CITY OF SAMMAMISH

Shoreline Master Program Update

Shoreline Inventory and Characterization Report

Prepared for: June 2007

City of Sammamish

Ecology Grant #G0600310

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1.0 INTRODUCTION

1.1. Purpose

The City of Sammamish (City) is updating its Shoreline Master Program (SMP) to comply with the Washington State Shoreline Management Act (SMA or the Act) requirements (Revised Code of Washington [RCW] 90.58), and the state's shoreline guidelines (Washington Administrative Code [WAC] 173-26, Part III), which were amended in 2003.

The purpose of this report is to provide a baseline inventory and characterization of the City's designated shoreline areas—Lake Sammamish, Pine Lake and Beaver Lake (Figure 1). The report addresses ecosystem-wide processes (also referred to as watershed processes) and shoreline ecological functions in accordance with the state shoreline guidelines (referred to as the guidelines) in Chapters 173-26-201(3)(c) and 173-26-201(3)(d) of the WAC. The information provided herein will be used to characterize shoreline functions and ultimately develop goals, policies, and regulations for shoreline management. Other steps to be completed during subsequent phases of the SMP update process will include:

1. Determining shoreline environment designations (SEDs);
2. Reviewing and revising development standards and use regulations for shoreline development;
3. Assessing cumulative impacts of shoreline development; and
4. Preparing a restoration plan.

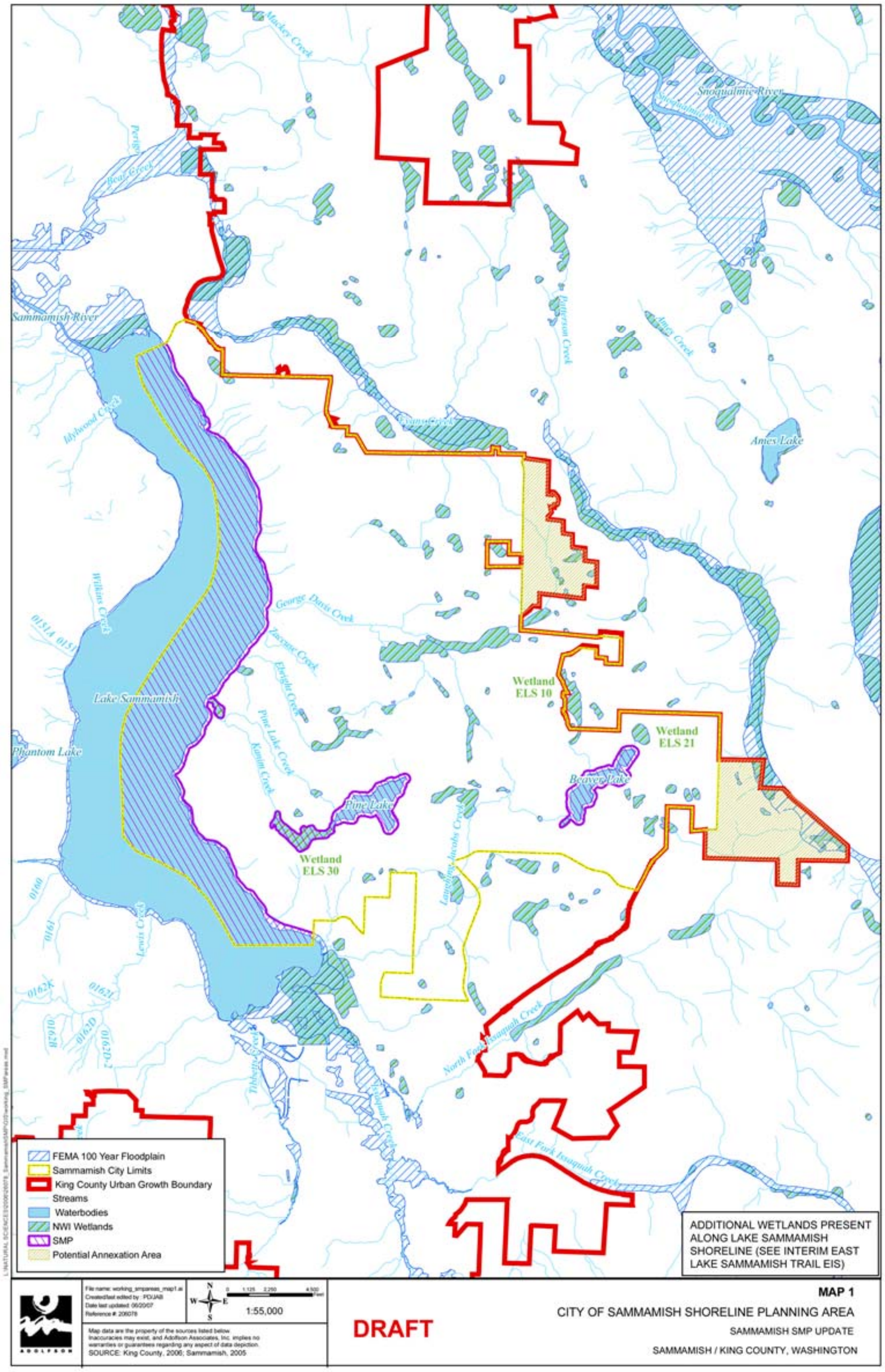
This work was funded in part through a grant from the Washington State Department of Ecology (Ecology), Grant #G0600310.

1.2. Regulatory Overview

The purpose of the SMA is to "…provide for the management of the shorelines of the state by planning for and fostering all reasonable and appropriate uses[1]." Ecology administers the Act, but gives primary permitting authority for shoreline development to local governments. Local governments are also charged with developing SMPs in accordance with the guidelines developed by Ecology. The guidelines give local governments discretion to adopt SMPs that reflect local circumstances and to develop other local regulatory and non-regulatory programs related to the goals of shoreline management as provided in the policy statements of RCW 90.58.020, WAC 173-26-176, and WAC 173-26-181.

[1] RCW 90.58.020

Figure 1. City of Sammamish and SMA-regulated Shorelines (Lake Sammamish, Pine Lake and Beaver Lake)



SMPs have a planning function as well as a regulatory function. Master programs balance and integrate the objectives and interests of local citizens and address the full variety of conditions on the shoreline. Master programs also establish a classification system for specific shoreline environments that is based on the biological and physical character of the shoreline, the existing use pattern, and the goals and aspirations of the community as expressed through the comprehensive plan (WAC 173-26-191 and 173-26-211).

The City's current SMP consists of the 1978 King County Shoreline Management Master Program, which has been in effect since incorporation in August of 1999. The City's shoreline regulations are codified in Title 25 of the Sammamish Municipal Code The City has not amended the King County shoreline master program.

1.3. Shoreline Jurisdiction and Definitions

SMA jurisdiction includes all "shorelines of the state" as defined in RCW 90.58.030. Shorelines of the state include the total of all "shorelines" and "shorelines of statewide significance." Shorelines means all of the water areas of the state, including reservoirs, and their associated "shorelands", together with the lands underlying them, except:

- Shorelines on segments of streams upstream of a point where the mean annual flow is 20 cubic feet per second (cfs) or less and the wetlands associated with such upstream segments; and
- Shorelines on lakes less than 20 acres in size and the wetlands associated with such small lakes.

In Sammamish, the designated shorelines of the state are Pine Lake, Beaver Lake and Lake Sammamish. These designations were established by the state in 1972 and are described in WAC 173-18. No streams within the City limits meet the 20 cfs mean annual flow threshold.[2]

The Potential Annexation Area (PAA) of the City includes a short reach of Patterson Creek, a shoreline of the state within the Snoqualmie Watershed of WRIA 7. As such, Patterson Creek and a small portion of the Patterson Creek basin area could eventually become part of the incorporated area under the City's jurisdiction. At present, the Patterson Creek shoreline is under King County's jurisdiction and subject to the County's development standards and regulations. The Patterson Creek shoreline and basin are described within this report so that City policies and regulations can be developed to address the area in the event that annexation occurs before the next comprehensive SMP update.

Generally, "shorelines of statewide significance" include portions of Puget Sound and other marine water bodies, rivers with mean annual flow of 1,000 cfs or greater[3], and freshwater lakes

[2] ESA Adolfson reviewed the latest USGS data regarding upstream boundaries for SSMA streams and rivers (USGS, Water-Resources Investigations Report 96-4208) as well as summary data provided by Ecology (available at http://www.ecy.wa.gov/programs/sea/sma/st_guide/jurisdiction/SMA%20Suggested%20Coordinates.xls) to confirm that there are no streams in Sammamish that meet the 20 cfs mean annual flow criterion.

[3] For rivers west of the Cascade Range crest.

1,000 acres or larger. Lake Sammamish is the only shoreline of statewide significance within the City of Sammamish (Map 1 in Appendix A)[4].

"Shorelands" or "shoreland areas" means those lands extending landward for 200 feet in all directions as measured on a horizontal plane from the ordinary high water mark (OHWM); floodways and contiguous floodplain areas landward 200 feet from such floodways; and all wetlands and river deltas associated with such streams, lakes, and tidal waters. In this context, "associated" wetlands means wetlands that are in proximity to shorelines or that influence or are influenced by waters subject to the SMA (WAC 173-22-030 (1)). These typically include wetlands that physically extend into the shoreline jurisdiction, and wetlands that are functionally related to the shoreline jurisdiction through a hydrologic connection and/or other factors.

1.4. Relationship to Other Plans

The SMA requires that local governments and state agencies review their plans, regulations, and ordinances that apply to areas adjacent to shoreline jurisdictions, and then modify those plans, regulations, and ordinances so they "achieve a consistent use policy" in conformance with the Act and the SMP[5]. This means that the Shorelines Element of the City of Sammamish's comprehensive plan and the City's development regulations must be consistent with the SMA.

The SMA also regulates development in designated critical areas as defined by the Washington State Growth Management Act (GMA) (RCW 36.70A). Although critical areas in shoreline jurisdiction are to be identified and designated under the GMA, they must also be protected under SMA. The Washington State Legislature and the Growth Management Hearings Board have determined that local governments must adopt master programs that protect critical areas within the shoreline at a level that is "at least equal" to the level of protection provided by the local critical areas ordinance (CAO).

The Legislature clarified that although Washington's shorelines may contain critical areas, designated shorelines of the state themselves are not critical areas by default as defined by GMA.

The GMA also calls for coordination and consistency of comprehensive plans among local jurisdictions. Because SMP goals and policies are an element of the local comprehensive plan, the requirement for internal and intergovernmental plan consistency may be satisfied by watershed-wide or regional planning. Consistent with this provision, the City of Sammamish is coordinating with King County and the neighboring cities of Bellevue, Issaquah, and Redmond during the SMP update process.

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[4] Portions of the Lake Sammamish shoreline also lie within the cities of Issaquah, Bellevue and Redmond.
[5] RCW 90.58.340

2.0 METHODS

2.1. Data Sources

A number of City of Sammamish, King County, and state and federal agency data sources and technical reports were reviewed to compile this inventory and characterization. This includes information sources pertaining to overall watershed conditions and ecosystem-wide processes as well as ecological functions of Sammamish's shorelines. Some of the main information sources reviewed for this report included, but were not limited to:

- The East Lake Sammamish Basin and Nonpoint Acton Plan (King County, 1994);
- The Beaver Lake Management Plan Update: A Report on the Quality of Beaver Lake for 1996-2000 (King County, 2000);
- The Management of Pine Lake Water Quality, Draft Report (Tetra Tech, 2006);
- City of Sammamish Stormwater Management Comprehensive Plan (CH2MHill, 2001);
- King County Lake Monitoring Report (King County, 2004);
- King County Lake Water Quality, A Trend Report on King County Small Lakes (King County, 2001);
- WRIA 8 Salmon and Steelhead Habitat Limiting Factors for the Cedar – Sammamish Basin (John Kerwin, Washington Conservation Commission, 2001); and
- The Current Status of Kokanee in the Greater Lake Washington Watershed (Berge and Higgins, 2003).

Mapping and aerial photographs of the study area were also consulted. Mapping and aerial photography integrated with geographic information system (GIS) data included:

- City of Sammamish GIS database (2006);
- King County GIS database (2006);
- King County aerial photos (2002a); and
- City of Sammamish aerial photos (2006a).

A map folio prepared for this report is included in Appendix A. Appendix B includes a glossary of terms. Photos of the City's shoreline are provided in Appendix C.

2.2. Determining Shoreline Planning Area Boundaries

This inventory focuses on shorelines of the state within the municipal limits and the designated PAA of the City of Sammamish (Map 1, Appendix A). The shoreline planning area shown on Map 1 represents the following areas:

- Lands within 200 feet of the mapped edges of Lake Sammamish, Pine Lake, and Beaver Lake, within the City's municipal limits;

- Lands within 200 feet of the mapped edges of Patterson Creek , within the designated PAA of the City;
- All floodways and 100-year floodplains currently mapped by the Federal Emergency Management Agency (FEMA) that are associated with the areas above; and
- All mapped wetlands that lie adjacent and contiguous to the areas above.

This area covers approximately 11.8 linear miles within the City's municipal limits – 7 linear miles along the east shore of Lake Sammamish, the entire Pine Lake shoreline (approximately 2.2 linear miles), and the entire Beaver Lake shoreline (approximately 2.6 linear miles) (Table 1). The shoreline planning area, including only the areas landward of the lakes' respective OHWMs, encompasses approximately 377 acres and represents approximately 3.25 percent of the land inside the City of Sammamish.

Planning area boundaries were derived using existing GIS information. For purposes of this report, the mapped edges of the lake and stream shorelines are assumed to generally correspond to the OHWM, but field inspection is required to identify the OHWM location on a specific property and determine regulatory setbacks. Similarly, the mapped wetlands are assumed to be "associated" wetlands (particularly the wetlands near the outlets of Pine and Beaver Lakes which have clear connection to the respective lakes); but generally a wetland's relationship to the shoreline must be determined in the field by on-site inspection[6].

The inventory area is intended for planning purposes only. As a result, the actual regulated boundaries of shoreline jurisdiction may differ from the area shown on Map 1 depending on information gathered on the ground at any specific location. Areas mapped as 100-year floodplain associated with Lake Sammamish were included in the shoreline planning area boundary.

Table 1. Shoreline Planning Area, City of Sammamish

Shoreline	General Boundaries	Approximate Size (Acres)[7]	Approximate Percentage of City's Shoreline Planning Area
Lake Sammamish	Stretches north to south along western edge of City limits from 187th Avenue NE on the north, to Peregrine Point Way SE on the south.	194	52%
Pine Lake	Located in south-central Sammamish, bounded by 212th Avenue SE on the west and 228th Avenue SE on the east.	130	34%
Beaver Lake	Located in the southeast corner of the City and bordered by Beaver Lake Drive SE.	53	14%

[6] Additional associated wetlands may be present that are not depicted on the available maps.

[7] Does not include open water areas, however does includes all known associated wetlands and floodplains based on existing mapping sources (see Map 1).

2.3. Approach to Characterizing Ecosystem-wide Processes and Shoreline Functions

The SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes. In this context, ecosystem-wide processes relate to the flow and movement of water, sediment, and organic materials; the presence and movement of fish and wildlife; and the maintenance of water quality. These processes are qualitatively described using available reports and maps related to topography, geology, soils, land cover, and other elements of the landscape. This approach facilitates a broad understanding of the factors that must be considered to protect the shoreline resources regulated by the City's SMP.

2.4. Approach to Inventory and Characterization of Regulated Shorelines

The inventory of Lake Sammamish, Pine Lake, and Beaver Lake at the shoreline reach scale is intended to characterize conditions adjacent to each of the SMA-regulated water bodies. GIS data were used to quantify certain conditions in this area (e.g., acres per zoning or land use designation). Aerial photography (King County, 2002a and Sammamish, 2006a) and existing reports and planning documents were reviewed to qualitatively describe conditions in this area. Discussion of the reach and basin of Patterson Creek within the City's PAA is included within the Ecosystem-wide Characterization section of this report (although this area is, and will continue to be, regulated by King County under the King County SMP until/unless annexation occurs).

3.0 ECOSYSTEM-WIDE CHARACTERIZATION

This section describes ecological conditions, processes, and functions at the following scales: (1) the Sammamish watershed; (2) East Lake Sammamish (ELS) basin; and (3) the individual subbasins that make up the ELS basin in the Sammamish City limits and the PAA. Ecological conditions, processes, and functions are also described for the Snoqualmie watershed and the Paterson Creek basin, as the City's PAA includes a short reach of Patterson Creek. Shoreline planning area or reach scale conditions are summarized in the following chapter.

3.1. Sammamish Watershed

The Sammamish watershed includes portions of the cities of Sammamish, Everett, Lynnwood, Kenmore, Brier, Mill Creek, Bothell, Woodinville, Redmond, Bellevue, and Issaquah as well as unincorporated areas of King and Snohomish Counties. The watershed is part of the Cedar – Sammamish River Water Resource Inventory Area (WRIA) known as WRIA 8, which includes two major river systems, the Cedar and Sammamish Rivers, as well as Lake Sammamish, Lake Washington, Lake Union, and numerous tributaries to each (Map 2, Appendix A). WRIA 8 is located predominantly within the borders of King County, with the northwest portion extending into Snohomish County. The boundaries of WRIA 8 follow the topographic features that define the drainage divide between the Snohomish WRIA (WRIA 7) to the east, and the Green/Duwamish WRIA (WRIA 9) and Puget Sound to the west (Kerwin, 2001)[8]. The majority (approximately 86 percent) of WRIA 8 is in the Puget Lowlands physiographic region, while the upper (eastern) portion of the WRIA is in the Cascade foothills.

WRIA 8 covers a land area of approximately 692 square miles and is the most populated WRIA in the state with roughly 1.4 million residents (Kerwin, 2001). The City and its PAA occupy approximately 21 square miles or about 3 percent of the WRIA 8 land area.

The majority of the City drains to the Sammamish watershed portion of WRIA 8, via the East Lake Sammamish (ELS) and Evans Creek basins. The far eastern edge of the City drains to the Snoqualmie watershed portion of WRIA 7 via the Patterson Creek basin.
The ELS basin encompasses most of the City of Sammamish including the City's three SMA-regulated lakes, as well as areas to the west and south of the City. The Evans Creek basin includes a small area of northeastern Sammamish and unincorporated areas northeast of the Sammamish City limits.

The Sammamish watershed has changed dramatically since the arrival of white settlers (U.S. Army Corps of Engineers and King County, 2002b; Kerwin, 2001), and intensively during the last few decades. During the first part of the 20th century, forests in the Sammamish area were largely harvested for lumber and many timber mills were located in present day Sammamish. After the area was cleared of timber it was used for dairy farming and other forms of agriculture for several decades. Significant watershed changes occurred in 1917 with the construction of the Hiram Chittenden Locks, which were built to connect the Lake Washington system with Puget

[8] A small portion of the City of Sammamish and PAA (east of Beaver Lake) is located in WRIA 7. WRIA 7 is the second largest area draining to the Puget Sound. The City and its PAA occupy approximately 2 square miles or about 0.1 percent of the land area in WRIA 7.

Sound. The navigational project lowered Lake Washington by 10 feet and Lake Sammamish by 6 feet, draining many of the associated wetlands, eliminating the majority of riverine and off-channel rearing-habitats for juvenile salmon, and ultimately reducing the Sammamish River gradient and flow patterns (the Sammamish River now represents a substantial thermal migration-barrier to adult salmon returning to their spawning grounds) (WRIA 8, 2005). Other major changes to the Sammamish system involved channelizing the Sammamish River for flood control purposes (which eliminated 12 miles of river channel), diverting and straightening tributary channels, withdrawing water from streams and aquifers, decreasing floodplain connectivity, filling and draining wetlands, and development of urban infrastructure (WRIA 8, 2005; Kerwin, 2001; Kahler, 2000). The construction of the Locks and development of the Seattle Ship Canal connection to the Puget Sound also caused the historical outflow of Lake Washington / Lake Sammamish system, the Black River, to go dry. Additionally, the Cedar River was rerouted to flow into the south end of Lake Washington, forming WRIA 8 as it is described today.

Beginning in the 1970s rural farms were subdivided and platted for residential and commercial development. Sammamish was part of unincorporated King County until it incorporated as a city in August 1999. Since that time urban development and services have increased, and growth has continued to transform and alter the ecology of the watershed.

Despite the alterations that have occurred over time, the Sammamish watershed contains important aquatic and terrestrial habitats that are of significant value to the fish, wildlife, and human occupants of the area. As an example, the watershed provides habitat for numerous anadromous fish species including Chinook (*Oncorhynchus tshawytscha*), coho (*O. kisutch*), sockeye/kokanee salmon (*O. nerka*); coastal cutthroat (*O. clarki clarki*) and steelhead trout (*O. mykiss*), and various other species. These species use Lake Sammamish and major tributaries such as Swamp Creek, North Creek, Bear Creek and Little Bear Creek, Cottage Lake Creek, Evans Creek, Issaquah Creek, Tibbetts Creek, and the Sammamish River for spawning, rearing, refuge, migration, and/or foraging (Table 2). Of these, Bear and Issaquah Creeks support the most significant salmonid populations (Kerwin, 2001). Additionally, numerous small streams along the Lake Sammamish shoreline including Ebright Creek provide spawning and rearing habitat for salmonids, such as late-run kokanee, coho and sockeye salmon and cutthroat trout.

Kokanee using smaller Lake Sammamish tributaries, such as Laughing Jacob's and Lewis Creeks, are genetically distinct from other populations in the Lake Washington/Sammamish Basin and are also believed to be of native origin. They are unique in that they spawn later than other stocks (November through January), and they are larger in size (approximately 17.7 inches) (King County, 2002b). An early-run population of kokanee, which once resided in Issaquah Creek, is now believed to be functionally extinct. Middle-run populations, which spawn from late September through November, currently use larger tributaries of the Sammamish River such as Bear Creek. Although recent escapement of middle and late-run kokanee populations have been somewhat stable, their sustainability may be at risk if development impacts continue to occur throughout the basin.

Other native fish species in the watershed are western brook lamprey, river lamprey, peamouth chub, largescale sucker, mountain whitefish, and one or more species of sculpin. Numerous (24) species of nonnative fish also occur in the watershed including brown bullhead, black crappie, pumpkinseed sunfish, and largemouth and smallmouth bass, which can be significant predators of juvenile salmonids (Kerwin, 2001; Parametrix, 2000).

Table 2. Documented Salmonid Use in Majors Streams of the Sammamish Watershed[9]

	Salmonid Species					
Stream	**Chinook**	**Sockeye**	**Kokanee**	**Coho**	**Steelhead**	**Cutthroat Trout**
Swamp Creek	⌧	⌧	⌧	⌧	⌧	⌧
North Creek	⌧	⌧	⌧	⌧	⌧	⌧
Bear Creek	⌧	⌧	⌧	⌧	⌧	⌧
Little Bear Creek	⌧	⌧	⌧	⌧	⌧	⌧
Cottage Lake Creek	⌧	⌧	⌧	⌧	⌧	⌧
Evans Creek	⌧	⌧	⌧	⌧	⌧	⌧
Issaquah Creek	⌧		⌧	⌧	⌧	
Tibbetts Creek					⌧	⌧
Sammamish River[10]	⌧	⌧	⌧	⌧	⌧	⌧

Lake Sammamish is a primary feature of the Sammamish watershed. Approximately 44 percent of the total area of Lake Sammamish is in the City's jurisdiction. The two major tributaries to the lake lie mainly outside the Sammamish City limits. Issaquah Creek[11], which enters at the south end of the lake, contributes approximately 70 percent of the surface flow (Entranco et al., 1996). Tibbetts Creek, which also enters the south end of the lake west of the Issaquah Creek mouth, is the second largest tributary, contributing approximately 6 percent of surface flow to the lake. The third major tributary is Pine Lake Creek, which is located entirely within Sammamish and contributes about 3 percent flow (Entranco et al., 1996). Surface water discharges from Lake Sammamish through the Sammamish River at the north end of the lake, where a flow control weir at Marymoor Park controls the discharge volume and rate. Additional information on Lake Sammamish is provided in the Reach Inventory and Analysis section.

3.1.1. East Lake Sammamish Basin and Subbasins

The ELS basin contributes only about one tenth of the surface flow from Issaquah Creek to Lake Sammamish (King County, 1994). The basin consists of approximately 16 square miles on the eastern shoreline of the lake and is composed of six individual subbasins— Inglewood, Panhandle, Monohan, Thompson, Pine Lake, and Laughing Jacob (CH2MHill, 2001) (Figures 2

[9] Source: King County Natural Resources and Parks Division, available at http://dnr.metrokc.gov/wlr/watersheds/samm.htm

[10] In addition to supporting Chinook, coho, sockeye, kokanee, steelhead, and coastal cutthroat, the Sammamish River and its tributaries are assumed to provide potential foraging habitat for bull trout, according to the U.S. Fish and Wildlife Service (USFWS) (Kerwin 2002).

[11] A small portion of the Issaquah Creek subbasin crosses the southern edge of the Sammamish City boundary.

and 3).[12] These basins drain to Lake Sammamish via several surface streams. The major streams in the area are, from north to south, George Davis Creek (WRIA 0144), Zaccuse Creek (0145), Ebright Creek (0149), Pine Lake Creek (0152) including Kanim Creek (0153) and Many Springs Creek (0164). Laughing Jacobs Creek (0166), located at the southeastern end of Lake Sammamish, is also part of the ELS basin; however, its mouth and a significant percentage of its drainage area are located within the City of Issaquah. About a dozen very small, named and unnamed streams and seeps also drain the western Sammamish Plateau (Map 3, Appendix A).

The ELS basin streams generally do not produce large numbers of anadromous fish compared to the streams in the nearby Bear and Issaquah Creek basins (Parametrix, 2006) (Table 3). Most of the streams have intermittent flow throughout the year[13], flow down steep, erosion- and landslide-prone ravines into Lake Sammamish and are not accessible to anadromous fish. Significant channel downcutting and development along the lakeshore have adversely affected habitat and blocked or partially blocked access to many upstream reaches. As a result, only 4 miles of stream in this basin are currently accessible to anadromous fish (perhaps 8 to 10 miles were accessible historically) (Parametrix, 2006). The majority of the accessible habitat is concentrated in three tributaries: Pine Lake Creek, Kanim Creek (a tributary of Pine Lake Creek), and Laughing Jacobs Creek. The remaining mile of accessible habitat is divided among four other streams: George Davis Creek, Zaccuse Creek, Ebright Creek, and Tributary 0163.

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[12] The City's other subbasins drain to the Evans Creek and Patterson Creek basins. A small portion of the ELS basin at the north end of the lake is in Redmond and unincorporated King County.

[13] Pine Lake Creek and Laughing Jacobs Creek regularly flow year round. Some of the Panhandle streams (0143B-L), the lower portion of George Davis Creek (0144), and possibly others may also flow year round (King County, 1994).

Figure 2. Subbasins and Streams in the City of Sammamish, Northern Portion (Source: Stormwater Management Comprehensive Plan (CH2M Hill, 2001)

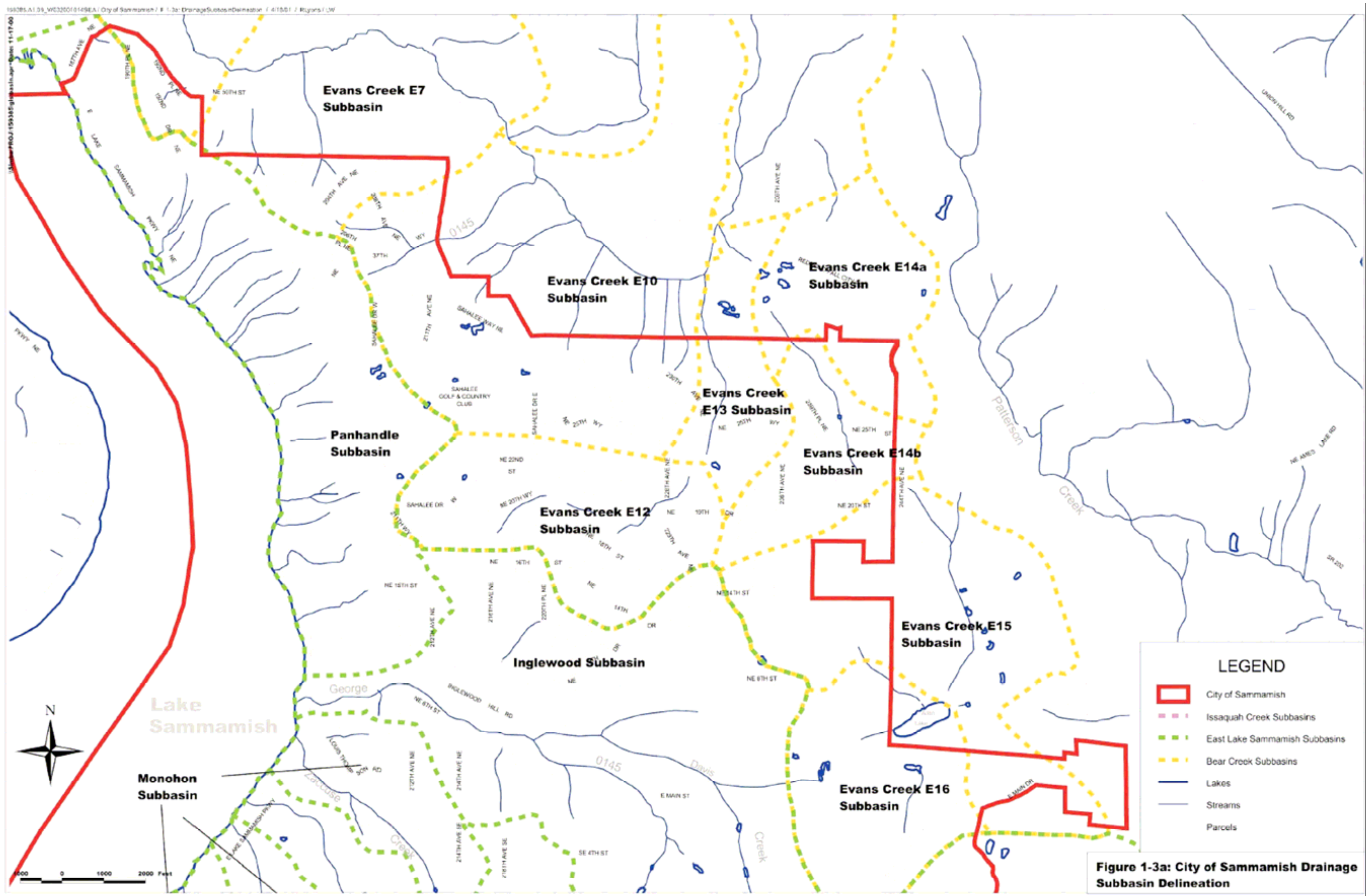

Figure 3. Subbasins and Streams in the City of Sammamish, Southern Portion (Source: Stormwater Management Comprehensive Plan (CH2M Hill, 2001)

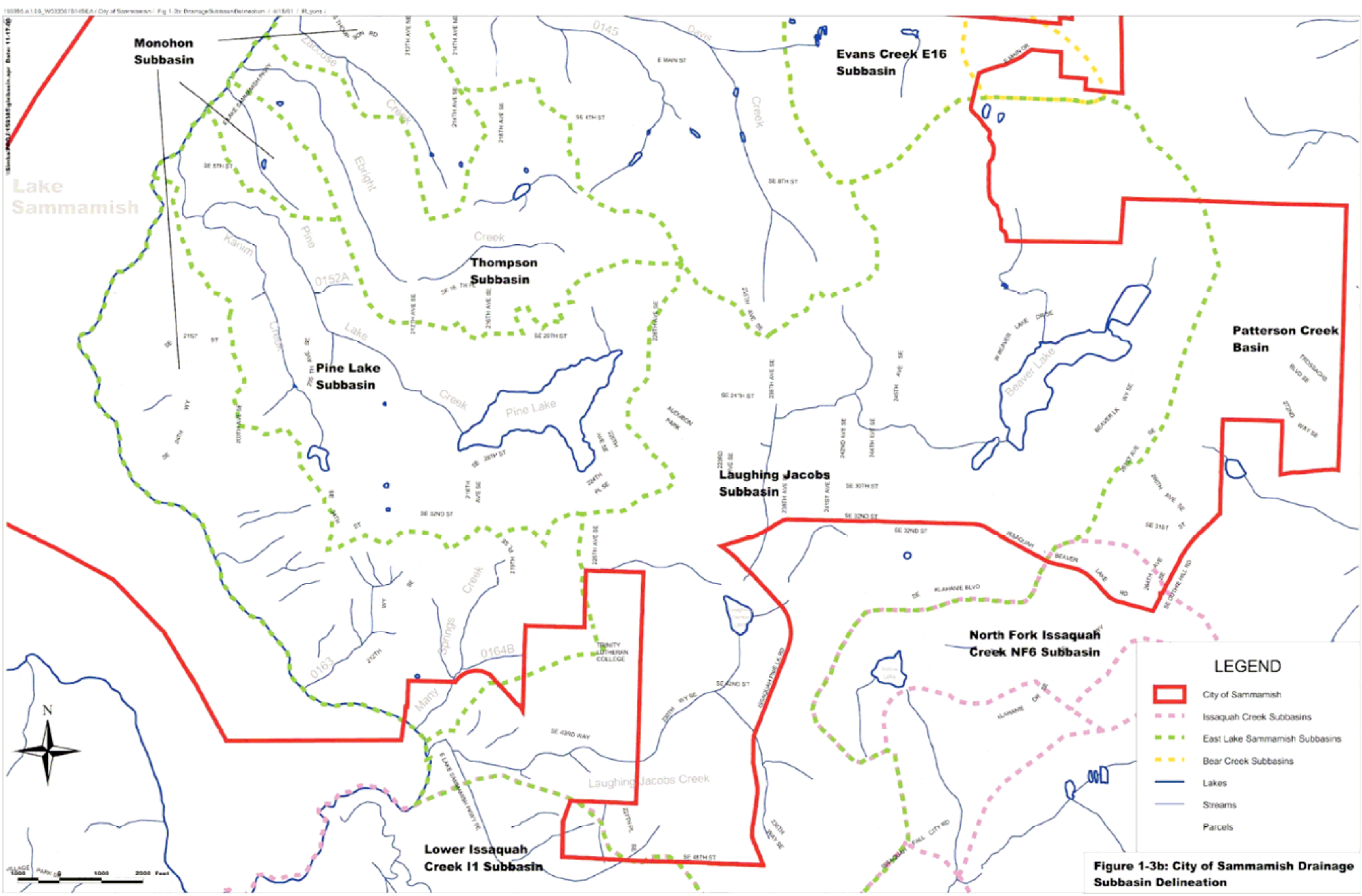

Table 3. Salmonid Use in East Lake Sammamish Tributaries

Stream (WRIA #)	Length (miles)	Salmonid Usage (Yes/No)
143A	0.43	No
143B	0.52	No
143C	0.46	No
143D	0.28	No
143E	0.30	No
0144 (George Davis Creek)	3.46	Yes
0145 (Zaccuse Creek)	1.18	Yes
0149 (Ebright Creek)	2.65	Yes
0152 (Pine Lake Creek)	2.84	Yes
0162A	0.28	No
0163	0.70	Yes
0164	0.86	Yes
0167 (Laughing Jacobs Creek)	4.9	Yes

Source: East Lake Sammamish Basin Plan (King County, 1994)

Historically, most of the streams draining the west slopes of Sammamish contained endemic populations of anadromous and adfluvial (lake spawning) fish in their lower reaches. Under current conditions anadromous and adfluvial fish production is generally restricted to the lower stream reaches (Parametrix, 2006).

Resident and anadromous species use Lake Sammamish primarily for rearing and as a migratory route. Sockeye and kokanee salmon also use portions of the lakeshore for spawning, although lake spawning data are limited[14]. Possible spawning localities are the east shore south of Weber Point near the alluvial deposits at the mouths of George Davis, Pike Lake and Many Springs Creeks center (Parametrix, 2006; King County, 2002b, King County 1994).

Soils in the East Lake Sammamish basin are primarily Alderwood and Everett gravelly sandy loams, with pockets of hydric mineral soil (Norma loam) and various organic soils (e.g., Shalcar muck, Tukwila muck, Seattle muck, Orcas peat). Wetlands occur primarily on these organic and hydric mineral deposits (Map 4, Appendix A).

No comprehensive survey of vegetation or wildlife was found for the ELS basin, but information from basin reports and other sources indicates that there are a diversity of vegetation types that reflect variations in geology, topography, climate, and land use. Vegetative cover in the urbanizing and suburbanizing areas is mainly ornamental gardens, lawns, and shrubby/grassy areas with scattered trees. Larger patches of conifer and mixed forest occur mainly outside of

[14] The East Lake Sammamish Basin Plan (King County, 1994) includes a map of known sockeye spawning areas along the Lake Sammamish shoreline. The King County Department of Natural Resources and Parks, Water and Land Resources Division conducted spawning surveys in many tributaries as part of their study entitled the *Current Status of Kokanee in the Greater Lake Washington Watershed* (Berge and Higgins, 2003).

UGAs including along some of the major stream corridors (e.g., Issaquah and Bear-Evans Creeks), on steep slopes that are generally unsuitable for development, and along the east edge of the watershed. The upper watershed in the south of Issaquah is almost entirely second-growth conifer forest composed of Douglas fir, western red cedar, and western hemlock. Patches of intact native vegetation including stands of mature cottonwoods occur intermittently along the Lake Sammamish, Pine Lake and Beaver Lake shorelines generally in association with wetlands and tributary streams. These areas provide habitat for several species of dabbling ducks, geese, coots, rails, and herons as well as kingfishers, red-tailed hawks, osprey, swallows, flycatchers, and red-winged blackbirds. Mammals such as deer, beaver, muskrat, shrews and bats also occupy the lakeshores and adjacent habitats.

Non-native plant species are prevalent in the ELS basin. Eurasian watermilfoil is common on the Lake Sammamish shoreline. Reed canarygrass, Himalayan blackberry, Japanese knotweed, and other invasive species have infested wetlands and riparian areas throughout the watershed.

According to data provided by the Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species (PHS) database, there are several priority wildlife species in the ELS basin including:

- Bald eagle (state and federal threatened)
- Great blue heron (state monitor)
- Green heron (state monitor)
- Merlin (state candidate)
- Pileated woodpecker (state candidate)
- Vaux’s swift (state candidate)

These are generally associated with Lake Sammamish as discussed in the Reach Inventory and Analysis section.

3.1.1.1. Subbasin Conditions

Inglewood Subbasin

Conditions in the Inglewood subbasin are described in the Inglewood Basin Plan (Entranco, 2005). The subbasin is in the center of the City and includes numerous wetlands, including an open-water wetland known as Llama Lake, and George Davis Creek. The creek originates from wetlands on the Sammamish Plateau and flows west to Lake Sammamish (King County, 1994). The headwater wetlands include a large wetland near 228th Street, north of Main Street, and a large wetland between 236th Avenue SE and 235th Avenue SE. A series of culverts at the mouth of the George Davis Creek create a partial barrier to upstream fish passage[15]. The upper reaches of George Davis Creek and its associated wetlands (upstream of 228th Ave SE) are part of a

[15] A recent electrofishing study conducted for a private property owner identified salmonids in George Davis Creek above Lake Sammamish Parkway (Kathy Curry, Personal communication, 2006).

designated wildlife corridor connecting the riparian and wetland areas to the Evans Creek corridor, Laughing Jacobs Lake, and other habitats within and outside the City.

The subbasin is underlain by porous outwash deposits flanked by less permeable till. The permeable outwash deposits infiltrate water and provide as much as 7,000-acre feet of water storage or detention, which helps mitigate effects of increased development and impervious surface (Entranco, 2005). The basin has 244 acres of impervious surface area, which comprises about 15% of the drainage area (Entranco, 2005) and there are no recent documented flooding problems; however the ELS Basin Plan reported localized flooding along portions of George Davis Creek in the early 1990s (King County, 1994). The lower reaches of the George Davis Creek ravine are mapped as a landslide hazard area.

The Inglewood basin is in transition from rural, hobby farm-type development to more dense residential and commercial development and these land uses are potential sources of point and nonpoint pollution. Recent sampling of George Davis Creek showed elevated levels of total phosphorus and copper in the creek, although the creek is not listed as an impaired water for these contaminants according to the 2004 Washington State Water Quality Assessment, known as the 303(d) list[16]. Elevated levels of fecal coliforms were documented in George Davis Creek in the early 1990s[17] and leaking septic systems were implicated as a potential source of this pollutant. Other possible bacteria sources include livestock, domestic pets, and waterfowl (Entranco, 2005). Stormwater samples from commercial areas had elevated levels of suspended solids and heavy metals, but base flow samples did not exceed state standards for dissolved oxygen, temperature, or pH. No recent water quality samples have been collected to update the creek's water quality status (Entranco, 2005).

Panhandle Subbasin

The Panhandle subbasin is a narrow subbasin bordering Lake Sammamish in the northwest corner of the City. Steep slopes with few areas of level ground characterize the subbasin. Landslide and erosion hazard areas are mapped along the entire west side of the basin. Thirteen unnamed streams have been identified in this subbasin (King County, 1994).

Unlike the Inglewood subbasin, the Panhandle subbasin is underlain primarily by impermeable deposits that limit infiltration. Highly erodible advance outwash sands and gravels occur beneath the till. These advance outwash materials create a groundwater aquifer that feeds the unnamed hillslope streams. Beneath the sand is a layer of silt and clay that limits the downward movement of groundwater and causes localized saturation and landsliding (King County, 1994).

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[16] The Department of Ecology compiles and assesses water quality data on a statewide basis to determine the overall status of water quality in Washington's waters. The results of the assessment are submitted to the Environmental Protection Agency (EPA) as an "integrated report" to satisfy federal Clean Water Act requirements of sections 303(d) and 305(b). The assessment includes the list of known polluted waters in the state, sometimes referred to as the 303(d) list. There are 5 categories of polluted waters: Category 1 - Meets tested standards for clean waters; Category 2 - waters of concern (some evidence of a water quality problem);Category 3 - no data; Category 4 - polluted waters that do not require a TMDL; and Category 5- polluted waters that require a TMDL.

[17] The creek was listed as impaired for fecal coliform on the 1998 303(d) list.

As a result of the geology and topography, the Panhandle subbasin has relatively few wetlands and most of these have been impacted by upstream development. The 1994 ELS Basin Plan noted a change from a predominantly groundwater driven hydrologic regime to one characterized by concentrated surface flow (King County, 1994).

Monohon Subbasin

Interspersed between the Inglewood, Thompson, and Pine Lake subbasins are several areas that collectively form the Monohon subbasin. The northern area is drained by Zaccuse Creek, the middle area by an unnamed tributary, and the southern area by Many Springs Creek, Tributary 0163, and several small unnamed streams. Although not as steep as the Panhandle subbasin, drainages in the Monohon subbasin are susceptible to erosion due to the underlying geology (King County, 1994). Landslide and erosion hazard areas are mapped near Many Springs Creek, Tributary 0163, and along the west facing slopes above the lakeshore south of Sulphur Springs Point. As a result, erosion and sedimentation are key concerns in this subbasin. The 1994 ELS Basin Plan pointed to channel incision and high suspended sediment loads as problems in Many Springs Creek and potentially elsewhere in the basin (King County, 1994).

This subbasin has limited aquatic habitat. Fish use of the streams is limited due to gradient and artificial passage barriers; only the downstream portion of Tributary 0163 is accessible to salmonids. A bog-like wetland (estimated to be about 3.5 acres in size) occurs in the headwaters of Many Springs Creek, but other wetlands are few (King County, 1994).

Thompson Subbasin

Ebright Creek is the primary drainage in the Thompson subbasin. Ebright Creek provides habitat for resident cutthroat trout as well as kokanee, coho, and sockeye salmon and is part of a designated wildlife corridor that connects Lake Sammamish to other habitats within and east of the City[18]. Anadromous fish access is limited to the lower half-mile of Ebright Creek due to artificial passage barriers.

There are numerous wetlands in the Thompson subbasin, some of which occur on organic deposits in the Ebright Creek headwaters. These wetlands have been identified as important water storage areas that if maintained could help to mitigate impacts associated with increased peak flows cause by urban development (King County, 1994).

Geology of this subbasin is highly variable with till, recessional outwash, and advance outwash deposits underlying the majority of the area. These conditions will influence the ecological responses to increased development. The 1994 ELS Basin Plan predicted that peak flows would increase in this basin by as much as 150 percent without mitigation. Increased erosion and sedimentation, turbidity, and/or nutrient loading can be expected to accompany the higher peak flows (King County, 1994). Ebright Creek is currently listed as a Category 5 water for fecal

[18] The Stormwater Management Comprehensive Plan (CH2MHILL 2001) states that Chinook salmon have been sighted in Ebright Creek, citing data from the Greater Lake Washington Technical Committee, 2001.

coliform on the state's 303(d) list, indicating it is a polluted water requiring a Total Maximum Daily Load (TMDL)[19].

Pine Lake Subbasin

The Pine Lake subbasin is one of the most important subbasins in the ELS basin in terms of aquatic resources. Key features of this area include Pine Lake (which is discussed in more detail in the Reach Inventory and Analysis Chapter), Kanim and Pine Lake Creeks and their tributaries, and numerous wetlands. One of the largest wetlands (approximately 50 acres) occupies a peat/muck deposit adjacent to the southwest corner of the Pine Lake. Other smaller wetlands are mapped near the downstream end of Pine Lake Creek, near the intersection of 212th Ave SE and SE 24th Street, and at scattered sites west of Pine Lake.

Kanim and Pine Lake Creeks provide some of the best habitat for resident and anadromous fish in the ELS basin. Pine Lake Creek has a year-round flow regime and high quality pool/riffle habitat in its lower reaches.

Portions of both the Pine Lake and Kanim Creek ravines are mapped as erosion or landslide hazard areas, and some channel erosion has occurred. Other concerns in the basin are related to water quality, peak flow increases and habitat loss, which are discussed in subsequent sections of this report.

Land use in the Pine Lake subbasin is mainly urban residential (zoned for 4 dwellings/acre) with the next largest component being open space (Tetra Tech, 2006). Residential land use is projected to increase and open space is projected to decrease. The amount of land occupied by commercial land use is not expected to change substantially.

The City recently prepared a Draft Management Plan for Pine Lake Water Quality that describes conditions in the Pine Lake subbasin as they relate to water quality and hydrology. This plan is expected to be finalized by the end of 2007. In addition, the City has designated Pine Lake and its environs as a special management district, primarily for purposes of controlling total phosphorus loading and other development impacts within the Pine Lake watershed.

Laughing Jacobs Subbasin

The southeastern one-third of the ELS basin comprises the Laughing Jacobs subbasin, which drains to Lake Sammamish via Laughing Jacobs Creek and five smaller tributaries (King County, 1994). The Laughing Jacobs subbasin includes Beaver Lake (which is discussed in detail in the Reach Inventory and Analysis section), Laughing Jacobs Lake, and many important wetlands including the Hazel Wolf Wetland Preserve, a 116-acre wetland/wildlife preserve that includes a 50-acre wetland complex and a wetland known as ELS 10 (King County, 2000). The Preserve was established in 1995 by concerned citizens, corporations, county government and the Cascade Land Conservancy. The area, which is located in unincorporated King County and is

[19] The TMDL or Water Quality Improvement Project process was established by Section 303(d) of the federal Clean Water Act (CWA), which requires states to identify sources of pollution in waters that fail to meet state water quality standards and develop Water Quality Improvement Reports to address those pollutants. The TMDL is a water cleanup plan that establishes limits on pollutants that can be discharged to a waterbody and still allow water quality standards to be met.

adjacent to the City's Beaver Lake Preserve, is heavily used by local residents and also used weekly as a field laboratory for local high school students.

Overall, there are more than 20 large wetlands documented in this subbasin, some of which are located outside the Sammamish City limits, including the Hazel Wolf Preserve (King County, 1994). These wetlands represent some of the most valuable habitat found in the urbanizing areas of King County and perform important functions related to water storage, nutrient cycling, and flood attenuation.

The geology of the subbasin is somewhat unique compared to other areas of the ELS basin (Map 6, Appendix A). The valley area south of Beaver Lake and east of Laughing Jacobs Creek is underlain by ice-contact deposits, which do not occur anywhere else in the basin. The hills on either side of Beaver Lake are mainly till, and the west boundary of the subbasin is recessional outwash. The basin consists mainly of moderately sloping topography with a maximum change in elevation of approximately 200 feet (King County, 2000).

A significant portion of this subbasin is designated as a high recharge area pursuant to the City's Critical Areas Regulations (Chapter 21A.50 of the Sammamish Municipal Code). These critical aquifer recharge areas are susceptible to groundwater contamination.

Channel erosion is a not major issue in the Laughing Jacobs subbasin as streams tend to be relatively low-gradient compared to those draining the west side of the plateau and Laughing Jacobs Creek is underlain by bedrock. There are no designated landslide or erosion hazard areas in the subbasin, yet King County identified active landslide areas in the Laughing Jacobs Creek ravine that contributed to sediment deposition in the lower reaches and localized flooding at the downstream end of the channel (King County, 1994). Poorly managed runoff from developed areas is believed to have contributed to the increased sediment delivery.

Water quality is a key concern in this subbasin. The City has designated Beaver Lake and its surrounding watershed as a special management area subject to stringent development standards designed to maintain the lake's water quality and ecological integrity (King County, 2000). Management recommendations have been developed through an ongoing effort involving King County, the City, and local residents since the 1980s. The Beaver Lake Management plan was initially prepared in 1993 and updated in 2000. The plan provides a detailed accounting of water quality conditions and a comprehensive approach for mitigating surface water impacts associated with future land development.

3.2. Snoqualmie Watershed

The Snoqualmie watershed within King County includes portions of the cities of Duvall, Carnation, Sammamish, Fall City, Snoqualmie, and North Bend, as well as significant unincorporated areas of King County. The watershed is part of the Snohomish River Water Resource Inventory Area (WRIA) known as WRIA 7, which includes two major river systems, the Skykomish and Snoqualmie (which converge to form the Snohomish River), as well as numerous tributaries to each. The majority of WRIA 7 is located within the borders of King County, however more than 40 percent of the area, including the estuary of the Snohomish River, exists within Snohomish County. The boundaries of WRIA 7 follow the topographic features that define the drainage, bordered by the Wenatchee and Upper Yakima WRIAs (WRIAs 45 & 39) to the east, the Stillaguamish and Upper Skagit WRIAs (WRIAs 5 & 4) to the north, the Cedar/Sammamish WRIA (WRIA 8) to the south and west, and Puget Sound to the west (Kerwin, 2001). WRIA 7 is divided between the Puget Lowlands (western portion) and Cascade foothills (eastern portion) physiographic regions.

3.2.1. Patterson Creek Basin Conditions

The Patterson Creek Basin covers 12,711 acres (19.86 square miles) in eastern King County, along the east slope of the Sammamish Plateau. Patterson Creek, a SMA-regulated shoreline of the state within the Sammamish PAA, is 12.1 miles long and flows into the Snoqualmie River north of Fall City. The Snoqualmie River flows into the Snohomish River and is one of three major watersheds within WRIA 7 (Map 2, Appendix A). King County assessed the conditions along Patterson Creek as part of their recent countywide shoreline inventory and determined that the reach in closest proximity to Sammamish and the PAA (Patterson Creek RIV246) is a 'Medium High Reach Quality' (King County, 2007). Scores for individual ecological processes within the reach are shown in Table 4. The 'Hydrologic Cycle' and 'Large Woody Debris' processes show the lowest condition level of the ecological processes examined in the reach, according to King County. This is likely due to a history of logging and low to moderate density residential development in the reach area. Overall, the Patterson Creek reach within the City and PAA, as well as other Patterson Creek reaches, show relatively unaltered and high-quality conditions when examined through the identified ecological processes.

Table 4. Ecological Processes Ratings for Patterson Creek Reach RIV246[20]

Reach	Hydrologic Cycle	Large Woody Debris	Light Energy	Nitrogen	Pathogens	Phosphorus	Sediment	Toxins
Patterson Creek RIV246	Medium	Medium	Medium-high	High	High	High	Medium-high	Medium-high

Glacial deposits largely formed the Patterson Creek Basin during the Vashon Period of the Fraser Glaciation 13,000 to 20,000 years ago, although some deposits predate that period. The basin originally had a full forest cover, but logging began in the region in the late 1800s. The primary soil units in the middle and upper portions of the basin are in the Alderwood-Kitsap-Indianola association. Glacial deposits in the basin are 79 percent till and 13 percent outwash.

The Patterson Creek Basin is complex, with numerous tributaries that descend from the upland plateau and adjacent hillsides to the low-gradient Patterson Creek floodplain. Many of the tributaries within Sammamish and the PAA originate in upland lakes and wetlands. According to King County Surface Water Management (SWM) division, this basin contains Chinook salmon, coho salmon, steelhead/rainbow trout, and coastal cutthroat trout (King County SWM,

[20] From King County (2007). Ratings are on a five-tiered scale (Low, Low-medium, Medium, Medium-high, High), with 'High' indicating a shoreline process that is least altered and in the best condition.

1993). Although highly developed, the basin remains biologically diverse and contributes a significant portion of the Snoqualmie River wild coho salmon fishery (King County SWM, 1993).

King County's reach analysis for Patterson Creek Reach RIV246 shows four parks within this portion of the basin: the Treemont Natural Area (245-acre with limited public access) along Redmond-Fall City Rd.; Fall City Park West (33.4 acres, no facilities) near Issaquah-Fall City Rd.; and the East Plateau Trail Site and Duthie Hill Park (120.4 acres with maintained trails) along SE Duthie Hill Rd (King County, 2007). Of these, only the Treemont Natural Area provides direct access to Patterson Creek.

Canyon Creek is the primary subbasin of Patterson Creek within the City of Sammamish PAA. It is a significant tributary for salmonid production in the Patterson Creek Basin (King County, 2004). The Canyon Creek drainage is a forested watershed that originates on Grand Ridge, and has some of the best high gradient channel stability and fish habitat in the Patterson Creek Basin (King County SWM 1993). The stream habitat is in relatively good condition, with clean gravel substrate, abundant woody debris, and complex in-stream habitat. The reach below RM 0.7 is the only significantly degraded portion of the subbasin, with degradation similar to other floodplain reaches in the Patterson Creek Basin. Canyon Creek is primarily a moderate-gradient, moderately contained channel type, with intermittent palustrine channels.

This is an area of higher residential zoning densities than other areas of the Patterson basin, including areas of R-6 and R-8 zoning. A subbasin alteration analysis by King County indicated that existing development in the upper watershed has altered the hydrology and negatively affected the stream channel (King County, 2004). Portions of both the Canyon Creek ravine are mapped as erosion or landslide hazard areas, heightening the potential impacts of basin development on channel erosion. Other concerns in the basin are related to water quality, peak flow increases and habitat loss, which are discussed in subsequent sections of this report (King County, 2004).

Patterson Creek is under a TMDL (total maximum daily load) water cleanup plan for fecal coliform, ammonia-nitrogen, and biochemical oxygen demand (BOD). The existence of a TMDL plan means that water discharges are subject to limitations for specific parameters established by the EPA. Sources of pollution within the basin include agricultural practices, failing septic systems, and pollutants associated with residential development. Patterson Creek was previously listed as an impaired waterbody in the state's 1994 water quality assessment known as the 303(d) list). Since the approval of the TMDL in 1996, Patterson Creek is no longer on the state's list of impaired waters; however, the TMDL plan is still in place.

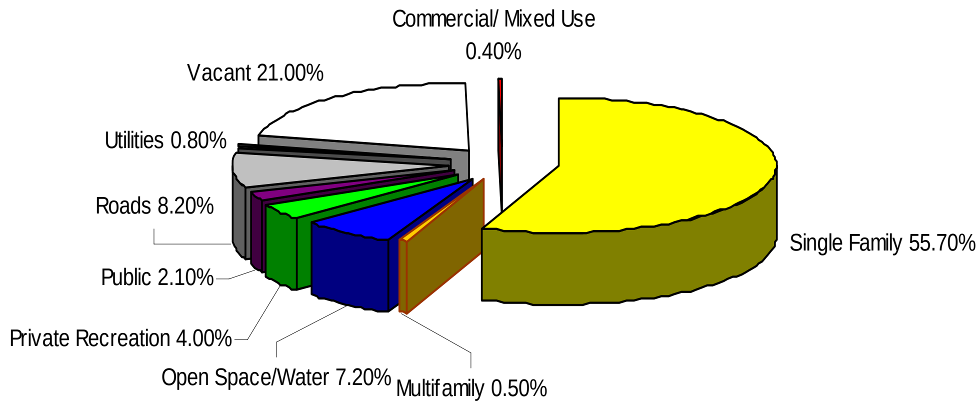
3.3. Land Use

Land use in the ELS basin ranges from low-density residential and pasture uses to high-density residential and commercial uses. The area is one of the fastest growing in King County with a population that increased 157 percent during the 1980s, and the planning area population is expected to double again by 2010.

Estimates of changes in forest cover and percent impervious surface for the ELS basin suggest that the total impervious area increased from 6.3 to 16.2 percent between 1991 and 2001 (Anchor Environmental, 2004), with an additional 10 percent increase expected by 2011. The increase in impervious surface corresponds with a 13 percent (39 to 26 percent) decrease in forest cover for the same 10 year period (1991-2001). By 2001, the expected decrease in forest cover was estimated to be additional 13 percent (Anchor Environmental, 2004).

An inventory of the existing land use within the Sammamish City limits was completed for the City's Comprehensive Plan (2003) (Map 5 in Appendix A). Figure 4 identifies the proportion of each land use category citywide. Single-family development represents the most predominant existing land use, with vacant land and roads the second and third most predominant.

Figure 4. Citywide Land Use (Acres by Percent)



Source: Sammamish Comprehensive Plan, 2003

3.4. Ecosystem Processes

This section describes key hydrology, sediment, and water quality processes at work in the basin and their relationship to the physical, chemical, and biological characteristics of the City's three SMA-regulated lakes. The operation of the key processes affects lake ecology; recreational appeal and suitability for humans; aesthetics; human health and safety; and other shoreline attributes. The processes are not distinct, but operate via interrelated mechanisms and feedback loops. The processes are controlled to a large extent by the surrounding climate, topography, and geology/soils (Ecology, 2005). Collectively, these controlling factors are referred to as the hydrogeologic setting.

3.4.1. Hydrogeologic Setting

The combined effects of climate, topography, and geology determine the amount, type, extent, and fate of water, sediments, nutrients, pathogens and organic materials as they enter, move through, and exit the watershed.

3.4.1.1. Climate

Sammamish's climate is dominated by maritime patterns that define the overall climate of the Puget Lowlands. These patterns include mild, wet fall to spring months, and cool dry summer months. Annual precipitation in the Puget Lowlands typically ranges from 32 to 37 inches, the vast majority of which is distributed between October and May. January temperatures typically range from lows around 30º F to highs around 43º F. July temperatures typically range from lows around 50º F to highs around 75º F (National Climatic Data Center [NCDC] Summary for Washington State, undated).

Precipitation typically occurs as low-intensity, long-duration storms (NCDC, undated). Precipitation as snow is relatively rare and short-lived in the lowlands. However, hydrologic systems in the Pacific Northwest are especially sensitive to warm rain-on-snow events, when significant volumes of water can be released into the system at one time.

3.4.1.2. Geology

The upland area upon which Sammamish is located is underlain by a complex sequence of glacial and nonglacial deposits that overlie Tertiary bedrock (Liesch et al., 1963; Livingston, 1971). The depth to bedrock in the vicinity of the project area is approximately 1,000 feet (Jones, 1996), except at the southern end of Sammamish, where bedrock rises sharply and is exposed at the ground surface. This sharp rise in the bedrock surface results from movement along the Seattle Fault. The Seattle Fault is considered active and has recently been identified on the western shore of Lake Sammamish opposite the southern end of the City of Sammamish (Sherrod, 2002).

The Puget Lowlands have been glaciated six or more times in the past 2 million years. Each glacial advance may have deposited a sequence of glacial deposits and may have partially to completely eroded sediments deposited by previous glaciations or during interglacial periods. Outwash deposits from one or more glacial advances comprise the main aquifers at depth beneath the uplands.

The topography and near-surface geology of the Sammamish Plateau are largely the product of the last glaciation (known as the Vashon Stade of the Fraser glaciation), which receded from the area about 13,500 years ago (Maps 3 and 6). The troughs presently occupied by the Snoqualmie and Sammamish Rivers were created as glacial ice or subglacial streams cut into overridden deposits of previous glacial advances or intervening interglacial times (Booth, 1994). The ice sheet deposited glacial drift on the expansive upland plains. Drift in the Sammamish area consists principally of till, outwash sand and gravel, and fine-grained glaciolacustrine deposits. The upland is largely mantled by lodgment till, which is partially buried by recessional sand and gravel deposits across much of the upland. Lodgment till has very low permeability and typically acts as an aquitard, restricting the downward flow of groundwater and reducing recharge of deeper aquifers.

The surface of the upland was shaped by the advancing ice and by meltwater streams generated as ice from the last glacial advance melted. During retreat of the Vashon ice sheet, large glacial lakes formed in the deep, northerly-trending troughs carved in the Puget Lowland. At the edge of the retreating ice front, channels were carved as melt water flowed along the ice front, spilling from one glacial lake to another (Curran, 1965; Booth, 1990). Patterson and Evans Creeks occupy one glaciofluvial feature on the northeast side of the Sammamish Plateau, just east of the basin boundary. North Fork Issaquah Creek flows within a second glaciofluvial feature at the southeast margin of the Sammamish Plateau. Water flowing in the channel now occupied by North Fork Issaquah Creek built a large sand and gravel delta into glacial Lake Sammamish just beyond the southern boundary of Sammamish (Liesch et al., 1963).

Recessional outwash and recessional lacustrine (lake) deposits of variable thickness commonly overlie the till. These sediments were deposited in topographic low areas in the till surface where melt water streams drained from the receding glacier, such as along the headwater areas now occupied by Pine and Beaver Lakes. Recent peat and muck deposits have accumulated on top of these poorly drained recessional lacustrine deposits or on top of recessional outwash deposits, where downward percolation of groundwater is impeded by the presence of till at shallow depths beneath the outwash (Turney et al., 1995). These areas of peat and muck deposits are the sites of the largest, most rare, and often most ecologically valuable wetlands within the watershed.

Underlying the till are thick deposits of sand and gravel separated by finer grained layers of clay and silt or tight, well-graded soils, such as till. These layers comprise several aquifers and aquitards within the subsurface and control subsurface water movement to Lake Sammamish and to the deeper river valleys that border the northeastern and southeastern sides of the Sammamish Plateau (Turney et al., 1995).

3.4.1.3. Topography

The City of Sammamish is located in the eastern portion of the Puget Lowland on a broad, northerly-trending, upland plateau bounded to the east and west by the broad valleys of the Snoqualmie and Sammamish Rivers, respectively (Map 6, Appendix A). The surface of the upland lies generally between 300 and 500 feet above sea level and is bordered by steep bluffs along deep troughs occupied by larger rivers. The upland surface exhibits low topographic relief, with hills rising typically between 20 and 100 feet, and poorly drained stream valleys and local closed depressions. The floors of the Sammamish River and Snoqualmie River valleys are relatively flat with low valley bottom gradients.

The upland area is incised along the edges by small streams, with a few larger streams that extend into the interior and lie in valleys more deeply incised into the upland surface. Three such streams, Patterson Creek and Evans Creek, to the northeast, and North Fork Issaquah Creek, to the southeast, form the boundaries of the physiographic sub-area known as the Sammamish Plateau, which is largely occupied by the City of Sammamish. These drainages are bounded by steep slopes along the margins of the plateau and are incised approximately 150 to 300 feet below the upland surface. The Sammamish Plateau is bounded to the west by steep slopes that descend to Lake Sammamish, which lies at the south end of the Sammamish River valley and extends to depths as much as 100 feet.

3.4.2. Processes Affecting Lakes

Lake environments are influenced by the volume of water flowing into and out of the lake, the hydraulic residence time[21], the degree and timing of density/temperature stratification, and the internal cycling of nutrients (particularly phosphorous and nitrogen). The movement of water, sediments, organic matter, and nutrients/pathogens through the watershed plays a key role in determining how these attributes function. Hydrology, sediment, and water quality processes also affect the physical configuration of the shoreline, the degree of light penetration of the water column, and the overall habitat variability of the lake.

3.4.2.1. Hydrology

The relationship between the volume of water entering a lake through precipitation, groundwater, overland runoff, and/or stream flow and the water exiting the lake via evapotranspiration, surface outflow, and seepage into groundwater is one of several fundamental determinants of lake ecology. Lake Sammamish, Pine Lake, and Beaver Lake are primarily fed by surface water inputs, as opposed to groundwater inputs, and therefore tend to be a high risk for water quality degradation. This is especially true because the watershed is becoming more urbanized and impervious surfaces have displaced permeable surfaces thereby altering the intensity, volume, timing, and duration of stormwater runoff. Higher peak flows in the watershed tends to increase the transport of bioavailable forms of phosphorus and nitrogen, which can alter the trophic state[22] (nutrient status) of a lake and create harmful conditions for fish and wildlife. This is the case for Lake Sammamish, Pine Lake, and Beaver Lake.

Increased impervious surface also decreases infiltration and groundwater exchange. This can be especially problematic in areas of highly permeable geologic deposits such the Inglewood and Laughing Jacobs subbasins. Properly functioning infiltration/recharge processes help to moderate the effects of storm events and maintain surface flows in tributary streams during the low flow periods. Baseflow support is essential for ensuring habitat availability for salmonids and other aquatic species.

Surface water storage (in wetlands and floodplains) is another important component of the hydrologic processes affecting Lake Sammamish, Pine Lake, and Beaver Lake. Loss of water

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[21] Hydraulic residence time refers to the length of time it takes for water to cycle through the lake.

[22] The trophic state is a measure of nutrient status and biological activity. A eutrophic state means high nutrient/ high biological activity; oligotrophic state means low nutrients/low biological activity. Mesotrophic is an intermediate state.

storage areas can exacerbate other effects of urbanization (such as increases in peak flows) by disrupting natural flood desynchronization[23] functions.

3.4.2.2. Sediment Generation and Transport

The primary sediment generation and transport processes within the drainage basins of the lakes are: (1) sediment buildup and wash-off from developed areas and construction sites, (2) landsliding on the steep slopes bordering Lake Sammamish and/or in the upper watershed, and (3) streambank erosion during storms. The generation, movement, and storage of sediment are largely driven by hydrologic factors and generally controlled by physical conditions such as topography (gradient), land cover (vegetation), soil characteristics (erodibility), and the transport capacity of moving water, including Issaquah and Tibbetts Creeks, which together deliver most of the sediment that reaches Lake Sammamish (Ecology, 2005).

Surface erosion, mass wasting, and in-channel erosion via channel meandering are natural forms of sediment generation in a watershed, but human activities such as land clearing, excavation, and grading influence and often exacerbate these natural processes. Increases in peak runoff volumes associated with urbanization can increase a streams' potential to move sediment downstream, causing in-channel erosion. This alteration is especially noticeable near Lake Sammamish as stream channels that initiate on the plateau drop to the lake via steep ravines along the bluff face. Changes in channel morphology within the ravines activate significant volumes of sediment via channel incision and widening and by destabilizing the ravine walls. Sediment deposition at the downstream reaches or at the stream mouth affects habitat, creates barriers to upstream fish passage, and/or contributes to localized flooding. Also, as tributary channels simplify in response to the altered flow and sediment transport processes, they become less likely to engage their floodplains, so there are fewer opportunities to mitigate contaminant inputs.

Road construction in urbanizing areas also increase fine sediment inputs as sediments generated from road surfaces are washed into storm drain systems or directly into tributaries or the lakes themselves during precipitation events. Increased sediment inputs have direct effects on lake water quality, particularly phosphorus loading.

The shores of Lake Sammamish, Pine Lake, and Beaver Lake are also prone to erosion from foot traffic, local surface runoff, and wind-driven waves. Lake Sammamish shores are also subject to the potentially erosive forces of waves from motorized watercraft.

Lakes in Sammamish serve as long-term storage areas for sediment. As an example, the alluvial delta at the southern end of Lake Sammamish (the location of the State Park, outside the City limits) has formed as the lake assimilates the sediment load of Issaquah and Tibet's Creeks. Nelson (undated) estimated the average annual growth rate of the delta to be approximately 2,600 tons/year, which compares to an estimated fine sediment input of 3,800 tons/year from Issaquah Creek. An unknown amount of this fine sediment input is carried in suspension out into the lake, but unlike in marine or large lake systems, along-shore sediment transport does not have a major effect on the morphology of the Lake Sammamish shoreline.

[23] Flood desynchronization refers to the process of slowing water velocities and spreading out the time of peak flows, thereby reducing the maximum flows.

Sediment loads entering Pine and Beaver Lakes, located higher in the basin, would naturally have been low as there would have been very little surface inflow to these lakes under predeveloped conditions. As a result, these lakes are very sensitive to urban development and inputs of sediment in surface water runoff.

When sediment delivery to a lake or other receiving body is increased as a result of anthropogenic disturbances, the capacity of the lake to assimilate sediment-associated contaminants is surpassed and water quality deteriorates. For this reason, increases in fine sediment loading are a key water quality consideration. Fine sediment (silt and finer) serves as a transport vector for nutrients, metals, and/or pathogens; phosphorous loading to lakes, in particular, is linked with increases in fine sediment loading.

Important areas for sediment processes in Sammamish include:

- Upland drainage basin to the lakes (sediment source area);
- Sediment storage locations (e.g., floodplains, lakes, wetlands, stream channels);
- Sediment generation and transport vectors (e.g., steep hillslopes, stream channels); and
- The steep ravines that deliver sediments from the plateau to the lowland areas.

3.4.2.3. <u>Water Quality</u>

The quality of the water flowing into, through, and out of Lake Sammamish, Pine Lake, and Beaver Lake is the result of the interaction of water with biota, soils, and urban land use and infrastructure. The concentration and transport of mineral and organic constituents are influenced by biotic uptake, decomposition, adsorption, and dissolution. In general, mineral and organic elements cycle between dissolved and particulate forms in the water column, to plants, animals, and soils, and back to the water column via decomposition. Water quality processes influence:

- Elemental cycling including the delivery and storage of nitrogen, phosphorus, metals, toxins, and pathogens; and
- Aquatic habitat affecting populations at all food web levels.

These processes occur over a variety of spatial and temporal scales. As water moves through an ecosystem, it has the opportunity to deposit, entrain, and/or transport mineral and organic constituents that can affect water quality. Therefore, the longer water is in contact with soil and vegetation, the more cycling will occur (increased cycling leads to cleaner water). Longer water contact times typically occur in low-gradient areas in the landscape, including wetlands.

Susceptibility to water pollution depends in part on landscape position and adjacent land uses. The City of Sammamish includes the relatively flat, upland plateau and several alluvial valleys that connect the plateau to the glacially-scoured Lake Sammamish basin. The two smaller lakes, Pine and Beaver, are located toward the upper part of the drainage basin, within either till or ice-contact deposits. These landscape positions indicate that water quality within these lakes is influenced mainly by surficial processes. Therefore, upland land uses have a high potential to impact water quality as there is limited potential for water storage/nutrient cycling between the contributing area and these small lakes. Lake Sammamish is similarly vulnerable to land use changes in the upper watershed, but via a different pathway than the smaller lakes. Since Lake Sammamish receives surface runoff from a large area that includes variable geology, soils, and vegetation, the lake acts to integrate the cumulative impacts of changes in the basin.

The link between urbanization and decreased water quality within Lake Sammamish has been well-established for some time, beginning with the efforts by Metro in the 1960s to limit the impacts of non-point pollution including excess nutrient loading on the major lakes in the Puget Lowlands. Gradual urbanization of all of the Sammamish drainage basins has increased nutrient and bacteria loading to the lake systems, which effects: (1) lake clarity, (2) growth of algae and submerged aquatic vegetation, (3) lake volume due to sediment loading (especially in the smaller lakes), and (4) increased bacteria levels.

A major concern for Sammamish's lakes is eutrophication, wherein nutrients and bacteria from the contributing area are transported to the lakes, resulting in excessive plant growth (algae, periphyton attached algae, and nuisance plants). This enhanced plant growth often reduces dissolved oxygen in the water when the plant material decomposes, which can cause other organisms to die.

A certain amount of nutrients, such as nitrogen, phosphorus, and silica, are necessary for plant and animal growth. Excessive amounts of nutrients, however, can increase the growth of aquatic plants, which subsequently decay and deplete oxygen to levels incapable of sustaining aquatic organisms. Phosphorus is the primary nutrient of concern in freshwater systems because, if present in excess amounts, it can cause nuisance algal blooms or, on occasion, toxic algal blooms.

Nutrient discharge to lakes is a natural process; however, anthropogenic practices can introduce new contaminant sources or can accelerate the delivery of nutrients to levels where the lake ecosystem is unable to assimilate. Phosphorus is generated by almost every land use activity in the basin: forestry, farms, residential lawns and gardens, septic systems, construction sites, natural erosion processes, commercial developments, car washing, and more. Phosphorus in lakes can be released into the water column when dissolved oxygen concentrations fall below 0.2 mg/L, which often occurs under highly stratified conditions during summer.

Wetlands can be important phosphorous sinks because they trap and store sediment. Denitrification and adsorption can also occur in wetlands, particularly those with alternating reducing and oxidizing conditions (Mitch and Gosselink 1993; Sheldon et al. 2003), or organic or clay soils (Sheldon et al. 2003; Woltemade 2000).

Fecal coliform bacteria also affect lake water quality, and all of the lakes in Sammamish show evidence of fecal coliform pollution (more so for Pine Lake and Lake Sammamish than for Beaver Lake). Microscopic fecal coliform bacteria live in animal wastes and can be washed into surface water systems by runoff from pastures, septic systems, and other areas, or be directly deposited there (by waterfowl or domestic animals for example). Lakes with high algal concentrations and low dissolved oxygen provide a favorable medium for the bacteria, which thrive in bottom sediments where the decayed algal material accumulates. Fecal coliform levels in a watershed or waterbody can change rapidly because the bacteria multiply quickly, but also die off easily in response temperature changes or exposure to direct sunlight.

Large scale water quality alterations have been addressed in the past by routing sewage into regional treatment centers and applying other engineering solutions. While these have improved water quality to some degree, rapid growth within the drainage basin will continue to create water challenges to preserving and improving water quality in the future. Further, there is often a lag time between the discontinuation of a specific discharge (e.g., phosphorus) and an improvement in water quality because contaminants continue to cycle internally.

Areas that have a major influence on water quality processes in Sammamish include:

- Low-gradient wetland systems with significant water contact time;
- Upland source areas on low-permeability soils;
- Fine sediment source areas (e.g., build-up and wash-off from roads); and
- Residential and commercial areas on septic systems.

4.0 REACH INVENTORY AND ANALYSES

4.1. Lake Sammamish

The portion of Lake Sammamish shoreline within the City is relatively homogenous in terms of land use. In general, the lakeshore is divided in to small (generally up to ~3,000 sq ft, some lots as large as 5,000 to 6,000 sq ft) residential lots and is densely developed (all of the land west of East Lake Sammamish Drive is zoned R-4). There are relatively few undeveloped waterfront lots, many which appear to be constrained by critical areas or other development limitations. For purposes of this shoreline inventory, the lakeshore can be divided into two segments[24]. The northernmost section of the lakeshore, extending from the northern City limits south for about 3,250 linear feet to just north of Weber Point, is somewhat less densely developed with homes and docks compared to areas to the south. This northern shoreline area is mostly designated "Conservancy" under the City's existing SMP. The area to the south is relatively uniform, but there are small pockets of ecological and/or morphological variability associated with points, creek mouths, wetlands, and small patches of relatively intact native vegetation. These "pockets" generally do not occupy more than about two hundred lineal feet of lakeshore each.

4.1.1. Physical Environment and Water Quality – Lake Sammamish

The fjord-like lake drains approximately 63,000 acres of land and has a mean depth of 58 feet and a maximum depth of 105 feet (Table 5) (King County, 1994). Issaquah Creek, located on the south end of the lake, is the major inlet to Lake Sammamish, while the Sammamish River to the north is the lake's main outflow. According to the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map, the Lake Sammamish flood level is 33 feet above sea level (National Geodetic Vertical Datum [NGVD] 1929)[25].

Table 5. Physical Attributes of Lake Sammamish

Attribute	Lake Sammamish
Surface Area	4,897 acres
Lake Volume	283,860 acre-ft
Maximum Depth	105 ft
Average Depth	58 ft

Source: http://dnr.metrokc.gov/wlr/waterres/lakes/LakeSammamish.htm

Lake Sammamish has turnover or flushing rate of about 56 percent per year and the volume of water in the lake is completely replaced approximately every 1.8 years. This relatively long hydraulic residence time (Lake Washington, which is twice as large and twice as deep, flushes at about the same rate as Lake Sammamish) allows ample time for algae to grow.

[24] The Watershed Company (2000) identified 4 distinct segments along the City's lakeshore in 2000 as part of a study of critical wildlife habitat (Watershed Company 2000)[24]. Three of the segments occur north of Inglewood Boulevard; the area from Inglewood Boulevard to the southern City limits was considered to be one segment.

[25] Lake elevations are generally given in one of two datum: NAVD 88 or NGVD 29. The difference between the NGVD 29 and NAVD 88 datum in the vicinity of Bellevue is +3.585 feet (Watershed Company, 2004) .

The typical period of stratification is between mid May and mid November. During this time, there are distinct density and temperature differences between different layers of the water column (cold, dense water on the bottom, warmer less dense water near the surface)[26]. Algae take up nutrients, which are then transported to the bottom when the algae die. Dissolved oxygen becomes more limiting at depth, thereby reducing food availability and habitat especially for species such as Chinook salmon that require access to cooler water. In the spring and fall, the thermal stratification breaks down, the water column becomes more mixed, and nutrients that have accumulated at the bottom of the lake are redistributed throughout the water column. Dissolved oxygen levels at all depths are higher than during the stratified period (summer).

Lake Sammamish is considered to have a mesotrophic (as opposed to eutrophic) state, meaning it has moderate levels of biological activity, moderate water clarity, moderate algal growth, and moderate phosphorus concentrations. The tropic status is very important because can affect ecological health and habitat quality (e.g. dissolved oxygen levels), aesthetics (algal blooms), recreational use. If the tropic status were to change from mesotrophic to eutrophic, a number of adverse effects would be likely including:

- Noxious algae (scums, blue-greens, taste and odor, visual);
- Loss of open water due to excessive macrophyte growth;
- Loss of clarity;
- Loss of habitat for fish and fish food (low dissolved oxygen)
- Smothering eggs and bugs (excessive organic matter production)
- Odors due to "toxic" gases (ammonia, hydrogen sulfide) in bottom water;

Between 1994 and 2004, the trophic state index (TVI) for Lake Sammamish as measured by King County averaged between 35 and 42 on a scale of 1 to 100[27], suggesting that conditions hover on the edge between mesotrophic (TVI between 40-50) and oligotrophic (TVI below 40) (King County, 2005).

There are seasonal variations in transparency or water clarity within Lake Sammamish. Transparency is typically lowest during the winter months when chlorophyll levels are low and streams deliver increased quantities of fine sediment, which creates turbid conditions. Summer transparency levels are higher as stream inputs become less important and primary productivity increases in response to higher temperature and increased daylight.

Total phosphorus levels in Lake Sammamish have tended to range from about 13 to 22 μg/L mean annual volume weighted total phosphorus per calendar year. This is based on sampling conducted between 1997 and 2005 at two stations located at the north and south ends of the lake (King County data available at http://dnr.metrokc.gov/wlr/waterres/lakes/LakeSammamish.ht).

[26] The layers of the lake water column are called the hypolimnion and epilimnion. The hypolimnion is the bottom and most dense layer of water in a thermally-stratified lake. Typically the hypolimnion is the coldest layer in the summer and the warmest during winter. It is isolated from surface wind-mixing and does not receive enough incoming light for photosynthesis to occur. The epilimnion is the top-most layer, above the hypolimnion. It is warmer and typically has a higher pH and dissolved oxygen concentration than the hypolimnion. Being at the surface, it is subject to surface wind-mixing.

[27] Each major division correlated to a doubling of the algal biomass related to water clarity and nutrient levels.

The state has established specific goals for water transparency, chlorophyll, and total phosphorus as follows:

- Transparency = June to September mean water transparency of 4 meters or more.
- Chlorophyll *a* = June to September mean below 2.8 µg/liter,
- Total Phosphorus = annual volume weighted concentration equal to or less than 22 µg/liter

Transparency and total phosphorus levels generally met these targets, but chlorophyll *a* levels exceeded the threshold in most years between 1997 and 2005 (King County data available at http://dnr.metrokc.gov/wlr/waterres/lakes/LakeSammamish.ht).

Although Lake Sammamish meets water quality standards for phosphorus, the lake is at risk for several other water quality parameters. Currently, Lake Sammamish is on Ecology's 303(d) list, as a Category 5 waterbody for ammonia N, dissolved oxygen, and fecal coliform[28] (Ecology 303(d) water quality data are available at http://www.ecy.wa.gov/programs/wq/303d/index.html).

4.1.2. Biological Resources – Lake Sammamish

Lake Sammamish provides significant habitat to numerous native and non-native species of fish. Five species of salmonids use the lake's open water habitat along with its tributaries for migration, spawning, and rearing. These species include Chinook, coho and sockeye/kokanee salmon, as well as steelhead/rainbow trout and coastal cutthroat trout. The WRIA 8 Technical Committee designated the lakeshore area as a "Tier 1" evaluation area for migrating and rearing Chinook salmon populations (King County et al., 2005) The lake's resident kokanee population has been determined to be genetically distinct; as such, additional study is underway to further understand this population. Invasive warmwater species of fish include both large and smallmouth bass, yellow perch, black crappie, pumpkinseed sunfish, and brown bullhead. These non-native species, particularly adult perch and bass, are known to be predators of juvenile salmon and their young will also compete with salmon for food in shallow water habitats (King County, 2005).

The primary wetland areas associated with Lake Sammamish are at the north and south ends of the lake in Marymoor Park and Lake Sammamish State Park, outside City jurisdiction. There are also dozens of small slope and riverine wetlands associated with the eastern shoreline of Lake Sammamish and its small tributaries[29]. In many cases, slope wetlands along the eastern shoreline of Lake Sammamish are a result of groundwater flow impeded by modified topography in the form of railroads, roads, and trails (King County, in preparation). Several small riverine wetlands have also been identified near the downstream ends of the Pine Lake/Kanim Creek drainages and Tributary 0155.

According to the WDFW, several known bald eagle nests are located along the eastern shoreline of Lake Sammamish (WDFW, 2006). A relatively undisturbed stretch of shoreline is located

[28] Category 5 refers to polluted waters that require a TMDL.

[29] These are identified in the Environmental Impact Statement being prepared for the East Lake Sammamish Trail, but are not depicted on some of the City's wetlands maps.

along the northeastern section of the lake near Inglewood Hill Road, the areas north and south of Weber Point, and extending north to the large wetlands of Marymoor Park. Along this stretch, neighborhoods are interspersed among sandy/gravelly beaches that provide salmon and eagle habitat. Much of the shoreline contains mature forest that provides important habitat for nesting and foraging eagles. Foraging is likely to occur throughout the entire shoreline of Lake Sammamish due to the abundance of fish and waterfowl. On any given day, this is the area where a visitor could observe most of the recreational fishing boats on the lake (Maren Van Nostrand, March 2007 personal communication).

Bald eagles are known to forage along the lake and perch in large cottonwoods on the shoreline (Parametrix, 2000). Great blue herons breed in rookeries at Lake Sammamish State Park, and some of these birds use the nearshore areas for foraging and rearing. An osprey nest is mapped several miles south of the Sammamish Town Center Sub-area. In addition, Lake Sammamish State Park is a designated waterfowl concentration area.

In addition to supporting bald eagles, the Lake Sammamish shoreline provides quality habitat for numerous other species of wildlife. Other avian predators, such as osprey and red-tailed hawks are frequently observed near the lakeshore and mergansers, cormorants, mallards, grebes, American coots, Canadian geese, gulls, swifts, great blue and green herons, and other waterfowl occupy open water areas. Some of the best habitat areas are at the north end of the lake where the shoreline is less heavily developed and relatively large patches of native vegetation still remain in tact (Watershed Company, 2000). Purple martins nest along the north end of the shoreline.

4.1.3. Cultural Resources – Lake Sammamish

Lake Sammamish is part of the usual and accustomed fishing area of the Muckleshoot Indian Tribe and the Snoqualmie Indian Tribe per the Treaty of Point Elliot. The lake has served as a cultural resource for the Muckleshoot, Snoqualmie and other tribes who have harvested fish, wildlife, and plant species in this area for generations. The names of the creeks in and around the City pay tribute to respected and honored Snoqualmie Tribe members: George Davis Creek, Zaccuse Creek, and Kanim Creek (Pat Kanim was the second signatory on the Pt. Elliott Treaty). Tribal members historically and currently use the shorelines in Sammamish for travel, fishing, hunting, gathering, as well as other economic and cultural activities. The Lake Sammamish area was once a gathering place for Native Americans, where they prepared for winter and celebrated their potlatch (winter festival) at the south end of the lake. Currently, Sammamish shorelines play an important part in the Snoqualmie Tribe's Canoe Family Journey. Snoqualmie village and camp sites are located within the City limits.

Recorded prehistoric sites are located in the vicinity of the Lake Sammamish shoreline planning area. Along the north end of Lake Sammamish, near Redmond there are eight known prehistoric sites, including the Marymoor Site (45-KI-9). Artifacts at this site include microblade cores and blades, Cascade points, large stemmed points, and basalt cobble tools (Greengo and Houston, 1970). Based on this assemblage and corrected radiocarbon dates, the site dates to between 4,200 and 2,700 years BP (before present) (Larson and Lewarch, 1995). Of the seven other sites in this area, three are presumed to have been destroyed. Nevertheless, it is highly likely that other cultural deposits are present in the area.

Within the Lake Sammamish shoreline planning area several historic sites have been identified. One known site consists of a low-density lithic (stone) scatter, possibly from the Olcott period (5,000 – 8,000 BP). The prehistoric materials were mixed with more than 250 historic artifacts. The site is likely related to the historic town at Monohon (Nelson, 1998; Norman, 2000). King County Cultural Resources Database (CRDB) identifies several culturally sensitive areas reported by local residents including numerous references to human burials (CRDB reference: KING01008; KING01091; KING01113; KING01135; KING01150). While these potential resources have not been formally recorded, they do provide insight into the types of resources that may be present within and adjacent to the shoreline planning area.

In the southern section, near Issaquah, one prehistoric site has been identified along the general route of an Indian trail identified by the General Land Office in the 1860s (Hudson et. al, 2003; United States Surveyor General, 1860). Several documents indicate the likelihood of additional Native American-related cultural resources in the area. Waterman (ca. 1920) identifies several ethnographic places near the shoreline planning area including an Indian village on Issaquah Creek at the present Lake Sammamish State Park. Robinson (1986) notes the presence of a Sammamish burial ground “in or near the present town of Issaquah”, although there is no more specific information available as to its location.

Other cultural deposits are likely present in the area. Previously noted Native American tribes have not yet shared information with the City about specific sites. The City intends to work with the tribes to obtain additional information in the future and will develop policies and regulations to ensure that cultural resources are protected.

4.1.4. Land Use and Other Alterations – Lake Sammamish

Land use patterns are described in the context of existing land use, as well as planned or future land uses that are established by the City’s comprehensive plan land use designations and zoning designations.

4.1.4.1. Land Use

Current land use designations in the Lake Sammamish shoreline planning area are predominantly detached single-family residences (1 to 6 dwelling units per acre) (Maps 5 and 7, Appendix A). Remaining land use is designated as park (see the description of the East Lake Sammamish Trail and the future East Lake Sammamish Waterfront Park under the Public Access below). There are very few undeveloped or vacant parcels in the shoreline planning area. Those that exist are primarily at the north end of the lake. A preliminary shoreline analysis by City planning staff indicates that of the 616 parcels in the Lake Sammamish shoreline planning area, a total of 108 are vacant. According to the City’s comprehensive plan there will be minimal up-zoning from R1 to R4 near the shoreline planning area at the north end of Lake Sammamish. Up-zoning could allow for higher levels of impervious surfaces associated with residential development, however impacts would likely be minimal due to the small area of up-zoning under consideration and existing development regulations within the City. Table 6 provides a detailed breakdown of land use in the Lake Sammamish shoreline planning area.

Table 6. Shoreline Land Use within the Lake Sammamish Planning Area

Shoreline	Land Use	Approximate Size (Acres)	Approximate Percentage of City's Shoreline Planning Area[30]
Lake Sammamish	Residential (R1)	7.8	2.9%
	Residential (R4)	211	81.7%
	Residential (R6)	4.5	1.7%
	Public/Institutional	5.7	2.2%
	East Lake Sammamish Parkway right-of-way	30.4	11.5%

A 2007 case study by the California Office of Environmental Health Hazard Assessment (OEHHA) estimating watershed imperviousness identified impervious surface coefficients (ISCs) for various categories of land use. According to the study, open space has an impervious surface coefficient of 2 percent, very low density residential development (defined as between 1.1 and 4 dwelling units per acre) has a coefficient of 26 percent while low density residential development (4.1 to 8 units per acre) has a coefficient of 40 percent. Using a worst-case scenario coefficient of 40 percent for the residential areas (which would cover all land use types between 1 and 6 units per acre), 2 percent for the Public/Institutional land, and 80 percent for the area within the East Lake Sammamish Parkway, the total impervious surface area in the Lake Sammamish planning area is estimated to be approximately 44 percent. This is considered to be a very rough and preliminary estimate since the coefficients were derived from a very different area and may not reflect actual build-out conditions in Sammamish.

4.1.4.2. Transportation and Utilities

Roads and other transportation infrastructure near or adjacent to water bodies can create adverse impacts to natural systems by impeding flow or reducing the ability of water to infiltrate into the ground. Roadways represent a significant source of pollution-generating impervious surface in urban areas. Auto-related pollutants including petroleum products, hydrocarbons, and heavy metals accumulate on road surfaces and are carried directly to nearby water bodies during storm events through sheet runoff, roadside ditches, or stormwater collection systems, rather than allowing filtration into the ground.

East Lake Sammamish Parkway, which parallels the entire lakeshore, encompasses approximately 38 percent by area of all roadways within the shoreline planning area. The only other major roadway within the planning area is East Lake Sammamish Lane, which runs between the lake shoreline and ELS Parkway for the majority of the southern extent of the City. The remaining roadway coverage is made up of numerous small access roads and cul-de-sacs leading to waterfront property off East Lake Sammamish Parkway. Runoff from the parkway, ELS Lane, and all other planning area roads is currently untreated prior to discharge to Lake

[30] The shoreline planning area used in this table excludes areas waterward of the OHWM of the Lake.

Sammamish via several stormwater outfalls. Improvements proposed for East Lake Sammamish Parkway include a series of stormwater treatment facilities from Inglewood Hill Road to 187th Ave NE, however these likely will not be in place until 2010 at the earliest.

Northeast Sammamish Sewer and Water District (NESSWD) and Sammamish Plateau Water and Sewer District (SPWSD) both supply sanitary sewer service and potable water service to residents in the Lake Sammamish planning area. Water and wastewater pipelines are located in, and cross, the East Lake Sammamish Parkway right-of-way throughout the City of Sammamish. Although there are no mapped sewer or stormwater outfall locations on Lake Sammamish, according to City staff, there are numerous outfalls along the lake.

Septic systems (tanks and drainfields) are a large source of phosphorus loading to urban water bodies. In the Lake Sammamish shoreline planning area approximately 45 percent of the parcels are on septic systems. New development is not required to hook up to municipal sewer, and depending on the specific location sewer hookup is not available to all areas. King County regulates septic system and drain field installations.

4.1.4.3. Shoreline Modifications

Shoreline modification refers to structural changes to the shorelines' natural bank. Examples include shoreline armoring[31] (bulkheads, riprap, etc.), overwater structures (docks and piers), or dredging and filling. The following assessment of the extent of shoreline modification is primarily based on aerial photo interpretation and data on the presence of docks, provided by King County GIS. The data being analyzed is based on 2002 aerial photography and may not contain the most recent dock developments.

According to initial estimates, over 53 percent of shoreline planning area parcels have docks present, which indicates a highly modified shoreline. Most docks range in length from 30 to 50 feet.

4.1.5. Public Access – Lake Sammamish

The City of Sammamish has a diversity of parks, open space, and public facilities (Map 8, Appendix A), but public access to the Lake Sammamish shoreline within the City limits is limited (City of Sammamish, 2004). The City's main public access on the Lake Sammamish shoreline is the interim East Lake Sammamish Trail. This recently completed interim trail runs north to south along the entire east shoreline in an abandoned railroad right-of-way. The trail surface generally lies between 50 and 300 feet east of the lake edge. It offers views of the water, but no physical water access. The trail links Marymoor Park in Redmond with Lake Sammamish State Park in Issaquah and is part of a larger trail/transportation system linking Lake Sammamish to Lake Washington via the Burke Gilman Trail. The trail is owned and maintained by King County Department of Natural Resources and Parks. King County has plans to pave and expand use of the trail.

[31] The term shoreline armoring in this report refers to shorelines and banks that have been "hardened" by rock, concrete, rip-rap and similar materials generally for the purpose of reducing/preventing erosion.

4.1.5.1. Opportunities for Public Access

There is currently one opportunity for future public access to the Lake Sammamish shoreline located at the northern City boundary currently called the East Lake Sammamish Waterfront Park. It encompasses a narrow strip of undeveloped land consisting of of two City-owned parcels situated between the East Lake Sammamish Trail and the Lake, covering 0.6 acre and including 300 feet of wooded shoreline. Protecting this portion of the shoreline, north of Weber Point, is identified as one of the near–term action agenda projects in the WRIA 8 Chinook salmon Conservation Plan (King County et al., 2005). The City of Redmond owns the adjoining parcel to the north, with additional shoreline frontage. According to the City of Redmond, their property could include a swimming beach, picnic area, fishing access, restrooms, parking, and access to the East Lake Sammamish Trail. The City of Sammamish would evaluate impacts on habitat and wildlife resources before any recreation- oriented development were to occur. This property is not currently open to the public.

Marymoor Park, at the north end of the lake outside the City limits, also provides public access to the Lake Sammamish shoreline, but unlike Lake Sammamish State Park (described below) does not have a boat launch or public beach. King County allows small, non-motorized water craft be carried from parking areas to the water for beach launches. Marymoor Park is the County's most popular park with more than 3 million visitors annually. At 640-acres, Marymoor Park provides access to soccer and baseball fields, a pea patch area (cooperative gardening), picnic tables and shelters, the lake and river for rowing and paddling, birding areas, cricket fields, and areas for model airplane flying.as Additionally, the park contains regional trails, the largest off-leash dog area in the state, a velodrome, and a climbing rock.

Lake Sammamish State Park, located outside the City limits at the south end of the lake, is a 512-acre day-use park. The large park is a very popular regional recreation area and features picnic areas, biking and walking trails, nearly 7,000 linear feet of beaches and nine full-size boat launches. Lake Sammamish State Park is by far the most popular public access area on Lake Sammamish and frequently draws very large crowds during the summer months, primarily because it is the only available public boat launch area on the lake. Based on State Park vehicle counts at the boat launch site, there were an average of 23,000 boat launches annually from 2000 to 2003, with the highest number occurring in the summer months.

The interconnections between Lake Sammamish, Lake Washington, and Lake Union via the Sammamish River and the Ship Canal provide an additional important form of public shoreline access. Described in a 2000 Seattle Post Intelligencer article at the time of designation as an official 'Water Trail' the Lakes-to-Locks Trail includes more than 100-shoreline miles and more than 100 public access points for non-motorized, small water craft. TheWater Trail designation recognized by the various cities along the shoreline as well as several other state and federal institutions, ensures that access points (of which there are none on the City's Lake Sammamish shoreline) will remain available to the public for day-use.

4.2. Pine Lake

The Pine Lake shoreline is 2.2 linear miles long and is divided into small residential lots. Nearly all of the lots are developed creating a relatively homogenous shoreline composed of single family homes and docks. The portion of the shoreline between Pine Lake Park and the northeastern corner of the lake is somewhat more heavily vegetated with trees than other areas of the lakeshore. Similarly, the area at the southwest end near Wetland ELS 30 is also forested and has a more natural character.

4.2.1. Physical Environment and Water Quality – Pine Lake

Pine Lake is a 88-acre, shallow lake located east of Lake Sammamish in the Pine Lake subbasin (Map 9, Appendix A);. The lake has a maximum depth of approximately 39 feet (Table 7) and is relatively sheltered from wind and has minimal fetch (Tetra Tech, 2006).

The Pine Lake subbasin drains approximately 1,175 acres of land, nearly half of which was forested in 1994 (King County, 1994). Residential development has likely displaced much of the forested area in the last 12 years as most areas are zoned for densities of 1 to 4 four lots per acre.

Table 7 Physical Attributes of Pine Lake

Attribute	Pine Lake
Surface Area	88 acres
Lake Volume	1,700 acre-ft
Maximum Depth	39 ft
Average Depth	19 ft

Source: Draft Pine Lake Management Plan (Tetra Tech, 2006)

The draft Pine Lake Management Plan (Tetra Tech, 2006) indicates that 24 percent of the Pine Lake watershed is currently undeveloped open space. However, the total watershed area reported by Tetra Tech is 502 acres compared to the subbasin area of 1,175 acres reported by King County (1994)[32].

Pine Lake has had a history of water quality problems (high phosphorus and algal blooms) dating back several decades. In the 1970s, Pine Lake was considered to have the poorest water quality of any Puget Sound lowland lake (Tetra Tech, 2006). Studies by Metro in the late 1970s and early 1980s determined that a substantial percentage of the soluble phosphorus entering the lake was attributable to runoff from an adjacent wetland. The flow from that wetland was diverted to the lake outlet in 1988 and water quality conditions have generally improved since that time.

Historically six streams flowed into Pine Lake; only three of these tributaries still contribute surface water—one enters at the northeast corner (WRIA 0152), one enters near the southeastern-most tip, and one enters on the south side (Tetra Tech, 2006). Water draining to the south side of the lake now enters detention ponds prior to discharging and runoff from 228th Street drains to the east away from the lake. Some of the drainage from the north that previously flowed into the lake in surface streams is now conveyed via pipes. Other existing and planned drainage collections facilities receive/will receive runoff from development on the south side of

[32] For this report, the reason for the discrepancy between the two reported subbasin areas could not be determined; it is assumed that the two referenced studies utilized different methodology in determining the limits of the Pine Lake Subbasin.

the lake. Thus, much of the free-flowing runoff that entered the lake in earlier years is being routed to water quality facilities for treatment (Tetra Tech, 2006). All of the inflow is ephemeral.

The lake drains via one surface stream to Lake Sammamish. Outflow is controlled by a weir at the headwaters of Pine Lake Creek. Beaver activity has reportedly blocked the outlet at various times increasing lake levels temporarily and altering water quality (Tetra Tech, 2006). Overall, water levels in Pine Lake have been relatively stable based on data collected between 2000 and 2004 (King County, 2004).

Pine Lake is oligotrophic based on measurements of total phosphorus, chlorophyll *a*, and transparency which averaged 37.5 during the 2004 sampling period (King County, 2004). According to the small lakes water quality trend report, values for each of the three TSI indices are closely clustered and have been relatively stable over the last several years (King County, 2004).

The state's 2004 water quality assessment lists Pine Lake as a Category 5 water for total phosphorus. The 303(d) listing cites data from Welch (2002) indicating that summer epilimnetic total phosphorus concentrations in Pine Lake remained high following the diversion of flow from the adjacent wetland in 1988. This is attributed to an estimated 56 percent increase in watershed development. Other problems cited in the 303(d) listing are blue-green algae, turbidity, dissolved oxygen, tributary nutrient inputs, and low transparency. The lake is currently also listed as a Category 5 water for fecal coliform. Pine Lake Creek is listed as a 303(d) Category 5 water for dissolved oxygen and fecal coliform.

According to the draft Pine Lake Management Plan for Water Quality (Tetra Tech, 2006), post diversion mean summer total phosphorus levels have decreased to around 10 µg/liter and summer means have never reached eutrophic levels. Mean surface total phosphorus was much higher prior to the wetland diversion and was higher in spring than in summer, which is typical for lakes in this region. Mean summer surface chlorophyll *a* levels have reportedly also decreased since the 1988 diversion to around 2.8 µg/liter (Tetra Tech, 2006). The reason surface levels are low in summer is that the lake becomes highly stratified and phosphorus is trapped in the hypolimnion. Since the lake is sheltered from wind there is relatively minimal opportunity for mixing so phosphorus generally does not become available in the epilimnion until the end of stratification in the fall. Algal blooms occur in the fall and winter in response to the release of trapped phosphorus.

Tetra Tech's data suggest that internal phosphorus cycling and levels is relatively unresponsive to changes in external phosphorus loading. This would suggest that phosphorus inputs entering the Pine Lake subbasin are sequestered and cycled within the watershed before they enter Pine Lake. As a result, they predict that if build out continues without mitigation to minimize phosphorus loading, total summer epilimnetic phosphorus levels would increase modestly by about 3 to 4 µg/liter with a corresponding increase of about 1 µg/liter in chlorophyll *a*. Total winter phosphorus would increase by 7 to 10 µg/liter with unmitigated build out, as the phosphorus cycling is largely dependant on vegetative uptake and plants are dormant through the winter. If new developments effectively detain 80% of total phosphorus as required by the City's

CAO[33], total phosphorus levels would only increase by about 2 µg/liter (~4 µg/liter in winter) and chlorophyll *a* concentrations would increase approximately 0.6 µg/liter (Tetra Tech, 2006). With these data in mind, Tetra Tech recommends the following goals for chlorophyll *a* and total phosphorus in Pine Lake:

- Chlorophyll *a* = winter mean concentration of 19 µg/liter or less and summer mean below 2.8 µg/liter;
- Total Phosphorus = winter whole lake concentration equal to or less than 19.2 µg/liter; summer epilimnetic concentration of 10 µg/liter.

These goals are believed to be achievable if the CAO restriction on phosphorus loading is implemented. Tetra Tech recommends additional mitigation measures such as a pet waste control program, a ban on phosphorus fertilizers in the watershed, and limits on lawn/garden irrigation to provide additional safeguards against water quality degradation. Of particular importance is maintaining existing lakeshore vegetation especially existing trees. Vegetated lakeshore buffers stabilize soil and provide areas for phosphorus uptake. Additionally, trees and woody vegetation shelter the lake from wind and minimize mixing of trapped phosphorus during the stratification period. Additional or revised recommendations may be developed when the management plan is finalized.

4.2.2. Biological Resources – Pine Lake

Pine Lake contains several non-native species of fish including largemouth bass, yellow perch, brown trout, and black crappie. Pine Lake is also stocked with rainbow trout—WDFW planted 20,000 adult rainbow trout in Pine Lake in the spring of 2006 (WDFW, 2006). The lake also likely supports a small population of native coastal cutthroat trout.

There is no anadromous fish use in Pine Lake. Significant concentrations of waterfowl, including Canadian geese, ruddy ducks and mallards, are also present within the vicinity of Pine Lake, and raptors such as bald eagles, ospreys and red-tailed hawks are routinely seen in the area (WDFW, 2006; King County, 2004). City staff have reported great blue herons at Pine Lake (Susan Cezar, personal communication 2006).

Pine Lake Creek, which is a salmonid-bearing stream, is the primary outflow of the lake and is located in the southwest corner of the lake. Pine Lake Creek has anadromous fish use up to river mile (RM) 0.60, and resident (nonadaromous) fish use above. Excellent pool/riffle habitat remains, particularly where the stream falls from the plateau to Lake Sammamish.

There is a large wetland at the mouth of Pine Lake Creek, where the creek enters Lake Sammamish. Another large, high quality wetland approximately 54 acres in size, is located on the southwestern shore of Pine Lake, just south of the outlet to Pine Lake Creek. King County designated this Wetland ELS 30 (King County, 1994). Several narrow wetlands are also present

[33] Within the Pine Lake special management area, development that exceeds 5,000 square feet of pollution generating impervious surface must be designed to remove 80 percent of all new phosphorus loading on an annual basis (per 21A.50.355 of the SMC).

along the northern and southeastern shorelines. These wetlands are connected to the regulated shorelines (Pine Lake) and are therefore "associated" wetlands.

4.2.3. Cultural Resources – Pine Lake

The Muckelshoot and Snoqualmie tribes are known to have lived and traveled in the Sammamish region, and it highly likely that cultural artifacts and cultural sites are present in the Pine Lake area. However, no known or prehistoric sites have been recorded in or near the Pine Lake shoreline planning area.

4.2.4. Land Use and Other Alterations – Pine Lake

4.2.4.1. Land Use

Current land use designations in the Pine Lake shoreline planning area are predominantly detached low-density single-family residences (1 to 4 dwelling units per acre). All of the lakefront parcels are zoned R4, however the shoreline planning area including and around Wetland ELS 30 to the west of 212th Avenue SE is . The remaining land use within the Pine Lake shoreline planning area is designated as public/institutional (with park land use). There are relatively few undeveloped or vacant lots in the shoreline planning area. According to the City's comprehensive plan, zoning will largely remain unchanged on Pine Lake. Despite the lack of zoning changes and paucity of vacant parcels, redevelopment in the Pine Lake Shoreline Planning Area is ongoing. In many cases, small older homes are being replaced by larger residences with attendant shoreline modifications. Table 8 provides a detailed breakdown of land use in the Pine Lake shoreline planning area.

Table 8 Pine Lake - Shoreline Planning Area Land Use

Shoreline	Land Use	Approximate Size (Acres)	Approximate Percentage of City's Shoreline Planning Area
Pine Lake	Residential (Areas zoned R4)	100.88	84.7%
	Residential (Areas designated R1- R4[34])	14.16	11.9%
	Public/Institutional	4.09	3.4%

Using the ISCs developed by the OEHHA (2007) study, and the areas per land use category shown in Table 8, total impervious surface area within the Pine Lake shoreline planning area is estimated to be approximately 39 percent.

[34] Where a range is given, this indicates parcels for which the density of R-1 is under review in accordance with Comprehensive Plan Policy LUP-9.1. The density would be between one and four residential units per acre if indicated to be in the category of R-1 to R-4.

4.2.4.2. Transportation and Utilities

Pine Lake is surrounded by major roads on three sides: north by SE 20th Street, east by 228th Avenue SE, and west by 212th Avenue SE. There are several minor collector streets that extend into the shoreline planning area and provide local access to residences on the shoreline. Runoff from these roads is not treated prior to discharge. Currently it is not known how much road runoff enters Pine Lake.

The Sammamish Plateau Water and Sewer District supplies sanitary sewer service and potable water service to residents in the Pine Lake planning area. Water and wastewater pipelines are located in, and cross, road right-of-way throughout the City of Sammamish. There are no mapped sewer or stormwater outfall locations on Pine Lake, but according to City staff there are outfalls present.

Septic systems (tanks and drainfields) can be a source of phosphorus loading to urban water bodies. In the Pine Lake shoreline planning area there are 207 parcels, including parks. Of these 159 parcels (74 percent) are on septic systems. At present, these systems are considered to be a relatively minor source of phosphorus in Pine Lake (Tetra Tech, 2006) and new development is not required to hook up to municipal sewer (depending on the specific location, sewer hookup is not available to all areas).

4.2.4.3. Shoreline Modifications

According to an informal shoreline field survey conducted by City staff 117 of the 207 parcels in the Pine Lake shoreline planning area, including parks, have docks. Eighty-five parcels have bulkheads, and 31 parcels have docks (Van Nostrand, personal communication 2006). For the purposes of this informal survey, a bulkhead was assumed to include any wall-like structure placed parallel to shore (at or near the OHWM) primarily for retaining fills and/or protecting upland areas from erosion or wave action. These numbers, which have not changed since 2002, indicate a highly modified shoreline. Most docks range in length from 30 to 50 feet.

4.2.5. Public Access – Pine Lake

One park, Pine Lake Park, provides public access to Pine Lake. It occupies a 19-acre site on the eastern side of the lake and makes up approximately 4 percent of the Pine Lake shoreline planning area (Map 8, Appendix A) (City of Sammamish, 2004). Pine Lake Park is owned and operated by the City of Sammamish and has approximately 550 feet of shoreline. Amenities at Pine Lake Park include barbecue grills, picnic tables, a swimming beach, a heavily used large dock with tables and benches, covered group picnic areas, nature trails, a Kiosk building with restroom and shower facilities, two play structures, soccer fields and softball/baseball fields. The swimming beach also has scheduled lifeguards on duty. Pine Lake Park offers one narrow boat ramp which is open during park hours. No combustion engines are permitted on Pine Lake per City ordinance # 0-2003-124. The City is planning to begin the second phase of Pine Lake Park development, including dock reconfiguration, beach shoreline work, and other development, starting in 2007. Access to the shoreline is also available via public street ends along the southern lobe of Pine Lake and along 29th street.

4.3. Beaver Lake

Beaver Lake includes 2.6 linear miles of shoreline encompassing three connected bodies of water that collectively form the lake (from east to west these are Beaver Lake 1, Beaver Lake 2 and Beaver Lake 3) . The shoreline on the north/west sides of the lake differs somewhat from the southern shoreline in that the northern shore includes several relatively large patches of forest. The most heavily forested (and least developed) areas of the lakeshore are along the north/northwest side of Beaver Lake 3, the western side of Beaver Lake 2 at its south end, and the northwest side of Beaver Lake 1.

4.3.1. Physical Environment and Water Quality – Beaver Lake

Beaver Lake is a relatively shallow lake (maximum depth of 55 feet) located at the eastern edge of the ELS basin. The three interconnected water bodies have a combined surface area of approximately 79 acres (Table 9; Map 10, Appendix A). The basin drains 1,184 acres and contains several unnamed streams and an abundance of high-quality wetland habitat. Beaver Lake is a popular recreational area and is used for swimming, fishing, picnicking, and observing wildlife.

Beaver Lake 1, which is the northeastern water body, is small and relatively deep for its size. The lakeshore is generally undeveloped and is directly connected to a large, high-quality wetland (ELS 21) by a small unnamed stream (0166). There is no public access to Beaver Lake 1, except by small boats from Beaver Lake 2. Beaver Lake 2 is by far the largest of the three water bodies. Its shoreline is almost exclusively comprised of residential properties and landscaping. This lake supports a variety of recreational activities, as a public park and boat launch are located on the southern end of the lake. Beaver Lake 3, located at the southwest end of the basin, is considerably smaller then the other two lakes in the system. Its surface area is only four acres and it is less then 10 feet deep in most areas (King County, 2000). Aquatic vegetation such as lilies, cattails and rushes are abundant throughout most of the open-water habitat in the lake.

Table 9 Physical Attributes of Beaver Lake

Attribute	Beaver Lake 1	Beaver Lake 2	Beaver Lake 3
Surface Area	13 acres	61.5 acres	4 acres
Lake Volume	271 acre-feet	1258 acre-feet	No data
Maximum Depth	55 feet	54 feet	No data
Average Depth	22 feet	21 feet	No data

Source: Beaver Lake Management Plan, King County, 2000

Only one unnamed intermittent stream (WRIA 0166D) provides inflow to Beaver Lake along the northwestern shoreline (King County, 1994). This tributary is associated with a large forested wetland (known as ELS 10) within the 116-acre Hazel Wolf Wetland Preserve, which constitutes the headwaters of the stream. The Preserve was established primarily to protect water quality in Beaver Lake and ELS 10 is considered one of the most pristine wetlands in King County (King County, 2000). Another high quality wetland (known as ELS 21), located immediately north of Beaver Lake 1, also drains directly into the lake. This bog is approximately 13 acres in size, has no surface water inputs, and is located directly to the east of the Beaver Lake Preserve. The

Preserve extends across Beaver Lake Road, and is bordered by the Hazel Wolf Wetland Preserve to the west

A second unnamed stream (WRIA 0166) is the major outflow of Beaver Lake discharging to Laughing Jacobs Creek (King County, 1994; King County 2000). The outflow location of this stream is at the southwest corner of the lake.

Beaver Lake is the focus of an intensive water quality monitoring program. Trained volunteers collect data on several water quality attributes including total phosphorus, chlorophyll, secchi depth (to measure transparency), bacteria levels, temperature dissolved oxygen and other attributes. The data are used to identify management practices designed to protect the water quality of the lake.

Beaver Lake's trophic state is intermediate between mesotrophic and eutrophic based on an average TSI[35] of 51.5 as measured in 2004 (King County, 2004). The TSI measurements may be slightly misleading since the values for transparency (determined based on secchi depth, a standard means of determining the transparency of water in a lake system) may be influenced by the color of the water. Lakes that receive inflow from bogs often have tea-colored water which affects transparency, but is not due to eutrophic conditions.

Beaver Lake typically becomes stratified in early summer when sunlight starts significantly warming surface waters. During the 2000 sampling year, minimum water temperatures were observed in February and maximum temperatures in late June.

Phosphorus is the limiting nutrient in Beaver Lake and is therefore a key factor in managing the lake quality. According to the Beaver Lake Management Plan, phosphorus levels in Beaver Lake 1 and Beaver Lake 2 have remained at similar levels over the three water years[36] between 1997 and 2000 (King County, 2000). However, higher surface concentrations were recorded for both lake basins during 1996-1997, possibly due to unusually high precipitation which increased surface runoff and therefore phosphorus input to the lakes. Currently, Beaver Lake 1 and Beaver Lake 2 are on Ecology's 2004 303(d) list as a Category 2 "waters of concern" for total phosphorus. Basin models show build-out will likely lead to increased phosphorus levels in coming years with greater impacts such as increased algae bloom frequency and diminished water clarity. Because of its smaller size, these effects are expected to be greater on Beaver Lake 1 than on Beaver Lake 2 (King County, 2000).

Dissolved oxygen levels in Beaver Lake generally remain good in the hypolimnion through June before finally dropping off to their lowest values in October. Fecal coliform counts at Beaver Lake also continue to be low, averaging less than 10 CFU/100 ml (King, County, 2000).

[35] TSI stands for Trophic State Index, which typically uses algal biomass as the basis for trophic state classification of a lake system.

[36] A *water year* is a 12-month period from October through the following September, which better describes the annual hydraulic cycle than a calendar year. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months.

Other key findings of the ongoing water quality monitoring program at Beaver Lake are as follows:

- Implementation of the most stringent stormwater treatment requirements standard in King County (after 1993 publication of Beaver Lake Management Plan) and preservation of wetland function has maintained water quality at levels relatively unchanged from the levels documented in the 1993 publication;
- Protection of wetland ELS 21 and its functions will be necessary to help protect Beaver Lake 1 from potential phosphorus impacts (ELS 21 is less protected than other basin wetlands, such as ELS 10, and efforts should be made to protect further encroachment and impacts to ELS 21);
- Development in the subbasin increases the likelihood of catastrophic erosion events that would impact water quality in the basin's streams, wetlands, and lakes; and
- Special efforts should be made to control erosion from recently cleared lands and other vulnerable areas.

4.3.2. Biological Resources – Beaver Lake

Beaver Lake provides habitat for a number of non-native warmwater species of fish, which are a considerable recreational attraction to the lake. These species include largemouth bass, yellow perch, pumpkinseed sunfish, and brown bullhead. Additionally, Beaver Lake is annually stocked with rainbow trout. According to the Washington Department of Fish and Wildlife's 2006 Hatchery Trout Stocking Plan, Beaver Lake received 10,000 adult rainbow trout along with 386 triploid (sterile) rainbow trout in the spring of 2006 (WDFW, 2006). Beaver Lake also supports a small population of resident cutthroat trout. Significant concentrations of waterfowl, including Canada geese, ruddy ducks and mallards, are also present within the vicinity of Beaver Lake and raptors such as bald eagles, ospreys and red-tailed hawks are routinely seen in the area (WDFW, 2006; King County, 2004). Additionally, the open water and shoreline habitat of Beaver Lake provides habitat for various species of frogs, salamanders and newts. Deer are also observed along the lakeshore. There is no anadromous fish use in Beaver Lake.

WDFW manages the lakeshore area for invasive plant species and periodically applies chemical herbicides. The last known spraying was August 2006 (Van Nostrand, personal communication, 2006).

The Hazel Wolf Wetland Preserve and adjoining Beaver Lake Preserve provide habitat for a variety of mammals, birds, reptiles and amphibians. Notable bird species that use the preserve include bald eagles, ospreys, great blue herons, mergansers and grebes (King County, 2000). Mammalian species such as beavers, muskrats, raccoons, bear and deer have also been documented within the Hazel Wolf Wetland Preserve area (Weinmann and Richter, 1999).

4.3.3. Cultural Resources – Beaver Lake

Shorelines are inherently rich in historic and prehistoric artifacts. The Muckelshoot and Snoqualmie tribes are known to have lived and traveled through the Sammamish region, including areas near Beaver Lake However, no known or prehistoric sites have been recorded in or near the Beaver Lake shoreline planning area. The Snoqualmie Tribe has installed story boards (similar to totem poles) and held a dance ceremony at Beaver Lake in 1988 and 1989. The park has a Native American theme with a large totem pole, Beaver carvings, and paintings with a longhouse appearance to the lodge.

4.3.4. Land Use and Other Alterations – Beaver Lake

Land use patterns are described in the context of existing land use, as well as planned or future land uses that are established by Comprehensive Plan land use designations and zoning designations.

4.3.4.1. Land Use

Land use in the Beaver Lake vicinity is transitioning from commercial forests and agriculture to suburban housing. In 1993, approximately 660 acres of the 1,100-acre watershed was in commercial forest uses. In 2000, approximately 462 acres remained as commercial forest. Under maximum build-out about 235 acres will remain, representing a 64 percent reduction from 1993 levels (King County, 2000).

Current land use in the Beaver Lake shoreline planning area is detached low-density single-family residences (4 dwelling units per acre). According to the City's comprehensive plan, there is no planned change in zoning in the Beaver Lake area. The single-family residences in the shoreline planning area are clustered around the lake and most lots are situated perpendicular to the water, so they have direct lake access. There appear to be relatively few undeveloped or vacant lots in the shoreline planning area. Single-family residential zoning (R4) makes up 85 percent of the shoreline planning area; Approximately 15 percent or 9.13 acres of this area is park land (designated Public/Institutional) (Table 10).

Using the ISCs developed by the OEHHA (2007) study, and the areas per land use category shown in Table 10, total impervious surface area within the Beaver Lake shoreline planning area is estimated to be approximately 35 percent.

Table 10 Beaver Lake - Shoreline Planning Area Land Use

Shoreline	Land Use	Approximate Size (Acres)	Approximate Percentage of City's Shoreline Planning Area
Beaver Lake	Residential (Areas zoned R4)	51.9	85%
	Public/Institutional	9.1	15%

4.3.4.2. Transportation and Utilities

Roads and other transportation infrastructure near or adjacent to water bodies can create adverse impacts to those natural systems by blocking flow or creating impervious surfaces. Roadways represent a significant source of impervious surface in urban areas. Auto-related pollutants including petroleum products, hydrocarbons, and heavy metals accumulate on road surfaces and are carried to nearby water bodies during storm events through sheet runoff or stormwater collection systems.

Beaver Lake is surrounded by a road located outside the shoreline planning area, with residential access provided by small residential streets. Traffic around Beaver Lake is assumed to be very light, primarily residents and park users. Road runoff is untreated and may discharge to Beaver Lake although the specific discharge areas are not mapped. City staff have stated that there are numerous stormwater outfalls in the vicinity.

Septic systems (tanks and drainfields) can be a large source of phosphorus loading to urban water bodies. The 2000 Beaver Lake Management Plan Update found 224 drainfields in the Beaver Lake watershed. Four percent of these were considered to be failing and causing excess phosphorus loading to Beaver Lake. In the shoreline planning area there are 137 parcels, of which 113 parcels are on septic systems (approximately 83 percent). New development is not required to hook up to municipal sewer, and depending on specific location sewer hookup is not available to all areas.

The SPWSD supplies sanitary sewer service and potable water service to residents in the Beaver Lake planning area. Water and wastewater pipelines are located in, and cross, road rights-of-way throughout the City of Sammamish. At this time there is no information on sewer or stormwater outfall locations on Beaver Lake, according to existing City and County GIS data.

4.3.4.3. Shoreline Modifications

Shoreline modification refers to structural changes to the shorelines' natural bank. Examples include shoreline armoring (bulkheads, riprap, etc.), overwater structures (dock and piers), or dredging and filling. The following assessment of the extent of shoreline modification is based on aerial photo interpretation and data on the presence of docks, provided by King County GIS as well as field reconnaissance. The data being analyzed are based on 2002 aerial photography and may not contain the most recent dock developments.

According to an informal field survey by City staff, 106 of the 137 parcels in the Beaver Lake shoreline planning area, including parks, have docks on Beaver Lake, 44 have bulkheads and 26 have docks (Van Nostrand, personal communication, 2006). For the purposes or this inventory, bulkhead was assumed to mean a wall-like structure placed parallel to shore (at or near the OHWM) for retaining uplands and protecting areas from erosion and wave action. Over 70 percent of the shoreline planning area parcels have docks present, which indicates a highly modified shoreline. Most docks range in length from 30 to 50 feet.

4.3.5. Public Access – Beaver Lake

Public access to the Beaver Lake shoreline is provided at three locations–Beaver Lake Park, Beaver Lake Preserve, and a WDFW-owned boat launch area (Map 8, Appendix A). Approximately 15 percent of the shoreline planning area is developed in parks or designated as open space.

Beaver Lake Park borders the shoreline planning area to the southwest. It is owned and operated by the City of Sammamish. Beaver Lake Park is approximately 83 acres in size and has approximately 2,000 feet of shoreline. Amenities at Beaver Lake Park include the Beaver Lake Lodge, barbecue grills, covered group picnic areas, play structures, and softball/baseball field (City of Sammamish 2004, 2006b). In addition, Beaver Lake Park features a 2,500-square-foot lodge, which has capacity for up to 260 people.

Beaver Lake Preserve is located on the northeast side of Beaver Lake. The City acquired the 54-acre property with the intent that it be maintained in a natural undeveloped state (City of Sammamish, 2006b). The Preserve provide opportunities for passive recreation such as hiking and bird watching, but preservation of native plants and animals is the highest priority. Currently, the City is partnering with Washington Trails Association (WTA) to build a 1.25-mile loop trail for visitors to explore the undeveloped forested wetland preserve (City of Sammamish 2006b).

The WDFW manages a public boat launch area directly across the lake from Beaver Lake Park. Only non-motorized boats or those with electric motors are allowed.

5.0 REACH SUMMARIES AND SHORELINE OPPORTUNITY AREAS

5.1. Lake Sammamish

5.1.1. Summary of Issues and Conditions

Key management issues for Lake Sammamish discussed in this section include:

- Effects of upland development on hydrology and sediment processes, primarily increased impervious surface;
- Water quality degradation related to altered water and sediment transport and increased contaminant inputs;
- Alteration of key habitat characteristics caused by shoreline modifications (docks, piers and bulkheads);
- Impacts of recreational activities on the lake; and
- Preservation of treaty-reserved fishing, hunting and gathering rights and the preservation of cultural resources dependant upon shorelines.

Increased residential and commercial development within the ELS basin and along the lakeshore, along with the necessary associated roadway infrastructure, has impaired several key ecological components of shoreline habitat. Increased impervious surface in upland areas has altered the intensity, timing, and duration of peak flows in many tributary streams in the basin. The short-circuiting of the natural drainage pathway that occurs when surface flows are concentrated rather than allowed to percolate has eroded the stream channels that drain the west slope of the plateau and increased their sediment transport capacity. Downstream habitat impacts at the mouth of these tributaries include reduced fish access due to channel incision, blocked culverts, buried spawning habitat, and localized flood and turbidity. These conditions have been exacerbated by the degradation and loss of headwater wetlands, which provided important water storage and nutrient cycling functions.

Water quality degradation is directly linked to the altered flow and sediment processes and to increase source inputs associated with urban land uses practices. Fine sediment is an effective transport vector for phosphorus, and the increased sediment inputs threaten the nutrient status of Lake Sammamish. The high percentage of homes on septic systems suggests that fecal coliform contamination may continue to be a problem in Lake Sammamish. Use of fertilizers for lawn maintenance along the lakeshore and on the plateau could trigger algal blooms during the summer months when the lake is highly stratified. This in turn could further decrease dissolve oxygen levels, which already create a limiting factor for salmon and other aquatic organisms.

Shoreline modifications are another significant concern along Lake Sammamish. The proliferation of residential docks, piers, and bulkheads along the lakeshore has reduced the quality and accessibility of rearing and migratory habitat for juvenile salmonids and other species. Much of the dense woody and emergent vegetation that once lined the Lake Sammamish shoreline has been replaced by structurally simple docks and piers causing a decrease in woody debris, overhanging vegetation, and detrital inputs. Docks and piers create artificial shading that reduces the amount of light available to phytoplankton and aquatic macrophytes, which can decrease primary productivity and ultimately reduce fish and invertebrate diversity (Kahler, 2001).

Bulkhead construction has also eliminated shoreline vegetation and displaced shallow-water refuge and foraging habitat for juvenile salmonids. Bulkheads can also change the slope, configuration, and/or substrate composition of the shoreline by cutting off upland sediment supply and increasing erosion on neighboring properties without bulkheads. In relatively low energy environments like Lake Sammamish, these effects tend to be localized, but they can still have adverse implications for aquatic habitat (Kahler, 2000).

Artificial shoreline structures alter natural predator-prey interactions and tend to create favorable conditions for predator fish species such as sculpin and smallmouth bass. Prey species require complex cover (such as brush piles, rootwads, and undercut banks) to avoid predators. In developed lakes, where natural cover has been replaced by artificial structures, prey species can become more vulnerable to ambush and other forms of predation. Some evidence suggests that predator species actually aggregate near piers and other structures. Kahler (2000) reported that unpublished data collected by the Muckleshoot Indian Tribe indicating that smallmouth bass were preferentially locating nests near residential piers in Lake Sammamish. Although the data on predator aggregation near piers is somewhat inconclusive, the fact that bass (especially smallmouth bass) thrive in lakes with developed shorelines while salmonids and other species decline suggests that predator species have an advantage over prey fish in structurally simple environments (Kahler, 2000).

Historically, docks and piers were constructed of chemically wood treated wood, which is a source of polycyclic aromatic hydrocarbons (PAHs) and heavy metals. These preservatives can leach into the water column and become toxic to aquatic organisms. The number of chemically-treated wooded docks on lake Sammamish is not known and it is expected that most new docks are constructed using alternative, less harmful materials such as metal.

There are additional adverse effects associated with dock, pier, bulkhead construction related to noise and pile driving. Noise and vibration caused by pile driving in marine environments has been shown to startle juvenile salmonids (Feist et al., 1996). These effects may also occur in lakes, although additional data on pile driving effects is needed.

Shore-spawning sockeye and kokanee salmon species in Lake Sammamish are especially susceptible to the construction of docks, piers, bulkheads (including skirted docks and piers) or any alterations that modify habitat structure, substrates, hydrology, water temperature, or water quality. Spawning areas can be degraded with sediment as scoured streambed material and fine sediment eroded from building sites and impervious surfaces are transported downstream to the lake. Vulnerable beach spawning areas include near-shore substrates that receive spring-fed upwelling, as well as alluvial fans at stream mouths. Although actual spawner numbers are unknown, shore spawning populations are believed to be declining (Parametrix, 2006).

No single form of shoreline modification is to blame for the loss of high quality aquatic habitat in lake Sammamish. Shoreline modifications occur in the context of urban development which creates a suite of physical, biological, chemical responses that occur at different scales of space and time. In summary, bulkheads, piers and docks can:

- Reduce primary productivity due to shading (docks);
- Alter predator-prey interactions in a manner that favors salmonid predators;
- Modify the physical configurations of the shore by disrupting sediment pathways, and causing erosion;
- Introduce toxic chemicals such as PAHs and heavy metals;
- Eliminate shallow water habitat which is an important migratory pathway for juvenile fish;
- Create noise and vibration, which can startle juvenile fish;
- Impact unmapped cultural resources, which are frequently found near lake and stream shorelines;
- Displace natural shoreline vegetation and reduce the organic inputs (terrestrial insects and detritus) to the lake; and
- Decrease shoreline habitat complexity due to loss of rootwads, overhanging vegetation and undercut banks.

Recreational use of Lake Sammamish creates additional challenges for maintaining ecological functions. Potential impacts include spreading exotic species of plants and plankton, noise impacts to fish and wildlife, increased wave energy and shoreline erosion, direct physical injury due to contact with people and watercraft, re-suspension of contaminated sediments and/or increased turbidity caused by propeller scour, and possible introduction of chemical pollutants from boat emissions.

Residential and associated shoreline modifications have the potential to impact cultural resources. These resources have typically been surveyed and mapped with higher frequency along the Lake Sammamish shoreline and, more generally along other lake and stream shorelines throughout the region.

5.1.2. Opportunities for Ecological Restoration/Conservation

Table 11 provides a summary of shoreline ecological functions for Lake Sammamish, causes of impairment, and the relative scale(s) at which impairments are occurring (e.g., watershed, basin City/PAA-wide, shoreline reach scale, or multiple scales). General or programmatic restoration and management opportunities to address impairments are also described.

Table 11 Summary of Shoreline Functions and Programmatic Restoration and Management Opportunities – Lake Sammamish

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration and Management Opportunities
Summer low flows in the East Lake Sammamish tributaries have declined. Causes include increased impervious area and increased stormwater runoff.	Basin scale	Hydrologic Hyporheic	• Protect groundwater and natural surface water sources to the lake. Restore wetlands. • Minimize impervious surface especially in areas of high infiltration (e.g., Inglewood and Laughing Jacobs subbasins).
Lake water quality is at risk due to inputs from septic systems, phosphorus, and altered sediment delivery from upstream areas.	Basin scale Reach scale	Hydrologic Hyporheic Water quality	• Encourage wise stewardship of shoreline properties to minimize inputs from lawns and other residential sources. • Implement BMPs to minimize erosion and sedimentation in upslope areas. • Limit the use of new septic systems.
The lack of lakeshore vegetation and riparian structure has decreased the habitat diversity, habitat quality, and reduced large woody debris and other forms of complex cover/structure.	Reach scale	Water quality Biological functions	• Provide/encourage native landscaping along the lakeshores, including forested riparian habitat wherever possible. • Promote development of natural in-water habitat structures such as downed trees/rootwads. • Minimize future removal of trees. • Educate property owners on the importance of the nearshore zone and general lakeside stewardship practices.
Docks, riprap and other hardshore armoring disrupt natural connections between the lake and riparian habitats. These structures also increase vulnerability of juvenile salmon to predation, as they provide cover to non-native species such as large and smallmouth bass.	Reach scale	Hydrologic Riparian habitats Biological function	• Discourage bulkhead and dock construction and promote replacement of armoring with soft shore alternatives. • Replant riparian habitats using native trees and shrubs.

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration and Management Opportunities
Increased surface water runoff from impervious surfaces delivers pollutants and sediment to the lake, which in turn adversely affects lake water quality. The potential causes of water quality impairment (i.e., contamination by fecal coliform and phosphorus loading) include leaking septic systems and animal wastes entering the watershed. Residential landscaping or other sources may be delivering increased nitrates, phosphorus and pesticides. Stormwater related pollutants may be the primary cause. Erosion and stream scouring caused by flash runoff from impervious surfaces.	Basin scale Reach scale	Hydrologic Water quality Riparian habitat	• Continue efforts in surface water quality improvement. • Manage, detain and treat stormwater discharging to the lake. • Coordinate with King County and adjacent cities to develop BMPs with existing property owners to reduce runoff and pollutant loading. • Protect and restore wetlands adjacent to the lake and in the upper basin that serve to improve water quality. • Target wetland restoration and mitigation in areas where they would provide water quality functions. • Encourage Low Impact Development and infiltration. • Retrofit existing roads to provide water quality treatment. • Limit the use of new septic systems.

5.1.2.1. Specific Ecological Restoration Opportunities

Enhancing natural shoreline vegetation and improving fish passage within tributary streams along the eastern shoreline of Lake Sammamish are among the most important restoration opportunities that currently exist within the shoreline planning area. Other opportunities include removing failing docks and bulkheads and/or replacing with softshore alternatives were possible.

With the exception of several small areas located on the northeastern shoreline, nearly all riparian habitat on the eastern shoreline of Lake Sammamish has been modified by single-family residential development. The relatively intact shorelines, which are located within a 0.25 mile north of Weber Point, have few modifications in the form of docks or bulkheads and contain significant numbers of mature conifers and cottonwoods. Bald eagles routinely use these areas for nesting and perching. Beaches in this area have natural gradients and substrates and considerable shoreline cover in the form of woody debris and riparian vegetation, providing excellent habitat for juvenile Chinook salmon. Preservation of these shoreline areas is addressed in the *Lake Washington/Cedar/Sammamish Watershed (WRIA 8) Chinook Salmon Conservation Plan* (King County et al., 2005) as important for the recovery of Chinook salmon within the watershed.

Repairing fish passage barriers within streams in the ELS basin should also be made a high priority. Man-made barriers occur on several salmonid-bearing streams within the City of Sammamish including George Davis Creek, Zaccuse Creek, and Ebright Creek. Removal of man-made barriers is often the most cost-effective method of increasing viable habitat for anadromous salmonids.

5.2. Pine Lake

5.2.1. Summary of Issues and Conditions

Preservation and improvement of water quality is the key management issue for Pine Lake. Development throughout the Pine Lake watershed has increased contaminant input and modified natural water quality processes. Increased impervious surface in upland areas as well as alteration and loss of wetland habitat around Pine Lake have eliminated areas for nutrient storage and cycling, and biotic uptake and altered the basin's natural water and sediment transport regimes. Under natural conditions, Pine Lake would have had very minimal sediment input, but road construction, residential development and changes in peak flow have increased sediment delivery to the lake, which leads to increased phosphorus input.

Preservation of existing woody vegetation along the lakeshore is a key issue for Pine Lake because the existing trees shelter the lake from wind mixing and reduce the potential for releasing phosphorus trapped in the hypolimnion into the epilimnion during the stratification period. Additionally implementation and enforcement of the CAO regulations pertaining to phosphorus retention are critical to ensuring good water quality in Pine Lake.

As with Lake Sammamish, residential and other forms of development, have the potential to impact cultural resources.

Many of the other issues described above for Lake Sammamish related to dock, pier, and bulkhead construction are pertinent to Pine Lake except that Pine Lake does not support salmonids.

5.2.2. Opportunities for Ecological Restoration/Conservation

Table 12 provides a summary of shoreline ecological functions for Pine Lake. Causes of impairment and the relative scale at which impairments are occurring (e.g., watershed, City/PAA-wide, shoreline reach scale, or multiple scales) are identified. Finally, general or programmatic restoration opportunities to address impairments are described.

5.2.2.1. Specific Ecological Restoration Opportunities

Nearly all shoreline habitat on Pine Lake has been modified by waterfront residences, many of which include docks, artificial shoreline substrates (gravel or beach sand) and mowed lawns. There are several small areas of natural shoreline habitat scattered around the lake that contain mature trees and dense vegetation, especially near the park on the eastern shoreline of the lake. The integrity of these natural shorelines should be preserved.

At Pine Lake, restoration opportunities include enhancement of lakeshore riparian areas with native vegetation, removal or replacement of failing docks, and protection of natural vegetation where present.

Since high phosphorus levels have been a chronic problem within the Pine Lake watershed, residents should be encouraged to provide buffer areas around landscaped areas and mowed lawns to provide an area in which phosphorus could be sequestered by native vegetation. Reducing phosphorus inputs will have positive implications for the water quality of Pine Lake, but could also benefit Pine Lake Creek, which is the major outflow of the lake. Downstream of Pine Lake, this stream supports spawning habitat for several species of salmonids. Additionally, information should be provided to educate residents on septic system maintenance, alternatives to phosphorus-based detergents, fertilizer alternatives, and oil and grease disposal.

Table 12 Summary of Shoreline Functions and Programmatic Restoration and Management Opportunities - Pine Lake

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration and Management Opportunities
Loss /disturbance of wetlands in the basin eliminates essential storage, recharge, or water quality improvement functions.	Watershed scale Reach scale	Hydrologic Hyporheic Water quality	• Encourage local wetland restoration and mitigation to increase storage, detention, and water quality functions. • Maintain connectivity of wetland areas to Pine Lake.
Loss of or a lack of woody vegetation allows for nearshore wind mixing and is detrimental to water quality.	Watershed scale Reach scale	Water quality Biological functions	• Provide/enhance native landscaping along the lakeshores, including forested riparian habitat • Minimize future removal of trees. • Educate property owners on the importance of the nearshore zone and general lakeside stewardship practices.
Docks, riprap and other hard shore armoring disrupt natural connections between the lake and riparian habitats.	Watershed scale Reach scale	Hydrologic Riparian habitats	• Discourage dock construction and promote replacement of armoring with softshore alternatives. • Require any new in-water structures to use non - chemically treated pilings • Replant riparian habitats using native trees and shrubs.
Surface water runoff from impervious surfaces delivers pollutants and sediment to the lake, which in turn adversely affects lake water quality. Potential causes of water quality impairment (i.e., contamination by fecal coliform and phosphorus loading) include leaking septic systems and animal wastes entering the watershed. Residential landscaping or other sources may be delivering increased nitrates, phosphorus and pesticides. Stormwater may be a primary cause.	Watershed scale Reach scale	Water quality	• Provide continued efforts in surface water quality improvement. • Manage, detain and treat stormwater discharging to the lake. • Implement and enforce CAO. • Protect adjacent wetlands that serve to improve water quality. Target wetland restoration and mitigation in areas where they would provide water quality functions. • Encourage Low Impact Development and infiltration. • Limit the use of new septic systems and require that no new subdivisions are on septic.

5.3. Beaver Lake

5.3.1. Summary of Issues and Conditions

Development throughout the Beaver Lake watershed has modified natural shoreline processes and many of the issue are similar to those described above for Pine Lake and Lake Sammamish. Restoration opportunities include enhancement of lakeshore riparian areas with native vegetation, removal or replacement of failing docks, and protection of natural vegetation where present.

As with the other lakes, residential and other forms of development, have the potential to impact cultural resources.

5.3.2. Opportunities for Ecological Restoration/Conservation

Table 13 provides a summary of shoreline ecological functions for Beaver Lake. Causes of impairment and the relative scale at which impairments are occurring (e.g., watershed, City/PAA-wide, shoreline reach scale, or multiple scales) are identified. Finally, general or programmatic restoration opportunities to address impairments are described.

To ensure the protection of Beaver Lake water quality, stringent measures should be undertaken to preserve the water quality function associated with wetland ELS 21.
The importance of this wetland for Beaver Lake water quality has been previously documented (King County, 1993a) and was discussed at length during a recent plat approval hearings for the Trossachs subdivision. As a condition of development, the Trossachs subdivision was required to amend their sandfilter treatment system with peat to ensure that wetland ELS 21 would not be adversely impacted by stormwater discharges from upland treatment ponds. Soil amendments alone, however, are not enough to ensure the preservation of Wetland ELS 21. Specific measures should be undertaken to protect and preserve the water quality functions provided by wetland ELS 21 (King County 2000). The Beaver Lake Management Plan (King County, 2000) identifies several additional recommendations for maintaining water quality and the ecological integrity of Beaver Lake, including:

- Acquire additional open space;
- Increase wetland and stream buffer size;
- Promote long-term land conservation via incentive programs;
- Enforce seasonal clearing and grading requirements;
- Enforce temporary erosion and sediment controls standards;
- Maintain AKART (all known, available, and reasonable methods of prevention, control, and treatment) standard for new development;
- Maintain stormwater facilities;
- Restore shoreline vegetation;
- Reduce lawn size and fertilizer use;
- Maintain properly functioning on-site septic systems;

- Reduce pet waste, car washing, and exposed soil; and
- Continue lake and stream monitoring.

Table 13 Summary of Shoreline Functions and Programmatic Restoration and Management Opportunities – Beaver Lake

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration and Management Opportunities
Wetland ELS 21 provides essential water quality and hydrologic protection for the lake.	Watershed scale Reach scale	Hydrologic Hyporheic Water quality	• Protect/restore this and other wetlands to provide storage, detention, and water quality functions. • Maintain connectivity of wetland areas to Beaver Lake.
Significant areas of natural vegetation exist along the north and west shores of the 3 water bodies. These areas provide habitat for a variety of wildlife species and protect the lake from disturbance.	Reach scale	Water quality Riparian habitats	• Preserve these areas of natural vegetation through buffer restrictions and other development restrictions to ensure habitat maintenance.
Docks, riprap and other hard shore armoring disrupt natural connections between the lake and riparian habitats.	Watershed scale Reach scale	Hydrologic Riparian habitats	• Require any new in-water structures to use non-chemically treated pilings. • Discourage new dock/bulkhead construction and promote replacement of armoring with softshore alternatives. • Replant riparian habitats using native trees and shrubs.
Surface water runoff from impervious surfaces delivers pollutants and sediment to the lake, which in turn adversely affects lake water quality. The potential causes of water quality impairment (i.e., contamination by fecal coliform and phosphorus loading) include leaking septic systems and animal wastes entering the watershed. Residential landscaping or other sources may be delivering increased nitrates, phosphorus and pesticides. Stormwater related pollutants (concentrated in urbanized areas including the City) may be the primary cause.	Watershed scale PAA wide Reach scale	Water quality Riparian habitat	• Provide continued efforts in surface water quality improvement. • Manage, detain and treat stormwater discharging to the lake. • Implement and enforce CAO. • Protect adjacent wetlands that serve to improve water quality. Target wetland restoration and mitigation in areas where they would provide water quality functions. • Encourage Low Impact Development and infiltration. • Limit the use of new septic systems.

5.3.2.1. Specific Restoration Opportunities

It is critical that the stewardship efforts of the Beaver Management District be supported, as recent implementation of more stringent developmental standards has already benefited water quality in Beaver Lake. Further development and armoring of shoreline habitat on Beaver Lake should be discouraged and natural shoreline habitat, such as the northeastern shoreline, should be preserved. Residents should be educated on such issues and encouraged to create a buffer of native vegetation between mowed lawns and shoreline habitat. Proper disposal of pet waste should also be encouraged, as it has been found that approximately 75 percent of residents in the area own cats and/or dogs (King County, 2000). Beaver Lake Park may be an appropriate place to promote such educational opportunities concerning lake stewardship.

6.0 USE ANALYSIS AND POTENTIAL CONFLICTS

The state shoreline guidelines require that local jurisdictions analyze current and projected shoreline use patterns and trends and identify potential conflicts (WAC 173-26-2013)(d)(ii)). Potential conflicts in this context are focused on competing objectives or planning priorities between the SMA policy intent and other interests or regulatory requirements affecting shoreline resources.

The previous sections of this report describe existing land use, public access, and the general pattern of development and infrastructure within the shoreline planning areas. The shoreline use pattern in Sammamish is well established and reflects a gradual trend from a semi-rural environment to a more urbanized area with increasing development and density. The shorelines of Lake Sammamish, Pine Lake and Beaver Lake are developed primarily for single-family residential use, with a small percentage of each lakeshore area devoted to parks and open space. There is relatively little undeveloped shoreline available for new subdivision or residential construction in Sammamish. Future development will likely include mainly redevelopment of existing parcels.

One area that may experience increased development is the southwest corner of the Pine Lake planning area. This area is designated as R1-4 indicating it can be developed at densities between 1 and 4 dwelling units per acre. The current development pattern is mainly large lot, low density residential, so increased density can be expected in the future. The affected area is relatively limited, comprising a very small percentage of the shoreline planning area, but it coincides with known wetlands and Kanim Creek. The effects of additional densification in this area could include increased impervious surface, critical area buffer reduction and/or other ecological impacts. Assuming this new development occurs in accordance with existing regulations addressing stormwater management and critical area protection, there should be no major conflicts with the goals of the SMP.

Residential use is consistent with the projected use as indicated by the City's Comprehensive Plan and zoning regulations. Single-family residential use is a priority use according to the SMA (RCW 90.58.020), when developed in a manner consistent with control of pollution and prevention of damage to the natural environment.

The City has no plans and there does not appear to be a need for other types of priority shoreline uses such as water-dependent port, industrial or commercial uses. Accommodating other priority shoreline uses would potentially be problematic in Sammamish because:

- These types of uses would potentially conflict with the existing residential character of the Lake Sammamish, Pine Lake and Beaver Lake shorelines and would be inconsistent with zoning and Comprehensive Plan designations.
- Water-dependent port, industrial or commercial uses would potentially cause greater ecological harm to the City's lakes because they typically require extensive infrastructure (parking, utilities, etc), involve in-water/over-water structures, are located immediately

adjacent to the shore (as opposed to being set-back), and often create noise and other types of secondary impacts.

- Pine and Beaver lakes are relatively small, and accessible only via residential streets. Use of watercraft on these lakes is limited by existing City regulations: only non-motorized or electric boats are allowed on Pine and Beaver Lakes and commercial watercraft are prohibited on all City lakes.

Future shoreline use in Sammamish is expected to involve increased recreational use of the City's existing parks including Pine Lake Park, Beaver Lake Park and Beaver Lake Preserve, and the still-to-be-developed Sammamish Waterfront Park. There is growing demand to accommodate additional water-oriented recreation in this areas and the City is planning to provide additional infrastructure and services (including possibly docks/floats) to support the anticipated visitor use. The increased use is consistent with the City Comprehensive Plan, Parks, Recreation and Open Space Plan and matches the SMA policy goal of providing public access to the shoreline and accommodating water-oriented recreation. As long as appropriate and required measures are implemented to protect water quality, the increased recreational use should not create a conflict with the policy goals of the Act.

In summary, the existing and planned uses are consistent with the SMA and with other existing plans and programs and no significant use conflicts are anticipated.

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APPENDIX A
MAP FOLIO

APPENDIX B
GLOSSARY OF TERMS

A

“Adfluvial fish” means fish species that spend most of their lifecycle in a lacustrine environment, but return to rivers and streams to reproduce.

“Administrator or Shorelines Administrator ” means the Director of the Community Development Department who is to carry out the administrative duties enumerated in this Program, or his/her designated representative.

“Advance outwash sands” means a soil type deposited as glacial ice receded from the Puget Sound lowlands which are typically highly permeable and generally contain significant amounts of groundwater

“Adverse impact” means an impact that can be measured or is tangible and has a reasonable likelihood of causing moderate or greater harm to ecological functions or processes or other elements of the shoreline environment.

"Alluvium" means a general term for clay, silt, sand, gravel, or similar other unconsolidated detrital materials, deposited during comparatively recent geologic time by a stream or other body of running water, as a sorted or semi-sorted sediment in the bed of the stream or on its floodplain or delta.

“Alteration” means any human induced change in an existing condition of a shoreline, critical area and/or its buffer. Alterations include, but are not limited to grading, filling, channelizing, dredging, clearing (vegetation), draining, construction, compaction, excavation, or any other activity that changes the character of the area.

"Anadromous fish" means fish species that spend most of their lifecycle in saltwater, but return to freshwater to reproduce.

“Appurtenance” means development that is necessarily connected to the use and enjoyment of a single-family residence.

“Archaeological Object” means an object that comprises the physical evidence of an indigenous and subsequent culture including material remains of past human life including monuments, symbols, tools, facilities, graves, skeletal remains and technological byproducts.

“Archaeology” means systematic, scientific study of the human past through time.

“Armoring” means the addition of hard structures or hardened material along the shoreline to decrease the impact of waves and currents or to prevent the erosion of banks or bluffs.

"Associated Wetlands" means wetlands that are in proximity to tidal waters, lakes, rivers or streams that are subject to the Shoreline Management Act and either influence or are influenced by are such waters. Factors used to determine proximity and influence include but are not limited to: location contiguous to a shoreline waterbody, formation by tidally influenced geo-hydraulic processes, presence of a surface connection including through a culvert or tide gate, location in part or whole within the 100 year floodplain of a shoreline, periodic inundation, and/or hydraulic continuity.

B

“Bedlands” means those submerged lands below the line of navigability of navigable lakes and rivers.

"Bedrock" means a general term for rock, typically hard, consolidated geologic material that underlies soil or other unconsolidated, superficial material or is exposed at the surface.

"Best management practices" means conservation practices or systems of practices and management measures that:

- Control soil loss and reduce water quality degradation caused by nutrients, animal waste, toxins, and sediment;
- Minimize adverse impacts to surface water and ground water flow, circulation patterns, and to the chemical, physical, and biological characteristics of waters, wetlands, and other fish and wildlife habitats;
- Control site runoff, spillage or leaks, sludge or water disposal, or drainage from raw material.

“Bioengineered shoreline stabilization” means biostructural and biotechnical alternatives to hardened structures (bulkheads, walls) for protecting slopes or other erosive features. Bioengineered stabilization uses vegetation, geotextiles, geosynthetics and similar materials. An example is Vegetated Reinforced Soil Slopes (VRSS), which uses vegetation arranged and imbedded in the ground to prevent shallow-mass movement and surficial erosion.

“Boathouse” means any roofed and enclosed structure built onshore or offshore for storage of watercraft or floatplanes.

"Boat Lift" is an in-water structure used for the dry berthing of vessels above the water level and lowering of vessels into the water periodically. A boat lift as herein defined is used to berth and launch a single vessel, suspended over the water's surface. A boat lift is generally a manufactured unit without a canopy cover and may be placed in the water adjacent to a dock or as stand-alone structure. A boat lift may be designed either for boats or personal watercraft. A boat lift is to be differentiated from a hoist or crane used for the launching of vessels.

“Bog” means a type of wetland dominated by mosses that form peat. Bogs are very acidic, nutrient poor systems, fed by precipitation rather than surface inflow, with specially adapted plant communities.

"Buffer (buffer zone)" means the area adjacent to a shoreline and/or critical area that separates and protects the area from adverse impacts associated with adjacent land uses.

“Building” means any structure used or intended for supporting or sheltering any use or occupancy as defined in the International Building Code.

“Bulkhead” means a wall-like structure such as a revetment that is placed at or near the ordinary high water mark and parallel to shore primarily for retaining uplands and fills prone to sliding or sheet erosion, and to protect uplands and fills from erosion by wave action.

C

“Candidate” means under a species consideration for listing as threatened or endangered under the US Endangered Species Act, indicating that there is a possibility that the species has potential to be at risk of becoming endangered in the foreseeable future.

“Channelization” means the straightening, relocation, deepening or lining of stream channels, including construction of continuous revetments or levees for the purpose of preventing gradual, natural meander progression.

“Chemicals” mean any synthetic substance or mixture of such substances used for a fertilizer, herbicide, pesticide, insecticide, or rodenticide.

“Clearing” means the removal of vegetation or plant cover by manual, chemical, or mechanical means. Clearing includes, but is not limited to, actions such as cutting, felling, thinning, flooding, killing, poisoning, girdling, uprooting, or burning.

“Commercial Development” means those primarily used for retail, service or wholesale trade or other commercial business activities. Included in this definition are hotels, motels, bed and breakfast establishments, shops, restaurants, banks, professional offices, grocery stores, laundromats, recreational vehicle parks, commercial rental campgrounds and cabins, whether public or private, and indoor or intensive outdoor commercial recreation facilities. Not included are private camping clubs, marinas, signs, utilities and other development.

"Conservation" means the prudent management of rivers, streams, wetlands, wildlife and other environmental resources in order to preserve and protect them. This includes the careful use of natural resources to prevent depletion or harm to the environment.

“Conservation easement” means a legal agreement that the property owner enters into to restrict uses of the land for purposes of natural resources conservation. The easement is recorded on a property deed, runs with the land, and is legally binding on all present and future owners of the property.

"Contaminant" means any chemical, physical, biological, or radiological substance that does not occur naturally in ground water, air, or soil or that occurs at concentrations greater than those in the natural levels (Chapter 172-200 WAC).

“County” means King County, Washington.

“Critical aquifer recharge area” means areas designated by SMC 21A.50 that are determined to have a critical recharging effect on aquifers (i.e., maintain the quality and quantity of water) used for potable water as defined by WAC 365-190-030(2).

“Critical area report” means a report prepared by a qualified professional or qualified consultant based on Best Available Science, and the specific methods and standards for technical study required for each applicable critical area. Geotechnical reports and hydrogeological reports are critical area reports specific to geologically hazardous areas and critical aquifer recharge areas, respectively.

"Critical areas" The following areas as designated in the Chapter 21A.50 of the City’s code:

- Critical Aquifer Recharge Areas
- Wetlands
- Geologically Hazardous Areas

- Frequently Flooded Areas
- Fish and Wildlife Habitat Conservation Areas

“Critical habitat” means habitat areas with which endangered, threatened, sensitive or monitored plant, fish, or wildlife species have a primary association (e.g., feeding, breeding, rearing of young, migrating). Such areas are identified herein with reference to lists, categories, and definitions promulgated by the Washington Department of Fish and Wildlife as identified in WAC 232-12-011 or 232-12-014; in the Priority Habitat and Species (PHS) program of the Department of Fish and Wildlife; or by rules and regulations adopted by the U.S. Fish and Wildlife Service, National Marine Fisheries Service, or other agency with jurisdiction for such designations.

D

"Deepwater habitats" means permanently flooded lands. Deepwater habitats include environments where surface water is permanent and often deep, so that water, rather than air, is the principal medium in which the dominant organisms live. The boundary between wetland and deepwater habitat in the riverine and lacustrine systems lies at a depth of two meters (6.6 feet) below low water; however, if emergent vegetation, shrubs, or trees grow beyond this depth at any time, their deepwater edge is the boundary.

"Delineation" means the precise determination of wetland boundaries in the field according to the application of the specific method described in the 1997 Washington State Wetland Delineation manual and/or the, Corps of Engineers Wetlands Delineation Manual 1987 Edition, as amended.

“Developable Area” means the portion of a parcel devoted to construction of a building to accommodate an allowed use, together with access facilities, appurtenances, landscaping, and other associated features.

Development” means a use consisting of the construction or exterior alteration of structures, dredging, drilling, dumping, filling; removal of any sand, gravel or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature that interferes with the normal public use of the surface of the waters overlying lands subject to the Act at any state of water level. This term includes subdivision and short subdivisions; binding site plans; planned unit developments; variances; shoreline substantial development; clearing activity; fill and grade work; activity conditionally allowed; building or construction; revocable encroachment permits; and septic approval and both exempt and substantial developments.

“Dock” means all platform structures or anchored devices in or floating upon water bodies to provide moorage for pleasure craft or landing for water-dependent recreation including but not limited to floats, swim floats, float plane moorages, and water ski jumps. Excluded are launch ramps.

E

“Ecological Functions” or ”Shoreline Functions” means the work performed or role played by the physical, chemical, and biological processes that contribute to the maintenance of the aquatic and terrestrial environments that constitute the shoreline's natural ecosystem. See WAC 173-26-200 (2)(c). Functions include, but are not limited to, habitat diversity and food chain support for fish and wildlife, ground water recharge and discharge, high primary productivity, low flow stream water contribution, sediment stabilization and erosion control, storm and flood water attenuation and flood peak desynchronization, and water quality enhancement through biofiltration and retention of sediments, nutrients, and toxicants. These beneficial roles are not listed in order of priority.

“Ecosystem Processes”, or “Ecosystem-wide processes” means the suite of naturally occurring physical and geologic processes of erosion, transport, and deposition; and specific chemical processes that shape landforms within a specific shoreline ecosystem and determine both the types of habitat and the associated ecological functions.

"Emergent wetland" means a wetland with at least thirty percent (30%) of the surface area covered by erect, rooted, herbaceous vegetation as the uppermost vegetative strata.

“Endangered” means listed and protected under the US Endangered Species Act, indicating that the described species is in danger of extinction throughout all or a significant portion of its range.

“Enhancement” means actions performed within an existing degraded shoreline, critical area and/or buffer to intentionally increase or augment one or more functions or values of the existing area. Enhancement actions include, but are not limited to, increasing plant diversity and cover, increasing wildlife habitat and structural complexity (snags, woody debris), installing environmentally compatible erosion controls, or removing nonindigenous plant or animal species.

“Epilimnion” means the top-most layer of the lake water column, above the hypolimnion. It is warmer and typically has a higher pH and dissolved oxygen concentration than the hypolimnion. Being at the surface, it subject to surface wind-mixing.

“Erosion” means a process whereby wind, rain, water and other natural agents mobilize, and transport, and deposit soil particles.

“Erosion hazard areas” means lands or areas underlain by soils identified by the U.S. Department of Agriculture Natural Resource Conservation Service (NRCS) as having “severe” or “very severe” erosion hazards and areas subject to impacts from lateral erosion related to moving water such as river channel migration and shoreline retreat.

“Eutrophic” means having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms.

“Excavation” means the disturbance, displacement and/or disposal of unconsolidated earth material such as silt, sand, gravel, soil, rock or other material from all areas landward of OHWM.

"Exotic" means any species of plants or animals that is not indigenous to the area.

F

“Fill material” means any solid or semi-solid material, including rock, sand, soil, clay, plastics, construction debris, wood chips, overburden from mining or other excavation activities, and materials used to create any structure or infrastructure, that when placed, changes the grade or elevation of the receiving site.

"Filling" means the act of transporting or placing by any manual or mechanical means fill material from, to, or on any soil surface, including temporary stockpiling of fill material.

"Fish and wildlife habitat conservation areas" are areas important for maintaining species in suitable habitats within their natural geographic distribution so that isolated populations are not created, as designated in SMC 21A.50.

"Fish habitat" means a complex of physical, chemical, and biological conditions that provide the life supporting and reproductive needs of a species or life stage of fish. Although the habitat requirements of a species depend on its age and activity, the basic components of fish habitat in rivers, streams, ponds, and nearshore areas include, but are not limited to, the following:

- Clean water and appropriate temperatures for spawning, rearing, and holding;
- Adequate water depth and velocity for migrating, spawning, rearing, and holding, including off-channel habitat;
- Abundance of bank and instream structures to provide hiding and resting areas and stabilize stream banks and beds;
- Appropriate substrates for spawning and embryonic development. For stream and lake dwelling fishes, substrates range from sands and gravel to rooted vegetation or submerged rocks and logs. Generally, substrates must be relatively stable and free of silts or fine sand;
- Presence of riparian/nearshore vegetation as defined in this article. Riparian vegetation creates a transition zone, which provides shade, and food sources of aquatic and terrestrial insects for fish;
- Unimpeded passage (i.e. due to suitable gradient and lack of barriers) for upstream and downstream migrating juveniles and adults.

"Fisheries" means all species of fish and shellfish commonly or regularly originating or harvested commercially or for sport in Lake Sammamish and its tributary freshwater bodies, together with the aquatic plants and animals and habitat needed for continued propagation and growth of such species.

"Fisheries Enhancement" means actions taken to rehabilitate, maintain or create fisheries habitat, including but not limited to hatcheries, spawning channels, lake rehabilitation, planting of fisheries stocks.

"Float" means a floating platform similar to a dock that is anchored or attached to pilings.

"Flood or Flooding" mean a general and temporary condition of partial or complete inundation of normally dry land areas from the overflow of inland waters and/or the unusual and rapid accumulation of runoff of surface waters from any source.

"Floodplain, FEMA" means all lands along a river or stream that may be inundated by the base flood of such river or stream.

"Floodplain Management" means a long term program to reduce flood damages to life and property and to minimize public expenses due to floods through a comprehensive system of planning, development regulations, building standards, structural works, and monitoring and warning systems.

“Food Chain” means the hierarchy of feeding relationships between species in a biotic community. The food chain represents the transfer of material and energy from one species to another within an ecosystem.

“Forest Land” means all land that is capable of supporting a merchantable stand of timber and is not being actively used, developed, or converted in a manner that is incompatible with timber production.

“Forest Practices” mean any activity conducted on or directly pertaining to forest land and relating to growing, harvesting, or processing of timber; including, but not limited to: (1) road and trail construction; (2) fertilization; (3) prevention and suppression of diseases and insects; or other activities that qualify as a use or development subject to the Act. Excluded from this definition is preparatory work such as tree marking, surveying and removal of incidental vegetation such as berries, greenery, or other natural products whose removal cannot normally be expected to result in damage to shoreline natural features. Also excluded from this definition is preparatory work associated with the conversion of land for non-forestry uses and developments. Log storage away from forest land is considered under Industry.

“Frequently flooded areas” means lands in the floodplain subject to a one percent (1%) or greater chance of flooding in any given year and those lands that provide important flood storage, conveyance and attenuation functions, as determined by the County in accordance with WAC 365-190-080(3). Classifications of frequently flooded areas include, at a minimum, the 100-year floodplain designations of the Federal Emergency Management Agency and the National Flood Insurance Program, as designated in SMC 21A.50.

“Function assessment or Functions and values assessment” mean a set of procedures, applied by a qualified consultant, to identify the ecological functions being performed in a shoreline or critical area, usually by determining the presence of certain characteristics, and determining how well the area is performing those functions. Function assessments can be qualitative or quantitative and may consider social values potentially provided by area. Function assessment methods must be consistent with Best Available Science.

G

"Game fish" means those species of fish that are classified by the Washington Department of Fish and Wildlife as game fish (WAC 232-12-019).

"Geologically hazardous areas" means areas designated in SMC 21A.50that, because of their susceptibility to erosion, sliding, earthquake, or other geological events, pose unacceptable risks to public health and safety and may not be suited to commercial, residential, or industrial development.

“Geologically Unstable” means the relative instability of a shoreform or land form for development purposes over the long term or the intended life of any proposed structure. Soil, slope, ground or surface water, other geologic conditions, vegetation and effects of development are common factors that contribute to instability. Areas characterized by banks or bluffs composed of unconsolidated alluvial or glacial deposits (till and drift material), severely fractured bedrock, active and substantial erosion, substantially deformed trees and shrubs, or active or inactive earth slides are likely to be considered geologically unstable.

“Geotechnical Report” or ”Geotechnical Analysis” means a scientific study or evaluation conducted by a qualified professional that includes a description of the ground and surface hydrology and geology, the affected land form and its susceptibility to mass wasting, erosion, and other geologic hazards or processes, conclusions and recommendations regarding the effect of the proposed development on geologic conditions, the adequacy of the site to be developed, the impacts of the proposed development, alternative approaches to the proposed development, and measures to mitigate potential site-specific and cumulative geological and hydrological impacts of the proposed development, including the potential adverse impacts to adjacent and down-current properties. Geotechnical reports shall conform to accepted technical standards.

"Gradient" means a degree of inclination, or a rate of ascent or descent, of an inclined part of the earth's surface with respect to the horizontal; the steepness of a slope. It is expressed as a ratio (vertical to horizontal), a fraction (such as meters/ kilometers or feet/miles), a percentage (of horizontal distance), or an angle (in degrees).

“Grading" means the movement or redistribution of the soil, sand, rock, gravel, sediment, or other material on a site in a manner that alters the natural contour of the land.

"Ground water" means all water that exists beneath the land surface or beneath the bed of any stream, lake or reservoir, or other body of surface water within the boundaries of the state, whatever may be the geological formation or structure in which such water stands or flows, percolates or otherwise moves (Chapter 90.44 RCW).

“Growth Management Act” means RCW 36.70A, and 36.70B, as amended.

H

“Hazardous Area” means any shoreline area which is hazardous for intensive human use or structural development due to inherent and/or predictable physical conditions; such as but not limited to geologically hazardous areas, frequently flooded areas, and coastal high hazard areas.

“Hazardous Materials” means any substance containing such elements or compounds which when discharged in any quantity in shorelines present an imminent and/or substantial danger to public health or welfare; including, but not limited to: fish, shellfish, wildlife, water quality, and other shoreline features and property.

“Hazardous substance” means any liquid, solid, gas, or sludge, including any material, substance, product, commodity, or waste, regardless of quantity, that exhibits any of the physical, chemical or biological properties described in WAC 173-303-090 or 173-303-100.

“Historic Site” means those sites that are eligible or listed on the Washington Heritage Register, National Register of Historic Places or any locally developed historic registry formally adopted by the Sammamish City Council.

“Hydric soil” means a soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions in the upper part. The presence of hydric soil shall be determined following the methods described in the Washington State Wetland Identification and Delineation Manual (RCW 36.70A.175).

"Hydrologic soil groups" means soils grouped according to their runoff-producing characteristics under similar storm and cover conditions. Properties that influence runoff potential are depth to seasonally high water table, intake rate and permeability after prolonged wetting, and depth to a low permeable layer. Hydrologic soil groups are normally used in equations that estimate runoff from rainfall, but can be used to estimate a rate of water transmission in soil. There are four hydrologic soil groups:

- Low runoff potential and a high rate of infiltration potential;
- Moderate infiltration potential and a moderate rate of runoff potential;
- Slow infiltration potential and a moderate to high rate of runoff potential; and
- High runoff potential and very slow infiltration and water transmission rates.

"Hydrophytic vegetation" means macrophytic plant life growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content.

"Hyporheic zone" means the saturated zone located beneath and adjacent to streams that contain some proportion of surface water from the surface channel mixed with shallow groundwater. The hyporheic zone serves as a filter for nutrients, as a site for macroinvertebrate production important in fish nutrition and provides other functions related to maintaining water quality.

"Hypolimnion" means the bottom and most dense layer of water in a thermally-stratified lake. It is the layer that lies below the thermocline. Typically the hypolimnion is the coldest layer in the summer and the warmest during winter. It is isolated from surface wind-mixing and is does not receive enough incoming light for photosynthesis to occur.

I

"Impervious surface" means a hard surface area that either prevents or retards the entry of water into the soil mantle as under natural conditions prior to development or that causes water to run off the surface in greater quantities or at an increased rate of flow compared to natural conditions prior to development. Common impervious surfaces may include, but are not limited to, roof tops, walkways, patios, driveways, parking lots or storage areas, concrete or asphalt paving, gravel roads, packed earthen materials, and oiled macadam or other surfaces which similarly impede the natural infiltration of storm water. Impervious surfaces do not include surface created through proven low impact development techniques.

"Infiltration" means the downward entry of water into the immediate surface of soil.

"Invasive species" means a species that is 1) non-native (or alien) to King County and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

L

"Lake" means a body of standing water in a depression of land or expanded part of a stream, of twenty acres or greater in total area. A lake is bounded by the OHWM, or where a stream enters the lake, the extension of the lake's OHWM within the stream. Wetland areas occurring within the standing water of a lake are to be included in the acreage calculation of a lake.

"Landslide" means a general term covering a wide variety of mass movement landforms and processes involving the downslope transport, under gravitational influence of soil and rock material en masse; included are debris flows, debris avalanches, earthflows, mudflows, slumps, mudslides, rock slides, and rock falls.

“Landslide hazard areas” means areas that, due to a combination of site conditions like slope inclination and relative soil permeability are susceptible to mass wasting.

“Launch Ramp” means an inclined slab, set of pads, rails, planks, or graded slope used for launching boats with trailers or occasionally by hand.

“Levee” means a natural or artificial embankment on the bank of a stream for the purpose of keeping floodwaters from inundating adjacent land. Some levees have revetments on their sides.

“Lot” means land described by final plat, short plat or metes and bounds description and is established pursuant to applicable state and local regulations in effect at the date a legal instrument creating the lot is recorded at the County auditor’s office.

M

"Maintenance and repair" means work required to keep existing improvements in their existing operational state. This does not include any modification that changes the character, scope, or size of the original structure, facility, utility or improved area.

“Marsh” means a low flat wetland area on which the vegetation consists mainly of herbaceous plants such as cattails, bulrushes, tules, sedges, skunk cabbage or other hydrophytic plants. Shallow water usually stands on a marsh, at least during part of the year.

“Mass wasting” means downslope movement of soil and rock material by gravity. This includes soil creep, erosion, and various types of landslides, not including bed load associated with natural stream sediment transport dynamics.

"Mean annual flow" means the average flow of a river, or stream (measured in cubic feet per second) from measurements taken throughout the year. If available, flow data for the previous ten (10) years should be used in determining mean annual flow.

“Mesotrophic” is a lake classification describing middle-aged bodies of water; between oligotrophic (young) and eutrophic (old) classifications. A body of water having a moderate amount of dissolved nutrients.

"Mitigation" means individual actions that may include a combination of the following measures, listed in order of preference:

- Avoiding an impact altogether by not taking a certain action or parts of actions;
- Minimizing impacts by limiting the degree or magnitude of an action and its implementation;
- Rectifying impacts by repairing, rehabilitating, or restoring the affected environment;
- Reducing or eliminating an impact over time by preservation and maintenance operations during the life of the action;

- Compensating for an impact by replacing or providing substitute resources or environments; and
- Monitoring the mitigation and taking remedial action when necessary.

“Monitoring” means evaluating the impacts of development proposals over time on the biological, hydrological, pedological, and geological elements of such systems and/or assessing the performance of required mitigation measures throughout the collection and analysis of data by various methods for the purpose of understanding and documenting changes in natural ecosystems and features, and includes gathering baseline data.

N

"Native vegetation" means plant species that are indigenous to the King County and the local area.

“No net loss” means the maintenance of the aggregate total of the City’s shoreline ecological functions. The no net loss standard requires that the impacts of shoreline development and/or use, whether permitted or exempt, be identified and mitigated such that there are no resulting adverse impacts on ecological functions or processes. Each project shall be evaluated based on its ability to meet the no net loss goal.

O

“Oil” means petroleum or any petroleum product in liquid, semi-liquid, or gaseous form including but not limited to crude oil, fuel oil, sludge, oil refuse and oil mixed with wastes other than dredging spoil.

“Oligotrophic” means lacking in plant nutrients and having a large amount of dissolved oxygen throughout.

“Open Space” means any parcel or area of land or water not covered by structures, hard surfacing, parking areas and other impervious surfaces except for pedestrian or bicycle pathways, and set aside/dedicated, for active or passive recreation, visual enjoyment or critical area buffers.

“Ordinary High Water Mark” or “OHWM” on all lakes and streams means that mark that will be found by examining the bed and banks and ascertaining where the presence and action of waters are so common and usual, and so long continued in all ordinary years, as to mark upon the soil a character distinct from that of the abutting upland, in respect to vegetation as that condition exists on June 1, 1971, as it may naturally change thereafter, or as it may change thereafter in accordance with approved development; provided that, in any area where the OHWM cannot be found, the OHWM adjoining fresh water shall be the line of mean high water. For braided streams, the OHWM is found on the banks forming the outer limits of the depression within which the braiding occurs.

P

"Pond" means an open body of water, generally equal to or greater than 6.6 feet deep, that persists throughout the year and occurs in a depression of land or expanded part of a stream and has less than thirty percent (30%) aerial coverage by trees, shrubs, or persistent emergent vegetation. Ponds are generally smaller than lakes

"Pool / riffle" means an area of stream or river habitat, in which a pool is where water flows through the channel without any change in surface gradient and a riffle is where water flows through the channel at a higher velocity with a moderate gradient.

"Potable" means water that is suitable for drinking by the public (Chapter 246-290 WAC).

"Preservation" means actions taken to ensure the permanent protection of existing, ecologically important areas that the City has deemed worthy of long term protection.

"Priority habitat" means a habitat type with unique or significant value to one or more species. An area classified and mapped as priority habitat must have one or more of the following attributes: Comparatively high fish or wildlife density; comparatively high fish or wildlife species diversity; fish spawning habitat; important wildlife habitat; important fish or wildlife seasonal range; important fish or wildlife movement corridor; rearing and foraging habitat; refuge; limited availability; high vulnerability to habitat alteration; unique or dependent species; or shellfish bed. A priority habitat may be described by a unique vegetation type or by a dominant plant species that is of primary importance to fish and wildlife (such as oak woodlands or eelgrass meadows). A priority habitat may also be described by a successional stage (such as, old growth and mature forests). Alternatively, a priority habitat may consist of a specific habitat element (such as talus slopes, caves, snags) of key value to fish and wildlife. A priority habitat may contain priority and/or non-priority fish and wildlife (WAC 173-26-020(24)).

"Priority species" means wildlife species of concern due to their population status and their sensitivity to habitat alteration, as defined by the Washington Department of Fish and Wildlife.

"Public Access" means the public's right to get to and use the State's public waters, the water/land interface and associated shoreline area. It includes physical access that is either lateral (areas paralleling the shore) or perpendicular (an easement or public corridor to the shore), and/or visual access facilitated by scenic roads and overlooks, viewing towers and other public sites or facilities.

R

"Reach" means a segment of shoreline and associated planning area that is mapped and described as a unit (for purposes of inventorying conditions) due to homogenous characteristics that include land use and/or natural environment characteristics.

"Recharge" means the process involved in the absorption and addition of water from the unsaturated zone to ground water.

"Recreation" means an experience or activity in which an individual engages for personal enjoyment and satisfaction. Most shore-based recreation outdoor recreation such as: fishing, hunting, clamming, beach combing, and rock climbing; various forms of boating, swimming, hiking, bicycling, horseback riding, camping, picnicking, watching or recording activities such as photography, painting, bird watching or viewing of water or shorelines, nature study and related activities.

"Recreational Development" means the modification of the natural or existing environment to accommodate recreation. This includes clearing land, earth modifications, structures and other facilities such as parks, camps, camping clubs, launch ramps, golf courses, viewpoints, trails, public access facilities, public parks and athletic fields, hunting blinds, wildlife enhancement (wildlife ponds are considered excavation), and other low intensity use outdoor recreation areas. Recreational homes and related subdivisions of land are considered residential; resorts, motels, hotels, recreational vehicle parks, intensive commercial outdoor or indoor recreation and other commercial enterprises are considered commercial.

"Re-establishment" means measures taken to intentionally restore an altered or damaged natural feature or process including:

- Active steps taken to restore damaged wetlands, streams, protected habitat, and/or their buffers to the functioning condition that existed prior to an unauthorized alteration;
- Actions performed to re-establish structural and functional characteristics of the critical area that have been lost by alteration, past management activities, or other events; and
- Restoration can include restoration of wetland functions and values on a site where wetlands previous existed, but are no longer present due to lack of water or hydric soils.

"Rehabilitation" means a type of restoration action intended to repair natural or historic functions and processes. Activities could involve breaching a dike to reconnect wetlands to a floodplain or other activities that restore the natural water regime.

"Renovation" means to restore to an earlier condition as by repairing or remodeling. Renovation shall include any interior changes to the building and those exterior changes that do not substantially change the character of the existing structure.

"Repair or maintenance" mean an activity that restores the character, scope, size, and design of a serviceable area, structure, or land use to its previously authorized and undamaged condition. Activities that change the character, size, or scope of a project beyond the original design and drain, dredge, fill, flood, or otherwise alter critical areas are not included in this definition.

"Resident fish" means a fish species that completes all stages of its life cycle within freshwater and frequently within a local area.

"Residential Development" means buildings, earth modifications, subdivision and use of land primarily for human residence; including, but not limited to: single family and multifamily dwellings, mobile homes and mobile home parks, boarding homes, family daycare homes, adult family homes, retirement and convalescent homes, together with accessory uses common to normal residential use. Camping sites or clubs, recreational vehicle parks, motels, hotels and other transient housing are not included in this definition.

"Restore", "Restoration" or "Ecological Restoration" means the re-establishment or upgrading of impaired ecological shoreline processes or functions. This may be accomplished through measures including, but not limited to, revegetation, 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. "Restoration" also means any activity that ensures watershed processes are reinstated.

"Rip Rap" means dense, hard, angular rock free from cracks or other defects conductive to weathering used for revetments or other shore stabilization or flood control.

"Riparian corridor or Riparian zone" mean the area adjacent to a water body (stream, lake or marine water) that contains vegetation that influences the aquatic ecosystem, nearshore area and/or and fish and wildlife habitat by providing shade, fine or large woody material, nutrients, organic debris, sediment filtration, and terrestrial insects (prey production). Riparian areas include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems (i.e., zone of influence). Riparian zones provide important wildlife habitat. They provide sites for foraging, breeding and nesting; cover to escape predators or weather; and corridors that connect different parts of a watershed for dispersal and migration.

"Riparian vegetation" means vegetation that tolerates and/or requires moist conditions and periodic free flowing water thus creating a transitional zone between aquatic and terrestrial habitats which provides cover, shade and food sources for aquatic and terrestrial insects for fish species. Riparian vegetation and their root systems stabilizes stream banks, attenuates high water flows, provides wildlife habitat and travel corridors, and provides a source of limbs and other woody debris to terrestrial and aquatic ecosystems, which, in turn, stabilize stream beds.

S

"Shoreline Modification" means any human activity that changes the structure, hydrology, habitat, and/or functions of a shoreline. Bulkheads, piers, docks, shoreline stabilization systems, berms, and dikes are all examples of shoreline modifications

"Shoreline Stabilization" are structural or non-structural modifications to the existing shoreline intended to reduce or prevent erosion of uplands or beaches. They are generally located parallel to the shoreline at or near the OHWM. Other construction classified as shore defense works include groins, jetties and breakwaters, which are intended to influence wave action, currents and/or the natural transport of sediments along the shoreline.

"Shorelands or Shoreland areas" mean 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 Chapter 90.58 RCW.

"Shorelines" are all of the water areas of the state as defined in RCW 90.58.030, including reservoirs and their associated shorelands, together with the lands underlying them except:

- Shorelines of statewide significance;
- Shorelines on segments of streams upstream of a point where the mean annual flow is twenty cubic feet per second (20 cfs) or less and the wetlands associated with such upstream segments; and

- Shorelines on lakes less than twenty (20) acres in size and wetlands associated with such small lakes.

"Shoreline Administrator" means the Director of Community Development or staff member designated by the Director to perform the review functions required in this program.

“Shoreline Jurisdiction” means all shorelines of the state and shorelands.

“Shoreline Permit” means a shoreline substantial development permit, a shoreline conditional use, or a shoreline variance, or any combination thereof issued by Whatcom County pursuant to RCW 90.58.

“Shorelines of Statewide Significance” means those lakes, whether natural, artificial, or a combination thereof, with a surface acreage of 1,000 acres or more measured at the ordinary high water mark including Lake Sammamish.

“Shorelines of the State” means the total of all “Shorelines” and “Shorelines of Statewide Significance” within the State.

“Single family development” means the development of a single family residence permanently installed and served with utilities on a lot of record.

“Site” means any parcel or combination of contiguous parcels, or right-of-way or combination of contiguous rights-of-way under the applicant’s/proponent’s ownership or control where the proposed project impacts an environmentally critical area.

"Slope" means:

- Gradient.
- The inclined surface of any part of the earth's surface, delineated by establishing its toe and top and measured by averaging the inclination over at least 10 feet of vertical relief.

"Soil" means all unconsolidated materials above bedrock described in the Soil Conservation Service Classification System or by the Unified Soils Classification System.

"Streams" are those areas where surface waters produce a defined channel or bed. A defined channel or bed is an area that demonstrates clear evidence of the annual passage of water and includes, but is not limited to, bedrock channels, gravel beds, sand and silt beds, and defined channel swales. The channel or bed need not contain water year round. This definition includes drainage ditches or other artificial water courses where natural streams existed prior to human alteration, and/or the waterway is used by anadromous or resident salmonid or other fish populations.

“Structure” means a permanent or temporary building or edifice of any kind, or any piece of work artificially built up or composed of parts joined together in some definite matter whether installed on, above, or below the surface of the ground or water, except for vessels (after International Building Code).

“Substantially Degrade” means to cause significant ecological impact.

“Substrate” means the underlying bed layer that makes up the bottom of a lake or stream, frequently composed of rock, gravel, sand, organic material, or a combination of these materials.

“Swamp” means a wetland that is often inundated and composed of woody vegetation.

T

“Threatened” means listed and protected under the US Endangered Species Act, indicating that the described species is likely to become endangered in the foreseeable future.

"Toe" means the lowest part of a slope or cliff; the downslope end of an alluvial fan, landslide, etc.

"Top" means the top of a slope; or in this chapter it may be used as the highest point of contact above a landslide hazard area.

“Total Maximum Daily Load” or “TMDL” is a calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. A TMDL is the sum of the allowable loads of a single pollutant from all contributing point and nonpoint sources. The Clean Water Act, section 303, establishes the water quality standards and TMDL programs.

“Transportation” means roads and railways, related bridges and culverts, fills, embankments, causeways, parking areas, truck terminals and rail switchyards, sidings, spurs, and air fields; not included are recreational trails, highway rest areas, ship terminals, seaplane moorages, nor logging roads; they are included respectively under Recreation, Piers and Docks, Residential, and Forest Practices.

“Trophic” of or relating to nutrition; “Trohpic level” means the position that an organism occupies in a food chain.

U

“Unavoidable” means adverse impacts that remain after all appropriate avoidance and minimization measures have been implemented.

“Unbuildable Land” means land that is not suitable for use as building sites or for impervious road, parking or storage areas, because of inherent hazards to structures or human activity thereon. Such lands may include, but are not limited to: some geologically hazardous areas, critical aquifer recharge areas, and frequently flooded areas.

“Upland” means dry lands landward of OHWM.

"Utilities" means all lines and facilities used to distribute, collect, transmit, or control electrical power, natural gas, petroleum products, information (telecommunications), water, and sewage.

“Utility Development” includes but is not limited to facilities for distributing, processing, or storage of water, sewage, solid waste, storm drainage, electrical energy including electronic communications, and their administrative structures, as well as pipelines for petroleum products, and fire fighting facilities.

V

“Vegetative Stabilization” means planting of vegetation to retain soil and retard erosion, reduce wave action, and retain bottom materials. It also means utilization of temporary structures or netting to enable plants to establish themselves in unstable areas.

W

“Water Body” means a body of still or flowing water, fresh or marine, bounded by the OHWM.

“Water Quality” means the characteristics of water, including flow or amount and related, physical, chemical, aesthetic, recreation-related, and biological characteristics.

"Watershed" means a geographic region within which water drains into a particular river, stream or body of water.

“Weir” means a structure in a stream or river for measuring or regulating stream flow.

“Wet season” means the period generally between November 1 and March 30 of most years when soils are wet and prone to instability. The specific beginning and end of the wet season can vary from year to year depending on weather conditions.

“Wetlands” means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas. Wetlands do not include those artificial wetlands intentionally created for non-wetland sites, including, but not limited to, irrigation and drainage ditches, grass lines swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from non-wetland areas to mitigate the conversion of wetlands.

“Wetland buffer” means a designated area contiguous or adjacent to a wetland that is required for the continued maintenance, function, and ecological stability of the wetland.

“Wetland class” means the general appearance of the wetland based on the dominant vegetative life form or the physiography and composition of the substrate. The uppermost layer of vegetation that possesses an aerial coverage of thirty percent (30%) or greater of the wetland constitutes a wetland class. Multiple classes can exist in a single wetland. Types of wetland classes include forest, scrub/shrub, emergent, and open water.

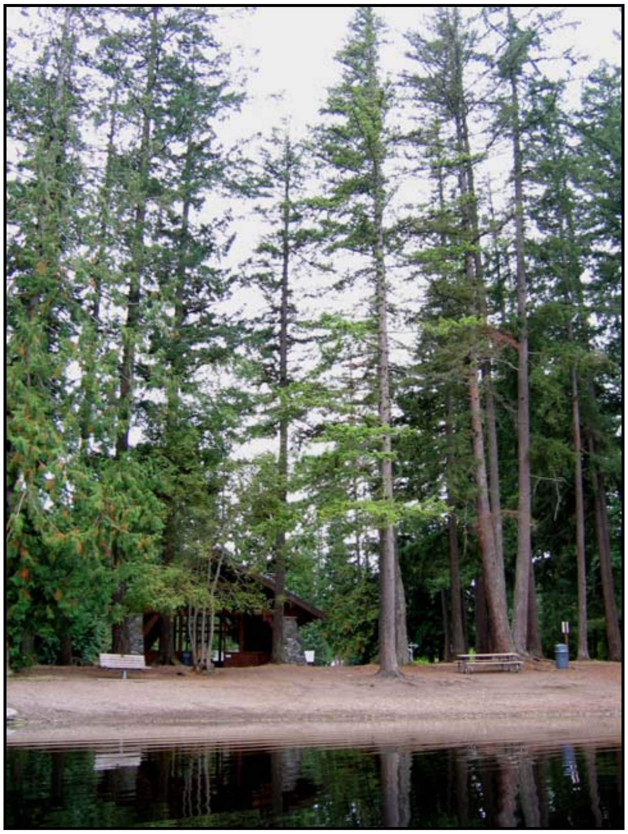
“Wetland edge” means the boundary of a wetland as delineated based on the definitions contained in this chapter.

"Wetland enhancement" See " mitigation."

“Wetland mitigation bank” means a site where wetlands and buffers are restored, created, enhanced, or in exceptional circumstances, preserved expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources.

"Windthrow" means a natural process by which trees are uprooted or sustain severe trunk damage by the wind.

APPENDIX C
SHORELINE PHOTOS

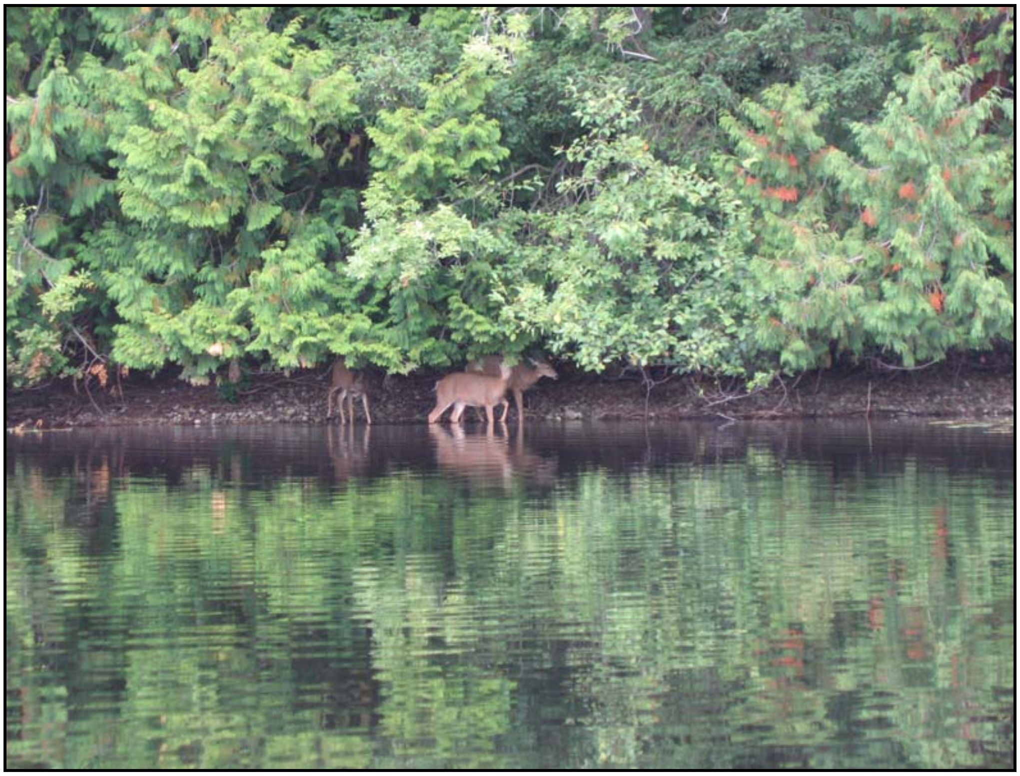


Beaver Lake – Tall trees sheltering the shoreline

(M. Van Nostrand)

Beaver Lake – Residential docks along the east shore

(M. Van Nostrand)



Beaver Lake – Deer using well-vegetated shore

(M. Van Nostrand)

Pine Lake - Native vegetation along the shoreline

(M. Van Nostrand)

Pine Lake – Wetland at the west outlet

(M. Van Nostrand)

Pine Lake – Typical lakeshore development

(M. Van Nostrand)

Lake Sammamish – East Lake Sammamish Trail and shoreline development (T. Larson)