Washington State Department of Transportation

SR 520 Bridge Replacement and HOV Program

I-5 to Medina: Bridge Replacement and HOV Project

JARPA Attachment I

Final Aquatic Mitigation Report

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

Prepared for

Washington State Department of Transportation

December, 2011

Washington State Department of Transportation

SR 520 Bridge Replacement and HOV Program

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Final Aquatic Mitigation Plan

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December 2011 (Revised February 2012)

This Final Aquatic Mitigation Plan was updated in February 2012 to reflect comments provided by the USACE. Please refer to Appendix F for the complete list of pages that have changed.

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Executive Summary

The Washington State Department of Transportation (WSDOT) is proposing to construct the SR 520, I-5 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina Project) to reduce transit and high-occupancy vehicle (HOV) travel times and to replace the aging spans of the Portage Bay and Evergreen Point bridges, which are highly vulnerable to windstorms and earthquakes. The project will also widen the State Route (SR) 520 corridor to six lanes from I-5 in Seattle to Evergreen Point Road in Medina, and will restripe and reconfigure the lanes in the corridor from Evergreen Point Road to 92nd Avenue NE in Yarrow Point. The project will complete the regional HOV lane system across SR 520, as called for in regional and local transportation plans.

The SR 520, I-5 to Medina project will extend approximately 5.2 miles from I-5 in Seattle to 92nd Avenue NE in Yarrow Point. The project will construct an additional bridge over the Montlake Cut and replace the Portage Bay Bridge, the Union Bay Bridge, and the vulnerable Evergreen Point Bridge with new structures. It will complete the regional HOV system across SR 520. The project passes through Section 24, in Township 25 North, Range 5 East, and Sections 20, 21, and 22 in Township 25 North, Range 4 East. The aquatic resources evaluated in this *Final Aquatic Mitigation Plan* analysis occur within and adjacent to the limits of construction.

Construction for the SR 520, I-5 to Medina project is planned to begin in 2012, with major construction expected to be completed in 2018. In order to maintain traffic flow in the SR 520 corridor, the project will be built in stages. The most vulnerable structures (Evergreen Point Bridge and Portage Bay Bridge) will be built first, followed by the less vulnerable components.

The environmental review process was originally initiated by WSDOT and Sound Transit in 2000, when a Notice of Intent was issued to prepare an environmental impact statement (EIS) to evaluate improvements in the SR 520 corridor. WSDOT issued a Draft EIS in 2006, a Supplemental Draft EIS, in 2010, and has since identified the preferred alternative in a Final EIS issued in June 2011 for the SR 520 Bridge Replacement and HOV Project. This aquatic mitigation plan is based on the preferred alternative identified in the Final EIS; thus, it presents the design and impacts associated with the preferred alternative. A formal decision on the selected alternative was described in the Record of Decision (ROD), issued in August 2011. During construction, the project will affect Portage Bay of Lake Union, the Lake Washington Ship Canal and Lake Washington, aquatic resources that are regulated by federal, state, or local agencies.

This aquatic mitigation plan serves to:

- Identify the project's impacts on aquatic resources;
- Describe project actions and design features that will minimize or avoid impacts on aquatic resources; and
- Describe proposed compensatory mitigation to offset unavoidable impacts to aquatic resources.

This aquatic mitigation plan also:

- Describes the updated design elements and construction techniques that have been identified through progression of final design for the floating bridge and its east approach; and
- Demonstrates that the overall environmental effects from the proposed changes would further minimize or avoid impacts on aquatic resources compared to the WSDOT conceptual design.

The mitigation plan is based on the most current information on project impacts and on characteristics of the mitigation site. WSDOT will continue to develop and modify the mitigation concept in response to agency comments, and additional technical investigations and analyses as they are completed.

Aquatic Resources Impacts

A diverse group of native and non-native fish species inhabit the Lake Washington watershed, including several species of native salmon and trout such as Chinook (*Onchorhynchus tshawytscha*), coho (*O. kisutch*), and sockeye (*O. nerka*) salmon; and steelhead *(O. mykiss*), rainbow (*O. mykiss irideus*), and cutthroat trout (*O. clarki clarki*). Most of these species are likely to occur at least occasionally in the project area, which is located adjacent to a primary migration corridor (i.e., Ship Canal) for all anadromous salmonids spawned in the watershed. The project has the potential to affect several life history stages of anadromous salmonids, primarily rearing and migrating juveniles. In addition to discussing these species, this report presents information on fish species that are significant predators on salmonids in Lake Washington, including bass and northern pikeminnow.

Construction and operation of the preferred alternative will result in long-term operational impacts and short-term construction impacts to the species and life history stages of the salmonids mentioned above. Project construction may result in long-term impacts to shoreline and open-water habitats in the project area. The largest impacts are associated with construction of a wider floating bridge, bridge approaches, and interchanges. The impacts include (1) loss of benthic habitat due to placement of larger (although fewer) bridge columns, (2) increased over-water bridge structure that could result in an increase in the amount or intensity of in-water shade, and (3) changes in habitat complexity (benefitting predators of juvenile salmonids) due to new arrangements of in-water piers and columns. Short-term construction impacts to the aquatic environment include pile driving, the construction of cofferdams, construction lighting, anchor placement, and other in-water work.

The mitigation team developed a conceptual model to characterize the interaction between anadromous salmonids and the aquatic habitat in the project area. The model is based on existing literature on salmonid habitat functions and features in Lake Washington. It uses the primary life history stages of anadromous salmonids as surrogates for related population-level metrics (i.e., survival, growth, fitness, and reproductive success) to represent all anadromous salmonids in the Lake Washington system, although the importance of specific habitat features varies by species.

The mitigation team reviewed the proposed project actions to determine the scope and scale of the impacts on relevant aquatic functions in the project area. Potential changes in aquatic functions were analyzed based on their effects on salmonid life history stages and populations. Based on this review, WSDOT determined which impact metrics best represented important aquatic impacts. The three primary metrics are as follows:

1. Area of over-water shading, which is tied to changes in juvenile salmonid outmigration.
2. Benthic fill, representing the physical displacement of aquatic habitat.
3. Habitat complexity, representing alterations in predation on juvenile salmonids.

A mitigation framework was created to assess impacts and resulting mitigation needs, based on salmonid life histories and habitat utilization. The framework was used to establish a methodology to assess both impacts and mitigation uplift. Impacts were assigned based on the two-dimensional area of affected habitat, modified by a geographic (spatial) factor called the Fish Function Modifier (this modifier accounts for differences in fish utilization). The resulting impacts are calculated in acres. The methodology also calculates temporary impacts by integrating the temporal aspect of the impact structures, and therefore results in impacts based on the integration of both impact area and duration (service-acre-years).

Under the mitigation approach used by WSDOT, compensation is required for unavoidable adverse impacts that exist after avoidance and minimization measures have been employed. With the exception of the three impact metrics listed above, other types of construction impacts, including in-water noise, temporary lighting, in-water turbidity/contaminants, and barge operation, have been avoided and/or minimized to the extent that compensatory mitigation will not be required. Similarly, potential operational effects such as stormwater discharge and permanent bridge lighting have also been sufficiently minimized through project design and will represent an improvement over the existing condition. Any residual effects are expected to be insignificant and will not require compensatory mitigation. This document describes the specific avoidance and minimization measures employed for potential construction and operational impacts.

Based on the types and locations of potential impacts, the project has the greatest potential to affect juvenile salmonids in the rearing/feeding and migration life history stages; impacts during these life history stages could result in decreases in juvenile growth, survival, and fitness. The impact assessment characterized effects on aquatic resources based on area (acreage) of bridge structures and related changes to salmonid life history stages. The raw area calculations were adjusted based on the use of specific impact zones by salmonids, including the amount and type of fish utilization. This application of the Fish Function Modifier factor adjusted the impacts according to their ecological relevance (in most cases the modified impact acreage is less than the un-modified impact area). The specific metrics for habitat impacts were calculated and the modified totals are 7.43 acres of permanent impacts and 16.73 acre-years of temporary impacts (one acre-year is defined as one acre of impact over one year). The modified totals are broken down as follows:

- Permanent shading impacts of 7.14 acres and temporary shading impacts of 12.49 acre-years.
- Permanent benthic fill impacts of 0.29 acre and temporary benthic fill impacts of 0.65 acre-years.
- Temporary habitat complexity impacts of 3.72 acre-years (no permanent habitat complexity impacts result from the project).

Aquatic Resources Mitigation

To offset project impacts that could not be adequately avoided or minimized, WSDOT focused on mitigation projects that would benefit the same salmonid species and life history phases to which impacts could occur. Because on-site, in-kind opportunities were not feasible, WSDOT sought off-site mitigation opportunities within the watershed that addressed the same functions and values that could be affected by the project.

The same conceptual model and impact assessment methodology used for calculation of impacts were also applied to the various mitigation sites to translate the type and amount of functional uplift at a given site to habitat acres. The acres were adjusted using the Fish Function Modifier, using the same criteria used for the impact sites. WSDOT also recognizes that some types of mitigation, such as riparian or floodplain enhancement, offer less direct improvement of aquatic habitat than do other types of mitigation that occur directly in the aquatic environment, such as beach creation or in-water structure removal. Therefore, WSDOT has reduced the mitigation credit for these activities to accurately characterize uplift to fish survival, growth, and fitness.

Using the methods listed above, it was determined that a suite of seven mitigation sites, located in various key locations in the Lake Washington basin, will mitigate for the temporary and permanent impacts of the project (Table ES-1). These seven sites were chosen primarily for the salmonid life history stages that will be enhanced (juvenile rearing and outmigration), although most of the sites will also have direct benefits to spawning salmonids. The entire mitigation package will equal about 8.56 acres of permanent mitigation credit and 38.66 acre-years of temporary mitigation credit, which will provide mitigation for project impacts sufficient to meet federal, state, and local regulatory requirements. Table ES-1 illustrates the proposed allocation of those credits.

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Table ES-1. Mitigation Sites, Activities, and Credits

Mitigation Site	Mitigation Actions	Species/ Life Stage Addressed	Permanent Mitigation Credit (acres)	Temporary Mitigation Credit (acre-years)
Seward Park 1	Shoreline enhancement + hard structure removal, riparian restoration	Chinook (juvenile rearing/ feeding, juvenile migration),	0	6.26
Seward Park 2	Shoreline enhancement (gravel supplementation)	Chinook (juvenile rearing/ feeding, juvenile migration), Sockeye (spawning, rearing/feeding)	0	0.85
Seward Park 3	Shoreline enhancement (gravel supplementation), riparian restoration	Chinook (juvenile rearing/ feeding, juvenile migration),	0	2.23
Seward Park 4	Shoreline enhancement (gravel supplementation)	Sockeye (spawning)	0	19.37
Magnuson Park 1	Shoreline Enhancement + Hard Structure Removal, Riparian Restoration	Chinook (Juvenile Rearing/ Feeding, Juvenile Migration),	0	1.88
Magnuson Park 2	Shoreline Enhancement + Hard Structure Removal	Chinook (Juvenile Rearing/ Feeding, Juvenile Migration),	0	2.89
Taylor Creek	Channel and Delta Restoration, Riparian + Floodplain Restoration	Chinook (Rearing/ Feeding) Sockeye (Spawning, Rearing/ Feeding), Coho (Spawning, Rearing/ Feeding)	0	5.20
South Lake Washington Shoreline Restoration	Shoreline Enhancement + Hard Structure Removal, Riparian Restoration, Dolphin Removal	Chinook (Juvenile Rearing/ Feeding, Juvenile Migration) Sockeye (Juvenile Rearing/ Feeding)	1.75	0
Bear Creek	Stream Enhancement, Riparian Restoration	Chinook (Rearing/ Feeding) Sockeye (Rearing/ Feeding) Coho (Rearing/ Feeding)	4.55	0

Mitigation Site	Mitigation Actions	Species/ Life Stage Addressed	Permanent Mitigation Credit (acres)	Temporary Mitigation Credit (acre-years)
Cedar River/ Elliott Bridge	River Margin and Aquatic Off-channel Creation, Riparian + Floodplain Restoration	Chinook (Spawning, Rearing/ Feeding) Sockeye (Spawning, Rearing/ Feeding) Coho (Spawning, Rearing/ Feeding) Steelhead (Spawning, Rearing/ Feeding)	1.67	0
East Approach	Shoreline enhancement (gravel supplementation, bulkhead removal), riparian enhancement	Sockeye (Spawning) Chinook (Juvenile Rearing/ Feeding, Juvenile Migration)	0.60	0
		Total	**8.56**	**38.66**

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Acronyms and Abbreviations

AKART	all known, available and reasonable technology
BMPs	best management practices
C	Celsius
CFR	Code of Federal Regulations
cfs	cubic feet per second
cm	centimeter
CWA	Clean Water Act
dB	decibel
DDD	metabolite of DDT
DDE	breakdown product of DDT
DDT	dichlorodiphenyltrichloroethane
DNR	Washington State Department of Natural Resources
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
ELJs	engineered logjams
ESA	Endangered Species Act
F	Fahrenheit
FHWA	Federal Highway Administration
FHWG	Fisheries Hydroacoustic Working Group
HOV	high-occupancy vehicle
HPA	Hydraulic Project Approval
HRM	*Highway Runoff Manual*
LWD	large woody debris
m	meter
mg/L	milligrams per liter
MITFD	Muckleshoot Indian Tribe Fisheries Division
mm	millimeter

NAVD	North American Vertical Datum
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Oceanic and Atmospheric Administration, National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NRTWG	Natural Resources Technical Working Group
OHW	ordinary high water
OHWM	ordinary high water mark
PAHs	polycyclic aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PGIS	pollutant-generating impervious surface
PSPL	Puget Sound Power and Light
ppm	parts per million
ROD	Record of Decision
SEL	sound exposure level
SPCC	Spill Prevention Control and Countermeasures (Plan)
SPL	sound pressure level
SPU	Seattle Public Utilities
SR	State Route
SWPPP	Stormwater Pollution Prevention Plan
TCDD	dioxin
TESC	Temporary Erosion and Sediment Control (Plan)
TSS	total suspended solids
TWG	Technical Work Group
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington State Department of Fish and Wildlife

WQPMP	Water Quality Protection and Monitoring Plan
WRIA	Water Resource Inventory Area
WSDOT	Washington State Department of Transportation
WWTIT	Western Washington Treaty Indian Tribes

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1. Introduction

The Washington State Department of Transportation (WSDOT) is proposing to construct the SR 520, I-5 to Medina: Bridge Replacement and HOV Project (SR 520, I-5 to Medina Project) to improve transit and high-occupancy vehicle (HOV) travel times and to replace the aging spans of the Portage Bay and Evergreen Point bridges, which are highly vulnerable to windstorms and earthquakes. Specifically, the project proposes to enhance travel time reliability, mobility, access, and safety for transit and HOVs in the rapidly growing areas along State Route (SR) 520 between I-5 in Seattle and 92nd Avenue NE in Yarrow Point (Figure 1-1). The project will have permanent and temporary impacts to fish habitat and aquatic resources.

This report identifies the project's permanent and temporary impacts to aquatic habitat and species, and describes the mitigation strategy for the project. Permanent and temporary impacts discussed in this report will result from over-water structure, benthic fill, and changes in in-water habitat complexity associated with the construction and operation of a widened roadway and accessory facilities. The mitigation strategy includes minimization and avoidance measures and a proposal for compensatory mitigation for the unavoidable permanent and temporary impacts of the project. The discussion in this report focuses on the project's compensatory mitigation elements.

A separate report, the *SR 520, I-5 to Medina: Bridge Replacement and HOV Project Final Wetland Mitigation Report* (WSDOT 2011a), discusses wetland impacts resulting from this project and mitigation for these impacts. For the purposes of this report, aquatic habitats are those areas without aquatic bed vegetation and/or habitats with water depths greater than 6.6 feet.

This report will be used in part to obtain the following permits:

- U.S. Army Corps of Engineers (USACE) – Clean Water Act (CWA) Section 404, Individual Permit and Section 10 Rivers and Harbors Act of 1899.

- Washington State Department of Ecology (Ecology) – CWA Section 401, Water Quality Certification.

- Washington State Department of Fish and Wildlife (WDFW) – Hydraulic Project Approval.

- City of Seattle – Shoreline Substantial Development Permit and Critical Areas Review.

- City of Medina– Shoreline Substantial Development Permit and Critical Areas Review.

Overall site conditions are discussed in the project Biological Assessment (WSDOT 2010a) and the Ecosystems Discipline Report, SR 520, I-5 to Medina: Bridge Replacement and HOV Project (appendix to WSDOT 2010b).

WSDOT is coordinating technical and planning efforts for the SR 520, I-5 to Medina Project through two teams: the Mitigation Core Team and the Mitigation Technical Work Group (which includes the Aquatic Resources Technical Work Group).

The Mitigation Core Team serves as a steering group for mitigation planning activities and is led by Shane Cherry (Confluence Environmental). The Mitigation Core Team is multi-disciplinary, composed of engineers, planners, and biologists from WSDOT HQ Environmental Services, the SR 520 Program, and private consulting companies. The Mitigation Core Team includes (or has included) the following individuals: Bill Leonard (WSDOT, initiation through December 2007), Paul Fendt (Parametrix, initiation through March 2008), Ken Sargent (Headwaters Environmental Consulting), Michelle Meade (WSDOT), Phil Bloch (WSDOT), Shane Cherry (Confluence Environmental), Jeff Meyer (Parametrix), Gretchen Lux (WSDOT, replaced Bill Leonard in December 2007), Chris Berger (Confluence Environmental), and Beth Peterson (HDR Engineering, Inc).

The Aquatic Resources Technical Work Group was led by Phil Bloch (through September 2011, replaced by Michelle Meade in October 2011), and provides technical detail and policy guidance to team members conducting analyses and preparing aquatic resource mitigation planning products. This group consists of Michelle Meade (WSDOT), Shane Cherry (Confluence Environmental), Chris Cziesla (Confluence Environmental), Beth Peterson (HDR Engineering, Inc.), Pete Lawson (Parametrix, through May 2011), Chris Berger (Confluence Environmental), and Chad Wiseman (HDR Engineering, Inc.).

WSDOT engaged regulatory agencies (USACE, USEPA, U.S. Coast Guard, WDFW, Ecology, Seattle Planning), the Services (NMFS, USFWS), the University of Washington, Seattle Parks, and the Muckleshoot Indian Tribe in a collaborative Natural Resources Technical Working Group (NRTWG) process to assist in identification and refinement of effect mechanisms on aquatic resources and in the development of appropriate mitigation measures. To observe existing conditions, WSDOT also conducted field trips with NRTWG members to the Evergreen Point Bridge across Union Bay and the I-90 Bridge across Mercer Slough.

An Initial Aquatic Mitigation Plan was prepared in 2006, and was superseded by the Conceptual Aquatic Mitigation Plan (WSDOT 2009b) incorporating field investigations, scientific research, and the collective knowledge from the TWGs and WSDOT project mitigation teams. The initial plan was submitted to the NRTWG for review and comment. In addition, the general methodologies for calculating project impacts and mitigation benefits were discussed, including potential project impacts, appropriate metrics to measure these impacts, and the general types of mitigation to offset these impacts. The NRTWG meetings in which impacts and compensatory mitigation were discussed were held from June to October 2010. The goal of the meetings was to clearly identify a set of impacts to aquatic resources associated with the project, and to then identify a list of potential mitigation sites that had the greatest potential to directly mitigate for the types and amounts of project effects. In some cases, the specific metrics and methods presented in the NRTWG meetings has changed slightly, based on refinements to project design or additional scientific information. All the changes are based on the best available science, which is discussed in the appropriate sections of this document. Likewise, each of the mitigation sites initially proposed in the NRTWG meetings underwent detailed additional analysis prior to inclusion in the final aquatic mitigation plan, resulting in slightly altered and refined mitigation concepts.

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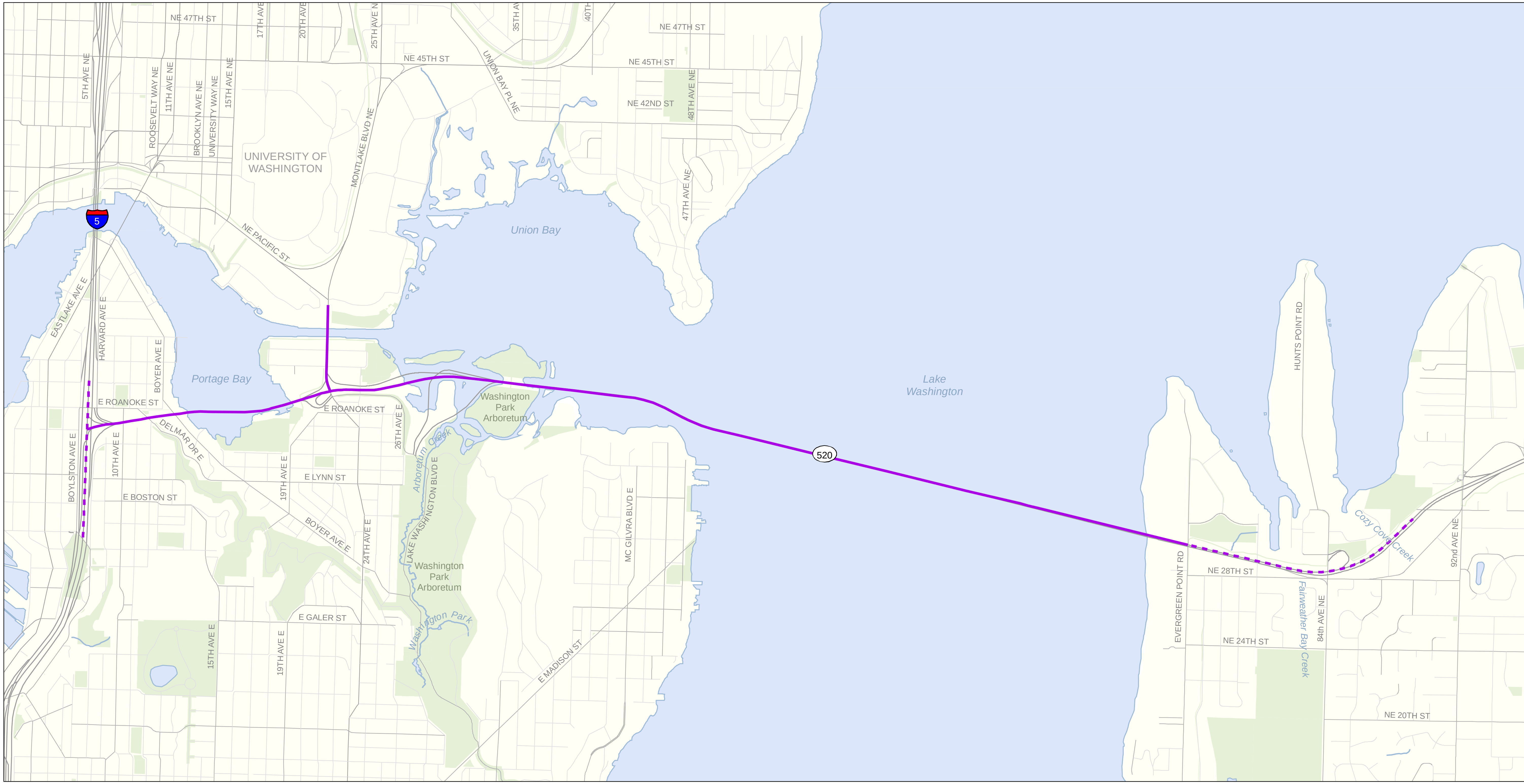

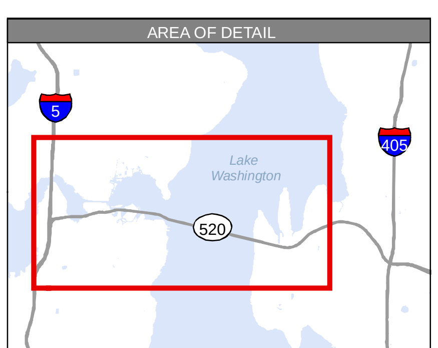

Project Extent
Limited Improvement
Stream
Park

N
0 500 1,000 2,000 Feet

Source: King County (2008) GIS Data (Streams, Streets, Water Bodies), CH2M HILL (2008) GIS Data (Parks). Horizontal datum for all layers is NAD83(91), vertical datum for layers is NAVD88.

Figure 1-1. **Project Vicinity Map**

I-5 to Medina: Bridge Replacement and HOV Project

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2. Project Description

The SR 520, I-5 to Medina Project will widen the SR 520 corridor to six lanes (Figure 2-1) from I-5 in Seattle to Evergreen Point Road in Medina, and restripe and reconfigure the traffic lanes between Evergreen Point Road and 92nd Avenue NE in Yarrow Point. The proposed SR 520 bridge will be six lanes (two 11-foot-wide outer general-purpose lanes in each direction and one 12-foot-wide inside HOV lane in each direction), and include a 14-foot-wide bicycle/pedestrian path), 4-foot-wide inside shoulders, and 10-foot-wide outside shoulders. The width of the combined roadway cross-section (115 feet) will be greater than the existing width of 60 feet, although in places the eastbound and westbound lanes will consist of separate structures with a gap between them. The additional roadway width is needed to accommodate the new HOV lanes and the wider, safer travel lanes and shoulders.

Final design of the Floating Bridge and Landings phase of the project began after WSDOT awarded a contract and issued the Record of Decision. As design has progressed, WSDOT has evaluated the potential impacts of design changes in updated NEPA, SEPA and ESA analyses. Subsequent to the analyses and determination that the overall environmental effects would be less than the WSDOT conceptual design, WSDOT determined that these changes should be reflected in all working environmental documents prior to approval of the final mitigation plan and permits. Including these updates will ensure that the final documents reflect the most current design.

Major elements of the project are discussed below in Section 2.1, while construction activities are summarized in Section 2.2. Operational elements of the project that have some potential to affect aquatic species or habitats (stormwater, lighting, etc.) are discussed in Section 2.3. For detailed design and construction elements, see the project Biological Assessment (WSDOT 2010a) and Supplemental Draft Environmental Impact Statement (EIS) (WSDOT 2010b) for the SR 520, I-5 to Medina Project.

As discussed, Sections 2.1 and 2.2 have been updated to reflect changes to the design and construction techniques of the floating bridge, east approach and bridge maintenance facility. The proposed design changes include 1) a revised combination of permanent bridge anchors, and increased impacts to aquatic substrate from anchor installation 2) fewer columns to support the east approach structure, reducing the permanent benthic impacts and effects to habitat complexity; 3) use of buried spread footings to support the east approach, reducing the permanent benthic impacts compared to mudline footings; 4) revised construction techniques, including a smaller work trestle and establishment of an eastside staging area, reducing the temporary benthic impacts as a result of fewer piles, but increasing shading in ecological zone 7; 5) fewer but larger drilled shafts to support Pier 36 at the west transition span, slightly increasing permanent benthic impacts, 6) additional but smaller in-water columns to support the maintenance dock, slightly increasing permanent benthic impacts.

2.1 Proposed Project Elements

To simplify the description of the proposed project, the sections below discuss project features in seven subareas within the project limits. Figure 2-1 shows the project limits and identifies the six subareas, as well as three discrete geographic areas (Seattle, Lake Washington, and the Eastside) that were incorporated into the Endangered Species Act (ESA) consultation and National Environmental Policy Act (NEPA) analysis.

2.1.1. I-5 Interchange Area

The SR 520 and I-5 interchange ramps will be reconstructed in generally the same configuration as those for the existing interchange. The only exceptions are that a new reversible HOV ramp will connect to the existing I-5 reversible express lanes south of SR 520, and the alignment of the ramp from northbound I-5 to eastbound SR 520 will shift to the south.

The East Roanoke Street bridge over I-5 will provide an enhanced pedestrian crossing. The 10th Avenue East and Delmar Drive East overcrossing will be rebuilt as part of the proposed lid structure, generally within the same alignment and with a similar vertical profile as the existing overcrossing.

Construction activities and durations in the I-5 area will occur over a 2- to 3-year period. Activities in this area will include roadway reconstruction, excavation and embankment grading, retaining wall and abutment construction, and paving. Up to two staging areas will be located within the existing right-of-way. Construction will result in the temporary clearing of approximately 2.9 acres of vegetation. Three facilities—a bioswale and two media treatment vaults—will be constructed to treat stormwater from the I-5 interchange area. No aquatic areas will be affected by the construction and demolition activities.

2.1.2. Portage Bay Area

WSDOT will replace the Portage Bay Bridge with a new bridge that will include two general-purpose lanes in each direction, an HOV lane in each direction (six lanes total), and a westbound managed shoulder. Connections between the new bridge and the exit lanes and ramps to Roanoke Street and northbound I-5 will be configured much as they are currently. Two facilities–one basic treatment bioswale and one constructed wetland for enhanced treatment—will be constructed to treat stormwater from this area.

The height of the western half of the new bridge will match that of the existing bridge, but the eastern half will be higher (Figure 2-2). The new bridge will be about 14 feet higher than the existing bridge’s lowest point near the middle of Portage Bay, and will remain at a greater height above the water than the existing bridge throughout the eastern portion. The new bridge will be supported by larger, but fewer, concrete columns than the existing bridge.

It will begin just east of Delmar Drive, extend across Portage Bay, and end west of Montlake Boulevard. The new Portage Bay Bridge will be a fixed-span bridge. The adjacent interchange ramps to I-5 and Montlake Boulevard will add width near the west and east ends of the bridge as they taper on and off the freeway.

The Portage Bay Bridge substructure will have three main parts: drilled shafts, shaft caps, and concrete support columns. Collectively, the substructure elements constitute a pier bent. The Portage Bay Bridge superstructure will consist of two main parts: cast-in-place box girders that span between the bridge piers and the roadway slab (bridge deck). The superstructure will also include false arches for aesthetic treatments under the westerly three over-water spans. The bridge configuration will range between 105 and 143 feet wide, compared to the 61- to 75-foot-wide existing bridge. The height of the western half of the new bridge would match the existing bridge, but the height of the eastern half will increase from 5 to 16 feet.

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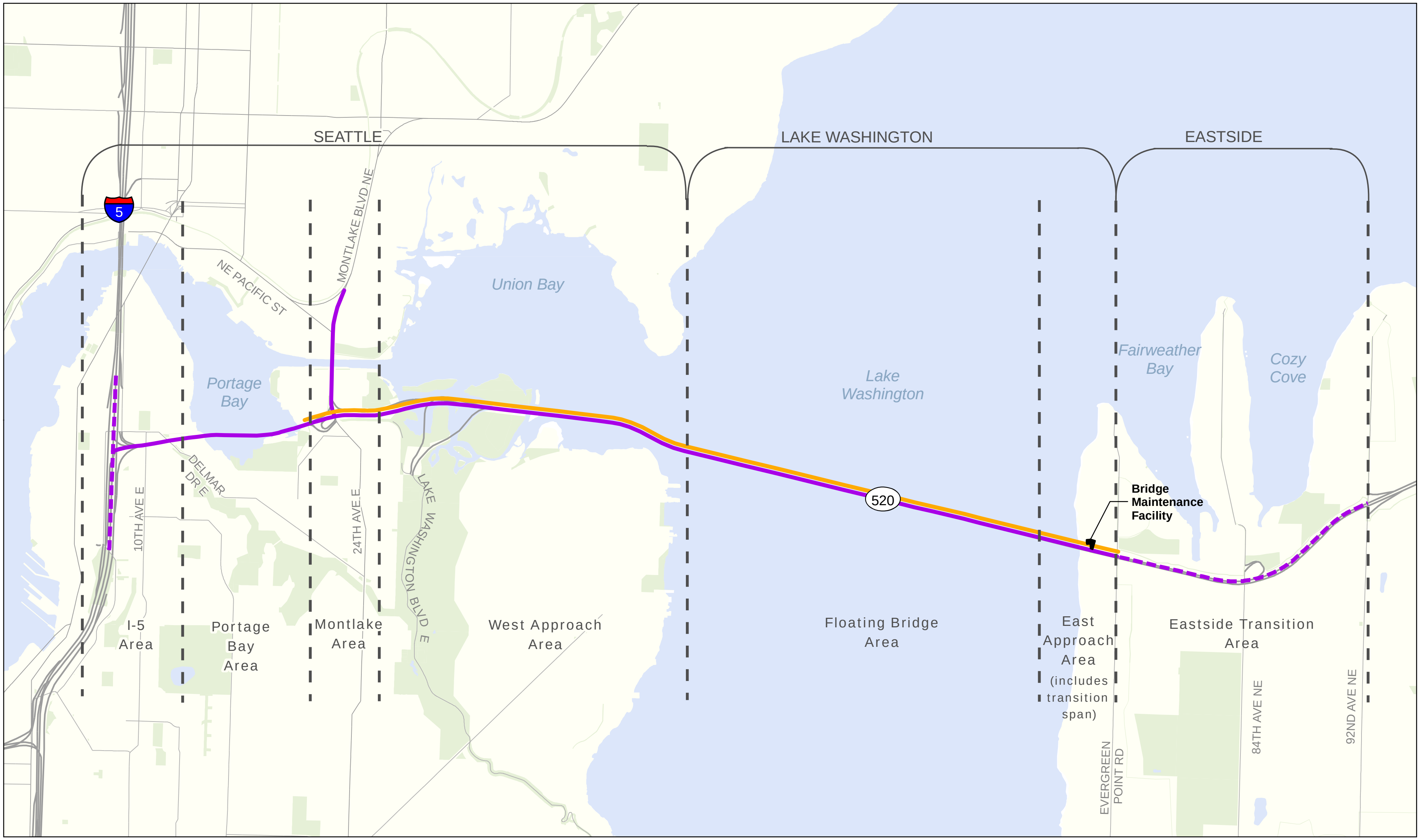

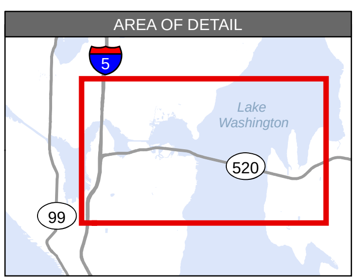

- Project Extent
- Denotes Limited Improvement
- Regional Bicycle/Pedestrian Path
- Park

N

0 1,000 2,000 4,000 Feet

Source: King County (2005) GIS Data (Stream and Street), King County (2007) GIS Data (Waterbody), CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Figure 2-1. **Geographic Areas within the Project Limits**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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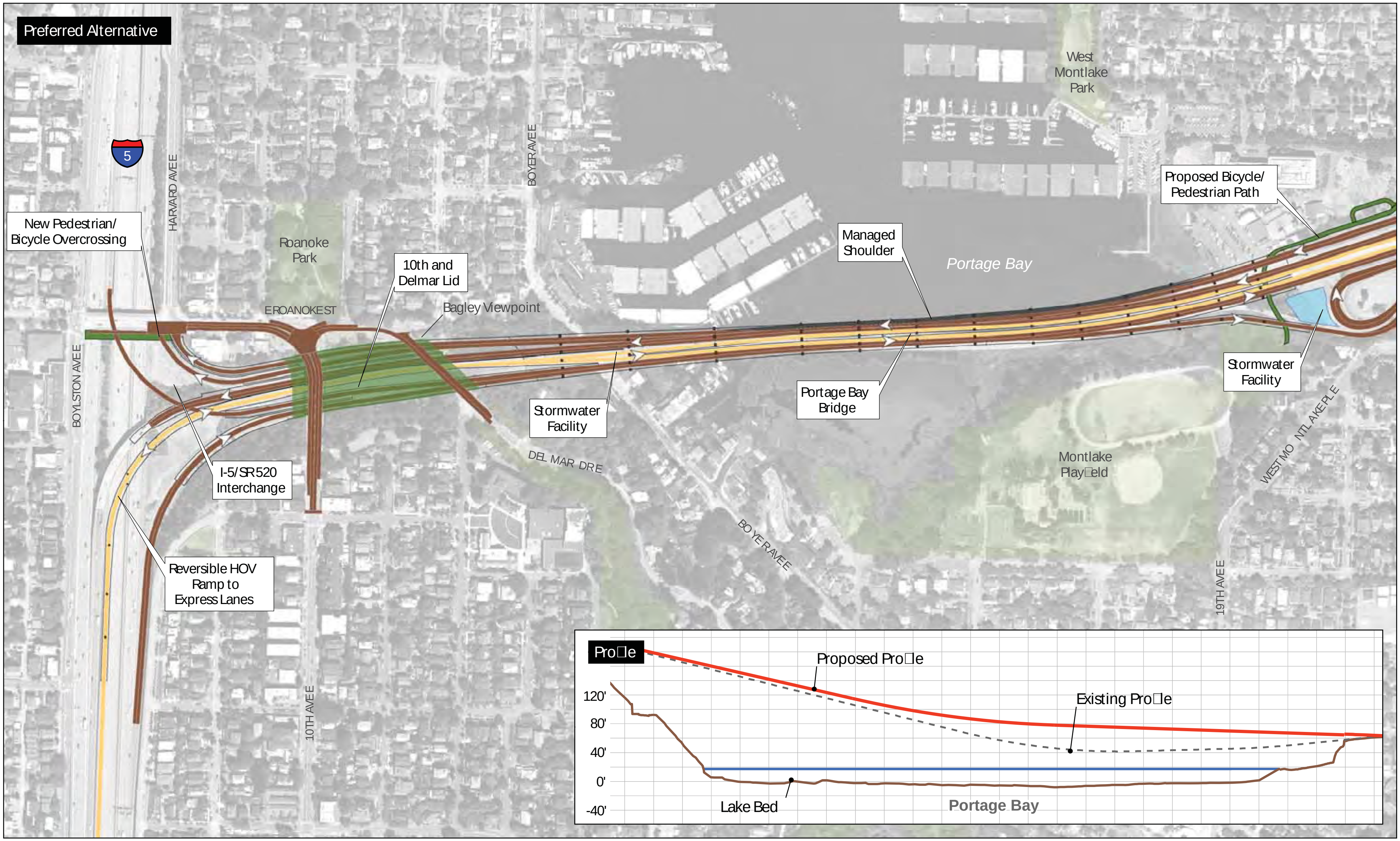

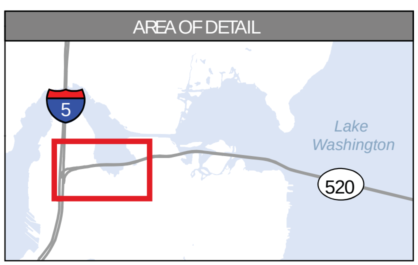

- • Column
- General-Purpose Lane
- HOV, Direct Access, and/or Transit-Only Lane
- Westbound Managed Shoulder
- Proposed Bicycle/Pedestrian Path
- Lid
- Park

N

0 200 400 800 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Figure 2-2. **Project Layout – I-5 to Portage Bay**

SR520, I-5 to Medina: Bridge Replacement and HOV Project

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The construction elements include the following:

- 75,000 cubic yards of excavation
- 82 drilled shaft foundations
- 17 upland shafts supporting individual columns
- 65 in-water shafts: 30 supporting mudline footings and 35 extending through the lake bed and supporting individual columns
- 3 mudline footings at lake bed (capping 10 drilled shafts each)
- 67 permanent concrete columns (50 in-water)
- 900 work bridge support piles
- 400 falsework piles
- 5- to 6-year construction duration, excluding mobilization and project closeout

Starting with the bottom foundation elements, the new bridge substructure will consist of a total of 82 drilled shafts with diameters of 8 to 10 feet; 65 of these shafts will be constructed in the water. Thirty-five of the proposed in-water shafts will intersect with the substrate, resulting in approximately 3,000 square feet of substrate displacement. Each mudline footing will consist of a rectangular concrete block embedded into the lake bed, and will typically be supported by 10 drilled shafts each (i.e., the remaining 30 shafts will terminate at mudline footings). The mudline footings will be constructed within cofferdams at the three westerly in-water pier bents (i.e., those with the longest span lengths) to tie the multiple shafts together and distribute the load from the columns. Two footings will be 116-by-35 feet, and one footing will measure 125-by-35 feet. These three footings will occupy approximately 12,500 square feet (0.3 acre) of bottom substrate.

The Portage Bay Bridge will be supported by 50 in-water columns (ranging in size from 7-by-7 feet to 7-by-10 feet). The support columns will be constructed either on top of the mudline footing or directly on top of the drilled shaft, and each pier bent will consist of five columns. Each of the three mudline footings will support five 7-by-10-foot bridge support columns extending from the top of the footing to the bottom of the bridge superstructure. The remaining 35 columns (7 feet in diameter) will be supported by individual drilled shafts. These columns will replace the 76 in-water columns (4.5 feet in diameter) currently supporting the Portage Bay Bridge. The column's cross-sectional area will occupy approximately 4,000 square feet of the lake's surface.

Substructure construction will occur from temporary work bridges. The work bridges will ultimately be designed by the contractor and will be built along the outer edge of both the north and south sides of the proposed structure. Finger piers will typically span beneath the existing and proposed bridge structures at regular intervals, connecting the north and south work bridges. The work bridges will not exceed 4.1 acres (1.9 acres over open water) and will consist of up to 900 steel piles with diameters of 24 to 30 inches.

The completed permanent substructure will consist of 11 in-water pier bents, with span distances (length between pier bents) ranging between 300 and 116 feet, moving from west to east. In-place casting of box girder bridge sections is proposed, which requires the use of falsework to support the concrete forms. Two falsework structures will be built, each supported by no more than 200 piles. Cast-in-place box girders generally allow for longer span lengths. The completed superstructure will have an over-water width of 124 feet at the west end, narrowing to 105 feet in the middle, and then widening to 143 feet at the east end. The bottom of the bridge deck will range from 62 to 16 feet above the water (moving west to east). Total over-water cover resulting from the Portage Bay Bridge will be approximately 4.5 acres.

Construction activities and durations in this area will occur over a 5- to 6-year period and will include construction of work bridges, falsework, and structures, as well as bridge demolition. The new Portage Bay Bridge will be built in halves (north and south) so that traffic flow will not be interrupted.

To accommodate four lanes of traffic for the duration of the project, construction must be sequentially staged by temporarily widening the existing Portage Bay Bridge to the south. Approximately 42 temporary 8-foot-diameter drilled shafts/columns, occupying about 0.01 acre of aquatic habitat, and 2.5 acres of additional superstructure will be constructed on the south side of the existing bridge. Traffic will be diverted to this expanded southern half of the bridge to allow the northern half of the existing bridge to be demolished and the northern half of the new bridge to be constructed. Following construction, traffic will be shifted to the newly constructed northern half of the proposed bridge to allow demolition of the existing and temporary south bridge lanes and construction of the new southern columns and superstructure to complete the proposed Portage Bay Bridge.

A detailed account of the construction and demolition activities and the duration and sequence of these activities by construction season is provided in the Biological Assessment (WSDOT 2010a). Construction seasons are structured around the published in-water construction period of October 1 to April 15.[1]

1 Some in-water construction elements (see Table 5-2) may occur outside of the published work window, as presented to the In-Water Technical Work Group (TWG) participants.

2.1.3. Montlake Area

The Montlake interchange will be widened to the north to accommodate a shift in the mainline alignment, HOV lanes and ramps, and the widened mainline ramps. The Montlake Boulevard and 24th Avenue East overcrossing structures will be demolished and replaced with a lid structure, and a new two-leaf bascule bridge (drawbridge) will be constructed over the Montlake Cut.

Montlake Interchange

The SR 520 interchange with Montlake Boulevard will be similar to the existing interchange, connecting to the University District via Montlake Boulevard and the existing and new bascule bridges (Figure 2-3). A large new lid will be provided over SR 520 in the Montlake area, configured for transit and bicycle/pedestrian connectivity. The alignment of Montlake Boulevard over SR 520 will be similar to that of the existing alignment; however, the new bridge over SR 520 will be longer and wider than the existing bridge and provide wider through lanes, shoulders, a center median, and additional turning lanes on Montlake Boulevard over SR 520. This bridge will be integrated as part of the new Montlake lid over SR 520.

Construction activities in this area will occur over about a 4-year period and will include roadway reconstruction, excavation, retaining wall and abutment construction, and paving. However, most of these construction activities will occur in upland areas, and with implementation of best management practices (BMPs), are not expected to affect aquatic habitat areas.

Bascule Bridge

Construction activities in the Montlake area also include constructing a new bascule bridge over the Montlake Cut, east of the existing bascule bridge. This new bridge will be approximately 60 feet wide, similar to the existing bridge. The two bridges will each operate with three lanes: the existing bridge will serve southbound traffic with three lanes, and the new bridge will serve northbound traffic with three lanes. In addition to the three travel lanes, each bridge will have a bicycle lane and sidewalks.

The bridge construction activities will be staged from the shoreline, and except for the temporary use of barges positioned in the Montlake Cut, no in-water construction activities are expected. Upland construction activities will occur outside and east of the existing Montlake Boulevard roadway and will consist of constructing upland pier supports to form the foundation for the bridge superstructure. Upland pier construction will be isolated from the water through the construction of cofferdams installed upland of the ordinary high water mark (OHWM).

After the upland pier supports are completed, the bascule-leaf structural steel members will be attached to the piers. A barge-mounted derrick will lift the bridge sections into position while they are attached to the support structures.

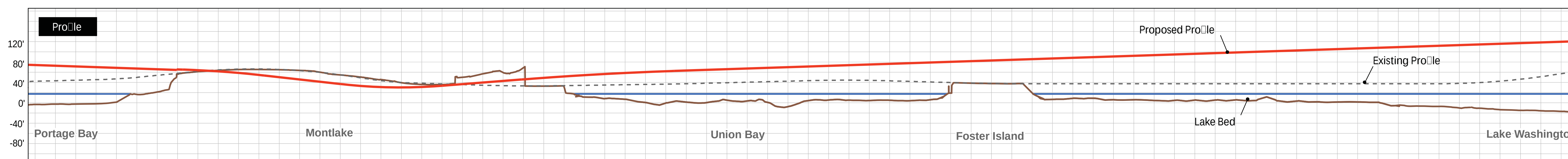
These on-water activities will likely require closing the Montlake Cut to boat traffic periodically over a 3- to 4-week period, typically for less than 48 hours at a time. The construction barges will be located in the Montlake Cut only during bridge assembly work. Based on these closure requirements, it is likely that this work will be scheduled during the winter months, when reduced boat traffic through the area is expected.

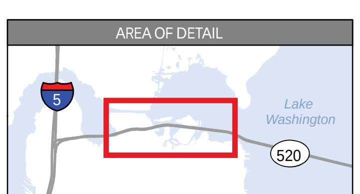
Construction of the bascule piers and the leaf spans is proposed to occur during the latter part of 2017 and extend into 2018.

2.1.4. Union Bay and West Approach Area

The existing Union Bay Bridge and the west approach will be replaced by two new west approach structures: an eastbound bridge and a westbound bridge with a gap between the structures. The new west approach structures will be continuous fixed-span bridges throughout their lengths. The west approach will begin in Montlake and extend through Union Bay, across Foster Island, and into Lake Washington, terminating at the west transition span and the beginning of the floating bridge (see Figure 2-3). The combined width of the west approach structures will be wider than the existing bridge. A constructed wetland for enhanced stormwater treatment will be built on the site occupied by the Museum of History and Industry. Barges and the staging sites described above for the Montlake interchange area will be used for construction staging. No construction staging will occur on Foster Island outside of the construction easement. Construction will include a temporary work bridge on Foster Island that will be removed after the permanent structure has been completed.

Like the Portage Bay Bridge, substructure elements will include drilled shafts and concrete support columns; however, no mudline footings are planned. The superstructure will consist of precast-concrete girders (which will not require falsework) and the roadway deck. The spans of the new bridges will be longer than those of the existing bridge (i.e., the pier bents will be farther apart). The increase in span length will result in fewer in-water columns and foundation shafts. Overall, the width of the new west approach will range between 252 feet near Montlake and 112 feet at the west transition span, with a gap width ranging between 7 and 40 feet. The width of the existing west approach varies between 57 and 104 feet. The height of the bridge over water will increase from a minimum of less than 3 feet to 11.6 feet near Montlake and from 45 to 48 feet near the west transition span. The proposed structure will have a constant grade, whereas the existing structure remains low from Montlake to east of Foster Island.





- Column
- Existing Regional Bicycle/Pedestrian Path
- Proposed Bicycle/Pedestrian Path
- General-Purpose Lane
- HOV, Direct Access, and/or Transit-Only Lane
- Westbound Managed Shoulder
- Stormwater Treatment Facility
- Lid
- Park

N

0 250 500 1,000 Feet

Source: King County (2006) Aerial Photo, King County (2008) GIS Data (Stream), CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Figure 2-3. **Project Layout – Portage Bay to Lake Washington**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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The construction elements include the following:

- 50,000 cubic yards of excavation
- 254 drilled shafts (233 in-water, with 46 extending above the lake bed, and 87 transition to columns at the mudline)
- 254 permanent concrete columns (233 in-water and 87 extending below the lake bed)
- 2,050 work bridge support piles
- 6-year construction duration, excluding mobilization and project closeout

The west approach substructure will consist of 42 pier bents: 39 in-water pier bents and an additional 3 pier bents on Foster Island. Most span lengths will be 150 feet, although spans #13 to #14 and #17 to #18 (on either side of Foster Island) will be 129 feet in length, and span #41 (the easternmost span before the transition span) will be 160 feet in length.

The west approach pier bents will consist of drilled shafts with columns attached directly to the shafts. No mudline footings or waterline shaft caps are proposed. Of the 254 10-foot-diameter shafts supporting the west approach, 233 will occur in the water. The Union Bay section (between Montlake and Foster Island) will consist of 104 in-water shafts, and the Lake Washington section (east of Foster Island) will consist of 129 in-water shafts. The bridge superstructure will be supported by either 6-by-6-foot (piers #2 to #22) or 7.5-by-7.5-foot (piers #23 to #42) square columns built on top of the drilled shafts. The westerly half of the shaft-to-column connections will occur below the mudline. For the easterly 21 pier bents (those in the deepest water), the drilled shafts will extend up through the water, and the connection to the columns will be above the surface water elevation. The shafts and columns combined will occupy approximately 13,000 square feet of substrate and in-water cross-sectional area.

The west approach is expected to consist of precast girders with a cast-in-place deck. The westbound structure will be 66 to 145 feet wide, while the eastbound approach structure will be 47 to 108 feet wide (moving east to west). The majority of the westbound structure will have a 66-foot deck width (approximately the easterly half-mile); however, as the span approaches Foster Island (within 840 feet), the deck width will increase gradually to 145 feet as it extends through Union Bay and makes landfall at the Lake Washington shoreline at Montlake. Through Union Bay, the combined deck width will range from 200 to 233 feet. The bottom of the bridge deck will range from 11 to 25 feet above the water in Union Bay, and from 28 to 68 feet above the water between Foster Island and the west transition span.

The new west approach area bridges will require construction of work bridges on both the north and south sides of the existing west approach structures and along the existing Lake

Washington Boulevard ramps. The construction work bridges will allow the new bridges to be built in halves so that traffic flow will not be interrupted. These work bridges will be in place for 3 to 5 years. Work bridges constructed adjacent to the Lake Washington Boulevard on- and off-ramps will be in place for 2 years, to facilitate demolition of these existing ramps.

The northern portion of the new west approach will be constructed first, with traffic diverted to this structure while the existing west approach bridge is demolished and construction of the southern half of the new west approach begins. Construction activities in this area will occur over a 5- to 6-year period.

Prior to construction of the west approach in its final configuration, WSDOT anticipates constructing a new interim connection, four lanes wide and approximately 1,500 feet long, between the new floating span and the existing west approach bridge. The interim connection will be supported on columns that will later be used for the new west approach bridge (eastbound structure) when it is constructed in a later phase. When the new west approach bridge is constructed, the interim bridge deck will be removed and the columns heightened to support the west approach bridge at its planned grade.

The interim connection structure will be a fixed-span bridge with substructure elements including drilled shafts and concrete support columns; however, no mudline footings are planned. The superstructure will consist of precast-concrete girders (which will not require falsework) and the roadway deck.

The interim west approach substructure will consist of 12 pier bents: the westerly six pier bents coinciding with the existing west approach piers (piers 25–30) and an additional six pier bents that will be used later for the new west approach structure (piers 31–36). Span lengths coinciding with the existing bridge will be 100 feet and the easterly six spans will be 150 feet in length.

The pier bents will consist of drilled shafts with columns attached directly to the shafts. Drilled shafts will range between 6 and 8 feet, and columns between 3.5 and 5 feet in diameter for piers 25–30. Piers 31–36 will consist of 10-foot-diameter shafts and 7.5-by-7.5-foot square columns built directly on top of the drilled shafts. The westerly six shaft-to-column connections will occur below the mudline. For the easterly six pier bents, the drilled shafts will extend up through the water, and the connection to the columns will be above the surface water elevation. The shafts and columns combined will occupy approximately 0.03 acre of substrate area. Of that, the temporary columns will occupy 0.01 acre of substrate area.

The interim west approach is expected to consist of precast girders with a cast-in-place deck. The easterly half of the structure from the floating bridge to pier 30 will be approximately 57 feet wide. The structure will taper down from 49 feet wide from the point where the interim structure joins the existing west approach (pier 30), to 11 feet wide at its western terminus (pier 25). Total over-water cover resulting from the interim west approach structure will be approximately 1.4 acres.

2.1.5. Evergreen Point Floating Bridge Area

The floating bridge will be replaced by an elevated roadway deck, supported by concrete columns on a foundation of hollow concrete pontoons connected in series across the deepest portion of Lake Washington. Figure 2-4 shows the alignment of the floating bridge and its connections to the west and east approaches.

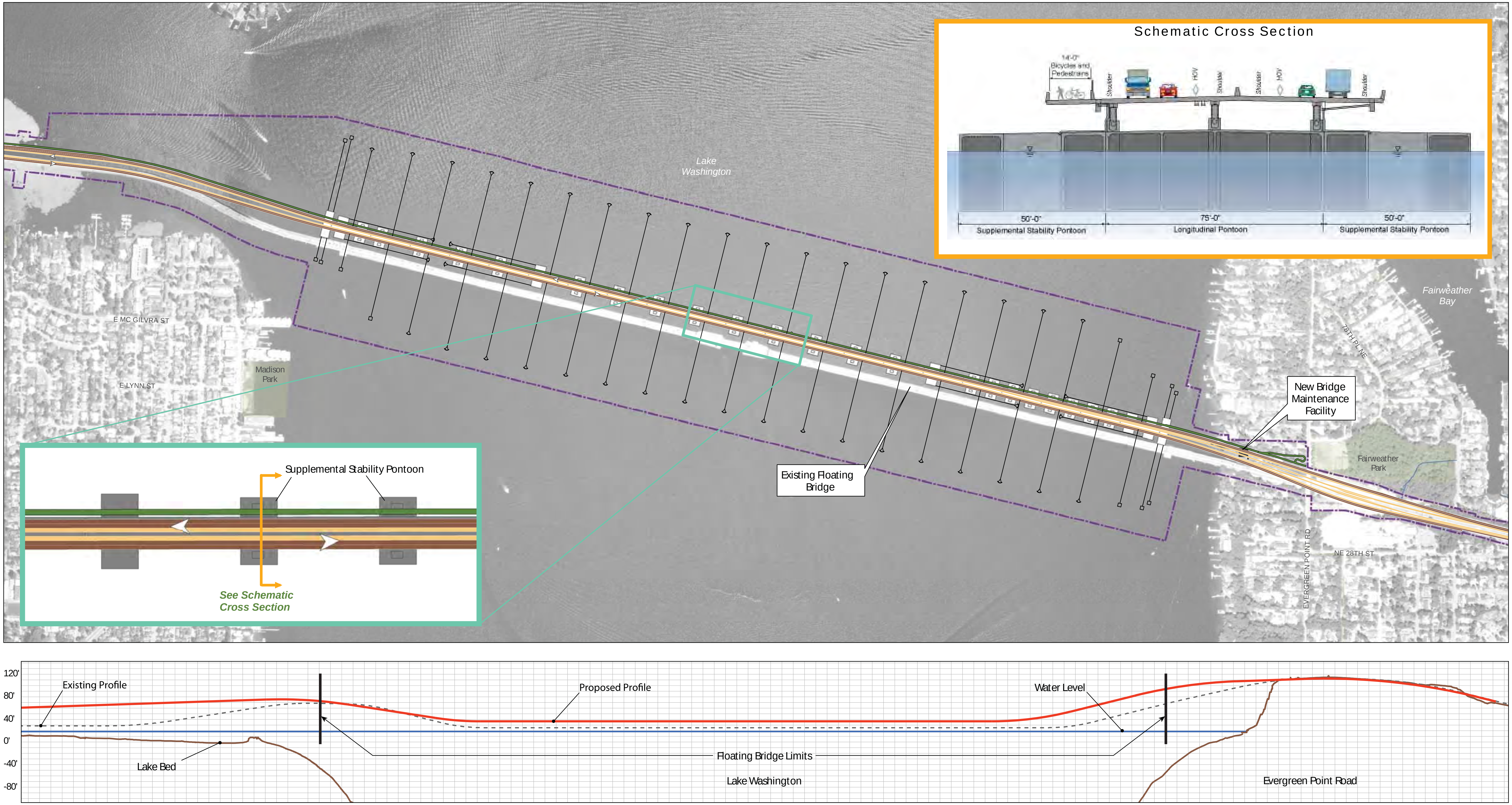
The new floating span will be located approximately 190 feet north of the existing bridge (measured from centerline to centerline). The new floating bridge will consist of two 11-foot-wide general purpose lanes in each direction and one 12-foot-wide HOV lane in each direction, along with 4-foot-wide inside shoulders and 10-foot-wide outside shoulders. A 14-foot-wide bicycle and pedestrian path with several scenic vantage points and pullouts will be located on the north side of the bridge. The project will eliminate the drawspan opening on the Evergreen Point Bridge, but two navigation channels will be maintained, with a maximum clearance height of 75 feet.

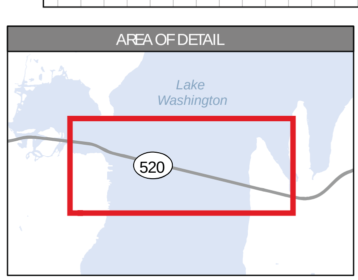
The foundation of the floating bridge will consist of a single row of 21 longitudinal pontoons connected end to end, two cross pontoons (one at each end), and 54 supplemental stability pontoons along the row of longitudinal pontoons (27 on each side). The longitudinal pontoons will measure 360-feet-long by 75-feet-wide by 28.5-feet-vertically. The cross pontoons will measure 240-feet-long by 75-feet-wide by 35-feet-vertically. The supplemental stability pontoons will measure 98-feet-long by 50- to 60-feet-wide by 28.5-feet-vertically. The overall length of the new floating span will be 7,710 feet, compared to the existing 7,580 feet. The new pontoons will have a deeper draft than the existing pontoons, typically ranging from 21.5 to 27.5 feet below the surface of the water, compared to existing pontoons at 7 to 14.5 feet below the water surface. The number and size of the new pontoons will be larger than the existing ones to provide the flotation needed for additional lanes, wider lanes, the bicycle/pedestrian path, and shoulders.

As with the existing floating bridge, the floating pontoons for the new bridge will be anchored to the lake bottom to hold the bridge in place. Anchor types are likely to consist of fluke anchors for the deepest anchor locations (180 feet deep or more), gravity anchors for shallower, sloped anchor locations (likely between 60 and 180 feet), and shaft anchors in the shallowest locations (likely less than 60 feet). A total of 58 anchors are proposed: 45 fluke anchors, 8 gravity anchors and 5 shaft anchors. Shaft anchors will be used in the shallower waters (less than 60 feet) in the northeastern and southwestern corners of the floating span layout.

The roadway will likely be supported above the pontoons by rows of three 10-foot-tall concrete columns spaced 30 feet apart, transversely, at both ends of the bridge. These rows of columns will be longitudinally spaced about 90 feet apart across the floating bridge. The roadway of the new bridge will be approximately 10 – 12 feet higher than the existing bridge and approximately 20 feet above the lake surface in the middle portion of the bridge.

Construction activities associated with pontoon installation will occur over an estimated 3-year period, beginning in the spring of 2012. The construction activities related to the floating bridge do not involve pile driving, cofferdam installation, or other activities that have the potential to substantially affect aquatic species; construction is not expected to be limited to in-water construction windows. Therefore, the sequence of activities refers to the calendar year as opposed to in-water work seasons.





Anchor and Cable

Pontoons

Limits of Construction

Proposed Bicycle/Pedestrian Path

General-Purpose Lane

HOV, Direct Access, and/or Transit-Only Lane

Park

N

0 500 1,000 2,000 Feet

Source: King County (2006) Aerial Photo, CH2M HILL (2008) GIS Data (Park). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.

Figure 2-4. **Project Layout – Floating Bridge and Approaches**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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2.1.6. East Approach and Maintenance Facility Area

WSDOT will replace the east approach span of the Evergreen Point Bridge with a new structure that is both higher and wider, and the alignment will be shifted north. The new east approach will consist of an eastbound and westbound structure with a gap in the middle. The east approach will span the east end of the floating bridge to the high bluff along the Medina shoreline. The east approach substructure will consist of spread footings, and four concrete support columns. The superstructure will also consist of precast box girders and a cast-in-place roadway deck. The combined width of the north and south structures will range from 134 to 152 feet, from west to east. The structure will be approximately 660 feet long and range from 66 to 78 feet above the water surface.

The east approach will have two column piers. Pier #1 will be approximately 280 feet (or less) out from the shoreline, and Pier #2 will be onshore, several feet from the shoreline. Each pier foundation will consist of a spread footing constructed (Pier 1 within a cofferdam) and two rectangular bridge columns. The spread footings would be buried approximately 8 to 10 feet below the mudline. As a result, the only permanent aquatic habitat impact of the in-water pier would be the square footage of the two in-water columns, which amounts to 440 square feet. The two columns supporting the westbound lands would be approximately 24 feet by 10 feet, and the two columns supporting the eastbound lanes would be slightly smaller, measuring 20 feet by 10 feet. The completed superstructure will have an over-water width of 83 and 51 feet (for the north and south bridges, respectively) at the west end, and then widening to 91 and 61 feet (north and south, respectively) at the east end. The gap between the bridges will gradually widen from 6 feet at the west end to 10 feet at the east end. The bottom of the bridge deck will range from a low of approximately 70 feet above the water at Pier #1 to 78 feet above the water at the midpoint of the adjacent (landward) span. An existing stormwater treatment wetland will be modified to accommodate additional flow from the increased area of impervious surface.

Construction of the new east approach span will be concurrent with the floating bridge construction, over a 3-year period starting in 2012. Construction will take place from work bridges and barges, as well as land-based and over-water staging areas. The south approach structure will be constructed before the north approach structure, as portable formwork will then switch from the south side to the north.

In an effort to reduce the number and extent of temporary work bridges adjacent to the east approach structure, contractors will install and use an over-water staging area for pontoon outfitting and assembly. The staging area will be located 100 feet north of the eastern most pontoons of the new bridge alignment. This Eastside staging area eliminates the need to construct a large temporary platform within the nearshore environment and instead uses the pontoons as the work and staging surface. It is in a different location than the work bridges and falsework, but is within the limits of construction defined in this mitigation plan and associated updated permit applications.

The staging area would be located approximately 450 feet from the eastern shoreline of Lake Washington. It would utilize six temporary pile anchor dolphins (each consisting of four 30-inch diameter steel piles) and 10 temporary Danforth type anchors within the WSDOT right of way to hold pontoons in place as they are being assembled and outfitted. The steel piles used in the temporary pile anchor dolphins will be installed and removed with the same techniques as work bridge piles, and would be located at approximately the same bathymetric contour as the westernmost piling on the original WSDOT work trestle (described in the Draft Aquatic Mitigation Plan and associated permit applications).

The Eastside staging area would replace the function of the original work bridge concept (land to water access for equipment and employees). Both approaches recognize the constraints of shallow water and the need for a land-lake interface on which to base the work. However, the Eastside staging area accomplishes the same purpose with less nearshore environmental impact (e.g. in-water structures, underwater noise, and substrate loss). By eliminating the need for most of the originally proposed work bridge area, the Eastside staging area reduces the number of piles and related impacts in the nearshore environment. It also supports the use of precast components that will be delivered from offsite, thereby eliminating the pile-supported falsework associated with cast-in-place techniques. With the change, approximately 100 fewer piles are needed for construction and benthic substrate displacement is reduced by approximately 400 square feet.

Maintenance Facility

A new bridge maintenance facility will be built at the same time as the east approach structure. Permanent and temporary access roads, retaining walls, a building, and a dock will be constructed while the east approach structure is being built. The facility will consist of a 15,000-square-foot, three-story maintenance building to house personnel and equipment, and a parking facility constructed in the hillside under the proposed approach span, as well as a working dock.

The proposed dock design will likely consist of a T-shaped (hammerhead) dock, with the moorage platform extending no more than 100 feet perpendicular to the shoreline. The dock stem will be approximately 10 feet wide, and the moorage platform may be as much as 14 feet wide. The total overwater area will be 1,546 square feet, including 320 square feet of fish-friendly grated decking, allowing light to penetrate below the structure. Therefore the overwater area contributing to shading is approximately 1,226 square feet. No creosote-treated wood will be used in the construction of the dock. Two work boats, as large as 32 and 50 feet long, may be moored at the dock. The dock may be supported by ten columns (9 in-water) measuring 2 feet in diameter. Three or four ladders will be mounted to the dock for safety and to provide access to the boats. These ladders will extend into the water a short distance. A fender system will be mounted to the dock to protect the boats and dock from damage. Fender spacing will be approximately 3 feet on-center along the mooring area and will extend approximately 5 feet below ordinary high water (OHW).

2.1.7. Eastside Transition Area

Once the east approach and floating portions of the Evergreen Point Bridge have been replaced, grading and paving operations will occur east to Evergreen Point Road, and the Evergreen Point Road transit stop will be relocated to the inside median (constructed as part of the SR 520, Medina to SR 202: Eastside Transit and HOV Project) at Evergreen Point Road.

In order to make ramps and lanes connect for proper traffic operations, the SR 520 mainline will be restriped, beginning at the east end of the physical improvements near Evergreen Point Road and extending east to 92nd Avenue NE. Lane restriping is needed to tie into improvements that are part of the SR 520, Medina to SR 202: Eastside Transit and HOV Project. This project activity will occur over a 3.5-year period starting in January 2012.

2.1.8. Ancillary Project Features

The project also includes ancillary features such as a regional bicycle and pedestrian path, noise reduction measures, stormwater treatment facilities, and lighting. These features are summarized below.

Regional Bicycle/Pedestrian Path

The project includes a 14-foot-wide bicycle/pedestrian path along the north side of SR 520 through the Montlake area and across the Evergreen Point Bridge to the Eastside. On the west side of the lake, the path will connect to the existing Bill Dawson Trail that crosses underneath SR 520 near the eastern shore of Portage Bay. It will also connect to the Montlake lid and East Montlake Park. On the east side of the lake, the path will connect to the bicycle/pedestrian path built as part of the SR 520, Medina to SR 202: Eastside Transit and HOV Project.

A new path beginning in East Montlake Park will connect to a proposed new trail in the Washington Park Arboretum, creating a loop trail. The portion of the existing Arboretum Waterfront Trail that crosses SR 520 at Foster Island will also be restored or replaced after construction of the SR 520 west approach structure.

Stormwater Treatment Facilities

The project includes the installation of stormwater treatment facilities to collect and treat stormwater runoff. Two facility types incorporating stormwater treatment methods approved by Ecology have been identified for the project biofiltration swales and constructed stormwater treatment wetlands. A portion of the land-based drainages associated with local streets currently discharges to the Seattle combined sewer system and/or the King County Metro combined sewer system. Those discharges are treated at the King County West Point Treatment Plant.

Lighting

The project includes roadway lighting, pedestrian lighting, and lighting for the maintenance facility dock. Roadway lighting will be limited to areas that constitute conflict points, such as merge lanes. All lighting will be designed to minimize spillage onto adjacent aquatic habitat.

2.2 Construction Activities

Project construction activities, sequencing, and scheduling within the project area have the potential to affect aquatic habitat and fish resources. A list of the typical construction activities and associated methods expected to be used for the proposed in-water, over-water, and upland structures is provided below. These activities include the following:

- Staging area establishment
- Implementation of BMPs
- Site preparation activities
- Work bridge construction
- Pile driving
- Drilled shaft construction
- Cofferdam construction
- Waterline shaft cap construction
- Column/pier construction
- Fixed bridge superstructure construction
- Bascule bridge construction
- Anchor installation
- Pontoon assembly

- Floating bridge superstructure outfitting
- Bridge maintenance facility and dock construction
- Materials transport, handling, and storage
- Demolition

Modified construction activities that support final design include the following:

- Construction of a smaller workbridge
- Traveling formwork
- Over-water construction staging area
- Mooring dolphin installation
- Temporary concrete conveyance system and catwalk
- Spread footing construction
- Figure 2-5 shows a preliminary project construction schedule.

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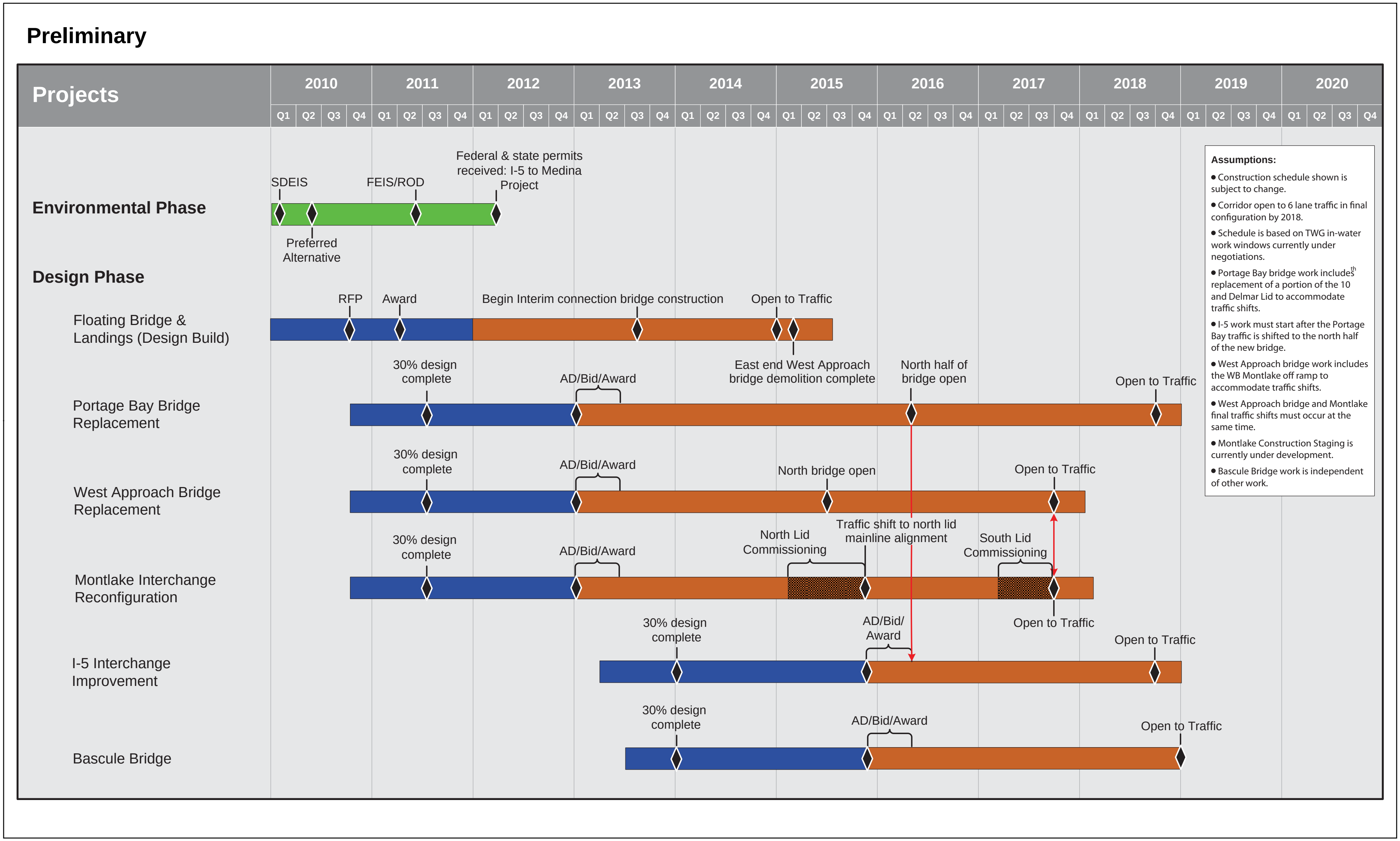

Environmental
Design
Construction

Figure 2-5. **Project Delivery Schedule**

SR 520, I-5 to Medina: Bridge Replacement and HOV Project

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2.3 Project Operation

Operation and maintenance of the SR 520, I-5 to Medina Project will differ from the existing operation and maintenance and have the potential to result in changes to the Lake Washington environment. The following section characterizes the long-term operation of the new facility and potential mechanisms of effects on aquatic species and habitats.

2.3.1. Stormwater

Stormwater treatment for the project is constrained by urban geography and the characteristics of the bridges. Stormwater treatment includes using the combined sewer system, conventional treatment BMPs, and—in the case of the floating bridge portion of the project—an innovative stormwater treatment approach identified in an “all known, available, and reasonable technology” (AKART) study (WSDOT 2010c).

The SR 520, I-5 to Medina Project will result in 42.6 acres of new pollutant-generating impervious surface (PGIS) and will replace 25.7 acres of existing PGIS, while 21.4 acres of existing PGIS will remain on-site for a total PGIS of 89.7 acres after project construction. The amount of post-construction PGIS requiring treatment will be reduced by 6.3 acres due to two landscaped lids, which will reduce the amount of effective PGIS contributing flows to outfalls. All new and replaced PGIS will receive stormwater quality treatment; however, approximately 13.12 acres of existing PGIS within the project limits will not be treated after project construction. Areas not receiving post-construction treatment are primarily associated with restriping activities in the I-5 interchange. Project stormwater will be treated by facilities that will be designed based on requirements identified in WSDOT's 2008 *Highway Runoff Manual* (HRM) and *Hydraulics Manual* (WSDOT 2010f). New and replaced PGIS requires stormwater treatment to a basic level of treatment for Lake Union and Lake Washington. The project will also provide enhanced treatment to stormwater discharging to Lake Washington from SR 520 to further minimize any effects on the lake due to dissolved metals. The proposed stormwater facilities will use eight existing outfall locations; however, three outfalls will need to be rebuilt to accommodate increased flow rates. All outfalls will be located above the OHWM, typically discharging to ditches for stormwater conveyance to the lakes. Four outfalls will discharge to Lake Union (including Portage Bay) and four will discharge to Lake Washington. The floating span will discharge directly to Lake Washington through stormwater wells in the stability pontoons.

The project proposes to provide water quality treatment for new and replaced PGIS wherever practicable; however, in some areas where stormwater currently flows to the combined sewer system, flows will continue to be routed to the combined sewer system for treatment and discharge. Contributions to the combined storm and sewer systems will be treated by the West Point Wastewater Treatment Plant and discharged to Puget Sound. The project will reduce the total area contributing to the combined sewer system by approximately 1.25 acres; however, the amount of PGIS contributing to the combined sewer system will increase slightly (0.27 acre) because of the conversion of existing surfaces to PGIS. WSDOT will provide detention for stormwater entering the combined system where required by the Seattle code. Since both Lake Washington and Lake Union are flow-exempt water bodies per Ecology, no detention will be required on the separate stormwater system.

The existing project corridor has no stormwater treatment prior to discharges into Lake Union, Lake Washington, or the combined sewer system. All proposed PGIS (new and replaced) draining to both water bodies will receive basic or enhanced treatment. While enhanced treatment is not required, WSDOT will provide for enhanced treatment where practicable to improve water quality and reduce effects on aquatic life. When insufficient space is available to provide enhanced treatment for a specific outfall, basic treatment will be included in the stormwater treatment design. For this project, stormwater wetlands are the proposed enhanced treatment BMP, and bioswales will be the BMPs used for basic treatment. Oil control will be provided for roadway intersections with an average daily traffic count greater than or equal to 15,000 vehicles, as prescribed by the HRM. Where existing PGIS located within the project area will not be altered (disturbed) by the project, it will not be redirected to a water quality facility.

The project will reduce the discharge concentrations of total suspended solids, and total and dissolved zinc and copper. More importantly, the project will reduce the total loading of these substances discharged into the receiving environment (Lake Washington and the Ship Canal), including reductions in both dissolved copper and dissolved zinc loading (WSDOT 2010a). In addition, the current floating bridge drainage system is leaching high levels of zinc, and the WSDOT (2005) stormwater monitoring report suggests that dissolved zinc may decrease dramatically in some areas of Lake Washington as a result of the proposed project because the drainage system of the new bridge will use materials constructed of alternative materials. Overall, all stormwater discharges will comply with Clean Water Act standards and will meet state water quality standards for the protection of aquatic life.

2.3.2. Artificial Lighting

Similar to the current roadway lighting configuration, continuous lighting will be provided along the SR 520 corridor from I-5 to Foster Island and on the bascule bridge crossing the Montlake Cut. Lighting is also proposed as part of four architectural elements, called sentinels, located at the east and west highrises. A lantern will be located at the top of each sentinel, and lights will progressively rise along the sentinel from the pontoon deck. Lanterns will also be affixed in minor way-finding elements, located at each pontoon joint. Light pollution from these features will be minimized through the use of uplighting.

The floating bridge will include six luminaires in the easternmost portion to illuminate a transit merge point. Recessed lighting will illuminate the proposed bicycle and pedestrian path along the west approach structure and the Evergreen Point Bridge. Lighting will be designed to minimize effects on aquatic habitat, likely through the use of shielded downlights similar to those on the I-90 floating bridges.

Artificial lighting currently illuminates the majority of the SR 520 corridor, including the entire existing bridge structure. The proposed design will reduce the overall artificial lighting for the replacement bridge. Artificial lighting from the roadway luminaires, pedestrian walkway, vehicles, and the maintenance facility dock is discussed below.

Roadway Lighting

For the replacement structure, overhead lighting will be limited to traffic conflict points (e.g., add lanes, drop lanes, merges, diverges, auxiliary lanes, or weaving sections) and the westernmost portion of the project between Foster Island and I-5. East of Foster Island, no roadway lighting is proposed, thus reducing the amount of light reaching the water surface compared to existing conditions.

Specifically, a continuous roadway illumination system will be installed from the I-5 interchange to Foster Island, including all major arterial streets within the construction limits. To reduce the effects of lighting on the Lake Washington fish habitat, roadway illumination will not be continuous in the section from where additional ramp lanes begin and end around the Foster Island area, to where the Evergreen Point Flyer stop merges (westbound) into the westbound HOV lane on the eastern portion of the floating span. This unlit section of the proposed bridge generally encompasses the primary migration areas of juvenile Chinook salmon (*Onchorhynchus tshawytscha*), located in the west approach area in the transition area between Lake Washington and the Ship Canal (Fresh et al. 2001; City of Seattle and USACE 2008; Celedonia et al. 2008b). However, a portion of the west approach span and a portion of the floating span in the vicinity of the west navigation channel will have temporary roadway illumination during interim traffic configurations. This interim lighting is expected to be in place for approximately 18 months. The approximate number of lights on each structure will be as follows:

- 12 lights on the Montlake bridges (6 existing)
- 18 lights on the Portage Bay Bridge (18 existing)
- 43 lights on the west approach bridge (52 existing)
- No lights on the floating bridge (44 existing)
- 6 lights on the east approach bridge (4 existing)

The existing roadway lighting on the floating bridge consists of WSDOT-standard cobra-head, flat-glass, high-pressure sodium light fixtures with Type III, 250-watt medium cut-off lights. These lights are staggered on both sides of the roadway at intervals of about 350 feet. The lights are mounted 30 to 40 feet above the roadway, with the shorter light standards occurring east of the center drawspan of the bridge. While the shorter lights are not shielded, the taller light standards have shielded light fixtures. Existing nighttime light levels extend up to 5 to 300 feet from the bridge near Portage Bay, and Foster Island has light levels measured from 0.45 to 0.01 foot candles (WSDOT 2009a).

Pedestrian Lighting

Lighting for the shared use pedestrian and bicycle pathway will be mounted on the backside of the traffic barriers to limit light pollution on the lake. The proposed design provides lighting fixtures recessed into the concrete barrier that separates the vehicular lanes and the pedestrian/bicycle path. Model predictions suggest that this design will prevent walkway lighting from reaching the lake surface. The maximum light level simulated was 0.05 foot candles.

Maintenance Dock Lighting

Lighting proposed for the maintenance dock beneath the east approach will have up to four Class C dock luminaires, in addition to path lighting. Overhead lights will be on-demand and will remain off except during dock use, while low-intensity path lighting will be on at all times. Private aids to navigation will be provided as required.

2.3.3. Maintenance Facility Operation

The proposed maintenance facility will be located directly beneath the east approach, built into the hillside along the Medina shoreline. The facility will consist of an upper-level parking area with elevator and stair access to mid-level office and storage spaces, and lower level work area and maintenance yard. The maintenance yard will open to a level terrace, roughly at lake level for staff and materials access to a dock, and the maintenance vessel moorage.

Several distinct operational elements are associated with the maintenance facility. In addition to lighting, operational elements that have some potential to affect listed salmonids include handling and transport of petrochemicals, and vessel moorage and operations.

Handling and Transport of Petrochemicals

Petrochemicals necessary for the operation and maintenance of the floating span will include fuels, lubricants, and hydraulic fluids. Much of the handling of these materials will occur on upland portions of the facility; however, fueling of the maintenance vessels and transport of some of these materials to the pontoons will occur over water. Activities to limit risks associated with material handling will include hazardous materials training for staff, use of properly functioning and secure containment devices, and implementation of BMPs such as drip pans and absorbent pads (refer to BMPs described in Section 5).

Vessel Moorage and Operations

The facility dock is expected to be used almost daily for mooring of maintenance vessels. The large maintenance vessel is expected to be in the 40- to 50-foot-long range and powered by an inboard diesel engine; the small maintenance vessel is expected to be in the 20- to 30-foot-long range. The dock will extend approximately 100 feet perpendicular from the shoreline, with boat moorage at the end in approximately 8 feet of water (relative to high lake level—18.72 feet).

2.3.4. Spill Control

Currently, any spills that occur on the existing bridge drain directly into Lake Washington, Union Bay, and Portage Bay if the quantities of spilled materials are large enough to reach storm drains. The existing Montlake Bridge is grated, so any spills on this bridge flow directly into the Montlake Cut. The replacement bridge over Lake Washington will discharge these spills into the adjacent spill control lagoons within the supplemental stability pontoons, allowing subsequent cleanup of floatable materials. Similarly, the replacement bridge structures over the Montlake Cut, including Portage Bay and Union Bay, will collect and route stormwater to treatment ponds in the Montlake area, before it is discharged to adjacent water bodies.

2.3.5. Traffic Noise and Vibration

Vehicle traffic on the floating portion of the Evergreen Point Bridge produces noise and vibration through movement of tires on the roadway. Although much of that sound is deflected into the air, some of the noise is transmitted into and through the pontoons to Lake Washington and, to a lesser extent, through the solid concrete support columns or anchor cables.

The existing bridge likely transmits more of the traffic noise to the water than the proposed replacement bridge will transmit, because the existing bridge’s roadway sits directly on the surface of the pontoons, while the replacement bridge deck will be constructed on columns and trusses to elevate it above the pontoons. This design places the bridge deck typically about 20 feet higher than the existing deck and about 10 feet above the pontoons. The new design will provide reduced transmission of noise to the pontoons; however, the degree of the reduction in noise level is unknown. Underwater noise monitoring during the SR 520 Test Pile Program (Illingworth and Rodkin, Inc. 2010) did not detect measurable levels of noise in the water obviously attributable to roadway noise from the existing 520 bridge.

3. Aquatic Habitat Baseline Conditions

The project is located in the Lake Washington watershed, which comprises 13 major drainage sub-basins and numerous smaller drainages, totaling about 656 miles (1,050 kilometers) of streams, two major lakes, and numerous smaller lakes. Lake Washington and its major drainages (Issaquah Creek, the Sammamish River, and the Cedar River) are located in the Cedar-Sammamish Watershed Basin, or Water Resource Inventory Area (WRIA) 8.

The majority of the watershed is highly developed, with 63% of the watershed fully developed; WRIA 8 has the highest human population of any WRIA in Washington State (NMFS 2008a). Lake Washington is the second largest natural lake in Washington with 80 miles (128 kilometers) of shoreline. The lake is approximately 20 miles long (32 kilometers) with a mean width of approximately 1.5 miles (2.4 kilometers), has a circumference of 50 miles (80 kilometers), covers 22,138 surface acres (8,960 hectares), and has a mean depth of approximately 100 feet (30 meters) and a maximum depth of approximately 200 feet (60 meters) (Jones and Stokes 2005).

3.1 Lake Washington Hydrology

The Lake Washington watershed has been dramatically altered from its pre-settlement conditions primarily due to urban development and removal of the surrounding forest, as well as the lowering of the lake elevation and rerouting of the outlet through the Ship Canal. As a result, the Cedar River is now the major source of fresh water to Lake Washington, providing about 50% (663 cubic feet per second [cfs]) of the mean annual flow entering the lake (NMFS 2008a). The Cedar River drainage area is approximately 184 square miles (476 square kilometers), which represents about 30% of the Lake Washington watershed area.

The Lake Sammamish basin is also a substantial source of fresh water, providing about 25% (307 cfs) of the mean freshwater flow into Lake Washington. The Sammamish sub-basin has a drainage area of about 240 square miles (622 square kilometers) and represents about 40% of the Lake Washington basin. Tributaries to the Sammamish River include Swamp, North, Bear, and Little Bear creeks, as well as the surface waters of Lake Sammamish. Hydrology in the Lake Sammamish sub-basin is generally affected by the same factors that affect Lake Washington.

The remainder of freshwater flow into Lake Washington originates from a variety of small creeks located primarily along the northern and eastern shores. These smaller tributaries and sub-basins in the Lake Washington system include Thornton, Taylor, McAleer, Forbes, Juanita, Kelsey, Coal, and May creeks, and Mercer Slough. Within Lake Washington, the natural hydrologic cycle has been altered. Historically, lake elevations peaked in winter and declined in summer. Present operation of the Hiram M. Chittenden Locks (Ballard Locks) produces peak elevations throughout most of the summer.

USACE is mandated by Congress (Public Law 74-409, August 30, 1935) to maintain the level of Lake Washington between 20 and 22 feet (USACE 1919 datum) as measured at the locks, which correlates to 16.72 and 18.72 feet NAVD 88 (the datum used by the project). USACE operates this facility to systematically manage the water level in Lake Washington over four distinct management periods, using various forecasts of water availability and use. The four management periods are as follows:

- Spring refill – lake level increases to 22 feet between February 15 and May 1 (USACE datum).
- Summer conservation – lake level maintained at about 22 feet for as long as possible, with involuntary drawdown typically beginning in late June or early July.
- Fall drawdown – lake level decreasing to about 20 feet from the onset of the fall rains until December 1.
- Winter holding – lake level maintained at 20 feet between December 1 and February 15.

Operation of the locks, and other habitat changes throughout the Lake Washington basin, have substantially altered the frequency and magnitude of floods in Lake Washington and its tributary rivers and streams. Historically, Lake Washington's surface elevation was nearly 9 feet higher than it is today, and the seasonal fluctuations further increased that elevation by an additional 7 feet annually (Williams 2000). In 1903, the average lake elevation was recorded at approximately 32 feet (USACE datum) (NMFS 2008a).

3.2 Lake Washington Shoreline Habitat

Lowering the lake elevation after completion of the Ship Canal in 1917 transformed about 1,334 acres (540 hectares) of shallow water habitat into upland areas, reducing the lake surface area by 7% and decreasing the shoreline length by about 13% (10.5 miles or 16.9 kilometers) (Chrzastowski 1983). The most extensive changes occurred in the sloughs, tributary delta areas, and shallow portions of the lake. The area of freshwater marshes decreased about 93%, from about 1,136 acres (460 hectares) to about 74 acres (30 hectares) (Chrzastowski 1983). The vast majority of existing wetlands and riparian habitat currently associated with Lake Washington, developed after the lake elevation was lowered 9 feet. Currently, this habitat occurs primarily in Union Bay, Portage Bay, Juanita Bay, and Mercer Slough (Dillon et al. 2000).

Lake level regulation by USACE has eliminated the seasonal inundation of the shoreline that historically shaped the structure of the riparian vegetation community. Winter lake drawdowns expose the roots of riparian vegetation in the drawdown zone to winter temperatures (rather than being protected by the standing water during this dormant period). This, in turn, produces a vegetation-free zone between the high and low lake levels (2 feet vertically, with variable horizontal distance depending on shoreline slope). Lake level regulation and urban development have replaced much of the hardstem bulrush- and willow-dominated community with developed shorelines and landscaped yards, and this affects the growth of many species of native terrestrial and emergent vegetation. In addition, lake level regulation indirectly buffers the shorelines from potential winter storm wave effects. The loss of natural shoreline has also reduced the historic complex shoreline features such as overhanging and emergent vegetation, woody debris (especially fallen trees with branches and/or rootwads intact), and gravel/cobble beaches. The loss of native shoreline vegetation and wetlands has reduced the input of terrestrial detritus and insects that support the aquatic food web.

These natural shoreline features have been largely replaced with armored banks, piers, and floats, and limited riparian vegetation. A survey of 1991 aerial photos estimated that 4% of the shallow water habitat within 100 feet (30.5 m) of the shore was covered by residential piers (ignoring coverage by commercial structures and vessels) (USFWS 2008). Later studies report about 2,700 docks in Lake Washington as well as armoring of more than about 80% of the shoreline (Warner and Fresh 1998; City of Seattle 2000; Toft 2001; DNR 2010).

An even greater density of docks and shoreline modifications occurs throughout the Ship Canal, Portage Bay, and Lake Union (City of Seattle 1999; Weitkamp et al. 2000). Areas that have some amount of undeveloped shoreline include Gas Works Park, the area south of SR 520 (in Lake Union and Portage Bay), and a protected cove west of Navy Pier at the south end of Lake Union. Vegetation within these areas is limited, with the area south of SR 520 possessing the highest abundance of natural riparian vegetation, consisting primarily of cattails (*Typha* spp.) and small trees (Weitkamp et al. 2000). The loss of complex habitat features (i.e., woody debris, overhanging riparian and emergent vegetation) and shallow water habitat in Lake Washington has reduced the availability of prey refuge habitat and forage for juvenile salmonids. Dense growths of introduced Eurasian milfoil and other aquatic macrophytes effectively isolate much of the more natural shoreline from the deeper portions of the aquatic habitat.

Portage Bay is lined by University of Washington facilities, commercial facilities, and houseboats. The southeastern portion of Portage Bay has an area of freshwater marsh habitat and naturally sloped shoreline, while the remainder of the shoreline is developed, with little natural riparian vegetation. The Montlake Cut is a concrete-banked canal that connects Portage Bay to Union Bay, which extends eastward to Webster Point and the main body of Lake Washington.

Prior to construction of the Ship Canal, Union Bay consisted of open water and natural shorelines extending north to 45th Street. The lowered lake levels resulting from the Ship Canal construction produced extensive marsh areas around Union Bay, with substantial portions of this marsh habitat subsequently filled, leaving only the fringe marsh on the southern end (Jones and Jones 1975). The south side of the bay is bordered by the Arboretum, with a network of smaller embayments and canals, and extensive marsh habitats. The north side of Union Bay contains a marshy area owned by the University of Washington; the area was previously filled with landfill material. Numerous private residences with landscaped waterfronts and dock facilities dominate the remainder of the shoreline.

Development and urbanization have also altered base flow in many of the tributary systems (Horner and May 1998). Increases in impervious and semi-impervious surfaces add to runoff during storms and reduce infiltration and groundwater discharge into streams and rivers. A substantial amount of surface water and groundwater is also diverted into the City of Seattle and King County wastewater treatment systems and is eventually discharged to Puget Sound.

Although the frequency and magnitude of flooding in the lake and the lower reaches of tributary streams have declined due to the operation of the locks, flooding has generally increased in the upstream reaches of tributary rivers and streams. This change is largely because of the extensive development that has occurred within the basin over the last several decades (Moscrip and Montgomery 1997).

No measurable changes in shoreline habitat condition are expected to occur in the near future, although gradual changes (both positive and negative) are likely to occur. Therefore, the existing degraded habitat in the greater Lake Washington watershed is expected to continue to affect salmonid species in the watershed for the foreseeable future.

3.3 Lake Washington Water Quality

The water quality and sediment quality in the Lake Washington basin are degraded as a result of a variety of current and historic point and non-point pollution sources. Historically, Lake Washington, Lake Union, and the Ship Canal were the receiving waters for municipal sewage, with numerous shoreline area outfalls that discharged untreated or only partially treated sewage directly into these waterways. Cleanup efforts in the 1960s and 1970s included expanding the area's wastewater treatment facilities and eliminating most untreated effluent discharges into Lake Washington. Although raw sewage can no longer be discharged directly into Lake Washington waters, untreated, contaminated flows in the form of combined sewer overflows occasionally enter these waterways during periods of high precipitation (NMFS 2008b). For example, a recent incident resulted in the accidental discharge of an estimated 6.4 million gallons of sewage into Ravenna Creek, which discharges into Union Bay (King County 2008). However, CSO events tend to occur during high stormwater flow when the composition of water in the system is approximately 90% stormwater.

In addition to point source pollution, a variety of non-point sources continue to contribute to the degradation of water and sediment quality. Non-point sources include stormwater and subsurface runoff containing pollutants from road runoff, failing septic systems, underground petroleum storage tanks, gravel pits/quarries, landfills and solid waste management facilities, sites with improper hazardous waste storage, and commercial and residential sites treated with fertilizers and pesticides.

Historical industrial uses in the basin, such as those around Lake Union and southern Lake Washington, Newcastle, Kirkland, and Kenmore, have contaminated sediments with persistent toxins; these toxins include polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals (King County 1995). The expanding urbanization in the basin has also increased sediment input into the Lake Washington system water bodies.

Along with the physical changes to the Lake Washington basin, substantial biological changes have occurred. Non-native plant species have been introduced into Lake Washington, and years of sewage discharge into the lake increased phosphorus concentration and subsequently led to extensive eutrophication. Blue-green algae dominated the phytoplankton community and suppressed production of zooplankton, reducing the available prey for salmonids and other species. However, water quality improved dramatically in the mid 1960s as sewage was diverted from Lake Washington to Puget Sound; at this time, dominance by blue-green algae subsided and zooplankton populations rebounded.

The Ship Canal and Lake Union are listed on the Ecology 303(d) list of impaired water bodies for exceeding water quality criteria for total phosphorous, lead, fecal coliform, and aldrin (Ecology 2008). In addition, portions of Lake Washington are listed on the 303(d) list for exceeding water quality criteria for fecal coliform, as well as the tissue quality criteria for 2,3,7,8 TCDD (dioxin), PCBs, total chlordane, 4,4’ DDD (metabolite of DDT) and 4, 4’ DDE (breakdown product of DDT) in various fish species (Ecology 2008). Therefore, the overall water quality conditions in the project vicinity are degraded compared to historical conditions.

3.3.1. Dissolved Oxygen and Temperature Conditions

Despite reversing the eutrophication trend in the lake, the introduction of Eurasian milfoil to Lake Washington in the 1970s caused additional localized aquatic habitat and water quality problems. Milfoil and other aquatic vegetation dominate much of the shallow shoreline habitat of Lake Washington, Lake Sammamish, Lake Union, Portage Bay, and the Ship Canal. Dense communities of aquatic vegetation, or floating mats of detached plants, can adversely affect localized water quality conditions. Dense communities can reduce dissolved oxygen (DO) to below 5 ppm (parts per million), and the decomposition of dead plant material increases the biological oxygen demand, further reducing DO and pH (DNR 1999). Under extreme conditions, these localized areas can become anoxic.

In addition to the substantial modification aquatic vegetation has made to habitat in the water column, excessive accumulation and decomposition of organic material has overlain areas of natural sand or gravel substrate with fine muck and mud. Substantial shoreline areas of Lake Washington, the Ship Canal, and the project vicinity have soft substrate, with substantial accumulations of organic material from the decomposition of milfoil and other macrophytes. The dense vegetation also reduces the currents and wave energy in these areas, which encourages the accumulation of fine sediment material. As microorganisms in the sediment break down the organic material, they consume much of the oxygen in the lower part of the lake. By the end of summer, concentrations of DO in the hypolimnion (the lowest water layer in the lake) can be reduced to nearly 0.0 milligrams per liter (mg/L). Despite these effects in some shallow nearshore habitats, mean hypolimnetic DO levels recorded at long-term monitoring sites in the lake between 1993 and 2001 ranged from 7.7 to 8.9 mg/L (King County 2003). However, it should be noted that water depths in the hypolimnion extend well below the photic zone, to more than 200 feet. Also, the portions of the hypolimnion closer to the shoreline, which show the lowest DO concentrations, support outmigrating and rearing juvenile salmonids to a greater degree than do deep water habitats.

The thermal stratification of Lake Washington and Lake Union can produce surface temperatures in excess of 68°F (20°C) for extended periods during the summer. In addition, there is a long-term trend of increasing summer and early fall water temperatures (Goetz et al. 2006; Newell and Quinn 2005; Quinn et al. 2002; King County 2007). From 1932 to 2000, there was a significant increase in mean August water temperature from about 66° to 70° Fahrenheit (F) (19° to 21° Celsius [C]) at a depth of 15 feet (Shared Strategy 2007). If this trend continues, surface water temperatures could exceed the lethal threshold (22° to 25° C) for returning adult salmon in some years.

3.3.2. Lake Washington Ship Canal

Saltwater intrusion occurs in the Ship Canal above the locks, but very little of the deeper, heavier salt water mixes with the lighter freshwater surface layer. Consequently, this area lacks the diversity of habitats and brackish water refuges characteristic of most other (unaltered) river estuaries. Usually, this saltwater intrusion extends to the east end of Lake Union, but can extend as far as the University Bridge in an extremely dry summer. The extent of this intrusion into the Ship Canal and into Lake Union is primarily controlled by outflow at the locks and the frequency of large and small lock operations.

Historical data indicate that reduced mixing of the water column due to the saltwater layer likely produced year-round anaerobic conditions in the deeper areas of Lake Union and the

Ship Canal (Shared Strategy 2007). The lack of mixing, along with a significant oxygen sediment demand, can reduce dissolved oxygen levels to less than 1 mg/L, and could prevent fish from using the water column below a 33 foot (10-meter) depth. This condition was likely more severe before about 1966, when a saltwater barrier was constructed at the locks, thereby improving water quality conditions upstream. Water quality in Lake Union has also improved since the 1960s because of the reduction in direct discharges of raw sewage and the closure of the Seattle Gas Light Company gasification plant, along with the upland cleanup activities at the gas plant and other industrial sites. However, Lake Union still experiences periods of anaerobic conditions that typically begin in June and can last until October (Shared Strategy 2007).

Adult fish returning through the Ship Canal and project area contend with anoxic conditions in the deeper water column from July through October (King County 2009). High temperatures in the upper layer generally restrict adult salmonid distribution, including Chinook salmon, to depths below 5 to 10 meters, while anoxic conditions below depths of 50 to 65 feet (15 to 20 meters) prevent Chinook use, thus concentrating them in the relatively narrow [16 to 32 feet (5 to 10 meters)] middle portion of the water column. These physical restrictions can also affect juvenile outmigrants, limiting foraging opportunities and exposing juvenile fish to predators occupying habitat in the metalimnion.

3.4 Fish and Aquatic Resources in Lake Washington and the Ship Canal

A diverse group of native and non-native fish species inhabit the Lake Washington watershed, including several species of native salmon and trout such as Chinook (*Onchorhynchus tshawytscha*), coho (*O. kisutch*), and sockeye (*O. nerka*) salmon; and steelhead *(O. mykiss*), rainbow (*O. mykiss irideus*), and cutthroat trout (*O. clarki clarki*). Most of these species are likely to occur at least occasionally in the project vicinity. The following section describes the various species of salmonids (the primary species of concern for compensatory mitigation) in the project area, and pertinent information on their habitat requirements and life history trajectories. In addition, information is presented on fish species that are significant predators on salmonids in Lake Washington, including bass and northern pikeminnow.

3.4.1. Salmonid Species and Life Histories

Salmonids in the Lake Washington watershed are a mix of native and non-native species, and sometimes a single species can include both native and non-native stocks. For example, recent evidence for sockeye indicates that the Cedar River and Issaquah Creek spawners are likely descendents of introduced fish (Baker Lake stock), while those spawning in Bear Creek may be native fish (Hendry et al. 1996). Man-made changes to the historical drainage patterns in the Lake Washington basin— such as the connection of the Cedar River, disconnection of the Black River, and creation of the Ship Canal—have had a significant effect on salmonid populations, including species distribution, within the Lake Washington system.

Chinook Salmon

Small numbers of Chinook fry begin migrating into Lake Washington from the Cedar River in January, while most Chinook fry enter the lake in mid-May. Initially, the Cedar River Chinook fry tend to concentrate in the littoral zone at the south end of Lake Washington between February and mid-May until they grow large enough to move offshore (Fresh 2000; Tabor et al. 2004a; Tabor et al. 2006). Therefore, the lakeshore area near the Cedar River mouth appears to be an important nursery area for juvenile Chinook salmon. Tabor et al. (2004a) found that the mean abundance of juvenile Chinook from February through May was positively related to proximity to the Cedar River mouth, but there was no difference by June. Juveniles migrate away from the Cedar River mouth and along the Lake Washington shorelines as they grow.

After entering the lake, the juvenile Chinook salmon rear in the shallow littoral zone (1 to 2 feet deep) as they gradually migrate to Union Bay and the Ship Canal. Juvenile Chinook salmon tend to prefer gradually sloping, sand-silt substrate habitat less than 1.6 feet deep (Tabor et al. 2006). They also congregate at the mouths of small tributary streams, possibly attracted by flow, shallow-water depths, benthic invertebrate or terrestrial insect food sources, fine particle substrate accumulated at the stream delta fans, or by some combination of these factors (Shared Strategy 2007). Juvenile Chinook salmon tend to increase their use of deeper-water habitat areas as they get larger, likely as a response to prey availability, reduced predation risks, and possibly more favorable water temperature conditions (Warner and Fresh 1998; Celedonia et al. 2008a).

Chinook fry typically rear in the lake from 1 to 4 months before migrating through the Ship Canal to Puget Sound (Seiler et al. 2004; Tabor et al. 2006). The larger fingerlings enter the lake between mid-May and June after spending up to 6 months rearing in the rivers and streams. Little information is available on the timing of north Lake Washington Chinook in the project vicinity.

Recent observations in the Ship Canal show that young Chinook salmon tend to be relatively uniformly distributed over a range of depths in this area (Celedonia et al. 2008b). Smaller juvenile Chinook salmon appear to prefer shallow areas with over-water cover, particularly during the day (Tabor et al. 2006), but tend to avoid overhead cover areas as they grow (Tabor et al. 2004a). While riparian vegetation tends to be the preferred over-water cover habitat, docks and piers are sometimes used as substitute cover, particularly during the day (Tabor and Piaskowski 2002). The large number of piers and docks lining the Lake Washington shoreline is expected to substantially affect the natural behavior of juvenile Chinook salmon and other salmonids rearing and migrating through the lake.

Celedonia et al. (2008b) determined that the response of juvenile Chinook salmon to the existing Evergreen Point Bridge was at least partially dependent on whether they were actively migrating or holding (remaining in one area). About two-thirds of actively migrating smolts appeared delayed by the bridge, while the remaining smolts appeared negligibly affected by the bridge. Delayed fish varied widely in the time of delay and distance traveled during delay. Nearly half (45%) of the delayed smolts took less than 3 minutes to pass beneath the bridge after the initial encounter, travelling less than 33 meters along the edge of the bridge during this time. Conversely, many smolts that exhibited holding behavior characteristics, as opposed to active migration behavior, appeared to selectively choose to reside in areas near the bridge for prolonged periods. This behavior was distinctly different from the apparent bridge-induced delay observed in some actively migrating smolts. Holding fish often crossed beneath the bridge to the north and were later observed returning to and holding in areas immediately adjacent to the bridge’s southern edge (less than 20 meters from the edge of the bridge). The bridge did not appear to be a factor in delaying the migration of fish that displayed holding behavior prior to continuing their outmigration.

Artificial lighting associated with the proposed roadway and bridge also has the potential to affect the distribution and behavior of fish, depending on its intensity and proximity to the water. Adaptations and responses to light are not universal for all species of fish—some predatory fish are adapted for hunting in low light intensities, while others are attracted to higher light intensities; some species school and move toward light sources (Machesan et al. 2005).

Based on Lake Washington tagging data, Celedonia et al. (2009) indicate that juvenile Chinook salmon are attracted to areas where street lamps on the existing Evergreen Point Bridge cast light onto the water surface, suggesting that bridge lighting is at least partially responsible for the nighttime selection of near-bridge areas by Chinook salmon. It has been conjectured that the illuminated areas may allow juvenile Chinook salmon an opportunity to forage throughout the night when under normal, low light conditions they would normally stop feeding.

Each year, adult Chinook salmon pass through the Ship Canal and Lake Union from the end of July through the beginning of September (City of Seattle and USACE 2008). The total time of adult Chinook salmon migration from the Ballard Locks to arrival at tributary spawning grounds can take up to 55 days, but averages less than 30 days (Fresh et al. 2000). In general, migration time, both through the Ship Canal and to spawning grounds, decreases as the season progresses and could reflect maturation level of the fish.

Once Chinook leave the locks, most fish move through the Ship Canal in less than 1 day (varying from 4 hours to 7.7 days) (Fresh et al. 1999; Fresh 2000). Adult Chinook salmon may enter Lake Washington several days before moving into rivers for spawning, with the average time spent by adult Chinook in Lake Washington around 3 days for Cedar River fish and 5 days for Sammamish watershed fish (Fresh et al. 1999). Due to the short time most Chinook adults spend in the lake and the Ship Canal, the modified habitat in these areas may have a limited effect on returning adults, although the relatively short time spent in the lake may be related to the long-term trend of increasing late summer water temperatures.

Acoustic and temperature tags on adult Chinook salmon show that these fish inhabit lake waters ranging from 48º to 70º F (9º to 21º C) (F. Goetz in City of Seattle and USACE 2008). The adult Chinook do not seem to seek out cool waters, but will hold near the mouths of the Cedar and Sammamish rivers in warm, shallow waters.

Steelhead

Juvenile steelhead migrating out of the Lake Washington watershed will pass through the project area. No information is available that identifies the project area as a location specifically used by juvenile steelhead for rearing. Juvenile steelhead rear in fresh water, including the lake, for several years before migrating to Puget Sound; therefore, they are expected to be less dependent on the shallow nearshore habitat in the lake than are the smaller Chinook salmon fry.

Adult steelhead pass through the Ballard Locks to Lake Washington between December and early May (WDFW et al. 1993). Spawning occurs throughout the Lake Washington basin, including the lower Cedar River, the Sammamish River and its tributaries, and several smaller Lake Washington tributaries (WDFW 2006). Steelhead spawn primarily in the main stem Cedar River from March through early June (Burton and Little 1997), although there are historical records of steelhead spawning in Cedar River tributaries such as Rock Creek.

Bull Trout

Little is known about the historical distribution and abundance of bull trout in the Lake Washington system. A 1-year survey in the Lake Sammamish basin during 1982 and 1983 reported no char (a subset of the salmonids that includes bull trout and Dolly Varden) (WDFW 1998). While bull trout occasionally occur in Lake Washington, there are no indications of an adfluvial population (i.e., lake residents that migrate up streams to spawn) in the lake, and bull trout are not expected to occur in the surface waters of Lake Washington during the summer when water temperatures typically exceed 59ºF (15ºC) for several months. Therefore, the apparent remnant anadromous population likely uses the lake primarily as a migration route to marine waters for foraging and rearing.

Although bull trout may occasionally occur in the project area, there is no known regular occurrence of bull trout in the lake. There have been only a few reports of bull trout and Dolly Varden in the entire Lake Washington watershed. Some bull trout are believed to enter the Lake Washington system from the isolated population above the Chester Morse Dam. No bull trout observations have been documented between October and December, likely because the fish are presumed to be on or near their spawning grounds during this time.

Several large native char (approximately 410 millimeters long) have been observed passing through the viewing chamber at the Ballard Locks, but only one was identified as bull trout (Bradbury and Pfeifer 1992; USFWS 1998). Bull trout were caught in Shilshole Bay and the Ballard Locks during late spring and early summer in both 2000 and 2001, with up to eight adult and subadult fish caught in Shilshole Bay below the locks between May and July in 2000. In 2001, five adult bull trout were captured in areas within and immediately below the Ballard Locks. One bull trout was captured within the large locks and one in the fish ladder, as well as three adult bull trout captured below the tailrace during the peak of juvenile salmon migration in mid-June (USFWS 2008). Observations of bull trout near the Ballard Locks suggest migration of bull trout from other core areas to Lake Washington.

Anadromous adult and subadult bull trout likely occur in the project area throughout the year, most likely in spring and early summer during outmigration of juveniles. This observation is based on bull trout captured at the Ballard Locks and the Ship Canal between May and July. Bull trout likely use the project area for either foraging or migrating through the area to other marine or estuarine foraging habitats. Bull trout in the project area likely originate from the core areas of the Stillaguamish, Snohomish-Skykomish, and Puyallup rivers.

Sockeye

Juvenile sockeye salmon commonly rear in the open-water habitat of the lake for a year before migrating to salt water, including the area along the floating portion of the Evergreen Point Bridge, although juvenile sockeye salmon use of Lake Washington varies. Smaller sockeye fry first entering the lake may inhabit shallow water areas such as river deltas at night (City of Seattle and USACE 2008) or other parts of the littoral zone (Martz et al. 1996), although the amount of time fry are present in this area is unknown. In general, sockeye fry travel in schools in limnetic areas (open-water areas of the lake away from shore) and are located below 66 feet in depth during the daytime, then ascend to shallower waters at dusk to feed during the night (Eggers et al. 1978). This diurnal difference in depth can be up to 43 feet. During summer lake stratification, sockeye are confined to deeper, cooler waters because during this period, sockeye are unable to access the high densities of zooplankton in the epilimneon (uppermost water layer in a lake) due to high water surface temperatures in Lake Washington.

Juvenile sockeye salmon begin to migrate out of Lake Washington in April and continue outmigration until June or early July. Sockeye are usually outmigrate at 1 year of age, after spending the previous summer and winter rearing in the lake, although some sockeye outmigrate within their first year. Outmigration behavior of sockeye has not been studied in Lake Washington.

In-lake survival for sockeye salmon, from fry entry to pre-smolts the following spring, was estimated to be about 2.91% over the 2000 to 2005 brood years (McPherson and Woodey 2009). This is a very low survival rate for this life history stage compared with that of other sockeye salmon populations. A hypothesis for this finding is based on timing of sockeye fry entry into Lake Washington, which often takes place before or early in the spring bloom period, potentially placing the fry at risk due to suboptimal food resources for large populations entering in the south end of the lake from the Cedar River (McPherson and Woodey 2009). However, studies of Lake Washington sockeye's pre-smolt to adult survival have indicated that survival is consistent with other sockeye stocks (Ames 2006).

Once adult sockeye have migrated through the Ballard Locks, they have a rapid migration through the Ship Canal, averaging about 4 days (Newell and Quinn 2005). As with Chinook salmon, timing of sockeye passage through the Ship Canal and Lake Union is thought to be influenced by several factors, including warm water temperatures in the Ship Canal.

All sockeye salmon tend to have similar life history patterns in the Lake Washington watershed, but the adult sockeye returning to spawn in the Cedar River tend to be larger and older than the Bear Creek spawners (Hendry and Quinn 1997). In addition to spawning in the Cedar River and other Lake Washington tributaries, sockeye salmon also spawn along Lake Washington's shoreline. This includes past spawning records for the existing and proposed east end of the Evergreen Point Bridge, based on WDFW map records (Buchanan 2004). However, no recent surveys have been conducted to determine whether sockeye salmon currently spawn in this location. This area is one of more than 85 shoreline spawning beaches and is less than 1% of the beach spawning habitat previously identified in Lake Washington on maps provided by WDFW (Buchanan 2004).

Estimated annual escapement of Lake Washington beach spawning sockeye (i.e., hatchery fish that spawn in natural areas versus returning to hatchery waters) varied from 54 to 1,032 fish from 1976 through 1991 (WDFW 2004). These sockeye spawn wherever suitable gravel beaches and groundwater upwelling occur around the lake, particularly along the north shore of Mercer Island and the east shore of Lake Washington. These spawning areas occur over a wide range of water depths. The estimated total beach spawning population ranged between 200 and 1,500 fish between 1986 and 2003 (WDFW 2004).

Coho Salmon

Not much information is known about coho salmon's use of Lake Washington habitats. In general, these fish enter Lake Washington with a typically larger body size than Chinook salmon, which influences their habitat choice. Upon initial entry into Lake Washington, these juvenile coho salmon are likely to eat prey items similar to those consumed by Chinook and sockeye. However, as these fish grow larger, they may switch to piscivory (eating other fish).

Age 1+ coho outmigration occurs from late April until late May, usually peaking in early May (Fresh and Lucchetti 2000). As with steelhead, it is thought that coho generally move through the lake and into marine waters more quickly than Chinook salmon because of their large size upon entry into Lake Washington. Most coho salmon tagged and released in the

Ship Canal pass the Ballard Locks within 2 weeks. Habitat use and behavior during this period have not been studied in Lake Washington, and are largely unknown.

Returning adult coho salmon pass through the project area from late September through November. Little is known about adult coho behavior and habitat choice upstream of the Ballard Locks.

Cutthroat Trout

Lake Washington contains populations of cutthroat trout, both anadromous (migrating from fresh to salt water) and potamodromous (migrating only within freshwater areas). Most anadromous cutthroat trout juveniles move to salt water at age 2 if they migrate to sheltered saltwater areas, or age 3 or 4 if they migrate to the open ocean. Seaward migration peaks in May. Potamodromous forms migrate to main stem rivers or to lakes; otherwise, their life history characteristics are much like those of the anadromous form. Prey includes insects, crustaceans, and other fish including perch, coho smolts, minnows, and other young fish.

3.4.2. Salmonid Distribution and Densities: Salmonid Functional Zones

Anadromous salmonids in the project area are classified into several stocks, based on both geographical distribution of the fish and genetic similarities. Table 3-1 lists the identified stocks of anadromous salmonids in the Lake Washington basin. Based on geography, all anadromous juveniles originating in the Cedar River or along the southern shoreline of Lake Washington (for beach spawning sockeye salmon) must migrate through the project area to reach the Lake Washington Ship Canal, the only available route to the marine environment of Puget Sound. In some cases, a high percentage of a particular salmon species originates in the Cedar River. For example sockeye salmon from the Cedar River have accounted for approximately 85.3% of sockeye (1982 to 2002 range: 68 to 98%; Standard Deviation: 7.8%) estimated to have spawned annually in the Lake Washington watershed (McPherson and Woodey 2009).

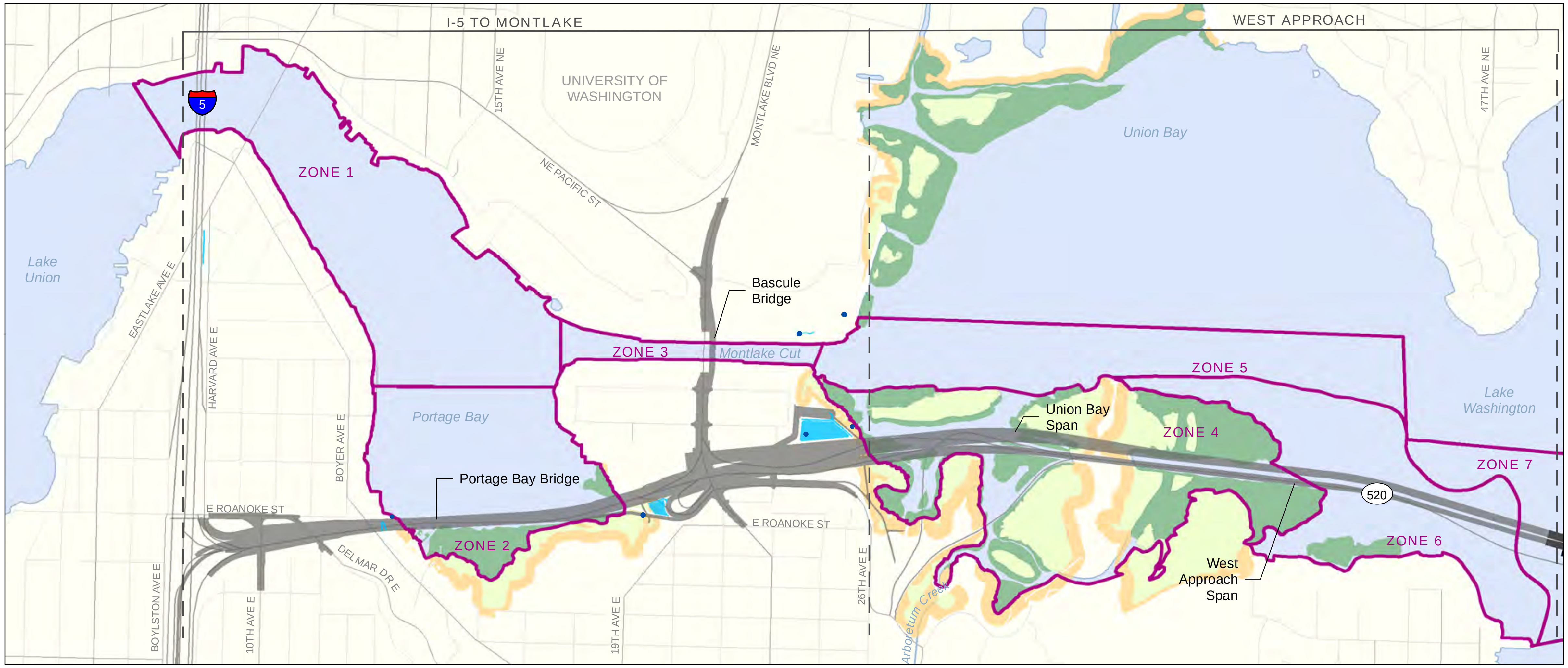
Table 3-1. Stock Summary of Lake Washington Basin Salmonids

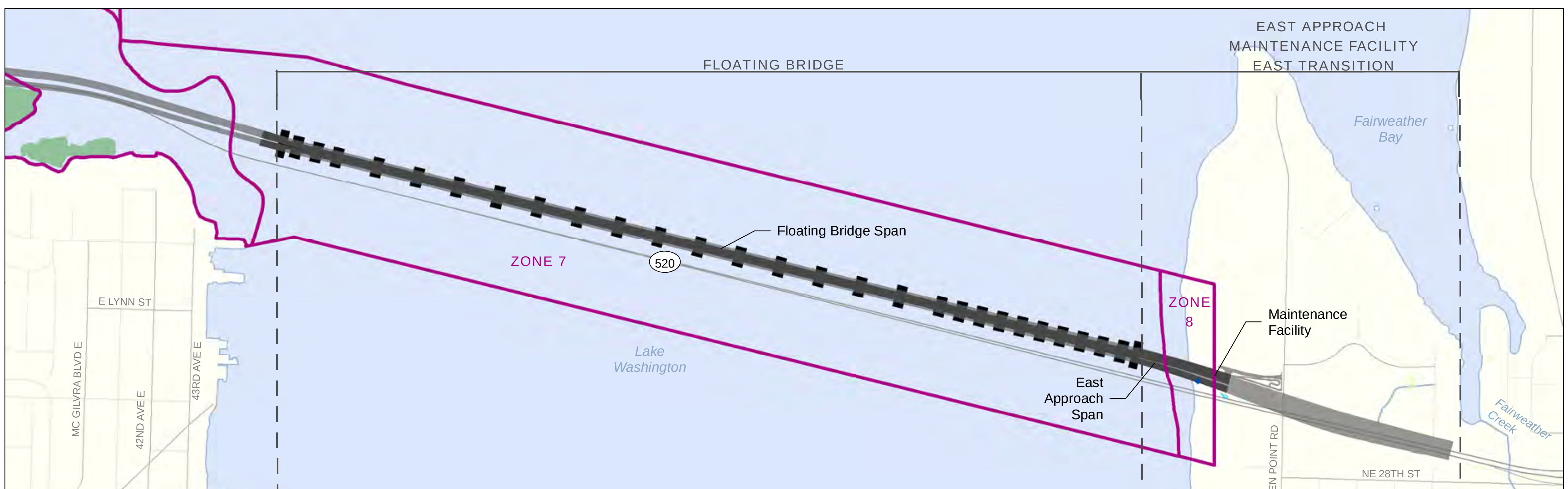
Species	Stock	Population Estimate Metric	1986–2003 Average (Max – Min)[b]
Chinook	Cedar River Chinook	Index escapement	525 (120 – 1540)
	Sammamish River[a]	Carcass counts and index escapement	3,438 (1,153 – 7,851)
Coho	Cedar River Coho	Cumulative fish-days	2,040 (128 – 9,204)
	Lake Washington/ Sammamish Tributaries Coho	Cumulative fish-days	4,120 (339 – 13,804)
Sockeye	Cedar River Sockeye	Run size	176,503 (30,084 – 512,257)
	Lake Washington Beach-Spawning Sockeye	Total escapement	1,895 (200 – 4,800)
	Lake Washington/ Sammamish Tributaries Sockeye	Total escapement	25,980 (2,080 – 81,090)
Steelhead	Lake Washington Winter Steelhead	Total escapement	158 (20 – 1,816)

[a] As defined by NOAA Fisheries Puget Sound Technical Recovery Team. This stock includes Issaquah Chinook and North Lake Washington Tributaries Chinook as listed in WDFW (2004). The stock includes substantial hatchery origin fish, including strays and fish allowed to spawn after egg taking goals have been achieved.
[b] Data from WDFW 2004

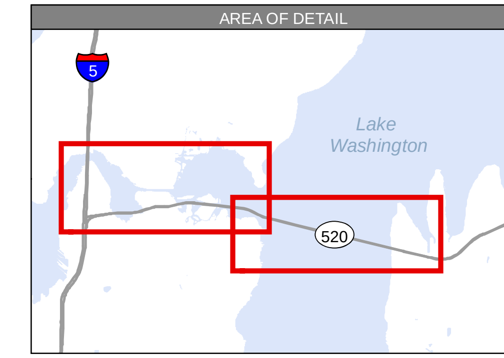
In other cases, salmonids spawn in the tributaries that enter the north end of the lake (e.g., Bear Creek, Issaquah Creek) or along Lake Washington's beaches to the north of the SR 520 bridge. Larger juvenile sockeye and Chinook salmon from these locations in Lake Washington inhabit deeper limnetic lake habitat prior to outmigration, although some outmigrants may cross back and forth through the bridge corridor during this time.

In addition to the geographic location of spawning areas, the density and distribution of salmonids in the project area are also determined by the physical, chemical, and biological conditions in the project area. To assess and discuss the salmonids' variable use of the project area, it is helpful to break the project area into smaller zones. Eight salmonid functional zones have been identified in Lake Washington and the Ship Canal (Figure 3-1) to characterize the ecological conditions, salmonid habitat functions, and salmonid species' use of each zone. The zones were defined, and fish use evaluated, by a team of technical experts on Lake Washington fisheries. The results identified by the team were then reviewed and approved by the NRTWG. Each zone is briefly described in more detail below.





Source: King County (2005) GIS Data (Streams and Streets). Horizontal datum for all layers is NAD83(91); vertical datum for layers is NAVD88.



Proposed Stormwater Outfall

Stream

Salmonid Use Ecological Zone

Zone 1. Ship Canal from Hiram M. Chittenden Locks to Portage Bay
All successful juvenile outmigrants and adult returns must pass through this zone during their life cycle.

Zone 2: Southern portion of Portage Bay
Highly used by University of Washington Hatchery fish. Sub-optimal rearing and migration habitat, believed to be little utilized by native salmonids.

Zone 3: Ship Canal Montlake Cut
Lack of suitable habitat. Shallow, warm and heavily armored on both sides makes residency times low, All juvenile outmigrants and returning adults must pass through this segment of the Ship Canal prior to entering Lake Union or Lake Washington, respectively.

Zone 4: Arboretum and Foster Island Waterways
Low habitat use by salmonids. Shallow, warmer environment with dense macrophytes. This is believed to provide habitat for bass and other species tolerant of warmer waters.

Zone 5: Union Bay
This area may be used by outmigrating juvenile Chinook salmon for extended time periods (multiple days) and it may provide rearing habitat or refuge to fish about to enter or just exiting the relatively hostile environs associated with the Ship Canal

Zone 6: SR 520 West Approach (Foster Island to 10 m depth)
Believed to be primary migration route for Cedar River juvenile outmigrants and returning adults. This area may be used by outmigrating juvenile Chinook salmon for extended time periods (multiple days) and it may provide rearing habitat (primarily in 2-6 m depths).

Zone 7: Floating Bridge (areas deeper than 10 m)
Deep water area believed to be of lower importance for juvenile salmonids, which are generally shoreline oriented, while adult salmonids may use this portion of the lake. Juvenile salmonids may migrate into deeper waters at night in pursuit of feeding opportunities or use pontoon edge as migration corridor.

Zone 8: East Approach (from 10-meter depth contour to shore)
The east shoreline of Lake Washington is believed to be of less importance to migrating juvenile salmonids, however some shoreline-oriented salmonids likely use this area. Lake spawning sockeye salmonids have been documented to spawn in the vicinity of the East Approach bridge structure.

Proposed Edge of Pavement

Aquatic Bed Wetland

Palustrine Wetland

Wetland Buffer

Proposed Stormwater Facility

Pontoon

Figure 3-1. **Project Scale - Salmonid Function Zones in Lake Washington**

I-5 to Medina: Bridge Replacement and HOV Project

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Salmonid Functional Zone 1 – Ship Canal West of Portage Bay

The Ship Canal is an 8.6-mile-long man-made navigation waterway connecting Lake Washington to Puget Sound in the city of Seattle. Lake Washington was isolated from Puget Sound until 1903, when the construction of the Ship Canal created a connection from Lake Washington to Puget Sound through Lake Union. From west to east, the Ship Canal passes through Shilshole Bay, Ballard Locks, Salmon Bay, the Fremont Cut, Lake Union, Portage Bay, the Montlake Cut, and Union Bay on the edge of Lake Washington. Although all successful juvenile outmigrants and adult returns must pass through this zone during their life cycle, project activities occurring in this area are minimal, and limited to the movement of barges and pontoons.

Salmonid Functional Zone 2 – Portage Bay

The project area crosses through the southern portion of Portage Bay, which is thought to be south of the primary salmonid migration route through the Ship Canal. This area is a shallow, quiescent bay with abundant aquatic macrophytes during the spring and summer months. It provides limited habitat for anadromous fish populations, which are believed to migrate relatively rapidly through the northern portion of Portage Bay.

Salmonid Functional Zone 3 – Ship Canal at Montlake Cut

The Ship Canal at Montlake Cut is relatively shallow, warm, and heavily armored on both sides. The lack of suitable habitat makes fish residency times low; however, all outmigrating juveniles and returning adult salmonids must pass through this segment of the Ship Canal prior to entering Lake Union or Lake Washington. Construction activities to build a second bascule bridge will occur above the Montlake Cut, and will be conducted primarily from upland areas, with some periodic support from barges and tugboats anchored or positioned in the Montlake Cut.

Salmonid Functional Zone 4 – Arboretum and Foster Island

This zone includes the Washington Park Arboretum, Foster Island, and Union Bay. The area is generally characterized by shallow, quiescent waterways where dense growths of macrophytes are abundant during the spring and summer months. This zone contains a single stream, Arboretum Creek, which may have historically supported salmonids, although it has since been modified and degraded to the point where under current conditions it does not support any salmonids. While much of this zone is thought to provide habitat for bass and other species tolerant of warmer waters, it is not considered important or highly utilized salmonid habitat. A substantial amount of in-water construction will occur in this zone, including the installation of temporary work bridges and permanent bridge columns and superstructure.

Salmonid Functional Zone 5 – Union Bay

This area may be used by outmigrating juvenile Chinook salmon for extended time periods (multiple days). It may also provide rearing habitat and refuge to fish about to enter or just exiting the relatively hostile environment associated with the Ship Canal. As with Salmonid Functional Zone 1, project construction activities in this area will generally be limited to the movement of barges and pontoons.

Salmonid Functional Zone 6 – West Approach

This zone occurs east of the dense macrophyte communities associated with Foster Island, out to the 10-meter depth contour. This area is believed to be the primary migration route for Cedar River juvenile outmigrants and returning adults. Recent fish tracking studies (Celedonia et al. 2008b) suggest that this area may be used by outmigrating juvenile Chinook salmon for multiple days, and may provide rearing habitat (primarily in 2- to 6-meter depths). Fish travelling to or from the southern end of Lake Washington generally pass underneath the bridge in this zone. In addition, there will be a substantial amount of in-water and over-water construction in this zone, including the installation of temporary work bridges and permanent bridge columns and superstructure.

Salmonid Functional Zone 7 – Floating Bridge

The floating portion of the Evergreen Point Bridge resides in deeper water (greater than 10 meters deep) supported by floating pontoons. This zone is believed to provide limited habitat for the smaller juvenile salmonids, which are generally shoreline-oriented; however, adult and larger juvenile salmonids may use this portion of the lake. In addition, juvenile salmonids may migrate into deeper waters at night or in pursuit of feeding opportunities because a preferred food item, zooplankton, tends to be more abundant offshore.

Salmonid Functional Zone 8 – East Approach

This zone occurs along the east shoreline of Lake Washington, which is thought to be of less importance to migrating juvenile and adult salmonids because these fish are generally believed to pass through the project area closer to the western shoreline of the lake. It is likely that some shoreline-oriented salmonids use this area. Sockeye beach spawning has also been identified historically in this area (see Section 3.5.1), though no surveys have been conducted recently. Construction activities in this zone include installation of permanent bridge columns and superstructure, and construction of the bridge maintenance facility and associated dock.

3.4.3. Salmonid Predators

Predation of salmonids by native and non-native predatory fishes is a substantial source of mortality in Lake Washington and the Ship Canal (Fayram and Sibley 2000; Warner and Fresh 1998; Kahler et al. 2000). However, any effects on associated predator–prey distributions resulting from the existing bridge and associated structures are expected to apply mainly to juvenile salmon outmigration. Current information does not indicate that the existing bridge structure has an influence on the predator–prey interactions associated with adult salmonids in Lake Washington.

Fayram and Sibley (2000) and Tabor et al. (2004a, 2006) demonstrated that bass may be a risk factor for juvenile salmonid survival in Lake Washington. Celedonia et al. (2008a, b) found that larger bass tend to be present near shoreline structures and bridge piers, including areas where young salmon are likely to migrate and rear. Therefore, juvenile Chinook and steelhead may be particularly vulnerable to predation as they migrate through Lake Washington to marine waters, as well as through the relatively-confined Ship Canal. The highly modified habitat throughout the Ship Canal and the locks may also contribute to an increased potential of predation due to the reduced refuge habitat available.

The primary freshwater predators of salmonids in the lakes and waterways in the Lake Washington basin include both native and non-native species. Primary non-native predator fish include yellow perch (*Perca flavescens*), smallmouth bass (*Micropterus dolomieui*), and largemouth bass (*Micropterus salmoides*). Predominant native fish predators include cutthroat trout, northern pikeminnow (*Ptychocheilus oregonensis*), and prickly sculpin (*Cottus asper*). However, sampling in February and June of 1995 and 1997 found only 15 juvenile Chinook salmon in the stomachs of 1,875 predators (prickly sculpin, smallmouth and largemouth bass, and cutthroat trout) examined, with most of the predation by prickly sculpin (Tabor et al. 2004a). These data suggest predation of less than 10% of the Chinook salmon entering the lake from the Cedar River.

Smallmouth bass distribution in Lake Washington overlaps with that of juvenile Chinook salmon in May and June, when both species occur in shoreline areas. However, predation rates are also affected by physical conditions. For example, smallmouth bass do not feed as actively in cooler temperatures as they do in waters above 68ºF (20ºC) (Wydoski and Whitney 2003), while Chinook avoid the warmer-water areas. Chinook also avoid overhead cover, docks and piers, and the coarse substrate habitat areas preferred by smallmouth bass (Tabor et. al 2004a; Gayaldo and Nelson 2006; Tabor et al. 2006; Celedonia et al. 2008a, b).

Tabor et al. (2006) concluded that under existing conditions, predation by smallmouth and largemouth bass has a relatively minor effect on Chinook salmon and other salmonid populations in the Lake Washington system. However, predation appears to be greater in the Ship Canal than in the lake. Tabor et al. (2000) estimated populations of about 3,400 smallmouth and 2,500 largemouth bass in the Ship Canal, with approximately 60% of the population occurring at the east end at Portage Bay. They also observed that smallmouth bass consume almost twice as many Chinook salmon smolts per fish as largemouth bass (500 smolts versus 280 smolts annually, respectively). This consumption occurs primarily during the Chinook salmon outmigration period (mid-May to the end of July) when salmon smolts represented 50 to 70% of the diet of smallmouth bass (Tabor et al. 2000). An additional study estimated the overall consumption of salmonids in the Ship Canal at between 36,000 and 46,000 juvenile salmon, corresponding to mortality estimates ranging from 0.5 to 0.6% (Tabor et al. 2006).

Although smallmouth bass showed an affinity for the bridge columns, information suggests that their overall abundance is no greater at the bridge than in other suitable habitat types (Celedonia et al. 2009). Also, a study of the stomach contents of predators under the existing bridge found that predator diets near the bridge include a similar proportion of salmonids as the diets of predators studied in other locations of Lake Washington (Celedonia et al. 2009).

In addition to selecting bridge columns as a structural habitat component, smallmouth bass were found to have an affinity for a depth of 4 to 8 meters and often sparse vegetation or edge habitat associated with macrophytes. Moderately dense to dense vegetation was used only occasionally. Neither pikeminnow nor smallmouth bass have been shown to have an affinity for the shading (i.e., overhead cover) provided by the overhead bridge structure.

As noted previously, artificial lighting associated with the proposed roadway and bridge could affect the distribution and behavior of fish. Any increased abundance of salmonids around illuminated areas may then also attract visual predators. Neither smallmouth bass nor northern pikeminnows appeared to be particularly attracted to the artificially illuminated area adjacent to the existing bridge. Other studies, however, suggest that predation rates by other salmonids such as cutthroat trout and rainbow trout may be higher due to increased visibility of the prey species in illuminated areas, even if the predators on the whole do not select these areas (Mazur and Beauchamp 2003; Tabor et al. 2004b). No information was presented regarding increased potential for predator detection by prey in artificially illuminated areas.

While there has been an obvious increase in the number of non-native predators in the lake in the twentieth century, changes in the number of native predators have been less apparent. However, there is some anecdotal evidence that the number of cutthroat trout has increased considerably over time (Nowak 2000). In addition, Brocksmith (1999) concluded that the northern pikeminnow population increased by 11 to 38% between 1972 and 1997. Brocksmith (1999) also found evidence that larger northern pikeminnows are more numerous than they were historically, indicating that the pikeminnow population is currently not limited by their density (i.e., they can increase in density if limiting environmental factors became more favorable). The greater number and the larger size of pikeminnows suggest an overall increase in predation mortality of anadromous juvenile salmonids, compared with historical conditions. The incidence of freshwater predation by fish in Lake Washington and the Ship Canal may also be increasing due to the increasing water temperatures that favor these species (Schindler 2000).

Data suggest that northern pikeminnow do not select areas near the bridge over other habitat types. Northern pikeminnow were primarily concentrated at 4- to 6-meter depths during all periods, and moderately dense vegetation was the most commonly used habitat type. Limited attraction to nighttime lights was noted, although this was inconsistent from year to year (Celedonia et al. 2008a, 2008b, 2009).

In general, the amount of predation currently occurring in the project area is likely to be primarily a function of the overlap in available predator and prey habitat areas and selection preferences. Assuming smallmouth bass are selecting the bridge columns as preferential habitat for predation, and that migrating Chinook show no preference where they cross in the primary migration corridor, predation is likely to occur adjacent to the in-water structure (columns) of the existing bridge structure.

Aside from potential changes in predator distribution, the information suggests that migrating juvenile salmonids that exhibit a holding behavior in association with the bridge are more likely to be susceptible to increased predation rates. The increased residence time around the structure may simply result in prolonged exposure to bridge-associated predators.

3.5 Lake Washington Salmonid Conceptual Model

A conceptual model was developed to characterize the interaction between anadromous salmonids and aquatic habitat in the project area. The model (Figure 3-2), based on literature on salmonid habitat functions and features in Lake Washington, uses the primary life history stages of anadromous salmonids as surrogates for related population-level metrics (i.e., survival, growth, fitness, and reproductive success). To simplify the model, the life history stages have been generalized, and serve to represent all anadromous salmonids within the Lake Washington system, although the importance of specific habitat features varies by species. For example, natural shoreline habitat is extremely important to Chinook fry when they enter the lake from the Cedar River, while sockeye salmon, which are generally larger upon lake entry, rely somewhat less on shoreline habitat and for a shorter period.

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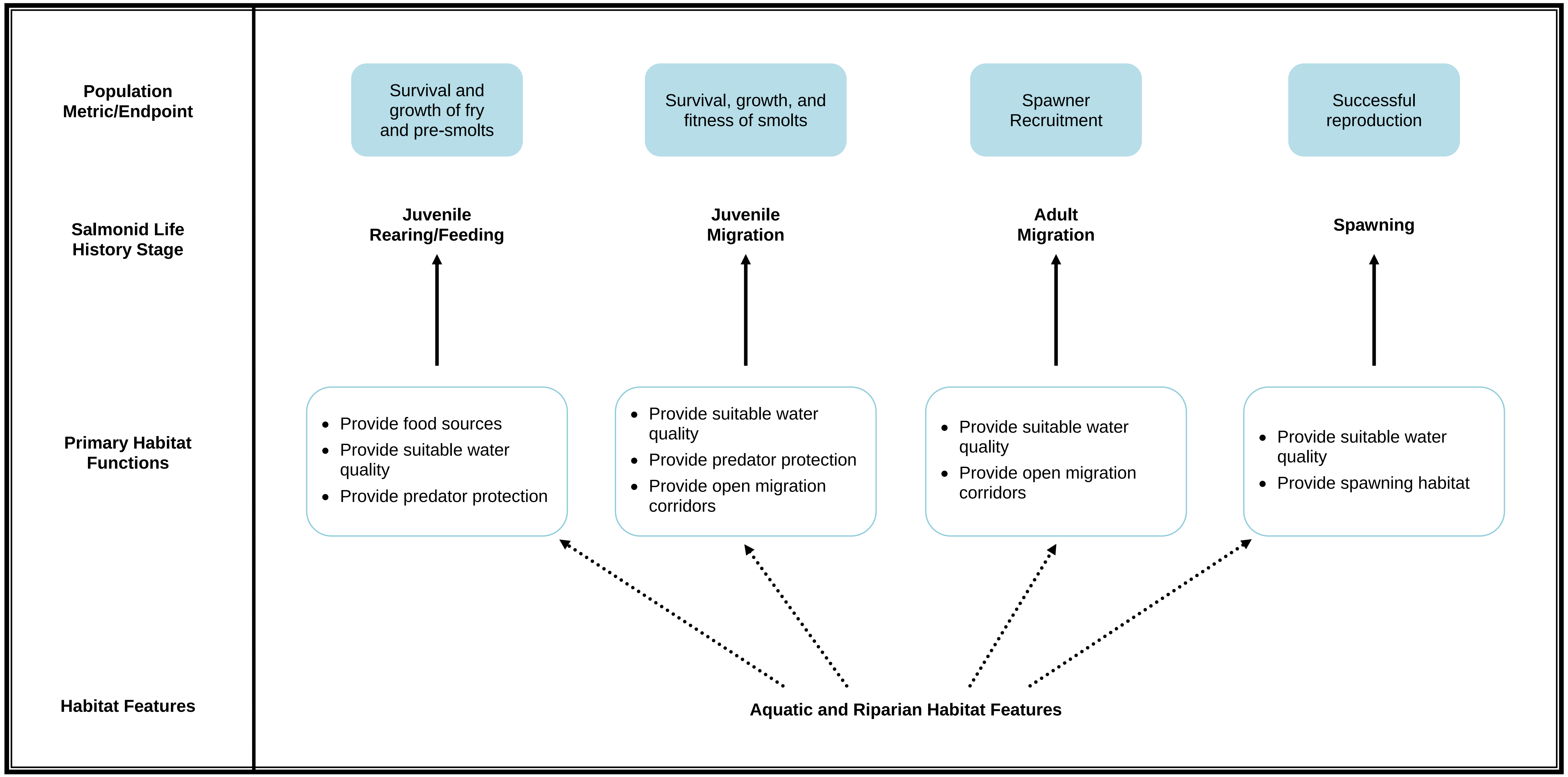
Figure 3-2. Conceptual Model of Anadromous Fish in Lake Washington



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The aquatic habitat functions listed in the model also apply to all species of anadromous salmon in the project area. These functions, listed in Figure 3-2 and listed in more detail in Table 3-2, are based on scientific literature on salmonid habitat requirements and limiting factors (City of Seattle and USACE 2008; Kerwin 2001; Wydoski and Whitney 2003) and directly relate to specific life history stages.

Table 3-2. Aquatic Habitat Functions and Related Salmonid Life History Stages

Aquatic Habitat Function	Primary Salmonid Life History Stage(s) Affected
Provide adequate food sources (macroinvertebrate and zooplankton)	Juvenile Rearing/Feeding Juvenile Migration
Provide water quality with constituents within acceptable levels for salmonids (DO, temperature, TSS, contaminants, etc.)	All stages
Provide protection from predator species (piscivorous and avian)	Juvenile Rearing/Feeding Juvenile Migration
Provide migration corridors free from obstruction and disturbance	Juvenile Migration Adult Migration
Provide accessible spawning habitat of suitable quantity and quality	Adult Spawning

DO = Dissolved oxygen
TSS = Total suspended solids

The model relates these general population metrics to specific habitat functions that support salmonid life stages. Each habitat function is supported by a number of physical, biological, and chemical habitat features that can be affected by project actions. Alteration of these habitat features can influence habitat functions, which then can affect salmonid life history stages and result in population-level effects. Since this methodology looks at salmonid life history and related population-level effects, it can be used to either assess project impacts (negative effects) or project mitigation (positive effects), and allows evaluation and comparison of both types of effects, using identical metrics.

The potential project impacts and mitigation actions may affect different habitat features, but the overall aquatic functions, and in turn, life history elements affected, are similar. The discussion below summarizes general information on the life histories of salmonids, and the relationship of several habitat features to these life stages.

3.5.1. Juvenile Salmonid Rearing and Feeding

Rearing

Juvenile salmonids require habitat that provides refuge from predatory, physiological, and high-energy challenges. High-quality freshwater refuge habitat, limited in Lake Washington and the Ship Canal (Tabor and Piaskowski 2002; Weitkamp et al. 2000), consists of unarmored, shallow-gradient littoral zone with large woody debris (LWD) and overhanging vegetation (Tabor and Piaskowski 2002). Low-quality refuge habitat is prevalent in most Lake Washington shoreline areas due to shoreline development, lack of LWD, and the proliferation of non-native predatory fish species. Shoreline modifications that preclude shallow water habitat comprise most of the Lake Washington shoreline (Toft 2001; Toft et al. 2003). In Lake Washington, pilings and riprap likely contribute to increased energy expenditure and risk of predation on juvenile salmonids by bass and northern pikeminnow (Celedonia et al. 2008 a, b). Riprap areas have been shown in other lakes to exhibit higher water velocities, depths, and steep slopes compared with unaltered habitats (Garland et al. 2002). Due to littoral zone activities and modifications including dredging, filling, bulkheading, and construction, very little native vegetation remains on the Lake Washington shoreline (Weitkamp et al. 2000; Toft 2001; Toft et al. 2003).

Refuge is limited in the Lake Washington basin near the fresh/saltwater transition at the Ballard Locks due to the limited natural habitat and sharp osmotic gradient. Juvenile salmonids exiting Lake Washington may seek tributary mouths as refuge habitats because overhead vegetative cover and the water from these tributaries provide refuge from higher salinities or temperatures (Seattle Parks and Recreation 2003). In nearshore shallow and/or marine areas, features considered to be high-quality refuge habitat are aquatic and marine riparian vegetation, LWD, and larger substrates (City of Seattle 2001). In Puget Sound, this habitat is limited due to the prevalence of bulkheads and over-water structures, and extensive filling, dredging, and grading in shoreline areas (Weitkamp et al. 2000; City of Seattle 2001).

Foraging

Juvenile salmon require habitat that provides and supports the production of ample prey resources; this habitat includes unaltered shorelines with organic inputs and small substrates. Juvenile Chinook in Lake Washington prey on insects and pelagic invertebrates, namely chironomids and *Daphnia* spp. (Koehler 2002). Juvenile salmonids in Puget Sound feed on forage fish larvae and eggs as well as on other pelagic, benthic, and epibenthic organisms from nearshore, intertidal, and eelgrass/kelp areas (Simenstad and Cordell 2000). Although the literature generally concludes that prey resources are not a limiting factor for juvenile salmon (Kerwin 2001), in-water construction activities have the potential to temporarily affect the juveniles’ foraging behavior by decreasing primary productivity, changing water clarity (sedimentation), or creating in-water noise and disturbance. Because the proposed project has the potential to temporarily affect the foraging ability of juvenile outmigrant salmonids, this life history element was incorporated into the conceptual model.

3.5.2. Juvenile Migration

Lake habitat that is generally considered favorable for migration includes gently sloping beaches with no over-water structures restricting light penetration of the water. Juvenile salmonids require habitat with few barriers to their seaward migration. Lake Washington is free of these barriers, but concern exists among biologists that over-water structures such as docks and piers may indirectly act as a barrier to alter migration patterns (Weitkamp et al. 2000). Juvenile salmon readily pass under small docks and narrow structures under which darkness is not complete, but studies have indicated that under some conditions, large over-water structures with dark shadows can alter migration (Fresh et al. 2001). However, juvenile migration of salmonids is complex and influenced by a variety of factors. In a study of the effects of the existing SR 520 bridge, Celedonia et al. (2008a) observed no apparent holding behavior of juvenile Chinook at the existing bridge during year 1 of the study, while in another year minutes to hours of holding were observed for about half the fish (Celedonia et al. 2008a). Some juveniles pass directly under the bridge without delay, while others spend up to 2 hours holding close to the bridge. Overall, these short delays are unlikely to result in detectable changes in survival of Chinook or other juvenile salmon as they migrate through Lake Washington and the Ship Canal.

Several studies have shown that in nearshore areas of the Duwamish estuary and Elliott Bay, over-water structures do not have a detrimental effect on juvenile salmonid migration patterns, unlike some larger docks and piers on Lake Washington. However, this has been attributed to the difference in size and construction of similar structures along the Lake Washington and Lake Union shorelines (Weitkamp et al. 2000). Some studies have shown that drastic changes in ambient underwater light environments may alter fish migration behavior (Nightingale and Simenstad 2001).

The migratory corridor is severely modified at the Ballard Locks, as the fresh- to saltwater transition occurs rather abruptly within the salt wedge and mixing zone near the locks.

3.5.3. Adult Migration

Adult salmonids returning to spawn in the Lake Washington basin must pass through the Ship Canal and the lake. Details on migration timing through the Ship Canal are discussed in Section 3.5.1. Adult Chinook salmon may enter Lake Washington days before moving into rivers for spawning. The average time spent by adult Chinook in Lake Washington in 1998 was 2.9 days (Fresh et al. 1999). For Sammamish watershed fish, the average was 4.9 days. Acoustic and temperature tags on adult Chinook salmon show that these fish inhabit waters of varying depths and temperatures. Temperature tag studies show that areas in the lake occupied by fish range in temperature from 48 to 70º F (9 to 21º C) (F. Goetz unpublished data in City of Seattle and USACE 2008). Adult sockeye salmon enter Lake Washington well before spawning. Freshwater entry occurs in the summer and the fish spawn in October and November (Newell and Quinn 2005). A fish tracking study conducted in 2003 indicated that 25 of 29 adult sockeye salmon that were initially detected south of the existing Evergreen Point Bridge were subsequently detected south of the bridge (Newell 2005). Of these, 10 fish exhibited back-and-forth behavior, meaning they swam under the bridge at least three times. Fish remained in the lake for an average of 83 days (range of 57 to 132 days) before migrating upstream to spawn; however, there was no apparent correlation between freshwater arrival date and spawning date. Most adult sockeye spend their time in Lake Washington below the thermocline, where temperatures are cooler. Over 90% of temperature detections in the lake were between 48° and 52° F (9° and 11°C), corresponding to water depths of 18 to 30 meters, with the fish rarely occupying available cooler and warmer waters (Newell 2005).

Ship Canal Water Quality Conditions and Adult Salmon Migration

Upstream of the Ballard Locks, water quality parameters such as temperature and DO may inhibit adult salmon movement away from the cool water refuge. The results of previous tagging studies indicate inter-annual variability in the duration of Chinook salmon holding just upstream of the locks, resulting in annual average delays of 2 days to 19 days (K. Fresh in City of Seattle and USACE 2008; Timko et al. 2002). These studies identified 19ºC as a temperature that most fish move through and 22ºC as the boundary beyond which fish do not migrate. In general, water temperatures above 19ºC correlate with fish staying longer at the locks.

This suggests that the Ballard Locks have been delaying the entry of some fish into Lake Washington, potentially based on elevated water temperatures. Water temperatures in the Ship Canal and Lake Union consistently exceed values that are physiologically stressful to salmon (i.e., greater than 20ºC) and can greatly exceed this threshold, as in 1998, when the daily average temperature peaks were 23.5ºC in early August (City of Seattle and USACE 2008).

Adult salmon passage through the Ship Canal and Lake Union is thought to be influenced by warm water temperatures in the Ship Canal, among other things. Both sockeye and Chinook salmon may be affected by these high temperatures. Sockeye tend to spend longer in the Ship Canal, but also keep to a tighter temperature range than Chinook. Chinook enter the Ship Canal later in the season when temperatures are higher, however.

The combined effect of the locks and the stratification of the water column contribute to water quality conditions that may adversely affect adult salmon, especially in years of high summer temperature. The potential biological effects on individual adult salmon from these degraded water quality conditions in the Ship Canal are not well documented; however, it is possible that physical conditions in the Ship Canal are a stress to holding or migrating adults that could cause pre-spawning mortality and reduced egg survival for those adults that survive to spawn, or make affected fish more susceptible to other stressors encountered during their migration.

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4. Impact Assessment

The purpose of this section is to characterize impacts on aquatic habitat and species from construction and operation of the SR 520 bridge replacement in Lake Washington and the Ship Canal, as part of the SR 520, I-5 to Medina Project. The characterization of impacts (and related mitigation benefits) required the development of impact assessment and mitigation methodologies that are applicable to the unique site conditions, impact types, and mitigation limitations of the proposed project, and that relate to the conceptual model presented in Section 3.6. The development of these methodologies was necessary to accurately describe and characterize those aquatic functions and values that will be negatively affected as a result of the project.

WSDOT recognizes that the mitigation benefits will almost certainly be of a different type than the impacts (based on the location and type of impacts); therefore, any methodology developed must be based on a framework that characterizes the aquatic functions and values lost at the impact site, as well as the aquatic functions and values improved at the mitigation sites.

In addition, some of the impact types for this project are unique and require a methodology that can accurately characterize and sum such impacts. One limitation to the methodology as proposed is that it is somewhat limited in its ability to characterize the benefits of minimization measures (such as bridge height) on impacts (e.g., shading).

An overriding goal of developing a conceptual framework and associated methodology was to create a relatively simple and tractable method for assessing impacts and benefits while acknowledging its limitations. Therefore, WSDOT developed a framework and associated methodology for impact assessment and mitigation evaluation that addresses the following key factors:

- **Biologically-Relevant Common Endpoints –** The methodology can sum a variety of stressors and impact mechanisms, as well as beneficial actions (e.g., mitigation actions) into several biologically-relevant endpoints, including life history stage effects and associated population endpoints/metrics. Endpoints were chosen based on their direct relation to important aquatic functions and values in the project area.

- **Spatial Sensitivity –** The methodology differentiates between the biological importance of specific geographic areas, and relates the physical impacts to the biological functions these areas support. The sensitivity includes the habitat/functional differences between various locations along the bridge alignment (floating bridge versus west approach) as well as differences between the project site and other sites (potential mitigation site locations) in the larger Lake Washington basin.

- **Temporal Sensitivity** – The methodology is able to integrate the overlap of temporary spatial impacts over time, which allows an assessment of the biological importance of impacts to specific fish life history stages.

The methodology described below was developed based on these key factors and was presented to resource agencies participating as part of NRTWG process. The final impact assessment methodology was formulated and refined incorporating NRTWG input.

The sections below describe the methodology in detail, including its direct application to the site-specific impacts of the SR 520, I-5 to Medina Project.

4.1 Impact Assessment Methodology

This section summarizes the project's approach to characterizing temporary and permanent aquatic impacts resulting from the project's construction and operation. The approach is applied to those impacts that cannot otherwise be avoided or minimized, and that are of a scale that will potentially negatively affect aquatic resources to a degree that will require compensatory mitigation. WSDOT has applied specific avoidance and minimization measures to potential impacts; these measures are discussed in detail in Section 5.The methodology focuses on those project impacts that deleteriously affect fish habitat, either directly or in most cases, indirectly (degradation of habitat functions), without full habitat displacement. The methodology is used to calculate both permanent and temporary impacts.

The use of such a habitat-based methodology is consistent with the guidance in WDFW Policy M-5002, which states that a project will not result in a net loss of aquatic habitat or habitat functions. The methodology was not designed to calculate other types of potential impacts that are disturbance-based or chemical in nature (e.g., pile driving or turbidity-related impacts) and that are generally related to construction activities. However, construction-related impacts do not result in a loss of habitat or function and their effect ceases almost immediately upon cessation of the activity. Furthermore, potential construction impacts, including in-water noise, temporary lighting, in-water turbidity/contaminants, and barge operation, have been avoided and/or minimized (see Section 5) to the extent that compensatory mitigation is not required. Similarly, potential non-habitat operational effects such as stormwater discharge and permanent bridge lighting (see Section 2) have been designed to be an improvement over the existing conditions.

The primary metrics for both impact characterization and subsequent calculation of functional uplift resulting from mitigation activities are based on the two-dimensional area of affected habitat. These metrics are then modified by a geographic (spatial) factor to account for differences in fish use by area and habitat type. The methodology calculates temporary impacts by integrating the temporal aspect of the impact-generating structures, and therefore results in impacts based on the concept of service-acre-years (the sum of impacted acres over time). The service-acre-year methodology proposed in this document is an adaptation of the concept used in Habitat Equivalency Analysis (NOAA 1995) to determine compensation for resource damages under the Natural Resource Damage Assessment (NRDA) process.

Figure 4-1 presents the primary functions in the aquatic habitat that will be affected by project construction and operation, and also shows the subsequent aquatic functions and salmonid life history stages affected. Habitat features will primarily be changed by physical mechanisms (e.g., alterations in benthic fill or daylight/shade-intensity), that in turn negatively affect aquatic habitat functions that support juvenile salmon migration and rearing. Based on an analysis of those habitat features substantially altered as a result of project construction and operation, three impact mechanisms were identified that produce the greatest effects on aquatic functions:

1. Artificial shading produced by project structures.
2. Changes in the number, size, and spacing of in-water structures all affect salmonid habitat complexity, which has the potential to attract salmonid predators.
3. Displacement of benthic habitat by in-water structures.

This impact assessment methodology is designed to calculate effects from habitat-based impacts. A detailed discussion of these three impact mechanisms is presented in Section 4.2.

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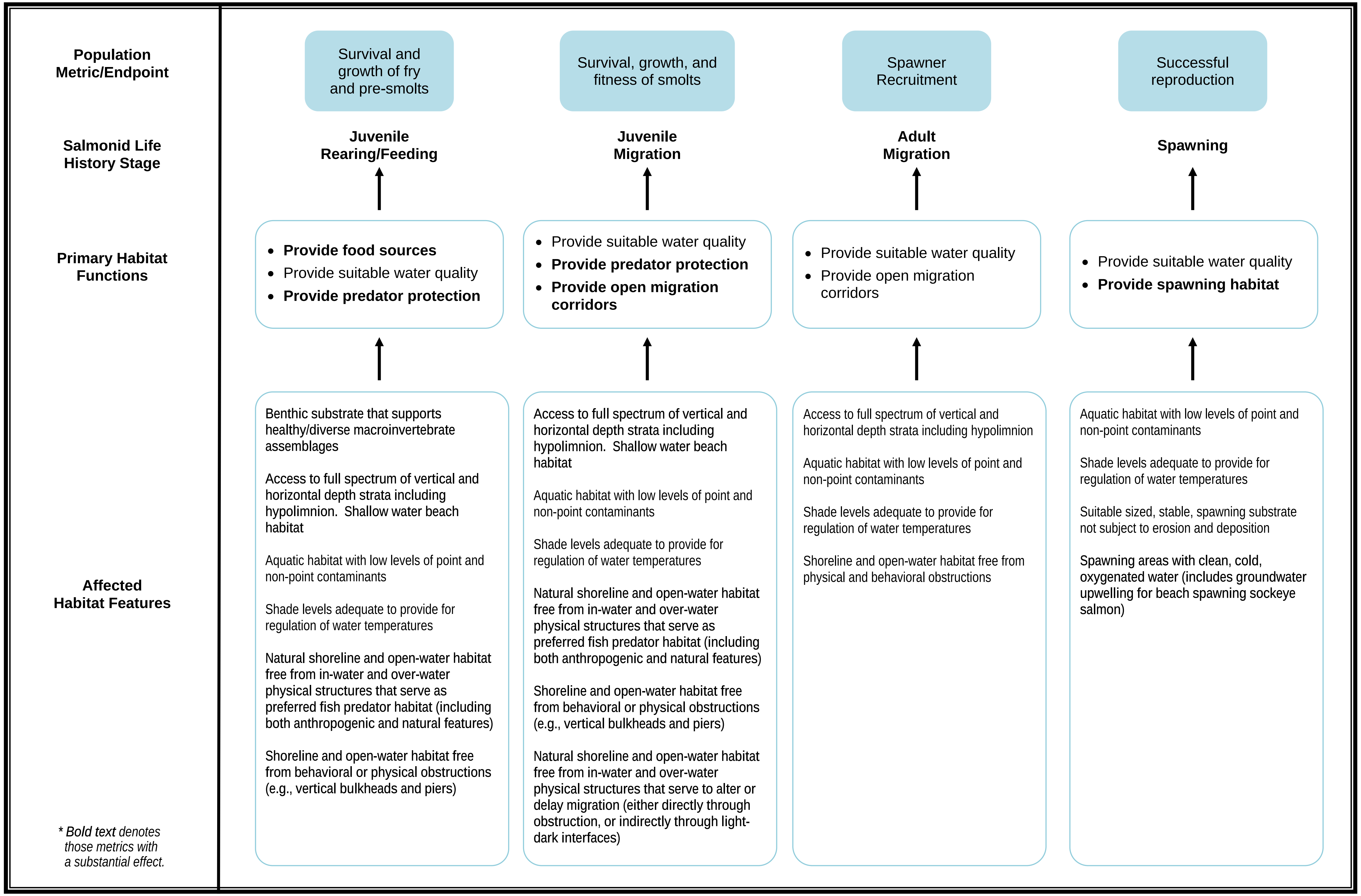
Figure 4-1. Conceptual Model of Project Impacts



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Fish Function Modifier

The impact assessment methodology applies a geographic (spatial) modifier to the impact metrics in order to characterize ecological function. This modifier (called the Fish Function Modifier) accounts for differing levels of fish use at various sites throughout Lake Washington. It is used to calculate the potential exposure of salmonid species to temporary and permanent stressors from project construction. Fish Function Modifiers were assigned based on (1) fish use numbers (i.e., the number of fish that likely use a specific geographic area); (2) the type of fish use (i.e., the life stages that are likely present); and (3) the duration of fish use (i.e., the temporal distribution of fish in the area throughout the year).

Project impacts were separated into eight geographically-distinct Salmonid Functional Zones that were based on salmonid utilization (as described in Section 3.5.2). Each zone containing a project-related impact was assigned an individual Fish Function Modifier, scaled to a number between 0 and 1. Zones 1 and 5 do not include any impacts and were not assigned a modifier. The modifier scores were based on the abundance and distribution factors listed above, and were scaled to represent the range of fish utilization in the Lake Washington basin. Table 4-1 describes the criteria used to determine the modifiers.

Two zones that have the highest fish use are Zones 3 and 6, which serve as the primary juvenile outmigration corridor for most (Zone 6) or all (Zone 3) salmonids spawned in the Lake Washington basin. These two zones were assigned the highest possible Fish Function Modifier, of 1.0. Zone 8, the East Approach Area, has some historical beach spawning use by sockeye salmon, as well as some use by shoreline-oriented juvenile outmigrants from the Cedar and Sammamish basins; therefore, the Fish Function Modifier is 0.8. Zone 2 (Portage Bay) has low to moderate use by Chinook and potentially by coho salmon outmigrants, although fish distribution is generally oriented away from the aquatic macrophytes beds on the zone's southern edge. Nonetheless, the entirety of the zone was assigned a Fish Function Modifier of 0.6. Zone 4 (Arboretum and Foster Island) was assigned a Fish Function Modifier of 0.1 based on the very low densities of Chinook and other juvenile salmonids present in this relatively shallow habitat that is heavily impacted by invasive aquatic macrophytes.

Zone 7 (Floating Bridge) represents deep-water and open-water habitat (depths greater than 30 feet). Although this zone has moderate use by rearing and outmigrating juvenile salmonids, it was assigned a relatively low Fish Function Modifier for several reasons. The mechanism of effect on salmonids is unique in this area (as discussed in Section 4.3.1), and does not fit well into the project effects analysis, which uses calculations based entirely on area. Therefore, the Fish Function Modifier in Zone 7 was adjusted downward for impact analysis purposes.

Furthermore, the Fish Function Modifier also takes into account the vertical distribution of fish in the water column in Zone 7. When considering Zone 7 from a plan view perspective (the entire water column bounded by the zone limits), the use of the entire zone by salmonids could be considered moderate. However, fish are not limited by depth; thus, their potential exposure to the project structures in the zone is expected to be fairly low. Likewise, returning adult salmonids are also able to use much of the water column during their spawning migrations, not only the portions of the water column containing the pontoons or their anchors. Therefore, the distribution of salmonids within Zone 7 that have the potential to be affected by the project is low in comparison with other habitat types. For these reasons, Zone 7 was assigned a Fish Function Modifier of 0.1.

Table 4-1. Proposed Scaling Factors and Criteria

Fish Function Modifier Score	Fish Function Modifier Criteria	Potential Impact Zones Within Category[a]
1 – Very High	Aquatic sites that are defined as critical migration or rearing areas for multiple species and stocks of juvenile salmon, or that serve as critical migration areas for multiple species and stocks of returning adults.	Zone 3 – Montlake Cut Zone 6 – West Approach
0.8 – High	Aquatic sites that are known to support documented spawning of at least one salmonid species, or Aquatic sites that serve as migration or rearing areas of considerable importance for one or more species of juvenile salmon, or that serve as migration areas of considerable importance for returning adults.	Zone 8 – East Approach
0.6 – Moderate	Aquatic sites that do not support salmon spawning, and where juvenile migration or rearing areas for juvenile salmonid species occurs, but where fish density, or temporal distribution of fish is lower compared to that of other sites.	Zone 2 – Portage Bay
0.1 – Low	Aquatic sites that do not support salmon spawning, and that have low or nominal use by salmonids for migration or rearing.	Zone 4 – Arboretum and Foster Island Zone 7 – Floating Bridge

[a] Zones 1 (north Portage Bay) and 5 (Union Bay) do not have structural impacts; therefore, no Fish Function Modifiers were assigned to these zones.

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4.2 Impact Characterization and Impact Mechanisms

The mitigation team calculated primary mechanisms of effect on aquatic ecological habitat by overlaying the proposed design onto the project base maps of aquatic features. The team then determined affected habitat areas as the area of intersection of the two sets, or a zone of effect around design features (e.g., predator habitat around bridge columns). Effects were calculated based on the project action that will cause the effect, and were broken down by the type of ecological stressors that the project action will affect. Specifically, impact characterization is based on areal cover of over-water structures (representing shading, which has potential impacts to fish migration and predator–prey relationships) and in-water structures (representing displacement of benthic habitat, and alteration of habitat complexity, which has potential impacts to fish predator–prey relationships).

The existing bridge structure likely has some effect on fish due to these mechanisms, and its removal will eliminate those effects. Therefore, the methodology for assessing permanent impacts estimates the change in effects to fish as a result of the project. Impact calculations are based on the net change (future conditions minus existing conditions) of area affected by the project to account for the ecological benefits of removing the existing structures.

Unlike the regulatory process for wetland mitigation, federal and state regulations and guidance do not prescribe calculation metrics or mitigation formulas for the majority of the effects to aquatic habitat. In addition, many of the potential effects to fish and other aquatic species will be indirect, and will result from effects to organism behavior patterns or effects to fish predators or prey resources. For example, partial shading effects from the new bridge structures could alter the migration patterns or timing of juvenile salmon, or influence the distribution of their predators. These effects could ultimately change the success rate of juvenile salmon migrating to marine waters.

Salmon, in particular Chinook salmon, were chosen as key indicator species when studying the impact mechanisms of the SR 520, I-5 to Medina Project, because these species are the most studied in the watershed, and a comprehensive data set is available that links habitat variables in the watershed to salmonids (City of Seattle and USACE 2008; King County 2005). The key salmonid life history functions that will be affected are directly related to the life history phases of the affected fish. These functions are juvenile rearing/feeding, juvenile migration, and beach spawning (sockeye) (see Figure 4-2).

The measurable impacts that affect the life history functions of salmonids are benthic habitat loss (e.g., fill), and those mechanisms that can alter fish behavior or predator–prey interactions (e.g., over-water and in-water structures, which can both increase predation and result in migration alterations or delays). It is important to note that of the identified and measurable impact mechanisms, the only category that includes complete habitat loss is the benthic habitat impact category. Shade and alteration of habitat complexity do affect fish, but do not measurably diminish the amount of available habitat. The following text describes each of these impact mechanisms in more detail.

4.2.1. Benthic Habitat Impacts

Biological effects to fish and benthic organisms come from the following:

- Temporary reduction in water quality associated with the installation and removal of temporary piles.
- Temporary loss of benthic organisms and other prey due to disturbance of the lake substrate.
- Permanent loss of benthic habitat from the installation of support columns and floating bridge anchors.

Increased turbidity is likely to occur from some of these project activities, although the distribution of the plumes will be limited due to the low-velocity water currents in the area. The size of the sediment particles is typically correlated with the duration of sediment suspension in the water column. Larger particles, such as sand and gravel, settle rapidly, but silt and very fine sediment may be suspended for several hours.

Sediment put into suspension by bottom disturbance may adversely affect salmonids' migratory and social behavior as well as their foraging opportunities (Bisson and Bilby 1982; Sigler et al. 1984; Berg and Northcote 1985). However, this impact pathway is considered temporary, and will be minimized by appropriate BMPs, as listed in Section 5.

Disturbed substrate sediments could have indirect effects on benthic flora and forage organisms, including the elimination or displacement of established benthic communities and thus a reduction in prey available for juvenile salmon. Suspended sediments can clog the feeding structures of filter-feeding benthic organisms; this reduces their feeding efficiency and increases their stress levels (Hynes 1970). However, benthic communities are expected to recover relatively quickly after the disturbance, resulting in a short-term loss rather than long-term loss. Also, there is no indication that prey abundance is a limiting factor in Lake Washington for salmonids. Some of the highest recorded juvenile sockeye growth rates have been observed in Lake Washington compared with the growth rates in other lacustrine systems (Eggers et al. 1978; Edmondson 1994), and Chinook salmon exhibit exceptional growth compared with growth in other populations (Koehler et al. 2006). Therefore, benthic habitat disturbance and displacement are expected to have potential effects only on those areas directly disturbed, and impacts to salmonid populations in Lake Washington and the Ship Canal will be minor.

4.2.2. Shading Impacts

Numerous factors are believed to affect the migration of salmonids through Lake Washington. It is unlikely that the presence of the existing bridge substantially affects most of these factors. Such factors include physiological development (smoltification) of migrating juvenile salmonids, overall water temperature of the lake and Ship Canal, and the size and condition of the migrating fish. However, the bridge and in-water bridge structures do present unnatural conditions in the migration corridor, which have the potential to alter the behavior of migrating fish. Alteration of migratory behavior could cause the fish to occupy or migrate through areas that are more or less productive than habitats they would otherwise occupy, require different energy expenditure levels, or subject the fish to more or less viable survival conditions.

The placement of permanent over-water structures will alter in-water shading intensities and patterns. Shade effectively creates a different habitat type that contrasts with the adjacent aquatic environment (lacking shade). In particular, the transition between light and shade (described as the edge effect) is considered a potential influence on fish behavior and habitat selection. The shadow cast by an over-water structure affects both the plant and animal communities below the structure.

Factors that influence in-water shade levels include the width and over-water height of new bridge decks, light diffraction (bending of light around an object) around the structures, light refraction (change in speed and direction of light when travelling from one medium to another, e.g., air to water), and the spatial alignment of the structures in relation to the path of the sun.

These factors are expected to change during project construction as temporary structures (e.g., work bridges) are built to facilitate construction, as the new bridge is constructed, and as the existing bridge is removed. Therefore, the overall extent and duration of over-water and in-water structures in the migration corridor will change over time, as will the potential effects of these changing features on migration behavior throughout the construction and operation phases of the SR 520, I-5 to Medina Project. Past studies of Lake Washington have indicated that the influence of in-water shading on fish behavior is complex and variable, and it may vary by species, time of year, and other factors.

New permanent fixed bridge structures will replace the existing Portage Bay Bridge and west approach. When the impact of shading from permanent bridge structures is considered, it is important to note that although these structures will be wider than the existing structure, they will also be substantially higher. The Portage Bay Bridge will be 7 to 11 feet higher (moving west to east) than the existing structure, and the new west approach structure will range in height above the water surface from approximately 18 feet just east of Foster Island to approximately 48 feet near the west transition span. Approximately 65% of the existing structure (western portion) is less than 10 feet above the surface water elevation at high water. This increase in height for the proposed structures will allow more ambient light under the structures, and although they will be wider, the intensity of the light-dark transition will be reduced overall.

Likewise, temporary over-water structures (work bridges) will also result in increased shading in the work area, although recovery to non-shaded conditions will be instantaneous and coincident with the removal of the structures. Furthermore, although work bridges tend to be very low to the water (5 to 10 feet), they are relatively narrow (about 30 feet) and in the case of the west approach, will extend only to approximately 10 feet of water depth. This means that much of the primary migratory corridor will be free of obstruction by work bridges, allowing fish to migrate around the work bridges, as fish have been documented to do for docks and other structures.

Shading and Effects on Outmigration

Shading from the bridge may affect several different salmonid species and stocks; particularly anadromous salmon produced in the Cedar River, because the proposed bridge will cross the migratory path of all juvenile fish from the river's spawning grounds. The bridge will cross the southeast edge of Union Bay, which serves as a migration corridor and as a short-term (less than 24 hours) holding area (Celedonia et al. 2008a). The new bridge will have an over-water approach structure at the edge of Union Bay, similar to the existing structure in this area. Studies of site-specific migration in this area focused on juvenile Chinook salmon, and these studies do not indicate that the existing bridge substantially alters the migration paths or timing of Chinook juveniles (Celedonia et al. 2008a, 2008b, 2009). As previously mentioned, the proposed bridge structure will be wider and higher above the lake surface than the existing bridge. Current information does not indicate that these differences are likely to substantially change the behavior of juvenile Chinook migrating under the bridge.

Some juveniles pass directly under the bridge without delay, while others spend up to 2 hours holding close to the bridge. These short delays are unlikely to result in detectable changes in survival of Chinook or other juvenile salmon as they migrate through Lake Washington and the Ship Canal. In-water and over-water structures could affect the rate and/or route of juvenile outmigration. However, the specific effect will differ by species and by the particular behavior patterns exhibited by individual fish. For some species and behavior patterns (e.g., Chinook juveniles exhibit active migration behavior), migration rates could be slowed slightly if fish tend to hold under a wider bridge deck for longer periods than they do under existing conditions. This change is not readily quantifiable; it is expected to be unmeasurable relative to existing conditions. Based on past studies, overall migration routes are unlikely to change significantly because individuals will encounter a transition point (i.e., shadow boundary) similar to that of the baseline condition and are expected to react in a similar manner. Therefore, the fish will pass through relatively quickly, move to deeper water to pass, or will be inclined to hold and/or rear for some period of time. Because salmonids can see in dim conditions, the information suggests that contrast in the boundary of shade may be the primary factor affecting behavior. Once the transition is made, fish either appear to move quickly through or hold in the shaded areas.

Celedonia et al. (2008b, 2009) showed that actively migrating fish demonstrated the three commonly observed behavior types: (1) minimal response, (2) paralleling, or (3) meandering or milling near the bridge after paralleling. The majority of fish that exhibited a holding behavior crossed multiple times or were observed milling under the bridge. None of these observations suggests that the width of the bridge shadow is influencing behavior. Spatial frequency data suggest that the majority of fish are not selecting for habitat under the bridge, so increased bridge width is not likely to result in a meaningful benefit in holding habitat. The data suggest that the transition between light and shade and the sharpness of that contrast may have the greatest influence on migration behavior.

Biological Effects of Outmigration Delays

A number of factors affect the migration rate and route of juvenile and adult salmonids through Lake Washington. Such factors include depth preferences, temperature gradients, macrophyte density, and size of the migrating fish. Although the project could incrementally affect fish behavior in terms of these innate biological factors, information on fish behavior in the project vicinity suggests that the existing structures do not result in substantial alterations of migration behavior. The location of new bridge will overlap the location of the existing bridge for a substantial portion of the primary juvenile migration route through the project area (near the west high-rise). Therefore, individuals will encounter a similar transition point (i.e., shade boundary) and similar depth conditions, although the extent and density of aquatic macrophytes could change slightly due to the wider bridge structure.

Studies indicate that active migration behavior is predominant in juvenile Chinook as opposed to holding behavior. Alteration of migration rate or migration route may result in increased energy expenditures by actively migrating fish that exhibit paralleling behavior. Relative to the overall energy expenditure (using time as a surrogate) of outmigration, actively migrating juvenile Chinook are adding only minutes to a migration typically lasting days to weeks. This change in the migration rate should not represent a significant disruption to migration behavior. Gauging any potential increase in energy expenditure in actively holding fish is speculative because they are likely taking advantage of foraging benefits during the holding period. Current information suggests that holding fish will likely behave in a manner similar to the current condition; moreover, the primary potential residual effect on migration behavior for holding fish may result in exposure to increased mean water temperatures from a later migration. The extent to which this effect may reduce survival is likely highly variable and speculative.

The project team concluded that a relatively minor migration delay may result from the increased shade from the new bridge structure. In many cases, this delay will have an insignificant effect on juvenile survival and fitness. In other cases, slight reductions to juvenile survival or fitness may result. However, several factors suggest that effects on migration patterns will be moderated:

1. Data do not indicate that the existing bridge has a detrimental influence on the migration behavior associated with adult or juvenile salmonids in the Lake Washington system.

2. Although the new structure will be wider, it will also be higher and will contain fewer columns than the existing structure. This will produce narrower, more diffuse shadows than the existing structure.

4.2.3. Habitat Complexity-Predation Impacts

The placement of temporary and permanent in-water structures will alter the structural complexity of the aquatic habitat. The effects of these structures on benthic habitat are discussed above; this section addresses the structures' effects on water column habitat.

Habitat complexity influences the behavior and distribution of fish, including both salmonids and their predators. Project-related factors that influence this complexity are primarily the amount of in-water structure per unit area and the spatial alignment of the structures in relation to one another, such as distance between shafts (or columns) and the distance between piers (span length).

Current information does not indicate that the existing bridge structure has any influence on adult salmonids' predator–prey interactions in Lake Washington. Because the new structures will be sufficiently similar in arrangement and size to the existing structures, they are not likely to have a different influence on these predator–prey interactions.

Therefore, any effects on associated predator–prey distributions requiring compensatory mitigation are expected to apply mainly to juvenile salmon outmigration. Any such effects will likely be much reduced for older age classes and larger-size fish (such as residual Chinook, steelhead, or coho). During outmigration, these larger fish are generally not exposed to predation because of their limnetic distribution; they do not show the same affinity for the shoreline as do smaller migrants such as 0-age Chinook salmon and sockeye.

The work bridges and the replacement bridge will result in substantial increases in shading and habitat complexity in the project area. These conditions are expected to provide additional predator habitat in the area during the proposed construction period, although the long-term habitat conditions are expected to be similar to existing conditions.

Species known to prey on juvenile salmon include northern pikeminnow and smallmouth bass. The data suggest that northern pikeminnow do not select areas near the bridge over other habitat types. Studies found that this species was primarily concentrated at 4- to 6-meter depths, and most commonly used habitat with moderately dense vegetation. Some attraction to nighttime lights was noted, although this was inconsistent from year to year (Celedonia et al. 2008a, 2008b, 2009). Although smallmouth bass showed an affinity for the bridge columns, information suggests that their overall abundance is no greater at the bridge than in other suitable habitat types. In addition to selecting the bridge columns as a structural habitat component, smallmouth bass were found to prefer a depth of 4 to 8 meters and often sparse vegetation or edge habitat associated with macrophytes. Moderately dense to dense vegetation was used only occasionally. Neither pikeminnow nor smallmouth bass have been shown to prefer the shade or cover provided by the overhead bridge structure.

The fewer and more widely spaced in-water columns of the proposed permanent bridge structures are expected to generally reduce habitat complexity in the immediate area of the bridge, although the columns will extend out. This alteration is not expected to substantially affect the quality of predator and prey habitat provided by the permanent bridge structures. With the exception of Zone 7 (Floating Bridge), the increased habitat complexity associated with temporary structures will occur primarily in shallow water areas, which already contain substantial complexity from aquatic macrophyte beds. An increase in bridge height could allow more ambient light under the bridge and an increase in macrophyte density, particularly along the southern exposure. An increase in height will also reduce the intensity of cover caused by shading. This increase could in turn positively affect northern pikeminnow habitat and negatively affect smallmouth bass habitat. Therefore, while the project may slightly increase the quality of the available predator habitat in the project area, this increase will generally be minor.

However, some proportion of outmigrating juvenile Chinook salmon (and possibly other salmonid species) is likely to exhibit a holding behavior, resulting in increased residence time around the west approach structure. Of those fish exhibiting holding behavior, some may experience direct mortality via predation while holding near the structure, or a reduction in overall fitness as suggested by later saltwater entry (Celedonia 2009).

Although impacts to the aquatic habitat are expected to occur due to increased shade and structural complexity, several factors suggest that associated changes to predator–prey relationships will be low:

1. The new bridge will represent an improvement over the baseline conditions because the bridge is higher (although wider) and has fewer and more widely spaced in-water structural elements, reducing the overall complexity per unit area.

2. Current data do not indicate that the existing bridge has an influence on predator–prey relationships associated with adult salmonids.

4.2.4. Potential Effects on Adult Salmon

The impact mechanisms associated with the long-term operation of the project (shading/migration effects, predation, and benthic fill) apply primarily to juvenile salmonids, specifically to outmigrating fish. Adult salmonids are not expected to be measurably affected by project operation because they are not rearing, nor are they subject to piscivory, and they migrate through the project area quickly in deeper water. However, returning adults will be migrating through the project area during a time when relatively intensive in-water construction activities occur. Project avoidance and minimization measures will limit or eliminate direct construction effects.

Data are insufficient to assess the potential influence of the existing west approach bridge structure on the migration behavior of adult salmonids as they return to the Lake Washington watershed to spawn. Most Lake Washington adult Chinook salmon adults are likely to migrate through the action area from June through late September. However, individual adult salmonids are expected to migrate relatively quickly through the project area, and in relatively deep water (where water temperatures are cooler) away from the most intensive in-water construction areas. This behavior is likely to minimize potential effects on adult salmonids. The average time spent by adult Chinook salmon in the Lake Washington in 1998 was 2.9 days (Fresh et al. 1999). This tendency of adult salmonids to migrate quickly through Lake Washington, once they begin moving, and their lack of dependence on shoreline habitat, limit their susceptibility to construction and operation of the Evergreen Point Bridge structures. The existing data indicate that adult salmon do not congregate within the west approach/Union Bay area during their migration to spawning areas in the Lake Washington basin. Available data do not indicate that returning adults respond to light and they are not susceptible to piscivory in Lake Washington.

An analysis of the extent of project-related construction impacts concludes that returning adult salmon will not be adversely affected. Through pre-project studies, including the test pile project, WSDOT has sought to identify and demonstrate that best management practices will minimize the potential for impacts to fish. Turbidity and noise observations during the test pile project (Illingworth and Rodkin 2010) suggest that construction impacts from in-water work activities are not expected to affect the primary migratory corridor for returning adult salmonids. Research suggests that adult salmon use a migratory corridor with water depths of approximately 20 feet or greater through the Ship Canal (Fresh et al. 1999). WSDOT analyses show that underwater noise and turbidity will not exceed identified thresholds within 300 feet of this migratory corridor in the Ship Canal. Although construction activities will cross the migratory corridor in the west approach vicinity, this is after adult fish have completed their migration through the Ship Canal, and adult fish are expected to use deeper water in this area where the only in-water construction activities will be anchor placement. Anchor placement occurs in Lake Washington in deep waters after adult salmon have successfully migrated through the Ship Canal. As such, the potential for adult exposure to construction-related impacts is considered to be very limited, and would most likely occur in the deep anchor placement locations where avoidance would require little effort.

For these reasons, no causal link can be established from the project regarding potential effects to adult fish, so direct compensatory mitigation for adults is not warranted. However, WSDOT recognizes that returning adult fish in the Lake Washington Ship Canal are exposed to potential stress due to degraded water quality conditions in this area (see Section 3.6.3 for discussion). Therefore, while the proposed mitigation activities are generally focused on offsetting impacts to future year-classes of juvenile salmonids, several mitigation actions are included that will also directly and indirectly benefit adult fish in the unlikely event that adult fish are affected by project construction activities.

4.2.5. Potential Effects on Limnology

In response to comments from the Muckleshoot Indian Tribe Fisheries Division (MITFD) on the potential effects of the floating span on lake circulation, WSDOT undertook a study to evaluate the possibility of effects to aquatic life (WSDOT 2011e). A conceptual model was developed to analyze the interaction of the proposed floating span on circulation and temperature, and found that the floating span will not have measurable effects on these limnological processes. As such, no impacts to aquatic life are anticipated from an alteration of limnological process.

4.3 Impact Assessment

4.3.1. Shading Impacts

To calculate the shading impacts of the permanent and temporary over-water structures, WSDOT first determined the total net acreage of (plan view) over-water structure resulting from construction and operation of the project (Figure 4-2; Tables 4-2 and 4-3). This calculation did not include the column and footing areas because these impacts were calculated as a separate impact type (see Section 4.3.2, Benthic Habitat Impact). For each impact type (permanent and temporary), the impacts were then sorted by Salmonid Functional Zone and multiplied by the appropriate Fish Function Modifier (see Section 4.1).

Impacts to juvenile salmonids, if any impacts occur in this zone, are believed to be generally limited to slight migration delays in the deep water habitat. Therefore, WSDOT used the total area of the pontoon structures to calculate the shading (migration) impact. WSDOT believes that this approach is a conservative approximation of environmental risks from the floating bridge, which are insignificant and discountable.

For permanent shading, the modified acreages were then summed to produce a total impact number (7.14 acres) that will require offsetting mitigation (see Table 4-2). For temporary shading impacts, a similar process was used, but the modified acreage was calculated by year (based on the area of over-water structure present during each construction year), and then summed to yield a time-weighted impact number of 12.36 acre-years (see Table 4-3). One acre-year is defined as one acre of impact over one year. This calculation takes into account the cumulative temporal effect of multiple structures present for specific time periods.

As noted in Section 4.1, impact calculation for shading (as a surrogate for migration impacts) in Zone 7 represents a special case, because unlike the other zones, any migration effects in this area would be caused by an obstruction in open water habitat and not shading on an open water column. Although the draft of the new pontoons will be slightly deeper than that of the existing pontoons, migrating fish could still move under the structure, and/or orient along the structure.

Additional over-water structure (potential shading impact) will result from construction of the new maintenance dock. However, this impact is considered self-mitigating because construction will require removal of two existing docks located directly under the new east approach bridges. Removal of the southern dock will eliminate about 860 square feet of over-water structure, while removal of the northern dock will benefit about 545 square feet of lake habitat. These docks are constructed of creosote-treated timber and have wooden decking with little to no space between the deck planks, both factors that are known to degrade habitat quality for salmonids. Therefore, removal of these two structures (totaling 1,405 square feet in over-water area) will fully offset construction of the maintenance facility dock (about 1,226 square feet of over water structure without grated decking). Approximately 1/3 of the decking will be grated, allowing a significant amount of ambient light to pass through. The new maintenance dock will be constructed using materials that do not negatively affect water quality. Finally, the maintenance facility dock will be generally higher off of the water surface than the existing docks (also increasing ambient illumination), ranging from about 1 foot off the water at the lowest point, gradually rising up to about 7 feet above the water at the shoreline. These actions will maintain or improve aquatic habitat conditions along the shoreline area of the east approach.

Temporary shade impacts will result from the work bridges in Portage Bay, the west approach, and the east approach, as well as the temporary widening of the existing Portage Bay Bridge. Further review of the impact assessment methodology described in the conceptual plan indicated that areas underneath the proposed bridge and work bridges were calculated as both temporary and permanent impacts for the same areas. This plan reflects a change to account for those areas affected only by the work bridges' temporary shade impacts and the proposed bridge's permanent shade impact.

During the NRTWG process, WSDOT described the elevation of temporary and permanent work bridges and explored whether higher bridges might have less impact on aquatic resources. During these discussions it was established that work bridges would likely have little clearance between the bottom of the structure and the water's surface, creating a high potential for shade impacts, whereas permanent bridges are expected to be considerably higher, providing opportunities for direct and refracted light to limit shade intensity. Ultimately, due to the complexities involved in analyzing shade impacts, the NRTWG group concurred with considering all areas under bridge limits to be shaded and to require equivalent impact quantification.

Shading impacts can be temporary or permanent, but not both. Therefore, aquatic habitat areas under the proposed permanent bridge limits that are also under proposed work bridges will be considered permanent shade impacts. The temporary shade impact quantities contained in this document reflect the area of work bridges over aquatic habitat outside of the proposed permanent bridge limits.

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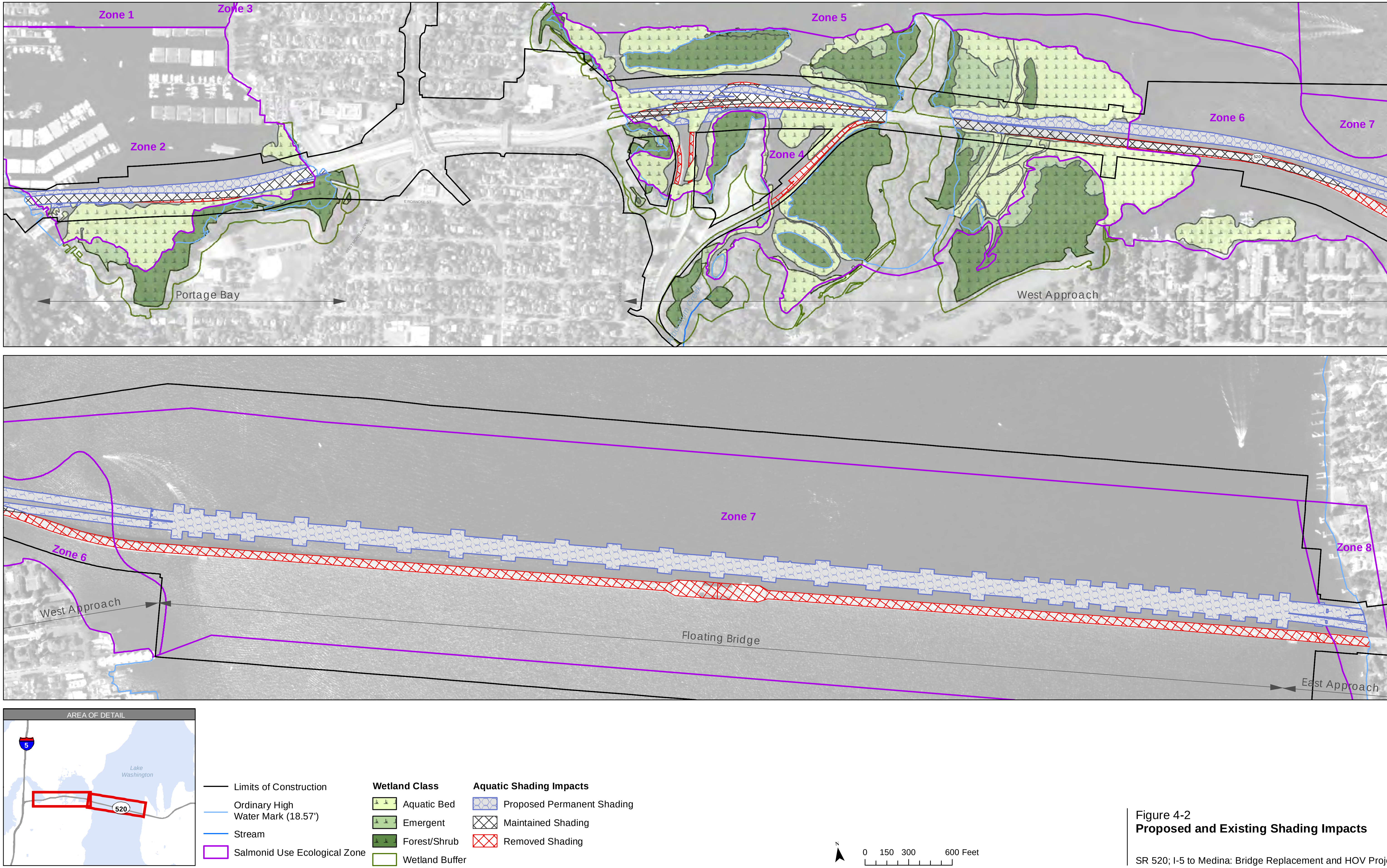

Figure 4-2
Proposed and Existing Shading Impacts

SR 520; I-5 to Medina: Bridge Replacement and HOV Project

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Table 4-2. Permanent Project Impacts

Salmonid Use Ecological Zone	Existing Acreage	Proposed Acreage	Net Acreage	Fish Function Modifier	Permanent Impacts (acres)[a]
Permanent Shading Impacts					
Zone 8: East Approach	0.30	0.91	0.61	0.8	0.49
Zone 7: Floating Bridge	12.09	26.54	14.45	0.1	1.45
Zone 6: West Approach	2.61	5.28	2.67	1.0	2.67
Zone 4: Arboretum and Foster Island	7.22	8.50	1.28	0.1	0.13
Zone 3: Montlake Cut	0.14	0.18	0.18	1.0	0.18
Zone 2: Portage Bay	3.13	6.85	3.72	0.6	2.23
		Total Permanent Shading Impacts			**7.14**
Permanent Benthic Impacts (includes impacts to sockeye spawning beach habitat)					
Zone 8: East Approach	0.18[b]	0.01	0.00	0.8	0.00
Zone 7: Floating Bridge	0.02	0.49	0.47	0.1	0.05
Zone 6: West Approach	0.03	0.09	0.06	1.0	0.06
Zone 4: Arboretum and Foster Island	0.11	0.09	-0.02	0.1	0.00
Zone 2: Portage Bay	0.04	0.34	0.30	0.6	0.18
		Total Permanent Benthic Impacts			**0.29**
Permanent Habitat Complexity Impacts					
Zone 8: East Approach	0.03	0.03	0.00	0.8	0.00
Zone 7: Floating Bridge	0.11	0.07	-0.04	0.1	0.00
Zone 6: West Approach	0.46	0.36	-0.10	1.0	-0.10
Zone 4: Arboretum and Foster Island	1.08	0.48	-0.60	0.1	-0.06
Zone 2: Portage Bay	0.37	0.25	-0.12	0.6	-0.07
	Total Permanent Habitat Complexity Impacts				**0.00[c]**
		Grand Total Permanent Impacts Acres			**7.43**

[a] The sum of individual impact numbers may not equal the totals due to rounding.

[b] Impact value includes the area of the spread footing (0.17 ac) for the purposes of CWA Section 404 permtting. This acreage is not carried forward for permanent impact mitigation accounting purposes since the footprint of the spread footing will be restored. The 0.17 acre impact is carried forward for temporary impact mitigation purposes below in Table 4.3.

[c] The negative values for each zone are negative, as is the total. Therefore, permanent habitat complexity habitat conditions will improve, and no impact will result.

Table 4-3. Temporary Project Impacts

Salmonid Use Ecological Zone	Sequence (Calendar Year)	Acreage	Fish Function Modifier	Modified Acreage	Impact Duration (Years)	Temporary Impacts (Acre-Year)
Shading Impacts						
Zone 8: East Approach	2012	0.19	0.8	0.15	1	0.15
	2013	0.19	0.8	0.15	1	0.15
	2014	0.19	0.8	0.15	1	0.15
	2015	0.0	0.8	0	1	0
	2016	0.0	0.8	0	1	0

Salmonid Use Ecological Zone	Sequence (Calendar Year)	Acreage	Fish Function Modifier	Modified Acreage	Impact Duration (Years)	Temporary Impacts (Acre-Year)
	2017	0.0	0.8	0	1	0
					Subtotal	**0.46**
Zone 7: Floating Bridge	2012	0.05	0.1	0.01	1	0.01
	2013	0.05	0.1	0.01	1	0.01
	2014	0.05	0.1	0.01	1	0.01
	2015	0	0.1	0	1	0
	2016	0	0.1	0	1	0
	2017	0	0.1	0	1	0
					Subtotal	**0.02**
.Zone 6: West Approach	2012	0	1.0	0.00	1	0.00
	2013	1.10	1.0	1.10	1	1.10
	2014	1.10	1.0	1.10	1	1.10
	2015	1.86	1.0	1.86	1	1.86
	2016	1.86	1.0	1.86	1	1.86
	2017	0.76	1.0	0.76	1	0.76
					Subtotal	**6.68**
Zone 4: Arboretum and Foster Island	2012	0	0.1	0.00	1	0.00
	2013	1.23	0.1	0.12	1	0.12
	2014	1.23	0.1	0.12	1	0.12
	2015	2.80	0.1	0.28	1	0.28
	2016	2.80	0.1	0.28	1	0.28
	2017	1.57	0.1	0.16	1	0.16
					Subtotal	**0.96**
Zone 2: Portage Bay	2012	0	0.6	0.00	1	0.00
	2013	1.99	0.6	1.19	1	1.19
	2014	2.16	0.6	1.30	1	1.30
	2015	2.16	0.6	1.30	1	1.30
	2016	0.69	0.6	0.41	1	0.41
	2017	0.30	0.6	0.18	1	0.18
					Subtotal	**4.38**
			Total Shading Temporary Impacts			**12.49**
Benthic Impacts[a]						
Zone 8: East Approach	2012	0.17[b]	0.8	0.14	1	0.14
	2013	0.01	0.8	0.01	1	0.01
	2014	0.01	0.8	0.01	1	0.01
	2015	0.0	0.8	0	1	0.00
	2016	0.0	0.8	0	1	0.00
	2017	0.0	0.8	0	1	0.00
					Subtotal	**0.16**
Zone 7: Floating Bridge	2012	0.03	0.1	0.00	1	0.00
	2013	0.01	0.1	0.00	1	0.00
	2014	0.01	0.1	0.00	1	0.00
	2015	0	0.1	0.00	1	0.00
	2016	0	0.1	0.00	1	0.00
	2017	0	0.1	0.00	1	0.00

Salmonid Use Ecological Zone	Sequence (Calendar Year)	Acreage	Fish Function Modifier	Modified Acreage	Impact Duration (Years)	Temporary Impacts (Acre-Year)
					Subtotal	**0.01**
Zone 6: West Approach	2012	0	1.0	0.00	1	0.00
	2013	0.04	1.0	0.04	1	0.04
	2014	0.04	1.0	0.04	1	0.04
	2015	0.07	1.0	0.07	1	0.07
	2016	0.07	1.0	0.07	1	0.07
	2017	0.03	1.0	0.03	1	0.03
					Subtotal	**0.25**
Zone 4: Arboretum and Foster Island	2012	0.00	0.1	0.00	1	0.00
	2013	0.06	0.1	0.01	1	0.01
	2014	0.06	0.1	0.01	1	0.01
	2015	0.13	0.1	0.01	1	0.01
	2016	0.13	0.1	0.01	1	0.01
	2017	0.07	0.1	0.01	1	0.01
					Subtotal	**0.05**
Zone 2: Portage Bay	2012	0.00	0.6	0.00	1	0.00
	2013	0.09	0.6	0.05	1	0.05
	2014	0.09	0.6	0.05	1	0.05
	2015	0.09	0.6	0.05	1	0.05
	2016	0.04	0.6	0.02	1	0.02
	2017	0.02	0.6	0.01	1	0.01
					Subtotal	**0.19**
			Total Benthic Temporary Impacts			**0.65**
Habitat Complexity/ Predator Impacts						
Zone 6: West Approach	2012	0	1.0	0.00	1	0.00
	2013	0.64	1.0	0.64	1	0.64
	2014	0.64	1.0	0.64	1	0.64
	2015	1.00	1.0	1.00	1	1.00
	2016	1.00	1.0	1.00	1	1.00
	2017	0.44	1.0	0.44	1	0.44
	Total Habitat Complexity/ Predator Temporary Impacts					**3.72**
		Grand Total Temporary Impacts				**16.87**

[a] Based on the absence of design information on the location of piles to support temporary work trestles, benthic habitat impacts were computed using the estimated pile area to work bridge area for the entire over-water structure area of the work bridge decks.

[b] Represents the spread footing impact footnoted under Table 4-2.

4.3.2. Benthic Habitat Impact

Permanent benthic habitat impacts were calculated for permanent over-water structures by first determining the total net acreage of benthic structures at all water depths less than60 feet (see Figure 4-3 and Tables 4-2 and 4-3). This depth cut-off was deemed appropriate by NRTWG participants based on the life history of salmonids in the project area because these salmonids do not use benthic habitat in these greater depths. These benthic habitat impacts were weighted by their respective fish function modifier and summed to produce a total impact of 0.29 acres that will require offsetting mitigation (see Table 4-2).

Temporary benthic impacts will result from the work bridges, mooring dolphins, cofferdams, bridge footings at the east approach, and the temporary columns associated with the temporary Portage Bay Bridge widening (2013) and the interim west approach connection (anticipated in construction years 2015 and 2016). The bridge footings at the east approach are considered a temporary benthic impact because they would be buried 8 to 10 feet below mudline, and the affected substrate habitat would recover after installation. The combination of the temporary construction elements would result in 0.64 acre-years of impact.

4.3.3. Habitat Complexity Impacts

To calculate the impacts of the permanent in-water structures (columns and piers) on habitat complexity (predation), WSDOT first determined the area of the predation zone around each in-water structure. The predation zone area is based on data describing predator behavior (discussed in Section 3) and is defined as the plan view distance of the portion of the water body extending from the outside edge of a column or pier to a distance of 5 feet (i.e. a 5-foot buffer around each vertical structure).

The 5-foot distance was chosen based on field observations and scientific studies of the visual detection and reaction distances in piscivorous fish. For example, Sweka and Hartman (2003) measured a maximum reactive distance for smallmouth bass of 65 centimeters (cm) (2.1 feet) in clear water. The reactive distance decreased exponentially with increasing turbidity. Similar reactive distances (between 0.8 and 6.6 feet) have been measured for largemouth bass (Howick and O'Brien 1983; Savino and Stein 1989), with the vast majority of strikes occurring within a distance of 5 feet. Based on these data, a predation zone of 5 feet was applied to each bridge column. For each Salmonid Functional Zone, the net change in predation area was calculated and then multiplied by the appropriate Fish Function Modifier (see Table 4-2).

For permanent habitat complexity impacts, all modified acreages for each Salmonid Functional Zone were negative. This indicates that the net predation area will decrease under future conditions. Therefore, no compensatory mitigation is required (see Figure 4-4 and Table 4-2). For temporary habitat complexity impacts, an identical method was used for impact calculation, although temporary predation was calculated only for Zone 6, the west approach, because it includes the only area where temporary in-water structure overlaps with the primary outmigration route. The modified acreage was calculated by year (based on the area of over-water structure present during each construction year), and then summed to yield a time-weighted impact number of 3.72 acre-years (see Table 4-3).

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