City of Lake Forest Park
Grant No. G00600133

FINAL

SHORELINE ANALYSIS REPORT
Including Shoreline Inventory and Characterization for the City of Lake Forest Park's Lake Washington Shoreline

Project: Comprehensive Shoreline Master Program Update
- **Task 4: Inventory and Map Shoreline Conditions**
- **Task 5: Conduct Analysis**
- **Task 6: Prepare Final Analysis Report and Refined Maps**

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The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies.

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TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

Appendices

List of Tables Page No.

1.0 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

The City of Lake Forest Park obtained a grant from the Washington Department of Ecology (Ecology) in 2005 to conduct a comprehensive Shoreline Master Program (SMP) update. The first steps of the update process are to inventory and characterize the City's shorelines as defined by the state's Shoreline Management Act (SMA) (RCW 90.58). The inventory and characterization were conducted according to direction provided in the Shoreline Master Program Guidelines and project Scope of Work promulgated by Ecology, and includes areas within the current City limits. This shoreline inventory and characterization will describe existing conditions and assess ecological functions and ecosystem-wide processes operating in the shoreline jurisdiction. This analysis will serve as the baseline from which future development actions in the shoreline will be measured. The Guidelines require that the City demonstrate that its updated SMP yields "no net loss" in shoreline ecological functions relative to the baseline due to its implementation. Ideally, the SMP in combination with other City and regional efforts will ultimately produce a net improvement in shoreline ecological functions (see Section 3.11 for more discussion).

A list of potential information sources was compiled and an information request letter was distributed to potential interested parties and agencies that may have relevant information (Appendix A). Collected information was supplemented with other resources such as City documents, scientific literature, personal communications, aerial photographs, internet data, and a brief physical inventory of the City's shorelines.

1.2 SHORELINE JURISDICTION

As defined by the Shoreline Management Act of 1971, shorelines include certain waters of the state plus their associated "shorelands." At a minimum, the waterbodies designated as shorelines of the state are streams whose mean annual flow is 20 cubic feet per second (cfs) or greater or lakes whose area is greater than 20 acres. Shorelands are defined as:

> "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 200 feet from such floodways; and all wetlands and river deltas associated with the streams, lakes, and tidal waters which are subject to the provisions of this chapter…Any county or city may determine that portion of a one-hundred-year-floodplain to be included in its master program as long as such portion includes, as a minimum, the floodway and the adjacent land extending landward two hundred feet therefrom (RCW 90.58.030)"

Shorelands in the City of Lake Forest Park include only areas within 200 feet of the ordinary high water mark, as established by the U.S. Army Corps of Engineers for Lake Washington, and any associated wetlands within shoreline jurisdiction. Lake Washington does not have a floodway or floodplain. As part of the shoreline jurisdiction assessment, McAleer Creek and Lyon Creek were reviewed. Both features were found to have mean annual flows of less than 20 cubic feet per second[1] and thus are not subject to regulation under the Shoreline Management Act. No associated wetlands have yet been identified that would extend shoreline jurisdiction beyond 200 feet from the Lake Washington ordinary high water mark.

1.3 STUDY AREA

The City of Lake Forest Park (City) is located in King County along a 2.22-mile portion of the northwestern shoreline of Lake Washington. The City is bordered to the south by the City of Seattle, to the west by the City of Shoreline, to the north by the Cities of Mountlake Terrace and Brier, and to the east by the City of Kenmore. State Highway 522 runs parallel to the City's Lake Washington shoreline, adjacent to the eastern edge of the City's business district. The City encompasses approximately 3.59 square miles. The study area for this report includes all land currently within the City's shoreline jurisdiction. The total area subject to shoreline jurisdiction is approximately 0.08 square miles, or 2.15 percent of the entire City.

2.0 CURRENT REGULATORY FRAMEWORK SUMMARY

2.1 CITY OF LAKE FOREST PARK

In compliance with Shoreline Management Act, the City of Lake Forest Park adopted the King County Shoreline Master Program (SMP) by reference in and continues to administer shoreline compliance through the King County SMP and King County Code Title 25 – Shoreline Management. As a result of annexations to the City of Lake Forest Park that occurred in 1993 and 1994, the City doubled in population and area, and the City's shoreline area along Lake Washington increased from 400 linear feet to 11,769 linear feet (Figure 1[2]). In response to this substantial increase in the area under SMP jurisdiction, the City of Lake Forest Park's Environmental Quality Commission (EQC), staff, and a team of consultants worked on amending the adopted SMP in the fall of 1994. Public input was received during the development of the 1995 Draft SMP; the City held two open houses and developed a survey to capture citizen opinions and comments on goals and policies. The City Planning Commission and City Council reviewed the SMP and public hearings were held; however, the Draft SMP was never adopted. The 1995 Draft SMP will be used as a starting point in the development of an SMP that will comply with the most recent Department of Ecology guidelines (Chapter 173-26 WAC). All shoreline areas in the City are currently designated as Urban in the adopted King County Shoreline Master Program ("Suburban Residential" is the designation in the 1995 Draft SMP) (Figure 2).

In addition to the City's existing Shoreline Master Program, lands in the City's shorelines are also currently regulated under the City's Comprehensive Plan and the Lake Forest Park Municipal Code, notably Title 19 (Environmental Protection) and Title 18 (Zoning). A variety of actions or exceedence of certain activity thresholds can trigger the need for City review.

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[1] http://dnr.metrokc.gov/wlr/waterres/hydrology/ParameterSelect.aspx?G_ID=117, http://dnr.metrokc.gov/wlr/waterres/hydrology/ParameterSelect.aspx?G_ID=120

[2] All figures are included in Appendix B at the end of this report.

Where the shorelines are concerned, state and federal regulations and guidance will result in updated City plans, policies and regulations that recognize and protect natural systems.

The Lake Forest Park Municipal Code (LFPMC) establishes specific and detailed regulations for most of the uses, development, and activities regulated in the SMP. The LFPMC and the SMP are intended to operate together to produce a coherent and thorough set of land use regulations. In all cases, uses, developments and activities must comply with both the LFPMC and the SMP. If there is a conflict between the two, the more restrictive applies.

In December 2005, the City adopted a revised Critical Area Ordinance (CAO) consistent with best available science and all other requirements of the Growth Management Act (RCW 36.70A). Consistent with Washington State ESHB 1933, critical areas, including those within the Shoreline Management Zone, are currently regulated under the CAO. If there is a conflict between the CAO and SMP, the regulations that offer the greatest environmental protection apply. Following adoption of the updated SMP, GMA critical areas within the shoreline zone will be regulated exclusively by the SMP. In December 2005, the City also adopted a new Comprehensive Plan pursuant to Growth Management Act requirements.

2.2 STATE AND FEDERAL REGULATIONS

State and federal regulations most pertinent to development in the City's shorelines include the federal Endangered Species Act, the Clean Water Act, and the State Hydraulic Code. A variety of agencies (e.g., U.S. Army Corps of Engineers, Washington Department of Ecology, Washington Department of Fish and Wildlife) are involved in implementing these regulations, but review by these agencies of shoreline development in most cases would be triggered by in- or over-water work, discharges of fill or pollutants into the water, or substantial land clearing. Depending on the nature of the proposed development, state and federal regulations can play an important role in the design and implementation of a shoreline project, ensuring that impacts to shoreline functions and values are avoided, minimized, and/or mitigated. A summary of some of the key regulations and agency responsibilities follows.

<u>Section 10</u>: Section 10 of the federal Rivers and Harbors Appropriation Act of 1899 provides the U.S. Army Corps of Engineers (Corps) with authority to regulate activities that may affect "navigable" waters. Lake Washington is a designated navigable water. Accordingly, proposals to construct new or modify existing in-water structures (including piers, marinas, bulkheads, breakwaters), to excavate or fill, or to "alter or modify the course, location, condition, or capacity of" Lake Washington must be reviewed and approved by the Corps.

<u>Section 404</u>: Section 404 of the federal Clean Water Act provides the Corps, under the oversight of the U.S. Environmental Protection Agency, with authority to regulate "discharge of dredged or fill material into waters of the United States, including wetlands" (http://www.epa.gov/owow/wetlands/pdf/reg_authority_pr.pdf). The extent of the Corps' authority and the definition of fill have been the subject of considerable legal activity. As applicable to the City of Lake Forest Park's shoreline jurisdiction, however, it generally means that the Corps must review and approve most activities in streams, wetlands and Lake Washington. These activities may include wetland fills, stream and wetland restoration, and culvert installation or replacement, among

others. Similar to SEPA requirements, the Corps is interested in avoidance, minimization, restoration, and compensation of impacts.

Federal Endangered Species Act (ESA): Section 9 of the ESA prohibits "take" of listed species. Take has been defined in Section 3 as: "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." The take prohibitions of the ESA apply to everyone, so any action of the City that results in a take of listed fish or wildlife would be a violation of the ESA and exposes the City to risk of lawsuit. Per Section 7 of the ESA, activities with potential to affect federally listed or proposed species and that either require federal approval, receive federal funding, or occur on federal land must be reviewed by the National Marine Fisheries Service (NOAA Fisheries) and/or U.S. Fish and Wildlife Service (USFWS) via a process called "consultation." As previously mentioned, a Corps permit under Section 10 of the Rivers and Harbors Appropriate Act is required for projects in Lake Washington. Since the listing of chinook salmon and bull trout as Threatened under the ESA, the Corps, NOAA Fisheries and USFWS have jointly developed extensive guidance for design of Lake Washington pier and bulkhead projects.

Section 401 Water Quality Certification: Section 401 of the federal Clean Water Act allows states to review, condition, and approve or deny certain federal permitted actions that result in discharges to state waters, including wetlands. In Washington, the Department of Ecology is the state agency responsible for conducting that review, with their primary review criteria of ensuring that state water quality standards are met. Actions within Lake Washington, or wetlands and streams within the shoreline zone that require a Section 10 or Section 404 permit (see above), will also need to be reviewed by Ecology.

Hydraulic Code: Chapter 77.55 RCW (the Hydraulic Code) gives the Washington Department of Fish and Wildlife (WDFW) the authority to review, condition, and approve or deny "any construction activity that will use, divert, obstruct, or change the bed or flow of state waters." As applicable to the City of Lake Forest Park's shoreline jurisdiction, however, it generally means that WDFW must review and approve most activities in streams and Lake Washington. These activities may include stream alteration, culvert installation or replacement, pier and bulkhead repair or construction, among others. WDFW can condition projects to avoid, minimize, restore, and compensate adverse impacts.

3.0 EXISTING CONDITIONS

The following discussion identifies each of the required inventory elements, sources of information for each element, and provides a descriptive shoreline-wide narrative for each element. Because the City's shoreline is almost entirely residential with no distinct transitions between different land uses or ecological condition, the shoreline has not been divided into discrete segments for analysis and discussion.

3.1 LAND USE PATTERNS

Land use patterns were derived from GIS mapping from the City's most recent Comprehensive Plan (Figures 3a-3c) (Table 1), and from review of aerial photography from 2002 and 2004. In general, the City of Lake Forest Park shoreline area is fully developed. The few areas not occupied by residential uses are either private recreation property, vacant lots, or a formal City park. Land uses along the shoreline are not expected to change, although re-builds and substantial remodels are anticipated.

Table 1. Land Use, Zoning, and Shoreline Environment Designations

Existing Land Use	Future Land Use	Zoning	Existing Shoreline Environment Designation
• Single family– 63% • Recreation/Open Spaces – 25% • Vacant – 1% • Right-of-way – 11%	• Single family residential, high – 64% • Recreation/Open Spaces – 25% • Right-of-way – 11%	Single Family Residential, High RS 7200 – 100%	Urban (Suburban Residential under 1995 Draft SMP) – 100%

Source: City of Lake Forest Park GIS 2004

The City's entire 2.22 miles of shoreline, which consists of 135 shoreline parcels, is zoned single-family residential, high (RS 7,200, minimum lot size of 7,200 square feet). Of that area, single-family uses comprise 63 percent and private and public recreation and open space uses comprise 25 percent of the shoreline zone. The Burke-Gilman Trail is a substantial element of the public recreation and open space, which is generally separated from the shoreline by single-family development. There is one City park and two private recreational clubs on the waterfront. There are only four privately owned lots within the shoreline jurisdiction that do not have a single-family home on them or a private recreational club associated with them. Each one of these "vacant" lots is owned by property owners that are either adjacent to the vacant lot or are separated from the lot by the Burke-Gilman Trail.

One lot is located in the 17000 block of Shore Drive NE. This lot is owned by the adjacent property owner to the north and is landscaped as an extension of the adjacent yard. More than half of the shoreline of this 14,425-square-foot lot is semi-natural beach. The other three lots are contiguous and are located towards the southern end of the shoreline near the 14800 block of Beach Drive NE, just north of where Beach Drive NE ends. These small and shallow properties range in size between just over 2,000 square feet and just under 4,000 square feet. The northernmost and central lots are owned by upland property owners to the west, across the Burke-Gilman Trail. The northernmost lot has a semi-natural shoreline and a fixed pier. The middle lot is very narrow, does not have road access or any over-water structures, and is protected by a rock bulkhead. This lot is landscaped as a small private park and is separated from the Burke-Gilman Trail by a chain link fence. The southernmost lot is owned by the adjacent shoreline property owner to the south and has a fixed pier and a rock bulkhead.

City parks and other City-owned shoreline properties are discussed below in Sections 3.6.1 and 3.6.2.

There are two privately owned recreational properties on the Lake Washington shoreline within Lake Forest Park. The Lake Forest Park Civic Club is a private waterfront recreation club that includes a clubhouse, picnic areas, swimming beach, large fixed-pile pier, boat launch and other amenities. The North Seattle Improvement Company granted this 1.5-acre site and the Civic Club was incorporated in 1924. The Club is located at the foot of Ballinger Way NE. The Club is a non-profit organization designated to act as trustee and, as such, has the duty of maintaining and preserving the common property.

The second privately owned recreational property is the 0.74-acre Sheridan Beach Community Club. The Beach Club includes sport courts and an outdoor heated swimming pool, in addition to beach access and a large fixed-pile pier.

As shown in Table 1, all land within the City's shoreline jurisdiction is zoned RS-7200 (single family residential, minimum lot size 7,200 square feet). The median upland area of all lots within shoreline jurisdiction is 8,104 square feet and the median upland area of all waterfront lots is 7,690 square feet. Thus, your typical shoreline lot is not much larger than the minimum lot size. Of the 196 lots that are located wholly or partially within the shoreline jurisdiction, 30 of those lots have upland areas that are at least two times the minimum lot size, which is generally a strong indicator that they may have subdivision potential. Of the 135 lots that have water frontage, 17 of those lots (not including the two private clubs or Lyon Creek Park) have upland areas that are at least two times the minimum lot size allowed under current zoning. However, private covenants, codes and restrictions may also restrict the ability for private property owners to subdivide. Individual site constraints and other City regulations likely further limit actual subdivision potential. It is important to note that additional lots can also be created by combining the land area of multiple lots (that may not be twice the minimum size, but are larger than the minimum size). Of the 196 lots in the shoreline jurisdiction, 117 are greater than 7,200 square feet and 76 of those lots are waterfront properties. However, the fact that there has not been a subdivision of a waterfront lot in recent memory, even with dramatically rising land prices, is an additional indication that the potential for a significant increase in the number of lots within the shoreline jurisdiction is limited. Some waterfront jurisdictions, including Mercer Island, have actually seen a decrease in the number of shoreline parcels as a result of lot aggregation to create larger waterfront estates.

Structures within the Lake Forest Park shoreline are generally located relatively close to the water. This reflects the substantial site constraints, including significant slopes, within much of the shoreline area. The median structure setback is approximately 20 feet and the mean (or average) setback is approximately 25 feet. The current minimum regulatory setback is 20 feet. Based on available information, up to half of the parcels may have setbacks which are equal to or less than this minimum setback. Structures at the two private clubs are located somewhat farther from the shoreline, the structure setback at the Civic Club approximately 37 feet and the Sheridan Beach Club structure located approximately 28 feet from the shoreline. The setback of residential structures along the Lake Forest Park Lake Washington shoreline varies somewhat by location; however, only 20 parcels have structure setbacks greater than 50 feet.

The size of the structure setback can be influenced by the depth of the parcel. Lake Forest Park has relatively modest depths for waterfront lots, with the median lot depth at approximately 113 feet. Lot depths range considerably, however, with approximately 20 lots of 75 feet or less and more than a dozen lots over 200 feet in depth. Lot depth and structure setback is generally largest in the portion of the waterfront near and between McAleer and Lyon Creeks, or more precisely between 47th Avenue NE on the north and NE 165th Street on the south. This area has a wider level area near the shoreline, likely due to the deposition of sediments from these creeks over time. Lot depth and structure setbacks are comparatively much smaller in the southern half of the City's Lake Washington shoreline, where steep slopes are found. Parcel depths and setbacks are also relatively small in the northernmost portion of the Lake Washington shoreline, which is also constrained by steep slopes.

3.2 TRANSPORTATION

There are very few major arterial road sections in the shoreline jurisdiction. Portions of State Highway 522 (Bothell Way NE) are parallel to and within the shoreline jurisdiction near the north end of Lake Washington. Several small residential access roads are located within the shoreline, specifically Beach Drive, Shore Drive, and Edgewater Lane. However, these are used primarily by local residents and are not major commuting corridors. Otherwise, roadways are limited to minor drives that each provide access off of these roads to a few homes or recreational sites. Notably, a 2.1-mile section of the Burke-Gilman Trail, a non-motorized, multiple-use trail running along an old railroad right-of-way, is located in the shoreline jurisdiction and is an important non-motorized public transportation facility.

3.3 STORMWATER AND WASTEWATER UTILITIES

3.3.1 Stormwater Utilities

Stormwater run-off is widely recognized as a major source of nonpoint pollution in Lake Washington. Therefore, City stormwater management efforts play an important roll in shoreline protection. The City of Lake Forest Park established a Storm and Surface Water Utility in 1990 to pay for surface water management activities including, but not limited to, basin planning, maintenance, operation and construction of facilities, and water quality and quantity control. The specifics are found in the City's Municipal Code Chapter 13.16. Administration duties and authority are given to the Public Works Director. The utility established a flat fee service charge for single-family residential parcels and a fee per impervious area for non-single-family residential parcels. Although much of the Utility's jurisdiction is outside of the shoreline zone, all of the regulated surface waters, both natural and piped, are discharged ultimately into Lake Washington and thus affect shoreline conditions. The Utilities and Surface Water Management Element of the 2005 *City of Lake Forest Park Comprehensive Plan* contains a number of policies geared towards the protection of water quality and the management of stormwater in ways that protects wetlands, streams and ultimately Lake Washington. However, even with the Storm and Surface Water Utility managing discharges to surface water bodies throughout the City, it is difficult to significantly reduce non-point pollution. The following goals and policies are aimed at maintaining and improving the functions of storm and surface water conveyance.

Key goals and policies include:

> *Goal: To implement a surface water management program that maintains, enhances and restores Lake Forest Park's water resources, including streams, wetlands and shorelines and ensures that surface water is appropriately controlled and treated.*

Policy 5.1: Maintain, enhance and restore the natural drainage systems to protect water quality, reduce flooding, reduce public costs and prevent associated environmental degradation.

Policy 5.2: Preserve natural surface water storage sites that help regulate stormwater flows and recharge groundwater.

Policy 5.3: Control the quantity of stormwater runoff from new development so that post-development flow rates are not greater than pre-development flow rates.

Policy 5.5: Minimize on-site and off-site erosion and sedimentation during and after construction by minimizing disturbance to existing vegetation and by using appropriate temporary and permanent erosion and sedimentation controls.

Policy 5.7: Participate in watershed management planning programs and implement measures to maintain, enhance and restore Lake Forest Park's water and shoreline resources, including measures to control and reduce nonpoint pollution.

Policy 5.8: Implement a public information and involvement program to encourage and promote protection of wetland, stream corridors and shoreline areas.

Policy 5.10: Encourage the use of alternative paving products, such as grasspaving, as a mechanism for reducing impervious surfaces and surface water runoff.

Policy 5.11: Establish development incentives associated with reduced impervious surfaces.

Policy 5.12: Maintain an inventory of the City's surface water management and drainage facilities that identifies outfalls, including those that discharge to waterways, catch basins, pipe materials and sizes and sedimentation ponds.

The City applied for its National Pollutant Discharge Elimination System (NPDES) Phase II permit in April 2003 from Ecology. The initial permit was issued in January 17, 2007. The NPDES Phase II permit is required to cover the City's stormwater discharges into regulated lakes and streams. Under the conditions of the permit, the City must protect and improve water quality through public education and outreach, detection and elimination of illicit non-stormwater discharges (e.g., spills, illegal dumping, wastewater), management and regulation of construction site runoff, management and regulation of runoff from new development and redevelopment, and pollution prevention and maintenance for municipal operations.

The City conducts all of the above at some level already, but significant additional effort may be needed. The City has various programs to control stormwater pollution through maintenance of public facilities, inspection of private facilities, water quality treatment requirements for new development, source control work with businesses and residents, and spill control and response. Monitoring may be required as part of an illicit discharge detection and elimination program, for certain construction sites, or in waterbodies with a Total Maximum Daily Load (TMDL) Plan for particular pollutants. General water quality monitoring was not required in the first five-year term of the draft Phase II permit that was issued in summer 2006; however, the draft permit asks municipalities to assist in development of a monitoring program that will be implemented during the second five-year permit term. General water quality monitoring concerns include a) stormwater quality, b) effectiveness of best management practices, and c) effectiveness of the stormwater management program.

The City currently follows the *1998 King County Surface Water Design Manual*, and is anticipating that it will be determined to be equivalent to Ecology's 2005 *Stormwater Management Manual for Western Washington* as the NPDES Phase II permit requires. The purpose of stormwater detention is to reduce flooding of roads and structures, and to reduce damage to stream channels (and associated fish habitat) that results from the more frequent and longer duration peak flows that come from developed watersheds.

Large lakes such as Lake Washington are not subject to damage from peak flows, and so detention is not required for projects draining directly to them. In addition, the lake level is managed and maintained by the Corps, which further reduces flooding potential.

However, discharges into the streams, such as McAleer Creek and Lyon Creek, can have a significant impact on in-stream habitat complexity, peak flow magnitude and duration, bank stability, substrate composition, and a number of other parameters. The water quality impact of stormwater inputs is also significant. Stormwater runoff carries pesticides, herbicides and fertilizers applied to lawns and sports fields; hydrocarbons and metals from vehicles; and sediments from construction sites, among other things. All of these things can harm fish and wildlife, their habitats, and humans. Per current standards, water quality treatment is required when 5,000 square feet or greater of "pollution generating" impervious surface (driveways, parking areas) is created or replaced, regardless of whether the system drains to a lake or a stream. The City is also in the process of evaluating which areas of the City have the most potential for generating stormwater pollution, and will be identifying treatment and source control options for those areas. This work will be complete in the first half of 2007.

There are 14 outfalls directly into the shoreline area, and several more that discharge just outside of shoreline jurisdiction but subsequently flow into the shoreline area (see Figure 15). The water quantity affect of the stormwater discharges on Lake Washington is insignificant as the lake level is managed and maintained by the U.S. Army Corps of Engineers. However, discharges into the tributary streams, such as McAleer and Lyon Creeks, can have a significant impact on in-stream habitat complexity, peak flow magnitude and duration, bank stability, substrate composition, and a number of other parameters. The water quality impact of stormwater inputs is also significant. Stormwater runoff carries pesticides, herbicides and fertilizers applied to lawns and sports fields; hydrocarbons and metals from vehicles; and sediments from construction sites, among other things. All of these things can harm fish and wildlife, their habitats, and humans.

Per current standards, water quality treatment is required when 5,000 square feet or greater of "pollution generating" impervious surface (driveways, parking areas) is created or replaced, regardless of whether the system drains to a lake or a stream. The City is also in the process of evaluating which areas of the City have the most potential for generating stormwater pollution, and will be identifying treatment and source control options for those areas. This work will be complete in the first half of 2007.

King County Department of Natural Resources and Parks conducts on-going monitoring of Lake Washington water quality. Thirteen monitoring stations are located throughout the lake, including one station (ID #0804) located at the north end of the lake, near the City of Lake Forest Park. No on-going water quality monitoring is believed to occur along the shoreline area of Lake Forest Park or, more specifically, in or adjacent to the outfalls within the shoreline jurisdiction, besides McAleer and Lyon Creeks. Both of these tributaries have been sampled for water quality parameters and are currently on the Washington Department of Ecology's 303d list for Dissolved Oxygen (McAleer Creek) and Fecal Coliform (McAleer and Lyon Creek).

3.3.2 Wastewater Utilities

The other relevant utility with the ability to directly and indirectly impact State shorelines is wastewater. Lake Forest Park is served by two sewer districts: the City of Lake Forest Park and the Northshore Utility District. Portions of the Lake Forest Park sewer service area are not served by central sewer. Households on these properties have on-site wastewater systems (septic tanks). Among these households there are properties that have failing on-site systems and households that have functioning on-site systems. High groundwater, soil conditions, and the nature of the terrain have contributed to a history of onsite sewer system problems in some areas. Failing on-site wastewater systems present human health hazards.

There are about 275 properties in Lake Forest Park, all outside of shoreline jurisdiction, that do not have public sewers available to them. The City of Lake Forest Park recently embarked on an effort to provide sewer service to these properties. The City Council is proceeding with Phase I of the project, which will be to provide sewer service to about 70 properties in an area southwest of the shopping center. Providing sewer service to all 275 properties should be complete in three to four years. Properties with functioning on-site septic systems will not be required to hook up to the sewer system. However, the connection charge must be paid when the property changes ownership. All households with on-site wastewater systems that have public sewers available (as defined in the municipal code) will be required to secure an annual license and will be subject to an on-site wastewater excise tax. This too, can be deferred until the property changes ownership. While none of the septic systems are located within the shoreline management jurisdiction, pollution associated with failing on-site wastewater systems does have the potential to impact surface waters and eventually the water of Lake Washington.

King County serves as the regional sewerage authority, providing sewage transmission, interception, treatment and disposal from various utilities. Wastewater from both service providers is treated by King County Natural Resources and Parks Wastewater Treatment Division (formerly known as Metro) at either the South or West Point Treatment Plants. Both Treatment Plants, located in Renton and Seattle, respectively, discharge into Puget Sound after providing primary, secondary, and disinfection treatments. Discharges from these Plants are regulated by the Washington Department of Ecology under National Pollutant Discharge Elimination System (NPDES) permits, which includes performance standards and monitoring requirements. Most of the shoreline area includes a sewer line parallel to Lake Washington, so repair work or line failures could directly impact Lake Washington water quality.

Metro was established in 1958 to eliminate wastewater discharges into Lake Washington that had such a profound adverse effect on water quality and habitat. By 1968, discharges of untreated sewage, which were once about 20 million gallons per day, had dropped to 0 (except for combined sewer overflows) and water quality in the lake rapidly and dramatically improved (Li *unknown date*; Edmondson 1991). As part of the sewage overhaul, Metro constructed the two treatment plants previously mentioned, and over 100 miles of trunk lines and interceptors. The trunk lines run along the perimeter of Lake Washington, in and outside of the lake. Combined sewer overflows (CSOs) still occur within City of Seattle jurisdiction during high rain events, but the incidence and overall volumes are being reduced. King County recently completed its final and largest Lake Washington CSO project in the Rainier Beach area. Prior to implementation of this project in late 2005, CSO volumes into Lake Washington were between 30 and 60 million gallons per year. Figure 4 shows the locations of all sewer lines within shoreline jurisdiction; shoreline modification projects and any upland development project should locate all lines prior to construction to avoid damaging the lines, incurring biological impacts, during construction. The potential exists for routine repair and maintenance activities or line failures to result in short-term discharges of sewage into the lake.

3.4 IMPERVIOUS SURFACES

Impervious surface mapping, including roads, parking lots, and rooftops, was obtained from King County (Figures 6a and 6b, Table 2). This summation does not include reduced perviousness caused by compaction or vegetative changes. According to the GIS analysis of King County's data, the Lake Forest Park shoreline area is 61 percent impervious and the entire City is 40 percent impervious. However, King County's impervious surface data is of limited accuracy because of the coarseness of the spatial data and may not yield an accurate assessment of impervious surface coverage in the shoreline area.

Suburban areas generally have 20 to 30 percent impervious surface (May et al. 1997a), and a nearby jurisdiction that has completed a more detailed study of impervious surface found that impervious surfaces in its shoreline area ranged from approximately 30 to 55 percent. Accordingly, the actual impervious area within the City is estimated to be 10 to 15 percent less than what is indicated by the King County data.

Table 2. Impervious Surface.

Area	Total Impervious Area	% Impervious Surface
Lake Forest Park Shoreline	30.1 acres	61%
City	923.3 acres	40%

Source: King County GIS

Impervious surface is relevant to shoreline functions because of the relationship between impervious surfaces and stormwater runoff. In a number of ways, vegetated areas slow the movement and reduce the quantity of runoff that makes its way into streams and other waterbodies. Rainwater can evaporate off of vegetation without ever reaching the ground, infiltrate into the soils where it is taken up by vegetation and evapotranspirated, infiltrate into the soils to recharge groundwater, or move over the surface or subsurface (slowed by vegetation) into a waterbody. Impervious surfaces replace vegetation and speed the movement of runoff into waterbodies while increasing the volume of the runoff, and may pick up pollutants in the process. Although modern stormwater management systems can moderate some of the effects of impervious surfaces, they still cannot perfectly mimic natural systems in terms of flow rate, duration, quantity, mechanism, and quality of the discharge.

Increases in impervious surface coverage, and the consequent reduction in soil infiltration, have been correlated with increased velocity, volume and frequency of surface water flows. This hydrologic shift alters sediment and pollutant delivery to streams and other receiving bodies (Booth 1998; Arnold and Gibbons 1996). These effects can be seen even in basins where stormwater management regulations have been widely implemented (Booth 1998). Increased surface water flows associated with impervious surface coverage of suburban areas (20-30%) has been linked to decreased bank stability and increased erosion (May et al. 1997a).

3.5 SHORELINE MODIFICATIONS

Shoreline modifications are anthropogenic alterations to the natural lake edge and nearshore environments, and primarily include a variety of armoring types (some associated with fill), piers, and other in-water structures such as boatlifts, boathouses, and moorage covers. These sorts of modifications alter the function of the lake edge, change erosion and sediment movement patterns, affect the distribution of aquatic vegetation, and are often accompanied by upland vegetation loss.

Shoreline armoring can have many justifications, but often the intent of bulkheads is to:

- protect shoreline property by reducing wave impacts and decreasing erosion,
- increase or maintain lawn areas, and/or
- coordinate style of neighboring shoreline properties.

While not all bulkheads are necessary to protect shoreline property from excessive erosion, there are many areas along the City’s shoreline, especially on shallow lots with steep banks, that may need some form of shoreline armoring in order to protect existing structures and land uses. The topography along the City’s waterfront varies widely from shallow, low-gradient shorelines around the City’s north end near the mouths of McAleer and Lyon Creeks to more steep-gradient shorelines near the southern portion of the City. Some of these topographic differences result from the lowering of the lake by 9 feet in 1916 during construction of the Hiram Chittenden Locks, where some shallow-water areas gave way to steep drop-offs. Historically, shoreline armoring constituted the use of concrete walls, large boulders, and wood timbers. However, many bioengineering techniques have been developed in recent years to provide alternative shoreline protection methods.

A combination of recent aerial photographs and a field inventory conducted by boat were used to collect information about shoreline modifications in the City (Figures 7a through 7d). Shoreline modifications are anthropogenic alterations to the natural lake edge and nearshore environments, and primarily include a variety of armoring types (some associated with fill) (Table 3), piers, and other in-water structures such as boatlifts (Table 4). These sorts of modifications alter the function of the lake edge, change erosion and sediment movement patterns, affect the distribution of aquatic vegetation, and are often accompanied by upland vegetation loss. These specific shoreline functions and the related effects of shoreline modifications are discussed in greater detail in Section 4.2 below.

Table 3. Shoreline Armoring.

Lake Edge Condition (linear feet)		
Vertical[1]	**Boulder**[2]	**Natural / Semi-Natural**[3]
5,567 (47%)	3,790 (32%)	2,412 (20%)

[1] "Vertical" shorelines encompass concrete, wood and mortared boulder armoring types. The key characteristic, besides a generally vertical orientation, is the lack of interstitial spaces in the face of the bulkhead that could provide some habitat.

[2] "Boulder" shorelines are typically angular or rounded granite or basalt. They may be vertical or sloped, but they all contain interstitial spaces, which provide some habitat and may absorb or attenuate some wave energy.

[3] "Natural/Semi-Natural" shorelines captures those areas that are not solidly armored at the ordinary high water line; they may include some scattered boulders or woody debris at or near the ordinary high water line. Except in areas of Segment B, "natural/semi-natural" designation is not intended to describe the environmental condition upland of ordinary high water.

Table 4. Shoreline Structures.

Piers	Piers / mile	Boatlifts	Boatifts w/ Canopy	Moorage Cover	Boathouses	Jetski Lifts	Platform Lifts
129	59	95	23	30	2	44	8

As noted above in Tables 3 and 4, the Lake Forest Park shoreline is heavily modified with close to 80 percent of the shoreline armored at or near the ordinary high water mark and a pier density of approximately 59 piers per mile. Many of the piers have one or more boatlifts, and approximately one-quarter of the boatlifts have canopies. Based on a review of 2004 aerial photographs, only approximately 6 out of the 135 shoreline parcels were without a pier. Of these six lots, only one appears undeveloped.

Total overwater cover and the number of structures are relevant to ecological function assessment. Total overwater cover is an indication of the amount of lake surface that is shaded, which can impact growth of aquatic vegetation and subsequently the food chain as a whole. Overwater cover is also implicated in exacerbating the predator-prey relationship between native and non-native fish, particularly between threatened chinook salmon and other salmonids and introduced bass (Fresh et al. 2003; Tabor et al. 2004a). The number of structures is relevant as it indicates the number of impedances to juvenile salmon migration along the shoreline. Studies have indicated that juvenile salmon approaching a sharp change in light and cover may attempt to go around the structure, which increases predation risk (Tabor et al. 2006). For additional discussion of the potential biological impacts of cover and structure, see Chapter 4.2.

The number of piers along the Lake Washington shoreline is not expected to increase significantly over time. Most of the properties that are suitable for moorage piers have already been developed with a pier. Our analysis indicates that there are only six waterfront parcels that do not currently have a pier. Some of these parcels may share a joint pier with an adjacent property. The potential for the subdivision of waterfront lots (and a related increase in the number of piers as a result), as discussed in Section 3.1 - Land Use Patterns, is also very limited. However, there is a somewhat greater potential for expansion of the area of existing piers and the related increase in total overwater cover.

3.6 EXISTING AND POTENTIAL PUBLIC ACCESS SITES

3.6.1 Overview

Both state-wide and within Lake Forest Park, single family residencies are the most common form of shoreline development (WAC 173-26-24(3)(j)). State law establishes single-family residences as a "preferred" use and provides for preferential accommodation of single-family residences and their appurtenant structures for the "limited instances" where alteration of the natural condition of the shoreline is authorized. The political and economic choices embodied in these facts are evident in the private waterfront homes that line the Lake Washington shoreline of Lake Forest Park. Active recreation and lawn areas are mixed with trees and park-like grounds, with facilities for motorized craft and other water recreation. When viewed from the water, steep treed hillsides often frame the views of a range of large and smaller homes, usually closely grouped along a shoreline largely hardened with bulkheads. Private beach clubs provide waterfront access to adjacent subdivisions, forming the center of weekend summer life and an important amenity for neighboring homes. Topography affords views of the water to adjacent properties and whole neighborhoods, particularly in the southeastern portion of the City.

The connection with the water is not always apparent from the surrounding Lake Forest Park streets and neighborhoods. Developed physical public access to the water is limited in Lake Forest Park itself, and consists only of Lyon Creek Waterfront Preserve. The City of Lake Forest Park benefits from the large developed park that is located in adjacent Kenmore, Tracy Owen Station (Log Boom) Park. This Park is connected to the City via the Burke-Gilman Trail, forming the backbone of public access to the shoreline for neighborhoods in both Kenmore and Lake Forest Park. Views of the water from the Burke-Gilman Trail refresh walkers and bikers and hint at the connections that could be made with the evolving town center and trails elsewhere through the forest neighborhoods of the City. The 1995 Draft SMP recognized the need to plan for increased public access to the Lake Washington shoreline in Lake Forest Park.

Lake Forest Park recognizes the need to plan for additional open space and this is embodied in its current *Comprehensive Park, Recreation, and Open Space Plan* and The Legacy Project planning effort. Policy 4.1 of the Plan reads:

> Continue to seek land for open space, giving priority to land acquisitions that preserve environmentally sensitive areas, provide wildlife habitat, or provide relief from urban development.

As part of the required analysis of shoreline issues of concern, local governments must "identify public access needs and opportunities within the jurisdiction and explore actions to enhance shoreline recreation facilities" (WAC 173-26-201(3)(d)(5)). Public access includes the "ability of the general public to reach, touch, and enjoy the water's edge, to travel on the waters of the state, and to view the water and the shoreline from adjacent locations" (WAC 173-26-221(4)). Information about public access sites in the City was drawn from site visits, aerial photographs, conversations with City staff, King County Assessor data, and City mapping of formal parks, open space, street-ends, and trail and utility corridors.

Existing public access to the shoreline area (Figure 8) in the City of Lake Forest Park is primarily limited to a single waterfront public park with developed access, with some visual access to the shoreline provided along the Burke-Gilman Trail. Developing public access to the shoreline is a need and a priority for the City; however, the existing private ownership and developed single-family nature of the land use within the shoreline area presents major challenges for the City as it seeks to provide greater public access to the shoreline area. Redevelopment of existing single-family lots with new, often larger, single-family homes, is unlikely to result in increased public access through the application of shoreline development standards in the short term because of the need to protect private property rights. Acquisition of additional sites over the medium to long term through purchase or donation is likely the best strategy for increasing public access to the water's edge within the City.

3.6.2 City Owned Shoreline Property

The City owns two properties along the Lake Washington shoreline. In addition, there are two waterfront parcels that appear to be unopened public street rights-of-way. By far the most significant of the public properties is the Lyon Creek Waterfront Preserve, located just north of the Lake Forest Park Civic Club, in the 17300 block of Beach Drive NE, just northeast of the Town Center. The City purchased this lot from a private seller in 1998. The park is 0.89 acre (38,836 ft^2) and was formerly a single-family home site. The home and related improvements have been removed and the area has largely been restored with native plants. The small park includes a small accessible parking area, short trails, grass sitting areas, benches, and a fixed pier. The park also includes a bridge that crosses Lyon Creek and has a structure and configuration that allows users to observe the creek in a center "cut-out" portion of the structure. The park has a natural shoreline and is located at the mouth of Lyon Creek. This park does not allow swimming or the launching of small boats and is intended to be a passive park and nature preserve. The City views the acquisition of this property from a willing seller, ecological restoration on the site, and conversion of this private property into a waterfront open space in total as a model for future efforts to increase public access to the Lake Washington shoreline.

The second City-owned waterfront property is a very small and narrow strip of land in the 15700 block of Beach Drive NE (PIN 6744701130). According to tax records, this property is approximately 210 square feet in size and approximately 2 feet wide. The property was purchased from Ronald Wastewater District in 2002. There is some anecdotal evidence that this waterfront access point has been used for the launching of small non-motorized boats. This property is not currently shown as a public park on any City maps. There is very limited parking available along the shoulder of Beach Drive NE.

There also appears to be an unopened City street right-of-way at the eastern terminus of NE 155th Street. This area can currently only be accessed via a private driveway and is landscaped as an extension of the adjacent private yards to the north and south. Finally, there also appears to be an unopened City street right-of-way at the eastern terminus of NE 145th Street that is approximately 25 feet wide. There seems to be encroachments, including landscaping, parking areas and a pier associated with adjacent private properties, at this third site. There is very limited parking along the shoulder of the narrow street, Edgewater Lane NE, that accesses these properties. The City needs to definitively verify the ownership of these parcels to determine if they are in fact public property.

3.6.3 The Burke-Gilman Trail and King County Ownership

The Burke-Gilman Trail is a 27-mile multi-purpose trail that connects communities from Seattle to Redmond. A 2.1-mile section of this trail runs through the entire length of the City near the Lake Washington shoreline. The Burke-Gilman Trail literally serves as the backbone for public access to the Lake Washington Shoreline for Lake Forest Park residents and visitors. Although the actual trail corridor does not provide physical access to the shoreline, it provides a critical connection between residential areas, the Town Center, Sheridan Beach Club, Lake Forest Park Civic Club, and Tracy Owen Station/Log Boom Park. The trail follows an old railroad right-of-way and the section through Lake Forest Park was completed in 1978. The trail represents a major use and recreational facility within the shoreline management zone.

In addition to the Burke-Gilman Trail right-of-way, King County also owns the northernmost shoreline parcel in the City (PIN 1126049127). This vacant parcel is 1,903 square feet and has steep slopes and an undeveloped shoreline. Due to topography, size and location near Tracy Owen Station/Log Boom Park, this parcel does not appear to be easily suited for the development of additional public access.

3.6.4 The Legacy Project and Assessment of Public Access Needs

The City of Lake Forest Park is in the early stages of initiating The Legacy Project. The Legacy Project will create a *Parks and Open Space Master Plan* that provides for a 100-year vision of what Lake Forest Park should be like in the near, intermediate and far future. It will culminate in a long-term plan for “Green Infrastructure.” The plan will provide guidelines and direction for the City in terms of purchasing and preserving property, accepting donations, fund development, and other actions. It will enable the City to respond to opportunities in a timely fashion.

“Green Infrastructure” has been defined by the Open Space Seattle 2100 initiative as a “comprehensive network of parks, civic spaces, streets, trails, shorelines, creeks, natural drainage features and urban forests that will bind neighborhoods to one another, create ecological conduits from the city’s boundaries to its shorelines, and ensure a wealth of green spaces for all of its citizens to enjoy”.

The Legacy Project will guide the City’s response to several of the key issues raised in the City’s Comprehensive Plan. These issues include the following:

> *The City has a limited amount of park and open space. To what sort of use should future purchases be dedicated? What should the criteria be for purchases? Where should additional park space be located? What activities should be available in the parks?*
>
> *A major trail corridor passes through the City. Should the City develop trails to connect with the Burke-Gilman Trail and other areas of the city? What areas throughout the City should be served by trails and what types of trails should be developed i.e. walking, biking, ADA accessible?*
>
> *The City has historically purchased open space as a method of preserving and enhancing environmentally sensitive areas. Should the City continue purchasing open space for these purposes? What sites are available for purchase? What criteria should be used for*

selecting properties? (City Of Lake Forest Park, Comprehensive Plan, adopted 12/01/2005, p.110.)

The outcome of the Legacy Project will be a *100-year Parks and Open Space Master Plan.* The plan will be formed from an inclusive community process that will focus City priorities for development of Green Infrastructure, public open space, recreation, and space for walking and alternative transportation. The Plan will include the following items:

- A Parks and Recreation Master Plan that meets the requirements of State and local funding programs.
- A collaborative vision for Lake Forest Park that identifies principles and priorities for acquisition and preservation.
- An Implementation Guide with specific action steps to guide the City.
- An inventory of tools for acquisition and funding.
- Incentives for putting land in conservation easements and in the Public Benefit Rating System, and possible public/private partnerships.
- Recommendations for short term, intermediate, and long term actions.
- Linkages within Lake Forest Park and between neighboring communities and the region.
- An inventory of current resources and options for their integration into the overall Green Infrastructure, including a ‘gap analysis’ identifying under-served areas of the City.
- Recommendations for ongoing monitoring and evaluation of the effectiveness of the plan.
- Assumptions used to forecast future conditions.

Substantive work on The Legacy Project is expected to begin in 2007 when Council funding and direction is provided. Implementation of this 100-year strategy is expected to eventually result in additional public access to the Lake Washington shoreline and a stronger connection between the Town Center commercial area and the waterfront over the long term. The Legacy Project and related implementation efforts will be incorporated into on-going Shoreline Master Program planning and will likely serve as the key vehicle for identifying addition public access sites and opportunity areas in the years to come.

3.7 CRITICAL AREAS

The inventory of critical areas was based primarily on data from King County and supplemented with information gathered by previous consultants. A complete listing of citations used to compile information on critical areas is included in Section 6.0 (References) at the end of this study. Approximately 26.3 acres (53%) of the shoreline zone contains one or more critical areas.

3.7.1 Frequently Flooded Areas

For all practical purposes, “frequently flooded areas” are those areas within the 100-year floodplain. Lake Washington does not have a floodplain, but portions of McAleer Creek and Lyon Creek have small areas (approximately 4,676 ft^2) within shoreline jurisdiction that are mapped as 100-year floodplain (Figure 9) (see Section 3.8 below).

3.7.2 Geologically Hazardous Areas

The City's mapping of geologically hazardous areas was derived from King County GIS mapping (2005) and Hammond, Collier & Wade-Livingstone Associates, Inc. (Figure 10). Shoreline jurisdiction within the City includes seismic hazards, landslide hazards, and erosion hazards. There are approximately 22 acres of geologically hazardous areas in shoreline jurisdiction, or approximately 44 percent of the total shoreline area.

3.7.3 Streams

Two major urban streams, Lyon and McAleer Creeks, flow through the City of Lake Forest Park and discharge directly to Lake Washington near the north end of the lake (Figures 11a and 11b). Sediment deltas are found at the mouth of each stream where it enters Lake Washington. Interpretation of recent aerial photos for this study appears to indicate that the larger of the two deltas is found at Lyon Creek, indicative of the severe erosion and sedimentation that occurs within this drainage basin. McAleer Creek also experiences erosion and sedimentation, but appears to benefit from the management of Lake Ballinger as an effective detention basin for the upper reaches of this subwatershed. Both streams and their tributaries, which originate north of the City in Snohomish County, are known to support anadromous salmonids for spawning and/or rearing (http://dnr.metrokc.gov/Wrias/8/ fish-maps/distmap.htm; Lake Forest Park Stewardship Foundation 2001). The mouth of Lyon Creek flows through the only City-owned public shoreline access parcel (Lyon Creek Waterfront Preserve) within the City limits. Several small streams farther south also flow directly into Lake Washington through the shoreline zone; although information about salmonids use of these streams could not be located.

According to WDFW (2006) and/or King County, Lyon Creek is utilized by coho and sockeye salmon, and steelhead and cutthroat trout. Although King County METRO rated salmonid habitat suitability as "good" in 1989, high stream flows resulting from urbanization without appropriate stormwater management has adversely affected substrate (and presumably in-stream complexity), and thus spawning habitat (http://dnr.metrokc.gov/wlr/waterres/streamsdata/ Lyon.htm). Historical accounts have noted large salmon runs in the early 1900s, but these runs have drastically declined, likely due to combined pressures from urbanization, deforestation, and in-stream pollutants (Lake Forest Park Stewardship Foundation 2001). Pesticides (18 types) and metals (9 types) have also been detected in Lyon Creek, although diazinon was the only pesticide that exceeded the "effects threshold" and copper was the only metal that was measured at a toxic level (King County and Parametrix 2002). Lyon Creek is also on the 2004 303(d) list for fecal coliform. An earlier study of the Lyon Creek watershed evaluated and mapped spawning and rearing habitat, siltation areas and silt sources, and water quality and migration hazards (Entranco Engineers 1981). Most of the stream rated "good" to "average" for rearing habitat, but "marginal" or "poor to non-existent" for spawning habitat. Entranco Engineers (1981) attributed the poor spawning habitat to the adverse effects of siltation resulting from increased flows rates and volumes from undetained impervious surface runoff that erode and scour the streambed and banks, as well as siltation from construction runoff and unstable banks. Culvert barriers block salmonid access to approximately 1.7 acres of potential spawning habitat and 1.2 acres of rearing habitat (Adopt-A-Stream Foundation 2003).

According to WDFW (2006) and/or King County, McAleer Creek is utilized by chinook, coho and sockeye salmon, and steelhead, rainbow and cutthroat trout. Several tributaries to McAleer

Creek, including Brookside and Whisper Creeks, also are known to support salmonids (Lake Forest Park Stewardship Foundation 2001). King County METRO has rated salmonid habitat suitability and water quality as "good" in McAleer Creek (http://dnr.metrokc.gov/wlr/waterres/ streamsdata/McAleer.htm). High flows in McAleer Creek from increased runoff have incised the creek channel, and produced high levels of suspended sediments that have created a large delta into Lake Washington at the mouth of the creek. To some degree, Lake Ballinger at the upstream end of McAleer Creek retains sediment and moderates stormwater inputs from urbanized areas higher in the watershed. McAleer Creek is also on the 2004 303(d) list for fecal coliform and dissolved oxygen. Culvert barriers block salmonid access to approximately 0.8 acre of potential spawning habitat and 1.6 acres of rearing habitat (Adopt-A-Stream Foundation 2003). Blue Heron Park is located adjacent to McAleer Creek, just upstream of the Burke-Gilman Trail and outside of shoreline jurisdiction. The Blue Heron Extension Project, which included removal of invasive species and replanting with native plants, restored an undeveloped parcel of land and "upgraded" part of Blue Heron Park to an "environmentally-friendly demonstration garden" (http://dnr.metrokc.gov/wlr/waterres/ streamsdata/McAleer.htm). The stated purpose of the project was to "preserve salmon habitat and contribute to clean water flow into Lake Washington."

Several local organizations and non-profit groups have been active in Lake Forest Park, working to restore, monitor and preserve the natural environment, including streams and stream habitat. Mapping and public information handbooks, such as *A Salmon's Guide to Lake Forest Park* (Lake Forest Park Stewardship Foundation 2001), provide in-depth, first-hand accounts of present and historical activities within the City's watersheds. Active organizations include the Lake Forest Park StreamKeepers, the Lake Forest Park Stewardship Foundation, which has completed restoration projects on tributaries of McAleer Creek, the Adopt-A-Stream Foundation, the Lake Forest Park Urban Forest Task Force, and others. The activities of these organizations will be discussed in greater detail in a separate Shoreline Restoration Plan document. The Lake Forest Park Stewardship Foundation website appears to have the most accurate map of the City's streams that is available. In addition to the Wetland and Stream Areas map in Figure 11a of Appendix C that was generated using data obtained from King County GIS and Hammond, Collier & Wade-Livingstone Associates, Inc., we have include the Lake Forest Park Stewardship Foundation map from *A Salmon's Guide to Lake Forest Park* as Figure 11b.

3.7.4 Wetlands

Wetland mapping within City limits is derived from King County GIS and Hammond, Collier & Wade-Livingstone Associates, Inc. (Figure 11a). These mapping efforts used a combination of aerial photographs, National Wetland Inventory maps, critical area reports submitted with development proposals, and some field inventory. Although no wetlands are mapped within shoreline jurisdiction, it is quite likely that small wetlands are present on some residential properties and along the stream corridors, particularly near their outlets into Lake Washington. The Natural Resource Conservation Service (NRCS) did not map soils in Lake Forest Park so no hydric soil information is available. The Lake Forest Park Stewardship Foundation map from *A Salmon's Guide to Lake Forest Park* (Figure 11b) also includes wetland data that appears to be more extensive and more detailed, however the City has not verified the accuracy of this map.

3.7.5 Other Fish and Wildlife Habitat Conservation Areas

The PHS maps do not identify any other priority habitats in the shoreline area of Lake Forest Park (Figure 12). There are a few narrow, linear patches of forested habitat on the upland side of the Burke-Gilman Trail (Figure 13); however, these are not contiguous with the lake. Urban wildlife such as raccoons, opossums, squirrels and some songbirds may find these areas suitable for some life history stages. Bald eagles and ospreys also regularly perch in the scattered large shoreline trees and forage in the lake.

3.7.6 Critical Aquifer Recharge Areas

As defined in the City's municipal code, critical aquifer recharge areas are "…those areas with a recharging effect on aquifers used for potable water and includes areas where an aquifer which is an essential source of drinking water is vulnerable to contamination that would create a significant hazard to public health" (LFPMC 16.16.030). No "critical aquifer recharge areas" are mapped within the City by either the City or King County. The City obtains its drinking water from Seattle Public Utilities, the Lake Forest Park Water District, the Shoreline Water District, and the Northshore Utility District. The Lake Forest Park Water District provides drinking water to approximately 855 single-family residences. The water source is eight artesian wells and three "deep water" wells located within the District's boundaries (in the City). The other drinking water providers obtain their water from the South Fork Tolt River Reservoir and/or the Cedar River Reservoir.

3.8 FLOODPLAINS AND CHANNEL MIGRATION ZONES

Floodplain boundaries were developed from the FEMA Flood Insurance Rate Map (FIRM) and King County's GIS mapping (Figure 10). As noted above, Lake Washington does not have a floodplain due to its lake elevation control by the Corps. However, small floodplain areas are designated for both McAleer and Lyon Creeks. Most of the McAleer Creek floodplain is upland of the shoreline jurisdiction, but a very small portion mapped as Zone A ("no base flood elevations determined") extends into shoreline jurisdiction. The Lyon Creek floodplain appears to be a small off-channel pond just inside of shoreline jurisdiction that is mapped as Zone AE ("base flood elevations determined"). Channel migration is not relevant in lake systems. Little to no channel migration is possible on either Lyon or McAleer Creeks due to the extent of bank hardening geared towards limiting channel migration through various means, such as rip-rap or concrete structures.

3.9 HISTORICAL OR ARCHAEOLOGICAL SITES

There are no known sites of historical or archeological significance within the shoreline area in Lake Forest Park. Nor does the City of Lake Forest Park have any special features that are documented by the Washington State Office of Archaeology and Historic Preservation (OAHP) (http://www.oahp.wa. gov/gis/INDEX.CFM).

Although not documented by the OAHP, the Snohomish tribe maintained a winter village site until approximately 1903, after which they moved to avoid the incoming settlers (http://www.historylink.org/essays/output.cfm?file_id=419). The Muckleshoot Tribe also has a long history of using Lake Washington, which is part of the Tribe's Usual and Accustomed Area, particularly for fish harvest to which the Muckleshoot's have established treaty fishing rights (http://www.muckleshoot.nsn.us/history.htm).

3.10 OTHER AREAS OF SPECIAL INTEREST

Areas of special interest not included in the other elements of the inventory, such as priority species use and habitats, rapidly developing waterfronts, eroding shorelines, or other degraded sites with potential for ecological restoration were identified based on the references described above and during the field reconnaissance of the study area in May 2006.

Information on special status fish and wildlife species and habitat areas was obtained from several sources. Special status species are species that are listed or proposed for listing under the State or Federal Endangered Species Act, identified by WDFW as state Priority Species, or identified by the U.S. Fish and Wildlife Service (USFWS) as Species of Concern. Information on Priority Species and general fish and wildlife habitat areas was obtained from the WDFW's Priority Habitats and Species (PHS) data. Information on sensitive species was obtained from websites of the USFWS and the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries).

The City does not have any active toxic or hazardous material clean-up sites or dredged disposal sites in its shoreline jurisdiction, however low level sites are known to exist nearby in the Town Center area. During the field inventory conducting in May 2006, no significant eroding shorelines were noted.

3.10.1 Priority Species

Specific information on fish occurrence and habitat use within the City was provided by the PHS data (WDFW 2006); *Washington State Salmon and Steelhead Stock Inventory* (SASSI) (WDF et al. 1993); the *SASSI Bull Trout/Dolly Varden Appendix* (WDFW 1998); the *Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region* (Williams et al. 1975); various maps and reports generated by the WRIA 8 stakeholders; and additional sources as cited in the text.

All game and food fishes, including salmon, trout, and char, are considered to be Priority Species by the Washington Department of Fish and Wildlife (WDFW). In addition, Coastal-Puget Sound bull trout are listed as threatened by the USFWS, Puget Sound chinook salmon are listed as threatened by NOAA Fisheries, and Puget Sound steelhead are proposed for listing as threatened by NOAA Fisheries.

The following Priority Species have been mapped in or are known to use Lake Forest Park's shoreline jurisdiction (WDFW 2006):

- Bald eagle (nesting, perching and foraging)
- Dolly Varden/bull trout (limited to occasional straying and/or short-term rearing by juveniles)
- Chinook salmon
- Coho salmon
- Sockeye salmon

- Winter steelhead trout
- Cutthroat trout

3.10.2 Water-Oriented Uses

According to Ecology's SMP Guidelines (173-26-020 WAC), "water-oriented use means a use that is water-dependent, water-related, or water-enjoyment, or a combination of such uses." No public or private marinas are located on the lake within the City of Lake Forest Park. A public marina, Kenmore Marina, is located just north of the City. However, several clubs and private community areas passively enjoy the Lake Washington shoreline: views, swimming beaches, and short-term boat moorage. Single-family residential areas are a "preferred use" in shoreline jurisdiction, and are often accompanied by private piers and other boating facilities or shoreline modifications that facilitate enjoyment of the shoreline. However, the single-family residential use by definition does not qualify as a "water-oriented use" because it 1) is not a "water-enjoyment use" because it is not open to the public, 2) is not a "water-related use" because it does not meet the "economic viability" standard, and 3) is not a "water-dependent" use because it can exist away from the water's edge.

3.10.3 Aquatic Invasive Species

Noxious weeds of Washington State are non-native, invasive plants defined by law as a plant that when established is highly destructive, competitive, or difficult to control by cultural or chemical practices (RCW 17.10). These plants have been introduced intentionally and unintentionally by human actions. Most of these species were brought in without any natural enemies, such as insects or diseases, to help keep their populations in check. As a result, these plants can often multiply rapidly (Ecology and Washington State Department of Agriculture 2004). Species of aquatic noxious weeds found throughout Lake Washington are listed in Table 5. The two most common invasive species that are impacting residential waterfront owners, parks, and wildlife are milfoil and water lily.

Table 5. Aquatic noxious weeds found in Lake Washington - modified from *Aquatic Plants and Fish* (WDFW 1997).

Common Name	Scientific Name	Growth Habitat
Eurasian watermilfoil	*Myriophyllum spicatum*	Submergent
Brazilian elodea	*Egeria densa*	Submergent
Parrot-feather	*Myriophyllum aquaticum*	Submergent
Hydrilla	*Hydrilla verticillata*	Submergent
Fanwort	*Cabomba caroliniana*	Submergent
Fragrant (or white) water lily	*Nymphaea odorata*	Floating mats

Impacts: The introduction of any non-native species has an effect on native species and habitats, although it is often difficult to predict those effects. However, there is a growing number of non-native aquatic plant and animal species whose current or potential impacts on native species, and habitats are known to be significant. Potential threats may be evidenced by the degree of negative impact these species have upon the environment, human health, industry and the economy (WDFW 2001). Potential negative impacts relevant to the Lake Washington environment include:

- loss of biodiversity;
- threaten ESA-listed species such as salmon;
- alterations in nutrient cycling pathways;
- decreased habitat value of infested waters;
- decreased water quality;
- decreased recreational opportunities;
- increased safety concerns for swimmers; and
- decrease in property values.

Control: The Washington Department of Fish and Wildlife has set guidelines for aquatic plant control and removal in the pamphlet *Aquatic Plants and Fish*.[3] This serves as the Hydraulic Project Approval (HPA) for any project that is conducted solely for the removal or control of such aquatic noxious weeds, provided that the project is carried out as described in the pamphlet. Mechanical and physical means of removal and control of aquatic noxious weeds are discussed in the pamphlet (more information can be found on WDFW's website). Mechanical and physical methods of removal discussed in the *Aquatic Plants and Fish* pamphlet include hand pulling, hand tools, bottom barrier, weed roller, mechanical cutters, and harvesters. Some mechanical methods may require an individual HPA. If the project calls for any use of herbicides, additional permits are required through Ecology.

Ecology currently issues coverage for aquatic herbicide use under the National Pollutant Discharge Elimination System (NPDES) permit to qualified applicants. The applicant must be a licensed pesticide applicator (WAC 16-228-1545) in the state of Washington and have an aquatic endorsement (WAC 16-228-1545 3[t]). The applicant must agree to comply with all requirements of the permit, including posting public notices, adhering to timing restrictions, complying with the specific application restrictions for each herbicide product, conducting monitoring, performing sampling and analytical procedures, and reporting and recordkeeping (Ecology 2006).

As of 2006, there are seven aquatic herbicides approved for the management of noxious aquatic plants in lakes, rivers, and streams. The characteristics and recommended usage of these herbicides are summarized in Table 6.

Table 6. Aquatic herbicides approved for use in Lake Washington requiring NPDES permit coverage through the Washington Department of Ecology.

Aquatic Herbicide Name	Type of Herbicide	Targeted Species and Recommended Usage
Glyphosate	Systemic broad spectrum, non-selective herbicide	Floating plants, not submerged plants

[3] [1] The online version of the Aquatic Plants and Fish pamphlet is for informational purposes only and copies of it do not satisfy the requirement to have a copy of the Aquatic Plants and Fish pamphlet on the job site when conducting aquatic plant control operations. An official copy must be obtained from WDFW.

Aquatic Herbicide Name	Type of Herbicide	Targeted Species and Recommended Usage
Fluridone	Broad spectrum, slow-acting systemic herbicide	Eurasian watermilfoil and Brazilian elodea
2,4-Dichlorophenoxyacetic acid, dimethyl-amine salt	Liquid formulation; fast-acting, systemic, selective herbicide	Selective to Eurasian watermilfoil and Brazilian elodea
Endothall - Dipotassium Salt	Fast-acting, non-selective contact herbicide	Short term (one season) control of a variety of aquatic plants
Diquat	Fast-acting, non-selective contact herbicide	Short term (one season) control of a variety of submersed aquatic plants
Triclopyr	Fast-acting, systemic, selective herbicide	Selective to Eurasian watermilfoil
Imazapyr	Systemic broad spectrum, slow-acting herbicide	Floating plants, not submerged plants
All aquatic herbicides may only be used by an approved licensed herbicide applicator (Ecology; http://www.ecy.wa.gov/programs/wq/plants/management/aqua028.html)		

Depending on the herbicide used, it may take several days to weeks or several treatments during a growing season before the herbicide controls or kills treated plants. Rapid-acting herbicides like endothall and diquat may cause low oxygen conditions to develop as plants decompose. Low oxygen can cause fish kills. Additional information about invasive aquatic plants and methods of control can be found in the Water Quality section of Ecology's website.

There is often a fine line between whether or not control is biologically necessary or justifiable. Depending on the method of control chosen, there could be disturbance of the substrate, reduction in benthic invertebrates (which are an important food source), and increased risk of spread of the invasive species to other areas. Depending on the condition of the sediments, substrate disturbance can result in acute, although temporary, increases in turbidity and may re-introduce pollutants bound to the sediments back into the water column. In addition, reductions in aquatic vegetation, whether native or non-native, reduce primary productivity, which is the foundation of the lake food chain. This could result in reduced fish production at the top of the food chain (Kahler et al. 2000). However, control of invasive aquatic vegetation may be biologically justifiable where the plants are so dense that dissolved oxygen (DO) levels fall to suboptimal or even lethal levels (2-4 mg/L). DO levels drop below dense surface mats because light is blocked to the submerged aquatic vegetation which produces the majority of the oxygen to the water column. Much of the oxygen produced by the surface mats of vegetation is lost to the atmosphere. Decomposition of submerged dead material also depletes the water column of oxygen. In addition, dense vegetation can reduce wave action at the surface, which would otherwise help oxygenate the water. Reduced wave action can also contribute to increased water temperature, as the cooler water from deep areas does not flush the warmer, vegetated shallow areas. Warmer water holds less oxygen than cold water.

City Conditions: Eurasian watermilfoil is a public and, in some areas, an ecological nuisance in patches along the shoreline. Where milfoil is dense and close to the surface, it can entangle swimmer's legs and clog boat props. Propeller action can also chop the milfoil into small bits, which disperse in the lake and start new infestations. Mechanical control per the WDFW HPA is likely occurring at numerous locations. Dense patches of aquatic vegetation, specifically milfoil and water lily, have been found to reduce DO to levels which are lethal to salmonids (Frodge et al. 1995). Other effects of low DO are mortality of the insect prey base of salmonids, reduced fish appetite and growth, and avoidance of the low-DO area, which may result in increased predation (Frodge et al. 1995).

As part of inter-agency coordination with other Lake Washington jurisdictions engaged in the SMP update process, the City of Lake Forest Park is collaborating with the City of Kirkland and King County on a joint, coordinated strategy for addressing aquatic invasive species around Lake Washington. To date, potential stakeholders who may be able to contribute to the development of a coordinated plan are being identified and contacted.

3.11 OPPORTUNITY AREAS

Ecology's *Shoreline Master Program Guidelines* (173-26 WAC) includes the following definition:

> "Restore," "Restoration" or "ecological restoration" means 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.

Consistent with Ecology's definition, use of the word "restore," or any variations, in this document is not intended to encompass actions that re-establish historic conditions. Instead, it encompasses a suite of strategies that can be approximately delineated into four categories: creation (of a new resource), restoration (of a converted or substantially degraded resource), enhancement (of an existing degraded resource), and protection (of an existing high-quality resource).

There is a critical distinction between restoration and mitigation. Mitigation requires applicants whose shoreline projects have adverse impacts to complete actions that return the impacted environment to its pre-disturbance condition or provide compensation in other ways for losses of ecological function. The City cannot require applicants to go beyond returning the impacted area (or compensating in other ways for lost functions) to the condition in just prior to the applicant conducting the approved project. However, the City can encourage applicants to implement restoration actions that will improve ecological functions relative to the applicant's pre-project condition. As stated in WAC 173-26-201(2)(c):

> It is intended that local government, through the master program, along with other regulatory and nonregulatory programs, contribute to restoration by planning for and fostering restoration and that such restoration occur through a combination of

> public and private programs and actions. Local government should identify restoration opportunities through the shoreline inventory process and authorize, coordinate and facilitate appropriate publicly and privately initiated restoration projects within their master programs. The goal of this effort is master programs which include planning elements that, when implemented, serve to improve the overall condition of habitat and resources within the shoreline area of each city and county."

The Opportunity Areas discussions in this section present options for "restoration" that would improve ecological functions (Figure 14). For example, enhancement of riparian vegetation, reductions or modifications to shoreline hardening, minimization of in- and over-water structures, and improvements to fish passage would each increase one or more ecological parameters of the City's shoreline. These options could be implemented voluntarily by the City or City residents, or depending on specific project details, could be incorporated into required mitigation. The *Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (Water Resource Inventory Area 8)* (Kerwin 2001) identifies the following five "limiting habitat factors and impacts on Lake Washington:"

- The riparian shoreline of Lake Washington is highly altered from its historic state. Current and future land use practices all but eliminate the possibility of the shoreline to function as a natural shoreline to benefit salmonids;
- Introduced plant and animal species have altered trophic interactions between native animal species;
- The known historic practices and discharges into Lake Washington have contributed to the contamination of bottom sediments at specific locations;
- The presence of extensive numbers of docks, piers and bulkheads have highly altered the shoreline; and
- Riparian habitats are generally non-functional.

Opportunity areas were initially identified during the compilation of the critical areas materials described above, review of 2005 aerial photographs, and a field reconnaissance in May 2006. Opportunity areas on City-owned property are very limited with the shoreline management area of Lake Forest Park. The City only owns one public access park (Lyon Creek Waterfront Preserve) and one other small property in the shoreline jurisdiction (Figure 14). Other restoration opportunities exist on private property in shoreline jurisdiction, including a small shoreline parcel owned by King County at the extreme northern end of the City (PIN 1126049127), on City and private properties along tributary streams, and two waterfront parcels that appear to be unopened public street rights-of-way near NE 145th and NE 155th street ends. Future open space acquisition efforts may eventually result in the acquisition of additional shoreline sites over the long-term.

<u>Tracy Owen Station/Log Boom Park</u>: The City of Kenmore owns and manages the adjacent Tracy Owen Station/Log Boom Park. This park could provide opportunities for enhancement of similar habitat within one mile of Lake Forest Park Town Center if the City of Kenmore is amenable. The City of Lake Forest Park could focus habitat improvement efforts at this site. The City could also choose to provide additional flexibility and synergy for permit applicants by allowing and encouraging off-site mitigation requirements at this location (i.e. mitigation beyond

that which is necessary on-site to assure no net loss of ecological functions necessary to sustain shoreline natural resources). Opportunities could include improving shoreline buffers by controlling invasive species and planting native vegetation and perhaps even the removal of derelict pilings. Closer investigation will likely provide additional opportunities for consideration. Opportunities for shoreline enhancement at Tracy Owen Station will be explored in a separate Shoreline Restoration Plan.

<u>General</u>: Many shoreline properties have the potential for improvement of ecological functions through: 1) reduction or modification of shoreline armoring, 2) reduction of overwater cover and in-water structures (grated pier decking, pier size reduction, pile size and quantity reduction, moorage cover removal), 3) improvements to nearshore native vegetative cover, and/or 4) reductions in impervious surface coverage. Similar opportunities would also apply to undeveloped lots which may be used as community lots for upland properties or local street-ends and utility corridors. Other opportunities may exist to improve either fish habitat or fish passage for those properties which have streams discharging to Lake Washington.

<u>Lyon and McAleer Creeks</u>: Restoration opportunities identified in the City's *McAleer and Lyon Creeks Drainage Basin Study* report (Hammond, Collier & Wade-Livingstone Associates, Inc. 1999) will be discussed in greater detail in a separate Shoreline Restoration Plan document. The report includes recommendations for culvert replacements (address flooding and fish passage) and regional detention pond construction (address water quantity and quality issues), among others. In addition, several local organizations and non-profit groups have been active in restoring and monitoring Lyon and McAleer Creeks and their tributaries. These organizations include the Streamkeepers of Lake Forest Park, the Lake Forest Park Stewardship Foundation, the Adopt-A-Stream Foundation, and others. The City should actively coordinate with these groups to maximize implementation of City projects and these groups' projects. The specific activities of these organizations will be discussed in greater detail in a separate Shoreline Restoration Plan document. Most of these City and non-profit organization projects are planned "upstream" of shoreline jurisdiction, but will still have positive effects on the shoreline environment. In general, projects that reduce stream and lake sedimentation should be prioritized, as well as public education efforts to reduce inputs of pesticides.

<u>WRIA 8 Recommendations</u>: The 2005 *Final Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan* includes two general project categories along the Lake Forest Park shoreline and one project just up--lake, as follows:

> <u>C302</u>: Explore opportunities to restore riparian vegetation and reduce number of docks by working with private property owners in section.
>
> <u>C303</u>: Explore opportunities to restore mouths of small tributaries in this section, including MacLeer [sic] Creek. Will require working with private property owners on revegetation. Many of small tributaries are steep, in pipes. Low feasibility. MacLeer [sic] Creek is a Chinook "sink." Avoid attracting more Chinook into creek.

In addition, a restoration opportunity at Tracy Owen Station/Log Boom Park, which is immediately adjacent to Lake Forest Park, is identified as project C298 in the *Final Lake*

Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan. The following description of that project is excerpted verbatim from the *Conservation Plan*:

> C298 Tracy Owen Station Park Shoreline Restoration: Shoreline near the mouth of the Sammamish River is degraded by the presence of weedy and invasive species, erosion, and shoreline armoring. A City of Kenmore project could explore removal of wood waste from area – potential bass habitat and bad for benthic conditions. Project may include beach creation in future. The proposed project could also restore the shoreline by removing invasive plant species, planting native vegetation, and replacing existing shoreline armoring with bioengineered stabilization features. Site is a tangle of willows, with open grass to the water. City of Kenmore is ready/interested in doing the project.

The 2005 *Final Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan* includes the following general recommendations to reduce predation on outmigrating juvenile chinook salmon in its "Action Start-List for Migratory Areas":

- Encourage salmon friendly shoreline design during new construction or redevelopment by offering incentives and regulatory flexibility to improve bulkhead and dock design and revegetate shorelines. Increase enforcement and address nonconforming structures over long run by requiring that major redevelopment projects meet current standards.
- Discourage construction of new bulkheads; offer incentives (e.g., provide expertise, expedite permitting) for voluntary removal of bulkheads, beach improvement, riparian revegetation.
- Support joint effort by NOAA Fisheries and other agencies to develop dock/pier specifications to streamline federal/state/local permitting; encourage similar effort for bulkhead specifications.
- Promote value of light-permeable docks, smaller piling sizes, and community docks to both salmon and landowners through direct mailings to lakeshore landowners or registered boat owners sent with property tax notice or boat registration tab renewal. Offer financial incentives for community docks in terms of reduced permit fees, loan fees/percentage rates, taxes, and permitting time, in addition to construction cost savings.
- Develop workshop series specifically for lakeshore property owners on lakeside living: natural yard care, alternatives to vertical wall bulkheads, fish friendly dock design, best management practices for aquatic weed control, porous paving, and environmentally friendly methods of maintaining boats, docks, and decks. Related efforts include creation of a website to convey workshop material, an awareness campaign, "Build a Beach," to illuminate impact of bulkheads on development of sandy beaches.
- Restore shoreline in Lake Washington Section 1: work with private property owners to restore shoreline in Section 1. Use interpretive signage where possible to explain restoration efforts.

Additional recommendations to further water quality restoration of the lake and its tributaries, reduce the population of cutthroat trout,[4] and enhance juvenile chinook rearing areas are as follows:

- Address water quality and high flow impacts from creeks and shoreline development through NPDES Phase 1 and Phase 2 permit updates, consistent with Washington Department of Ecology's 2001 *Stormwater Management Manual*, including low impact development techniques, on-site stormwater detention for new and redeveloped projects, and control of point sources that discharge directly into the lakes. Stormwater impacts from major transportation projects (for new and expanded roadways proposed during the next ten years) should be addressed. Encourage low impact development through regulations, incentives, education/training, and demonstration projects throughout the subarea.
- Protect and restore water quality and other ecological functions in tributaries to reduce effects of urbanization and reduce conditions which encourage cutthroat. Protect and restore forest cover, riparian buffers, wetlands, and creek mouths by revising and enforcing critical areas ordinances and Shoreline Master Programs, incentives, and flexible development tools.
- Promote through design competitions and media coverage the use of "rain gardens" and other low impact development practices that mimic natural hydrology. Combine a home/garden tour or "Street of Dreams" type event featuring these landscape/engineering treatments.

A Restoration Plan document will be prepared in 2007 as a later phase of the Shoreline Master Program update process, consistent with WAC 173-26-201(2)(f). The Restoration Plan will "include goals, policies and actions for restoration of impaired shoreline ecological functions. These master program provisions should be designed to achieve overall improvements in shoreline ecological functions over time, when compared to the status upon adoption of the master program." The Restoration Plan will mesh the specific potential projects identified in this report, with regional or City-wide efforts and programs of the City, watershed groups, and environmental organizations that contribute or could potentially contribute to improved ecological functions of the shoreline. Prioritization of specific projects and project types will be based on a semi-quantitative assessment, and implementation strategies and schedule will be outlined.

4.0 ANALYSIS of ECOLOGICAL FUNCTIONS and ECOSYSTEM WIDE PROCESSES

4.1 LAKE WASHINGTON WATERSHED

The Lake Washington watershed (Water Resource Inventory Area 08 [WRIA 08]) encompasses 692 square miles, collecting water from two major rivers (Cedar and Sammamish Rivers) before flowing through Lake Union and ultimately into Puget Sound via the Lake Washington Ship

[4] Cutthroat trout are currently considered the dominant predator in Lake Washington. See section 4.2.3 for more information on predator-prey interactions in Lake Washington.

Canal and Hiram Chittenden locks. The baseline conditions that aquatic species presently face in Lake Washington result from considerable human alterations of the environment.

The following information is presented to give historical context to the analysis of existing ecological functions and processes (i.e. baseline conditions). The urbanization of the Lake Washington watershed has increased impervious area, reduced forest cover, and increased nutrient and chemical loading to environmentally sensitive areas. These factors eventually contribute to increased storm flows, channel incision, sedimentation, and reduction in water quality, to name a few, ultimately impacting downstream receiving water bodies such as Lake Washington. As previously mentioned, the *Salmon and Steelhead Habitat Limiting Factors Report for the Cedar-Sammamish Basin (Water Resource Inventory Area 8)* (Kerwin 2001) identifies the following five "limiting habitat factors and impacts on Lake Washington:"

- The riparian shoreline of Lake Washington is highly altered from its historic state. Current and future land use practices all but eliminate the possibility of the shoreline to function as a natural shoreline to benefit salmonids;
- Introduced plant and animal species have altered trophic interactions between native animal species;
- The known historic practices and discharges into Lake Washington have contributed to the contamination of bottom sediments at specific locations;
- The presence of extensive numbers of docks, piers and bulkheads have highly altered the shoreline; and
- Riparian habitats are generally non-functional.

The lowering of the lake that resulted from the construction of the Lake Washington Ship Canal and Hiram Chittenden locks (completed in 1916) and the concurrent elimination of the Black River and the diversion of the Cedar River into Lake Washington were the most monumental modifications. Lake Union was connected to Lake Washington via the Montlake Cut, and the former outlet to Lake Union was enlarged to form the Fremont Cut. Locating the locks near the western terminus of Salmon Bay converted the formerly saltwater inlet into a freshwater channel, eliminating over 7 km (4 mi.) of estuarine habitat. Lowering Lake Washington and diverting the Cedar River affected both the fish populations and the condition of the habitat. Cedar River fish stocks were locally adapted to a riverine migration and an extensive estuary, instead of the current lengthy lacustrine migration and an abrupt transition between warm, fresh water and significantly colder, more saline conditions below the locks. Lake Washington fish stocks, while accustomed to the lengthy lacustrine migration, were also adapted to an extensive estuary. The approximately 9-foot reduction in lake level eliminated much of the available shallow-water and freshwater marsh habitat, and decreased the length of the shoreline. Chrzastowski (1983) reports a loss of 15.3 km (9.5 miles) of shoreline, and an estimated loss of 410 hectares (1,013 acres) of wetland resulting from the lowering of the lake.

The construction of the Hiram Chittenden locks and subsequent water level regulation in Lake Washington by the Corps eliminated the annual flood-driven seasonal inundation of the shoreline that historically shaped the structure of the vegetation community. The hardstem bulrush- and willow-dominated community which existed prior to 1916 has been replaced by developed shorelines with landscaped yards. The management of the lake level by the Corps to maintain a high water volume throughout the summer and subsequently lowering the lake during the late fall and winter essentially reverses the natural lake hydrograph. This reversal impacts the growth of many species of native terrestrial and emergent vegetation. Conversely, this hydrograph reversal indirectly acts to buffer shorelines from potential wind-driven wave impacts during winter storms. The loss of natural shoreline has reduced complex shoreline features such as overhanging and emergent vegetation, woody debris (especially fallen trees with branches and/or rootwads intact), and gravel/cobble beaches. Evermann and Meek (1897) noted in 1896 that "the shore of Lake Washington is not well adapted to collecting with a seine" due to the abundant submerged woody debris, and dense underbrush, small trees, and tule (hardstem bulrush) that fringed the shoreline. The loss of native shoreline vegetation and wetlands has also reduced allocthonous input of detritus and terrestrial insects.

The woody debris, once abundant along the shoreline of Lake Washington in its historical condition has been replaced with structurally simple piers. A survey of 1991 aerial photos estimated that 4 percent of the shallow-water habitat within 30.5 m of the shore was covered by residential piers (ignoring coverage by commercial structures and vessels) (Malcom, pers. comm., 22 November 1999). A study conducted in 2000 reported that there were 2,737 docks in Lake Washington, and that approximately 71 percent of the shoreline was armored (Toft 2001). The loss of complex habitat features (i.e., woody debris, overhanging vegetation, emergent vegetation), and shallow-water habitat in Lake Washington has reduced the availability of prey refuge habitat and forage for juvenile salmonids. As NOAA Fisheries- and USFWS-mandated standard conservation measures are implemented with individual shoreline projects, and bioengineering methods and other "fish-friendly" designs for shore protection are adapted to lakeshore use, the condition of the Lake Washington shoreline, in terms of fish and wildlife habitat may improve over time. However, the present availability of quality shoreline habitat for salmonids and their prey species remains substantially below its historical level. Recent and ongoing efforts to address the concern of growth management within the watershed and facilitate recovery efforts for salmon and salmon habitat, specifically for chinook salmon, include working with local jurisdictions to implement shared strategies for salmon recovery (WRIA 8 Steering Committee 2005; WRIA 8 Steering Committee 2002).

While water quality in Lake Washington is often considered moderate to good, the present state is a tremendous improvement from its condition just 50 years ago. Prior to the formation of Metro (now part of King County's Department of Natural Resources and Parks) in 1958, local sewage treatment plants around Lake Washington discharged effluent directly into the lake, resulting in large cyanobacteria (*Oscillatoria rubescens*) blooms that made the lake unsafe for recreation. After the construction of regional wastewater treatment facilities in Renton and at West Point in Seattle, effluent discharges dropped from approximately 20 million gallons per day to zero (Edmondson 1991). The subsequent reduction in phosphorus loading from the effluent discharges resulted in relatively immediate improvements to the lake's water quality. While water clarity was measured to be only 30 inches in 1964, clarity improved to 10 feet by 1968, reaching 25 feet by 1993.

A key feature of urban areas is impervious surface coverage. Increases in impervious surface coverage, and the consequent reduction in soil infiltration, have been correlated with increased velocity, volume and frequency of surface water flows. This hydrologic shift alters sediment and pollutant delivery to streams and ultimately to downstream receiving water bodies (Booth 1998; Arnold and Gibbons 1996). Increased surface water flows associated with impervious surface coverage of suburban areas (20-30%) has been linked to decreased bank stability and increased erosion (May et al. 1997a). Knutson and Naef (1997), in their literature review, concluded that as little as 10 percent impervious surface coverage is sufficient to alter streambank stability and erosion. Changes in hydrology and stream morphology brought on by impervious surfaces have also been linked to shifts in macroinvertebrate community composition, which could have profound and far-reaching impacts on the productivity of a watershed (Pederson and Perkins 1986, as cited in Leavitt 1998). Changes in fish assemblages have been correlated with changes in stream temperature and base flow as a result of increased impervious surface coverage (Wang et al. 2003). Increases in flood frequency and volume have been correlated to declining salmon populations in some Puget Sound lowland streams (Moscrip and Montgomery 1997). Riparian areas can protect against these factors by moderating surface water and sediment inputs. However, while riparian quality has been shown to be inversely proportional to the level of urbanization (May et al. 1997b), impervious surface area alone is not the only component to predicting stream biological conditions (Booth et al. 2004).

Many concerns have arisen in recent years over the impacts from the urbanization of predominantly forested areas, especially areas which contain erosion-susceptible geologic substrate and relatively high gradients (Booth and Henshaw 2001). Booth et al. (2002) conclude that under typical rural land uses, impacts to watershed ecology from reduced forest-cover area can be as great or greater than similar increases in impervious area. Threshold levels of 10 percent impervious coverage and 35 percent deforested area have been found to mark a distinct transition towards severely degraded stream conditions, regardless of the implementation of surface water management controls (Booth 2000).

In general, development is known to have detrimental effects on salmonids, particularly with spawning abundance and success. Pess et al. (2002) found that wetland occurrence, local geology, stream gradient, and land use were significantly correlated with adult coho salmon abundance. While positive correlations were found between spawner abundance and forested areas, negative correlations were found between spawner abundance and areas converted to agriculture or urban development. Fish species diversity has been found to decline with increasing levels of urban development, while cutthroat trout tend to become the dominant salmonid species (Lucchetti and Fuerstenberg 1993; Ludwa et al. 1997). The WRIA 8 Steering Committee has recently recognized the need to restore coho salmon spawning habitat in order to reduce the population of cutthroat trout, a known predator of juvenile chinook salmon (WRIA 8 Steering Committee 2005).

The remainder of this discussion describes the baseline conditions within Lake Washington in terms of the following parameters as enumerated by NOAA Fisheries' draft Lake Matrix of Pathways and Indicators established for chinook salmon (Table 7): 1) water quality, 2) habitat access, 3) habitat elements, 4) shoreline conditions.

Table 7. Checklist for Documenting Environmental Baseline of Relevant Indicators – Draft modified by NOAA Fisheries for lakes.

PATHWAYS INDICATORS	**SUMMARY OF LAKE WASHINGTON CONDITIONS**
Water Quality	

PATHWAYS INDICATORS	**SUMMARY OF LAKE WASHINGTON CONDITIONS**
Temperature/Dissolved Oxygen	At Risk: Surface water temperatures often exceed the critical threshold for juvenile salmonids, creating inhospitable shallow nearshore areas typically between July and October. However, juvenile salmonids are not likely to be present in the nearshore at this time of year. Conversely, DO rarely falls below acceptable levels in surface waters (1-10m). However, DO concentrations below dense growths of aquatic macrophytes, Eurasian milfoil in particular, can be lethally low.
pH	At Risk: pH levels are found typically within acceptable levels, but can become higher during the late spring/early summer months.
Chem. Contamination	At Risk: Chemical contamination consists primarily of hydrocarbon input from the urbanized watershed, but the lake has also been on the 303d list for fecal coliform, ammonia, and PCBs.
Nutrients/Total P	At Risk: Nutrient levels in Lake Washington typically do not represent a problem for salmonids. However, localized algal blooms have occurred at various points throughout the lake.
Habitat Access	
Physical Barriers	At Risk: While fish passage is not physically blocked by the locks, the barrier presented by the locks and corresponding fish ladder causes stress and mortality for migrating salmonids.
Habitat Elements	
Exotic Species (in water)	Not Properly Functioning: Many invasive aquatic plants, such as Eurasian milfoil, have become extremely prevalent throughout the lake, often times outcompeting native species and reducing overall structural complexity.
Shoreline Upwelling/ Downwelling	Not Properly Functioning: The extent of shoreline armoring has reduced the natural influx of gravel via erosion processes and increased rates of sediment transport, which in turn has decreased the extent of shoreline upwelling/downwelling.
Structural Complexity (LWD/emergent/ submergent vegetation)	At Risk: Much of the loss in structural complexity dates back to the lowering of the lake by the U.S. Army Corps of Engineers during construction of the Hiram Chittenden Locks. The manual control of the lake elevation and the subsequent reversal of the natural hydrograph does not support the natural establishment of emergent vegetation similar to the historical condition. Shoreline development has decreased shoreline vegetation and subsequently removed and prevented further additions of LWD.
Substrate Composition	Not Properly Functioning: Due to the extent of shoreline armoring around Lake Washington, which effectively limits the natural erosion processes leading to sediment transport, the composition of most shoreline substrates do not contain habitat suitable to most salmonids. The extensive armoring also results in a lack of habitat structure used for rearing and allocthonous inputs necessary to support foraging. Juvenile salmonids primarily feed on aquatic and terrestrial invertebrates. The lack of overhanging and emergent vegetation limits allocthonous input of both detritus and invertebrates.
Shoreline Conditions	

PATHWAYS INDICATORS	**SUMMARY OF LAKE WASHINGTON CONDITIONS**
Shoreline Vegetation and Riparian Structure	Not Properly Functioning: Residential development around much of the lakeshore has resulted in a general lack of shoreline vegetation and riparian structure. The historical shoreline of Lake Washington included a mix of willow, dogwood, and other large shrubs along with upland conifers. The development of the lakeshore has effectively removed this native vegetation and replaced it with small shrubs and grass lawns, neither of which provide the habitat complexity of the historical shoreline.
Shoreline Gradient	Not Properly Functioning: Similar to the concerns regarding Shoreline Upwelling/Downwelling and Substrate Composition, Shoreline Gradient has also been negatively affected by shoreline armoring.

1. Water Quality: In general, Lake Washington surface water temperatures between 1 and 8 meters deep exceed 17°C from July to October, as measured at King County Monitoring Station 804, located at the north end of Lake Washington near the City of Lake Forest Park (http://dnr.metrokc.gov/wlr/waterres/lakes/Graph.aspx?Locator=804). This temperature appears to be a critical threshold for the distribution of juvenile anadromous salmonids. The expectation is that shallow nearshore areas of Lake Washington would be inhospitable for those species during periods of high temperatures.

   Conversely, dissolved oxygen (DO) levels rarely fall below 8 mg/L at similar depths (http://dnr.metrokc.gov/wlr/waterres/lakes/Graph.aspx?Locator=804). DO levels below 4 mg/L are considered dangerous for salmonids. Thus, ambient DO levels exceed acceptable levels for salmonids. However, DO concentrations below dense growths of aquatic macrophytes, Eurasian water-milfoil in particular, can be lethally low (Frodge et al. 1995).

   From 2000 through 2006, measures of pH at 1-meter and 8-meter depths (http://dnr.metrokc.gov/wlr/waterres/lakes/Graph.aspx?Locator=804) were typically between 7 and 9, rarely exceeding 8.5. These pH levels are acceptable for salmonids.

   Other water quality concerns include chemical contaminants and fecal coliform levels. Lake Washington was on the U.S. EPA 2004 303(d) list for fecal coliform at fifteen sample locations, ammonia at two locations, and polychlorinated biphenyls (PCBs) at one location. Chemical contamination of the waters of Lake Washington consists primarily of hydrocarbon input from the urbanized watershed. Wakeham (1977) computed a hydrocarbon budget for Lake Washington and determined that the majority of the hydrocarbons were from stormwater runoff either directly to the lake or via rivers, while 85 percent of the hydrocarbon removal is via sedimentation. Wakeham (1977) indicated that the primary source of hydrocarbons in the urban runoff to Lake Washington is automotive, both oil and grease, and products of combustion (polycyclic aromatic hydrocarbons - PAHs); outboard engine operation likely contributes a very small fraction of total input (less than 1%). PAHs are a common pyrolytic byproduct of all internal combustion engines and are now commonly found in most aquatic systems, near industrialized and urbanized centers (Green and Trett 1989).

Overall, relatively little is known about the impacts of PAHs to aquatic organisms. Evidence for immunosuppression resulting from exposure to PAHs was reported by Arkoosh et al. (1998), who determined that chinook smolts from urban estuaries (Duwamish) exhibited a higher cumulative mortality after exposure to the marine pathogen *Vibrio anguillarum* than smolts from a non-urban estuary. Tissue examinations of the chinook smolts indicated that those from the urban estuary had been exposed to higher levels of PAHs and PCBs than smolts from the non-urban estuary (Arkoosh et al. 1998).

Present nutrient levels in Lake Washington do not represent a problem for salmonids. Total phosphorus, as measured from 2000 through 2006 at Metro station 0804, varied little between seasons, and has generally been below 0.04 mg/L. Total nitrogen has generally been below 0.7 mg/L. Although King County claims that "[t]here have been no measurements of ammonia at or above toxic levels in Lake Washington," Lake Washington is on the 2004 303(d) list for ammonia nitrogen.

The *Final Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan* listed Lake Union, the Ship Canal and the Sammamish River as waterbodies with degraded water quality, but did not include Lake Washington (WRIA 8 Steering Committee 2005). The *Lake Washington Existing Conditions Report* (Tetra Tech ISG, Inc. and Parametrix, Inc. 2003) summarizes and analyzes 12 years of water quality data. The Report concludes the following:

> "Overall, Lake Washington has recovered from the eutrophic, over enriched state that existed in the 1950s to 1960s. The key to rapid recovery was the lake's depth, which contained large stores of dissolved oxygen and the reduction in P loading that occurred with sewage diversion. The lake is sensitive to P loading, and the maintenance of present-day water quality is dependent on keeping P loading at or below current levels. Minimal development of the Cedar River basin has been a key factor in recovery and maintenance of lake water quality."

2. <u>Habitat Access</u>: The Hiram Chittenden Locks represent a barrier to fish passage by creating a combination of physical and biological obstacles to fish migration. While fish passage is not physically blocked by the locks, the physical and biological obstacles that the locks create, result in a significant level of stress and mortality for adult and juvenile salmonid migrants.

3. <u>Habitat Elements</u>: Exotic aquatic plant and animal species inhabit much of the Lake Washington system. Milfoil and fragrant white water lily are exotic aquatic macrophytes in Lake Washington that have demonstrated a negative affect on fish on occasion (Frodge et al. 1995). Reduced DO levels and consequent fish mortality has been observed within dense patches of either species in shallow, poorly circulating water (Frodge et al. 1995). Low DO conditions under aquatic macrophytes have only been observed in small lakes or in sheltered bays of Lake Washington. Yellow perch, brown bullhead, smallmouth bass, and largemouth bass are exotic predators with the potential to prey on juvenile chinook and coho salmon. Yellow perch utilize "non-structural" areas (Paxton and Stevenson 1979) and brown bullhead are benthic foragers, and are thus less likely than bass to utilize developed areas. Yellow perch of piscivorous size are also generally limnetic. Largemouth bass are the most likely exotic

predators in nearshore areas because of the abundant aquatic vegetation. Observing where sockeye salmon beach spawn best identifies the presence of shoreline upwelling or downwelling in Lake Washington. While sockeye spawning locations have been mapped by WDFW (including three small areas in Lake Forest Park), very little beach spawning has been documented in recent years. Shoreline hardening and the lack of erodible soils and subsequent sediment drift have likely resulted in a negative impact to shoreline upwelling/downwelling conditions.

Structural complexity in Lake Washington currently consists of submerged aquatic macrophytes, some small and large woody debris primarily located along undeveloped shorelines, and piers or other man-made in-water structures. The lake is generally lacking in structural complexity relative to natural shorelines. The implications for juvenile salmonids are that the present lack of complex structure throughout most of Lake Washington provides an advantage to large piscivorous fish.

Substrate composition throughout Lake Washington is influenced by shoreline hardening, which restricts erosional sediment input. Without supplemental substrate to cover and replace contaminated areas, exposed areas with high levels of PCBs and PAHs may be available to impact the aquatic food chain. Although not specifically studied in Lake Washington, immunosuppression responses have been observed in salmonids migrating through similar Puget Sound urban areas (Arkoosh et al. 1998). Lake Washington was on the U.S. EPA 1998 303(d) list for sediment bioassay at one location near the mouth of May Creek and the 2004 303(d) list for PCBs at one location near the north end of Lake Washington. While these locations are not specifically along the City shoreline, they are within the same waterbody and can affect the aquatic food chain lake-wide. Thus, discussion of water quality impacts, especially those derived by anthropogenic effects, is warranted.

4. Shoreline Conditions: The urbanization of the Lake Washington shoreline has resulted in a shoreline generally lacking native vegetation. There are very few sources of woody debris recruitment that remain and these are primarily associated with the only remaining undeveloped shorelines. The result is a lack of habitat structure used for rearing and allocthonous inputs necessary to support foraging. Juvenile salmonids primarily feed on aquatic and terrestrial invertebrates. The lack of overhanging and emergent vegetation limits allocthonous input of both detritus and invertebrates.

4.2 EFFECTS OF SHORELINE MODIFICATIONS ON AQUATIC ORGANISMS AND THEIR HABITATS

Shoreline modifications and nearshore structures around Lake Washington have dramatically altered the lake’s aquatic ecosystem. Although some changes in the Lake environment are not completely understood, the effects of physical modifications to shoreline habitats on some aquatic species, particularly chinook salmon, have been very well studied. Because of their sensitivity to changes in the aquatic ecosystem, anadromous salmonids are commonly used as a biological indicator species for the aquatic health of Lake Washington. There are many indigenous aquatic species inhabiting Lake Washington, but salmonids are one of the most sensitive. Due to their “threatened” status under the ESA, funding and other resources have been made available for the study of chinook salmon utilizing Lake Washington, which are an important part of the Puget Sound Chinook Salmon Evolutionary Significant Unit (ESU). The life history pattern and habitat requirements of the chinook salmon reflects the needs of other salmonid and non-salmonid aquatic species indigenous to Lake Washington, and information concerning the chinook salmon serves as a good proxy for other species in the Lake. Similarly, habitat restoration efforts designed to benefit chinook or other salmonids will also be beneficial for other native species inhabiting Lake Washington.

As an important and attractive asset to the City of Lake Forest Park, the City's shoreline has been extensively modified with bulkheads, piers, and other overwater structures (Toft 2001). Common modifications to nearshore aquatic habitats around much of Lake Washington include 1) the construction of bulkheads, which result in the structural simplification of shoreline habitats, and 2) the construction of piers, which block sunlight and create large areas of overhead cover within the littoral zone. These types of structural modifications to shorelines are now known to benefit non-native predators (like largemouth and smallmouth bass), while reducing the amount of complex aquatic habitat formerly available to salmonids rearing and migrating through Lake Washington (Kahler et al. 2000; Kerwin 2001; Tabor et al. 2006). Adult salmonids tend to utilize deepwater habitats in Lake Washington and structural changes to nearshore habitats typically have a lesser affect on adults than they do on juvenile salmonids. Lake Washington serves as an important rearing area and migration corridor for juvenile salmonids, however, and due to their affinity to nearshore, shallow-water habitats, juvenile salmonids are greatly affected by physical changes at the shoreline.

4.2.1 Anadromous Fish in the Lake Washington Watershed

Adult chinook salmon migrate from Puget Sound through the Chittenden Locks and into Lake Washington between July and September, continuing on to various tributary streams where they spawn in October and November. Although most chinook salmon production in the Lake Washington watershed occurs in the Cedar River, the North Lake Washington tributary streams (feeding into the Sammamish River), or at the Issaquah Fish Hatchery, chinook salmon (as well as coho and sockeye) also use many other, smaller Lake Washington tributary streams. A few of the tributary streams in the Lake Forest Park area that are used by chinook salmon or other anadromous salmonids include McAleer and Lyon Creeks. Chinook fry emerge from their redds between January and March, and either rear in their natal stream or emigrate to Lake Washington for a rearing period extending from three to five months. Emigrating through the Chittenden Locks and into Puget Sound between May and August, juvenile chinook salmon leave the Lake Washington system during their first year (Kerwin 2001; Tabor and Piaskowski 2002). Other anadromous salmonids spawning and/or rearing in the Lake Washington watershed include sockeye salmon, coho salmon, steelhead trout, and possibly bull trout.

After emerging from the gravel, chinook fry from Lake Washington tributaries either emigrate directly to the Lake, or rear to the fingerling stage in their natal stream before entering the Lake (Seiler et al. 2005). This process occurs between February and June. After they enter Lake Washington, juvenile chinook often congregate near the mouths of tributary streams, and prefer low gradient, shallow-water habitats with small substrates (Tabor and Piaskowski 2002; Tabor et al. 2004b; Tabor et al. 2006). Chinook fry entering Lake Washington early in the emigration period (February and March) are still relatively small, typically do not disperse far from the mouth of their natal stream, and are largely dependant upon shallow-water habitats in the littoral zone with overhanging vegetation and complex cover (Tabor and Piaskowski 2002; Tabor et al 2004b). The mouths of creeks entering Lake Washington (whether they support salmon spawning or not), as well as undeveloped lakeshore riparian habitats associated with these confluence areas, attract juvenile chinook salmon and provide important rearing habitat during this critical life stage (Tabor et al. 2004b; Tabor et al. 2006). Later in the emigration period (May and June), most chinook juveniles have grown to fingerling size and begin utilizing limnetic areas of the Lake more heavily. As the juvenile chinook salmon mature to fingerlings and move offshore, their distribution extends throughout Lake Washington.

Lake Forest Park is relatively close to the mouth of the Sammamish River, and early (February and March) chinook salmon migrants from the north Lake Washington tributaries (one of the primary production areas for the Lake Washington watershed) likely exit the Sammamish and rear along portions of the Lake Forest Park shoreline. These early emigrants from the Sammamish River are smaller, and more dependent on nearshore habitats than the later, larger Sammamish River emigrants that undergo a longer rearing phase in the north Lake Washington tributaries. Later emigrants would be less dependent on nearshore, shallow-water habitats and these larger juveniles would more likely utilize deeper waters slightly further from shore (Tabor and Piaskowski 2002; Tabor et al. 2006). Any salmon fry produced in smaller tributaries such as McAleer Creek or Lyon Creek would also depend upon nearshore, shallow-water habitats along the Lake Forest Park waterfront. Annual emigrant migration data from the Bear Creek watershed (a major tributary to the Sammamish River) shows that an early cohort of chinook fry emigrates downstream to Lake Washington in February/March, while the remainder of the juvenile chinook rear in the upper watershed before emigrating in late May to early June (Kiyohara and Volkhardt 2007; Volkhardt et al. 2006; Seiler et al. 2005). Although residence times in the Sammamish River can vary (Jeanes and Hilgert 2001), many of the juvenile salmonids (both early and late migrants) migrating down the Sammamish spend little time in the river and proceed directly to Lake Washington. The Lake Forest Park waterfront is ecologically important in that it contains some of the first lakeshore habitats that many of these emigrants (juvenile chinook, sockeye, and coho salmon, and cutthroat trout) will experience.

4.2.2 The Effects of Overwater Shading and Shoreline Armoring

Piers and other overwater structures shade the lake bottom and inhibit the growth of aquatic vegetation. Overwater structures affect the size, density, and species composition of aquatic macrophytes living directly beneath them (Fresh and Lucchetti 2000). The magnitude of this effect on aquatic macrophytes varies with the size (square footage) of the structure and the amount of sunlight it blocks. Changes in the physical structure of the aquatic plant community affect juvenile salmonids, as well as other indigenous fishes that use this vegetation in the nearshore environment. Spatial heterogeneity in aquatic vegetation increases the amount of edge habitat, improving the quality of foraging habitat available to ambush predators like the bass (Bryan and Scarnecchia 1992, Weaver et al 1997; Kahler et al 2000). The combined effect of an overwater structure and a dramatic change in aquatic vegetation results in a behavior modification in juvenile salmonids moving through both littoral and limnetic habitats. Juvenile salmonids migrating parallel to the shoreline will often change course to circumvent large piers or other overwater structures rather than swimming beneath them (Tabor and Piaskowski 2002, Tabor et al. 2004b, Tabor et al. 2006). These behavior modifications disrupt natural patterns of migration and can expose juvenile salmonids to increased levels of predation. Minimizing overwater coverage and associated support structures will benefit salmon fry rearing in the littoral zone as well as older salmon fingerlings utilizing the limnetic zone. Studies related to shading effects from varying types of pier decking indicate that grated decking provides significantly more light to the water surface than traditional decking methods and may lead to improved migratory conditions for juvenile chinook salmon (Gayaldo and Nelson 2006).

Bulkheads or other types of shoreline armoring affect juvenile salmonids by eliminating shallow-water refuge habitat, or indirectly, by the elimination of shoreline vegetation and in-water woody debris that generally accompanies bulkhead construction. Placing bulkheads waterward of OHWM creates an abrupt, deep-water drop-off at the shoreline while eliminating shallow water habitat in the nearshore. Lange (1999) found that bank stabilization (i.e., various forms of erosion control structures that we refer to as "bulkheads") was negatively correlated to fish abundance and species richness at all spatial scales investigated. Juvenile chinook salmon and other small fishes rely on shallow-water habitats in the littoral zone for foraging, refuge, and migration (Collins et al. 1995; Tabor and Piaskowski 2002). Shoreline armoring and bulkheads are also known to result in local reductions to the species diversity and abundance of both the fish community as well as the macroinvertebrate population inhabiting the littoral zone (Schmude et al. 1998; Lange 1999; Jennings et al. 1999).

4.2.3 Predator-prey Interactions in Lake Washington

Indigenous Lake Washington fish species that prey on juvenile salmonids include cutthroat trout, rainbow trout, coho salmon, northern pikeminnow, five species of sculpin, and lamprey. Non-native predators currently present in the Lake include smallmouth bass, largemouth bass, and yellow perch. Native cutthroat trout populations (adfluvial and anadromous) are strong in Lake Washington, and this species is currently considered the primary predator of juvenile chinook, sockeye, and coho salmon.. Smaller-sized cutthroat trout prey on juvenile salmonid fry inhabiting the littoral zone early in the spring, while larger individuals feed on salmonid fingerlings migrating and rearing in the limnetic zone later in the season (Nowak et al. 2004; Tabor et al 2004a). A small proportion of northern pikeminnow, yellow perch, and smallmouth bass reside in nearshore regions during winter, but the majority moves offshore in the spring as temperatures in nearshore areas warm (Bartoo 1972; Olney 1975; Coutant 1975). The distributions of these fishes overlap primarily with the peak out-migration of chinook through the littoral zone, whereas the overlap of cutthroat and chinook distributions is continuous. Sculpins are present in the littoral zone year-round and are also known to eat juvenile chinook salmon (Tabor et al. 1998; Tabor et al 2004a). In mid-summer, temperatures in the littoral zone become undesirable for juvenile chinook and coho salmon, and the majority leave the lake or seek cooler temperatures away from the littoral zone, thus segregating themselves from littoral predators, but remaining vulnerable to cutthroat trout and potentially prickly sculpin.

Shoreline development could potentially increase the rate of predation on juvenile salmonids by several principal means: 1) reducing the amount of refuge habitat available to prey species like juvenile salmonids by modifying the structure of the shoreline; 2) providing concealment structures for ambush predators such as bass and sculpin; 3) providing artificial lighting that allows for around-the-clock foraging by predators; and 4) altering migration routes for smolts and rearing fry. Although many predators that feed on juvenile salmonids are active, cruising hunters (i.e., other salmonids, piscivorous birds, northern pikeminnow), smallmouth and largemouth bass generally utilize ambush or habituation foraging strategies (Hobson 1979). Fayram and Sibley (2000) determined that smallmouth bass in Lake Washington occupied littoral home ranges that radiated 100 to 200 meters from the focal point and generally did not extend below 8-meter depths. Because of their propensity for ambush foraging and shoreline orientation, bass in Lake Washington benefit from artificial structures placed in the littoral zone, whereas yellow perch are more likely to utilize "non-structural" areas (Paxton and Stevenson 1979).

Increased useage of complex cover (e.g., aquatic vegetation, woody debris, substrate interstices, and undercut banks) by prey fishes in the presence of predators, and reduced foraging efficiency of predators due to habitat complexity has been well documented (Wood and Hand 1985; Werner and Hall 1988; Bugert and Bjornn 1991; Tabor and Wurtsbaugh 1991; Persson and Eklov 1995). Juvenile salmonids, like many other prey species, modify their behavior in the presence of predators by seeking or orienting to complex refuge (Gregory and Levings 1996; Reinhardt and Healey 1997), emigrating from areas with predators (Bugert and Bjornn 1991), aggregating (Tabor and Wurtsbaugh 1991), and adopting diel vertical migrations (Eggers et al. 1978). Complex habitat features that exclude predators, physically or through risk-aversion can function as prey refuge. Examples of effective prey refuge include complex substrate, aquatic and emergent vegetation, overhanging terrestrial vegetation, undercut banks, and submerged pieces of large wood. Shallow water also functions as a refuge from predation for small fish, especially in the absence of complex habitat features such as woody debris or submerged vegetation. Historically, Lake Washington's riparian and littoral zones were well vegetated, and interspersed with an abundance of large wood that had fallen along the shoreline (Evermann and Meek 1897; Stein 1970). The lowering of the Lake Washington water level and substantial shoreline development eliminated much of the vegetation and structural complexity historically available to juvenile salmonids rearing and migrating in the nearshore. Management plans seeking to encourage healthy assemblages of native fish should avoid the simplification of shoreline habitat, and the reduction of refuge-habitat for prey species.

Although the magnitude of avian predation in Lake Washington is unknown, piscivorous birds are present and this source of predation must be considered among potential threats to most fish, including juvenile salmonids. Common mergansers are abundant in the spring. Double-crested cormorants are common in Lake Washington, typically perching on the log booms at Union Bay and May Creek rather than on docks and bulkheads. Cormorants also commonly perch on individual piles. Western grebes inhabit enclosed bays (and some marinas), and forage throughout the lakes on calm days. Gulls are common, perching on log booms and on low docks, and are also known to feed on juvenile salmonids (Ruggerone 1986). In-water structures provide perching platforms for avian predators, from which they can launch feeding forays or dry plumage (Kahler et al. 2000). Incorporating anti-perching devices and grating in the design of overwater piers or related structures would work to minimize any advantage these structures convey to piscivorous birds.

4.2.4 Non-native Predators in the Nearshore Environment

The habitat requirements and behavior patterns of bass species have been studied extensively throughout their range, including Lakes Washington and Sammamish. A growing body of bass-related research has collectively demonstrated that bass species have an affinity for structural elements, and that bass prey on juvenile salmonids in Lake Washington. Smallmouth bass are more abundant in Lake Washington than largemouth bass, but both species are present in the system.

Although smallmouth and largemouth bass are known to prefer natural cover types like brush, logs, aquatic vegetation, or boulders (Stein 1970), these adaptive species readily utilize floating docks and the support piles of piers in the absence of natural cover types. Artificial structures and cover types that promote shade or darkness are frequently favored by yearling bass species (Haines and Butler 1969; Bassett 1994). Bass species are known to select low-gradient, shallow-water (0.6-1.5 meters), silty to gravelly habitats near structural features for spawning (Pflug 1981; Heidinger 1975; Allan and Romero 1975), and prefer similar habitat types near cover while foraging or resting (Vogele and Rainwater 1975). Although the habitat preferences of largemouth and smallmouth bass are generally similar, smallmouth bass generally select drop-offs or outcroppings, cover in the form of logs or rocks, and hard substrates without aquatic vegetation (Pflug 1981; Pflug and Pauley 1984), whereas largemouth bass generally prefer softer-bottom substrates and aquatic macrophytes (Coble 1975). These aspects of bass ecology are consistent with observations of bass behavior from across their geographic range (Bryan and Scarnecchia 1992; Kraai et al. 1991; Bassett 1994).

Logs, brush, or other pieces of large wood are rare along developed sections of the shoreline within the City of Lake Forest Park. Piers provide alternative sources of shade, overhead cover, and in-water structure (piles and boatlifts) that attract bass (Fresh et al. 2003). Piers and piles differ from natural cover/structure elements, such as brush piles, primarily in their lack of structural complexity. This difference is critical for prey fish, which rely on structural complexity for avoidance cover in the presence of predators. In developed lakes, piers become the dominant structural features, at the expense of natural complex structures such as woody debris and emergent vegetation (Bryan and Scarnecchia 1992; Poe et al. 1986; Lange 1999). In areas of Lake Washington where smallmouth bass are present, they preferentially select habitats beneath piers and near in-water support pilings (Fresh et al. 2003). Lake Washington smallmouth concentrations tend to be highest around large docks extending over deeper water, equipped with skirting and numerous support piles. Management plans designed to minimize any advantage non-native predators hold over juvenile salmonids in the littoral zone of Lake Washington should also seek to minimize the amount of overwater cover and support structure associated with pier or dock projects along the shoreline.

4.3 CITY OF LAKE FOREST PARK

4.3.1 Summary of City's Analysis

The inventory discussion of Lake Forest Park in Section 3 adequately summarizes existing conditions for most of Lake Forest Park's shoreline jurisdiction. Section 4.1 presents lake-wide conditions and function/process performance, with the latter organized per NOAA Fisheries' draft *Lake Matrix of Pathways and Indicators* established for chinook salmon (see Table 7). The latter discussion is focused on the aquatic lake environment, not the associated upland shoreline areas. The following discussion ties together Sections 3 and 4.1 consistent with the lake function delineation as presented in WAC 173-26-201(3)(d)(i)(C) and the processes outlined in WAC 173-26-201(3)(d)(i)(D). Table 8 summarizes the performance of those ecological functions.

Table 8. Lake Forest Park Shoreline Function Summary.

Function	Performance
Hydrologic	
Storing water and sediment	LOW-MODERATE: The lake of course provides excellent water and sediment storage functions. However, the uplands have low water and sediment storage functions. Impervious surfaces and compact managed lawns interfere with infiltration of precipitation and rapidly send water "downstream." Wetlands and other natural water and sediment storage features are generally lacking.
Attenuating wave energy	LOW: The changes to the lake elevation per the 1916 modifications made the nearshore environment generally steeper, with less opportunity for gradual nearshore slopes to attenuate wave energy. Bulkheading and other shoreline modifications have further steepened the nearshore. However, the reversal of the natural lake hydrograph has ameliorated the affects somewhat.
Removing excess nutrients and toxic compounds	LOW: The upland shoreline areas are more often a source of nutrients and toxic compounds, via lawn treatment runoff (pesticides, fertilizers, herbicides) and road runoff (hydrocarbons, metals).
Recruitment of LWD and other organic material	LOW: Upland modifications restrict the ability of the lake to recruit LWD and organic material.
Vegetation	
Temperature regulation	LOW: Lack of dense shoreline vegetation virtually eliminates potential for shading of the shallow-water nearshore area. However, most of the City's shoreline is east-facing, so morning sun may be a larger factor in nearshore water temperatures than the absence of vegetation.
Water quality improvement	LOW: Residential areas dominated by lawn and landscaping, but without dense buffers of lakeside vegetation, are sources of water quality contaminants such as fertilizers, herbicides and pesticides. Piped runoff converged via outfalls from the urban impervious surfaces is also not filtered through any vegetation. In addition to the residential pollutants, urban runoff carries hydrocarbons, metals, sediments and other pollutants from roads and parking lots.
Attenuating wave energy	LOW: Prior to construction of the Locks and subsequent lowering of the lake elevation, the lake was ringed with emergent wetlands and mature mixed-forest communities. Those communities are now almost entirely absent, so vegetation does not provide any significant wave attenuation function. Both wind- and boat-driven waves can increase erosion on unprotected shorelines.
Sediment removal and bank stabilization	LOW: Under natural conditions, there would be a certain rate of shoreline erosion, which is essential to maintaining substrate conditions. This rate would be partially determined and moderated by the presence of shoreline vegetation whose root systems would hold bank material in place. Instead, these segments have little shoreline vegetation and approximately 80% of the shoreline is armored. While this "stabilizes" the banks, it limits natural recruitment of lakebed materials. Non-armored banks did not appear to be unstable.
LWD and organic matter recruitment	LOW: Again, loss of shoreline vegetation other than lawn and some landscaping has largely eliminated large woody debris and organic matter recruitment potential within these segments. Any "complex" (e.g., having lots of branches and other structure) trees or large debris that do enter the lake are likely to be quickly removed to reduce risk of property damage or harm to humans. Some of the properties with beaches have log elements on their shoreline, but these are generally out of the water above the OHWM.

Function	Performance
Hyporheic	
Removing excess nutrients and toxic compounds	LOW-MODERATE: The hyporheic zone is restricted by extensive shoreline armoring, but likely does provide some nutrient and toxic compound removal when water from the uplands infiltrates into the hyporheic zone instead of running off the surface. Lake water quality is generally good (see previous discussions), but further improvements are likely when upland runoff moves through the hyporheic zone.
Water storage	LOW-MODERATE: Again, the hyporheic zone is restricted by shoreline armoring, although the water storage function is of low importance in a managed lake. Quantitative data are not available.
Support of vegetation	LOW: Much of the shoreline zone within range of the hyporheic zone is vegetated with lawn, which is not generally supported by hyporheic water storage, but instead, by irrigation or precipitation.
Sediment storage and maintenance of base flows	LOW: The hyporheic zone is restricted by extensive shoreline armoring, which limits movement of fines from the lake into the hyporheic zone. However, neither sediment composition nor base flows are particularly important in Lake Washington.
Habitat	
Physical space and conditions for life history	LOW: Under natural conditions, the lake bottom gradually rises in a shallow wedge such that incoming waves would roll up the bottom, losing energy. This reduced energy environment would be more hospitable to emergent vegetation, which further attenuates wave energy, providing a refuge for small fish and amphibians. Shallow nearshore areas in Lake Washington provide critical rearing, foraging and migration habitat for fish, particularly salmonids. Shoreline armoring, however, generally eliminates the low-energy shallow-water environment, creating a deeper, turbulent nearshore that is inhospitable to small fish and amphibians, as well as to emergent vegetation. Shoreline armoring can also reduce upwelling/downwelling areas, which are optimal for sockeye salmon spawning. The deeper water also allows larger fish predators to prey on the small fish. Aquatic mammals, like muskrats, seem to have adapted to the armored shoreline, and still find den sites in the looser boulder bulkheads. The absence of dense shoreline vegetation is a limiting factor in terrestrial species (birds, mammals, amphibians) use of the shoreline, since cover, food, nesting sites, travel corridors, etc. are absent.
Food production and delivery	LOW: Food production from the uplands is very limited by lack of native seed- and fruit-bearing vegetation. Not only does upland vegetation provide food directly for terrestrial wildlife, but it is a source of insects and other organic matter that drop into the water and provide food for fish and other aquatic life. The historical emergent wetland areas that are now absent also provided productive foraging areas for small mammals, wading birds and waterfowl.

Water quantity and water quality issues in lake environments are generally equally distributed throughout the lake, rather than being reach- or segment-specific such as may occur in stream environments with uni-directional flow. Although Lake Washington regularly receives inputs of nutrients (fertilizers), hydrocarbons (from in-water vehicles and road runoff), pesticides, and other pollutants, the *Final Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan* does not identify Lake Washington as a waterbody with degraded water quality.

Large woody debris (LWD) recruitment potential has been virtually eliminated from Lake Forest Park in conjunction with shoreline armoring, landscaping, and view maintenance. Scattered large trees do remain on individual properties, but are insufficient to develop a migratory corridor for wildlife. The property owner would likely either remove a large shoreline tree when it becomes a hazard to the residence, or would remove the tree to eliminate a safety hazard to boaters and swimmers if the tree falls into the lake. Loss of large woody debris in the nearshore area reduces a habitat component that provides cover for fish, perches for piscivorous birds, basking sites for turtles, and attachment sites for invertebrates and aquatic vegetation. Large woody debris can also affect the movement and distribution of substrate material.

There is some LWD recruitment potential remaining in some of the tributary stream corridors. However, most of the recruitment would likely be from deciduous species, such as red alder and black cottonwood, which have reduced longevity relative to Douglas-fir or western red cedar. Further, to benefit the in-water shoreline environment, large woody debris must be able to move downstream to the lake. Roads and culverts, as well as insufficient stream flows, are barriers to movement of the wood from stream corridors into the lake. Smaller organic debris (sticks, twigs, leaves, etc) that enters the streams may find their way into the lake and provide some habitat benefits.

As discussed above, shoreline armoring has extensive adverse affects on nearshore habitat (emergent and riparian vegetation, sediment recruitment and distribution, turbulence, non-native predator habitat, etc.). Approximately 80 percent of the City's shoreline is armored as a reaction to a real erosion problem (often resulting from removal of stabilizing vegetation), a perceived potential erosion problem, or historically to increase the amount of level yard or buildable area. While many shorelines would be stable during most natural conditions on the lake, boat-generated wakes in more recent years can substantially increase erosion rates. In a 2001 study (Toft), the entire shoreline of Lake Washington was determined to be 70.65 percent armored, indicating that shorelines within the City are measurably more altered or hardened than the average lake-wide condition. The average number of piers per mile within the City is 59; a 2001 study reported a lake-wide average of 36 piers per mile. This demonstrates that the level of shoreline modification within the City is significantly greater than the lake-wide average. Thus, adverse effects on nearshore habitat associated with these modifications could be expected to be comparatively greater.

Significant wildlife habitat in shoreline jurisdiction has been virtually eliminated. Much of the habitat was lost with the lowering of the lake elevation, but residential development close to the shoreline, with accompanying landscaping and shoreline modifications, has removed much of the remaining potential riparian habitat. Species that do utilize the upland and/or aquatic areas of the shoreline include otter, muskrat, great blue heron, perching and foraging raptors, and waterfowl (including Canada geese which can produce a human health hazard and are considered a nuisance by many shoreline residents and users). Other suburban- and urban-adapted birds and mammals may also reside in these areas. The habitat value in the few linear patches of habitat is limited by low connectivity to large patches of habitat, adjacent development, and other factors.

Based on the above qualitative evaluation of shoreline functions (see Table 8) and the City's nearly homogeneous shoreline structure (i.e. highly residential with only one small City park), the City's shoreline is uniformly characterized as low functioning.

In order to protect existing ecological functions and potentially enhance degraded systems, several recommendations are outlined below. Based on the existing conditions described above, these recommendations include: 1) minimizing shoreline armoring to only that which is necessary to protect existing structures and/or uses; 2) providing incentives for bioengineered solutions to shoreline stabilization issues; 3) reducing the amount of over- and in-water structures; 4) providing incentives to enhance shoreline habitat, including revegetation; and 5) mitigating impacts to achieve no net loss of ecological function. These recommendations are designed to help provide the basis for future Restoration Plan development and formulation of appropriate SMP goals and policies.

4.3.2 Summary of King County's Analysis

King County conducted a County-wide shoreline inventory and characterization that used a GIS-based "spatially explicit raster model." Each of nine processes that operate in lacustrine environments was modeled and scored, with scoring assigned as a particular process in the "pixel" (smallest evaluation unit, 25 ft^2) rated relative to all other King County lake shoreline pixels. Potential scores ranged from 0 to 4, with 0 representing "highly altered conditions" and 4 representing little or no alteration. Pixel scores were then combined at the reach scale (delineated by King County using geomorphic data only).

King County ran the model for the City of Lake Forest Park, although the scoring is still assigned relative to all County shoreline lakes. The scores for Lake Forest Park for each process are shown below in Table 9. The process scores were averaged for each pixel and divided into three generalized categories of low, medium or high function. Maps showing the results are provided in Appendix D.

Table 9. King County Characterization Model Result for the City of Lake Forest Park by Ecological Process.

PROCESS	City of Lake Forest Park Score
Light energy	0.87 (Medium Low)
LWD	0.69 (Medium Low)
Nitrogen	2.96 (Medium High)
Pathogens	3.00 (Medium High)
Phosphorus	1.09 (Medium Low)
Sediment	2.13 (Medium)
Toxins	0.79 (Medium Low)_
Hydrologic cycle	1.14 (Medium Low)
Wave energy	1.03 (Medium Low)

King County's assessment of ecological function is at a different scale than the City's, factors in nine specific processes, and places the City in the context of all lakes in the County. In spite of these differences, both the City's and King County's characterizations identify the majority of the shoreline area as having relatively low quality. King County's assessment found over 50 percent of all evaluated land pixels to be medium-low quality (Table 10). However, both methods do recognize that there is some limited variation. Both characterizations identify a small area of high functioning shoreline near the mouth of Lyon Creek, where a City Park and portions of the private Civic Club are located. Both methods also note the contribution of significant forest fragments along the more upland portions of the north and south ends of Lake Forest Park's Lake Washington shoreline. These small areas are noted as having medium/high quality in the King County characterization. Portions of the City's shoreline that contains less impervious surface coverage and/or natural shorelines (primarily near the central portion of the City's Lake Washington shoreline) also receive slightly higher scores (medium) in King County's assessment. The King County model generally rates most of the shoreline as medium/low functioning (51.3%) with progressively smaller percentages rating as Medium (35.5%), Medium High (11.5%) and High (1.7%) (Table 10). However, the King County's model includes the flood plain of McAleer Creek, which is not included in the City's actual shoreline jurisdiction. This difference results in a considerably higher percentage of the shoreline being classified as Medium or Medium/High than would otherwise be the case.

Table 10. Percent of Land Area Pixels in Each Rating Category

Ecological Function Rating	Percent of Land Area Pixels
Low	0.0
Medium Low	51.3
Medium	35.5
Medium High	11.5
High	1.7

The King County model can score small areas with a higher level of accuracy and detail. For example, the King County characterization appears to recognize the contribution of the undeveloped private park-like parcel and adjacent forest fragments along the Burke Gilman Trail near the eastern terminus (14900 block) of Edgewater Lane NE. The City method uses more qualitative indicators of function on a larger scale. Accordingly, while both methods generally recognize Lyon Creek Park, forest fragments, undeveloped parcels and lots with lower impervious surface coverage as contributing to correspondingly higher levels of function, King County can more precisely select out specific small areas as having a comparatively higher level of function. Comparing King County's map (Appendix D) with the City's Map Folio (Appendix C), it appears that the County's high- and medium-functioning areas within the City roughly correspond to areas with less armoring, parks, larger lots or retained pockets of vegetation. The King County model generally identifies most of the City as medium/low functioning, while the City's method identifies it primarily as low functioning. This is likely an artifact of the model's setting Lake Forest Park within the King County lake-wide context, which includes more intensely developed urban areas, such as Seattle and Renton.

5.0 INFORMATION GAPS

During the course of this inventory, the following information gaps were noted:

- NRCS has not mapped soils in Lake Forest Park.

- Impervious surface data is of limited accuracy because of the coarseness of the spatial data and may not yield an accurate assessment of impervious surface coverage in the shoreline area.

- The City should consult further with the The Lake Forest Park Stewardship Foundation to verify the accuracy of the stream and wetland data The Foundation has generated and (based on this assessment) update the information the City uses in its internal operations and the data it provides to customers.

- The City should definitely verify the ownership of two waterfront parcels that appear to be unopened public rights-of-way at the eastern terminuses of NE 145th Street and NE 155th Street.

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6.0 LIST OF ACRONYMS and ABBREVIATIONS

CAO ....City of Lake Forest Park Critical Areas Ordinance

Corps....................U.S. Army Corps of Engineers

Ecology ....Washington Department of Ecology

GMA ....Growth Management Act

HPA......................Hydraulic Project Approval

LFPMC ....Lake Forest Park Municipal Code

LWD ....Large Woody Debris

NOAA Fisheries...National Marine Fisheries Service

NRCS ....Natural Resources Conservation Service

PAHs....................polycyclic aromatic hydrocarbons

PCBs ....polychlorinated biphenyls

PHS ....Priority Habitats and Species

SMA.....................Shoreline Management Act

SMP......................Shoreline Master Program

USFWS ................U.S. Fish and Wildlife Service

WDFW.................Washington Department of Fish and Wildlife

APPENDIX A

INFORMATION REQUEST LETTER AND DISTRIBUTION LIST

CITY OF LAKE FOREST PARK
INCORPORATED 1961

17425 Ballinger Way NE
Lake Forest Park. WA 98155

FAX: (206) 368-6251

Date

Name
Address
Address

RE: Lake Washington Shoreline Inventory and Assessment, request for existing information

Dear Stakeholders:

The City of Lake Forest Park is in the early stages of examining its Lake Washington Shoreline for the purposes of updating its Shoreline Master Program (SMP) per requirements of the Washington State Department of Ecology. We have recently hired The Watershed Company to assist with this work, including shoreline characterization, analysis, preparation of the restoration plan and regulatory review and revision. A shoreline inventory, conducted by biologists from The Watershed Company, will be the first step. The products of the inventory include a map portfolio and a report characterizing ecological functions and ecosystem-wide processes, among other things.

The City is requesting your help in obtaining all existing physical and biological information regarding Lake Washington, associated riparian and wetland areas, and other water systems that eventually drain into Lake Washington within the City of Lake Forest Park (see attached map). We are interested in any and all inventories, assessments, water quality analyses, and/or fish and wildlife distribution and habitat information.

We are hoping to complete the inventory by June 30, 2006 and complete the characterization by August 30, 2006 in order to complete the necessary analysis and resultant SMP recommendations in a timely manner. If possible, please provide hard copies or electronic files of any studies instead of a list of citations; contact the City if a copy fee is required. If you believe that another individual within your organization would be a more appropriate contact for this solicitation, please forward this letter to that individual, and notify us of the change in contact.

If you have any questions, would like to be notified of future opportunities to provide additional input or review products, or need additional information, you can reach me at (206)368-5440 or steve@cityoflfp.com.

Sincerely,

Steve Bennett
Planning Director

Encl.

Distribution List for City of Lake Forest Park Shoreline Master Program Inventory Information Solicitation

King Conservation District
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Renton, WA 98055
(425) 277-5581
district@kingcd.org

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Muckleshoot Indian Tribe
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National Marine Fisheries Service
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U.S. EPA Region 10
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roger_tabor@fws.gov

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Mill Creek, WA 98012-1296

Washington Department of Fish and Wildlife
Priority Habitats and Species Program
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Olympia, Washington 98501-1091

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Aquatic Lands and Resources Program
1111 Washington St. SE, MS: 47027
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Washington Department of Natural Resources
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Kenmore WA 98028
(425) 316-8592

City of Seattle
DPD
Attn: Miles Mayhew
700 5th Ave., Suite 2000
PO Box 34019
Seattle, WA 98124-4019

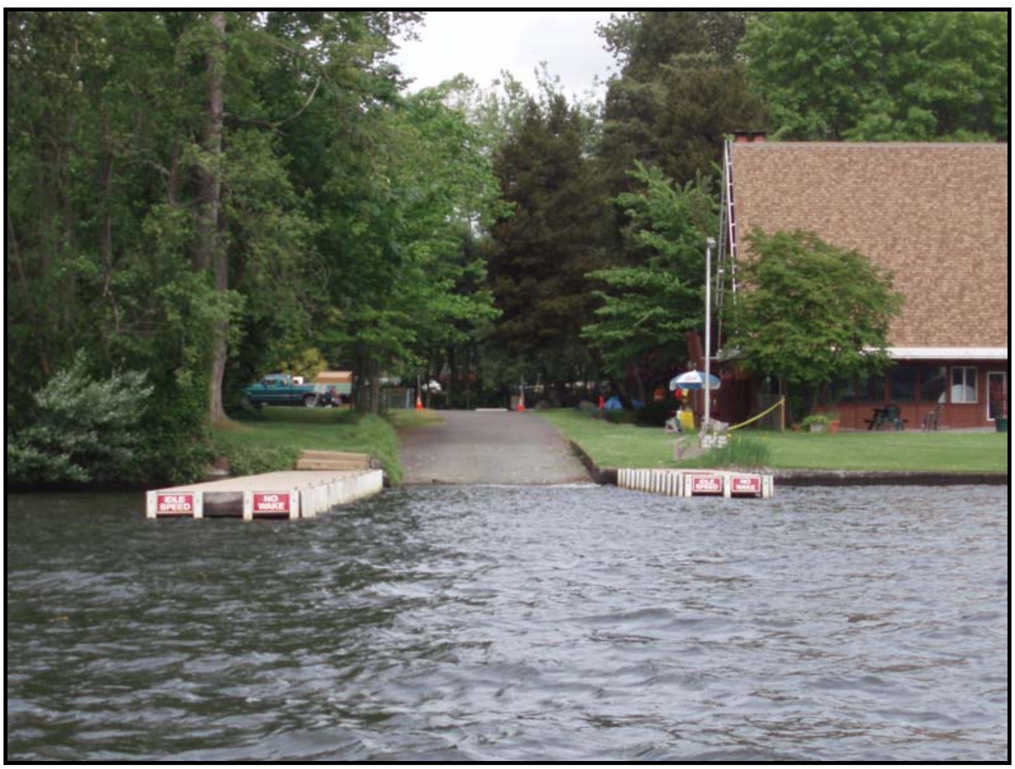
Lake Forest Park Stewardship Foundation
17171 Bothell Way NE, PMB 175
Lake Forest Park, WA 98155
206-361-7076

Northwest Stream Center
Attn: Streamkeepers of Lake Forest Park
600 - 128th Street SE
Everett, Washington

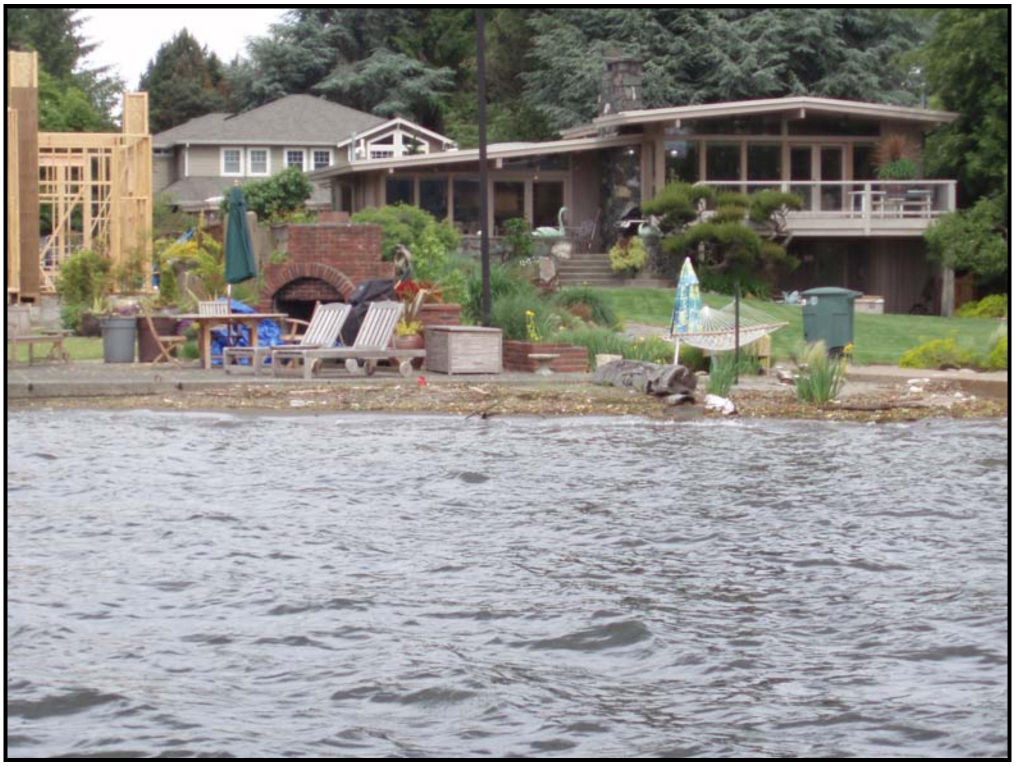
APPENDIX B

PHOTOGRAPHS

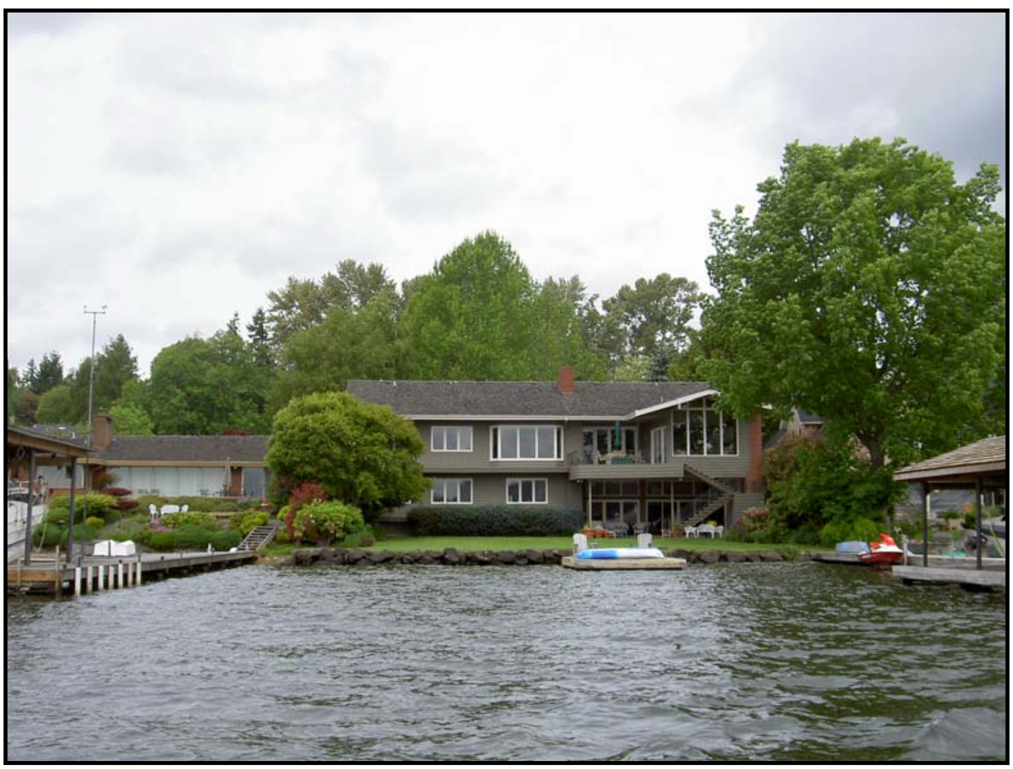
Mouth of Lyon Creek with Lyon Creek Preserve to the right.



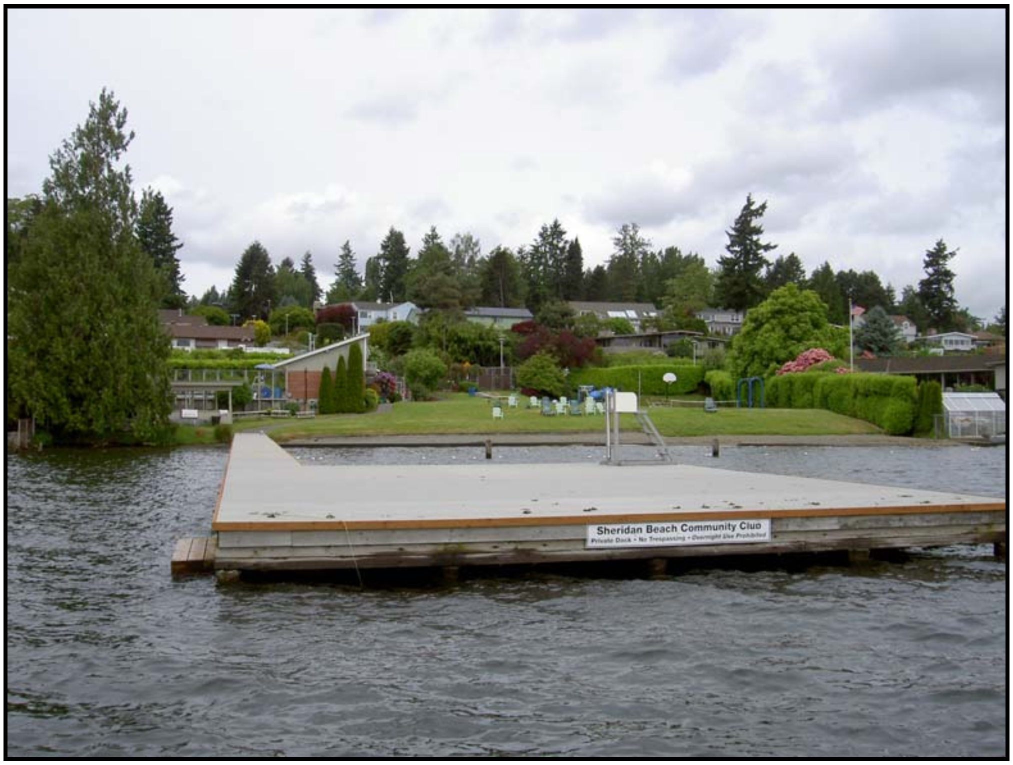
Example of concrete boat launch.



Small area of semi-nature shoreline with gravel beach, a log structure, and some minor emergent vegetation.



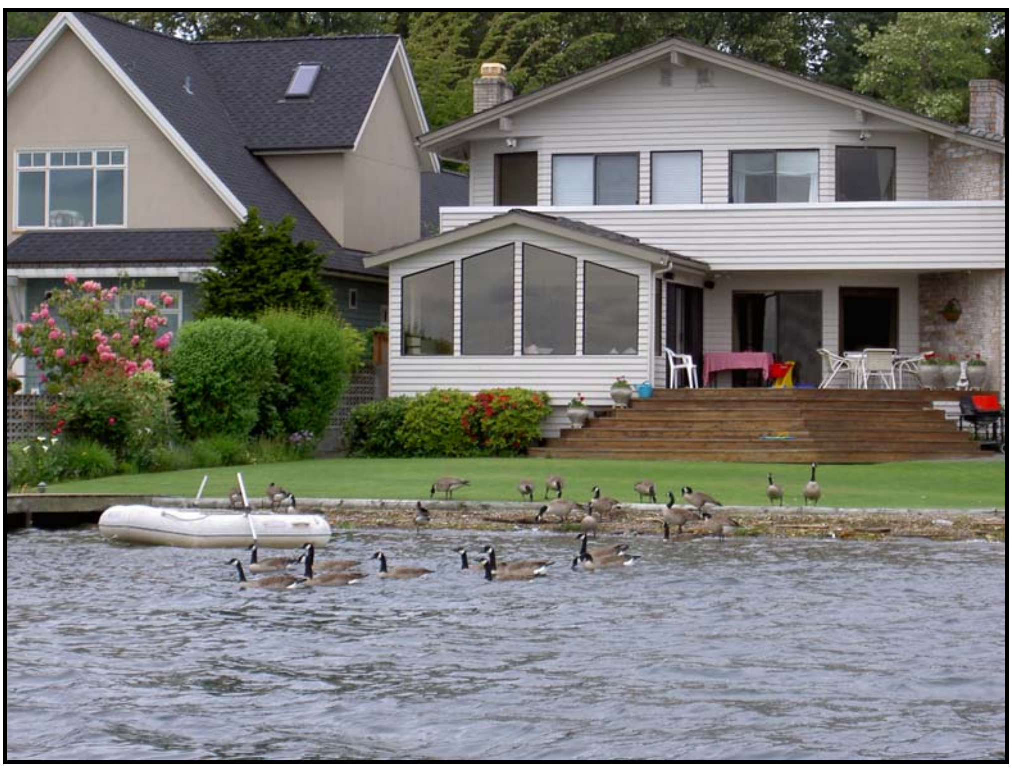
Typical boulder bulkhead and lawn, with over-water structures.



Sheridan Beach Community Club.

Typical waterfront with shoreline armoring and abundant over- and in-water structures.

Typical vertical bulkhead with lawn.



Semi-natural shoreline with gravel beach and lawn.

APPENDIX C

MAP FOLIO

APPENDIX D

King County's Shoreline Characterization Results for Lake Forest Park