

DRAFT

RESTORATION AND PROTECTION PLAN  
CITY OF SEATTLE  
SHORELINE MASTER PROGRAM

---

**Prepared for**

City of Seattle

Department of Planning and Development

700 Fifth Avenue, Suite 2200

Seattle, Washington 98124

**Prepared by**

Anchor QEA, LLC

1423 3rd Avenue, Suite 300

Seattle, Washington 98101

**December 23, 2011**

---

## **ACKNOWLEDGEMENTS/COLLABORATORS**

This report was prepared by Anchor Environmental QEA Inc. with input from the City of Seattle Department of Planning and Development. Review of the report was conducted by the following City of Seattle departments: Public Utilities, Transportation and Parks and Recreation. The base information for this report is from Seattle's Shoreline Characterion Report completed in March of 2009 and available for review on DPD's website at: [www.seattle.gov/dpd/Planning/ShorelineMasterProgramUpdate/ReportsMaterials/default.asp](http://www.seattle.gov/dpd/Planning/ShorelineMasterProgramUpdate/ReportsMaterials/default.asp). The contributions of these authors and reviewers are acknowledged and appreciated.

---

## TABLE OF CONTENTS

<b>EXECUTIVE SUMMARY .....</b>	<b>1</b>
Vision and Goals.....	2
Existing Restoration Planning, Programs and Partners.....	2
Applicable Restoration Actions.....	2
Citywide Impairments Summary .....	3
Lake Washington.....	3
Lake Union and Ship Canal .....	4
Duwamish River.....	5
Puget Sound, including Shilshole Bay and Elliott Bay.....	5
Green Lake.....	6
Implementation .....	7
<b>1 INTRODUCTION .....</b>	<b>8</b>
1.1 Plan Purpose and Scope .....	8
1.2 SMP Restoration Vision and Goals .....	9
1.3 No Net Loss of Ecological Function .....	11
<b>2 EXISTING RESTORATION PLANNING, PROGRAMS AND PARTNERS .....</b>	<b>11</b>
<b>3 RESTORATION STRATEGY .....</b>	<b>14</b>
3.1 Assessment of Existing Shoreline Impairments.....	14
3.2 Landscape Context Considerations in Restoration Planning.....	15
3.3 Habitat Protection and Conservation .....	18
3.4 Restoration Strategy .....	18
3.5 Application of Restoration Strategy.....	20
3.6 Project Identification .....	21
<b>4 APPLICABLE RESTORATION ACTIONS.....</b>	<b>23</b>
4.1 Citywide Impairments Summary .....	23
4.2 Lake Washington .....	24
4.2.1 Impairments.....	25
4.2.2 Applicable Restoration Actions.....	28
4.3 Lake Union and Ship Canal .....	34
4.3.1 Impairments.....	34

---

4.3.2	Applicable Restoration Actions .....	36
4.4	Duwamish River.....	40
4.4.1	Impairments.....	41
4.4.2	Applicable Restoration Actions .....	43
4.5	Puget Sound, including Shilshole Bay and Elliott Bay.....	49
4.5.1	Impairments.....	49
4.5.2	Applicable Restoration Actions .....	53
4.6	Green Lake.....	60
4.6.1	Impairments.....	61
4.6.2	Applicable Restoration Actions .....	62
<b>5</b>	<b>IMPLEMENTATION .....</b>	<b>64</b>
5.1	Implementation Strategy .....	64
5.2	Timeline, Benchmarks, and Monitoring.....	64
5.3	Potential Funding.....	65
5.4	Conclusions.....	67
<b>6</b>	<b>REFERENCES .....</b>	<b>68</b>

### List of Tables

Table 1	Guidance for Suitability of Restoration Strategies based on Level of Impairment.....	17
Table 2	Restoration Actions and Watershed Processes Addressed.....	21
Table 3	Freshwater Reach Assignments Based on Reach and Sub-reach Impairment Category .....	24
Table 4	Marine Reach Assignments Based on Reach and Sub-reach Impairment Category .....	24
Table 5	Lake Washington Reach Assignments Based on Reach and Sub-reach Impairment Category.....	25
Table 6	Impairment Category from Shoreline Characterization Report (Seattle 2009) for Various Watershed Processes at Lake Washington—City Shorelines.....	27
Table 7	Applicable Restoration Actions—Lake Washington .....	30
Table 8	Restoration Projects for Lake Washington.....	32

---

Table 9	Lake Union Reach Assignments Based on Reach and Sub-reach Impairment Category .....	34
Table 11	Applicable Restoration Actions—Lake Union and Ship Canal.....	37
Table 12	Restoration Projects for Lake Union and the Ship Canal.....	39
Table 13	Duwamish River Reach Assignments Based on Reach and Sub-reach Impairment Category.....	41
Table 14	Impairment ranges from Shoreline Characterization Report (Seattle 2009) for various watershed processes at Duwamish River – City shorelines .....	42
Table 15	Applicable Restoration Actions—Duwamish River .....	44
Table 16	Restoration Projects for the Duwamish River .....	46
Table 17	Puget Sound (including Shilshole and Elliott Bay) Reach Assignments Based on Reach and Sub-reach Impairment Category .....	49
Table 18	Impairment Ranges from Shoreline Characterization Report (Seattle 2009) for Various Watershed Processes at Puget Sound—City Shorelines.....	52
Table 19	Applicable Restoration Actions—Puget Sound .....	54
Table 20	Restoration Projects for Puget Sound .....	57
Table 21	Green Lake Reach Assignments based on Reach and sub-reach Impairment	60
Table 22	Impairment Ranges Impairment Ranges from Shoreline Characterization Report (Seattle 2009) for Various Watershed Processes at Green Lake–City shorelines.....	61
Table 23	Applicable Restoration Actions—Green Lake .....	63

## List of Maps – Separate Documents

Map A

Map Folio - Maps 1 through 25

---

## LIST OF ACRONYMS AND ABBREVIATIONS

ALEA	Aquatic Lands Enhancement Account
City	City of Seattle
CSO	combined sewer overflow
Ecology	Washington State Department of Ecology
GIS	Geographic Information System
Large Woody Debris	LWD
LDR Plan	Lower Duwamish River Habitat Restoration Plan
OHW	ordinary high water
NOAA	National Oceanic and Atmospheric Administration
PSNERP	Puget Sound Nearshore Ecosystem Restoration Project
Plan	Restoration and Protection Plan
RCW	Revised Code of Washington
SFLO	Washington Department of Natural Resources Small Forest Landowner Office
SMA or the Act	Washington State Shoreline Management Act
SMP	City of Seattle Shoreline Master Program
SRFB	Salmon Recovery Funding Board
TIA	total impervious surface area
WAC	Washington Administrative Code

---

## GLOSSARY

The following terms will have these definitions in the context of this Restoration and Protection Plan, in alphabetical order:

- **Ecological function:** the influences of the living and nonliving environment on organisms; functions provide for the growth and survival of organisms.
- **Goals:** measures by which the City of Seattle’s vision can be met.
- **Habitat:** an ecological or environmental area that is inhabited by and may have capacity to support the survival and growth of organisms.
- **Habitat action:** a general term for any intentional effort to improve or maintain habitat.
- **Habitat activity:** a specific work element; e.g., removal of unnecessary bulkheads and groins.
- **Impairment:** habitat degradation; in this document, refers to the loss of ecological function of shorelines as described in the *Shoreline Characterization Report* (Seattle 2009).
- **Impervious surface:** a hard surface area which either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development. Also refers to a hard surface area that causes water to run off the surface in greater quantity or at an increased rate of flow from the flow present under natural conditions prior to development.
- **Measure of Success:** measurable criteria that are currently quantified and which are suitable for before/after comparison. The City of Seattle may use these to evaluate site-specific or overall restoration project success; e.g., compare total linear feet of bulkhead in an area before and after a restoration project or set of projects.
- **Applicable Restoration Actions:** a list of the actions on which to focus effort and funding for restoration.
- **Project:** a site-specific set of habitat activities.
- **Reach:** for the purposes of this report a reach is a contiguous area within the shoreline jurisdiction that has somewhat consistent physical and biological conditions.
- **Restoration:** “the reestablishment or upgrading of impaired ecological shoreline processes or functions. This may be accomplished through measures including but not limited to re-vegetation, removal of intrusive shoreline structures and removal or

---

treatment of toxic materials. Restoration does not imply a requirement for returning the shoreline area to aboriginal or pre-European settlement conditions” (Washington Administrative Code [WAC] 173-26-020).

- **Restoration Strategy:** refers to whether the restoration prescribed supports habitat forming processes sustainably or substitutes a habitat sustaining process with constructed habitat structure. Strategies include protection, process restoration, rehabilitation, or creation.
- **Shorelands:** means those lands extending landward for 200 feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all wetlands and river deltas associated with the streams, lakes, and tidal waters.
- **Structure:** the composition and arrangement of physical attributes that compose habitat and that are formed as a result of watershed processes.
- **Sub-reach:** Contiguous areas of shorelands with relatively consistent levels of impairment, contiguous areas with variations in impairment that fall within a distinct range, contiguous areas with impairment that follows a consistent trend and in rare cases contiguous areas with heterogeneous levels of impairment.
- **Vision:** conceptual description of desired future shoreline condition.
- **Watershed processes:** the dynamic physical and chemical interactions that form and maintain the landscape at the geographic scales of watersheds to basins (hundreds to thousands of square miles; Stanley et al. 2005). These processes include the delivery, movement, and loss of water, large woody debris, sediment, phosphorus, nitrogen, toxins, and pathogens, as well as wave energy, tidal influences, and light energy.

---

## EXECUTIVE SUMMARY

This Restoration and Protection Plan (Plan) is prepared in support of the City of Seattle's Shoreline Master Program (SMP) update. The State's SMP guidelines require that SMPs promote restoration of impaired shoreline ecological functions identified based on a detailed inventory and characterization of the shoreline ecosystem. This Plan includes a description of this inventory and characterization and describes how and where shoreline ecological functions can be restored within City of Seattle (City) boundaries. It also outlines how future restoration activities will align with regional and other restoration efforts.

This Plan includes the following elements, according to SMP recommendations:

- Overall vision and goals for restoration of degraded shoreline areas and impaired ecological functions (Section 2).
- Identification of current and ongoing restoration plans applicable to the City shorelines and a description of restoration programs in the vicinity (Section 3).
- Procedures used for identification of degraded areas, impaired ecological functions, and sites with potential for restoration for City shorelines (Section 4).
- Identification of impairments and applicable restoration actions needed to achieve restoration goals for various City shorelines (Section 5).
- Description of strategies to ensure that restoration projects and programs will be implemented according to plans and to appropriately review the effectiveness of the projects and programs in meeting the overall restoration goals. This includes timelines and benchmarks for implementing the strategy, prospective funding sources for restoration projects and programs, obstacles and challenges to achieving local restoration goals, and a description of monitoring for the Plan (Section 6).
- Identify areas that should be preserved based on the results of the Shoreline Characterization Report.

This Plan is not a regulatory document or a set of regulatory requirements. There are several policies in the SMP, however, that point to this Plan as a guide for improving shoreline ecological function.

## **Vision and Goals**

As part of the SMP update process, the City has developed an overall vision for shoreline restoration. Goals have been developed that describe the specific measures that should be undertaken to meet the vision and which, in most cases, can be used as metrics to monitor the City's progress in achieving the vision.

## **Existing Restoration Planning, Programs and Partners**

Seattle, through the efforts of several city departments, is involved with restoration planning, restoration project implementation and monitoring of restoration projects.

Seattle Public Utilities is part of salmon recovery planning for Watershed Resource Inventory Areas 8 and 9 and has helped coordinate and fund both scientific research regarding salmonid use of shorelines and effectiveness monitoring of restoration projects. Seattle Parks and Recreation has implemented many shoreline restoration projects along Lake Washington, the Ship Canal, the Duwamish River and Puget Sound and has received funding from both the King Conservation District and Salmon Recovery Funding Board for these projects. Seattle Department of Transportation is involved with planning for the replacement of the seawall along Seattle's waterfront and has been testing alternatives to the homogenous surface with the goal of improving habitat for salmonid species and other aquatic organisms in Elliott Bay.

## **Applicable Restoration Actions**

Determining the applicable actions for restoration to take on the City shorelines relied upon a detailed shoreline analysis, which included a classification of impairment levels for basic ecological functions. These results were presented in the *City of Seattle Shoreline Characterization Report* (Seattle 2009). Shorelines assessed included Lake Washington; Lake Union and the Ship Canal; the Duwamish River; Puget Sound, including Elliott Bay and Shilshole Bay; and Green Lake. The framework was based on a method that provides a streamlined approach for characterizing watershed processes used by regional scientists. Processes evaluated included delivery, movement, and loss of water, large woody debris (LWD), sediment, phosphorus, nitrogen, toxins, and pathogens, as they enter, pass through, and eventually leave the watershed; wave energy and tidal influences (along marine shorelines only); and light energy (which includes artificial light). The assessment identified

the level of impact on habitat function in discrete shoreline reaches within City limits. Reaches were classified in the analysis into five categories of degradation: most impaired, more impaired, moderately impaired, less impaired, and least impaired.

This Plan acknowledges that the context of the impairments within the overall landscape should be considered. As sites vary in their landscape context and condition, they are appropriate for certain restoration strategies over others. The City will implement restoration through the general strategies of protection, process restoration, rehabilitation, and creation.

Restoration needs were determined for shoreline areas by evaluating the degree of ecological impairment for various watershed processes and by identifying restoration actions that would address these processes. Applicable actions were thus set to improve impaired ecological functions and/or protect existing function. Restoration and/or protection actions to be taken are provided with general descriptions on a reach scale. Detailed site-specific descriptions are not included because this information is already available in several existing restoration planning documents (documents listed in Section 3).

### ***Citywide Impairments Summary***

Within Seattle, all shoreline habitats have been impaired to some degree by human alterations; however, there are some areas that continue to provide relatively high quality habitat. The distribution of habitat impairments is uneven. The heavily industrialized shorelines of Lake Union downstream to the Ballard Locks, Elliott Bay, and the Harbor Island portion of the Duwamish River Estuary are the most impacted reaches, and even within these, there are some areas with higher habitat function (i.e., less impairment). Among the least impacted areas in the City are Seward Park, Union Bay, West Point and Magnolia Bluffs and Lincoln Park to Fauntleroy Cove.

### ***Lake Washington***

Highest functioning areas:

- Mature vegetated areas of the segment along the Burke-Gilman Trail, Matthews

Beach, the Thornton Creek delta, Northern Union Bay, and the parks

Lowest functioning habitats:

- Residentially developed areas where docks and armoring predominate, particularly in the areas south of Seward Park and from Madison Park to Colman Park (not including the parks)

Most impaired processes:

- Toxins, pathogens, sediment, water and wave

Highest applicable restoration actions:

- Armoring removal, water treatment, and riparian vegetation restoration

High priority areas for habitat protection:

- Areas with the least impairments; among these are wetland habitats of Union Bay and the areas of unarmored shoreline and riparian vegetation at Seward Park, in addition to any recent restoration project sites
- Stream mouths.

### ***Lake Union and Ship Canal***

Highest functioning areas:

- South shoreline of Portage Bay

Lowest functioning habitats:

- West shoreline of Portage Bay and Fisherman's Terminal

Most impaired processes:

- LWD, phosphorus, sediment, toxins, and water

Highest applicable restoration actions:

- Armoring removal, stormwater treatment, riparian vegetation restoration, substrate debris removal.

High priority areas for habitat protection:

- East Montlake Park and recent restoration sites, such as Salmon Bay Natural Area
- Undeveloped shoreline areas in Lake Union
- Creek mouths
- Areas with kelp or eelgrass beds

### ***Duwamish River***

Highest functioning areas:

- Kellogg Island, the adjacent shoreline, and the shore across the river from the island

Lowest functioning habitats:

- Industrial shorelines of remainder of Duwamish River study area

Most impaired processes:

- Light, LWD, nitrogen, phosphorus, toxins, water, and wave energy

Highest applicable restoration actions:

- Armoring removal, water treatment, and riparian vegetation restoration

High priority areas for habitat protection:

- Recent restoration sites, such as Kellogg Island, Herring's House Park, and the Terminal 105 Coastal America site

### ***Puget Sound, including Shilshole Bay and Elliott Bay***

Highest functioning areas:

- Unarmored portions of Golden Gardens Park, the creek mouth at the southern end of

Golden Gardens Park, and their associated marshes; Discovery Park, Lincoln Park, and Seola Park

Lowest functioning habitats:

- Shilshole Bay and Elliott Bay Marinas, the central waterfront, and Terminals 90 and 91

Most impaired processes:

- Pathogens and sediment

Highest applicable restoration actions:

- Armoring removal, stormwater treatment, riparian vegetation restoration, beach nourishment, LWD placement and daylighting streams.

High priority areas for habitat protection:

- Discovery Park, primarily West Point and Magnolia Bluffs, as well as recent restoration project sites such as Olympic Sculpture Park

### **Green Lake**

Highest functioning areas:

- Unarmored shores, vegetated riparian zones

Lowest functioning habitats:

- Armored shores, unvegetated riparian zones

Most impaired processes:

- Nitrogen and phosphorus

Highest applicable restoration actions:

Alum treatment or other similar action to treat high phosphorus levels. Bioswales or

similar treatments that would help to reduce the input of nutrients and pollutants into the lake.

High priority areas for habitat protection:

- Unarmored shores, vegetated riparian zones

## **Implementation**

Implementation of the restoration plan will be a joint effort of many City departments. The City's Comprehensive Plan will direct City departments to continue their work restoring the City's shorelines and to use the Shoreline Restoration Plan to guide their efforts.

The City's restoration work as it relates to this Plan will be monitored and evaluated on a set timeline against a suite of benchmarks to determine consistency with the State's SMP standard to improve ecological function over-time with the implementation of the Shoreline Restoration Plan. This Plan will be implemented when Seattle's Shoreline Master Program is adopted by the Washington State Department of Ecology, with a timeline based on 10-year intervals. At each interval, ecological benchmarks will be evaluated for change.

There is currently no dedicated funding source for the restoration actions presented here. Restoration described in this Plan is dependent on grant funding, and a variety of outside funding sources are available for restoration projects in the area. It is expected that funding will be derived from various sources.

As is the case for most restoration work, the opportunities described in this plan will require extensive cooperation and coordination with citizens, public agencies, private landowners, and other stakeholders.

---

## 1 INTRODUCTION

This Restoration and Protection Plan (Plan) is prepared in support of the City of Seattle's Shoreline Master Program (SMP) update. The SMP is being updated to comply with the Washington State Shoreline Management Act (SMA or the Act) requirements (Revised Code of Washington [RCW] 90.58) and the state's SMP guidelines (Washington Administrative Code [WAC] 173-26, Part III-201 2[f]), which were adopted in 2003. The City of Seattle (City) SMP is composed of policies and regulations that regulate the use and development of the City's rivers, lakes and marine shorelines and this Restoration and Protection Plan. The purpose of the SMP is to accommodate preferred shoreline uses, protect shoreline natural resources and provide for public access to public shorelines.

Washington State's shoreline guidelines define restoration as "the reestablishment or upgrading of impaired ecological shoreline processes or functions". This may be accomplished through measures including but not limited to re-vegetation, removal of intrusive shoreline structures and removal or treatment of toxic materials. Restoration does not imply a requirement for returning the shoreline area to aboriginal or pre-European settlement conditions" (WAC 173-26-020).

The State's SMP guidelines require that SMPs promote restoration of impaired shoreline ecological functions identified based on a detailed inventory and characterization of the shoreline ecosystem. To this end, the SMP must include a "real and meaningful" strategy to address shoreline restoration.

The scope of this document, the vision for restored shorelines and the context of this plan in complying with the state's SMP policies are discussed next.

### 1.1 Plan Purpose and Scope

The purpose of this Plan is to describe how and where shoreline ecological functions can be restored within City boundaries and to outline how future restoration activities will align with regional and other restoration efforts. City boundaries, shoreline reaches and shoreline restoration projects are shown on Map A (Separate document).

This Plan discusses the overall goals and applicable restoration actions of degraded shoreline areas and impaired ecological functions (Section 2). The Plan then identifies current and ongoing Plans applicable to the City shorelines and a description of restoration programs in the vicinity (Section 3). A discussion of the procedures used in an analysis to identify degraded areas, impaired ecological functions and sites with potential for restoration for City shorelines is also included (Section 4). The results of this analysis and the most applicable actions needed to achieve restoration goals for various City shorelines are provided in Section 5.

Finally, the Plan identifies strategies to ensure that restoration projects will be implemented and to appropriately review the effectiveness of the projects and programs in meeting the overall restoration goals (Section 6). This includes timelines and benchmarks for implementing the strategy, prospective funding sources for restoration projects and programs, obstacles and challenges to achieving local restoration goals and a description of monitoring for the Plan.

## **1.2 SMP Restoration Vision and Goals**

The City's vision for restoration in this SMP is based on science, policy, and public input. The *Seattle's Urban Blueprint for Habitat Protection and Restoration* (Seattle 2003) is a document which provides the science behind the City's desired future shoreline conditions and describes a variety of project actions that along with policy and public education actions can lead to restored habitats in Seattle. The SMA policy goals for SMPs were considered, (preferred shoreline uses, environmental protection, and public access). To develop the vision, the City undertook a community visioning process. During this process the citizens of Seattle expressed the desire to balance the three goals of the SMA and expressed a strong wish for the protection of Seattle's more natural and better functioning shoreline natural resources (details on the visioning process are described in the Draft Vision Report; Seattle 2008). Vision statements are summarized here.

The City's vision for restoration includes a shoreline with net gains in:

- Preferred shoreline uses:
  - Thriving water-dependent industrial and commercial uses.

- Educational opportunities to reflect Seattle’s maritime history and water-dependent business.
- Environmental protection:
  - Shoreline ecological function by protecting and/or improving watershed processes and the habitat features that those processes support.
  - Salmon populations and other fish and wildlife that depend on resources or habitat associated with the shoreline (e.g. eagles, great blue herons, otters).
  - Public understanding of the impact of policy and land use changes on environmental health
- Public access:
  - Variety of public access points for various users.
  - Views of the water and connectivity in green spaces with pedestrian and bicycle corridors.
  - Public transit and parking that serves public shoreline access.

This Plan describes a variety of project actions that along with policy and public education actions can help the city to achieve the vision. Goals have been developed that describe the specific restoration measures that should be undertaken to meet the vision and which, in most cases can be used as metrics to monitor the City’s progress in achieving the vision.

The City’s goals for shoreline restoration are to:

- Protect and restore shoreline processes and functions, especially in those areas identified as having geological or biological significance.
- Protect and restore softer, more natural shorelines that feature native plants and control of noxious weeds; more trees in more locations; and improved water quality.
- Protect and restore a diversity of habitats and strengthen ecological and physical connections between habitats.
- Support the monitoring and study of the shoreline systems that will provide a continuously updated baseline against which to judge the impact of any action.
- Support programs that inform the public about shoreline conservation practices, and identify methods by which public and private shoreline owners or community groups may encourage wild, aquatic, and botanical life, and require such methods when appropriate and provide incentives for such projects.

These restoration goals can be met by applying appropriate restoration strategies and implementing restoration actions, as discussed in Sections 4 and 5 of this report. Section 6 includes a discussion of the implementation strategy and benchmarks that will be used to determine if these goals are being met and the vision is being achieved.

### **1.3 No Net Loss of Ecological Function**

The state's SMP policies include a standard of no net loss of ecological functions that are necessary to sustain shoreline natural resources that must be adhered to by new SMPs. The Washington State Department of Ecology (Ecology) has clarified that this means that "establishing uses or conducting development are identified and mitigated with a final result that is no worse than maintaining the current level of environmental resource productivity" and "no uses or development supersede the requirement for environmental protection" (Ecology 2004). Restoration goes beyond no net loss by establishing an increase in the amount, size, and/or functions of an ecosystem or components of an ecosystem compared to a baseline condition (Thom et al. 2005). Achieving restoration of shoreline ecological conditions is a requirement of the SMP and is the key role of this Plan. This plan outlines the means and methods by which restoration will be accomplished for Seattle.

## **2 EXISTING RESTORATION PLANNING, PROGRAMS AND PARTNERS**

There is a sizable body of literature on recent habitat and environmental planning that pertain to City shoreline ecosystems, flora and fauna. These documents collectively describe a number of plans, projects and status of the science within the City. The documents are:

- *Seattle's Urban Blueprint for Habitat Protection and Restoration* (Seattle 2003)
- *Seattle Shoreline Park Inventory and Habitat Assessment* (Anchor 2003)
- *Marine Shoreline Inventory Report: Seattle WRIA 9* (Anchor 2004)
- *Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 and 9* (CGS 2005)
- *Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Conservation Plan* (WRIA 8 2005)
- *Salmon Habitat Plan, Green/Duwamish and Central Puget Sound Watershed*

*Resource Inventory Area 9 (WRIA 9 2005)*

- *Prioritization of Marine Shorelines of WRIA 9 for Juvenile Salmonid Habitat Protection and Restoration* (Anchor 2006)
- *Synthesis of Salmon Research and Monitoring, investigations conducted in the western Lake Washington Basin* (SPU and USACE 2008)
- *Lower Duwamish River Habitat Restoration Plan* (Port of Seattle 2009)
- *Draft Puget Sound Action Agenda* (PSP 2011)

Several city of Seattle departments are involved with planning and implementing shoreline restoration. Seattle Public Utilities (SPU) implemented the Aquatic Habitat Matching Grant Program, which has funded projects aimed to improve the environmental conditions in Seattle's streams and shorelines. Two shoreline projects day lighted streams at their mouths; Madrona Creek which feeds Lake Washington and Fauntleroy Creek, which feeds the Puget Sound. Additionally, SPU has secured funding for important monitoring work at several habitat restoration projects in the City including: the Sea Wall test panels along the Central Waterfront, The Olympic Sculpture Park, and Salmon Bay Natural Area.

Seattle has completed its Natural Resource Damage Assessment (NRDA) requirements in the Duwamish but continues pay for monitoring of the restoration sites to determine if the restoration sites converge with the monitored reference sites.

Seattle Parks Department takes an active role in undertaking shoreline restoration work and managing shorelines to a more natural state. Examples of this work include less riparian vegetation removal along Lake Washington Boulevard before the Seafair boat races and improvements at maintenance and operations facilities that minimize the potential for contaminating stormwater.

Over the past ten years Parks Department has made improvements including one or more of the following: bulkhead removal, beach creation, beach nourishment and riparian plantings; at Chinook Beach Park, Seward Park, the Arboretum, Magnuson Park, Denny Blaine Park, Golden Gardens Park, Herrings House Park, Martha Washington Park, Lake Washington Boulevard at Alaska and Adams Streets, Lake Washington Pritchard Preserve and Intertidal marsh restoration at Lowman Beach Park. Many of these projects received grants from the King Conservation District and the Salmon Regional Funding Board.

Additionally, a marina was removed at Chinook Beach Park and wetlands were restored at the Montlake playfield (Portage Bay) and Lake Union Park. Seattle Parks Department also offers educational programs and employs beach naturalists at their shoreline parks and the

Seattle Aquarium and Environmental Learning Centers. The beach naturalists program is partially funded by the King Conservation District.

The City of Seattle is involved with government and non-government agencies partnering on shoreline restoration planning. Seattle is a partner with King County and other city governments for implementing the adopted Salmon Plans for WRIAs 8 and 9, administered under Interlocal Agreements within each watershed. The City participates in the governing forums, which direct and oversee implementation as well as addresses policy and funding issues. Each WRIA has a 3 year work-plan, which are updated annually as more information is available or as opportunities arise to implement the plans. Seattle is the alternate for King County on the Stakeholder Advisory Group for the South Puget Sound Central Action area for the Puget Sound Partnership Ecosystem Coordination Board.

Puget Sound Partnership Coordinated Monitoring Program – Seattle with other local jurisdictions and State and Federal agencies is participating in developing a model monitoring program to measure the impacts from stormwater runoff. This information will help inform the next National Pollutant Discharge Elimination System (NPDES) permit requirements.

Through the Seattle Department of Transportation's (SDOT) street vacation process public access and shoreline restoration is a requirement and SDOT's shoreline street end permit requirements often require shoreline restoration. Additionally SDOT is involved with planning for the replacement of the seawall along Seattle's waterfront and has been testing alternatives to the homogenous surface with the goal of improving habitat for salmonid species and other aquatic organisms in Elliott Bay.

Bluefields Holdings, a Seattle "eco-development" company worked with Seattle Mayor Greg Nickels and City Council on an agreement to lease and restore salmon habitat at seven city-owned parcels on the Duwamish River. This opportunity will accelerate the completion of habitat restoration in the Duwamish providing increased habitat function for the species that utilize this area. The company will then sell "restoration credits" to polluters that are required under Superfund laws to enhance the City's industrial waterway.

Seattle is leading green roof monitoring at four sites over the course of three years. These projects are being monitored for stormwater quantity to inform the effectiveness for Ecology to apply appropriate credit for these types of projects.

In addition to restoration work and monitoring the City of Seattle has funded research on habitat use and behavior of juvenile Chinook salmon in the Lake Washington system. This

research has been used by jurisdictions throughout Lake Washington to improve the management of their shorelines.

City of Seattle assisted with staff time and funding for four Green Shorelines workshops that were intended to both gather and provide information to regulatory agencies and the public regarding the appropriate places for green shorelines and indentifying the barriers to green shorelines.

City of Seattle also funded a survey regarding green shorelines to find out what the barriers are to these types of projects. University Washington students supplemented the survey by including residents from other jurisdictions along Lake Washington.

### **3 RESTORATION STRATEGY**

This Section describes the methods by which SMP restoration strategies and applicable restoration actions were determined for Seattle shorelines. Identifying the applicable restoration actions relied upon the results of Seattle's Shoreline Characterization Report, which included a classification of impairment levels for basic ecological functions. The restoration actions identified are those actions that improve the impaired ecological functions and/or those actions that protect existing functions.

#### **3.1 Assessment of Existing Shoreline Impairments**

To assess degraded shoreline areas within the City, a science-based geographic information system (GIS) model was used to characterize the relative degree of habitat function or impairment of the City's shoreline habitat conditions. The results of this assessment are presented in the *City of Seattle Shoreline Characterization Report* (Seattle 2009). All City shorelines under SMP jurisdiction were evaluated, including those portions of the following waterbodies that occur in the City boundaries: Lake Washington, Lake Union and the Ship Canal, the Duwamish River, Puget Sound, including Elliott Bay and Shilshole Bay, and Green Lake. Associated wetlands along these shorelines also fall under shoreline management jurisdiction and were also evaluated the characterization report.

The characterization framework incorporated and applied current knowledge of Seattle's marine, estuarine, and lake shoreline ecology. The framework was based on a method that

provides a streamlined approach for characterizing watershed processes developed by Stanley and others (2005), and adapted to this plan using strategies identified by the Puget Sound Nearshore Ecosystem Restoration Project (PSNERP) Nearshore Science Team (Simenstad et al. 2006) and Battelle Marine Sciences Laboratory (The details of the assessment methods were largely patterned after King County's SMP *Appendix E, Technical Appendix*. (2007) This appendix may be consulted for further information.

The *Shoreline Characterization Report* (Seattle 2009) identified the level of impact on habitat function in discrete shoreline areas, called "sub-reaches" within City limits. A consistent method was used for delineating sub-reaches in both marine and freshwater environments of the assessment area. The approach used aggregated areas based on a manual interpretation of natural breaks in the model results. These included areas of the shoreline with relatively consistent scores and areas with scores that varied within a distinct range, areas with a consistent trend in the scores along the shoreline, and in some cases distinct areas with extremely heterogeneous scores. Sub-reaches were grouped together to form reaches. Reach breaks were determined based on a transition in shoreline habitat condition or a change based on land use (e.g., include a park in one reach) or ecosystem (e.g., separate freshwater from marine). Reaches are depicted in Map A, Sub Reaches are depicted in the accompanying Map Folio, maps 1 - 25. Map A and the Map Folio are located in two separate documents.

Reaches were classified into five categories of degradation: most impaired, more impaired, moderately impaired, less impaired, and least impaired. These categories were useful for interpreting the relative level of impact among reaches and were appropriate for comparison across all shoreline environments of Seattle.

### **3.2 Landscape Context Considerations in Restoration Planning**

This Plan considers impairment at the site scale in the context of the impairments within the larger landscape that encompasses the site, a context that is an important consideration in determining the appropriate restoration strategies for a site. For example, consider two sites that both scored as being moderately impaired in terms of sediment processes. One site is within a larger area (reach) that maintains some degree of natural sediment processes. A

process restoration strategy for this site that is targeted to sediment process would be an appropriate strategy due to the fact that restoration is more likely to be sustained by intact processes nearby. Then, consider a second site located within a landscape that is severely impaired with regard to natural sediment processes. A process restoration strategy focused on sediment processes at the site scale is not likely to be sustained due to the lack of intact processes in the surrounding landscape. For the second site, a strategy of rehabilitating the habitat by providing sediment in the area (e.g. beach nourishment), or a strategy focusing on other functions that are not as impaired at a reach scale (e.g. wave energy or toxins would be more appropriate.

The following table provides guidance for strategies for each reach that could be suitable with a given level of impairment at sub-reaches versus reaches, depending on site and landscape characteristics (Table 1). The organization of the table was based on similar work cited in Stanley and others (2005), by Shreffler and Thom (1993), and by Booth and others (2004) that contemplated suitable restoration and protection efforts based on the degree to which the watershed processes and site functions have been altered. The table axes reflect the City's shoreline characterization impairment categories, and the contents are adapted as appropriate for the City's shoreline conditions.

The concept of "*likelihood*" was carried through the table to list strategies that were logical for each landscape context scenario covered in Seattle's SMP. For example, consider a site along Seattle's Central Waterfront located in a "most impaired" sub-reach within the context of a "most impaired" reach. Because the shoreline is highly developed and degraded in this context, the restoration strategies that would be *likely* to succeed and be maintained over time are those that raise functionality by improving local habitat features, as opposed to processes. For this highly modified reach, these strategies would include rehabilitation and creation, which aim to improve existing habitat conditions at the site. Strategies that aim to restore processes are less appropriate, since the context would not be supported long-term without some landscape level change to land use, and also because the strategy may be inconsistent with purpose of the shoreline environment in the area. The fact that process based restoration in highly impaired areas of the shoreline that are highly developed, should not preclude such restoration, when and where opportunities for sustainable projects arise.

**Table 1**  
**Guidance for Suitability of Restoration Strategies based on Level of Impairment**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairment	Most	Restore Process Rehabilitate*	Restore Process Rehabilitate*	Rehabilitate Restore Process Create*	Rehabilitate Create	Rehabilitate Create
	More	Restore Process Rehabilitate*	Restore Process Rehabilitate	Rehabilitate Restore Process Create	Rehabilitate Create	Rehabilitate Create
	Moderate	Restore Process Protect Rehabilitate	Restore Process Protect Rehabilitate	Rehabilitate Protect Restore Process Create	Rehabilitate Create Protect	Rehabilitate Create Protect
	Less	Protect Restore Rehabilitate	Protect Restore Process Rehabilitate	Protect Restore Process Rehabilitate	Protect Rehabilitate Create	Protect Rehabilitate Create*
	Least	Protect	Protect Restore Process Rehabilitate	Protect Restore Process Rehabilitate	Protect Rehabilitate	Protect Rehabilitate*

## Notes:

\* These combinations did not occur in the City's shorelines, as described in the *Seattle Shoreline Characterization Report* (Seattle 2009).

Table 1 indicates strategies that are considered most likely to succeed and most likely to be available. The absence of certain strategies in various boxes of the guidance in Table 1 would not preclude using other strategies if opportunities were to arise for a valuable project. For example, in a highly impaired sub-reach in a highly impaired reach, "protect" is not identified as a restoration strategy. However, if an opportunity arose to protect a valuable area within the sub-reach, the effort to do so might still be valuable, and the strategy of protection should not be dismissed.

In this Plan, Table 1 is used as guidance to match potential restoration strategies to various shorelines within the City. For this analysis, each sub-reach of the City's shorelines was fitted to boxes in this table, depending on its impairment level and the impairment level of its landscape (results of the impairment assessment are described in Section 5).

### **3.3 Habitat Protection and Conservation**

Given the urban nature of the City, existing areas with high ecological function are rare. The areas that do exist are generally parks or other open space. Any protections that can be offered through implementation of this Plan or the SMP should maximize the conservation of ecological function. This will help meet the City's goals of protecting shoreline processes and functions, creating more natural shorelines that feature native plants and a diversity of habitats, and strengthening ecological and physical connections between habitats.

### **3.4 Restoration Strategy**

Restoration strategy is rooted in an understanding of how habitats are formed and maintained. The habitat type and habitat functions provided to specific species in shoreline and aquatic areas are products of the interaction of physical, chemical, and biological processes that occur in both the aquatic system and adjacent terrestrial areas (Naiman et al. 1995). In *Ecology's Guide to Watershed Planners to Understand Watershed Processes* (Stanley et al. 2005; Ecology publication No. 05-06-027), the authors use the term watershed processes to refer to "the dynamic physical and chemical interactions that form and maintain the landscape at the geographic scales of watersheds to basins (hundreds to thousands of square miles)." These processes and human-caused stressors combine to create, maintain, or destroy habitat.

This Plan considers ten processes in identifying the applicable restoration actions: delivery, movement, and loss of water, large woody debris (LWD), sediment, phosphorus, nitrogen, toxins, and pathogens, as they enter, pass through, and eventually leave the watershed. It also includes wave energy and tidal influences (tidal for marine shorelines only) because they are important processes affecting the shape and function of shorelines. Light energy is also included because light is an important control on vegetation and animal growth, distribution, and behavior. Changes in these processes impact the functions that the habitat supports for organisms. Therefore, the distribution and behavior of plants and animals are a response to the watershed processes that occur and the structure of habitat that is created.

Where unfavorable changes have occurred in habitat structure and function due to interruption of these watershed processes, organisms are directly or indirectly negatively impacted, and there is a need to reinstate these processes for ecological health. To do this, the City will use the general strategies of protection, process restoration, rehabilitation, and creation, as defined below. These strategies were initially developed by the Puget Sound Technical Recovery Team (2003) for salmon habitat in the region, but also apply well to shoreline habitats in general because salmon are highly dependent on shoreline areas for their growth and survival. To avoid confusion, because ‘restoration’ is one of these strategies, the word ‘restoration’ in this document will be used to apply to these strategies as a whole, and the individual strategy will always be referred to as ‘process restoration’, as described below. The strategies are defined as:

- **Protection:** protect habitat by procuring easements or other development controls; appropriate where habitat is presently functioning at a high level and supports natural habitat-forming or -sustaining processes.
- **Process Restoration:** re-establish natural processes and habitat structure that supports those processes; appropriate where habitat is impaired but natural processes can be recovered.
- **Rehabilitation:** improvements to functions and supporting processes through partial re-establishment of ecosystem processes or functions; appropriate where habitat is impaired and restoration of full function and supporting processes appears infeasible.
- **Creation:** creation of habitat features to replace lost function; appropriate where habitat function is lost through anthropogenic degradation, and where process restoration and/or rehabilitation are not possible.

The order of the above general strategies reflects the degree to which a watershed process would be re-established or protected if the action were taken. That is, protection maintains natural processes, process restoration fully establishes natural processes, rehabilitation will partially re-establish natural processes, and creation will provide habitat features but does not address processes. Ideally, the preference for use of the strategies would be: 1) protect, 2) restore processes, 3) rehabilitate, and 4) create. However, in a highly developed area the order is dependent on the site conditions. Depending on the location of a restoration site, the preference order would be modified where there are considerations of feasibility and likelihood of project success (discussed further in Section 3.2).

### **3.5 Application of Restoration Strategy**

Identifying applicable restoration actions are necessary in order to guide the City's restoration implementation. Table 2 provides a list of restoration actions that encompass the typical elements of shoreline restoration projects reviewed for this analysis. This is not a comprehensive list of all restoration actions that are possible; it is a generalized list of the types of actions that have been proposed for Seattle shorelines. Table 2 identifies which watershed processes these restoration actions would generally address.

Restoration actions have been described in this document as High, Medium, or Low for large areas, or waterbodies (i.e., multiple reaches), of the City shoreline. In addition, priority should be given for actions that address the specific, existing impacts to habitat function (these are discussed in more detail in the *Shoreline Characterization Report* (Seattle 2009).

Following the description of restoration actions, a short discussion highlights projects that have been proposed as well as other restoration actions that address shoreline impairments identified in the Shoreline Characterization Report. This process is described in a step-by-step manner next in Section 4.

**Table 2**  
**Restoration Actions and Watershed Processes Addressed**

Restoration Action	Light	LWD	Nitrogen	Pathogens	Phosphorus	Sediment	Tide	Toxins	Water	Wave
Riparian Restoration, noxious plant removal	X	X	X		X	X		X	X	
Daylighting Streams, rehabilitate channels		X	X	X		X	M			
Intertidal or Littoral Debris Removal, Groin Removal						X				X
Beach Nourishment						X				
Armoring Removal, LWD placement		X				X	M		X	X
Overwater Structure Removal	X	X								
Stormwater treatment; contaminant removal			X	X	X			X		
Wetland Restoration			X	X	X	X		X	X	

## Notes:

X Addresses process in both freshwater and marine waters

F Addresses process only in freshwater

M Addresses process only in marine waters

### 3.6 Project Identification

This Plan makes use of existing research, monitoring and restoration planning efforts to identify feasible shoreline habitat restoration opportunities that could offer substantial improvement in shoreline ecosystem function. These potentially improved functions are then compared against the results of the shoreline characterization effort to determine where the greatest need for restoration occurs. To determine restoration actions, the land use of the site, the level of impairment at the site, the opportunity for restoration and how well the restoration actions are able to address the impairments to specific shoreline processes are considered.

Every waterbody and shoreline that is the subject of this plan is included in one or more of the following restoration or monitoring plans;

- Green Lake Vegetation Management Plan (Seattle 1996)
- *Seattle's Urban Blueprint for Habitat Protection and Restoration* (Seattle 2003)

- *Seattle Shoreline Park Inventory and Habitat Assessment* (Anchor 2003)
- *Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Conservation Plan* (WRIA 8 2005)
- *Salmon Habitat Plan, Green/Duwamish and Central Puget Sound Watershed Resource Inventory Area 9* (WRIA 9 Steering Committee 2005)
- *Prioritization of Marine Shorelines of WRIA 9 for Juvenile Salmonid Habitat Protection and Restoration* (Anchor 2006)
- *Synthesis of Salmon Research and Monitoring, investigations conducted in the western Lake Washington Basin* (SPU and USACE 2008)
- *Lower Duwamish River Habitat Restoration Plan (Port of Seattle 2009)*
- The Elliott Bay General Investigation (USACE 2009)

Projects identified as a priority for implementation within each of the restoration documents were reviewed for this Plan and categorized by the specific restoration actions included in the description of the project. Projects typically include more than one restoration action (i.e., bulkhead removal, littoral debris removal and restoration of riparian vegetation). This information was used to determine which potential projects have been identified as feasible and the specific impairments to shoreline habitat the restoration actions are most likely to address.

Strictly analyzing the results of the Shoreline Characterization Report, projects in highly impaired areas have a greater capacity for improvement to shoreline ecological function than areas with low impairments. However, restoration projects in highly impaired areas in the Urban Industrial and Urban Maritime shoreline environments may not be consistent with the City's vision to support water dependent industrial uses and the goals of the SMP to provide for areas for water-dependent uses. These projects can also be less sustainable due to impairments of the processes necessary to sustain them over the long term (see section 3.2). Therefore, rather than set high priorities for projects in the most impaired areas, this Plan puts a priority on restoration actions that provide the best opportunity for restoration (based on the project being identified as a priority in one or more of the existing restoration plans) and that address the City's overall vision.

## 4 APPLICABLE RESTORATION ACTIONS

This section provides a summary of citywide impairments and provides detail on impairments and the applicable restoration actions for Seattle's shorelines. Specific waterbodies are discussed in the following order: Lake Washington; Lake Union and the Ship Canal; the Duwamish River; Puget Sound, including Elliott and Shilshole Bays; and Green Lake. Impairments and restoration strategies are discussed on a reach scale, and this plan identifies the types of restoration actions within each reach that would be most productive in meeting the overall plan goals. Detailed descriptions of previously developed site-specific projects are available from the existing restoration planning documents listed in Section 3.6.

### 4.1 Citywide Impairments Summary

Within Seattle, all shoreline habitats have been impaired to some degree by human alterations. There are some areas, however, that continue to provide relatively high quality habitat to a diversity of species, and have relatively intact shoreline ecosystem processes. The distribution of habitat impairments is uneven; the heavily industrialized shorelines of Lake Union downstream to the Ballard Locks, Elliott Bay, and the Harbor Island portion of the Duwamish River Estuary are the most impacted reaches with respect to their historic function. Even within these most impacted reaches, there are some areas with higher habitat function (i.e., less impairment). The least impacted areas in Seattle include Seward Park, Union Bay, West Point and Magnolia Bluffs, and Lincoln Park to Fautleroy Cove. These areas provide relatively high quality habitat and intact processes. Between these two ends of the impairment spectrum are reaches with moderate amounts of impairment.

As explained in Section 3.1, as part of the shoreline characterization, each reach within the City was categorized as most, more, moderate, less, or least impaired. Reaches were aggregations from smaller assessment units called sub-reaches which offer a finer scale indication of functional impairment (Maps 1 through 25). The restoration strategies for each sub-reach are determined by the level of impairment of that sub-reach and the reach that encompasses it (see Table 1). The number of sub-reaches with similar levels of impairment at the reach and sub-reach scale are shown below in Tables 3 and 4 for freshwater and marine shorelines, respectively. For freshwater habitats, many subreaches fall into the more

impaired and most impaired categories at both the sub-reach and reach scale; according to Table 1, rehabilitation and creation are key strategies for a large number of Seattle's freshwater subreaches. For marine/estuarine sub-reaches, many were moderately impaired or most impaired categories on the sub-reach scale as well as the reach scale, and therefore the strategies of rehabilitation, protection, restoration, and creation are important in these subreaches. Overall, this table illustrates that much of the City's highly impaired shoreline habitat is within a landscape context of high impairment as a whole. Similarly, habitat that is highly functional is generally within the context of highly functional landscapes as well.

**Table 3**  
**Freshwater Reach Assignments Based on Reach and Sub-reach Impairment Category**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairment	Most				3	12
	More		4	1	7	13
	Moderate	1	3	3	8	4
	Less	1	4	5	5	
	Least	5	6		1	

**Table 4**  
**Marine Reach Assignments Based on Reach and Sub-reach Impairment Category**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairment	Most				8	10
	More				8	3
	Moderate			13	18	6
	Less	3	7	6	4	
	Least	6	1	2	3	

## 4.2 Lake Washington

Lake Washington has lost much of its shoreline habitat connectivity and complexity because of hydrologic modifications within the Lake Washington system, including the lowering of lake level by approximately 10 feet, loss of riparian vegetation, installation of bank armoring,

and construction of overwater structures associated with the urbanized watershed today. About 66 percent of the lake shoreline in the City is armored and more than 900 overwater structures are in place (Toft et al. 2003a and 2003b). Less than 25 percent of the shoreline contains natural vegetation (Toft 2001). Overwater structures have the potential to negatively impact benthic production and fish communities, including the rearing and migration of juvenile salmon and other fish species supported by the shallow water habitat.

#### 4.2.1 Impairments

The number of sub-reaches in Lake Washington with specific levels of impairment at the reach and sub-reach scale are summarized below in Table 5, based on the restoration strategies in Table 1.

**Table 5**  
**Lake Washington Reach Assignments Based on Reach and Sub-reach Impairment Category**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairments	Most				2	
	More		4	1	6	
	Moderate	1	3	2	6	
	Less	1	4	4	5	
	Least	5	6			

On the northern shores of Lake Washington within City limits, residential development has contributed to higher amounts of impervious surface, a lack of overhanging and riparian vegetation, extensive shoreline armoring, and numerous docks and overwater structures. Riparian vegetation does occur at some small locations, such as parks along the Burke Gilman multi-use Trail and the Thornton Creek delta. South of Magnuson Park, there is a large wetland complex and intact mixed forest near the shore, and further south, the northern portion of Union Bay has extensive marshy shorelines with unarmored conditions and some mature trees. Between the Washington Park Arboretum and Seward Park, shorelines decrease in ecological function, as docks and armoring increase and shoreline vegetation is limited. Park shorelines are typically not as impaired; in fact the arboretum, Seward Park

and Colman Park shorelines all have relatively high ecological function, with generally little shoreline armoring and relatively high native or mixed-native vegetation cover. The remainder of the Lake Washington segment to the southern City limit is characterized by patches of higher habitat functionality, generally where parks occur. In much of this area, shoreline armoring, docks, and lawns occur, and habitat function is more impaired.

In summary, highest functioning areas include mature vegetated areas of the segment along the Burke-Gilman Trail, Matthews Beach (although these shorelands are set back from the water's edge), the Thornton Creek delta, Northern Union Bay, and parks including the Washington Park Arboretum. Lowest functioning habitats include residentially developed areas where docks and armoring predominate, particularly in the areas south of Martha Washington Park and from Madison Park to Colman Park (not including the parks).

Using the analysis described in Section 4.1, reaches were scored based on the condition of the various ecosystem processes. This score information can be further used to identify processes contributing most to shoreline impairment for a given area. *The Shoreline Characterization Report* (Seattle 2009) provided process rank scores for each reach and charted the score distribution among reaches with the classification breaks between high, moderate, and low impairment. Table 6 shows these impairment categories.

These results indicate that the most impaired process in the Lake Washington shoreline segment is nitrogen; however, data taken by King County indicate that nitrogen is not a problem unless current levels of phosphorous increase (Tetra Tech and Parametrix 2003). Nitrogen can be a problem for Puget Sound and because Lake Washington drains into Puget Sound the nitrogen from Lake Washington will enter the Sound. The many tributary streams and drainage pipes that enter Lake Washington carry both phosphorous and nitrogen from runoff that contains fertilizers sourced from lawns in residential areas. Wetlands that historically provided nutrient uptake for streams entering Lake Washington have been removed and there are now more impervious surfaces in the watersheds.

**Table 6**  
**Impairment Category from Shoreline Characterization Report (Seattle 2009) for Various**  
**Watershed Processes at Lake Washington—City Shorelines**

Reach No.	Reach Description	Reach Impairment Category	Light	LWD	Nitrogen	Pathogens	Phosphorus	Sediment	Toxins	Water	Wave
1	Northern City Limit to Magnuson Park	Moderately Impaired	Low	Low	High	Moderate	Moderate	High	Moderate	Moderate	Moderate
2	Magnuson Park	Less Impaired	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
3	Laurelhurst	Less Impaired	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
4	Union Bay	Least Impaired	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
5	Madison Park to Colman Park	More Impaired	Low	Low	High	Moderate	Moderate	Moderate	High	Moderate	Moderate
6	Colman Park to Seward Park	Less Impaired	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
7	Seward Park	Least Impaired	Low	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
8	Seward Park to Southern City Limit	More Impaired	Low	Low	High	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Notes:

-  High Impairment
-  Moderate Impairment
-  Low Impairment

Other highly impacted processes are sediment, toxins, pathogens, phosphorus, water and waves. Sediment processes are more impaired at the northern and southern city limits, due to the high amounts of impervious surface area near the shoreline. Pathogens and toxins impair shorelines on a patchy basis, depending on the level of development of the nearby shoreline. The water process is more impaired south of Union Bay as development increases and unarmored shorelines are limited. Wave processes are impacted by extensive overwater structures and shoreline armoring.

As shown in Table 6, model results suggested that the least impaired processes in the Lake Washington segment are LWD and light. LWD occurs along lake shorelines where shores

are less developed, such as near the parks and vegetation cover is present in many areas within shorelands (200 feet of the shoreline), light conditions are not likely to be limited in these areas. The City's Lake Washington shoreline, however, does have approximately 750 residential docks that extend 30 to 100 feet from the shoreline and cover an estimated 4 percent of the lake surface area within 100 feet of the shore (Weitkamp et al. 2000). Residential structures are densely concentrated at the shoreline in many areas, creating a barrier between the shorelands and the water. Natural light conditions would be limiting in the shallow aquatic zones just waterward of these areas due to the overwater pier structures.

Artificial lighting at night was not part of the characterization report; however, artificial light has been shown to impact fish predation (Tabor and others 1998). Projects that reduce the amount of artificial light would benefit fish habitat within Seattle.

#### **4.2.2 Applicable Restoration Actions**

Based on these impairments, the applicable restoration actions for the Lake Washington segment determined to be High, Moderate, or Low in Table 7. This table was completed by combining the impairment levels for each reach presented in Table 6 with the restoration actions and watershed processes addressed that were described previously in Table 2. For example, Table 6 shows that in Reach 1 (Northern City Limit to Magnuson Park), the watershed process "nitrogen" and "sediment" are highly impaired. Table 2 identifies the restoration actions that would address nitrogen issues as: riparian restoration/noxious plant removal, daylighting streams/rehabilitating channels, stormwater treatment/contaminant removal, and wetland restoration and these five actions would be assigned as most applicable restoration actions for this reach. The sediment process was also highly impaired, so the actions of intertidal/littoral rubble/groin removal, beach nourishment, armoring removal/LWD placement, and wetland restoration would also be assigned as the most applicable restoration actions for this reach. The LWD process was moderately impaired, so riparian restoration/noxious plant removal, daylighting streams/rehabilitating channels, armoring removal/LWD placement, and overwater structure removal would be assigned as moderately applicable for this reach. However, riparian restoration/noxious plant removal and armoring removal/LWD placement were already assessed as being most applicable; therefore these actions remain highly applicable. Restoration actions to address "low

impairment” light conditions would include riparian restoration/noxious plant removal and overwater structure removal, and riparian and overwater structure work are already assigned as most applicable, so these actions remain highly applicable. Additionally, the actions identified for restoration are also considered important for providing habitat for juvenile Chinook salmon.

Reaches that have the greatest need for restoration actions are those that are highest impaired in the Lake Washington segment, referenced by Reach Impairment Category in Table 7: Reach 5 (Madison Park to Colman Park) and Reach 8 (Seward Park to Southern City Limit).

Previous restoration planning documents (see Section 3.6) do not identify any restoration projects for Reach 5, but protecting high quality habitat where it exists in small patches has been suggested. The *Seattle Shoreline Park Inventory and Habitat Assessment* (Anchor 2003) recommended protecting the high quality aspects of swim beach habitat at Madison Park, Madrona Beach, and Colman Park. Compared to armored shorelines of most of Lake Washington, swim beaches typically have small substrates with gentle shoreline slopes that can provide refuge and feeding habitat for juvenile salmon and other small fish. Tabor and others (2004) noted relatively high juvenile Chinook salmon use of such areas in the southern parts of Lake Washington. Restoration actions that are most applicable in this reach would include those that would address nitrogen and toxin inputs and its upstream tributary subbasins, with actions such as riparian restoration, stormwater treatment/contaminant removal and wetland restoration, as suggested above. The remaining processes are “moderately” impacted; therefore, additional restoration actions would include overwater structure removal, LWD placement and removal of shoreline armoring.

**Table 7**  
**Applicable Restoration Actions—Lake Washington**

Reach #	Reach	Reach Impairment Category <sup>1</sup>	Reach Protection Category <sup>2</sup>	Riparian Restoration	Daylighting Streams (where piped streams occur)	Nearshore Debris Removal/ Groin Removal	Beach Nourishment	Armoring Removal	Overwater Structure Removal	Stormwater treatment	Wetland Restoration
1	Northern City Limit to Magnuson Park	Moderately Impaired	Low	High	High	High	High	High	High	High	High
2	Magnuson Park	Less Impaired	Moderate	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate
3	Laurelhurst	Less Impaired	Moderate	High	High	Moderate	Moderate	Moderate	Moderate	High	High
4	Union Bay	Least Impaired	High	Moderate	Moderate	Low	Low	Low	Low	Moderate	Moderate
5	Madison Park to Colman Park	More Impaired	Low	High	High	Moderate	Moderate	Moderate	Moderate	High	High
6	Colman Park to Seward Park	Less Impaired	Moderate	High	High	Low	Low	Moderate	Low	High	High
7	Seward Park	Least Impaired	High	Low	Low	Low	Low	Low	Low	Low	Low
8	Seward Park to Southern City Limit	More Impaired	Low	High	High	Moderate	Moderate	Moderate	Moderate	High	High

Notes:

- a. Based on the results of the *Shoreline Characterization Report* (Seattle 2009).
- b. Reach was considered High priority for protection if reach impairment category was “least”; moderate priority if reach impairment category was “less”; low priority for all other reach impairment categories (“moderate,” “more,” and “most”).

In Reach 8, several projects have been proposed and implemented, including completed beach nourishment and substrate enhancements at Seward Park and in-progress enhancements near South Alaska Street (Seattle 2003). Three littoral zone and shoreline riparian restoration projects have been proposed or completed: one proposed at Pritchard Island Beach, and two completed, one at Martha Washington Park and the other at Rainier Beach, also known as Chinook Beach (Anchor 2003). Additionally, daylighting Mapes Creek at its mouth is a proposed restoration project that will occur in the next several years. The completed projects were too recent to be reflected in datasets used in the GIS model, but they address most of the elements assigned as applicable actions because they provide riparian vegetation and improvements to substrate that will benefit fish and wildlife using the shoreline. Similar to the northern reach discussed previously, restoration actions are still needed that would address the nitrogen problem in the reach as well as its contributing drainage areas.

High priority areas for habitat protection include those with the least impairments: the wetland habitats of Union Bay and the areas of unarmored shoreline and riparian vegetation at Seward Park, in addition to any recent restoration project sites.

Table 8 provides a list of restoration projects for the Lake Washington shoreline segment, including the name of the habitat plan that proposed the project, the sub-reach ID number from the *Shoreline Characterization Report* (Seattle 2009), and the sub-reach impairment and reach impairment categories from the report. For each project, applicable restoration actions and the processes that would be addressed by those restoration actions are identified.

**Table 8**  
**Restoration Projects for Lake Washington**

<b>Project or Site Name</b>	<b>Plan that Identifies Project or Site<sup>1</sup></b>	<b>Sub-Reach ID</b>	<b>Sub Reach Impairment Category</b>	<b>Reach Impairment Category</b>	<b>Applicable Restoration Actions<sup>2</sup></b>	<b>Process Addressed by Restoration Actions<sup>3</sup></b>
Matthews Beach	Parks	1-e	More Impaired	Moderately Impaired	<ul style="list-style-type: none"> <li>• <b>Riparian</b></li> <li>• <b>Armor</b></li> </ul>	Light LWD <b>Nitrogen</b> Pathogens Phosphorus Sediment Toxins Water Wave
Matthews Beach	Parks	1-f	Less Impaired	Moderately Impaired	<ul style="list-style-type: none"> <li>• <b>Riparian</b></li> <li>• <b>Armor</b></li> </ul>	Light LWD <b>Nitrogen</b> Sediment Water Wave
Sand Point Magnuson Park	Parks	1-g	Moderately Impaired	Moderately Impaired	<ul style="list-style-type: none"> <li>• <b>Riparian</b></li> <li>• <b>Armor</b></li> </ul>	Light LWD <b>Nitrogen</b> Sediment Water Wave
Sand Point Magnuson Park	Parks	2-a	More Impaired	Less Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> <li>• Armor</li> </ul>	Light LWD <b>Nitrogen</b> <b>Sediment</b> Water Wave
Sand Point Magnuson Park	Parks	2-b	Least Impaired	Less Impaired	<ul style="list-style-type: none"> <li>• Protect<sup>4</sup></li> <li>• Riparian</li> <li>• Beach</li> <li>• Armor</li> </ul>	Light LWD <b>Nitrogen</b> Sediment Water Wave
Sand Point Magnuson Park	Parks	2-c	More Impaired	Less Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> <li>• Armor</li> </ul>	Light LWD <b>Nitrogen</b> Sediment Water Wave
East Montlake Park	Parks	4-c	Least Impaired	Least Impaired	<ul style="list-style-type: none"> <li>• Protect</li> </ul>	Light LWD <b>Nitrogen</b> Pathogens Phosphorus Sediment Toxins Water Wave

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Applicable Restoration Actions <sup>2</sup>	Process Addressed by Restoration Actions <sup>3</sup>
Madison Park	Parks	5-a	More Impaired	More Impaired	<ul style="list-style-type: none"> <li>Armor</li> </ul>	LWD Sediment Water Wave
Madison Park	Parks	5-b	Less Impaired	More Impaired	<ul style="list-style-type: none"> <li>Armor</li> </ul>	LWD Sediment Water Wave
Colman Park	Parks	6-a	Least Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect</li> </ul>	Light LWD Nitrogen Pathogens Phosphorus Sediment Toxins Water Wave
Lake WA Blvd South near South McClellan St	Blueprint	6-c	Least Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect <b>Riparian</b></li> </ul>	Light LWD Nitrogen Sediment
Seward Park	Parks	7-a	Least Impaired	Least Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Riparian</li> <li>Beach</li> <li>Armor</li> </ul>	Light LWD Nitrogen Sediment Water Wave
Seward Park	Parks	7-b	Least Impaired	Least Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Riparian</li> <li>Beach</li> <li>Armor</li> </ul>	Light LWD <b>Nitrogen</b> Sediment Water Wave
Pritchard Island Beach	Parks	8-c	Less Impaired	More Impaired	<ul style="list-style-type: none"> <li>Riparian</li> <li>Armor</li> </ul>	Light LWD <b>Nitrogen</b> Sediment Water Wave
Mapes Creek Daylighting	N/A	8-e	More Impaired	More Impaired	<ul style="list-style-type: none"> <li>Daylighting Streams</li> <li>Riparian</li> <li>Armor</li> </ul>	Light LWD Sediment Water Wave

## Notes:

- 1 Parks: *Seattle Shoreline Park Inventory and Habitat Assessment* (Anchor 2003)  
 Blueprint: *Seattle's Urban Blueprint for Habitat Protection and Restoration* (Seattle 2003)

- 2 Restoration Actions are those listed in the proposed project in the relevant plan. **Bold** indicates that the Habitat Action is highly applicable within the reach based on Table 7.  
 Riparian: riparian vegetation restoration  
 Beach: beach nourishment or enhancement, Armor: removal of artificial shoreline hardening including bulkheads and seawalls.  
 Armor: armoring removal, LWD placement
- c. **Bold** indicates that the specific process addressed is highly impaired within the sub reach.
- d. "Protect" is listed as a habitat action for the project if both reach/subreach impairment categories were either "least" or "less" or if subreach category was "least."

### 4.3 Lake Union and Ship Canal

For the Lake Union and Ship Canal segment, reach assignments based on reach and sub-reach impairment categories are summarized in Table 9. This table illustrates that most Lake Union shorelines are located within a landscape context of most impairment.

**Table 9**  
**Lake Union Reach Assignments Based on Reach and Sub-reach Impairment Category**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairment	Most				1	9
	More				3	10
	Moderate				2	2
	Less				1	
	Least	1		1	1	

The following section describes the impairments in the Lake Union and Ship Canal segment, as well as applicable restoration actions.

#### 4.3.1 Impairments

The shoreline in the Lake Union and Ship Canal segment is highly urbanized. Numerous water-dependent facilities dominate the shoreline and have displaced most riparian vegetation with heavy shoreline armoring, near continuous impervious surfaces, overwater structures, and combined sewer overflow (CSO) and stormwater outfalls. However, this area is the migration corridor for all salmonids into and out of the system. The south shoreline of

Portage Bay is the highest functioning habitat in this segment, while the west shoreline of Portage Bay and Fisherman’s Terminal are the most impaired.

Table 10 illustrates impairment ranges for the reaches in this segment. This table was completed in the same manner as Table 6.

Table 10  
Impairment Ranges from Shoreline Characterization Report (Seattle 2009) for Various Watershed Processes at Lake Union and Ship Canal—City Shorelines

Reach No.	Reach	Reach Impairment Category	Light	LWD	Nitrogen	Pathogens	Phosphorus	Sediment	Toxins	Water	Wave
9	Montlake Cut and Portage Bay	More Impaired	Moderate Impairment	Moderate Impairment	Low Impairment	Moderate Impairment	Moderate Impairment	Moderate Impairment	High Impairment	Moderate Impairment	Moderate Impairment
10	Lake Union	Most Impaired	High Impairment	High Impairment	Low Impairment	High Impairment	High Impairment	High Impairment	High Impairment	High Impairment	High Impairment
11	Fremont Cut	Most Impaired	Moderate Impairment	Moderate Impairment	Moderate Impairment	Moderate Impairment	High Impairment	High Impairment	High Impairment	High Impairment	High Impairment
12	Salmon Bay Waterway	Most Impaired	High Impairment	Moderate Impairment	Moderate Impairment	High Impairment	High Impairment	High Impairment	High Impairment	High Impairment	High Impairment

Notes:

	High Impairment
	Moderate Impairment
	Low Impairment

These results indicate that the most highly impaired processes in Lake Union and Ship Canal shorelines are LWD, phosphorus, sediment delivery and movement, toxins, and water, with toxins as the most impaired. The impairment of toxins, as well as other water quality processes, is caused by contaminated surface water discharge from the upland areas in addition to several CSO locations in this segment. The lower levels of nitrogen impairment identified in the model result from differences in the inputs into the nitrogen process model relative to other water quality related process (namely the presence of lawn areas within 200 feet of the shoreline). Sediment and water processes have been impaired by the high levels of

impervious surface area throughout the shoreline of the segment. Water processes have also been impaired by the management and constriction of water flow to and from Lake Union through the Ballard Locks. Lack of source wood is one reason for LWD impairment, because riparian vegetation is almost completely absent from this urbanized and industrial shoreline.

Additionally, water quality studies indicate that high water temperatures and low dissolved oxygen are problems in late summer, which will stress salmonids.

#### **4.3.2 Applicable Restoration Actions**

Based on these impairments, applicable restoration actions for the Lake Union and Ship Canal waterbody are categorized as High, Moderate, or Low in Table 11. This table was completed in the same manner as Table 7.

Given the reach impairment categories shown in Table 11, all restoration actions are applicable for all the reaches; Reach 9 (Montlake Cut and Portage Bay) is slightly less impaired than the other three reaches.

The WRIA 8 2005 Salmon Conservation Plan identifies several actions that could benefit habitat and water quality in the Lake Union and Ship Canal area. In Reach 9 (Montlake Cut and Portage Bay) these activities include exploring methods to reduce salmonid predation in Portage Bay and exploring options for deepening the Montlake Cut to allow colder water from Lake Washington to flow into Lake Union. The impetus behind this project is to address water temperature issues in Lake Union to benefit juvenile salmon, and it could potentially change the movement of water in the reach and beyond. The *Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Conservation Plan* notes that technical water quality and hydrodynamic issues would need to be evaluated before this project could move forward. Restoration of sediment processes has been proposed for the area on the south side of the Ship Canal through Salmon Bay (CGS 2005).

**Table 11**  
**Applicable Restoration Actions—Lake Union and Ship Canal**

Reach No.	Reach	Reach Impairment Category <sup>1</sup>	Reach Protection Category <sup>2</sup>	Riparian Restoration	Daylighting Streams (where piped streams occur)	Nearshore Debris Removal/ Groin Removal	Beach Nourishment/ Substrate Enhancement	Armoring Removal	Overwater Structure Removal	Stormwater Treatment	Wetland Restoration
9	Montlake Cut and Portage Bay	More Impaired	Low	High	N/A	Moderate	Moderate	High	Moderate	High	High
10	Lake Union	Most Impaired	Low	High	N/A	High	High	High	High	High	High
11	Fremont Cut	Most Impaired	Low	High	N/A	High	High	High	High	High	High
12	Salmon Bay Waterway	Most Impaired	Low	High	N/A	High	High	High	High	High	High

## Notes:

1 Based on the results of the *Shoreline Characterization Report* (Seattle 2009).

2 Reach was considered High priority for protection if reach impairment category was “least”; moderate priority if reach impairment category was “less”; low priority for all other reach impairment categories (“moderate,” “more,” and “most”).

In Reach 10 (Lake Union), the action proposed is to improve drainage from Wallingford. In Reach 11 (Fremont Cut), projects proposed are to improve water quality by implementing riparian restoration near the Ballard Bridge and treatment of run-off from the bridge (WRIA 8 2005). This would improve the following processes: LWD, nitrogen, pathogens, phosphorus, sediment, toxins, and water in this area.

Reach 12 (Salmon Bay Waterway) terminates at the Ballard Locks, which constrain water flow between Lake Union and Puget Sound. There are two proposed projects in this area. One project proposes constructing a more natural, fairly wide, and long channel at the locks to allow for better salmon passage (WRIA 8 2005). This project would likely change movement of water in the reach and beyond, and the *Lake Washington/ Cedar/ Sammamish Watershed Chinook Salmon Conservation Plan* notes that there are significant design challenges and feasibility that would need to be evaluated before this project could move forward. Another project at Commodore Park, just downstream of the locks on the south bank, proposes to remove the seawall, re-grade the shoreline to a gentler slope, daylight Wolfe Creek (that flows into the park) and create a pocket estuary in this location (WRIA 8 2005). There are several other projects proposed at the locks, mostly related to improving fish passage and the location and size of the saltwater transition zone.

Because the impairment level of the Lake Union and Ship Canal reaches is so high, essentially every category of restoration action in Table 11 is an applicable restoration action in this area, and projects most needed are those that combine restoration actions to address several processes at once.

High priority areas for habitat protection include those with the least impairments, such as East Montlake Park, as well as any recent restoration project sites such as Salmon Bay Natural Area.

Table 12 provides a list of priority projects for the Lake Union and the Ship Canal shoreline segment, including the name of the habitat plan that proposed the project, the sub-reach ID number from the *Shoreline Characterization Report* (Seattle 2009), and the sub-reach impairment and reach impairment categories from the report. For each project, applicable

restoration actions and the processes that would be addressed by those restoration actions are identified.

**Table 12**  
**Restoration Projects for Lake Union and the Ship Canal**

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Process Addressed by Restoration Actions <sup>3</sup>
7th Avenue Street End Restoration	WRIA 8	9-b	More Impaired	More Impaired	Nitrogen Pathogens Phosphorus <b>Toxins</b> Water
Montlake Playfield	--	4-c 4-d 4-e	Least Impaired	More Impaired	--
South Wallingford Drainage Improvements M212	WRIA 8	10-a 10-b 10-c 10-d	Moderately to Most Impaired	Most Impaired	Nitrogen <b>Pathogens</b> <b>Phosphorus</b> <b>Toxins</b> Water
Bank Softening at Gasworks Park M213	WRIA 8	10-b	Moderately Impaired	Most Impaired	Light <b>LWD</b> Nitrogen Sediment Water Wave
Remove North Lake Union In-Water Structures, M214	WRIA 8	10-a 10-b 10-c 10-d	Moderately to Most Impaired	Most Impaired	<b>Sediment</b>
Aurora Bridge Shoreline Restoration, M211	WRIA 8	10-d, 10-m	Most Impaired	Most Impaired	Light <b>LWD</b> Nitrogen <b>Sediment</b> Water <b>Wave</b>
Fremont Bridge Shoreline Restoration, M210	WRIA 8	11-a, 11-e	Moderately Impaired, More Impaired	Most Impaired	Light <b>LWD</b> Nitrogen <b>Sediment</b> Water

					Wave
Ballard Bridge Shoreline Restoration, M208	WRIA 8	12-a, 12-e	More Impaired, Most Impaired	Most Impaired	<b>Light LWD</b> Nitrogen <b>Sediment</b> Water <b>Wave</b>
Ballard Bridge Water Quality Improvements M209	WRIA 8	12-a, 12-e	More Impaired, Most Impaired	Most Impaired	Nitrogen Pathogens <b>Phosphorus</b> <b>Toxins</b>
Commodore Park and Wolf Creek Restoration M250	WRIA 8	17d	Less Impaired	More Impaired	LWD Nitrogen Pathogens <b>Sediment</b> <b>Tide Water</b> <b>Wave</b>

- 1 WRIA 8: *Lake Washington/ Cedar/ Sammamish Watershed Chinook Conservation Plan* (WRIA 8 2005)
- 2 Restoration Actions are those listed in the proposed project in the relevant plan. **Bold** indicates that the Restoration Action is highly applicable within the reach based on Table 7.  
Protect: protect and conserve  
Riparian: riparian vegetation restoration  
Debris Removal: Intertidal or littoral rubble removal, groin removal  
Armor: removal of artificial shoreline hardening including bulkheads and seawalls
- 3 **Bold** indicates that the specific process addressed is highly impaired within one or more of the sub reaches covered by the project.
- 4 "Protect" is listed as a restoration action for the project if both reach/subreach impairment categories were either "least" or "less" or if subreach category was "least."

#### 4.4 Duwamish River

For the Duwamish River segment, reach assignments based on reach and sub-reach impairment categories are summarized in Table 13. This table illustrates that many Duwamish River shorelines are located within a landscape context of more impairment.

**Table 13**  
**Duwamish River Reach Assignments Based on Reach and Sub-reach Impairment Category**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairment	Most				3	
	More				2	
	Moderate				9	1
	Less				2	
	Least				3	

The following section describes the impairments in the Duwamish River segment, as well as applicable restoration actions.

#### **4.4.1 Impairments**

In the Duwamish River segment, shoreline habitat conditions along Harbor Island and its waterways contain mainly port terminals and commercial shipping facilities. Because of this, shallow shoreline habitat is almost entirely absent or impacted due to the extensive dredging and overwater coverage created by numerous docks and wharfs. There is one small area along Harbor Island providing shallow water habitat despite armored shorelines: the southern shoreline of Terminal 27 on the eastern shore of the East Waterway. The headwaters of Puget Creek, located on the western shore of the Duwamish River, have been the focus of much restoration. Further upstream in the Duwamish, shorelines are heavily urbanized to support industrial activities, but the multiple small areas that have been restored contribute some functional value.

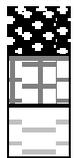
There are few high functioning habitat areas in the Duwamish River segment; these shoreline areas are found along Kellogg Island, the adjacent shoreline to the west, and the eastern shore across the river from the island. Lowest functioning habitats include the industrial shorelines of the rest of the segment.

Table 14, indicates impairment ranges for the reaches in the Duwamish River segment; lower values indicate lower function. This table was completed in the same manner as Table 6.

**Table 14**  
**Impairment ranges from Shoreline Characterization Report (Seattle 2009) for various watershed processes at Duwamish River – City shorelines**

Reach No.	Reach	Reach Impairment Category	Light	LWD	Nitrogen	Pathogens	Phosphorus	Sediment	Tide	Toxins	Water	Wave
13	Harbor Island and Waterways	Most Impaired	High Impairment	High Impairment	High Impairment	Moderate Impairment	High Impairment	Moderate Impairment	High Impairment	High Impairment	High Impairment	High Impairment
14	Lower Duwamish River	More Impaired	Moderate Impairment									

## Notes:



High Impairment

Moderate Impairment

Low Impairment

These results indicate that the most highly impaired processes along the Duwamish River segment are light, LWD, nitrogen, phosphorus, toxins, water, and wave energy. An almost complete lack of riparian vegetation in the zone within 200 feet of the shoreline and the numerous overwater structures such as docks and piers on the industrial shorelines of the river itself are key reasons for impaired shoreline light conditions. Impairment of the LWD process is caused by the lack of riparian vegetation that provides LWD sources both in the river and upstream. This lack of LWD is a persistent problem throughout Seattle's marine shoreline. Impairment of water and water quality processes is mainly due to urban development impacts such as wetland and shoreline vegetation loss in the Duwamish Estuary, and the high levels of impervious surface area in this segment. This problem occurs at a high level along the industrial shorelines of most of the segment.

Results also indicate that processes that are not as highly impaired across Duwamish River segment shorelines are sediment and tidal regime. These processes are still impaired, but not as highly as the other eight processes. The key reason for impairment of tidal regime is the encroachment of shoreline armoring on ordinary high water (OHW), which in the Duwamish River is often sheet-pile wall or other near-vertical armoring. Disruptions in

sediment processes and wave energy are also due to this armoring, which occurs on virtually all of the shorelines in this segment.

#### **4.4.2 Applicable Restoration Actions**

Based on these impairments, the applicable restoration actions for the Duwamish River segment are categorized as High, Moderate, or Low in Table 15. This table was completed in the same manner as Table 7.

Given the reach impairment categories shown in Table 15, all restoration actions are highly applicable in both reaches; the Lower Duwamish River reach is slightly less impaired than the Harbor Island and Waterways reach.

In Reach 13 (Harbor Island and Waterways), several projects have been proposed that include a number of the restoration actions listed as most applicable. At Terminal 105, West Bank line at River Mile 0.1, a pocket habitat project has been suggested, to include armoring removal, wetland and riparian vegetation plantings, and gentler shoreline slopes (Port of Seattle 2009). Completed projects include the Terminal 105 Coastal America site, which constructed a long channel perpendicular to the river that provides riparian and wetland habitat (Seattle 2003); and the Spokane Street Bridge landscaping project, which regraded the shoreline to increase middle and upper intertidal habitat and included plantings of riparian and emergent vegetation. The most applicable projects are those that include armoring removal and riparian and marsh vegetation restoration.

In Reach 14 (Lower Duwamish River), many projects have been proposed that include armoring and rubble removal, shoreline regrading, bank revegetation, marsh plantings, LWD installations, and other shoreline-focused activities, as detailed in the *Lower Duwamish River Habitat Restoration Plan* (LDR Plan; Port of Seattle 2009). A completed project of this type in this area is Herring's House Park, which established areas of high intertidal salt marsh vegetation with a protective perimeter buffer of upland riparian vegetation. These are

**Table 15**  
**Applicable Restoration Actions—Duwamish River**

Reach No.	Reach	Reach Impairment Category <sup>1</sup>	Reach Protection Category <sup>2</sup>	Riparian Restoration	Daylighting Streams (where piped streams occur)	Nearshore Debris Removal/Groin Removal	Beach Nourishment/Substrate Enhancement	Armoring Removal	Overwater Structure Removal	Stormwater Treatment	Wetland Restoration
13	Harbor Island and Waterways	Most Impaired	Low	High	High	Moderate	Moderate	High	High	High	High
14	Lower Duwamish River	More Impaired	Low	Moderate	Moderate	Moderate	Low	Moderate	Moderate	Moderate	Moderate

Notes:

- 1 Based on the results of the *Shoreline Characterization Report* (Seattle 2009).
- 2 Reach was considered High priority for protection if reach impairment category was “least”; moderate priority if reach impairment category was “less”; low priority for all other reach impairment categories (“moderate,” “more,” and “most”).

the types of projects that are highest priority in order to address the impairments in this reach. Connecting several of these projects on a landscape level as suggested in the LDR Plan, is likely to have the most benefit, as this reach is highly impacted and industrial as a whole.

High priority areas for habitat protection in the Duwamish River include those with the least impairments, which are sparse in Reach 14. These areas would likely be limited to recent restoration project sites such as Kellogg Island, Herring's House Park, and the Terminal 105 Coastal America site.

Table 16 provides a list of priority projects for the Duwamish River shoreline segment, including the name of the habitat plan that proposed the project, the sub-reach ID number from the *Shoreline Characterization Report* (Seattle 2009), and the sub-reach impairment and reach impairment categories from the report. For each project, applicable restoration actions and the processes that would be addressed by those restoration actions are identified.

**Table 16**  
**Restoration Projects for the Duwamish River**

<b>Project or Site Name</b>	<b>Plan that Identifies Project or Site<sup>1</sup></b>	<b>Sub-Reach ID</b>	<b>Sub Reach Impairment Category</b>	<b>Reach Impairment Category</b>	<b>Applicable Restoration Actions<sup>2</sup></b>	<b>Process Addressed by Restoration Actions<sup>3</sup></b>
BE-1 (near Pier 20)	Elliott Bay	13-a	Moderately Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• <b>Overwater</b></li> </ul>	Light LWD <b>Sediment</b> <b>Toxins</b> <b>Wave</b>
BE-1 (near Pier 20)	Elliott Bay	13-b	Most Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• <b>Overwater</b></li> </ul>	Light LWD <b>Toxins</b> <b>Wave</b>
Fisher Mills	Elliott Bay	13-l	Most Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• <b>Riparian</b></li> </ul>	Light LWD <b>Nitrogen</b> <b>Sediment</b>
KI-4-1 Smith Cove and Elliott Bay	CGS	13-n	More Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• <b>Riparian</b></li> <li>• <b>Beach</b></li> </ul>	Light LWD <b>Nitrogen</b> <b>Sediment</b>
Section 1, North, Terminal 106, East Bank Line	LDR Plan	14-a	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> </ul>	Light LWD <b>Nitrogen</b> Sediment
Section 2, North Central, Northwestern Glass Company, East Bank Line	LDR Plan	14-e	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal</li> <li>• Beach</li> </ul>	Light LWD <b>Nitrogen</b> Sediment <b>Wave</b>
Section 2, North Central, Northwestern Glass Company, East Bank Line	LDR Plan	14-f	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal</li> <li>• Beach</li> </ul>	Light LWD <b>Nitrogen</b> Sediment Wave
Section 2, North Central, British Plaster Board, East Bank Line	LDR Plan	14-g	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal (shoreline)</li> <li>• Beach</li> </ul>	Light LWD <b>Nitrogen</b> Sediment

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Applicable Restoration Actions <sup>2</sup>	Process Addressed by Restoration Actions <sup>3</sup>
Section 2, North Central, Southwest corner Slip Two, East Bank Line	LDR Plan	14-h	Most Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal (shoreline)</li> <li>• Beach</li> </ul>	<b>Light LWD Nitrogen Sediment</b>
Section 2, North Central, Cold Storage Warehouse / Industrial Upland Site, East Shoreline	LDR Plan	14-k	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal (shoreline)</li> </ul>	<b>Light LWD Nitrogen Sediment</b>
Section 3, South Central, South Othello Street to 8th Avenue South, East Shoreline	LDR Plan	14-m	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal (shoreline)</li> </ul>	<b>Light LWD Nitrogen Sediment</b>
Section 3, South Central, SW Corner Slip 4 and Adjacent Upstream Bank line, East Shoreline	LDR Plan	14-o	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal (shoreline)</li> <li>• Beach</li> </ul>	<b>Light LWD Nitrogen Sediment</b>
Section 3, South Central, SW Corner Slip 4 and Adjacent Upstream Bank line, East Shoreline	LDR Plan	14-p	Most Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Debris Removal (shoreline)</li> <li>• Beach</li> </ul>	<b>Light LWD Nitrogen Sediment</b>

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Applicable Restoration Actions <sup>2</sup>	Process Addressed by Restoration Actions <sup>3</sup>
West Marginal Way SW at Terminal 107	LDR Plan	14-t	Least Impaired	More Impaired	<ul style="list-style-type: none"> <li>Protect<sup>4</sup></li> <li>Riparian</li> <li>Debris removal (shoreline and littoral)</li> <li>Beach</li> </ul>	Light LWD Nitrogen Sediment Wave
Section 1, North, Terminal 107, Kellogg Island, West Bank Line	LDR Plan	14-u	Least Impaired	More Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Riparian</li> <li>Debris Removal (shoreline and littoral)</li> <li>Beach</li> </ul>	Light LWD Nitrogen Sediment Wave
Section 2, North Central, North First Avenue South Bridge, West Shoreline	LDR Plan	14-x	More Impaired	More Impaired	<ul style="list-style-type: none"> <li>Riparian</li> <li>Armor</li> <li>Overwater</li> </ul>	<b>Light LWD Nitrogen Sediment Toxins Water Wave</b>
Section 2, North Central, South First Avenue South Bridge, West Shoreline	LDR Plan	14-y	More Impaired	More Impaired	<ul style="list-style-type: none"> <li>Riparian</li> <li>Debris Removal (shoreline)</li> </ul>	Light LWD <b>Nitrogen</b> Sediment
Section 3, South Central, South Chicago Street to South Kenyon Street, West Shoreline	LDR Plan	14-aa	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>Riparian</li> <li>Debris Removal (shoreline)</li> <li>Beach</li> </ul>	Light LWD <b>Nitrogen</b> Sediment

- Elliott Bay: Elliott Bay General Investigation (USACE 2009)  
CGS: *Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 and 9* (CGS 2005)  
LDR Plan: *Lower Duwamish River Habitat Restoration Plan* (Port of Seattle 2009)
- Restoration Actions are those listed in the proposed project in the relevant plan. **Bold** indicates that the Restoration Action is highly applicable within the reach based on Table 7...  
Protect: protect and conserve

Riparian: riparian vegetation restoration

Debris removal: Intertidal or littoral rubble removal and/or groin removal

Beach: beach nourishment or enhancement

Armor: removal of artificial shoreline hardening including bulkheads and seawalls.

Overwater: removal of overwater structures.

3 **Bold type** indicates that the specific function addressed is highly impaired within one or more of the sub reaches covered by the project

4 "Protect" is listed as a restoration action for the project if both reach/subreach impairment categories were either "least" or "less" or if subreach category was "least."

#### 4.5 Puget Sound, including Shilshole Bay and Elliott Bay

For the Puget Sound segment within the City, reach assignments based on reach and sub-reach impairment are summarized in Table 17. This table illustrates that many Puget Sound shorelines are located within a landscape context of moderate, more, and most impairment.

**Table 17**  
**Puget Sound (including Shilshole and Elliott Bay) Reach Assignments Based on Reach and Sub-reach Impairment Category**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Impairment	Most				1	3
	More				3	1
	Moderate			9	3	1
	Less	1	1	4	1	
	Least	2	1	1		

The following section describes the impairments in the Puget Sound segment, as well as the applicable restoration actions.

##### 4.5.1 Impairments

In the northernmost portion of Puget Sound in the City, shorelines are entirely armored in association with the rail line along the shore. The presence of the rail line precludes adjacent riparian vegetation and impacts sediment processes due to interruption of sediment supply to the beach from the numerous shoreline bluffs. Additionally this area is impaired by fertilizer run-off from the many surrounding residential lawns. Two forested ravines (Broadview Creek and Pipers Creek) exist in this area, these ravines have less impervious surface than the

surrounding residential areas. Shilshole Bay Marina contains large amounts of overwater structures and shoreline armor.

Near the Ballard Locks, further impaired conditions occur in a critical ecological position, as this area is the estuary for the Lake Washington/Lake Sammamish/Cedar River drainage. In this area, juvenile salmon make the physiologically demanding transition from fresh water to salt water, and the presence of the locks makes the transition quite abrupt. Ecological function improves moving through Discovery Park, as the eroding bluffs along the south shoreline and the vegetated creek drainage in the north are particularly high functioning areas. Toward Elliott Bay and the urban core, conditions deteriorate due to increasing shoreline armoring, overwater cover, and impervious surfaces, and decreasing riparian vegetation and intertidal habitat. In the downtown area, shorelines are entirely armored, have extensive overwater cover and fill, and are almost entirely impervious surface. CSOs and stormwater outfalls are present, and roads are in direct proximity to the shoreline. Along western Elliott Bay and toward West Seattle, shorelines are still armored but impervious surface area decreases. Near Lincoln Park in South Seattle, extensive vegetation and minimal impervious surfaces abound, but the area surrounding the Fauntleroy ferry terminal is highly impaired for toxins, pathogens, and sediment processes. At the south end of the project boundary, Seola Park offers high functioning habitat due to vegetated and minimally impacted shorelines. Impairments to water quality in the southern portion of this segment result from outfalls from large basins and culverts that carry pollutants from upland activities.

In summary, the highest functioning habitats in the segment are found along the unarmored portions of Golden Gardens, the creek mouths, and their small associated wetlands, and Discovery, Lincoln, and Seola parks. Lowest functioning habitats in the segment include Shilshole Bay and Elliott Bay Marinas, the central waterfront, and Terminals 90 and 91.

Table 18 indicates impairment ranges for the reaches in the Puget Sound segment; lower values indicate lower function. This table was completed in the same manner as Table 6.

These results indicate that the most highly impaired processes in the City's marine nearshore include pathogens and sediment. Key reasons for the impairment of sediment processes is the

urban and shoreline residential and transportation (rail and road) development which disconnects sediment source bluffs from the shoreline. In addition, jetties, breakwaters, and groins present throughout the marine shoreline restrict sediment movement once it reaches the shore, creating a persistent problem. Impairment of water quality due to pathogens is mainly linked to urban development impacts such as CSOs in the downtown core, and wetland and shoreline vegetation loss and increased impervious surface area from Elliott Bay throughout the downtown core.

Other processes that are still impaired—but not as highly as the other two processes—include LWD, nitrogen, phosphorus, toxins, water, and wave energy. The reasons for impairment of the water quality processes of nitrogen, toxins, and phosphorus are the same as those listed above for pathogens. LWD processes have been disrupted on a large scale throughout the City’s Puget Sound shorelines due to removal of source trees and vegetation from the nearby shore to facilitate urban development and due to encroachment of armoring into intertidal areas, which restricts accumulation. In addition, source wood is no longer provided from river mouths in the region due to development in their watersheds.

The water process has been impaired mainly by urban development and increased impervious surface area, now common on most City shorelines. Disruptions in wave energy along the Seattle shore include armoring, jetties, groins breakwaters, and overwater structures. These are interspersed throughout Seattle, but are particularly heavy near Shilshole and the downtown core.

Tidal regime is the process least impaired in this segment, although it is still impaired. Impacts to tidal regime in Puget Sound are due to channelized streams, the Ballard Locks, and encroachment of armoring on OHW. Armoring and tidal encroachment occurs throughout almost the entire Seattle shoreline.

**Table 18**  
**Impairment Ranges from Shoreline Characterization Report (Seattle 2009) for Various**  
**Watershed Processes at Puget Sound—City Shorelines**

Reach No.	Reach	Reach Impairment Category*	Light	LWD	Nitrogen	Pathogens	Phosphorus	Sediment	Tide	Toxins	Water	Wave
15	North Bluffs	Less Impaired	Low	Low	Low	High	Low	High	Low	Low	Low	Low
16	North Beach & Golden Gardens Park	Mod. Impaired	Low	High	Low	High	High	Low	High	Low	Low	High
17	Shilshole Bay and Marina	More Impaired	High	High	Low	High	High	High	High	High	High	High
18	West Point and Magnolia Bluffs	Least Impaired	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
19	Magnolia	Less Impaired	Low	Low	Low	High	Low	High	High	Low	Low	High
20	Elliott Bay Marina and T 90 and 91	Most Impaired	High	High	High	High	High	High	High	High	High	High
21	Myrtle Edwards Park and Olympic Sculpture	More Impaired	High	High	High	High	High	High	High	High	High	High
22	Central Waterfront	Most Impaired	High	High	High	High	High	High	High	High	High	High
23	Southwest Elliott Bay	More Impaired	High	High	High	Low	High	High	High	High	High	High
24	Duwamish Head	More Impaired	High	High	High	High	High	High	High	High	High	High
25	Alki Beach to Lincoln Park	Mod. Impaired	High	High	High	High	High	High	High	High	High	High
26	Lincoln Park and Fautleroy Cove	Less Impaired	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
27	South Seattle to Seola Creek	Mod. Impaired	Low	High	Low	Low	Low	High	High	Low	Low	High

Notes:

-  High Impairment
-  Moderate Impairment
-  Low Impairment

#### **4.5.2 Applicable Restoration Actions**

Based on these impairments, applicable restoration actions for the Puget Sound segment are categorized as High, Moderate, or Low in Table 19. This table was completed in the same manner as Table 7.

Given the reach impairment categories shown in the table, the reaches in highest need for restoration actions include Shilshole Bay and Marina and those south from Elliott Bay Marina through Duwamish Head.

In the Reach 17 (Shilshole Bay and Marina), restoration of sediment processes has been proposed for the areas south of Carkeek Park through Salmon Bay, as well as from Shilshole Bay to West Point (CGS 2005). In Reaches 20 through 24 (south from Elliott Bay Marina through Duwamish Head), a number of projects have been proposed in Elliott Bay proper to create intertidal embayments and which would relocate armoring to above OHW (Anchor 2004), partly addressing the sediment issue. Projects of this kind that have been recently completed include Myrtle Edwards Park and at Olympic Sculpture Park.

Because many of the Puget Sound reaches are “most” and “more” impaired reaches, high applicable restoration actions would essentially include those in every category in Table 19. Projects most needed are those that combine restoration actions to address several processes at once.

High priority areas for habitat protection include Discovery Park, primarily West Point and Magnolia Bluffs, Magnolia, Lincoln Park and Fauntleroy reach, as well as any recent restoration project sites such as Olympic Sculpture Park.

**Table 19**  
**Applicable Restoration Actions—Puget Sound**

Reach No.	Reach	Reach Impairment Category <sup>1</sup>	Reach Protection Category <sup>2</sup>	Riparian Restoration	Daylighting Streams (where piped streams occur)	Nearshore Debris/ Jetty/Groin/ Breakwater Removal	Beach Nourishment/ Substrate Enhancement	Armoring Removal	Overwater Structure Removal	Stormwater Treatment	Wetland Restoration
15	North Bluffs	Less Impaired	Moderate	Low	High	High	High	High	Moderate	Moderate	Moderate
16	North Beach and Golden Gardens Park	Moderately Impaired	Low	Moderate	High	Low	Low	Moderate	Moderate	High	High
17	Shilshole Bay and Marina	More Impaired	Low	High	High	High	Moderate	High	High	High	High
18	West Point and Magnolia Bluffs	Least Impaired	High	Low	Low	Low	Low	Low	Low	Low	Low
19	Magnolia	Less Impaired	Moderate	Moderate	High	Moderate	Moderate	Moderate	Low	High	High
20	Elliott Bay Marina and Terminals 90 and 91	Most Impaired	Low	High	High	High	High	High	High	High	High

Reach No.	Reach	Reach Impairment Category <sup>1</sup>	Reach Protection Category <sup>2</sup>	Riparian Restoration	Daylighting Streams (where piped streams occur)	Nearshore Debris/Jetty/Groin/Breakwater Removal	Beach Nourishment/Substrate Enhancement	Armoring Removal	Overwater Structure Removal	Stormwater Treatment	Wetland Restoration
21	Myrtle Edwards Park and Olympic Sculpture	More Impaired	Low	High	High	High	High	High	High	High	High
22	Central Waterfront	Most Impaired	Low	High	High	High	High	High	High	High	High
23	Southwest Elliott Bay	More Impaired	Low	High	High	High	High	High	High	High	High
24	Duwamish Head	More Impaired	Low	High	High	High	High	High	High	High	High
25	Alki Beach to Lincoln Park	Moderately Impaired	Low	High	High	Moderate	Moderate	Moderate	Moderate	High	High
26	Lincoln Park and Fautleroy Cove	Less Impaired	Moderate	Low	Low	Low	Low	Low	Low	Low	Low
27	South Seattle to Seola Creek	Moderately Impaired	Low	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

## Notes:

- 1 Based on the results of the *Shoreline Characterization Report* (Seattle 2009).
- 2 Reach was considered High priority for protection if reach impairment category was “least”; moderate priority if reach impairment category was “less”; low priority for all other reach impairment categories (“moderate,” “more,” and “most”)

Table 20 provides a list of restoration projects for the Puget Sound shoreline segment, including the name of the habitat plan that proposed the project, the sub-reach ID number from the *Shoreline Characterization Report* (Seattle 2009), and the sub-reach impairment and reach impairment categories from the report. For each project, applicable restoration actions and the processes that would be addressed by those restoration actions are identified.

**Table 20**  
**Restoration Projects for Puget Sound**

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Applicable Restoration Actions <sup>2</sup>	Process Addressed by Restoration Actions <sup>3</sup>
SN-3 Northern Railroad (Carkeek)	CGS	15-d	Less Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect<sup>4</sup></li> </ul>	--
Pipers Creek to Golden Gardens	Blueprint	15-e	Less Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect</li> </ul>	--
KI-2-1 Carkeek to Shilshole	CGS	16-a/b	Moderately/Least Impaired	Moderately Impaired	<ul style="list-style-type: none"> <li>Protect</li> </ul>	--
KI-2-1/KI-2-2 South Golden Gardens, Shilshole N. Salmon Bay	CGS	17-b	More Impaired	More Impaired	<ul style="list-style-type: none"> <li>Debris Removal</li> <li>Overwater</li> </ul>	Light LWD Sediment Toxins Wave
KI-2-1/KI-2-2 South Golden Gardens, Shilshole N. Salmon Bay, KI-2-2 Salmon Bay into Ship Canal, North side	CGS	17-c	Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>Riparian</li> <li>Debris Removal</li> <li>Beach</li> <li>Armor</li> <li>Overwater</li> </ul>	Light LWD Nitrogen Sediment Toxins Wave
Locks - Barnacle Removal	Blueprint	17-d	Less Impaired	More Impaired	N/A	N/A
KI-2-4 Shilshole Bay to Westpoint	CGS	18-b	Least Impaired	Least Impaired	<ul style="list-style-type: none"> <li>Protect</li> </ul>	--

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Applicable Restoration Actions <sup>2</sup>	Process Addressed by Restoration Actions <sup>3</sup>
KI-2-4 Shilshole Bay to Westpoint	CGS	18-d	Less Impaired	Least Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Riparian</li> <li>Wetland Restoration</li> <li>Debris Removal</li> </ul>	Light LWD <b>Nitrogen</b> Pathogens Phosphorus <b>Sediment</b> Toxins Water Wave
KI-3-2 Magnolia Bluffs to Smith Cove	CGS	18-e	Least Impaired	Least Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Debris Removal</li> </ul>	<b>Sediment</b> Wave
Magnolia Bluffs	WRIA 9	19-a	Less Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Debris Removal (shoreline and in-water)</li> </ul>	Sediment Wave
Magnolia Bluffs	WRIA 9	19-b	Least Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Debris (shoreline and in-water)</li> </ul>	Sediment Wave
KI-3-2 Magnolia Bluffs to Smith Cove	CGS	19-c	Less Impaired	Less Impaired	<ul style="list-style-type: none"> <li>Protect</li> <li>Beach</li> <li>Debris (in-water)</li> </ul>	Sediment Wave
KI-3-2/KI-3-3 Smith Cove Marina and Breakwater	CGS	20-a	Most Impaired	Most Impaired	<ul style="list-style-type: none"> <li><b>Beach</b></li> </ul>	Sediment
KI-3-2/KI-3-3 Smith Cove Marina and Breakwater	CGS	20-b	Moderately Impaired	Most Impaired	<ul style="list-style-type: none"> <li><b>Riparian</b></li> <li><b>Beach</b></li> <li><b>Stormwater treatment</b></li> <li><b>Debris (in-water)</b></li> </ul>	Light LWD <b>Nitrogen</b> <b>Pathogens</b> Phosphorus Sediment Tide <b>Toxins</b> <b>Water</b>

Project or Site Name	Plan that Identifies Project or Site <sup>1</sup>	Sub-Reach ID	Sub Reach Impairment Category	Reach Impairment Category	Applicable Restoration Actions <sup>2</sup>	Process Addressed by Restoration Actions <sup>3</sup>
Elliott Bay, Northeastern section	WRIA 9	20-c/d	Most/Moderately Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> </ul>	Light LWD Nitrogen Phosphorus Sediment Toxins Water
Myrtle Edwards Park	Blueprint	21-a/b	Most/Moderately Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> </ul>	Light LWD Nitrogen Phosphorus Sediment Toxins Water
Elliott Bay, Industrial and Port Areas	WRIA 9	22-a,b	Most Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> <li>• Overwater</li> </ul>	Light LWD Nitrogen Phosphorus Sediment Toxins Water
Elliott Bay, Industrial and Port Areas	WRIA 9	22-c	Most Impaired	Most Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> </ul>	Light LWD Nitrogen Phosphorus Sediment Toxins Water
Elliott Bay, West	WRIA 9	23-a	More Impaired	More Impaired	<ul style="list-style-type: none"> <li>• Riparian</li> <li>• Beach</li> </ul>	Light LWD Nitrogen Phosphorus Sediment Toxins Water
West Seattle, mouth of Schmitz Creek	WRIA 9	25-b	Less Impaired	Moderately Impaired	<ul style="list-style-type: none"> <li>• Protect</li> <li>• Daylight Stream</li> <li>• Debris Removal (shoreline and in-water)</li> </ul>	LWD, Nitrogen Pathogens Sediment Tide Wave
Lincoln Park	Parks	26-b	Least Impaired	Least Impaired	<ul style="list-style-type: none"> <li>• Protect</li> </ul>	--

- 1 Blueprint: *Seattle's Urban Blueprint for Habitat Protection and Restoration* (Seattle 2003)  
CGS: *Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 and 9* (CGS 2005)  
WRIA 9: *Salmon Habitat Plan, Green/Duwamish and Central Puget Sound Watershed Resource Inventory Area 9* (WRIA 9 2005)  
Parks: *Seattle Shoreline Park Inventory and Habitat Assessment* (Anchor 2003)
- 2 **Bold** indicates that the Restoration Action is highly applicable within the reach.  
Protect: protect and conserve  
Riparian: riparian vegetation restoration  
Debris removal: Intertidal or littoral rubble removal and/or groin removal  
Beach: beach nourishment or enhancement  
Armor: removal of artificial shoreline hardening including bulkheads and seawalls.  
Overwater: removal of overwater structures.
- 3 **Bold type** indicates that the specific process addressed is highly impaired within one or more of the sub reaches covered by the project.
- 4 "Protect" is listed as a habitat action for the project if both reach/subreach impairment categories were either "least" or "less" or if subreach category was "least."

## 4.6 Green Lake

For the Green Lake segment within the City, reach assignments based on reach and sub-reach impairment are summarized in Table 21. This table illustrates that Green Lake's shorelines are located within a landscape context of moderate and less impairment.

**Table 21**  
**Green Lake Reach Assignments based on Reach and sub-reach Impairment**

		Reach Scale Impairment				
		Least	Less	Moderate	More	Most
Sub-reach Scale Impairment	Most					
	More					
	Moderate			1		
	Less			1		
	Least					

The following section describes the impairments in the Green Lake segment, as well as applicable restoration actions.

#### 4.6.1 Impairments

Green Lake's shoreline contains more riparian vegetation, has a wider corridor of open park areas with less impervious surfaces, fewer parking lots, and fewer filled wetlands than in most areas of the City. The main concern with Green Lake, however, is the high amounts of nitrogen and phosphorus in the lake and its resulting water quality. The north portion of Green Lake is less impacted than the southern shore.

Table 22 indicates impairment ranges for the reaches in the Green Lake segment; lower values indicate lower function. This table was completed in the same manner as Table 6.

**Table 22**  
**Impairment Ranges from Shoreline Characterization Report (Seattle 2009)**  
**for Various Watershed Processes at Green Lake–City shorelines**

Reach No.	Reach	Overall Impairment Category	Light	LWD	Nitrogen	Pathogens	Phosphorus	Sediment	Toxins	Water	Wave
28	Green Lake	Moderately Impaired			* * * * *		* * * * *				

Notes:

-  High Impairment
-  Moderate Impairment
-  Low Impairment

These results indicate that the most highly impaired processes at Green Lake are nitrogen and phosphorus. Key reasons for this impairment are the sediment and inputs from adjacent lawn areas and nonpoint urban runoff. Processes not as highly impaired are light and sediment; vegetation cover is present in many areas within the area studied (200 feet of the shoreline) and light conditions are not likely to be limiting in these areas. The sediment process at Green Lake is not as impaired because lake slopes are typically gentle and armoring is generally limited.

#### **4.6.2 Applicable Restoration Actions**

Based on these impairments, applicable restoration actions for the Green Lake segment are categorized as High, Moderate, or Low in Table 23. This table was completed in the same manner as Table 7.

At Green Lake, no projects have been recently proposed to address any of the watershed processes described as impaired. The most applicable restoration actions would include bioswales or similar stormwater treatments that would help address the nutrient issues in the lake and continued alum treatment to reduce the internal phosphorous levels. High priority areas for habitat protection include those with the least impairments, which would include the areas with riparian vegetation and unarmored shorelines at the lake identified in the Green Lake Vegetation Plan<sup>1</sup>.

---

<sup>1</sup> available at [www.seattle.gov/parks/parkspaces/GreenLakePark/VMP.htm](http://www.seattle.gov/parks/parkspaces/GreenLakePark/VMP.htm).

**Table 23**  
**Applicable Restoration Actions—Green Lake**

Reach No.	Reach	Reach Impairment Category <sup>1</sup>	Reach Protection Category <sup>2</sup>	Riparian Restoration	Daylighting Streams (where piped streams occur)	Nearshore Debris Removal	Beach Nourishment/ Substrate Enhancement	Armoring Removal	Overwater Structure Removal	Stormwater treatment	Wetland Restoration
28	Green Lake	Moderately Impaired	Low	High	High	Low	Low	Moderate	Moderate	High	High

## Notes:

1 Based on the results of the *Shoreline Characterization Report* (Seattle 2009).

2 Reach was considered High priority for protection if reach impairment category was “least”; moderate priority if reach impairment category was “less”; low priority for all other reach impairment categories (“moderate,” “more,” and “most”)

---

## 5 IMPLEMENTATION

### 5.1 Implementation Strategy

Implementation of the restoration plan will be a combined effort of many City departments. Department of Planning and Development is including language in the City's Comprehensive Plan that will direct departments that own and manage land along the shorelines to continue to implement restoration projects on their properties where appropriate and to continue to improve management practices to minimize impacts to the shoreline environment from maintenance and operations. Additionally the Comprehensive Plan will direct City departments to develop a strategy for restoration planning and implementation in a coordinated manner using the restoration plan as guidance.

Seattle Public Utilities will help to implement the Restoration Plan through the Restore Our Waters initiative, which coordinates restoration of City shorelines. SDOT street end management will also use the restoration plan to guide actions on street ends. The recent adoption of the Parks and Green Spaces levy will provide \$500,000 for street end work. Through the implementation of this work shoreline restoration will occur on street ends. Seattle Department of Parks and Recreation will use the restoration plan to guide the management and restoration planning of their shoreline property and will continue to seek funding for shoreline restoration projects.

### 5.2 Timeline, Benchmarks, and Monitoring

The City's restoration work as it relates to this Plan will be monitored and evaluated on a set timeline against a suite of benchmarks to determine consistency with the State's SMP policy standard of no net loss of ecological functions. This Plan will be implemented when the SMP is adopted by the Department of Ecology, with a timeline based on ten year intervals. At each ten year interval, ecological benchmarks will be evaluated for change. These benchmarks will include variables occurring in currently available datasets such as GIS layers of shoreline features. Measurable benchmarks<sup>2</sup> may include the following:

- Linear distance of armoring above OHW mark
- Number of jetties/breakwaters/groins/boat ramps
- Area of overwater structures

---

<sup>2</sup> Benchmarks apply for the area within 200 feet of the shoreline.

- 
- Linear distance with continuous trees adjacent to shore
  - Linear distance with patchy trees adjacent to shore
  - Linear distance with no cover/grass or trees/shrubs separated from shore
  - Linear distance with adjacent trees and overhanging
  - Number of completely or partially altered channelized streams
  - Number of CSO outfalls
  - Wetland acreage existing or lost
  - Number of concentrations of animals in public areas
  - Number of feeder bluffs
  - Linear distance of roads within 100 feet of shore
  - Total impervious surface area (TIA) of basin
  - Linear distance with less than 50 percent impervious (1 to 12.5, 12.5 to 50, etc.)
  - Numbers of marinas or houseboats present
  - Number of CSO events within the 7-year timeframe

At the conclusion of each ten year interval, current data for each of these benchmarks will be compiled and the GIS model (as described in Section 4.1) will be re-run to evaluate SMP policy consistency.

### 5.3 Potential Funding

There is currently no dedicated funding source for the restoration actions presented here. Restoration described in this plan is dependent on grant funding, and a variety of outside funding sources are available for restoration projects in the area. Funds are distributed through grant-making agencies at the local, state, and federal level; opportunities described below are primarily administered by state and federal agencies. It is expected that funding will be derived from various sources. Sources listed here do not represent an exhaustive list of potential funding opportunities, but are meant to provide an overview of the types of opportunities available. These sources include the following:

- Recreation and Conservation Office of Washington
- Ecology
  - Aquatic Weeds Financial Assistance Program
  - Water Quality Program

- 
- Coastal Protection Fund
  - Coastal Zone Management Administration/Implementation Awards
  - Washington Department of Fish & Wildlife
    - Aquatic Lands Enhancement Account (ALEA) Volunteer Cooperative Projects Program
    - Landowner Incentive Program
  - National Fish and Wildlife Foundation
    - Bring Back the Natives: A Public-Private Partnership for Restoring Populations of Native Aquatic Species
    - Five-Star Restoration Matching Grants Program
    - Marine Debris Prevention and Removal Program
    - Native Plant Conservation Initiative
    - Puget Sound Marine Conservation Fund
    - The Migratory Bird Conservancy
  - King Conservation District
  - Salmon Recovery Funding Board (SRFB)
  - National Oceanic and Atmospheric Administration (NOAA) Restoration Center
    - Community-based Restoration Program
    - NOAA CRP 3-Year Partnership Grants
    - NOAA CRP Project Grants
  - American Sportfishing Association's FishAmerica Foundation Grants
  - Environmental Protection Agency Region 10: Pacific Northwest
    - The Clean Water State Revolving Fund Program
    - Nonpoint Source Implementation Grant (319) Program
    - Wetland Protection, Restoration, and Stewardship Discretionary Funding
  - U.S. Fish & Wildlife Service
    - Partners for Fish and Wildlife Program
    - Puget Sound Program
    - National Fish Passage Program
    - Cooperative Endangered Species Conservation Fund

- 
- North American Wetlands Conservation Act Grants Program
  - Puget Sound Nearshore Ecosystem Restoration Project
  - Washington Department of Transportation City Fish Passage Grant Program
  - Washington Department of Natural Resources Small Forest Landowner Office (SFLO)
  - Private foundations, businesses, and other groups administer grant programs that include funding for shoreline habitat and ecosystems, including:
    - The Russell Family Foundation
    - William C. Kenney Watershed Protection Foundation
    - Northwest Fund for the Environment
    - Kongsgaard-Goldman Foundation
    - The Bullitt Foundation
    - The Compton Foundation
    - Doris Duke Charitable Foundation
    - The Hugh and Jane Ferguson Foundation
    - Washington Trout
    - Midsound Fisheries Enhancement Group
    - People for Puget Sound
    - The Seattle Aquarium

## 5.4 Conclusions

This plan identifies the applicable restoration actions and the areas that should be protected based on the results of the Shoreline Characterization Report. As is the case for most restoration work, the restoration and protection actions described in this Plan will require extensive cooperation and coordination with citizens, public agencies, private landowners, and other stakeholders. Additionally some of the actions require the acquisition of private land, relocation of public infrastructure, changes in land use and potential restrictions on future development. It is the City's intent to use this plan to guide their restoration and habitat protection efforts so these actions result in a net increase in shoreline ecosystem function over time consistent with the vision for the shoreline of its citizens.

---

## 6 REFERENCES

- Anchor Environmental, L.L.C (Anchor). 2003. Seattle Shoreline Park Inventory and Habitat Assessment. Prepared for Seattle Parks and Recreation. June 2003.
- Anchor. 2004. Marine Shoreline Inventory Report: WRIA 9. Prepared for Seattle Public Utilities. Anchor Environmental, L.L.C. Funded by King Conservation District and the Washington State Salmon Recovery Funding Board.
- Anchor. 2006. Prioritization of Marine Shorelines of WRIA 9 for Juvenile Salmonid Habitat Protection and Restoration. Prepared for WRIA 9 Technical Committee. May 2006.
- Booth, D.B., J.R. Karr, S. Schaumann, C.R. Konrad, S.A. Morley, M.G. Larson, and S.J. Burges. 2004. Reviving urban streams: land use, hydrology, biology, and human behavior. *Journal of the American Water Resources Association* 40(5): 1351-1364.
- City of Seattle. 2003. Seattle's Urban Blueprint for Habitat Protection and Restoration. City of Seattle Salmon Team. December 2003.
- City of Seattle. 2008. Draft Vision Report. Seattle's Shorelines Today and Tomorrow: Updating Seattle's Shoreline Master Program. April 2008. Available at: [http://www.seattle.gov/DPD/static/Vision%20Report%202008\\_LatestReleased\\_DPDP\\_022390.pdf](http://www.seattle.gov/DPD/static/Vision%20Report%202008_LatestReleased_DPDP_022390.pdf)
- City of Seattle. 2009. Draft Shoreline Characterization Report. March 2009.
- Coastal Geologic Services, Inc (CGS). 2005. Inventory and Assessment of Current and Historic Beach Feeding Sources/Erosion and Accretion Areas for the Marine Shorelines of Water Resource Inventory Areas 8 and 9.
- King County. 2007. King County Shoreline Master Program. Appendix E: Technical Appendix. Contains: Shoreline Inventory and Characterization Methodology and Results. May 2007.
- Naiman, R.J., J.J. Magnuson, D.A. McKnight, J.A. Stanford, and J.R. Karr. 1995. Freshwater Ecosystems and Their Management: A National Initiative. *Science* 270: 584-585.
- Port of Seattle. 2009. Lower Duwamish River Habitat Restoration Plan and Inventory of Port of Seattle Properties. January 2009.

- 
- Puget Sound Partnership (PSP). 2009. Draft Puget Sound Action Agenda.
- Puget Sound Technical Recovery Team (Puget Sound TRT). 2003. Integrated Recovery Planning for Listed Salmon: Technical Guidance for Watershed Groups in Puget Sound.
- Seattle Public Utilities and the U.S. Army Corps of Engineers (SPU and USACE). 2008. Synthesis of salmon research and monitoring, investigations conducted in the western Lake Washington Basin. Available online at:  
[http://www.govlink.org/watersheds/8/pdf/LWGI\\_SalmonSyn123108.pdf](http://www.govlink.org/watersheds/8/pdf/LWGI_SalmonSyn123108.pdf)
- Seattle Department of Parks and Recreation. 1996. Green Lake Vegetation Management Plan. Available online at: <http://www.seattle.gov/parks/Horticulture/VMP/GreenLake.htm>
- Simenstad, C, M Logsdon, K. Fresh, H. Shipman, M. Dethier, J. Newton. 2006. Conceptual model for assessing restoration of Puget Sound nearshore ecosystems. Puget Sound Nearshore Partnership Report No. 2006-03. Published by Washington Sea Grant Program, University of Washington, Seattle, Washington. Available at <http://pugetsoundnearshore.org>.
- Stanley, S., J. Brown, and S. Grigsby. 2005. Protecting aquatic ecosystems: A guide for Puget Sound Planners to understand watershed processes. Washington State Department of Ecology. Publication #05-06-027. Olympia, WA. Available online at: <http://www.ecy.wa.gov/biblio/0506027.html>
- Shreffler, D. K., and Thom, R. M. 1993. Restoration of urban estuaries: New approaches for site location and design by: Washington Department of Natural Resources: Battelle Pacific Northwest Laboratories; 1993107.
- Tabor, Roger, and G. Brown, and V. Luiting. 1998. The Effect of Light Intensity on Predation of Sockeye Salmon Fry by Prickly Sculpin and Torrent Sculpin. Prepared by U.S. Fish and Wildlife Service; Publication FP137.PDF.
- Tabor, Roger, and J A. Scheurer, H. A. Gearns, and E. P. Bixler. 2004. Nearshore Habitat Use by Juvenile Chinook Salmon in the Lentic Systems of the Lake Washington Basin, Annual Report 2002. Prepared by U.S. Fish and Wildlife Service for Seattle Public Utilities. 2004.

- 
- Tetra Tech ISG, Inc. and Parametrix, Inc. 2003. Lake Washington Existing Conditions Report. Prepared for King County Department of Natural Resources and Parks, Water and Land Resources Division.
- Thom, R.M., and G. Williams, A. Borde, J. Southard, S. Sargeant, D. Woodruff, J.C. Laufle and S. Glasoe. 2005. Adaptively addressing uncertainty in estuarine and near coastal restoration projects. *Journal of Coastal Research* 40: 94-108.
- Toft, J.D. 2001. Shoreline and dock modifications in Lake Washington, Technical Report SAFS-UW-0106. Published by School of Aquatic and Fishery Sciences, University of Washington. 2001.
- Toft, J. and C. Simenstad, C. Young, and L. Stamatiou. 2003a, Inventory and Mapping of City of Seattle Shorelines along Lake Washington, the Ship Canal and Shilshole Bay. 33 pp. Prepares for Seattle Public Utilities. Published by School of Aquatic and Fishery Sciences, University of Washington. 2003.
- Toft, J. and C. Simenstad, K. Dodd, and T Miller. 2003b. Inventory and Mapping of City of Seattle Shorelines along Lake Washington, the Ship Canal and Shilshole Bay. Prepared for City of Seattle. . Published by School of Aquatic and Fishery Sciences, University of Washington. 15 pp. 2003.
- U.S. Army Corps of Engineers (USACE). 2009. Meeting between Pat Cagney, Linda Smith and Scott English from the Corps; Margaret Glowacki and Sandy Gurkewitz from the City of Seattle; Paul Schlenger and John Small from Anchor QEA. July 14, 2009.
- Washington State Department of Ecology (Ecology). 2004. A Department of Ecology Report: What Does No Net Loss Mean in the 2003 SMA Guidelines? June 2004.
- Williams, G.D., R.M. Thom, J.E. Starks, J.S. Brennan, J.P. Houghton, D. Woodruff, P.L. Striplin, M. Miller, M. Pederson, A. Skillman, R. Kropp. A. Borde, C. Freeland, K. McArthur, V. Fagerness, S. Blanton, and L. Blackmore. 2001. Reconnaissance assessment of the state of the nearshore ecosystem: eastern shore of central Puget Sound, including Vashon and Maury islands (WRIAs 8 and 9). J.S. Brennan, editor. Report prepared for King County Dept. Natural Resources, Seattle, WA.
- Williams G.D., R.M. Thom, and N.R. Evans. 2004. Bainbridge Island Nearshore Habitat Characterization and Assessment, Management Strategy Prioritization, and

- Monitoring Recommendations. PNWD-3391. Prepared for the City of Bainbridge Island, Washington, by Battelle Marine Sciences Laboratory, Sequim, Washington
- Water Resource Inventory Area 8 Steering Committee (WRIA 8). 2005. Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Conservation Plan. July 2005.
- Water Resource Inventory Area 9 Steering Committee (WRIA 9). 2005. Salmon Habitat Plan, Green/Duwamish and Central Puget Sound Watershed Resource Inventory Area 9.
- WRIA 8. 2005. Lake Washington/Cedar/Sammamish Watershed Chinook Salmon Conservation Plan. July 2005.