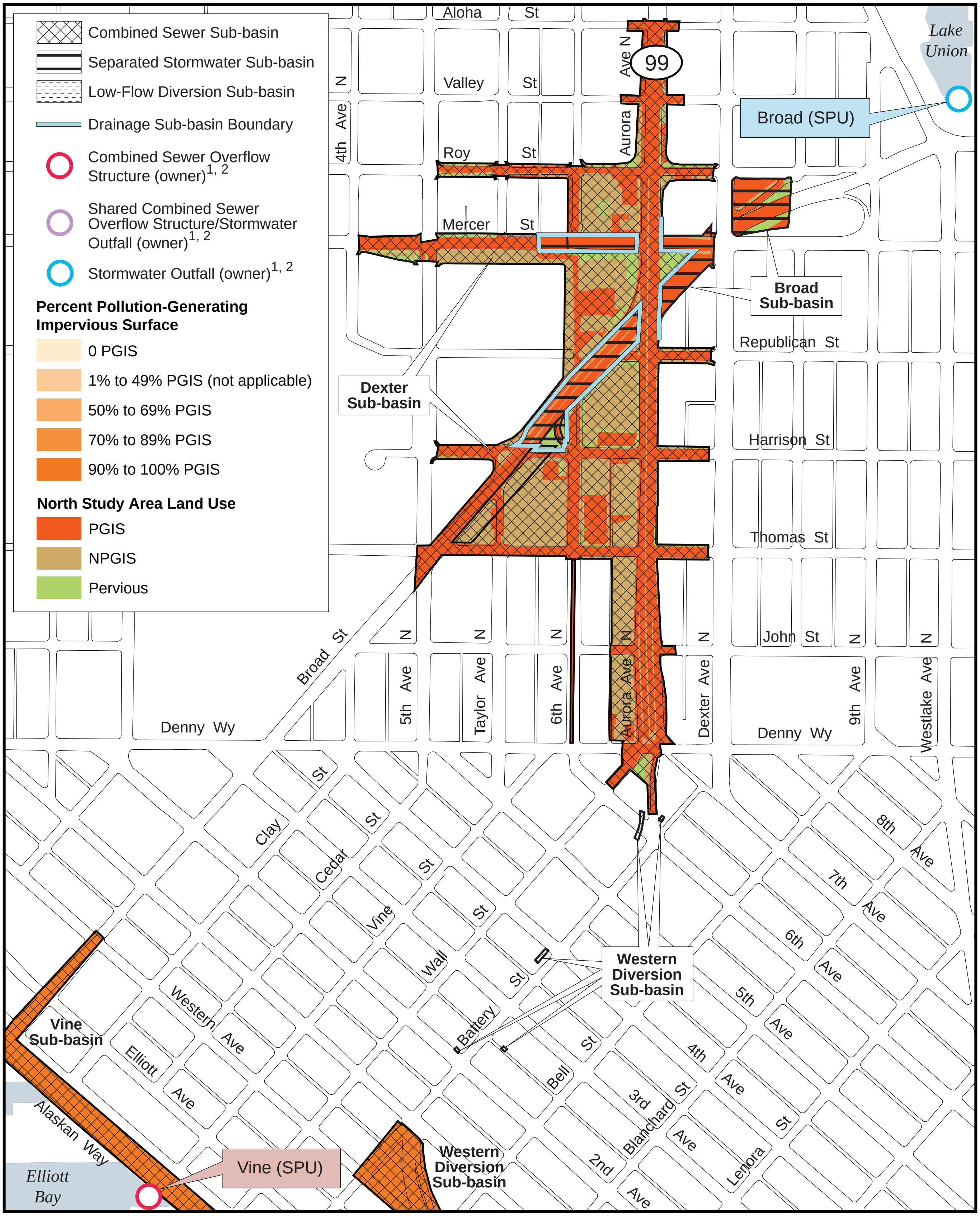
Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 4-2
Existing Drainage Configuration - Central



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SCALE IN FEET

Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 4-3
Existing Drainage Configuration - North

Exhibit 4-4. Overview of Drainage in the Study Area

Sub-basin (Type)	Outfall/Overflow Structure (1) Primary Outfall (2) Overflow [1] (3) Overflow [2]	Outfall/Overflow Structure Owner (Type)	Existing Water Quality Treatment	Receiving Water
Royal Brougham South (low-flow diversion[1])	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Kingdome/ Connecticut	SPU/KC[2] (shared[3])	None	Elliott Bay
Royal Brougham North (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Kingdome/ Connecticut	SPU/KC[2] (shared[3])	None	Elliott Bay
King (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) King Street	KC (combined)	None	Elliott Bay
Washington (storm)	Washington	SPU (storm)	None	Elliott Bay
Madison (storm)	Madison	SPU (shared[3])	None	Elliott Bay
Madison (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Madison	SPU (shared[3])	None	Elliott Bay
Seneca (storm)	Seneca	SPU (storm)	None	Elliott Bay
University (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) University	SPU (shared[3])	None	Elliott Bay
University (storm)	University	SPU (shared[3])	None	Elliott Bay
Pike (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Elliott West	KC (TP[4])	TP[4]	Elliott Bay
	(3) Denny Way	KC (combined)	None	Elliott Bay
	(4) University	SPU (shared[3])	None	Elliott Bay
Pine (storm)	Pine	SPU (storm)	None	Elliott Bay
Vine (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Elliott West	KC (TP[4])	TP[4]	Elliott Bay
	(3) Denny Way	KC (combined)	None	Elliott Bay
	(4) Vine Street	SPU (combined)	None	Elliott Bay
Western Diversion (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Elliott West	KC (TP[4])	TP[4]	Elliott Bay
	(3) Denny Way	KC (combined)	None	Elliott Bay
	(4) Vine Street	SPU (combined)	None	Elliott Bay
Dexter (combined)	(1) West Point	KC (WWTP)	WWTP	Puget Sound
	(2) Elliott West	KC (TP[4])	TP[4]	Elliott Bay
	(3) Denny Way	KC (combined)	None	Elliott Bay
	(4) Dexter Street	KC (combined)	None	Lake Union
Broad (storm)	Broad (storm)	SPU (storm)	None	Lake Union

Notes: KC = King County; SPU = Seattle Public Utilities; TP = wet-weather treatment; WWTP = wastewater treatment plant

[1] Low-flow diversion sub-basins regulate stormwater flow into the combined sewer system with an actuated gate operated by King County. During heavy rains, if the water surface elevation in the combined sewer reaches a set point, the gate is closed and untreated stormwater is discharged directly to Elliott Bay.

[2] The Kingdome/Connecticut outfall structure has shared ownership between the City and King County. The outfall pipe is owned and maintained by the City, the storm drain flows are considered City discharges, and the combined sewer overflows are King County discharges.

[3] Shared outfalls discharge both separated stormwater runoff and combined sewer overflows.

[4] During heavier storms, the Elliott West Combined Sewer Overflow Control Facility provides primary treatment and disinfection to flows and then discharges them to Elliott Bay.

4.2.3 Combined Sewer System

The combined sewer system collects stormwater runoff from the study area and conveys it to the City's combined sewer system, where it mixes with sewage. Water within this system is managed using diversion structures and regulators that connect to the County's regional combined sewer system. The County's regional wastewater system serves approximately 420 square miles (268,800 acres) and 1.4 million people in urban King County and parts of Snohomish and Pierce Counties (HDR 2007), but Seattle is the only portion of the County's wastewater system where stormwater is introduced. The City's combined sewer system constitutes about 7 percent of the County's service area (King County 2009c), or approximately 29 square miles (18,800 acres).

In general, the City manages diversion structures, which consist of weirs and/or orifices that passively control the amount of flow. The County manages several regulators within the study area, which typically contain gate valves that are actively controlled to change the combined sewer flow rates (HDR 2007). The County's system includes large interceptor (or collector) pipes that convey the sewage/stormwater mixture to the WWTP during normal flow conditions. This wastewater is treated at the WWTP before being discharged to Puget Sound. The main collector pipe serving the study area is known as the Elliott Bay Interceptor (EBI). When flows exceeds the capacity of the EBI, typically during heavy rain events, diversion structures and regulators divert the flows to backup wet-weather treatment facilities or discharge the untreated diluted wastewater directly to combined sewer overflow structures that drain to Elliott Bay and Lake Union.

Exhibits 4-5 and 4-6 summarize the frequency and volumes of recorded untreated combined sewer overflow events at County and City outfalls, respectively.

Exhibit 4-5. Untreated King County Combined Sewer Overflow Events

		2007		2008		2009	
Receiving Water	Outfall	Number of Events	Total Volume (million gallons)	Number of Events	Total Volume (million gallons)	Number of Events	Total Volume (million gallons)
Lake Union	Dexter	9	28.99	3	3.6	11	8.12
Elliott Bay	Denny	1	29.07	2	0.08	4	0.95
Elliott Bay	King	6	25.38	3	0.82	15	56.24
Elliott Bay	Kingdome/ Connecticut	6	28.56	1	0.23	8	3.54

Sources: King County 2007, 2008, 2009b, 2010.

Exhibit 4-6. Untreated City of Seattle Combined Sewer Overflow Events

Receiving Water	Outfall	2005 Number of Events	2005 Total Volume (million gallons)	2006 Number of Events	2006 Total Volume (million gallons)	2007	2008 Number of Events	2008 Total Volume (million gallons)	2009 Number of Events	2009 Total Volume (million gallons)
Elliott Bay	Vine	3	17.02	4	0.78	(No data)	1	0.07	3	0.19
Elliott Bay	University	3	22.42	1	0.35		0	0	2	0.01
Elliott Bay	Madison	3	9.1	5	1.62		2	0.15	5	0.37
Elliott Bay	Washington	0	0	1	0.12		0	0	0	0

Source: Tetra Tech 2008, 2010.

4.3 Receiving Waters and Tributary Areas

4.3.1 Elliott Bay

Elliott Bay makes up the eastern portion of central Puget Sound. Although this estuary is as much as 590 feet deep (Ecology 1994), it is shallower (to varying depths) in the nearshore and in the areas where the outfalls discharge. A more detailed description of the nearshore environment of Elliott Bay is provided in Appendix N, Wildlife, Fish, and Vegetation Discipline Report.

The Duwamish Waterway flows into the southern portion of Elliott Bay and is the primary source of fresh water to the bay. The Duwamish Waterway is tidally influenced and has a variable salinity gradient that depends on river flow and tidal fluctuations. The southern portion of Elliott Bay is within Water Resource Inventory Area (WRIA) 9, while the northern areas are part of WRIA 8. Residence time of fresh water in the Inner Harbor varies from 1 to 10 days, depending on the weather. Based on the results of numerous studies, estuarine water in Elliott Bay generally circulates counterclockwise. Fresh water enters from the Duwamish River, moves north along the Inner Harbor, and then flows out to Puget Sound (Ecology 1995; URS Engineers and Evans-Hamilton 1986). Water currents in the Inner Harbor are generally slow, and velocities are typically oriented parallel to the faces of downtown waterfront piers (Sillcox et al. 1981).

Ecology has established water quality protection criteria for Elliott Bay for the following uses: excellent aquatic life, shellfish harvesting, primary contact recreation, wildlife habitat, commerce/navigation, miscellaneous harvesting, boating, and aesthetics (WAC 173-201A). Elliott Bay is listed on Ecology's 303(d) water quality list (Ecology 2009) for exceeding the criteria for fecal coliform bacteria. No total maximum daily loads (TMDLs) for pollutants of concern have been prepared for Elliott Bay. In addition, the nearshore sediments of Elliott Bay and the Duwamish Waterway contain high concentrations of various metals and chemical compounds that are considered pollutants, which are discussed in Section 4.4.

The Duwamish Waterway is included on the 303(d) list for exceeding the criteria for fecal coliform bacteria and dissolved oxygen and has a designated TMDL for ammonia. A portion of the Duwamish Waterway near the south end of the study area is also undergoing cleanup as a Superfund site under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Stormwater runoff drains to Elliott Bay from the southern portion of the study area and the existing Alaskan Way Viaduct via City stormwater outfalls and shared City stormwater outfalls/combined sewer overflow structures (see Exhibits 4-1 and 4-2). These outfalls drain the Royal Brougham South, Washington, Madison, Seneca, University, and Pine sub-basins. Other combined sewer overflow structures at S. King Street, Vine Street, and Denny Way also discharge to Elliott Bay when capacity in the combined sewer system conveyance pipe is exceeded during heavier storms. Under normal operating conditions, the contributing flows for these sub-basins are treated at the West Point WWTP.

Royal Brougham South Sub-basin

The study area is located in two Royal Brougham sub-basins, Royal Brougham South and Royal Brougham North (see Exhibit 4-1), located between S. Holgate Street and Railroad Way S. The Royal Brougham South sub-basin, 1 acre of which lies within the study area, is managed by low-flow diversion. As discussed in Section 4.2.2, low-flow diversion sub-basins are managed by regulating the flow of stormwater into the combined sewer system with a gate operated by the County. When the water surface elevation in the combined sewer system reaches a set point, the County closes the gate, at which point stormwater is discharged to Elliott Bay without treatment. When the low-flow diversion gate is closed, stormwater runoff from the Royal Brougham South sub-basin is collected in a stormwater drainage system that conveys stormwater to the 72-inch-diameter shared Kingdome/Connecticut stormwater outfall/combined sewer overflow structure, from which it is discharged to Elliott Bay with no treatment.

The County operates the Kingdome/Connecticut (Royal Brougham) regulator as part of the EBI system to regulate combined sewer overflow events that occur at the Kingdome/Connecticut outfall. The County plans to construct a new wastewater treatment facility in the vicinity of Royal Brougham by the year 2026. This facility is intended to treat combined sewer flows from the Royal Brougham and King sub-basins. A summary of past discharges from this County combined sewer overflow structure are shown in Exhibit 4-5.

In addition to the Kingdome/Connecticut combined sewer overflow structure, The County operates the King and Denny combined sewer overflow structures, which receive runoff from the study area and drain to Elliott Bay. These combined sewer overflow structures are discussed in Section 4.2.3. The Royal Brougham North combined sewer sub-basin is discussed in Section 4.3.3.

Washington Sub-basin

The Washington sub-basin is located in the central portion of the study area between S. King Street and Yesler Way (see Exhibit 4-1) and makes up approximately 6.7 acres of the study area. As part of the City's Elliott Bay partial separation project, completed in the early 1990s, stormwater runoff in this area of the sub-basin was separated from the combined sewer system and is now collected and discharged via a storm drainage system. As a result, stormwater runoff from this portion of the sub-basin discharges to Elliott Bay via a 72-inch-diameter stormwater outfall with no water quality treatment (see Exhibit 4-1).

A second outfall at S. Washington Street, located just north of the stormwater outfall, functions as an overflow for the City's combined sewer system (see Exhibit 4-1). Under existing conditions, no stormwater runoff from the study area flows to this outfall. In addition to the Washington combined sewer overflow structure, the City also maintains shared stormwater outfall/combined sewer overflow structures at Madison and University Streets and a combined sewer overflow structure at Vine Street within the study area.

Madison Sub-basin (Separated Storm)

Approximately 4.9 acres in the central portion of the study area lie within the Madison sub-basin (see Exhibits 4-1 and 4-2). As part of the City's Elliott Bay partial separation project, completed in the early 1990s, stormwater runoff in this portion of the sub-basin was separated from the combined sewer system and is now collected and discharged in a storm drainage system. As a result, stormwater runoff from this area discharges untreated to Elliott Bay via a 60-inch-diameter shared stormwater outfall/combined sewer overflow structure (see Exhibit 4-2). This outfall is also a City combined sewer overflow structure; past discharge volumes and frequencies of combined sewer overflow are shown in Exhibit 4-6.

Seneca Sub-basin

The Seneca sub-basin includes 2.5 acres of the central portion of the study area located between Spring Street and University Street (see Exhibit 4-2). Untreated stormwater runoff from this sub-basin discharges to Elliott Bay via a 10-inch-diameter stormwater outfall. None of the stormwater runoff from this sub-basin is diverted to the West Point WWTP.

University Sub-basin (Separated Storm)

The University sub-basin is located in the central portion of downtown and collects stormwater runoff from approximately 3.5 acres of the existing viaduct between Union and University Streets (see Exhibit 4-2). Stormwater runoff in this portion of the sub-basin was separated from the combined sewer system as part of the City's Elliott Bay partial separation project completed in the early 1990s. As a result, stormwater from this area is now collected and discharged untreated to Elliott Bay. This stormwater runoff discharges via a 48-inch-diameter shared stormwater outfall/combined sewer overflow structure with a 24-inch-diameter drop structure built into the seawall at University Street. This outfall serves as a City combined sewer overflow structure; past discharge volumes and frequencies of combined sewer overflow are shown in Exhibit 4-6.

Pine Sub-basin

The Pine sub-basin, which covers approximately 5.9 acres of the study area, is located between Pike Street and Lenora Street (see Exhibit 4-2). The existing viaduct and local surface streets make up most of the land use in this sub-basin. Untreated stormwater runoff from this sub-basin discharges to Elliott Bay via a 16-inch-diameter stormwater outfall. None of the stormwater runoff from this sub-basin is diverted to the West Point WWTP.

Individual Sub-basins

There are several small sub-basins along the Elliott Bay waterfront that collect untreated runoff from the existing Alaskan Way surface street and discharge directly to Elliott Bay through individual outfall structures. The sub-basins are located between approximately Bay and Seneca Streets along the Alaskan Way surface street. Under all of the build alternatives, each of these smaller sub-basins would be combined with the larger adjacent separated sub-basin. Therefore, for the purposes of this study, these sub-basins have been tracked and analyzed in combination with the larger sub-basins that they are adjacent to.

4.3.2 Lake Union

Lake Union, which is part of WRIA 8, is located north of the study area, in a highly urbanized watershed. Within the study area, only the Broad sub-basin has a dedicated outfall to Lake Union. In addition, the Dexter sub-basin, discussed in detail in Section 4.3.3, has a combined sewer overflow structure that can discharge to Lake Union. The water quality of Lake Union is influenced by freshwater inflows from Lake Washington and discharges from storm drains and combined sewer overflows. The lake represents a transitional area between the fresh waters of Lake Washington and the marine waters of Puget Sound. At depth, water quality is also influenced by saline water introduced through the navigation locks.

During the summer (primarily July, August, and September), a layer of saline water with a very low concentration of dissolved oxygen forms along the bottom of Lake Union (Hansen et al. 1994). The saline water and summer lake water temperature cause stratification of the water column, which inhibits mixing of the surface and bottom waters during summer months (CH2M Hill 1999). Typically, the anoxic bottom layer in Lake Union rapidly breaks up during the fall, along with the thermocline in Lake Washington.

Ecology has established water quality protection criteria for Lake Union for the following uses: core summer habitat, excellent primary contact recreational uses, water supply (domestic, industrial, agricultural, and stock), wildlife habitat, miscellaneous harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A). Lake Union has been listed on Ecology's 303(d) water quality Category 5 list (Ecology 2009) for exceeding the criteria for aldrin, fecal coliform bacteria, lead, and total phosphorus. It has also exceeded the sediment bioassay criteria, as described in Section 4.4.

Broad Sub-basin

The Broad sub-basin is located along Broad Street and collects stormwater from approximately 4.9 acres of the study area (see Exhibit 4-3). Land use in this sub-basin is primarily surface streets. Stormwater runoff is collected in a separated storm drainage system and discharged without treatment to Lake Union via a 30-inch-diameter stormwater outfall.

4.3.3 Puget Sound

Puget Sound is a large marine water body that covers approximately 900 square miles, including Elliott Bay. Ecology has established water quality protection criteria for Puget Sound for the following uses: extraordinary aquatic life, shellfish harvesting, primary contact recreation, wildlife habitat, miscellaneous harvesting, commerce/navigation, boating, and aesthetics (WAC 173-201A). Other than Elliott Bay, no portion of Puget Sound within the study area has been listed on Ecology's 303(d) water quality list (Ecology 2009). No TMDLs have been prepared for Puget Sound in the vicinity of the study area.

Under normal operating conditions, stormwater runoff from the King, Pike, Vine, Denny, and Dexter sub-basins is collected in combined sewer pipes, treated at the West Point WWTP, and discharged to Puget Sound through a deep water outfall. During large storm events, when the combined sewer capacity is exceeded, flows from the combined sewer are diverted to backup wet-weather treatment facilities or are discharged untreated as combined sewer overflows to Elliott Bay and/or Lake Union.

Royal Brougham North Sub-basin

The Royal Brougham North sub-basin covers approximately 10.5 acres of the study area and includes the existing viaduct between Railroad Way S. and S. King Street (see Exhibit 4-1). Stormwater runoff in this sub-basin is collected by the combined sewer system, conveyed to the West Point WWTP for treatment, and discharged to Puget Sound. During large storm events, combined stormwater runoff is discharged untreated through a 72-inch-diameter pipe to Elliott Bay as a combined sewer overflow through the Kingdome/Connecticut structure. A summary of past discharges from the County combined sewer overflow structure are shown in Exhibit 4-5.

King Sub-basin

The King sub-basin covers approximately 10.8 acres of the study area in the vicinity of S. King Street (see Exhibit 4-1). The King sub-basin is part of a larger sub-basin that extends east of Interstate 5. Stormwater runoff in the King sub-basin is collected in separated storm pipes; however, they connect to the combined sewer system upstream of a diversion structure. Therefore, under normal operating conditions, stormwater runoff from this sub-basin is diverted to the EBI, conveyed to the West Point WWTP for treatment, and discharged to Puget Sound. During large storm events, combined stormwater runoff is discharged untreated in a 48-inch-diameter pipe to Elliott Bay as a combined sewer overflow. A summary of past discharges from the County combined sewer overflow structure are shown in Exhibit 4-5.

Madison Sub-basin (Combined Sewer)

Approximately 0.9 acre of the central portion of the study area lies within the Madison combined sewer system sub-basin (see Exhibits 4-1 and 4-2). During normal operations, stormwater runoff from this sub-basin is collected in the combined system, conveyed to the West Point WWTP for treatment, and discharged to Puget Sound. During heavier storms, flows from this sub-basin are discharged untreated to Elliott Bay via a 60-inch-diameter shared stormwater outfall/combined sewer overflow structure (see Exhibit 4-2). This outfall is also a City combined sewer overflow structure; past discharge volumes and frequencies of combined sewer overflow are shown in Exhibit 4-6.

University Sub-basin (Combined Sewer)

Approximately 0.2 acre in the central portion of the study area lies within the University combined sewer system sub-basin (see Exhibit 4-2). During normal operations, stormwater runoff from this sub-basin is collected in the combined system, conveyed to the West Point WWTP for treatment, and discharged to Puget Sound. During heavier storms, flows from this sub-basin are discharged untreated to Elliott Bay. This stormwater runoff discharges via a 48-inch-diameter shared stormwater outfall/combined sewer overflow structure with a 24-inch-diameter drop structure built into the seawall at University Street (see Exhibit 4-2). This outfall serves as a City combined sewer overflow structure; past discharge volumes and frequencies of combined sewer overflow are shown in Exhibit 4-6.

Pike Sub-basin

The Pike sub-basin covers approximately 1.6 acres of the central portion of the study area (see Exhibit 4-2). Runoff from this sub-basin is collected in combined sewer pipes and conveyed to the Pike Street adit structure, a vault that contains transitional pipes conveying flow from the University regulator structure to the EBI. During normal operations, stormwater runoff from this sub-basin is collected in the combined system, conveyed to the West Point WWTP for treatment, and discharged to Puget Sound. During heavier storms, flows from this sub-basin are diverted to the Elliott West Combined Sewer Overflow Control Facility, a wet-weather treatment facility constructed in 2005. The Elliott West facility provides primary treatment and disinfection to flows and then discharges them to Elliott Bay. When the Elliott West facility is at capacity, untreated overflows are discharged to Elliott Bay through the County's Denny Way regulator structure. Flows from the Pike sub-basin may also be discharged as a combined sewer overflow through the City's University outfall structure.

Vine Sub-basin

The Vine sub-basin includes approximately 10.5 acres of the north-central portion of the study area (see Exhibit 4-2). Within this portion of the sub-basin, the existing Alaskan Way is located partially on the viaduct structure and partially in the Battery Street Tunnel. Stormwater runoff from surface streets and the portion of the viaduct exposed to precipitation is collected in the combined system. During normal operations, stormwater runoff from this sub-basin is conveyed to the West Point WWTP for treatment and discharged to Puget Sound. During large storm events, flows are treated at the Elliott West Combined Sewer Overflow Control Facility (providing primary treatment and disinfection) and then discharged to Elliott Bay. When the Elliott West facility is at capacity, untreated overflows are discharged to Elliott Bay through the County's Denny Way regulator structure. Flows from the Vine sub-basin may also be discharged untreated via the City's 24-inch-diameter Vine Street outfall as a combined sewer overflow. Past discharge volumes and frequencies of combined sewer overflow from the Vine Street outfall are shown in Exhibit 4-6.

Western Diversion Sub-basin

The Western Diversion sub-basin comprises 4 acres of the central portion of the study area between Western Avenue and Fifth Avenue (see Exhibit 4-2) and conveys runoff from surface streets to the combined system. During normal operations, this sub-basin conveys flows to the Lake Union tunnel. The Lake Union tunnel conveys flows from the south end of Lake Union through the EBI to the West Point WWTP for treatment and discharged to Puget Sound. During large storm events, some of the combined sewage from the Western Diversion sub-basin is redirected to the Vine sub-basin, where it follows the path described in the previous section.

Dexter Sub-basin

The Dexter sub-basin is located in the northern portion of the study area and currently includes approximately 31.3 acres of the study area along Aurora Avenue, Dexter Avenue, and Mercer Street (see Exhibit 4-3). During normal operations, runoff from this area is collected in combined sewer pipes, conveyed north in pipes under streets near the western shore of Lake Union to the West Point WWTP for treatment, and discharged to Puget Sound. During large storm events, flows can be routed to treatment at the Elliott West Combined Sewer Overflow Control Facility (providing primary treatment and disinfection) and then discharged to Elliott Bay through the Elliott West outfall. When the Elliott West facility is at capacity, untreated overflows are discharged to Elliott Bay through the County's Denny Way regulator structure. In addition, runoff flows from the Dexter sub-basin may potentially be stored in the Mercer underground stormwater tunnel until capacity increases enough for the flows to be discharged back into the combined system. During large storm events, runoff from the Dexter sub-basin also may be discharged untreated to Lake Union as a combined sewer overflow via the County's 42-inch-diameter Dexter Street combined sewer overflow structure. A summary of past discharges from the County combined sewer overflow structure is shown in Exhibit 4-5.

4.4 Nearshore Sediments

The Washington State Sediment Management Standards use two different levels of criteria for Puget Sound sediment: the sediment quality standards (SQS) and the cleanup screening levels (CSL). The SQS set the limits for sediment quality that will result in no adverse effects on biological resources or no significant risk to human health. The CSL denote sediment quality that may result in minor adverse effects. The SQS serve as the objective for all cleanup actions. However, factors such as cost, technical feasibility, and net environmental effects may allow the goal for a given cleanup project to be set within the range of a designated CSL (Ecology 2008).

Sediments in central Puget Sound, the Elliott Bay waterfront area, and Lake Union contain various pollutants at concentrations that exceed the SQS and CSL (Ecology 2006; Parametrix 2007). Given that the pollutants most common to urban roadway runoff include suspended solids and metals (zinc and copper), it is likely that the wider array of pollutants found in these sediments have been generated by additional sources, such as industrial activities or sewage discharges. Exhibit 4-7 indicates the locations near the study area that are included on Ecology's sediment quality 303(d) list as Category 4 or Category 5 for contaminated sediments (Ecology 2009). Existing information on known contaminants in nearshore sediments in these areas is described below.

4.4.1 Elliott Bay

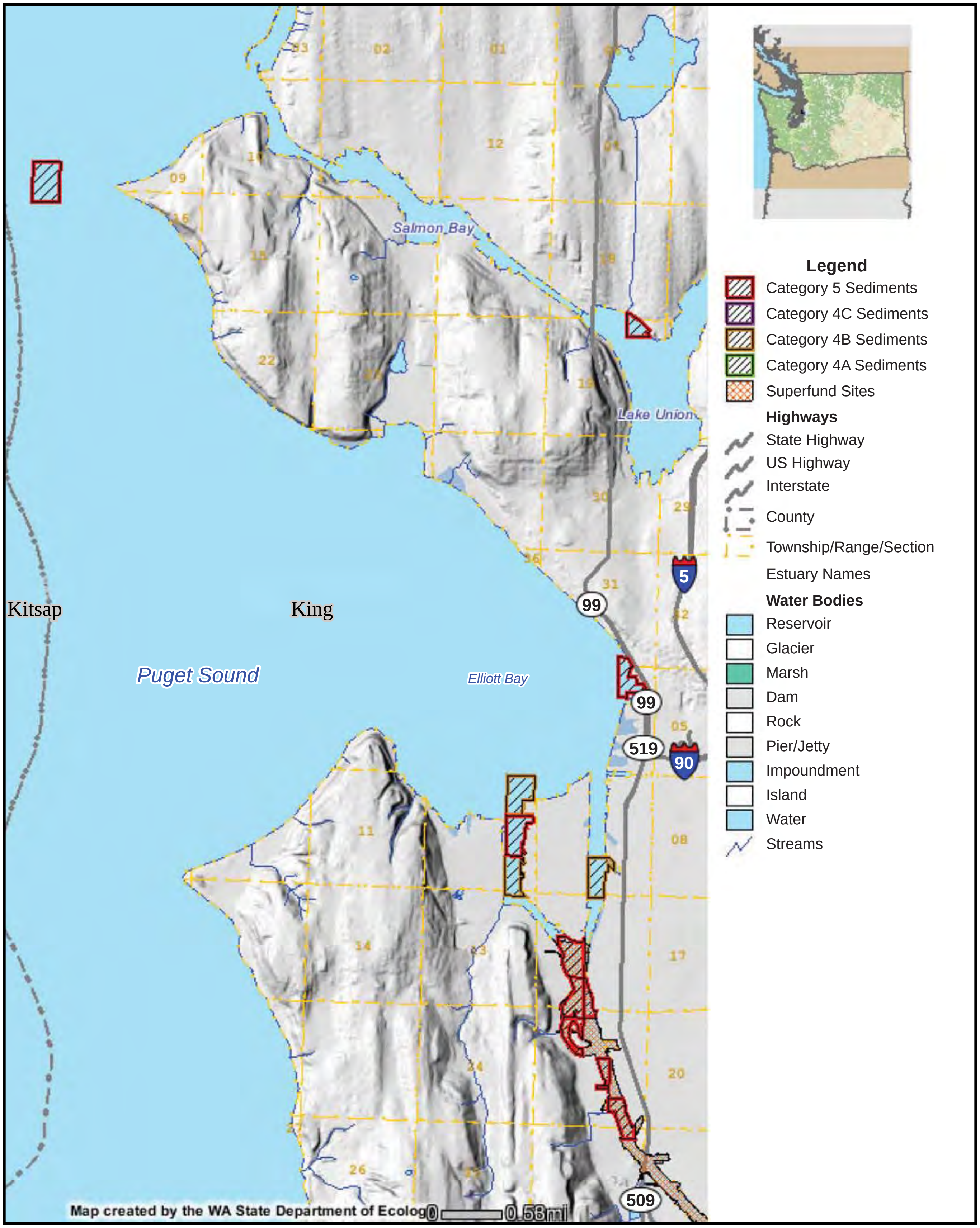
Sediment Quality Conditions

Elliott Bay nearshore sediments contain high concentrations of various metals and chemical compounds that are considered pollutants (Romberg et al. 1984; EPA 1988; Metro 1988b, 1989, 1993; Tetra Tech 1988; Hart Crowser 1994; King County 1994; Norton and Michelson 1995; Ecology 1995). These contaminants include mercury, silver, lead, zinc, copper, PAHs, PCBs, and other metals and organic compounds (Ecology 2006; Parametrix 2007). Nearshore sediments along the project area outside the wave-action zone have a high percentage of fine sediment (40 to 70 percent if not disturbed by vessel activity, cap placement, or dredging).

Nearshore sediments are often further classified as either surface or subsurface and may have different levels of contamination. Within the study area, surface and subsurface sediments contain contaminants at concentrations that exceed the applicable SQS and CSL. These sediments have been listed on Ecology's 303(d) list for exceeding standards for numerous pollutants of concern. Exceedances of sediment criteria are generally associated with previous industrial activities, stormwater discharges, and combined sewer overflows.

Sediment Quality Remediation Projects

Several sediment remediation projects have been completed to improve the quality of nearshore sediments along Elliott Bay. These sediment remediation projects have involved placing clean sediment (generally sand) on top of contaminated sediment, a method called "sediment capping." The cap of clean sediment protects benthic organisms from coming into contact with contaminated sediment and prevents or reduces suspension of the contaminated sediments into the water column. Within the study area, sediment remediation projects have been completed at Pier 51 (under a portion of the ferry terminal in 1989), Piers 53 to 55 (1992), and Denny Way (1992). Ecology determined that discharges from stormwater outfalls and combined sewer overflow structures do not contain enough pollutants to result in recontamination of remediated sediments at levels higher than the applicable CSL (Ecology 1995). However, numerous outfalls in the vicinity may be ongoing sources of pollutants. Recontamination may also occur from nonpoint sources such as spills, creosote pilings, and bulkheads.



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Source: http://apps.ecy.wa.gov/wqawa2008/viewer.htm.

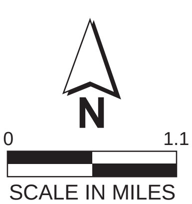


Exhibit 4-7
Project Area Receiving Waters - Contaminated Sediments

4.4.2 Lake Union

Washington State has not promulgated chemical standards for freshwater sediment. However, chemicals of potential concern in the south end of Lake Union in the vicinity of the Broad stormwater outfall and the Dexter combined sewer overflow structure include naphthalene, PCBs, PAHs, cadmium, copper, lead, mercury, zinc, nickel, antimony, chromium, and various other organic compounds (Ecology 2006). Lake Union is also on the state's 303(d) list (Ecology 2009) for failing the freshwater sediment bioassay test.

4.4.3 Central Puget Sound

Central Puget Sound nearshore sediments contain concentrations of several different contaminants at concentrations exceeding the SQS and CSL. The area at the West Point WWTP outfall has been placed on the 2008 303(d) list (Ecology 2009) for failing the sediment bioassay test. Contaminants that exceed the SQS and CSL in the vicinity of the West Point WWTP outfall include mercury, total PCBs, chrysene, and various other organic compounds (Ecology 2006).

Chapter 5 Operational Effects, Mitigation, and Benefits

This chapter describes the potential operational effects and benefits of the alternatives on surface water, as well as proposed mitigation for any potential adverse effects. Section 5.1 discusses the effects, mitigation, and benefits of all the build alternatives; including a land use analysis evaluating potential changes in hydrology and a pollutant loading analysis evaluating potential changes in water quality. Operational effects, mitigation, and benefits specific to the Viaduct Closed (No Build Alternative) and each build alternative are described in Sections 5.2 through 5.5. Potential effects of construction associated with the build alternatives are discussed in Chapter 6.

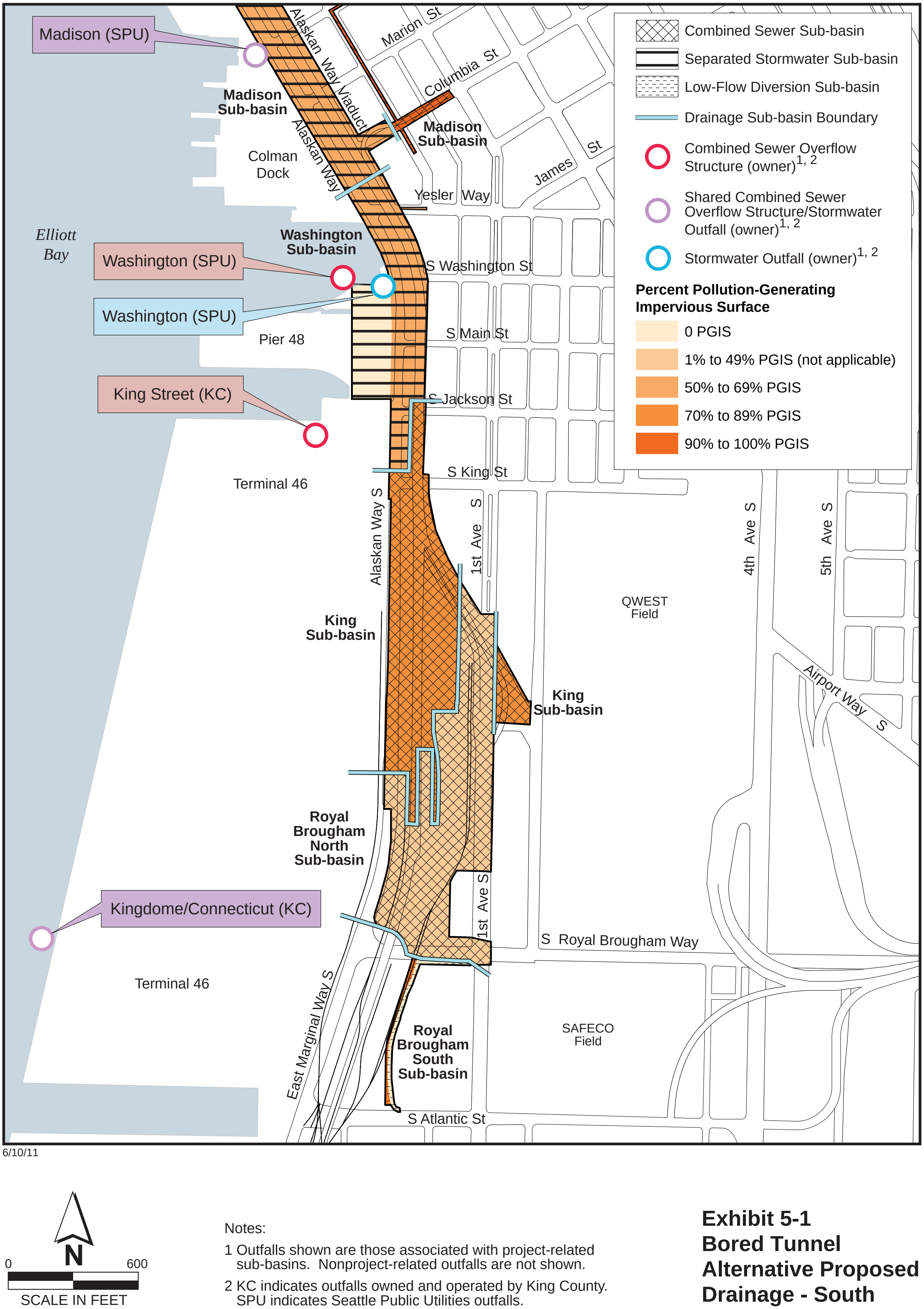
5.1 Common to All Alternatives

5.1.1 Overview of Operational Effects

Changes in Land Use and Hydrology

Removing vegetation and increasing the amount of impervious surface in a watershed can change the hydrologic cycle by reducing infiltration, increasing the volume of surface runoff, and increasing the peak flow rate generated by a storm event (WSDOT 2008). In urban areas like the study area, the land use has been mostly impervious for over 100 years. Runoff is discharged to large receiving waters (Elliott Bay, Lake Union, and Puget Sound) that are not as susceptible to minor changes in hydrology as smaller water bodies such as streams. However, increases in impervious surface within the study area could pose a risk of increased pollutant loads and increased volume and/or frequency of combined sewer overflows. Therefore, a land use analysis was conducted to look at changes in impervious surface area resulting from each of the alternatives compared to existing conditions.

The proposed drainage layout of each build alternative is shown in Exhibits 5-1 through 5-9. The results of the land use analysis are summarized in Exhibit 5-10. Detailed results of the land use analysis are provided in Attachment A. Compared to existing conditions, the Viaduct Closed (No Build Alternative) would not change the amount of impervious surface within the study area. Each of the build alternatives would slightly decrease the amount of total impervious area (TIA) in the study area.

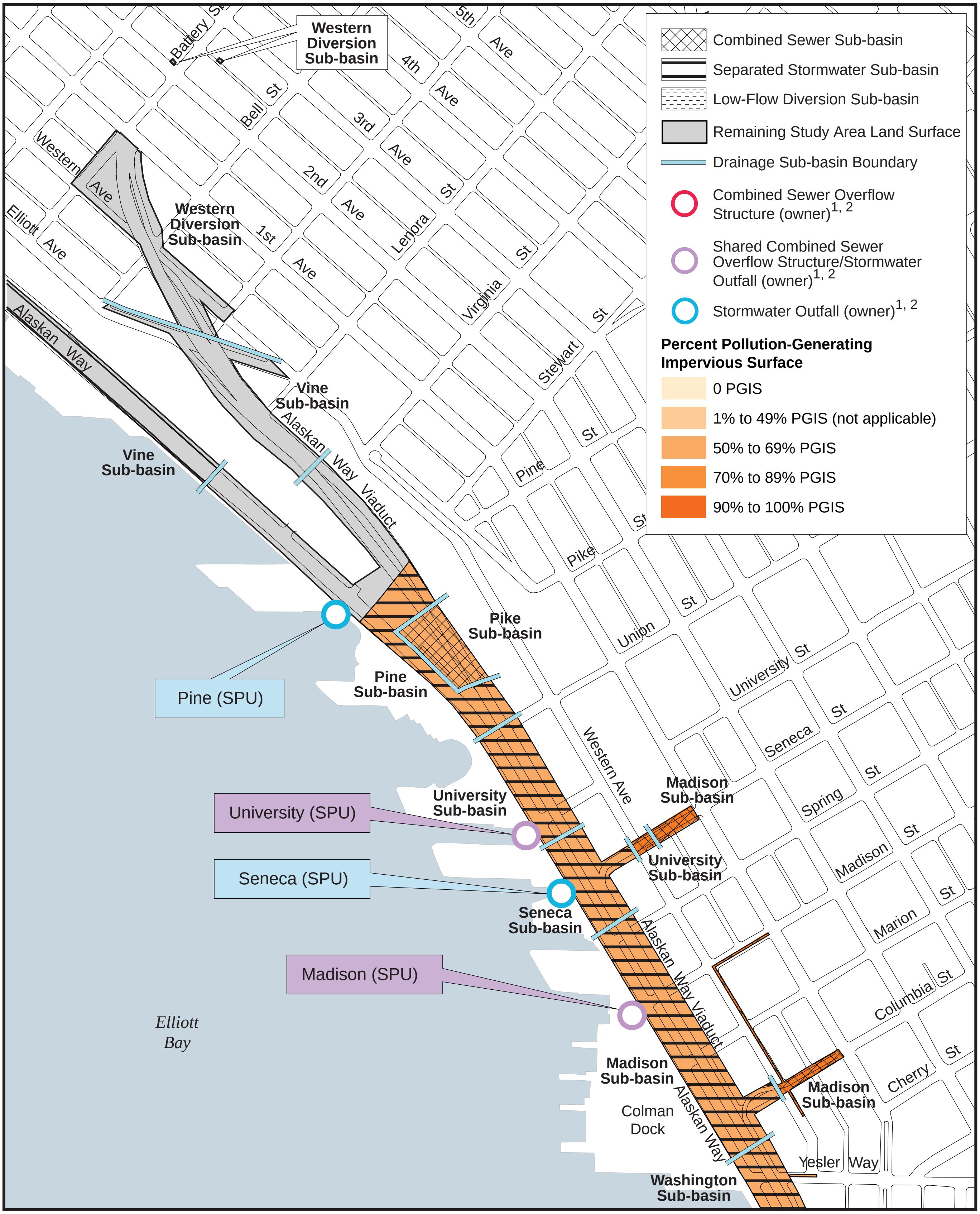


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-1
Bored Tunnel Alternative Proposed Drainage - South



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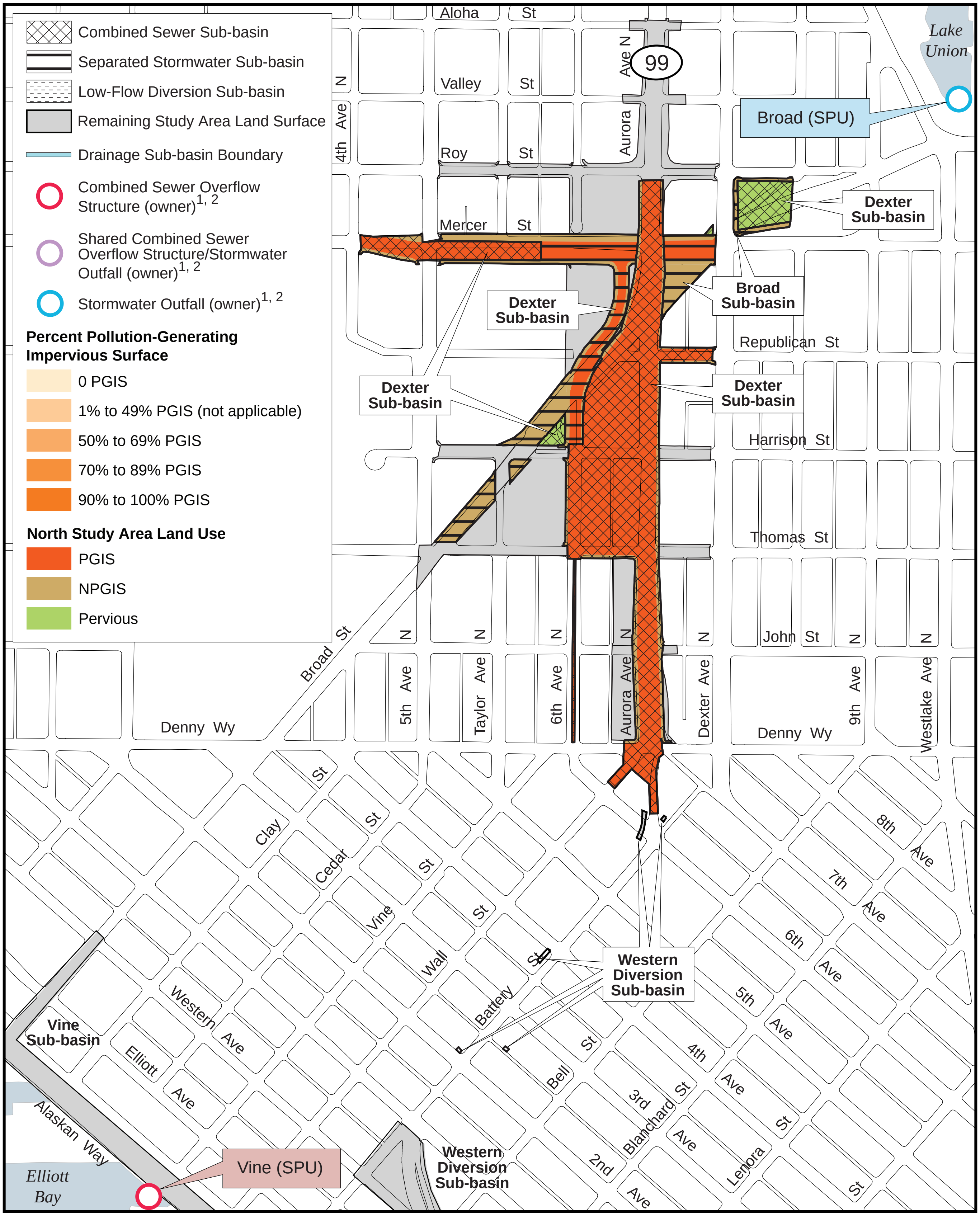
SCALE IN FEET

Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-2
Bored Tunnel Alternative Proposed Drainage - Central



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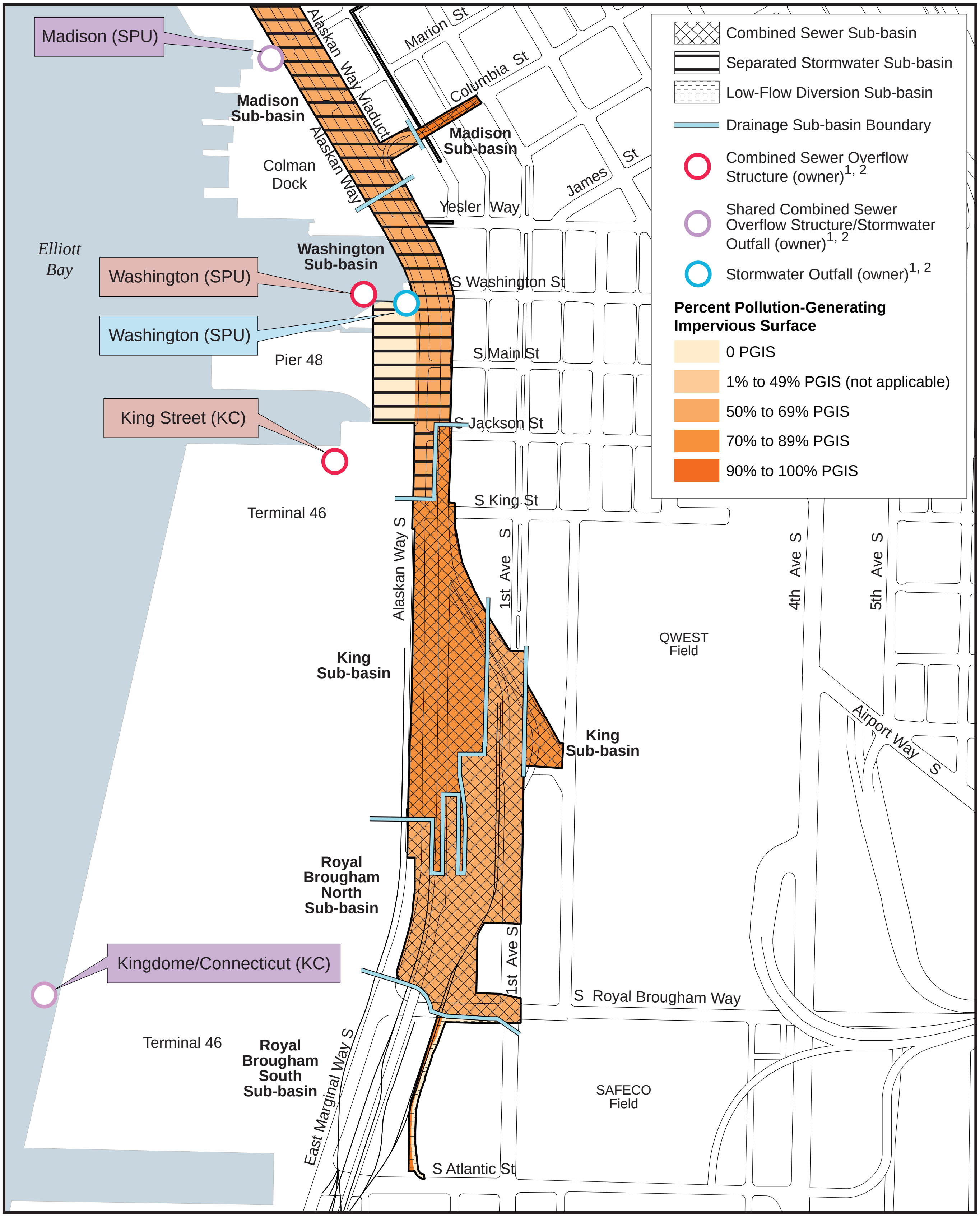
0 600
SCALE IN FEET

Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-3 Bored Tunnel Alternative Proposed Drainage - North



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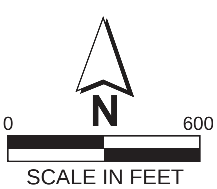
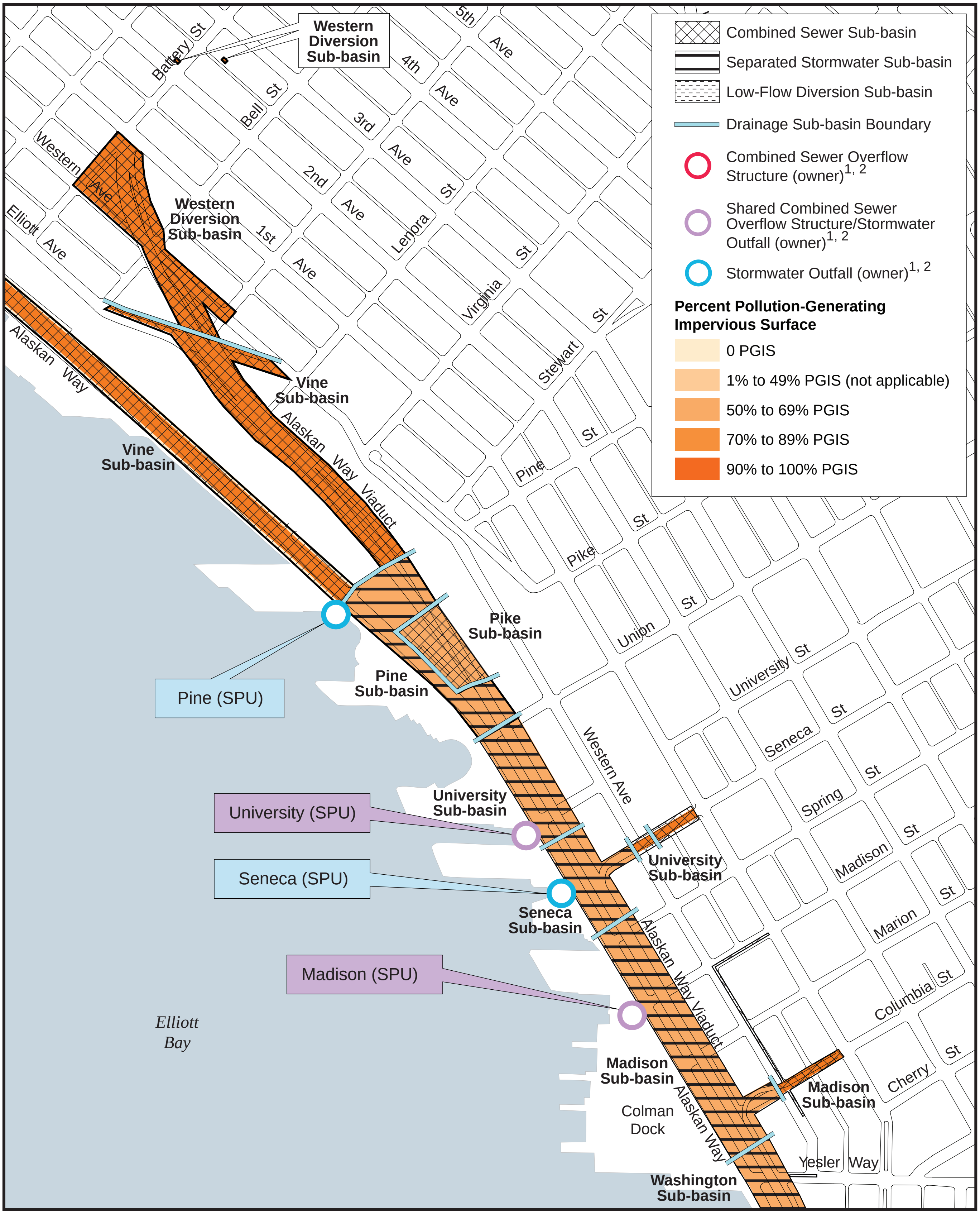


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-4
Cut-and-Cover Tunnel Alternative Proposed Drainage - South



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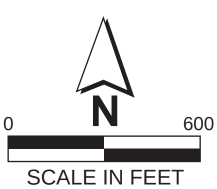
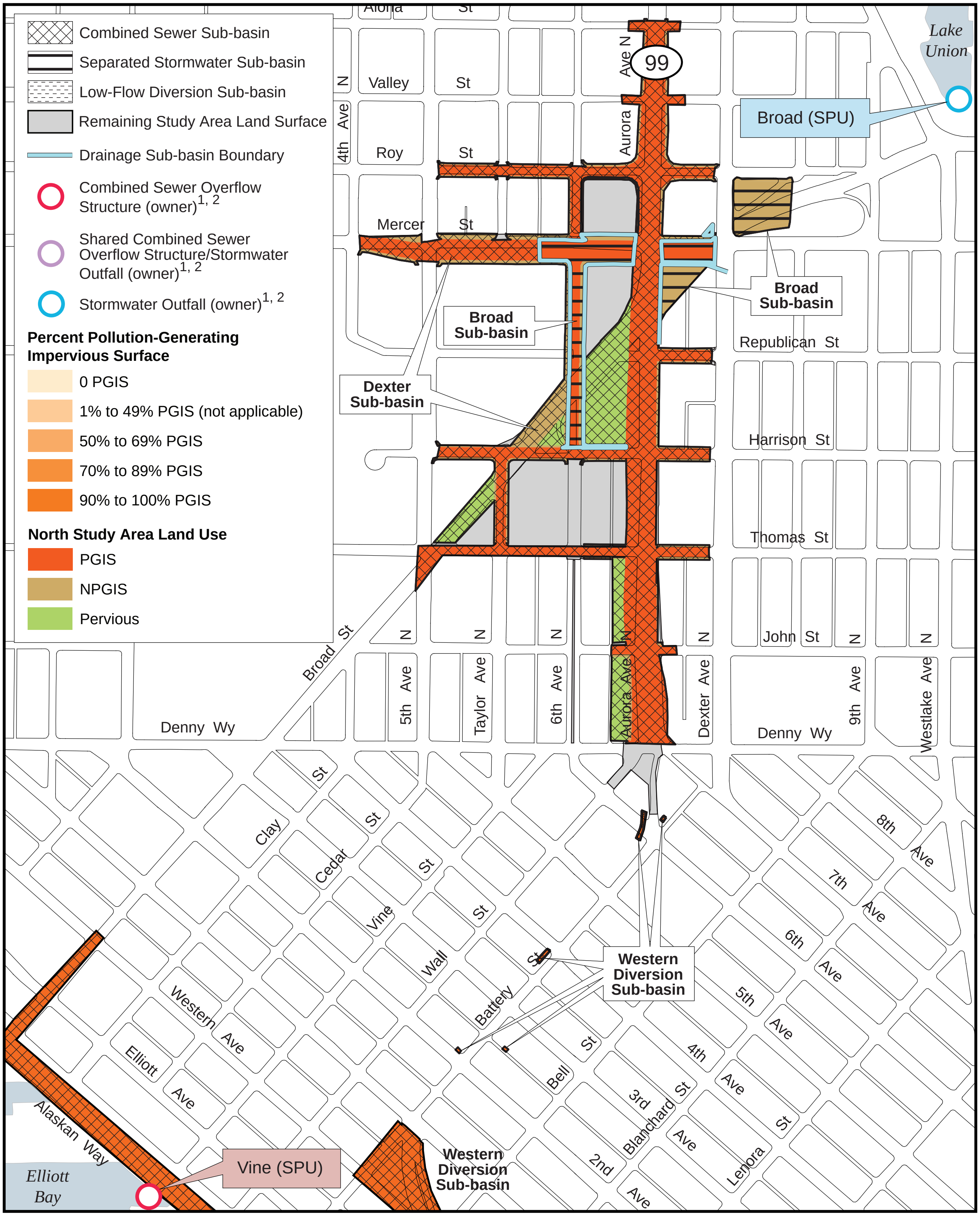


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-5
Cut-and-Cover Tunnel Alternative Proposed Drainage - Central



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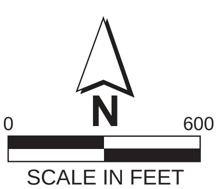
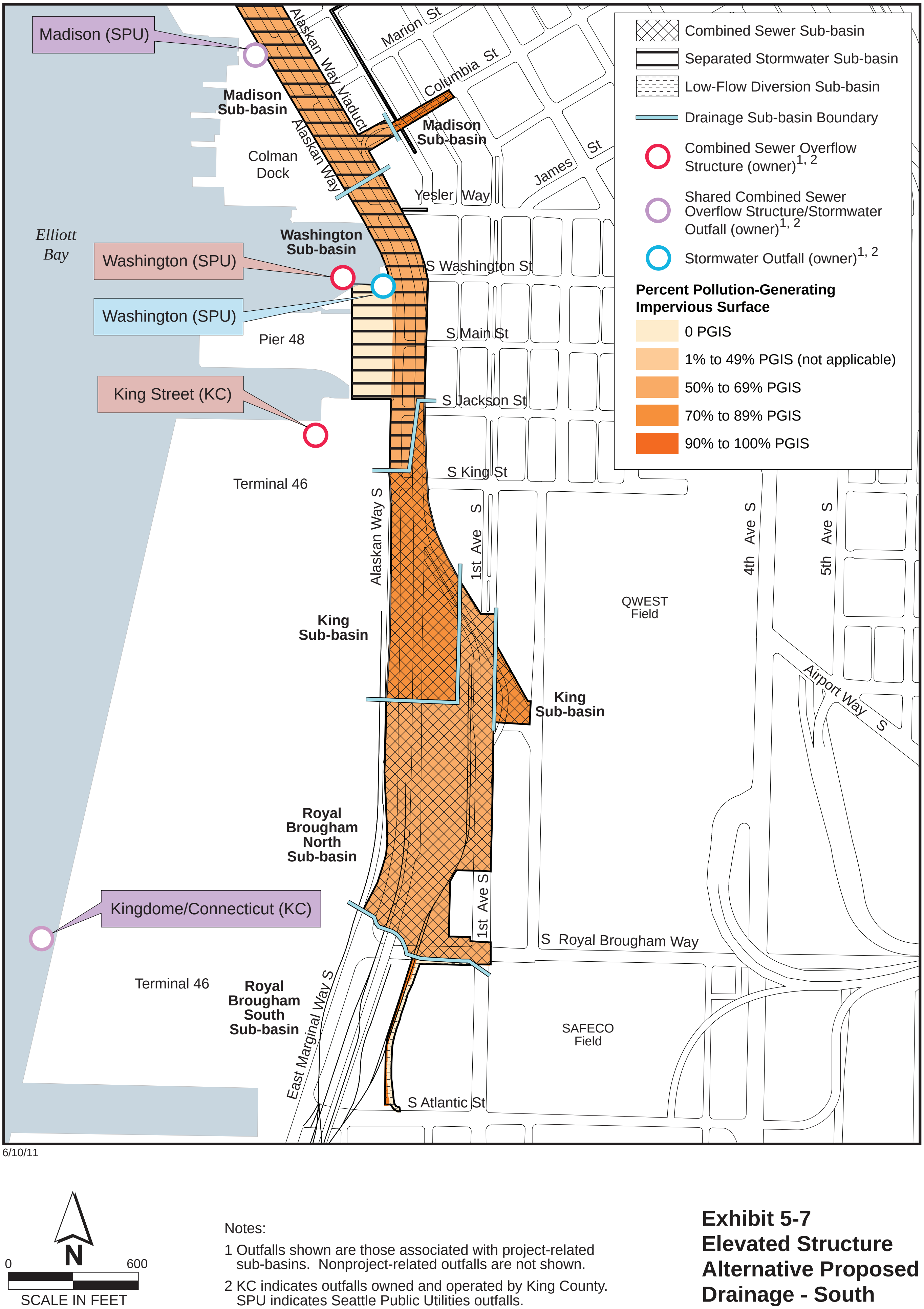


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-6
Cut-and-Cover Tunnel Alternative Proposed Drainage - North

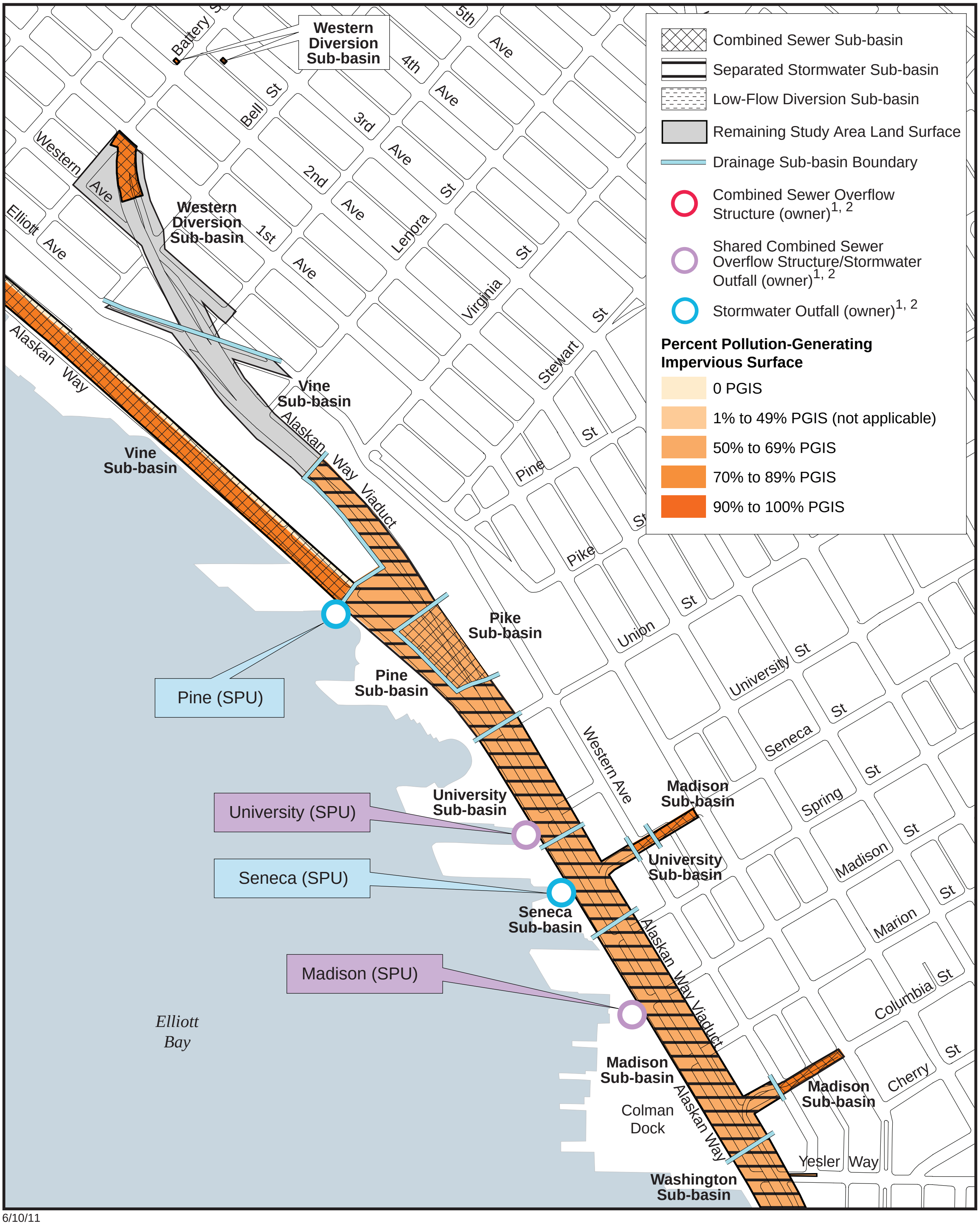


Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-7
Elevated Structure Alternative Proposed Drainage - South



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SCALE IN FEET

Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-8
Elevated Structure Alternative Proposed Drainage - Central

Notes:

1 Outfalls shown are those associated with project-related sub-basins. Nonproject-related outfalls are not shown.

2 KC indicates outfalls owned and operated by King County. SPU indicates Seattle Public Utilities outfalls.

Exhibit 5-9
Elevated Structure Alternative Proposed Drainage - North

Exhibit 5-10. Summary of Land Use Changes

Land Use	Area (acres)				
	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Pervious surface	2.8	2.8	5.1	6.7	8.7
NPGIS	17.3	28.3	30.7	30.4	29.0
PGIS	78.9	67.9	63.3	62.0	61.4
TIA	96.2	96.2	94.0	92.3	90.4
Total area	99.0	99.0	99.0	99.0	99.0

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA= total impervious area

Pollutant Loads

Runoff from streets and highways, particularly in urban environments, contains pollutants that can affect the water quality of the receiving water. Studies conducted on runoff in the Seattle area indicate that highways are a measurable source of suspended solids, metals (zinc and copper), and other pollutants (Driscoll et al. 1990). Pollutant loads in stormwater runoff vary depending on the amount and type of PGIS, traffic volume and average speed, duration and intensity of a storm event, time of year, antecedent weather conditions, and several other factors.

The results of the pollutant loading analysis are summarized in Exhibit 5-11. Detailed results are provided in Attachment A. As the results show, pollutant loading would decrease relative to existing conditions for the Viaduct Closed (No Build Alternative) and each of the build alternatives primarily due to a reduction in PGIS (Exhibit 5-10). Therefore, each alternative would potentially result in a benefit to surface water and sediment quality in the study area receiving waters.

Exhibit 5-11. Summary of Pollutant Loading Analysis

Pollutant of Concern	Pollutant Load (pounds per year)				
	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
TSS	60,669	52,221	38,176	39,393	37,894
Total copper	12.6	10.9	8.3	8.5	8.2
Dissolved copper	3.2	2.7	2.4	2.4	2.3
Total zinc	77.3	66.5	50.2	51.4	49.6
Dissolved zinc	24.5	21.1	17.0	17.1	16.7

Note: TSS = total suspended solids

Detailed discussions of the potential operational effects of each alternative are included in the following sections.

5.1.2 Southern Portion of the Study Area

Proposed changes to the land use that would potentially affect hydrology in the southern portion of the study area are summarized in Exhibit 5-12. The overall size of the southern portion of the study area would increase slightly under each build alternative due to sub-basin boundary shifts between the King and Washington Sub-basins. TIA in the southern portion would decrease under each build alternative. Unlike other portions of the study area, detention would not be provided in the southern portion under any of the alternatives. Modeling has shown that the use of surface water detention in the southern portion would not reduce the potential frequency and/or volume of overflows from the combined sewer system. Therefore, the City has granted an exception from the peak flow control requirements in the Seattle Stormwater Code for runoff from the southern portion of the study area (City of Seattle 2009b).

Exhibit 5-12. Land Use Changes in the Southern Portion of the Study Area

	Area (acres)				
Land Use	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Pervious surface	0.0	0.0	1.5	0.5	0.4
NPGIS	0.9	3.3	7.1	7.1	8.1
PGIS	21.3	19.0	13.9	14.9	13.9
TIA	22.3	22.3	21.0	22.1	22.0
Total area	22.3	22.3	22.6	22.6	22.4

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

Estimated pollutant loads for the southern portion of the study area under each alternative are summarized in Exhibit 5-13. Total pollutant loads are expected to be reduced in the southern portion due to the decrease in PGIS under each alternative. Water quality treatment for the most of the southern portion would continue to be provided by discharging runoff to the combined sewer system, similar to existing conditions. In addition, under each build alternative, water quality treatment would be provided for PGIS in the Royal Brougham South low-flow diversion sub-basin, which currently has no treatment. This area would be treated using BMPs selected from the Seattle *Stormwater Manual* (City of Seattle 2009a) and/or the WSDOT *Highway Runoff Manual* (WSDOT 2008).

Exhibit 5-13. Pollutant Loading Analysis for the Southern Portion of the Study Area

Pollutant of Concern	Pollutant Load (pounds per year)				
	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
TSS	16,400	14,591	10,509	11,296	10,556
Total copper	3.4	3.0	2.2	2.4	2.2
Dissolved copper	0.9	0.8	0.6	0.6	0.6
Total zinc	20.9	18.6	13.4	14.4	13.5
Dissolved zinc	6.6	5.9	4.3	4.6	4.3

Note: TSS = total suspended solids

5.1.3 Central Portion of the Study Area

Proposed changes to the land use in the central portion of the study area are summarized in Exhibit 5-14. The overall size of the central portion of the study area would decrease slightly under each build alternative due to sub-basin boundary shifts between the King and Washington Sub-basins. TIA would also decrease for each build alternative beyond the amount attributed to the total area change (pervious surface would increase). In addition, peak flow control would be provided in accordance with the requirements of the Seattle Stormwater Code to reduce risk of increased frequency or volumes of combined sewer overflows. Flow control would be provided by the installation of one or more on- or off-site stormwater detention facilities.

Exhibit 5-14. Land Use Changes in the Central Portion of the Study Area

Land Use	Area (acres)				
	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Pervious surface	0.6	0.6	1.1	1.2	1.0
NPGIS	3.2	11.8	11.3	11.9	11.8
PGIS	36.8	28.1	27.9	27.3	27.5
TIA	39.9	39.9	39.2	39.1	39.4
Total area	40.6	40.6	40.3	40.3	40.4

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

Estimated changes in pollutant loads for the central portion of the study area are summarized in Exhibit 5-15. Total pollutant loads are expected to be reduced under each build alternative due to the decrease in PGIS. Also, water quality treatment would continue to be provided by discharging runoff to the combined sewer system for sub-basins that are currently part of the combined sewer system. Water quality treatment would also be provided for PGIS in the separated storm sub-basins, which currently do not all have treatment. These areas would be treated by BMPs selected from the Seattle *Stormwater Manual* (City of Seattle 2009a) and/or the WSDOT *Highway Runoff Manual* (WSDOT 2008).

Exhibit 5-15. Pollutant Loading Analysis for the Central Portion of the Study Area

	Pollutant Load (pounds per year)				
Pollutant of Concern	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
TSS	28,276	21,637	12,574	14,369	13,601
Total copper	5.9	4.5	2.9	3.2	3.1
Dissolved copper	1.5	1.1	1.0	1.0	1.0
Total zinc	36.0	27.6	17.3	19.3	18.4
Dissolved zinc	11.4	8.7	6.4	6.8	6.6

Note: TSS = total suspended solids

5.1.4 Northern Portion of the Study Area

Proposed changes to land use in the northern portion of the study area are summarized in Exhibit 5-16. TIA in the northern portion would decrease under each build alternative. In addition, peak flow control would be provided as required by the Seattle Stormwater Code in areas that discharge runoff to the combined sewer system to reduce risk of increased frequency or volumes of combined sewer overflows. Flow control would most likely be provided by the installation of one or more detention facilities.

Exhibit 5-16. Land Use Changes in the Northern Portion of the Study Area

	Area (acres)				
Land Use	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Pervious surface	2.2	2.2	2.5	5.0	7.2
NPGIS	13.2	13.2	12.2	11.4	9.1
PGIS	20.8	20.8	21.5	19.8	19.9
TIA	34.0	34.0	33.7	31.2	29.0
Total area	36.2	36.2	36.2	36.2	36.2

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

Estimated changes to pollutant loads for the northern portion of the study area are summarized in Exhibit 5-17. Total pollutant loads are expected to be reduced in the

Estimated changes to pollutant loads for the northern portion of the study area are summarized in Exhibit 5-17. Total pollutant loads are expected to be reduced in the northern portion with each build alternative due to proposed water quality treatment. Specifically, water quality treatment BMPs would be provided for all PGIS in the Broad sub-basin, which currently has no treatment. This area would be treated using BMPs selected from the Seattle *Stormwater Manual* (City of Seattle 2009a) and/or the WSDOT *Highway Runoff Manual* (WSDOT 2008). Also, for runoff discharging to the Dexter sub-basin, water quality treatment would continue to be provided by discharging runoff to the combined sewer system, similar to existing conditions.

Exhibit 5-17. Pollutant Loading Analysis for the Northern Portion of the Study Area

	Pollutant Load (pounds per year)				
Pollutant of Concern	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
TSS	15,993	15,993	15,094	13,728	13,738
Total copper	3.3	3.3	3.2	2.9	2.9
Dissolved copper	0.8	0.8	0.8	0.8	0.8
Total zinc	20.4	20.4	19.4	17.7	17.7
Dissolved zinc	6.4	6.4	6.3	5.8	5.8

Note: TSS = total suspended solids

5.1.5 Mitigation of Operational Effects

The stormwater management approach proposed for all build alternatives would address potential risks of adverse effects; therefore, mitigation measures are likely unnecessary. In addition, the Seattle Stormwater Code would require the use of green stormwater infrastructure (GSI) practices to the maximum extent feasible for each build alternative. The use of GSI is expected to provide additional benefit to surface water in the study area. GSI measures are discussed in detail in the *Bored Tunnel Corridor Final Conceptual Hydraulic Report* (CH2M Hill 2010). It is assumed that similar measures could be incorporated into each of the build alternatives.

GSI includes BMPs that are designed to reduce runoff from development using infiltration, evapotranspiration, and stormwater reuse (City of Seattle 2009a). Examples of GSI include management of post-construction soil quality and depth, tree planting and retention, downspout dispersion, sheet flow dispersion, bioretention, rainwater harvesting, permeable pavement, and green roofs. The use of GSI depends on several factors, including groundwater conditions. Appendix P, Earth Discipline Report, discusses groundwater in detail.

Southern Portion of the Study Area

In the southern portion of the study area, GSI measures such as new tree plantings and rain gardens would potentially be integrated into the design of the City Side Trail, a multi-use (pedestrian and bicycle) trail that would be constructed along the east side of Alaskan Way S. in the southern portion of the study area. GSI measures along this section would improve aesthetics while potentially reducing stormwater runoff by means of tree and plant canopy interception, evapotranspiration, and possible infiltration.

The existing soils in the southern portion of the study area pose some constraints to the use of GSI measures because they are generally not favorable for infiltration. Also, groundwater in the southern portion is relatively shallow, and contaminated soils are known to exist. These factors may limit the use of some types of GSI, such as infiltration facilities. However, rain gardens, tree box filters, bioretention swales, and permeable pavement may still be feasible if used in combination with underground liners and underdrains.

Central Portion of the Study Area

The use of GSI for the build alternatives in the central portion of the study area has not been evaluated. However, similar to the southern portion of the study area, shallow groundwater and potentially contaminated soils may limit the use of the types of GSI facilities that depend on infiltration or require overexcavation.

Northern Portion of the Study Area

In the northern portion of the study area, there would potentially be several opportunities for implementing GSI measures. Bioretention swales and/or stormwater planters could be located within the median and adjacent to the roadway in certain wide pedestrian areas. Pervious sidewalks and rain gardens could be placed in the area north of Harrison Street. Vegetated street bulbs with rain gardens could be constructed along portions of Sixth Avenue N. There would also be several areas where tree planters could be incorporated.

The soils in the northern portion of the study area range from clayey and silty soils with low infiltration rates to sands and gravels that may have a higher infiltration potential. In addition, areas of perched, shallow groundwater may exist. More detailed investigation would be necessary to evaluate these soils before proceeding with further consideration of GSI measures.

5.1.6 Operational Benefits

In addition to the Viaduct Closed (No Build Alternative), all of the build alternatives are expected to improve the water quality of runoff being discharged from the project area by reducing the overall amount of PGIS relative to existing conditions (see Exhibit 5-10). In addition, in accordance with the requirements of the Seattle Stormwater Code, peak flow control would be provided in the central and northern portions of the study area to reduce the frequency and volume of overflows from the combined sewer system. This would, in turn, potentially improve water quality by reducing the risk of untreated sewage release to Elliott Bay and Lake Union. Also, basic stormwater quality treatment would be provided for PGIS draining to separated stormwater and low-flow diversion systems.

5.2 Viaduct Closed (No Build Alternative)

Two scenarios were evaluated as part of the Viaduct Closed (No Build Alternative):

- Scenario 1 – Sudden unplanned closure of the viaduct for some structural deficiency, weakness, or damage, but without major collapse, due to a smaller earthquake event.
- Scenario 2 – Catastrophic failure and collapse of the viaduct.

In Scenario 1, effects on hydrology would not be expected, because there would be no changes in amount of pervious or impervious surface. It is assumed that the existing viaduct would no longer be pollution-generating, although PGIS areas in the remainder of the study area would not be changed. As shown in Exhibit 5-11, pollutant loads to surface water generated under this scenario are expected to be lower than the loads under existing conditions. This reduction in pollutant load would be the result of the removal of traffic from the existing viaduct surface.

Scenario 2, a major collapse of the existing viaduct, would likely result in significant short-term effects on surface water. As discussed in Appendix P, Earth Discipline Report, a high liquefaction hazard zone extends along the downtown Seattle waterfront. Therefore, this scenario would potentially result in the collapse of not only the viaduct, but the seawall as well, and the liquefaction of some or all of the ground in the vicinity. Collapse of the sewers in the vicinity would result in the discharge of untreated sewage. The nearshore areas of Elliott Bay would be severely affected by the influx of debris and contaminated soil from beneath the viaduct, and the existing contaminated sediments that currently lie beneath Elliott Bay would potentially be resuspended. In addition, collapse of the existing viaduct would result in a dramatic disruption of the existing stormwater conveyance systems. In the event of a major collapse, the water quality impacts would potentially be short term, until recovery measures are completed to stabilize the area.

No long-term operational impacts are expected under either scenario; therefore, no mitigation would be necessary.

5.3 Bored Tunnel Alternative

5.3.1 Southern Portion of the Study Area

Operational effects for the Bored Tunnel Alternative in the south portal area would be similar to those discussed in Section 5.1.2.

5.3.2 Central Portion of the Study Area

Bored Tunnel

The bored tunnel is expected to discharge drainage flows from several different sources. As discussed in the *Bored Tunnel Corridor Final Conceptual Hydraulic Report* (CH2M Hill 2010), some stormwater is expected to enter the tunnel in each portal area. Also, non-stormwater drainage flows would be generated from sources such as testing and operation of the emergency fire suppression system, tunnel washing, and groundwater seepage. All of this water would drain to sumps in the tunnel, which would provide significant detention (several acre-feet, depending on pump design). Eventually, the collected drainage would be pumped back to one or both portals for discharge. The exact tunnel drainage discharge rates and point(s) of discharge will be determined as the design progresses in consultation with the receiving utility owner (either the City or the County). This consultation will occur in the course of the King County Industrial Wastewater Discharge Permit process.

The stormwater flows generated by the Bored Tunnel Alternative are expected to be similar to existing conditions, but impervious surfaces and associated volumes of surface water runoff would not be increased by the Bored Tunnel Alternative (Exhibits 5-10 and 5-14). Non-stormwater sources of drainage would be controlled and/or minimized wherever possible. Chlorinated water would be introduced into the tunnel during testing and operation of the emergency fire suppression system. Chlorinated water would also be used during tunnel washing; however, detergent would not be added to this water. Groundwater seepage would also occur in the tunnel on a continuous basis. The tunnel would be designed to industry standards that would minimize groundwater seepage into the tunnel to approximately 9 gallons per minute (0.02 cubic feet per second) for the entire tunnel length. Exhibit 5-18 summarizes the frequencies, rates, and durations of these non-stormwater drainage events. Controllable activities that would contribute to the pumping demand, such as tunnel washing and fire suppression system testing, would be limited to dry weather periods in order to reduce the risk of overloading the receiving utility. In addition, before being pumped from the tunnel, the water would receive treatment if required by the receiving utility.

Exhibit 5-18. Non-Stormwater Tunnel Flows for the Bored Tunnel Alternative

Event	Frequency	Inflow Rate (gallons per minute)	Duration
Tunnel seepage	Continuous	9	Continuous
Tunnel washing	One to two times per year	35 to 70	Several days
Fire suppression – valve testing	Once per year	100	Intermittently over several days
Fire suppression – sprinkler system testing	Every 5 years	2,500	Intermittent during test period
Fire suppression – major fire event	Rare	Up to 4,000	Up to several hours

Sources: CH2M Hill 2010, HDR 2011.

Viaduct Removal

After completion of the new SR 99 bored tunnel, the existing viaduct would be removed. Removal of the existing viaduct is not expected to result in any change in stormwater runoff volumes compared to existing conditions. The area beneath the viaduct is predominantly impervious surface and is expected to produce the same runoff volumes as those generated with the structure in place. In addition, pollutant loads for the existing viaduct area under the Bored Tunnel Alternative were assumed to be similar to existing conditions. Existing land uses under the viaduct structure include parking and arterial streets. For the purposes of the pollutant loading analysis, these land uses were assumed to remain unchanged in the event that the viaduct is removed, and they were included as pollution-generating surfaces in the calculations.

Battery Street Tunnel Decommissioning

The Battery Street Tunnel would be decommissioned (removed from service) as part of the Bored Tunnel Alternative. One likely decommissioning option would be to partially fill the tunnel with rubble and/or crushed concrete debris from the demolition of the existing viaduct structure. The remainder of the empty space in the tunnel above the crushed concrete would then be injected with controlled-density fill to provide a uniform load support for surface streets. No changes in surface water runoff volumes or operational effects on surface water quality are expected to result from the filling of the subsurface Battery Street Tunnel. Potential construction effects are discussed in Chapter 6.

5.3.3 Northern Portion of the Study Area

Operational effects for the Bored Tunnel Alternative in the north portal area would be similar to those discussed in Section 5.1.4.

5.3.4 Mitigation

As discussed in Section 5.1.5, the water quality and peak flow control BMPs proposed for all build alternatives would address potential risks of adverse effects; therefore, mitigation measures are likely unnecessary.

5.4 Cut-and-Cover Tunnel Alternative

5.4.1 Southern Portion of the Study Area

Operational effects for the Cut-and-Cover Tunnel Alternative in the southern portion of the study area would be similar to those discussed in Section 5.1.2.

5.4.2 Central Portion of the Study Area

Operational effects for the Cut-and-Cover Tunnel Alternative in the central portion of the study area would be similar to those discussed in Section 5.1.3. In addition, oil control BMPs may be required along Alaskan Way S. between S. King Street and Yesler Way (RoseWater Engineering 2006). There would be no operational effects from the seawall replacement element of the Cut-and-Cover Tunnel Alternative. In addition, there are no expected operational effects on groundwater from the Cut-and-Cover Tunnel Alternative. The tunnel is designed to be watertight and to withstand groundwater hydraulic pressures, and no long-term tunnel dewatering is planned. Groundwater in the tunnel vicinity would flow around, under, or over the tunnel structure.

5.4.3 Northern Portion of the Study Area

Operational effects for the Cut-and-Cover Tunnel Alternative in the northern portion of the study area would be similar to those discussed in Section 5.1.4.

5.4.4 Mitigation

As discussed in Section 5.1.5, the water quality and peak flow control BMPs proposed for all build alternatives would address potential risks of adverse effects; therefore, mitigation measures are likely unnecessary.

5.5 Elevated Structure Alternative

5.5.1 Southern Portion of the Study Area

Operational effects for the Elevated Structure Alternative in the southern portion of the study area would be similar to those discussed in Section 5.1.2.

5.5.2 Central Portion of the Study Area

Operational effects for the Elevated Structure Alternative in the central portion of the study area would be similar to those applicable to all build alternatives as discussed in Section 5.1.3, and to those applicable to the Cut-and-Cover Tunnel Alternative, as discussed in Section 5.4.2.

5.5.3 Northern Portion of the Study Area

Operational effects for the Elevated Structure Alternative in the northern portion of the study area would be similar to those discussed in Section 5.1.4.

5.5.4 Mitigation

As discussed in Section 5.1.5, the water quality and peak flow control BMPs proposed for all build alternatives would address potential risks of adverse effects; therefore, mitigation measures are likely unnecessary.

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Chapter 6 CONSTRUCTION EFFECTS AND MITIGATION

6.1 Common to All Build Alternatives

6.1.1 Construction Effects

Construction-related effects from any of the build alternatives would be temporary and would be minimized or prevented through proper selection and implementation of BMPs. Construction effects on surface water would generally be the result of earthwork, concrete work, paving, stockpiling, equipment leaks or spills, material transport, storm drainage and/or combined sewer utility work, and dewatering. In addition, pH can be increased if runoff comes into contact with curing concrete or bentonite drilling slurry. If not properly controlled through the use of temporary construction BMPs, construction-related pollutants can increase turbidity and affect other water quality parameters, such as the amount of available oxygen in the water.

Also, temporary construction-related effects on water quality would potentially be increased by other projects that are constructed either simultaneously or immediately before or after. Concurrent construction effects would be minimized or prevented through the selection and implementation of appropriate BMPs. The scale of construction and related excavation in the downtown Seattle area that would be required by each of the build alternatives could provide an access opportunity for independent third-party projects in the vicinity. Specifically, independent third-party projects requiring below-grade work could potentially save excavation costs by implementing work concurrently with the excavation for the Bored Tunnel Alternative. Any independent, third-party project that would potentially be constructed at the same time as the Alaskan Way Viaduct Replacement Project would be independently analyzed and designed.

Mitigation of the construction effects discussed in this section is presented in Section 6.1.2. Additional construction effects associated with spoils removal and hazardous materials are discussed in Appendix Q, Hazardous Materials Discipline Report. An overview of the proposed construction for each build alternative and the locations of the staging areas are provided in Appendix B, Alternatives Description and Construction Methods Discipline Report.

Earthwork, Concrete Work, Paving, and Stockpiling

One of the highest risks of construction-related water quality effects is erosion of disturbed soil areas or soil stockpiles by stormwater runoff, which in turn could transport silt and sediment to receiving waters, resulting in increased turbidity. Fugitive dust, particularly during saw cutting or demolition, could also be a source of turbid runoff if precipitation comes in contact with dust and the runoff is not controlled. Concrete work also poses a high risk of water quality effects, since it can elevate the pH of runoff that comes in contact with the concrete during the curing process. The pH limit for fresh and marine waters (WAC 173-201A) and the state construction general permit benchmark for pH is a maximum of 8.5 units. Sediment and other contaminants could increase turbidity and affect other water quality parameters, such as the amount of available oxygen in the water.

Equipment Leaks or Spills

Stormwater runoff may carry contaminants such as fuel, oil, or grease released by spills or leaks from construction equipment. The highest probability for effects associated with spills of such materials during construction is typically in staging areas, though there is also some risk in each construction area. Also, because the staging areas for the each build alternative would mostly be located adjacent to water, there is a greater potential for water quality to be affected by spills during the refueling or servicing of equipment and by stormwater runoff from stockpiled soil or other materials. Surface spills from construction equipment or fuel/oil storage tanks that occur near an excavated area could travel through the exposed soil into the groundwater. Further discussion of these effects is included in Appendix Q, Hazardous Materials Discipline Report.

Material Transport

Sediment and other contaminants could fall onto roadways and be captured in stormwater runoff along haul routes (i.e., routes over which construction materials and excavation spoils are transported to and from staging areas and between the project construction sites). In addition, because many of the construction materials and excavation spoils may be transferred over water by barge, there is an increased risk of contaminant transport to Elliott Bay during material transfer from the staging areas.

Storm Drainage and Combined Sewer Utilities

Excavation activities performed in the vicinity of existing storm drainage and/or combined sewer utility pipes increase the risk of an interruption of service if the pipes are inadvertently damaged during construction or relocation. Detailed information on temporary effects on underground utilities is provided in Appendix K, Public Services and Utilities Discipline Report.

Dewatering

Dewatering during construction could result in groundwater flow toward the excavated area; therefore, subsurface contaminants, including total petroleum hydrocarbons, total suspended solids (TSS), and trace organics, could migrate toward the excavation from areas outside the alignment and increase pollutant concentrations in dewatering water (Parsons Brinckerhoff 2009). As a result of dewatering, water table drawdown in soils in the vicinity could result in ground settlement, which could damage sensitive structures and facilities. Details regarding mitigation measures for dewatering effects are presented in Section 6.1.2.

6.1.2 Mitigation of Construction Effects

Universal Measures

Construction-related runoff and dewatering water would be discharged to the combined sewer system for treatment at the West Point WWTP. The project would need to obtain a wastewater discharge permit or authorization from the County before discharging construction stormwater or dewatering water to the combined sewer. Also, due to the extent of the construction required, the project would need to obtain an NPDES construction stormwater permit from Ecology. The construction mitigation measures would also need to be reviewed by the City for compliance with applicable regulations, including the Stormwater Code, the Shoreline Master Program, and the Environmentally Critical Areas Ordinance. Finally, the project should coordinate with the Port of Seattle for all construction staging activity taking place on Port property to comply with existing Port permit requirements. Before discharge to either the combined sewer or the separated storm drain, stormwater runoff from active construction areas would need to be treated as necessary to meet the requirements of the County and state permits. Any dewatering water that reaches contaminant thresholds would have to be treated to the acceptable standards of the King County Wastewater Discharge Permit or Authorization before being discharged to the combined sewer system, or it would have to be disposed of at an approved off-site hazardous waste facility. Monitoring should also be performed in accordance with the applicable standards.

Construction effects on surface water would be avoided, minimized, and mitigated, and the amount of required treatment would be minimized and mitigated by the development, implementation, and ongoing updating (based on field conditions) of certain management plans. These plans and their key contents are summarized as follows:

- **Construction Stormwater Pollution Prevention Plan** – This plan would serve as the overall stormwater mitigation plan and would include each of the plans discussed below (e.g., Temporary Erosion and Sediment Control Plan) as appendices.
  - Describe overall BMPs, including location, size, maintenance requirements, and monitoring
  - Specify methods for handling dewatering water, including storage, treatment, and discharge or disposal

- Discuss fugitive dust control, including surface protection and wetting techniques
  - Outline flow control, including methods for routing off-site stormwater around the construction area and for controlling on-site stormwater discharges
  - Address detention requirements and protocols to meet requirements and maintain existing conveyance system capacity
  - Describe temporary water quality treatment for on-site stormwater runoff and/or dewatering water, including methods, location, and treatment goals
  - Specify storm drain protection, maintenance, and monitoring
  - Provide a list of Certified Erosion and Sediment Control Leads who would monitor and manage implementation and maintenance of BMPs
  - Outline water quality monitoring requirements, including location, frequency, and reporting

- **Temporary Erosion and Sediment Control Plan** – This plan would outline the design and construction specifications for BMPs to be used to identify, reduce, eliminate, or prevent sediment and erosion problems.

- **Spill Prevention, Control, and Countermeasures Plan** – This plan would outline requirements for and implementation of spill prevention, inspection protocols, equipment, material containment measures, and spill response procedures.

- **Concrete Containment and Disposal Plan** – This plan would outline the management, containment, and disposal of concrete debris, slurry, and dust and discuss BMPs that would be used to reduce high pH.

- **Dewatering Plan –** This plan would outline procedures for pumping groundwater away from the construction area, and storing (as necessary), testing, treating (as necessary), and discharging or disposing of the dewatering water.

- **Fugitive Dust Plan –** This plan would outline measures to prevent the generation of fugitive dust from exposed soil, construction traffic, and material stockpiles.

Water quality monitoring would be performed in accordance with the applicable standards.

Earthwork, Paving, and Stockpiling

Effects from earthwork, paving, and stockpiling would be mitigated by implementation of the plans discussed previously under "Universal Measures."

Equipment Leaks or Spills

Effects from potential leaks or spills of construction equipment fuel, oil, and grease would be mitigated by implementation of the plans discussed previously under "Universal Measures."

Material Transport

Effects from the transport of construction material would be mitigated by implementation of the plans discussed previously under "Universal Measures." The measures described in these plans should include a requirement that all material handling and transfers be conducted only by trained personnel.

Storm Drainage and Combined Sewer Utilities

Effects from storm drainage and/or combined sewer utility work would be mitigated by implementation of the plans discussed previously under "Universal Measures." In addition, significant coordination between the project's utility design team, affected utility providers, and construction personnel would be required to minimize construction effects during storm drainage and/or combined sewer utility work. Care should be taken to locate existing utilities as accurately as possible before construction activity begins.

Dewatering

Effects from construction dewatering would be mitigated by implementation of the plans discussed previously under "Universal Measures." The measures described in these plans should include treatment of water generated by dewatering of shallow groundwater areas before discharge. Groundwater that is removed from deeper soil units is less likely to contain contaminants. Water quality treatment for shallow dewatering could consist of storing the water to allow particles to settle or adding flocculants (chemicals that promote flocculation by causing colloids and other suspended particles in liquids to clump together into a mass, called a *floc*) to reduce suspended particles before the water is discharged from the project area. Any water with contaminant concentrations that reach the contaminant thresholds would have to be treated to the acceptable standards of the King County Wastewater Discharge Permit or Authorization before being discharged to the combined sewer system, or it would need to be disposed of at an approved off-site hazardous waste facility.

In addition, given the rates of pumping for dewatering water in some areas, detention of this water may be necessary before its discharge to either the storm drainage system or the combined sewer system to meet the requirements of the King County Wastewater Discharge Permit or Authorization and to avoid overwhelming these conveyance systems. Depending on the volumes and timing, if discharging dewatering flows to the stormwater or combined sewer system would not be feasible, off-site disposal would be required.

Ground settlement that may result from dewatering would be mitigated by means of reinjection wells near the excavation area, supplied by water from the dewatering operation. Excess water that is not used for the injection well system would need to be treated and disposed of in the sanitary sewer in accordance with the King County Wastewater Discharge Permit or Authorization (Shannon & Wilson 2010). In addition, ground treatment techniques such as freezing may also reduce the need for dewatering. However, adequate site investigation would be necessary to select and design the best ground treatment approaches.

6.2 Bored Tunnel Alternative

6.2.1 Southern Portion of the Study Area

Construction in the south portal area of the bored tunnel would involve construction of a perimeter of secant piles, referred to as a "protection box" around the tunnel boring machine (TBM) between approximately S. Royal Brougham Way and S. Main Street. The protection box would be constructed to reduce the risks of settlement and to help isolate the TBM from soil and groundwater as the tunnel begins its drive underground. This portion of the alignment at the south portal would be a cut-and-cover tunnel but may involve excavation and fill as well. The majority of the storm drainage and combined sewer utility lines would be replaced.

The south portal area would be the launch location for the TBM. A staging area would be established at the Washington-Oregon Shippers Cooperative Association site to include facilities needed to support construction in the south portal area, operation of the TBM, and the internal construction of the tunnel. These facilities could include material laydown areas, an electrical power substation, maintenance workshops, construction worker parking, and field offices. In addition, these facilities could include a spoils storage areas to manage the materials generated during operation of the TBM.

As discussed in Appendix P, Earth Discipline Report, the water table in the south portal area is located about 6 to 10 feet below the ground surface. Therefore, dewatering would be required during construction of the cut-and-cover tunnels and most of the retained cut sections. Preliminary analyses by the design team indicate that the pumping rates along the alignment may range from 100 to 1,000 gallons per minute (approximately 0.2 to 2 cubic feet per second) per 100 feet of open excavation. Dewatering would likely continue until the construction of the tunnel retaining wall is completed, which is estimated to take approximately 9 months.

6.2.2 Central Portion of the Study Area

Bored Tunnel

Because of the depth of the bored tunnel, its construction is not expected to disturb storm drainage or combined sewer utility pipes except at the tunnel portals. In addition, most of the tunnel boring would take place below the groundwater table. The earth pressure balance TBM has been selected by the design-builder as the appropriate type to be used for the Bored Tunnel Alternative. Dewatering during tunnel boring would not be needed. Specifically, the earth pressure balance TBM can function underwater and does not require dewatering during operation. In addition, ground treatments such as freezing generally eliminate the need for dewatering during the boring process.

Viaduct Removal

During removal of the viaduct, it is expected that the columns and footings would be removed to an estimated depth of 5 feet below existing grade in addition to the removal of the existing aboveground viaduct structure. Utilities located on the viaduct and, where necessary, those under the viaduct would be relocated during demolition of the existing structure. Some excavations adjacent to the existing structure would be required for the relocated utilities. The location and depth of the required excavations is not yet determined, but they could be several feet deep. There is a risk of an interruption of service if the storm drainage and/or combined sewer utility pipes being relocated are inadvertently damaged during the process. Material stockpiling would be substantial during the dismantling and crushing of the existing viaduct structure. Stormwater exposure to the crushed concrete and associated fugitive dust could result in increased turbidity and pH levels in surface water runoff. Some localized paving may be required for the restoration of surfaces once the viaduct is removed and after utility replacement or relocation. Such paving activities may result in some minor risk of silt and sediment transport and/or increases in pH if runoff comes in contact with concrete during the curing process.

Battery Street Tunnel Decommissioning

Decommissioning the Battery Street Tunnel is not expected to require substantial earthwork, although there may be some concrete stockpiling during the filling of the tunnel. Stormwater exposure to crushed concrete could result in increases in the turbidity and pH of surface water runoff. In addition, stormwater exposure to the controlled-density fill that could be injected into the tunnel could increase the pH of the associated runoff. Finally, potential paving that may be required to close out the tunnel portals could also slightly increase the risk of silt and sediment transport and/or increases in pH if runoff comes in contact with concrete during the curing process. The existing combined sewer utility pipes are currently located in and around the Battery Street Tunnel. During the filling of the tunnel, there is a risk of an interruption of service if these pipes are inadvertently damaged.

6.2.3 Northern Portion of the Study Area

Tunnel boring operations would end just north of Thomas Street. Construction at the north portal of the bored tunnel would involve a cut-and-cover tunnel from Thomas Street to Harrison Street, with the excavation ranging from 30 to 90 feet deep and 70 to 150 feet wide. The transition from the cut-and-cover tunnel to the existing roadway would extend from Harrison Street to Mercer Street. Excavations would be made for utility relocations, foundation construction, retained cuts, and cut-and-cover tunnel. The majority of the storm drainage and combined sewer utility lines would be replaced.

As discussed in Appendix P, Earth Discipline Report, the groundwater table in the north portal area is located more than 80 feet below the ground surface; therefore, the need for significant dewatering is not expected. Perched seepage zones that potentially exist above the groundwater table typically can be controlled by sumps and pumps in the excavations. The remainder of the construction effects in the north portal area of the bored tunnel is expected to be similar to those described in Section 6.1.1.

6.2.4 Mitigation

Mitigation measures for the construction effects of the Bored Tunnel Alternative would be similar to those described in Section 6.1.2.

6.3 Cut-and-Cover Tunnel Alternative

6.3.1 Southern Portion of the Study Area

For the Cut-and-Cover Tunnel Alternative, soil improvements are proposed along the western side of SR 99 using several potential methods, including stone columns (vibro-replacement), jet grouting, and deep soil mixing. The pH of the generated spoils would be greater than 12 units. Other construction effects would be similar to those described in Section 6.1.1.

6.3.2 Central Portion of the Study Area

The Cut-and-Cover Tunnel Alternative would require substantial earthwork, especially in the central portion of the study area, because a large part of the project would require excavation. Also, soil improvements are proposed behind the Elliott Bay seawall and would likely consist of jet grouting. The pH of the generated spoils would be greater than 12 units. Potential water quality impacts from soil improvements include runoff from spoils stockpiles entering adjacent drainage facilities or receiving waters and grout seeping into Elliott Bay through cracks in the existing seawall.

The Cut-and-Cover Tunnel Alternative would replace the existing seawall with a new face panel, a reinforced concrete L-wall support structure, and cantilevered sidewalk north of Union Street to Broad Street. In the area near Pier 66, between Blanchard and Battery Streets, only soil improvements would be needed. The new seawall would be built in generally the same location as, or slightly landward of, the existing seawall. Potential construction effects could include increased turbidity during the installation of containment walls and the removal of riprap in the vicinity of the seawall construction. In addition, in-water construction in this area could pose a risk of resuspending nearby contaminated sediments and spreading the pollutants over a broad area.

Several of the stormwater outfalls and combined sewer overflow structures would need to be replaced during construction of the seawall. The location and depths of the new outfalls and overflow structures are expected to be the same as existing conditions, and additional in-water work beyond what is required for reconstruction of the seawall is not expected (Cosmopolitan Engineering Group, Inc. 2007).

The Cut-and-Cover Tunnel Alternative would require continuous dewatering throughout the construction process. The soil in the vicinity of the tunnel excavation would need to be predrained before removal, and the groundwater in the vicinity of the excavation would need to be pumped continuously to provide a clean and competent working surface. Dewatering alternatives that have been developed generally include the installation of dewatering wells outside the tunnel excavation (or inside, depending on the dewatering alternative chosen), and sumps and ditches within the excavation to convey groundwater to a central location before it is pumped to the ground surface (Shannon & Wilson 2007). The quantities of water that would be produced from the dewatering wells have not been estimated, because long-term (30-day) pumping tests have not been performed. Dewatering could lower the groundwater table in shallow fill. Reinjection of pumped water is being considered to mitigate the lower groundwater table in shallow soils. The water removed from shallow soil units could contain contaminants, including total petroleum hydrocarbons, TSS, and trace organics. Deeper groundwater that is removed from deeper soil units is not as likely to contain contaminants.

Other construction effects would be similar to those described in Section 6.1.1.

6.3.3 Northern Portion of the Study Area

Potential construction effects for the Cut-and-Cover Tunnel Alternative in the northern portion of the study area would be the result of street improvements and would be similar to those described in Section 6.1.1.

6.3.4 Mitigation

Mitigation measures for the construction effects of the Cut-and-Cover Tunnel Alternative would be similar to those described in Section 6.1.2.

In addition, a containment system would be installed on the waterward side of the existing seawall to minimize or prevent construction-related pollutants from entering Elliott Bay during the seawall replacement (Parsons 2006). The following steps would be followed for construction of the containment system:

1. The existing seawall would be surveyed for size and location of cracks and other potential leakage points.
2. Temporary repairs would be made to the existing seawall to retain upland grout when it is placed.
3. A turbidity curtain would be installed to minimize turbidity in the construction area and prevent water quality impacts outside the work area.
4. A movable containment panel would be installed adjacent to the existing seawall, including an impervious mat to be placed over the riprap adjacent to the seawall. The size and location of the panel-mat system would be determined by the secant pile installation and grouting operations.

If spoils from jet grouting are dewatered on site, a temporary treatment facility would likely be required to treat the water to adjust pH and potentially remove sediment before discharge.

It is possible that the Cut-and-Cover Tunnel Alternative would require improvements to the secant pile tunnel/seawall in the Colman Curve section of the construction area. Riprap in this area would be removed before the installation of the sheet pile wall, and a turbidity curtain would be installed before the riprap is removed. Outfalls that require replacement would be constructed at the same time as the seawall construction activities, using similar BMPs.

Mitigation measures would be implemented during the replacement of stormwater outfalls and combined sewer overflow structures to continue drainage service during construction. Depending on the location and feasibility, either flows would be diverted to an adjacent outfall, or a temporary diversion pipe would be constructed to discharge flows at the existing location.

6.4 Elevated Structure Alternative

6.4.1 Southern Portion of the Study Area

Potential construction effects for the Elevated Structure Alternative in the southern portion of the study area would be the result of street improvements and would be similar to those described in Section 6.1.1.

6.4.2 Central Portion of the Study Area

The Elevated Structure Alternative would generate a large volume of spoils because of the L-wall type seawall construction that would occur along a large portion of the waterfront.

The Elevated Structure Alternative would involve in-water work activities and result in potential construction effects similar to those of the Cut-and-Cover Tunnel Alternative, including construction of the seawall, temporary overwater structures, outfall reconstruction, and use of Pier 48 for construction staging. The Elevated Structure Alternative would replace the existing seawall with an L-wall type seawall. The new seawall would be located in about the same plane as, or landward of, the existing seawall.

Large amounts of dewatering are not expected during construction for the Elevated Structure Alternative. There are no major excavations planned, and the elevated structure would be supported primarily on drilled shafts that would not require dewatering during installation. Localized dewatering may be required for utility excavations, though analyses have not been performed to estimate quantities of water that may be removed for utility work.

Other construction effects would be similar to those described in Section 6.1.1.

6.4.3 Northern Portion of the Study Area

Potential construction effects for the Elevated Structure Alternative in the northern portion of the study area would be the result of street improvements and would be similar to those described in Section 6.1.1.

6.4.4 Mitigation

Mitigation measures for the potential construction effects of the Elevated Structure Alternative would be similar to the measures applicable to all build alternatives described in Section 6.1.2 and the measures applicable to the Cut-and-Cover Tunnel Alternative described in Section 6.3.4.

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Chapter 7 TOLLING

A range of tolling proposals was considered and analyzed for the Alaskan Way Viaduct replacement facility. The considerations included using low, medium, or high tolls; varying the toll by time of day; applying a peak-only toll; tolling the tunnel segment only; or tolling the tunnel and the SR 99 corridor, by charging drivers who use the corridor to get to or through downtown Seattle from points beyond north and south of the tunnel. The analysis did not assume that transit or carpools would pay a toll.

Tolling is not expected to have any effects on surface water in the study area. Tolls would be collected electronically, so the project would not include structures such as toll booths or any increased impervious surface areas.

A major potential effect of tolling at any rate level or location is the diversion of traffic to other routes, since those who do not want to pay the toll would choose to travel on a more congested route to save money. Much of the diverted traffic would use the closest alternate routes to SR 99: Alaskan Way or First Avenue/First Avenue S. However, these alternate routes would be on existing surface streets, so no new impervious surface area would be added due to this increase in traffic. In addition, none of the three build alternatives under consideration increase the impervious surface area over existing conditions. Therefore, tolling would not have any adverse effect on surface water quality in the study area.

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ATTACHMENT A

Water Quality Analysis

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ATTACHMENT A
WATER QUALITY ANALYSIS

A.1 BACKGROUND AND PURPOSE

This analysis was conducted in support of the Alaskan Way Viaduct Replacement Project Final Environmental Impact Statement (EIS) to evaluate potential effects on water quality. Within the study area, land use and pollutant loading calculations were made for the existing conditions, the Viaduct Closed (No Build Alternative), and the Bored Tunnel Alternative (preferred), the Cut-and-Cover Tunnel Alternative, and the Elevated Structure Alternative.

A.2 LAND USE ANALYSIS

Increases in total impervious area (TIA) and pollution-generating impervious surface (PGIS) within the study area could pose a risk of increased pollutant loads and increased volume and/or frequency of combined sewer overflows. A land use analysis was conducted to (1) determine changes in TIA resulting from each alternative compared to existing conditions to evaluate potential changes in the volume of water discharged to the combined sewer system, and (2) determine the changes in PGIS resulting from each alternative compared to existing conditions to support the pollutant loading analysis.

A.2.1 Methodology

Sub-basin Delineation

The study area for the surface water analysis was defined by combining the footprints of the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives. The project design team delineated 13 sub-basins throughout the study area using existing survey data, City of Seattle side sewer cards, and field verification. Sub-basins were delineated on the basis of topography, collection system, and discharge location. The sub-basin boundaries were mapped using GIS and the areas were calculated. Sub-basins for the existing conditions are shown in Exhibit 4-1 through 4-3 in the main report. Sub-basins for the Bored Tunnel, Cut-and-Cover Tunnel, and Elevated Structure Alternatives are depicted in Exhibits 5-1 through 5-3, 5-4 through 5-6, and 5-7 through 5-9, respectively, in the main report.

Land Use Categories

Within the study area, land uses were defined as pervious surface, non-pollutant-generating impervious surface (NPGIS), and PGIS. These types of land uses were identified on the basis of aerial photography and conceptual design drawings. In general, the land uses within each sub-basin were determined using the following methods:

- In the Broad and Dexter sub-basins, each type of land use was delineated directly from aerial photography for existing conditions and from design drawings for each alternative.
- In the remainder of the sub-basins, the percentage of each type of land use was estimated by the design team based on aerial photographs of existing conditions and from design drawings for each alternative (Exhibit A-1).

Exhibit A-1. Land Use Percentages Under Existing Conditions

Sub-basin	Percentage of Total Area		
	Pervious	NPGIS	PGIS
Royal Brougham South	0%	0%	100%
Royal Brougham North	0%	0%	100%
King	0%	10%	90%
Washington – Pier 58	0%	0%	100%
Washington – other	5%	10%	85%
Madison – separated storm area	0%	10%	90%
Madison – combined sewer area	0%	0%	100%
Seneca	5%	10%	85%
University – combined sewer area	0%	0%	100%
University – separated storm area	5%	10%	85%
Pine	5%	10%	85%
Pike	5%	10%	85%
Vine – roadway	0%	0%	100%
Vine – sidewalks	0%	100%	0%
Western Diversion	0%	0%	100%

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface

For the Viaduct Closed (No Build Alternative) and each build alternative, land use is equivalent to existing conditions in portions of the study area that would not be changed by the alternative. Additional assumptions used to define land use for each of the alternatives are described in the following subsections.

Viaduct Closed (No Build Alternative)

Under this alternative, the existing viaduct structure would be in place but without the stability to support traffic. Therefore, the viaduct was assumed to be NPGIS for this alternative.

Bored Tunnel Alternative

Under the Bored Tunnel Alternative, the existing viaduct would be removed and the remaining surfaces beneath the viaduct were assumed to be PGIS. Land use percentages for the Bored Tunnel Alternative are shown in Exhibit A-2.

Exhibit A-2. Land Use Percentages for the Bored Tunnel Alternative

Sub-basin	Percentage of Total Area		
	Pervious	NPGIS	PGIS
Royal Brougham South – roadway	0%	0%	100%
Royal Brougham South – pedestrian/bicycle	0%	100%	0%
Royal Brougham North	1%	50%	49%
King	14%	10%	76%
Washington – Pier 58	Assumed equivalent to existing conditions.		
Washington – other			
Madison – separated storm area			
Madison – combined sewer area			
Seneca			
University – combined sewer area			
University – separated storm area			
Pine			
Pike			
Vine – roadway			
Vine – sidewalks			
Western Diversion			

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface

Cut-and-Cover Tunnel Alternative

Under the Cut-and-Cover Tunnel Alternative, the existing viaduct would be removed and replaced by the proposed design. Land use percentages for the Cut-and-Cover Tunnel Alternative are shown in Exhibit A-3.

Exhibit A-3. Land Use Percentages for the Cut–and-Cover Tunnel Alternative

Sub-basin	Percentage of Total Area		
	Pervious	NPGIS	PGIS
Royal Brougham South – roadway	0%	0%	100%
Royal Brougham South – pedestrian/bicycle	0%	100%	0%
Royal Brougham North	0%	50%	50%
King	5%	10%	85%
Washington – Pier 58	0%	100%	0%
Washington – other	5%	40%	55%
Madison – separated storm area	5%	40%	55%
Madison – combined sewer area	0%	0%	100%
Seneca	5%	40%	55%
University – combined sewer area	0%	0%	100%
University – separated storm area	5%	40%	55%
Pine	5%	40%	55%
Pike	5%	40%	55%
Vine – roadway	0%	0%	100%
Vine – sidewalks	0%	100%	0%
Western Diversion	5%	0%	95%

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface

Elevated Structure Alternative

Under the Elevated Structure Alternative, the existing viaduct would be removed and replaced by the proposed design. Land use percentages for the Elevated Structure Alternative are shown in Exhibit A-4.

Exhibit A-4. Land Use Percentages for the Elevated Structure Alternative

Sub-basin	Percentage of Total Area		
	Pervious	NPGIS	PGIS
Royal Brougham South – roadway	0%	0%	100%
Royal Brougham South – pedestrian/bicycle	0%	100%	0%
Royal Brougham North	0%	50%	50%
King	5%	10%	85%
Washington – Pier 58	0%	100%	0%
Washington – other	5%	40%	55%
Madison – separated storm area	5%	40%	55%
Madison – combined sewer area	0%	0%	100%
Seneca	5%	40%	55%
University – combined sewer area	0%	0%	100%
University – separated storm area	5%	40%	55%
Pine	5%	30%	65%
Pike	5%	30%	65%

Exhibit A.4. Land Use Percentages for the Elevated Structure Alternative (continued)

Sub-basin	Percentage of Total Area		
	Pervious	NPGIS	PGIS
Vine – roadway	0%	0%	100%
Vine – sidewalks	0%	100%	0%
Western Diversion	0%	0%	100%

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface

Area Calculations

The area of each type of land use was calculated for each sub-basin by multiplying the percentage of each land use type by the sub-basin area for existing conditions and each of the alternatives.

Impact Evaluation

Potential impacts on water quality due to increases in TIA were evaluated qualitatively by comparing the amount of TIA created by the project within each sub-basin to the amount of TIA in that sub-basin under existing conditions. Sub-basins that drain directly to Lake Union or Elliott Bay were not considered because these water bodies are not affected by changes in the rate or volume of stormwater runoff. In sub-basins that drain to a combined sewer system, if the TIA increases, there is a potential for impacts due to an increase in the frequency or volume of combined sewer overflow events.

A.2.2 Results

Exhibit A-5 summarizes the results of the land use analysis under existing conditions and for the project under each of the alternatives.

Exhibit A-5. Summary of Land Use Changes

Land Use (acres)	Alternative				
	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Pervious surface	2.8	2.8	5.1	6.7	8.7
NPGIS	17.3	28.3	30.7	30.4	29.0
PGIS	78.9	67.9	63.3	62.0	61.4
TIA	96.2	96.2	94.0	92.3	90.4
Total area	99.0	99.0	99.0	99.0	99.0

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

The results of the land use analysis for the southern, central, and northern portions of the study areas are presented in Exhibits A-6 through A-8, respectively.

Exhibit A-6. Changes in Land Use – Southern Portion of the Study Area

Sub-basin	Land Use (acres)	Alternative				
		Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Royal Brougham South	Pervious surface	0.0	0.0	0.0	0.0	0.0
	NPGIS	0.0	0.0	0.4	0.4	0.4
	PGIS	1.0	1.0	0.3	0.3	0.3
	TIA	1.0	1.0	0.7	0.7	0.7
	Total area	1.0	1.0	0.7	0.7	0.7
Royal Brougham North	Pervious surface	0.0	0.0	0.1	0.0	0.0
	NPGIS	0.0	0.9	5.7	5.7	6.9
	PGIS	10.5	9.6	5.9	6.0	6.9
	TIA	10.5	10.5	11.7	11.8	13.8
	Total area	10.5	10.5	11.8	11.8	13.8
King	Pervious surface	0.0	0.0	1.4	0.5	0.4
	NPGIS	0.9	2.4	1.0	1.0	0.8
	PGIS	9.8	8.4	7.7	8.6	6.8
	TIA	10.8	10.8	8.7	9.6	7.6
	Total area	10.8	10.8	10.1	10.1	7.9
Total area	Pervious surface	0.0	0.0	1.5	0.5	0.4
	NPGIS	0.9	3.3	7.1	7.1	8.1
	PGIS	21.3	19.0	13.9	14.9	13.9
	TIA	22.3	22.3	21.0	22.1	22.0
	Total area	22.3	22.3	22.6	22.6	22.4

Notes: PGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

Exhibit A-7. Changes in Land Use – Central Portion of the Study Area

Sub-basin	Land Use (acres)	Alternative				
		Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Washington	Pervious surface	0.2	0.2	0.2	0.2	0.2
	NPGIS	0.3	1.5	4.1	4.1	4.2
	PGIS	6.2	5.1	2.6	2.6	2.7
	TIA	6.5	6.5	6.7	6.7	6.8
	Total area	6.7	6.7	6.9	6.9	7.1

Exhibit A-7. Changes in Land Use – Central Portion of the Study Area (continued)

Sub-basin	Land Use (acres)	Alternative				
		Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Madison (separated)	Pervious surface	0.0	0.0	0.3	0.3	0.3
	NPGIS	0.4	1.6	2.0	2.0	2.0
	PGIS	4.6	3.4	2.8	2.8	2.8
	TIA	4.9	4.9	4.8	4.8	4.8
	Total area	4.9	4.9	5.0	5.0	5.0
Madison (combined)	Pervious surface	0.0	0.0	0.0	0.0	0.0
	NPGIS	0.0	0.0	0.0	0.0	0.0
	PGIS	0.9	0.9	0.9	0.9	0.9
	TIA	0.9	0.9	0.9	0.9	0.9
	Total area	0.9	0.9	0.9	0.9	0.9
Seneca	Pervious surface	0.1	0.1	0.1	0.1	0.1
	NPGIS	0.2	0.6	0.8	0.8	0.8
	PGIS	2.2	1.8	1.1	1.1	1.1
	TIA	2.4	2.4	1.9	1.9	1.9
	Total area	2.5	2.5	2.0	2.0	2.0
University (combined)	Pervious surface	0.0	0.0	0.0	0.0	0.0
	NPGIS	0.0	0.0	0.0	0.0	0.0
	PGIS	0.2	0.2	0.2	0.2	0.2
	TIA	0.2	0.2	0.2	0.2	0.2
	Total area	0.2	0.2	0.2	0.2	0.2
University (separated)	Pervious surface	0.1	0.1	0.1	0.1	0.1
	NPGIS	0.3	1.2	0.9	0.9	0.9
	PGIS	3.1	2.2	1.3	1.3	1.3
	TIA	3.3	3.3	2.2	2.2	2.2
	Total area	3.5	3.5	2.3	2.3	2.3
Pike	Pervious surface	0.0	0.0	0.1	0.1	0.1
	NPGIS	0.1	0.7	0.6	0.6	0.5
	PGIS	1.4	0.8	0.9	0.9	1.0
	TIA	1.5	1.5	1.5	1.5	1.5
	Total area	1.6	1.6	1.6	1.6	1.6
Pine	Pervious surface	0.2	0.2	0.3	0.2	0.3
	NPGIS	0.4	2.3	1.4	1.4	1.5
	PGIS	5.3	3.4	5.2	1.9	3.3
	TIA	5.7	5.7	6.6	3.3	4.8
	Total area	5.9	5.9	6.9	3.5	5.0
Vine	Pervious surface	0.0	0.0	0.0	0.0	0.0
	NPGIS	1.5	2.7	1.5	2.0	2.0
	PGIS	9.0	7.7	9.0	11.9	10.3
	TIA	10.5	10.5	10.5	13.8	12.3
	Total area	10.5	10.5	10.5	13.8	12.3

Exhibit A-7. Changes in Land Use – Central Portion of the Study Area (continued)

Sub-basin	Land Use (acres)	Alternative: Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Western Diversion	Pervious surface	0.0	0.0	0.0	0.2	0.0
	NPGIS	0.0	1.2	0.0	0.0	0.0
	PGIS	4.0	2.8	4.0	3.8	4.0
	TIA	4.0	4.0	4.0	3.8	4.0
	Total area	4.0	4.0	4.0	4.0	4.0
Total area	Pervious surface	0.6	0.6	1.1	1.2	1.0
	NPGIS	3.2	11.8	11.3	11.9	11.8
	PGIS	36.8	28.1	27.9	27.3	27.5
	TIA	39.9	39.9	39.2	39.1	39.4
	Total area	40.6	40.6	40.3	40.3	40.4

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

Exhibit A-8. Changes in Land Use – Northern Portion of the Study Area

Sub-basin	Land Use (acres)	Alternative: Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Broad	Pervious surface	0.5	0.5	0.0	0.0	1.6
	NPGIS	0.6	0.6	3.8	3.0	1.0
	PGIS	3.8	3.8	2.1	2.2	2.3
	TIA	4.4	4.4	6.0	5.2	3.2
	Total area	4.9	4.9	6.0	5.2	4.9
Dexter	Pervious surface	1.7	1.7	2.4	5.0	5.6
	NPGIS	12.6	12.6	8.4	8.4	8.1
	PGIS	17.0	17.0	19.4	17.6	17.6
	TIA	29.7	29.7	27.8	26.0	25.7
	Total area	31.3	31.3	30.2	31.0	31.3
Total area	Pervious surface	2.2	2.2	2.5	5.0	7.2
	NPGIS	13.2	13.2	12.2	11.4	9.1
	PGIS	20.8	20.8	21.5	19.8	19.9
	TIA	34.0	34.0	33.7	31.2	29.0
	Total area	36.2	36.2	36.2	36.2	36.2

Notes: NPGIS = non-pollution-generating impervious surface
PGIS = pollution-generating impervious surface
TIA = total impervious area

A.3 POLLUTANT LOADING ANALYSIS

In addition to increased volume and/or frequency of combined sewer overflows caused by increases in TIA, water quality could also be adversely affected by an increase in pollutants associated with stormwater runoff from the project area. This section quantitatively evaluates potential changes in pollutant loads using the methods and assumptions discussed in Section A.3.1. The results of this analysis are provided in Section A.3.2.

A.3.1 Methodology

Pollutant loads were calculated for existing conditions and each alternative using Washington State Department of Transportation (WSDOT) Method 1. This is the method approved in the 2010 *Environmental Procedures Manual* (WSDOT 2010) and outlined in the *Quantitative Procedures for Surface Water Impact Assessments* (WSDOT 2009). This method was developed from Federal Highway Administration guidance documents and provides a rough quantitative volume-based pollutant loading analysis to compare project alternatives.

Method 1 relies on two input parameters: PGIS and pollutant loading coefficients for five representative pollutants (Exhibit A-9).

Exhibit A-9. Annual Pollutant Loading Coefficients

Pollutant	Annual Mean Load (pounds per acre)	
	Untreated Surfaces	Treated Surfaces
TSS	769	88
Total copper	0.16	0.04
Dissolved copper	0.04	0.030
Total zinc	0.98	0.21
Dissolved zinc	0.31	0.14

Note: TSS = total suspended solids

The annual mean pollutant load is calculated by multiplying the PGIS values calculated in the land use analysis in Section A.2 by the appropriate annual pollutant loading coefficient from Exhibit A.9.

For the purposes of this analysis, the following assumptions were made about the level of treatment:

- In applicable separated stormwater sub-basins (see Exhibit A.10), on-site water quality BMPs selected from the Seattle *Stormwater Manual* (City of Seattle 2009) and/or the WSDOT *Highway Runoff Manual* (WSDOT 2008) would be applied. In these sub-basins, the areas of PGIS were multiplied by the coefficient for treated annual pollutant loads (Exhibit A.9).

- Runoff from combined sewer system sub-basins is treated off site at the West Point wastewater treatment plant and backup wet-weather treatment plants. PGIS in these areas was assumed to be untreated *within the study area boundaries*. Therefore, areas of PGIS in combined sewer sub-basins were multiplied by the coefficient for untreated annual pollutant loads (Exhibit A-9).

Exhibit A-10 summarizes the water quality treatment used in this analysis for existing conditions and each build alternative.

Exhibit A-10. Water Quality Treatment by Sub-basin

	Water Quality Treatment Type				
Sub-basin	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Royal Brougham – South A	Off-site	Off-site	BMPs	BMPs	BMPs
Royal Brougham – South B	Off-site	Off-site	BMPs	BMPs	BMPs
Royal Brougham – North	Off-site	Off-site	Off-site	Off-site	Off-site
King	Off-site	Off-site	Off-site	Off-site	Off-site
Washington A	Untreated	Untreated	Untreated	BMPs	BMPs
Washington B	Untreated	Untreated	Untreated	BMPs	BMPs
Madison A	Untreated	Untreated	Untreated	BMPs	BMPs
Madison B	Off-site	Off-site	Off-site	Off-site	Off-site
Seneca	Untreated	Untreated	Untreated	BMPs	BMPs
University A	Off-site	Off-site	Off-site	Off-site	Off-site
University B	Untreated	Untreated	Untreated	BMPs	BMPs
Pike	Off-site	Off-site	Off-site	Off-site	Off-site
Pine	Untreated	Untreated	Untreated	BMPs	BMPs
Vine A	Off-site	Off-site	Off-site	Off-site	Off-site
Vine B	Off-site	Off-site	Off-site	Off-site	Off-site
Western Diversion	Off-site	Off-site	Off-site	Off-site	Off-site
Broad	Untreated	Untreated	BMPs	BMPs	BMPs
Dexter	Off-site	Off-site	Off-site	Off-site	Off-site

Notes: Off-site treatment is applied to sub-basins that drain to a combined sewer system.
"BMPs" refers to on-site surface water quality treatment.
Untreated refers to sub-basins that receive no treatment.
BMP = best management practice

A.3.2 Results

The results of the pollutant loading analysis are summarized in Exhibit A-11. Individual pollutant loading analyses for the southern, central, and northern portions of the study areas are presented in Exhibits A-12 through A-14, respectively.

Exhibit A-11. Summary of Annual Pollutant Loading

Pollutant (pounds per year)	Alternative				
	Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
TSS	60,669	52,221	38,176	39,393	37,894
Percent change	0.0%	-14%	-37%	-35%	-38%
Total copper	12.6	10.9	8.3	8.5	8.2
Percent change	0.0%	-14%	-34%	-33%	-35%
Dissolved copper	3.2	2.7	2.4	2.4	2.3
Percent change	0.0%	-14%	-25%	-25%	-27%
Total zinc	77.3	66.5	50.2	51.4	49.6
Percent change	0.0%	-14%	-35%	-34%	-36%
Dissolved zinc	24.5	21.1	17.0	17.1	16.7
Percent change	0.0%	-14%	-30%	-30%	-32%

Note: TSS = total suspended solids

Exhibit A-12. Annual Pollutant Loads – Southern Portion of the Study Area

Sub-basin	Pollutant (pounds per year)	Alternative				
		Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Royal Brougham South	TSS	755	755	22	22	22
	Total copper	0.2	0.2	0.0	0.0	0.0
	Dissolved copper	0.0	0.0	0.0	0.0	0.0
	Total zinc	1.0	1.0	0.1	0.1	0.1
	Dissolved zinc	0.3	0.3	0.0	0.0	0.0
Royal Brougham North	TSS	8,079	7,380	4,558	4,646	5,332
	Total copper	1.7	1.5	0.9	1.0	1.1
	Dissolved copper	0.4	0.4	0.2	0.2	0.3
	Total zinc	10.3	9.4	5.8	5.9	6.8
	Dissolved zinc	3.3	3.0	1.8	1.9	2.1
King	TSS	7,567	6,457	5,929	6,628	5,202
	Total copper	1.6	1.3	1.2	1.4	1.1
	Dissolved copper	0.4	0.3	0.3	0.3	0.3
	Total zinc	9.6	8.2	7.6	8.4	6.6
	Dissolved zinc	3.1	2.6	2.4	2.7	2.1

Exhibit A-12. Annual Pollutant Loads – Southern Portion of the Study Area (continued)

Sub-basin	Pollutant (pounds per year)	Alternative: Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Total pollutant load	TSS	16,400	14,591	10,509	11,296	10,556
	Percent change	0.0%	-11%	-36%	-31%	-36%
	Total copper	3.4	3.0	2.2	2.4	2.2
	Percent change	0.0%	-11%	-36%	-31%	-35%
	Dissolved copper	0.9	0.8	0.6	0.6	0.6
	Percent change	0.0%	-11%	-35%	-30%	-35%
	Total zinc	20.9	18.6	13.4	14.4	13.5
	Percent change	0.0%	-11%	-36%	-31%	-36%
	Dissolved zinc	6.6	5.9	4.3	4.6	4.3
	Percent change	0.0%	-11%	-36%	-31%	-35%

Note: TSS = total suspended solids

Exhibit A-13. Annual Pollutant Loads – Central Portion of the Study Area

Sub-basin	Pollutant (pounds per year)	Alternative: Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Washington	TSS	4,778	3,893	229	229	236
	Total copper	1.0	0.8	0.1	0.1	0.1
	Dissolved copper	0.2	0.2	0.1	0.1	0.1
	Total zinc	6.1	5.0	0.5	0.5	0.6
	Dissolved zinc	1.9	1.6	0.4	0.4	0.4
Madison (separated)	TSS	3,516	2,614	243	243	243
	Total copper	0.7	0.5	0.1	0.1	0.1
	Dissolved copper	0.2	0.1	0.1	0.1	0.1
	Total zinc	4.5	3.3	0.6	0.6	0.6
	Dissolved zinc	1.4	1.1	0.4	0.4	0.4
Madison (combined)	TSS	665	665	665	665	665
	Total copper	0.1	0.1	0.1	0.1	0.1
	Dissolved copper	0.0	0.0	0.0	0.0	0.0
	Total zinc	0.8	0.8	0.8	0.8	0.8
	Dissolved zinc	0.3	0.3	0.3	0.3	0.3

Exhibit A-13. Annual Pollutant Loads – Central Portion of the Study Area (continued)

Sub-basin	Pollutant (pounds per year)	Alternative: Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Seneca	TSS	1,684	1,352	99	99	99
	Total copper	0.4	0.3	0.0	0.0	0.0
	Dissolved copper	0.1	0.1	0.0	0.0	0.0
	Total zinc	2.1	1.7	0.2	0.2	0.2
	Dissolved zinc	0.7	0.5	0.2	0.2	0.2
University (combined)	TSS	126	126	126	126	126
	Total copper	0.0	0.0	0.0	0.0	0.0
	Dissolved copper	0.0	0.0	0.0	0.0	0.0
	Total zinc	0.2	0.2	0.2	0.2	0.2
	Dissolved zinc	0.1	0.1	0.1	0.1	0.1
University (separated)	TSS	2,368	1,676	113	113	113
	Total copper	0.5	0.3	0.1	0.1	0.1
	Dissolved copper	0.1	0.1	0.0	0.0	0.0
	Total zinc	3.0	2.1	0.3	0.3	0.3
	Dissolved zinc	1.0	0.7	0.2	0.2	0.2
Pike	TSS	1,115	639	675	675	798
	Total copper	0.2	0.1	0.1	0.1	0.2
	Dissolved copper	0.1	0.0	0.0	0.0	0.0
	Total zinc	1.4	0.8	0.9	0.9	1.0
	Dissolved zinc	0.4	0.3	0.3	0.3	0.3
Pine	TSS	4,061	2,593	462	168	289
	Total copper	0.8	0.5	0.2	0.1	0.1
	Dissolved copper	0.2	0.1	0.2	0.1	0.1
	Total zinc	5.2	3.3	1.1	0.4	0.7
	Dissolved zinc	1.6	1.0	0.7	0.3	0.5
Vine	TSS	6,890	5,944	6,890	9,131	7,958
	Total copper	1.4	1.2	1.4	1.9	1.7
	Dissolved copper	0.4	0.3	0.4	0.5	0.4
	Total zinc	8.8	7.6	8.8	11.6	10.1
	Dissolved zinc	2.8	2.4	2.8	3.7	3.2
Western Diversion	TSS	3,074	2,136	3,074	2,920	3,074
	Total copper	0.6	0.4	0.6	0.6	0.6
	Dissolved copper	0.2	0.1	0.2	0.2	0.2
	Total zinc	3.9	2.7	3.9	3.7	3.9
	Dissolved zinc	1.2	0.9	1.2	1.2	1.2

Exhibit A-13. Annual Pollutant Loads – Central Portion of the Study Area (continued)

Sub-basin	Pollutant (pounds per year)	Alternative				
		Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Total pollutant load	TSS	28,276	21,637	12,574	14,369	13,601
	Percent change	-	-23%	-56%	-49%	-52%
	Total copper	5.9	4.5	2.9	3.2	3.1
	Percent change	-	-23%	-51%	-46%	-48%
	Dissolved copper	1.5	1.1	1.0	1.0	1.0
	Percent change	-	-23%	-33%	-32%	-33%
	Total zinc	36.0	27.6	17.3	19.3	18.4
	Percent change	-	-23%	-52%	-47%	-49%
	Dissolved zinc	11.4	8.7	6.4	6.8	6.6
	Percent change	-	-23%	-44%	-40%	-42%

Note: TSS = total suspended solids

Exhibit A-14. Annual Pollutant Loads – Northern Portion of the Study Area

Sub-basin	Pollutant (pounds per year)	Alternative				
		Existing Conditions	Viaduct Closed (No Build Alternative)	Bored Tunnel Alternative	Cut-and-Cover Tunnel Alternative	Elevated Structure Alternative
Broad	TSS	2,916	2,916	189	194	198
	Total copper	0.6	0.6	0.1	0.1	0.1
	Dissolved copper	0.2	0.2	0.1	0.1	0.1
	Total zinc	3.7	3.7	0.5	0.5	0.5
	Dissolved zinc	1.2	1.2	0.3	0.3	0.3
Dexter	TSS	13,076	13,076	14,904	13,534	13,539
	Total copper	2.7	2.7	3.1	2.8	2.8
	Dissolved copper	0.7	0.7	0.8	0.7	0.7
	Total zinc	16.7	16.7	19.0	17.2	17.3
	Dissolved zinc	5.3	5.3	6.0	5.5	5.5
Total pollutant load	TSS	15,993	15,993	15,094	13,728	13,738
	Percent change	-	-	-6%	-14%	-14%
	Total copper	3.3	3.3	3.2	2.9	2.9
	Percent change	-	-	-4%	-13%	-13%
	Dissolved copper	0.8	0.8	0.8	0.8	0.8
	Percent change	-	-	1%	-7%	-7%
	Total zinc	20.4	20.4	19.4	17.7	17.7
	Percent change	-	-	-5%	-13%	-13%
	Dissolved zinc	6.4	6.4	6.3	5.8	5.8
	Percent change	-	-	-2%	-11%	-10%

Note: TSS = total suspended solids

A.4 REFERENCES

Seattle, City of. 2009. Stormwater Manual [Directors' Rules for Seattle Municipal Code, Chapters 22.800–22.808 (Stormwater Code)], Volumes 1–4. Seattle Public Utilities, Department of Planning and Development. Publications SPU 2009-003 through 2009-006 and DPD 15-2009 through 18-2009. Seattle, Washington. November 5, 2009.

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