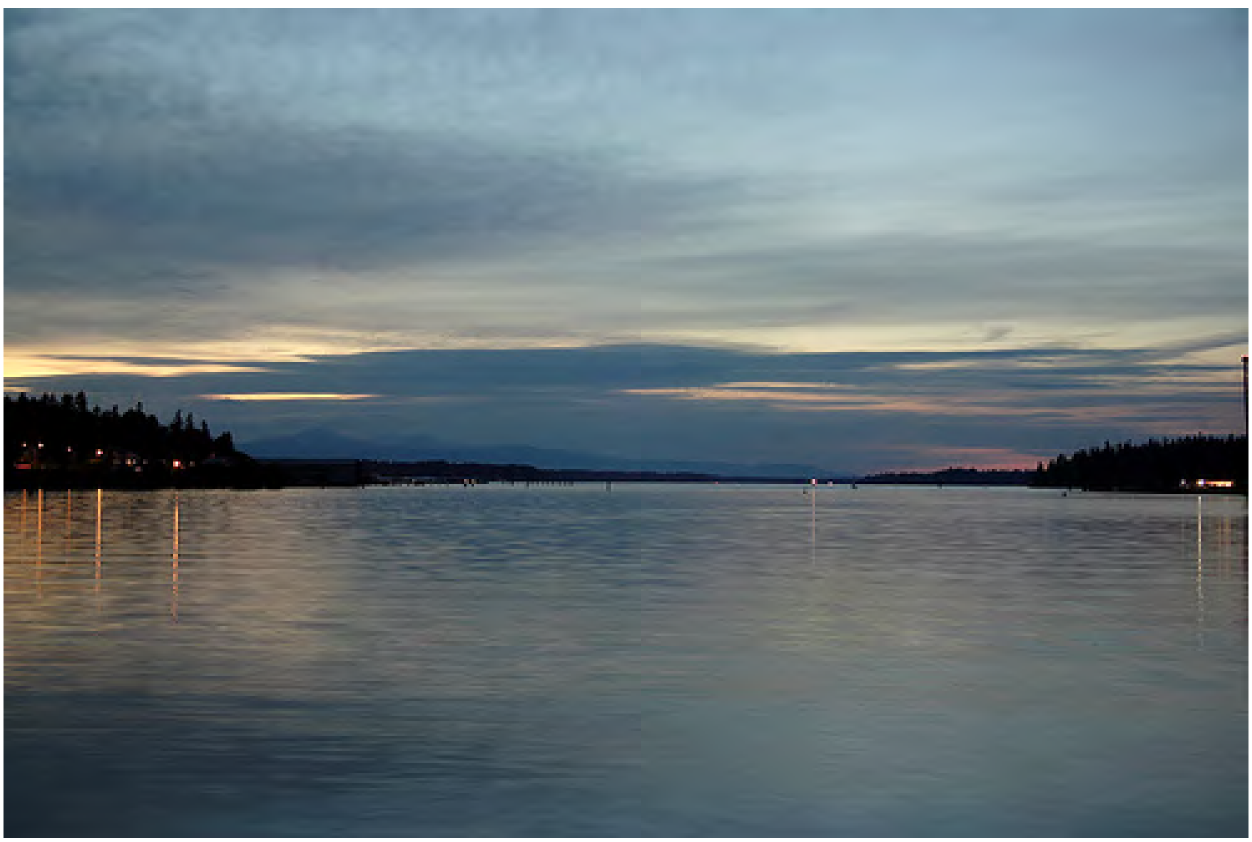
LACEY, OLYMPIA, AND TUMWATER

Shoreline Analysis & Characterization Report

Prepared for:

Thurston Regional Planning Council

December 2008



ESA Adolfson

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1.0 INTRODUCTION

1.1 Background and Purpose

The purpose of this study is to conduct a baseline analysis and characterization of conditions relevant to the shoreline resources within the cities of Olympia, Tumwater and Lacey, Washington. According to Substitute Senate Bill (SSB) 6012, passed by the 2003 Washington State Legislature, cities and counties are required to amend their local shoreline master programs (SMPs) consistent with the Shoreline Management Act (SMA), Revised Code of Washington (RCW) 90.58, and its implementing guidelines, Washington Administrative Code (WAC) 173-26. This shoreline analysis and characterization has been prepared by ESA Adolfson for the Thurston Regional Planning Council (TRPC).

Thurston County and the cities within the County are required to complete the amendment process by the end of 2011. The TRPC is working with the cities of Olympia, Tumwater and Lacey to conduct a comprehensive SMP update within the cities over the next few years. The first step in the process is development of an inventory, analysis and characterization of the shorelines within those cities and their urban growth areas (UGA). The inventory, analysis and characterization documents current shoreline conditions and provides a basis for updating the County's SMP goals, policies, and regulations. In support of this process, TRPC has prepared a Preliminary Draft Shoreline Inventory dated March 2008. Based upon comments from the Shoreline Technical Advisory Committee, the TRPC then revised the information and prepared a Final Draft Shoreline Inventory dated June 2008. This document provides the shoreline analysis and characterization to help the cities identify existing conditions, evaluate existing functions and values of its shoreline resources, and explore opportunities for conservation and restoration of ecological functions.

Funding for this effort has been provided by Washington State Department of Ecology (Ecology) to TRPC through a SMA grant (Agreement No. G0800096). The state funds are provided by Budget Bill ESSB 6090 to implement local shoreline management and federal Coastal Zone Management funds. As per the requirements of the grant, the County's SMP update is scheduled to be completed by June 30, 2011.

This study analyzes and characterizes both ecosystem-wide processes and how these processes relate to shoreline functions. Processes and functions are evaluated at two different scales: (1) a watershed or landscape scale, and (2) a shoreline reach scale. The purpose of the watershed or landscape scale characterization is to identify ecosystem processes that shape shoreline conditions and to determine which processes have been altered or impaired. The intent of the shoreline reach scale analysis and characterization is to: (1) identify how existing conditions in or near the shoreline have responded to process alterations; and (2) determine the effects of the alteration on shoreline ecological functions. These findings will help provide a framework for future updates to city shoreline management policies and regulations.

1.2 Report Organization

The information in this report is divided into five chapters. Chapter 1 – the Introduction - discusses the purpose of this report and describes the regulatory context for shoreline planning. Chapter 2 describes the methods, approach, and primary data sources used for this inventory and characterization. Chapter 3 provides a profile of the ecosystems within the County. This ecosystem profile discusses regional overview, process controls (e.g., climate, geology), and key ecosystem-wide processes and landscape analysis.

Chapter 4 includes the shoreline analysis and characterization organized by waterbody within the Olympia/Tumwater/Lacey area. Waterbodies within Chapter 4 are organized by type of waterbody (i.e., marine, river, lake) similar to the Preliminary Draft Shoreline Inventory Report (Thurston Regional Planning Council, March 2008). Chapter 4 provides information on both the waterbody and the reach scale assessment, including land use patterns and the physical and biological characterization of conditions in the vicinity of the shoreline regulatory zone (referred to as the shoreline planning area).

Chapter 5 provides a summary and conclusion for this inventory and analysis. This section summarizes conditions for each shoreline area in the City's planning area, provides an assessment of shoreline functions, and identifies and discusses potential opportunity areas for protection, enhancement, and restoration. References are contained in the last section of the report.

1.3 Regulatory Overview

1.3.1 Shoreline Management Act and Shoreline Guidelines

Washington's Shoreline Management Act (SMA) was passed by the State Legislature in 1971 and adopted by the public in a referendum. The SMA was created in response to a growing concern among residents of the state that serious and permanent damage was being done to shorelines by unplanned and uncoordinated development. The goal of the SMA was "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines." While protecting shoreline resources by regulating development, the SMA is also intended to provide for appropriate shoreline use. The SMA encourages public access and use of the shoreline and provision of water-dependent uses, as well as land uses that enhance and conserve shoreline functions and values.

The primary responsibility for administering the SMA is assigned to local governments through the mechanism of local shoreline master programs, adopted under guidelines established by Ecology. The guidelines (WAC 173-26) establish goals and policies that provide a framework for development standards and use regulations in the shoreline. The SMP is based on state guidelines but tailored to the specific conditions and needs of individual communities. The SMP is also meant to be a comprehensive vision of how the Cities' shoreline area will be managed over time.

1.3.2 Shoreline Jurisdiction

The shoreline minimum jurisdiction to be regulated under Lacey, Olympia and Tumwater's SMPs must include all shorelines of statewide significance, shorelines of the state, and their adjacent shorelands, defined as the upland area within 200 feet of the OHWM, as well as any "associated wetlands" (RCW 90.58.030). Generally, "shorelines of statewide significance" include portions of Puget Sound and other marine waterbodies, rivers west of the Cascade Range that have a mean annual flow of 1,000 cubic feet per second (cfs) or greater, rivers east of the

Cascade Range that have a mean annual flow of 200 cfs or greater, and freshwater lakes with a surface area of 1,000 acres or more (RCW 90.58.030). "Shorelines of the state" are generally described as all marine shorelines and shorelines of all streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area 20 acres or greater (RCW 90.58.030).

"Associated wetlands" means those wetlands that are in proximity to and either influence or are influenced by tidal waters or a lake or stream subject to the SMA (WAC 173-22-030 (1)). These are typically identified as wetlands that physically extend into the shoreline jurisdiction, or wetlands that are functionally related to the shoreline jurisdiction through surface water connection and/or other factors. The specific language from the RCW describes the limits of shoreline jurisdiction as follows:

> *Those lands extending landward for two hundred feet in all directions as measured on a horizontal plane from the ordinary high water mark; floodways and contiguous floodplain areas landward two hundred feet from such floodways; and all associated wetlands and river deltas* (RCW 90.58.030(2)(f)).

Local jurisdictions can choose to regulate development within the 100-year floodplain or a smaller area as defined above (RCW 90.58.030(2)(f)(i)).

Waterbodies in the Olympia/Tumwater/Lacey area regulated under the SMA and updated SMPs include marine shorelines of Puget Sound, rivers and streams, and numerous lakes. Shorelines of statewide significance include marine waterbodies below the extreme low tidal mark.

1.3.3 Other Regional Plans and Policies

A variety of other regulatory programs, plans, and policies work in concert with local SMPs to manage shoreline resources and regulate development near the shoreline. The individual Cities' development standards and use regulations for environmentally critical areas are particularly relevant to the Cities' SMPs. Designated environmentally critical areas are found throughout the Olympia/Tumwater/Lacey area, including streams, wetlands, fish and wildlife conservation areas, flood hazard areas, and geologic hazard areas.

1.3.4 Coordination with Local Jurisdictions

The GMA calls for coordination and consistency of comprehensive plans among local jurisdictions. Because SMP goals and policies are an element of the local comprehensive plans, the requirement for internal and intergovernmental plan consistency may be satisfied by watershed-wide or regional planning. The State's shoreline guidelines (WAC 173-26-191(d)) further encourages adjacent local governments to jointly prepare master programs. Consistent with both of these directives, this analysis and characterization report is being prepared by the TRPC for the three cities of Lacey, Olympia, and Tumwater. As part of this work, TRPC is coordinating with Thurston County during its SMP update process.

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2.0 METHODS

2.1 Data Sources

The state master program guidelines state that shoreline inventory and characterizations to support local SMP amendments should be based on scientific and technical information. Inventories should use existing sources of information that are both relevant and reasonably available (WAC 173-26-201(3)(c)).

This shoreline analysis and characterization report relies upon data provided in the Draft Shoreline Inventory prepared by TRPC staff (2008). Data acquired included available and existing data and reports prepared by the Cities of Lacey, Olympia and Tumwater, as well as Tribes, county, regional and state agencies, conservations districts, and non-profits. Geographical information system (GIS) data has been provided and summarized by TRPC staff. Maps and other GIS products are based on data sources referenced in the Draft Shoreline Inventory report and were prepared by TRPC (2008).

2.2 Determining Shoreline Jurisdiction and Planning Area Boundary

This analysis and characterization is focused on those shorelines of the state in the Cities of Lacey, Olympia, and Tumwater and their urban growth areas. This includes:

- 12.2 miles of marine shoreline,
- 15.1 miles of freshwater river, and
- 46.6 miles of lakeshore.

The total shoreline miles in the Thurston Regional Planning area is 73.9 miles. Shoreline miles are based on the ordinary high water mark in marine areas, the river centerline, or the lake perimeter). Marine shorelines include Nisqually Reach and Budd Inlet. Freshwater shorelines of the state include five rivers or streams and 15 lakes.

2.3 Approach to Ecosystem-Wide Processes and Shoreline Functions

SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes during the SMP updates. Ecosystem-wide processes that create, maintain, or affect the three City’s shoreline resources were characterized using an adapted version of the five-step approach to understanding and analyzing watershed processes described in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley et al, 2005). This approach defines watershed processes as the delivery, movement, and loss of water, sediment, nutrients, toxins, pathogens, and large woody debris. While the methodology described in Stanley et al., is focused on the freshwater resources, the concepts and approach are applied to the marine nearshore environment to describe nearshore coastal processes, including littoral drift; coastal erosion; sediment supply, transport, and deposition; and functions provided by nearshore marine riparian vegetation. The processes are qualitatively described using available reports and spatial most appropriate at the watershed scale. However, examining conditions and processes at the watershed and City-wide scales informs local shoreline planning by providing a broader understanding of how ecosystem-wide processes form and influence conditions in the shoreline planning areas. Natural processes and alterations to those processes are described at a variety of geographic scales based on existing reports and the readily available mapping and GIS data from TRPC.

2.4 Approach to Characterization and Analysis of Jurisdictional Shorelines

This analysis is intended to characterize conditions in and adjacent to the jurisdictional shorelines of regulated waterbodies within the cities of Lacey, Olympia and Tumwater. The shoreline planning area roughly approximates the regulatory limits of the SMPs. GIS data were used to quantify shoreline conditions to the extent possible. Aerial photography and a review of existing reports were used to qualitatively describe conditions in the shoreline.

For purposes of the analysis and characterization, shoreline planning areas depicting the minimum shoreline jurisdiction, were divided into "reaches" based upon shoreline type (i.e., marine, river or lake). Many factors were considered in delineating the reach breaks including topography and land cover, hydrology, existing land use patterns, and biological resources. Reach break boundaries were also drawn at the city limits for each jurisdiction (i.e., Chambers Lake which lies within both Lacey and Olympia). Detailed methods for determining the shoreline reach boundaries are provided in the appendix to the Draft Inventory. Shoreline reach boundaries are shown on Maps L-1, O-1 and T-1. Individual shorelines are listed in the following summary tables by city jurisdiction.

City of Lacey has a total of 21.4 miles of shoreline within its city limits and UGA. This shoreline length includes marine shorelines, one stream and 5 lakes as shown in Table 2-1.

Table 2-1. City of Lacey shoreline waterbodies and reaches

City Jurisdiction or UGA	Shoreline Waterbody	Number of Shoreline Reaches in City	Length (miles)
Lacey	Puget Sound, Nisqually Reach	2	1.82
	Woodland Creek	2	1.64
	Chambers Lake	2	2.05
	Hicks Lake	2	2.63
	Long Lake	6	7.75
	Pattison Lake	4	4.45
	Southwick Lake	1	1.04
		Total	**21.4 miles**

City of Olympia has a total of approximately 31.6 miles of shoreline within its city limits and UGA. This includes Budd Inlet, Deschutes River and three streams, and seven lakes as shown in Table 2-2.

Table 2-2. City of Olympia shoreline waterbodies and reaches

City Jurisdiction or UGA	Shoreline Waterbody	Number of Shoreline Reaches	Length (miles)
Olympia	Budd Inlet	8	10.37
	Black Lake Drainage Ditch	Portion of 1 reach	0.64
	Chambers Creek	1	1.55
	Deschutes River	1 (Left bank)	0.78
	Percival Creek	1	1.09
	Bigelow Lake	1	2.52
	Capitol Lake	Parts of all 7 reaches	4.14
	Chambers Lake	1	2.41
	Grass Lake (Lake Louise)	1	4.51
	Hewitt Lake	1	0.88
	Ken Lake	1	1.32
	Ward Lake	1	1.39
		Total	**31.6 miles**

City of Tumwater has a total of approximately 24.0 shoreline miles in its City limits and UGA. This shoreline length includes no marine shoreline. However, most of the Deschutes River shoreline in the Thurston Regional Planning Council study area lies within Tumwater, along with small sections of three streams. In addition, five lakes are included in the Tumwater jurisdiction as described in Table 2-3 below.

Table 2-3. City of Tumwater shoreline waterbodies and reaches

City Jurisdiction or UGA	Shoreline Waterbody	Number of Shoreline Reaches	Length (miles)
Tumwater	Black Lake Drainage Ditch	1 (out of 2 reaches)	1.61
	Chambers Creek	1	0.07
	Deschutes River	7 reaches	11.67 (including length of each bank)
	Percival Creek	1	0.08
	Barnes Lake	1	1.16
	Black Lake	2 (eastern shore)	2.89
	Capitol Lake	2 (out of 7 reaches)	2.98
	Munn Lake/Lake Susan	3	1.97
	Trosper Lake	1	1.56
		Total	**24.0 miles**

3.0 ECOSYSTEM-WIDE PROCESSES

Chapter 3 is intended to provide a broad overview of how the marine and fresh waters in the Shoreline Planning Area function as part of the south Puget Sound ecosystem. This background provides the ecological context that can be used to inform the development of regulatory elements of the SMP to be protective of the resource, and help support restoration planning. A description and analysis of ecosystem-wide processes is required by the 2003 shoreline guidelines in WAC 173-26.

This chapter is divided up into three general parts. The first provides a narrative overview of the study area, with special focus provided for key features of the landscape and regulatory shoreline. The second and third sections discuss both the process controls and the ecosystem functions that occur within both the marine and freshwater portions of the study area, respectively (see Figure 3-1 for the conceptual relationship between these items). Both the marine and freshwater sections conclude with a synthesis of the key functions that occur in the landscape, their current level of functioning, and their potential for protection or restoration.

Process controls are defined as the landscape factors that set the stage for ecosystem-wide processes. Process controls include factors such as local climate, topography, and geology, each of which determines the type of processes that will occur in a region. For example, the climate (e.g., amount and type of precipitation), topography (e.g., steep or low gradient), and geology/soils (e.g., permeable or impermeable deposits) of a region act together to influence the hydrologic processes (e.g., surface and groundwater movement and storage) within a watershed. These ecosystem processes also control the physical form of the landscape and the type and extent of habitats that occur throughout the ecosystem. Ecosystem processes function at multiple scales, from the watershed scale to site-specific habitat scale (Figure 3-1).

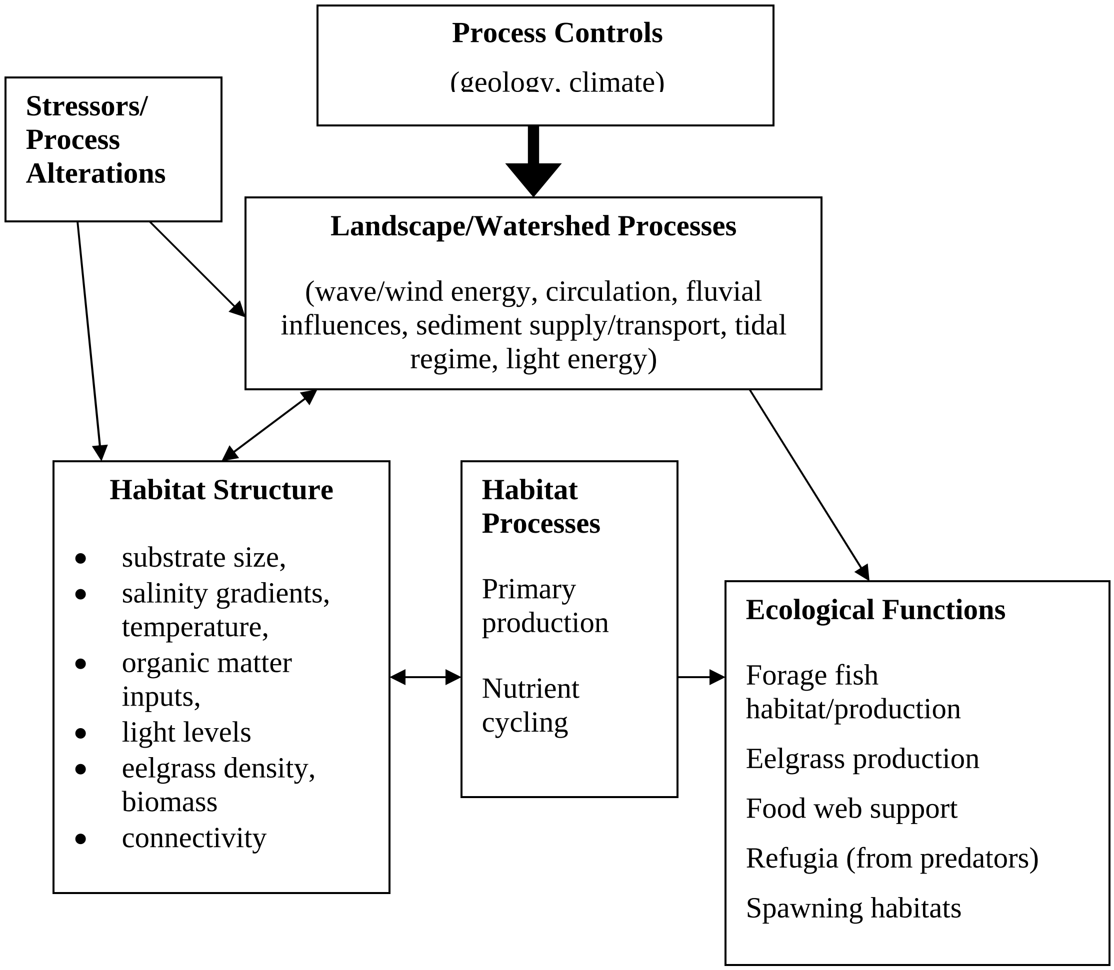


Figure 3-1. Linkages between controlling factors and processes operating at landscape and local scales, habitat structures and ecological functions in the nearshore environment (adapted from Williams et al., 2001; Simenstad et al., 2006; Ruckelshaus and McClure, 2007)

This analysis includes the application of a landscape-level analysis tool that has been developed by the Department of Ecology (Ecology, 2005). This analysis specifically looks at hydrologic processes, where the important areas are, and how they have been altered over time. The two results are then taken together to suggest areas where protection or restoration of ecosystem process would be the most effective. While this analysis is specifically focused on hydrologic processes, the parameters used are fairly general landscape-level measures that can be used as a general proxy for overall level of functioning.

3.1 Regional Overview

The Shoreline Planning Area for the TRPC covers a portion of the south Puget Sound that extents from the Nisqually delta west to Budd Inlet. From south to north, the study area extends generally from the drainage divide to the Chehalis basin north to marine waters. The study area is primarily within the Deschutes River drainage (Water Resource Inventory Area [WRIA] 13, but also includes portions of the Upper Chehalis River and Nisqually basins (WRIAs 23 and 11, respectively). Of the 53,000 acre area that includes the three cities, including UGAs, 83 percent of the area is within the Deschutes WRIA, 11 percent is in the Chehalis WRIA, and 6 percent is in the Nisqually WRIA.

This planning area is part of the larger South Puget Sound eco-region, encompassing the area that drains into Puget Sound south of the sill at Tacoma Narrows. The south sound is an incredibly productive area, but due to its low flushing rate and disconnection from marine waters in the Georgia basin, the South Puget Sound is more sensitive to pollutant and sediment loading than other portions of Puget Sound (Albertson et al, 2002).

The study area encompasses one of the most rapidly urbanizing portions of Puget Sound. The population of Thurston County in general has exceeded the statewide growth rate since the 1960s. Between 2000 and 2007, Thurston County's population grew by 14.8 percent, reaching approximately 238,000 residences (TRPC, 2007). Around 67 percent of the population resides in cities or their UGAs.

Documents from the 1970s and 1980s describe the land use in the area as primarily agriculture. In the last 15 years, land cover has rapidly converted to urban and suburban signatures. Land cover analyses performed by the TRPC (2002) indicate that urban land cover has substantially increased throughout the study area.

Table 3-1. Land cover change from rural to urban (TRPC, 2002)

Watershed	Additional Urban Area (1985-2000)	Percent Increase from 1985
Deschutes River	1,700 acres	19
Henderson Inlet	1,300 acres	25
Nisqually River	1,100 acres	27
Black River	712	28

The Deschutes River and Capitol Lake are the significant freshwater features within the Shoreline Planning Area. Capitol Lake was constructed in 1951 via the construction of a dam at the mouth of the former Deschutes River estuary to form a freshwater lake and support a revitalization effort along Olympia's waterfront. Poor water quality within Capitol Lake has instigated numerous studies and inquiries into possible solutions, including the removal of the dam to re-introduce tidal flux into the area. These studies have typically been performed to develop a Capitol Lake Adaptive Management Plan (CLAMP).

3.2 Process Controls

Process controls provide the raw materials and energy that support terrestrial and aquatic ecosystems. These are broad subjects that influence elements of the marine and freshwater systems, and so are presented here to provide the deeper landscape context. By necessity, these sections only provide an overview of the information; more in-depth information is available in the citations provided. The primary process controls within this study area are: (1) climate, (2) geology, and (3) tidal circulation.

3.2.1 Climate

The study area has the cool Mediterranean climate that is typical of the Puget Sound lowlands. This portion of Thurston County's climate is influenced by maritime patterns that define the overall climate of Western Washington. In general, climate in Western Washington is characterized by mild, wet fall to spring months, and cool dry summer months. Precipitation typically occurs as low-intensity, long-duration storms. The county spans at least two of Washington's climatic regions identified by the National Climatic Data Center branch of NOAA, the Puget Sound Lowlands, and the western Cascades.

NOAA precipitation data from 1971 to 2000 indicates that average annual precipitation in the study area ranges from 40 to 60 inches a year. The higher average annual precipitation figures typically correlate with higher elevations and this pattern occurs here with the highest precipitation occurring in the headwaters of the Deschutes, and in the Black Hills, west of the study area.

The vast majority of precipitation is distributed between October and May. Rain and snowfall quantifies generally increase with distance south of the Canadian border, and with distance away from marine waters. 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 Summary [NCDC] for Washington State).

Hydrologic systems in the Pacific Northwest are especially sensitive to warm rain-on-snow events, when significant volumes of surface water can be released into the system at one time. The upper portion of the Deschutes River basin the only area that drains into the study area which is mapped within WDNR's rain-on-snow and snow dominated areas (WDNR, 1991).

3.2.1.1 Climate Change

Fluctuations in climate occur at all temporal scales ranging from thousands of years (ice ages) to changes over decades (ENSO). These fluctuations in climate have, in large part, shaped the glacially- and fluvially-dominated landscape, especially in the portions of the study area below 2,500 feet where flood regimes shape the landscape.

The Intergovernmental Panel on Climate Change (IPCC) has published several reports that indicate that there is an overall warming climate trend (for example, see the Fourth Assessment Report IPCC, 2007 http://www.ipcc.ch/ipccreports/ar4-syr.htm). The exact implications of this trend for specific regions, such as the Puget Sound, are unclear. The climate impacts Group at the University of Washington (cses.washington.edu) has used climate models to identify some possible climate impacts in the Puget Sound:

- Continued warming on the order of 0.2 to 1.0ºF per decade;
- Possible decrease in summer precipitation and increase in winter precipitation with little change in the annual mean (http://cses.washington.edu/cig/pnwc/cc.shtml).

Other researchers identify the possibility of greater warming, on the order of 0.5 to 2.5 degrees C (0.9 to 4.5 degrees F) by the 2020s, with an increase in summer precipitation (Mote et al, 2003).

Taken together, these factors have the potential to influence the functioning of Puget Sound ecosystems. Warmer temperatures will influence the nature and geographic extent of the snowpack that feeds higher elevation streams. Warmer temperatures could also result in higher summer water temperatures, having the potential to negatively impact several water quality parameters. Additional precipitation, and a broadened rain-on-snow area, has the potential influence flow regimes.

One of the anticipated effects of climate change in the Pacific Northwest is sea-level rise. Sea-level rise will likely change coastal processes and habitats, if water elevations increase as predicted. A recent study has been published by the National Wildlife Federation (NWF) on sea-level rise and coastal habitats in the Pacific Northwest (NWF, 2007). This study evaluated the Puget Sound, southwestern Washington, and northwestern Oregon coasts specifically, and identified 11 different sites within the Puget Sound for sea-level modeling. The model used a range of sea-level rise scenarios as predicted by the IPCC from 0.08 meter (3.0 inch) increase in global sea levels by 2025 to a 0.69 meter (27.3 inches) increase to 2100. Sea-level rise within this range is anticipated to affect coastal habitats and fish and wildlife dependent upon the coastal areas of the Puget Sound. Predicted habitat changes in the Puget Sound are loss of estuarine beach and tidal flat areas, reduction in tidal marshes, saltwater intrusion into freshwater wetlands and brackish marshes, and increased shoreline erosion (NWF, 2007).

Sea level rise also has implications for increased coastal flooding within the study area, particularly in the low-lying portions of Olympia. Portions of downtown Olympia at the head of Budd Inlet are currently within the FEMA 1 percent annual chance coastal flooding area; therefore, any increase in typical water levels could increase flood hazards in the downtown Olympia area (Craig, 1993).

Table 3-2. Estimated projections of sea-level rise for Thurston County (in Herrera, 2005)

Factors Affecting Sea Level	1990	2000	2025	2050	2075	2100
Global average sea-level rise (ft.)	0.0	0.1	0.3	0.7	1.2	1.6
East Pacific surcharge (ft.)	0.0	0.1	0.3	0.3	0.8	0.7
Local subsidence (ft.)	0.0	0.1	0.2	0.6	0.4	0.6
Total Sea-level Rise (ft.)	0.0	0.2	0.8	1.2	2.3	2.9

Source: Canning (2001).

3.2.2 Geology

The underlying geology of the study area is the end product of long term-tectonic, glacial, fluvial, and hillslope processes occurring at the western end of the North American plate for over 40 million years (see for example ; Noble and Wallace, 1966; Drost et al., 1998; Walsh and Logan, 2005; Sinclair and Bilhimer, 2007; Raines, 2007). Glacial processes dominate the surficial deposits and landforms in the South Puget Sound region. The complex geologic history of the region can be boiled down into three general time frames, ordered here from oldest to newest.

From 50 to 2 million years ago, volcanism and marine deposition formed bedrock which is now the basement rock that underlies the study area at depth. This volcanism likely occurred as the North American plate overrode more dense oceanic rocks. All of these rocks have been modified by compression stresses and faulting toward the end of this period. These rocks are typically referred to as the 'Tertiary bedrock' denoted on regional geology maps (WDNR, 2005)

Next, the landscape underwent glacial and inter-glacial periods between 2 million to 14,000 years ago. For much of the Pleistocene epoch, multiple continental glaciations have occurred that have provided the raw materials and shaped much of the modern landscape in the Puget Sound lowlands. The Vashon stade, ending around 14,000 years ago, was the most recent period where the study area was covered with glacial ice. Meltwater patterns from the retreating ice carved complex drainageways that likely included an outlet from the Puget Sound lowlands to what is now the Chehalis River and Grays Harbor. Significant deposition of coarser (outwash) and finer (till and lacustrine) glacial layers occurred during this period, resulting in unconsolidated deposits of greater than 900 feet thick in the study area (Jones, 1996).

Finally, from 14,000 years ago to present, the post-glacial reorganization occurred following the recession of the large ice sheets. New drainage patterns formed when fluvial and hillslope processes modified the surficial landforms throughout the study area. Most of the drainage within the study area is focused northward, often resulting in smaller channels occupying larger glacial meltwater channels. These younger features include alluvial floodplains, wetlands, landslide deposits, and coastal features.

These processes result in some relatively unique geologic features of the study area. These features include the broad glacial outwash plain that extends generally south from I-5 towards the Deschutes River. This broad, flat, plain is pocked by kettle depressions, formed as blocks of ice trapped in fluvially-deposited outwash materials melt, allowing the surface to collapse. Many of the lakes and depressional wetlands in the region have formed within these kettles, including Ward Lake.

The bedrock outcrop at Tumwater Falls is another geologic feature that influences the functioning of the Deschutes River system. This outcrop has resulted in a long-lasting sharp bend in the lower section of the river, and likely was a full natural blockage to salmonid migration until a ladder was constructed. The bed control as this location is important for the overall functioning of the lower Deschutes River, as it disconnects the river from tidal influence, and also limits potential channel down-cutting.

3.2.2.1 Geologic Hazards

Geologic hazards within the study area focus primarily on erosion-prone soils and positions and hillsides that are prone to landsliding, and seismic events. These risks do not appear to be major, and state-wide inventories (e.g., WA DNR erosion and landsliding) do not map any instances within the study area. Qualitatively, landsliding hazards are most likely highest along coastal bluffs.

Erosion areas within the study area are most prevalent along streams, typically within the channel migration zone. In particular, the Deschutes River, Percival Creek, and Chambers Creek are meandering streams for part of their length, or flow through a steep ravine. Both cases will result in erosion, as evidenced by the deposition of sediment within Capitol Lake over the past 60 years (Green et al., 2006).

The study area is within the mapped tephra fall zone from any major Cascade volcano (Hoblitt et al., 1998). The lower Nisqually River could also receive a lahar from Mount Rainier, but the lower Nisqually lies outside the study area.

3.2.3 Tidal Circulation

Oceanographic processes in this area are characteristic of the normal mean circulation pattern in a fjordal estuary, with seaward flow at the surface and landward flow at depth. Freshwater derived from local rivers typically flows seaward at the surface, while colder, more saline water originating from the Pacific Ocean flow landward along the bottom (Nightengale, 2000).

The combined forces of lunar influence, winds and bathymetry determine the extent to which these layers are mixed. During neap tides (the moon is in the first and last quarters) when the tidal range is least, seawater intrusions and the influx of saltier water to Puget Sound is greatest. During spring tides (the moon is full or new), higher velocity tidal currents result in increased mixing of fresh and salt water (Nightengale, 2000). A temperature, salinity and density difference between freshwater runoff and nutrient upwelling from ocean water determines the extent of mixing. This is influenced strongly by the force exerted on the water surface by wind (Nightengale, 2000).

Pacific Ocean water enters through the Strait of Juan de Fuca then diverges north to the Northwest Straits and south to the inland waters of central and southern Puget Sound. Tides throughout the region are semi-diurnal, exhibiting unequal two high tides and two unequal low tides per day. Mean tidal range in the Straits and Sound increases with increasing distance from the Pacific Ocean with some of the largest tide ranges occurring within this study area. The portion of Puget Sound in the study area is typically considered to be macrotidal (greater than 4 meters between MLLW and MHHW) (Finlayson, 2006). The largest tide range occurs within the confined area in Budd Inlet (4.4 meters with spring maximum tides of over 5 meters).

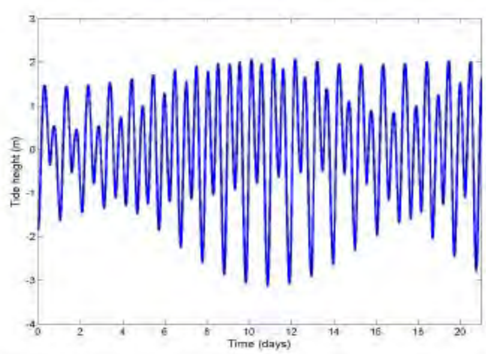


Figure 2.4. Semi-diurnal spring-neap tidal record (m MSL) extracted from the National Ocean Service water level station at Gull Harbor in eastern Budd Inlet (station #9446807). The maximum range during a normal tidal cycle is 5 m but seasonal extreme tides can temporarily cause larger ranges.

Figure 3-2. Semi-diurnal spring-neap tidal record (USGS, 2006)

The strong tidal currents typical of the central and northern Puget Sound are muted within the South Sound, especially within the protected Henderson, Budd, and Eld Inlets (Albertson et al., 2002). The most exposed portion of the marine shoreline occurs in the eastern portion of the study area, occurring on the margins of the larger Nisqually estuary. Tidal currents here are typically stronger than in Budd Inlet, with a net direction to the northwest. These patterns can be seen in the results of hydrodynamic models produced as part of larger investigations into hydraulic and water quality processes within the South Sound (Albertson et al., 2002).

Tidal currents are very well understood within Budd Inlet, as a result of measurements and the Environmental Fluid Dynamics Code (EFDC) model developed as part of the Budd Inlet Scientific Study Report (Aura Nova et al., 1998). This work established that flushing rates for Budd Inlet range between 8 to 12 days, and established overall circulation patterns.

3.3 Nearshore Marine

The marine nearshore is the zone of interface between the subtidal marine habitats of Puget Sound, the freshwater habitats of rivers and streams and the adjacent uplands along the shore (Williams et al., 2001; Redman et al., 2005). The nearshore extends generally from the lower limit of light penetration in offshore waters (i.e., the photic zone, about 20-30 m below mean lower low water [MLLW]) to the mean higher high water [MHHW] line along the shoreline and/or the upper limit of tidal influence in rivers and streams. Nearshore habitats also include upland and backshore areas that directly influence the adjacent aquatic habitats (e.g., marine riparian vegetation and bluffs).

The marine nearshore within South Puget Sound is recognized as one of the most ecologically productive in the region. The South Sound has a disproportionate length of marine shoreline compared to the rest of the Sound, due primarily to the numerous complex inlets along the margins of the land (Herrera, 2005). Further the marine nearshore area is generally wider along the coastline due to shallower water depths in South Sound.

The shoreline planning area for the TRPC includes two distinct portions of the marine shoreline: the southern half of Budd Inlet and a relatively short (6,500 feet) stretch of shoreline within the “Nisqually Reach” west of the Nisqually Delta. The Budd Inlet portion has been intensely studied as part of long-term research to support decision making for the future of Capitol Lake. Less information is available for the Nisqually reach, but good relevant information for the South Sound area.

Several past researchers have developed conceptual models of ecological functioning within the marine shoreline of Puget Sound, and particularly the South Sound (Brennan and Calderwell, 2004; Shipman, 2004; Williams et al., 2001). All agree that the marine landscape is complex, with numerous interrelationships between each component. These concepts focus on the interaction of physical structure, water quality, and biological communities to form the important habitat types and extents that occur within the marine shoreline of the South Sound. These key elements are described below. Alterations to the processes are also addressed, setting up a framework to assess overall level of functioning.

The primary ecological functions and biological resources of estuarine shorelines include:

- Flood attenuation;
- Tidal exchange/organic matter exchange;
- Stream base-flow and groundwater support;
- Water quality improvement (nutrient retention, nutrient cycling);
- Erosion/shoreline protection; and
- Biological support and wildlife habitat including:
    - Food web support
    - Habitat structure
    - Habitat connectivity
    - Salinity gradients
    - Refugia from predators (i.e., turbid waters of tidal channels and salmon).

3.3.1 Physical Processes

Three main process controls (climate, geology, tidal regime) interact to form the physical structure of the marine nearshore environment (Finlayson, 2006). Sediments delivered to the nearshore are sorted into distinctive patterns and profiles, creating the base structure for broader ecological functioning.

Physical processes that influence the physical structure of the nearshore include:

- Wind Energy and exposure;
- Net shore-drift;
- Coastal bluff landslides; and
- Fluvial influences.

Beaches in the Puget Sound often have two distinct foreshore components: a high-tide beach and a low-tide terrace (Downing, 1982). The high-tide beach consists of a relatively steep beachface with coarse sediment and an abrupt break in slope at its waterward extent. Sand in a mixed sand and gravel beach is typically winnowed from the high-tide beach by waves (Chu, 1985 in Herrera 2005) and deposited on the low-tide terrace. Extending seaward from the break in slope, the low-tide terrace typically consists of a gently sloping accumulation of poorly sorted fine-grained sediment. Lag deposits derived from bluff recession are also found in the low tide terrace. These deposits are typically comprised of larger rocks, ranging from cobbles to boulders.

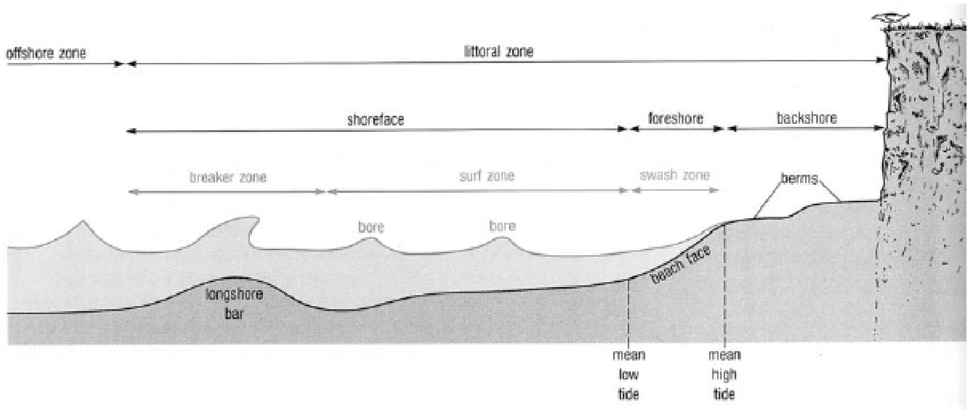


Figure 3-3. Nearshore Features of a Beach Profile (Herrera, 2005)

Wind-generated wave action gradually erodes beaches and the toe of coastal bluffs, leading to landslides. These coastal bluffs are the primary source of sediment for most Puget Sound beaches, including the study area (Keuler, 1988; Downing, 1983). Bluff composition and wave energy influence the composition of beach sediment. Waves sort coarse and fine sediment and large waves can transport cobbles that small waves cannot. Additionally beaches supplied by the erosion of coarse gravel bluffs will differ in composition from those fed by the erosion of sandy material. The exposed strata of the eroding bluffs in the study area are largely composed of sand, gravel, and silt (DNR, 2001; DOE, 1979). These same materials dominate sediment found on the beaches, with the exception of silt (and clay), that is winnowed from the beach face and deposited in deeper water.

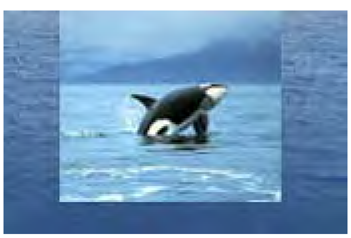
3.3.2 Water Quality Processes

Overall water quality within the marine nearshore of Puget Sound is the end result of a complex set of interactions between physical and biological processes. Puget Sound is the largest fjord-type estuary in the continental United States. While the main Basin of Puget Sound is over 900 feet deep, the South Sound basin is much shallower than the main basin. The sphere of influence on water quality is broad; it includes deeper marine waters from the Pacific Ocean, the extent of the terrestrial watersheds that contribute surface and groundwater flow to the Sound, and atmospheric inputs. Nutrients, organic matter, pathogens, and inorganic compounds are delivered to the marine nearshore by marine waters that are drawn into the Sound by tidal currents and terrestrial inputs that include freshwater runoff and groundwater discharge. Bottom sediments provide a reservoir for potential storage and release of materials (e.g., nutrients, organic matter, etc.) that influence water quality.

These inputs then mix differentially based on the physical structure of the nearshore. In general, the influence of deeper marine waters is reduced with distance south from the Straight of Juan de Fuca, with corresponding increasing importance of terrestrial inputs. These raw materials provide the basis for biological processes (e.g., primary production of algae and other plankton) also influence and provide important feedback loops for water quality. In addition, shoreline conditions will also influence water quality. For example, a shaded shoreline will receive lower levels of solar radiation than an exposed shoreline. Greater solar radiation can support higher levels of primary production, again influencing end water quality.

In general, inputs from natural sources of nitrogen and phosphorus are several orders of magnitude greater than anthropogenic sources in Puget Sound (Harrison et al., 1994). However, a number of the South Sound's characteristics lead to a greater contribution from terrestrial and anthropogenic sources of nutrients compared to oceanic influences (Albertson et al., 2002). The South Sound is thus relatively sensitive to eutrophication and low dissolved oxygen (DO) related to anthropogenic sources of nutrients (Newton and Reynolds, 2002 in Albertson et al. 2002). Inputs of excess nutrients, toxins, and pathogens are affected by the volumes of river discharges to the Sound, land cover in the contributing watersheds of rivers discharging to the Sound, presence of agricultural land uses which concentrate manure or fertilizers, failing septic systems, fertilizers and pesticides from residential areas, contaminated sediments from industrial or commercial operations, and stormwater runoff from impervious surfaces (Embrey and Inkpen, 1998).

The Puget Sound Partnership and the State of Washington has declared that one of the objectives for recovery of Puget Sound is to significantly improve water quality by reducing toxics and pollutants entering the Sound. Toxic contaminants in Puget Sound have threatened water quality, reduced marine habitat, resulted in shellfish closures, and have been documented as an ever increasing problem in the South Sound area. Toxic contaminant loading to Puget Sound is currently being studied by Department of Ecology and other state agencies in an effort to identify sources of toxic inputs. Results from the first phase of this study indicate that surface water runoff and stormwater may be the largest contributing factor in pollutant loading in the Sound (Hart Crowser et al., 2007). Toxics include metals such as copper, lead, mercury, zinc and other persistent chemicals including PCBs, phthalates, and flame retardants. These toxics concentrate in the food chain with detrimental effects to fish, shellfish, Puget Sound orca and other marine life. Studies by Canada's Department of Fisheries and Oceans have found that southern resident Puget Sound orcas have high concentrations of fire retardants and PCBs, in fact some of the highest concentrations in the world found in marine mammals (Ross, 2005).



The South Sound is characterized by protected bays and narrow inlets, relatively shallow depths, stratification of the water column, slow flushing times, and a high shoreline to water surface-area ratio (Albertson et al., 2001; Herrera, 2005). Under these conditions, nutrients entering the nearshore from adjacent uplands, rivers, and streams are not easily diluted by mixing or flushing. The shallow nature of the bays and inlets results in high productivity – given abundant nutrients and light, plankton and other algae have high growth rates (Nakata and Newton, 2001). The South Sound likely experienced greater periods of low DO historically due to its physical characteristics, but these also make the region more vulnerable to increased low DO levels and eutrophication associated with rural and urban development in the adjacent uplands. The South Puget Sound area experiences a greater frequency of periods with dissolved oxygen (DO) levels low enough to kill marine organisms more frequently than other areas of Puget Sound (Newton et al., 1997).

Excess nutrients entering these areas can lead to water quality problems associated with eutrophication – algal blooms and low levels of dissolved oxygen (hypoxia), which can be detrimental to marine organisms. Greater phytoplankton growth or algal blooms stimulated by excess nutrients reduces light levels reaching the bottom, and reduces the growth and vigor of other plants, such as eelgrass and macroalgae (Williams and Thom, 2001). Eutrophication can also lead to contamination of shellfish beds from the harmful bacteria associated with some nutrient sources (i.e., fecal coliforms), and from harmful algal blooms, which are thought to contribute to Paralytic Shellfish Poisoning (PSP) and Amnesiac Shellfish Poisoning (ASP) (WDOH, 2005). In addition, excess nutrients can affect phytoplankton community composition and therefore, indirectly affect marine food webs that rely on phytoplankton.

3.3.3 Habitats and Species

The resulting landforms and end water quality within the marine nearshore results in characteristic habitat types that support all levels of the food web. Key marine habitats in the study area include: eelgrass and kelp beds, shellfish beds, forage fish spawning areas, estuaries and other intertidal wetlands/marshes, nearshore riparian habitats, and waterfowl concentration areas. With the exception of the highly urbanized and altered habitats along the head of Budd Inlet, the majority of the marine nearshore environment either supports or has the potential to support valuable and ecologically sensitive resources.

Key habitats and species that occur in the study area include:

- Sand and cobble beaches;
- Forage fish spawning areas;
- Tidal sand , mud flats, and sub-tidal shoals;
- Shellfish resources
- Eelgrass and kelp beds;
- Estuaries and intertidal wetlands and marshes;
- Marine riparian vegetation;
- Seabird and waterfowl concentration areas; and
- Marine mammal habitats.

3.3.4 Nearshore Marine Important Areas and Alterations

Important areas and alterations within the marine nearshore focus on:

- Freshwater inputs to salt water;
- Structural hydro-modifications (e.g., the Capitol Lake Dam);
- Known areas with water quality degradation (e.g., Category 5 303(d) listings, WDOH Shellfish closures);
- Sources and sinks of sediment (e.g., feeder bluffs);
- Substrate type and composition;
- Presence of artificial structures along the shoreline (e.g., seawalls, bulkheads);
- Presence of important habitat types (e.g., eelgrass beds, pocket estuaries, forage fish spawning areas, tidal marsh); and

- Presence of a forested marine riparian area.

To assess the relative condition of each of the marine nearshore reaches within the TRPC shoreline planning area, general GIS databases provided by the TRPC were queried to provide a baseline summary of each parameter listed above, and these results are summarized below in Table 3-3. These results were then translated into numerical scores and summed to develop a single number for each reach. The results were then divided into three groups (high, medium, and low) using the maximum score divided into three equal segments. This provides a first order, simplified assessment of the overall condition of each reach. Please note that importance and alteration are combined in this method, to provide one measure, therefore these results do not directly suggest areas where restoration would be most effective.

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Table 3-3. Nearshore Marine Important Areas and Alterations

Reach	Hydrology		Water Quality		Sediment			Habitat				Landscape
	Mapped Freshwater Input?	*Hydro-modification?*	*303(d) list?*	*WA DOH Shellfish Closures?*	*Potential feeder bluff?*	*Upper Substrate Type*	*Bulkhead/ revetment Present?*	*Eelgrass/ kelp mapped?*	*Pocket Estuary?*	*Forage fish spawning?*	*Marsh*	*Forest along shoreline?*
Budd-1	Yes	Yes (Capitol Lake dam)	Yes - DO	Closed	Yes (1)	Inclined Beach – Pebbles over sand	Yes - seawall	No	No	Yes	Yes	Medium
Budd-2	No	Yes (Capitol Lake dam)	Yes - DO	Closed	Yes (1)	Inclined beach – Pebbles over sands, fines, and mud	Yes - seawall	No	No	Yes	No	High
Budd-3	Yes	Yes (Capitol Lake dam)	Yes - DO	Closed	No	Tidal flat – Fines and mud	Yes - seawall	No	No	No	Yes	Low
Budd-4	Yes	Yes (Capitol Lake dam)	Yes - DO	Closed	No	Tide flat - Fill	Yes – dam/riprap	No	No	No	No	Low
Budd-5	No	Yes (Capitol Lake dam)	Yes - DO	Closed	No	Tide flat and wharf – mud and landfill	Yes	No	No	No	No	Low
Budd-6	Yes	Yes (Capitol Lake dam)	Yes - DO	Closed	No	Tidal flat – Fines	Yes	No	No	No	No	Low
Budd-7	No	Yes (Capitol Lake dam)	Yes - DO	Closed	No	Beach Face– Sand	Yes	No	No	Yes	No	Low
Budd-8	Yes	Yes (Capitol Lake dam)	Yes - DO	Closed	Yes (2)	Inclined Beach –Sand	No	No	Yes*	Yes	Yes	High
Nisqually 1	No	No	No	Yes (2006)	Yes (1)	Pebble overlying sand	No	No	Yes	Yes	Yes	High
Nisqually 2	Yes	No	No	No	No	Sand, pebble	Yes, seawall	Yes	No	Yes	No	Low

*Not mapped, but apparent on aerial photograph

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3.3.5 Assessment of Nearshore Marine Shorelines

By reviewing the results of the important areas and alterations for each of the major function groups, a qualitative assessment of the overall condition of the nearshore marine environment within the study area can be developed. This assessment uses a generalized scoring approach using the results of the reach analysis above. The scoring approach takes the following general form:

Score = Hydrology + Water Quality + Sediment + Habitat + Landscape

Where: Hydrology = Freshwater input (yes = 1, no = 0) + Hydro-modification (no = 1, yes = 0)

Water Quality = 303(d) list (yes = 0, no = 1) + Shellfish Closure (yes = 0, no = 1)

Sediment = Feeder bluff (score = number of mapped bluffs) + presence of bulkhead/revetment (yes = 0, no = 1)

Habitat = Score equals the number of key habitats present

Landscape = Forest cover along marine riparian (>50% = 2, 25 to 50% = 1, <25% = 0)

Table 3-4. Relative condition and importance of each marine nearshore reach within the TRPC Shoreline Planning Area

Reach Name	Condition	Notes
Budd-1	Medium	Alterations low, with the exception of the overall hydromodification of Capitol Lake Dam; few sediment or habitat important areas.
Budd-2	Medium	Alterations low, with the exception of the overall hydromodification of Capitol Lake Dam. Few sediment or habitat important areas.
Budd-3	Low	High level of alteration due to fill and marina; no key habitats.
Budd-4	Low	High level of alteration due to Capitol Lake dam; no key habitats.
Budd-5	Low	High level of alteration due to fill and industrial land use; no key habitats.
Budd-6	Low	High level of alteration due to fill; no key habitats.
Budd-7	Low	High level of alteration due to residential development; only forage fish spawning habitat.
Budd-8	High	Low level of alteration (part of a Priest Point Park)
Nisqually 1	High	Low level of alteration, several key habitats.
Nisqually 2	Medium	Medium level of alteration, several key sediment and habitats

These results should only be used for general discussion; no sensitivity analysis or other quality control has been performed on this approach.

However, these results have generally good agreement with the preservation and restoration recommendations included in the *Marine Shoreline Sediment Survey and Assessment* (Herrera 2005). Reaches that have been designated high priority for forage fish spawning protection in the 2005 report are listed as 'high' in this assessment.

3.4 Freshwater Rivers and Lakes

For freshwater systems in the study area, ecosystem processes focus on the movement, partitioning, and storage of water, sediment, nutrients, bacteria, pathogens, and plants within an ecosystem at multiple spatial and temporal scales. This section focuses on natural processes that are the intrinsic building blocks for ecosystem functioning, specifically in the freshwater portion of the TRPC's shoreline planning area.

For the purposes of this discussion, we grouped processes under these broad headings:

- Physical processes (e.g., hydrology, sediment generation and transport);
- Water Quality; and
- Habitat.

An overall description of how these processes occur within the study area is included below. The purpose of this discussion is to identify important areas for ecosystem processing in the landscape. Alterations to those processes are also identified, and ranked in relative terms.

This analysis relies heavily on the landscape analysis approach developed by the Department of Ecology as generally discussed in Stanley et al 2005. This approach focuses heavily on hydrologic processes, since it is the generation, storage, and transport of water that is the process that is most effective in connecting upland and aquatic ecosystems.

3.4.1 Physical Processes

The primary physical processes that influence shoreline ecosystem processing is hydrology and sediment generation and transport. These processes are often tightly linked, since surface water is one of the primary vectors for sediment entrainment and transport. Hillslope processes also function to mobilize sediments from uplands to alluvial valleys where they are more likely to reach aquatic systems.

3.4.1.1 Surface Water Runoff

Surface water runoff within the cities of Lacey, Olympia and Tumwater occurs through many river and stream channels that drain from the broad upland plain northward to the marine nearshore. A small portion of the study area drains to the southwest into the Chehalis River basin. Major surface water channels that are Shorelines of the State include: the Deschutes River, Percival Creek, Chambers Creek, and Woodland Creek.

Many smaller tributaries have been mapped and identified throughout the study area. They are typically short in length, given the small lateral extent of watersheds in this area. These tributaries are typically either short, low gradient channels that connect large wetland or lake systems, or steep channels that flow through ravines at the margins of the glacial upland.

Surface runoff patterns are strongly seasonal; as an example, see the following graphic for the Deschutes River developed by the USGS (Sinclair and Bilhimer, 2007). Much of study area is at low elevation, generally less than 1,000 feet above sea level, indicating that snowmelt and rain-on-snow events are less important for overall surface water hydrologic patterns. These events can, however, drive peak flows, especially in the larger Deschutes River basin.

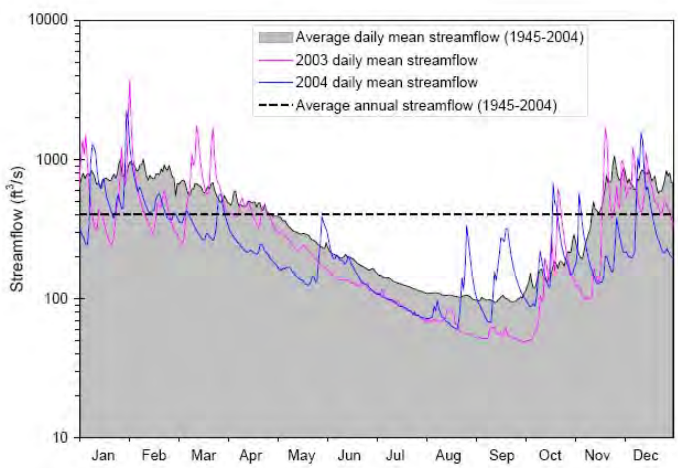

Figure 3-4. Streamflow of USGS Station 12088010, Deschutes River at E-Street Bridge in Tumwater (Sinclair and Bilhimer, 2007)

3.4.1.2 Groundwater Patterns

Groundwater flow patterns within the study area depend upon the translation of infiltrated rainfall into a complex sequence of glacial deposits that include several major regional aquifers. Precipitation that falls within the study area that infiltrates has the potential to reach several aquifers that occur in the 1,200 to 1,800 feet of sediments that overlie Tertiary bedrock in this area.

Groundwater aquifers and flow patterns have been investigated in the past by the USGS, with more recent efforts focused on detailed investigations of surficial recharge and discharge patterns along the Deschutes River (Drost et al., 1998; Sinclair and Bilhimer, 2007). These efforts included the collection of well monitoring data, geological borings, instream piezometers, and seepage runs. General results of inferred regional groundwater flow directions along the Deschutes River shown on Figure 3-X, below, and please refer to Drost et al. (1998) for more detail.

This past work identified at several geohydrologic units below the study area. These units include several significant regional aquifers, as shown in the conceptual section included below. These aquifers are typically separated by materials that can contain water, but do not provide significant yield. A surficial aquifer consisting of both young alluvium and recessional outwash (Qvr) materials exists over much of the study area. This aquifer is typically unconfined, and can often intersect with the ground surface in depressions, forming lakes or depressional wetland systems. This surficial aquifer is often underlain by a compacted till layer (typically Qvt), which acts to slow percolation to lower, coarser geo-hydrologic units.

A deeper aquifer exists within advance outwash (Qva) materials, which are typically coarse materials that have been overridden by the advancing glacier. These materials underlie the majority of the study area, and are usually between 15 and 35 feet thick. The Qva aquifer provides much of the municipal and industrial water source for the Tumwater area. The Qva aquifer is confined below by the Kitsap formation deposit (Qf), which is typically fine-grained enough to limit downward percolation.

The Salmon Springs Drift (Qc) is the most widely utilized aquifer in the study area. This unit is typically 30 feet thick, but can be greater than 200 feet thick. This unit can reach elevations up to 50 feet below sea level, but is usually between 50 and 150 feet above sea level.

Below the Qc unit is a mix of unconsolidated sediments termed unit TQu in Drost et al 1998. This layer can contain localized lenses of water, but can be highly variable. The interface between fresh and saline waters typically occurs within this unit. The TQu unit is underlain by Tertiary bedrock, which typically acts as a lower limit of significant groundwater volume.

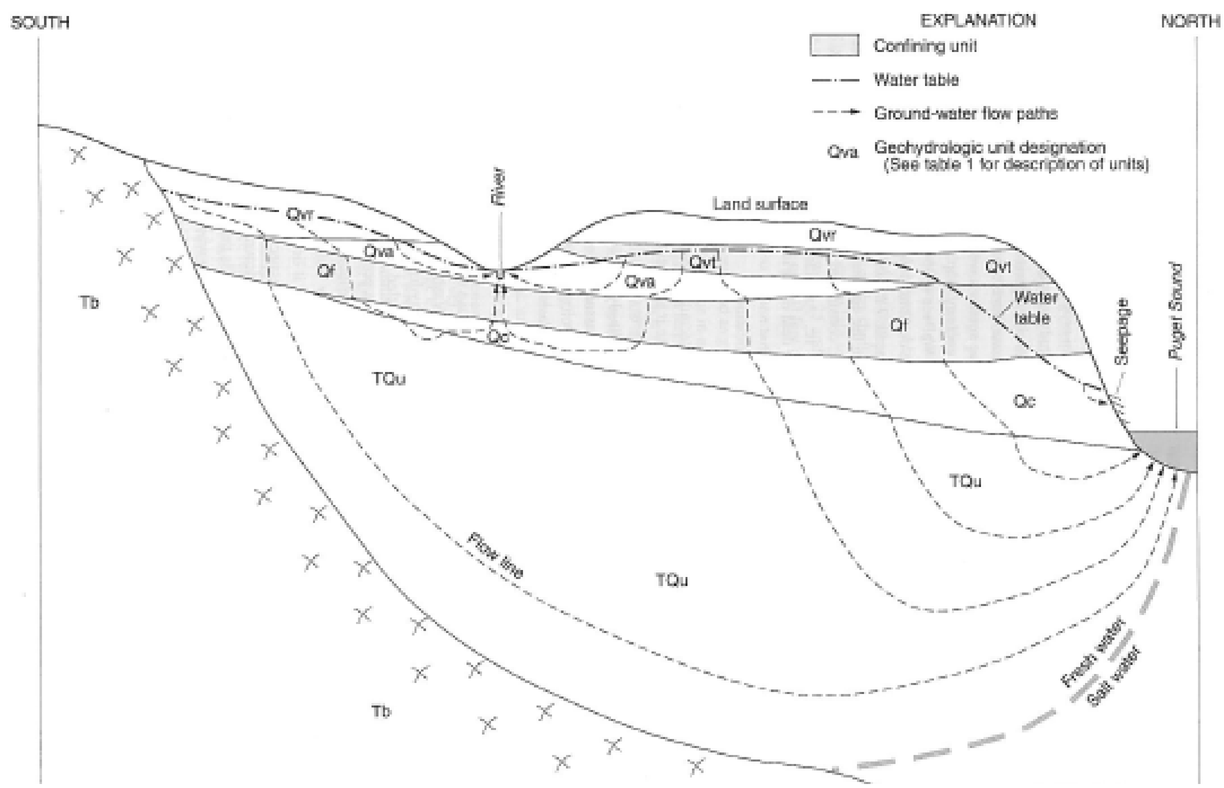

Figure 3-5. Conceptual model of the ground-water system for northern Thurston County (Drost et al., 1998)

The prevalence of relatively coarse, water-bearing layers at and near the surface indicates the importance of recharge of precipitation to support the many lake and wetland systems within the study area. These deposits result in aquatic systems that are tightly linked to land use in the contributing basin.

This pattern can also result in groundwater flooding, as storm flows that are translated quickly through the shallow subsurface concentrate in depressions. Water volumes within these depressions can be significant enough to spill into nearby infrastructure (USGS, 2000).

Therefore, important areas for groundwater resources consist primarily of recharge areas in locations with surficial deposits with high permeability.

3.4.1.3 Sediment Generation and Transport

The generation and transport of sediment is a key ecological process, especially for fluvial and lacustrine systems. Streams function to transport sediment throughout the watershed, and stream channels are constant evidence of erosion in the landscape. The processes that govern the production, storage, and transport of sediment play a significant role in shaping the morphology and functioning of freshwater ecosystems. Sediment is delivered to channels via overland flow, mass wasting (e.g., landslides, lahars), and channel migration (e.g., eroding the outside of a meander bend) (Stanley et al., 2005). The relative importance of sediment generation and transport pathways is typically a result of the interaction between climate and physical features of the landscape. For lakes, sedimentation can substantially change the overall shape, volume, and hydraulic residence time over the course of their existence.

The movement of sediment into, through, and out of the freshwater shoreline ecosystem influences the form and functions of freshwater lake and river shorelines within the study area, including: (1) shoreline morphology, (2) hydrologic and hydraulic characteristics, (3) ability of surface and groundwater to interact, and (4) type and extent of aquatic habitat.

Channel migration in rivers is a key source of sediment within the study area (McNicholas, 1984; Collins, 1994; Raines, 2007). As channels naturally migrate within the alluvial valley, erosion at the outside of meander bends provides sediment to the channel. This process is especially important along the Deschutes River, which meanders through a glacial upland with numerous opportunities to erode glacial terraces composed of outwash or till. Collins (1994) suggests that erosion of glacial terraces between river miles 2 and 16 (the majority of the study area) is one of the key sediment production areas in the watershed. Raines (2007) asserts that erosion of glacial terraces appears to account for two-thirds of all fine sediments, and about one-half of the annual average sediment accumulation in Capitol Lake. Sediment contribution from channel migration likely varies over time, as stream channels adjust during and after significant runoff events (e.g., January 1990).

Sediment delivery from the Deschutes River is a key process since these sediments, along with a smaller contribution from Percival Creek, are being deposited within Capitol Lake. A bathymetric study indicates that approximately 1.6 million cubic yards of sediment have accumulated in the lake since the dam was closed in 1951 (George et al., 2006).

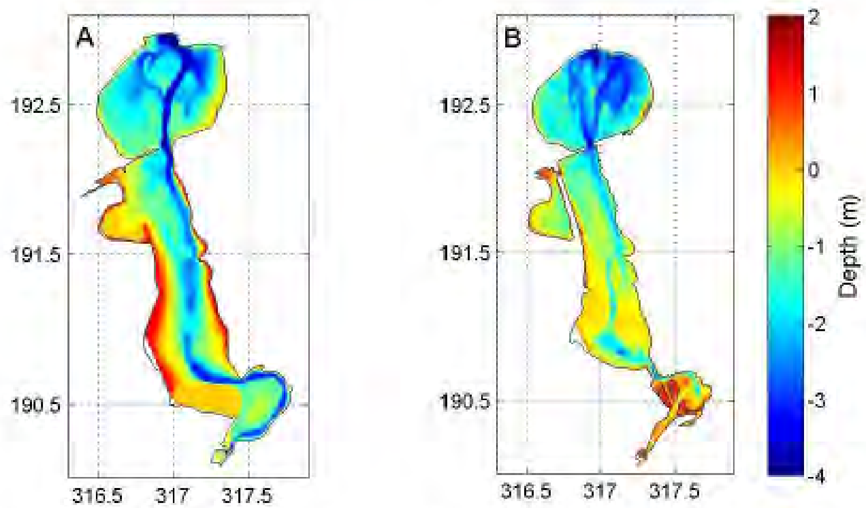

Figure 1.4. Bathymetric maps of Deschutes Estuary in 1949 (A) and Capitol Lake in 2004 (B). Blues are deeper water and reds are shallower (m MSL). Large changes to the shoreline and amount of open water are observed around Percival Cove and between South and Middle Basins.

Figure 3-6. Bathymetric maps of Deschutes Estuary in 1949 (A) and Capitol Lake in 2004 (B)

Channel migration is a natural process, and is essential for the transfer of nutrients between the channel and floodplain, as well as an on-going source for streambed gravels. However, migration rates and streambank erosion can be accelerated by changes in flow patterns and loss of riparian cover including the loss of root masses which stabilize river banks.

Landslide and erosion-prone areas are also key sediment producing areas in the Puget Sound lowlands. However, these areas are relatively rare within this study area (see inventory map X), and are typically focused along bluffs above the marine shoreline.

Changes in land use, including timber harvesting, urbanization, and associated road construction, have generally accelerated production of fine sediment throughout the study area. A recent estimate indicates that anthropogenic sources account for 26 to 32 percent of fine sediment load assessed (Raines 2007). The removal of forest cover can increase production of fine sediment as runoff volumes and peak flows are increased. Increased flows increase in channel erosion and channel destabilization. Further, removal of fine-root biomass increases the potential for mass-wasting.

Increases in fine sediment loading can adversely impact aquatic habitat by filling in the interstitial spaces of channel bed gravels and reducing the exchange of water and oxygen between stream flow and the channel bed. Fine sediment can also act as a transport vector for nutrients, metals, and other pollutants. Throughout the study area, this process likely occurs along the Pattison/Long Lake drainage system, which is on the 303(d) list for total phosphorous.

3.4.2 Water Quality Processes

The quality of the water flowing through aquatic systems is the end result of the interaction of water with biota, soils, and urban and rural land uses, and infrastructure. Ecosystem processes that impact the source, concentration, and transport of mineral and organic constituents are: biotic uptake (e.g., plant growth), decomposition (e.g., plant death), adsorption (e.g., chemical binding), and dissolution (e.g., chemical unbinding). In general, elements cycle between dissolved and particulate forms in water to plants, animals, and soils; and back to the water column via decomposition.

Processes that influence water quality occur over a variety of scales. As water moves through an ecosystem, it has the opportunity to cycle (deposit, uptake, entrain, and/or transport) mineral and organic constituents that can affect water quality. The longer water is able to contact soil and vegetation, the more cycling can occur. Longer water contact times typically occur in low gradient areas in the landscape such as riverine and depressional wetland systems. Water contact time is shorter in areas where rivers have been channelized, and the floodplain filled and paved.

Water quality within the many lakes in the study area is a significant concern. Lakes are typically sensitive to changes in nutrient loading, which can drive significant ecological changes (e.g., algal blooms, changes in dissolved oxygen levels, etc.). Water temperatures increase in lakes within urban areas where shoreline vegetation is lacking and urban runoff is a primary water source. Higher water temperatures affect dissolved oxygen and encourage the growth of algae and aquatic plants. In this way, changes in land use in the contributing area can have significant influence on overall lake water quality.

Alterations to water quality processes have occurred throughout the study area. These alterations span a range of activities, and include point sources (e.g., focused discharge from a wastewater treatment plant), and non-point sources (e.g., diffuse discharge from agricultural fields).

Within urban areas of the study area, water quality processes have been altered by the installation of impervious surfaces and stormwater conveyance infrastructure, which can bypass natural hydrologic pathways that include infiltration and percolation through soils. Constituents that can negatively impact water quality (e.g., metals, oils and grease, nutrients, bacteria) can build up on impervious surfaces, to be washed off during storm events.

Water quality alterations can be generally assessed by comparing water quality in streams and lakes to State water quality standards. The Department of Ecology maintains a database of water bodies where known water quality issues exist, known generally as the 303(d) list. Category 5 waters are those with known exceedences of State water quality standards. Within the study area there are several waterbodies that are listed as Category 5, or Category 4, which indicates that a clean up plan (also known as a Total Maximum Daily Load [TMDL]) has been developed and is being implemented.

Typical concerns within the study are focus on common degradations of water quality including:

- Bacteria (e.g., fecal coliform);
- Temperature;
- Phosphorous; and
- Dissolved oxygen.

For a complete listing of water bodies and their status on the 303(d) list, please refer to the inventory (TRPC 2008).

3.4.3 Habitats

The interaction of physical, water quality, and biological processes result in the many distinct terrestrial and aquatic habitats in the regions. The study area is located within the Puget Trough province, and the *Tsuga heterophylla* zone as defined by Franklin and Dyrness (1973). This ecosystem is dominated by the presence of a broad coniferous forest. Within the southern Puget Sound area, this forested ecosystem can include unique features, such as prairies (e.g., Wier Prairie near Olympia) and oak woodlands.

The freshwater aquatic systems of this region are highly influenced by the presence of a formerly ubiquitous forest. Large wood (known as Large Woody Debris [LWD]) significantly influences the geomorphic form and ecological functioning of riverine and lacustrine ecosystems in the Pacific Northwest (Maser et al., 1988; Nakamura and Swanson, 1993; Collins and Montgomery, 2002; Abbe and Montgomery, 1996; Collins et al., 2002; Montgomery et al., 2003a; Montgomery et al., 2003b). LWD consists of logs or trees that have fallen into a river or stream. In a natural system, LWD provides organic material to aquatic ecosystems and is considered a principal factor in forming stream structure and associated habitat characteristics (e.g., pools and riffles). Riparian vegetation is the key source of LWD. LWD is primarily delivered to rivers, streams, or wetlands by mass wasting (landslide events that carry trees and vegetation as well as sediment), windthrow (trees, branches, or vegetation blown into a stream or river), or bank erosion (Stanley et al., 2005).

The presence, movement, storage, and decomposition of LWD influence shoreline functions as follows:

- Delivery of wood and organics affects vegetation and habitat functions such as instream habitat structure (pools and riffles) and species diversity; and
- Riparian vegetation and LWD, provides habitat in the form of nesting, perching, and roosting as well as thermal protection, nutrients, and sources of food (terrestrial insects) to a variety of fish and wildlife species.

3.4.4 Freshwater Important Areas and Alterations

Freshwater important areas and alterations for the study area have been identified and assessed, consistent with the methods in Stanley et al. (2005). These areas, and the metrics used to assess them, are summarized below in Tables 3-5 and 3-6. Each metric was assessed within each of 106 analytical units that were, developed from existing sub-basin mapping.

Table 3-5. Freshwater important areas with metric and data source

Important Area	Metric	Data Source	Notes
Rain on Snow and Snow Dominated Areas	Percent of area within mapped polygons	WA DNR	Less than 0.1 percent of the study area is in ROS or SD areas
Precipitation	Weighted average precipitation within analysis unit	NOAA 1971 to 2000 climate normals	Weighted average ranges from 44.4 to 61.6 inches per year
Groundwater Recharge Areas	Geology map with high, medium, or low permeability assigned to each unit	WA DNR 1:100,000 geology mapping	Approximately 2/3 of the study area is in 'high' or 'medium' categories.
Historic depressional wetland (potential)	Percent potential wetland area	Intersect of NRCS hydric soil and <2 percent slope calculated from 6m DEM	Area within analysis units ranges between 0 and 18 percent, with approximately 3 percent of the overall area included as wetland.
Stream Confinement over Recharge Areas	Length of stream in unconfined, moderately confined, or confined areas intersected with Highly permeable areas	SSHIAP, WA DNR 1:100,000 geology mapping	

Table 3-6. Freshwater alterations with metric and data source

Alteration	Metric	Data Source	Notes
Impervious surface	Percent of area covered with impervious surface	TRPC land cover data	Used suggested transformations in TRPC 2001.
Forest Loss	Percent forest remaining	TRPC land cover data	Removed 'water' category from overall percent calculation
Road density	Road length divided by analysis unit area	TRPC roads layer	Categorically scored using Issaquah buckets.
Urban areas on highly permeable deposits	Intersect of urban areas and geology.	TRPC land cover data and DNR 1:100,000 geology	
Altered confined, moderately confined, and unconfined streams flowing over high or low permeability deposits.	Intersect streams with urban areas, then intersect with geology.	SSHIAP stream data; TRPC land cover data, and DNR 1:100,000 geology	
Wetland alteration	Intersect historic wetland layer with urban areas	Potential wetlands (described above), TRPC land cover data.	Likely under counts wetland area, and therefore wetland loss.
Forest loss over highly permeable areas	Intersect Forest Loss with Permeability data	TRPC land cover data, and DNR 1:100,000 geology	

Important areas and level of alteration were assessed using a three-step framework developed by Ecology to create a relative ranking of where protection or restoration would be most appropriate at the watershed scale. The framework develops a High, Medium 1, Medium 2, or Low score for both importance and alteration for each sub-basin within a study area. The scores for both importance and alteration are then taken together to develop an overall ranking of appropriate actions. Important areas include: 1) rain on snow areas; 2) surface storage (historic depressional wetlands) and floodplains; 3) recharge areas; 4) storage capacity areas; and 5) discharge areas.

The types of alterations that the framework considers are: 1) forest clearing; 2) filling of depressional wetlands; 3) channelization of streams; 4) road presence and density; and 5) impervious surface. The analysis helps identify a set of actions that would be most appropriate for each sub-basin within the watershed

Figure 3-7 shows how the combined alteration and importance rankings are used to prioritize where development, protection and restoration could occur in the watershed to target a net gain in ecosystem functioning. Areas providing a high level of important watershed processes and having a high level of degradation or alteration would be most suitable for "Restoration." Areas providing a low level of watershed processes and are highly altered would be most suitable for "Development." Finally, those areas with high level of providing important watershed processes and with low alteration are designated most suitable for "Protection." In the middle of the matrix, areas are denoted Protection/Restoration, as either method may be more appropriate. Please note, however, that this analysis should not be interpreted to indicate the only action that is appropriate in any given basin. The resolution of this analysis is limited by the resolution of the supporting datasets, and can only identify high-level trends in the landscape.

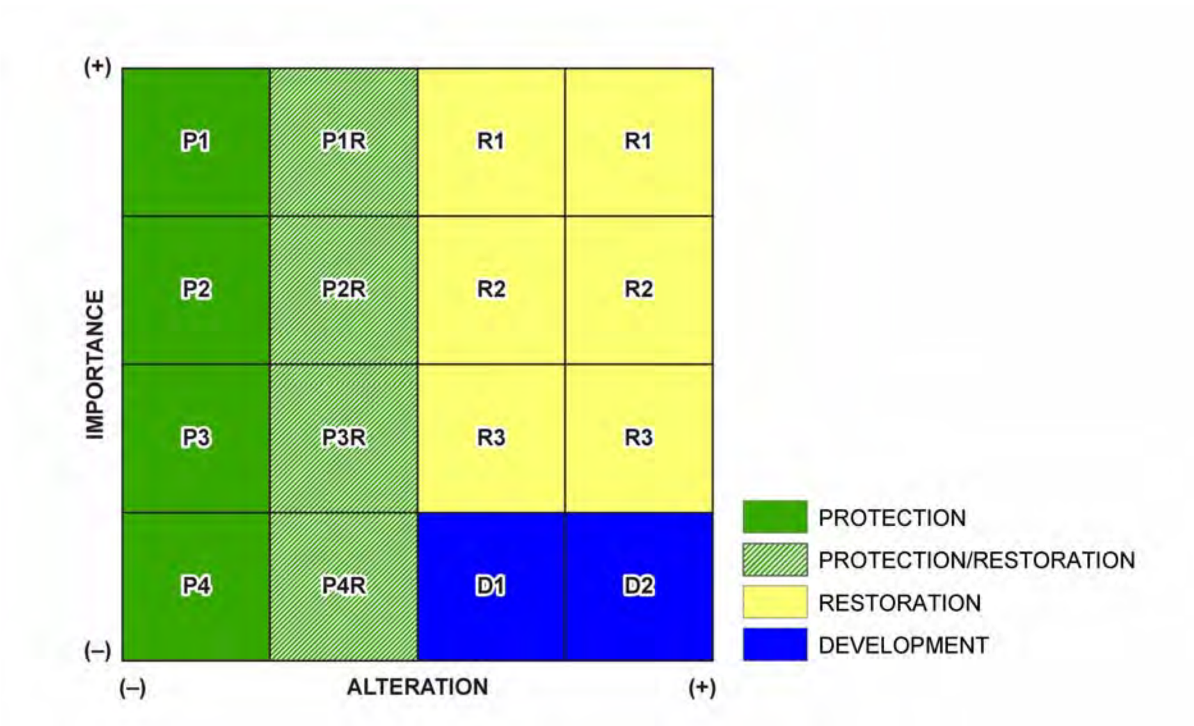

Figure 3-7. Conceptual view of the landscape analysis framework

3.4.4.1 Results

The overall initial results of the freshwater landscape analysis are depicted in the following three figures, showing the important areas, relative level of alteration, and the overall assessment which considers importance and alteration together. These results are shown with more resolution in figures provided in Appendix A. Data generated during the analysis is provided in Appendix B. Figure 3-8 shows the relative importance ranking of the drainage basins based upon the results of the landscape analysis.

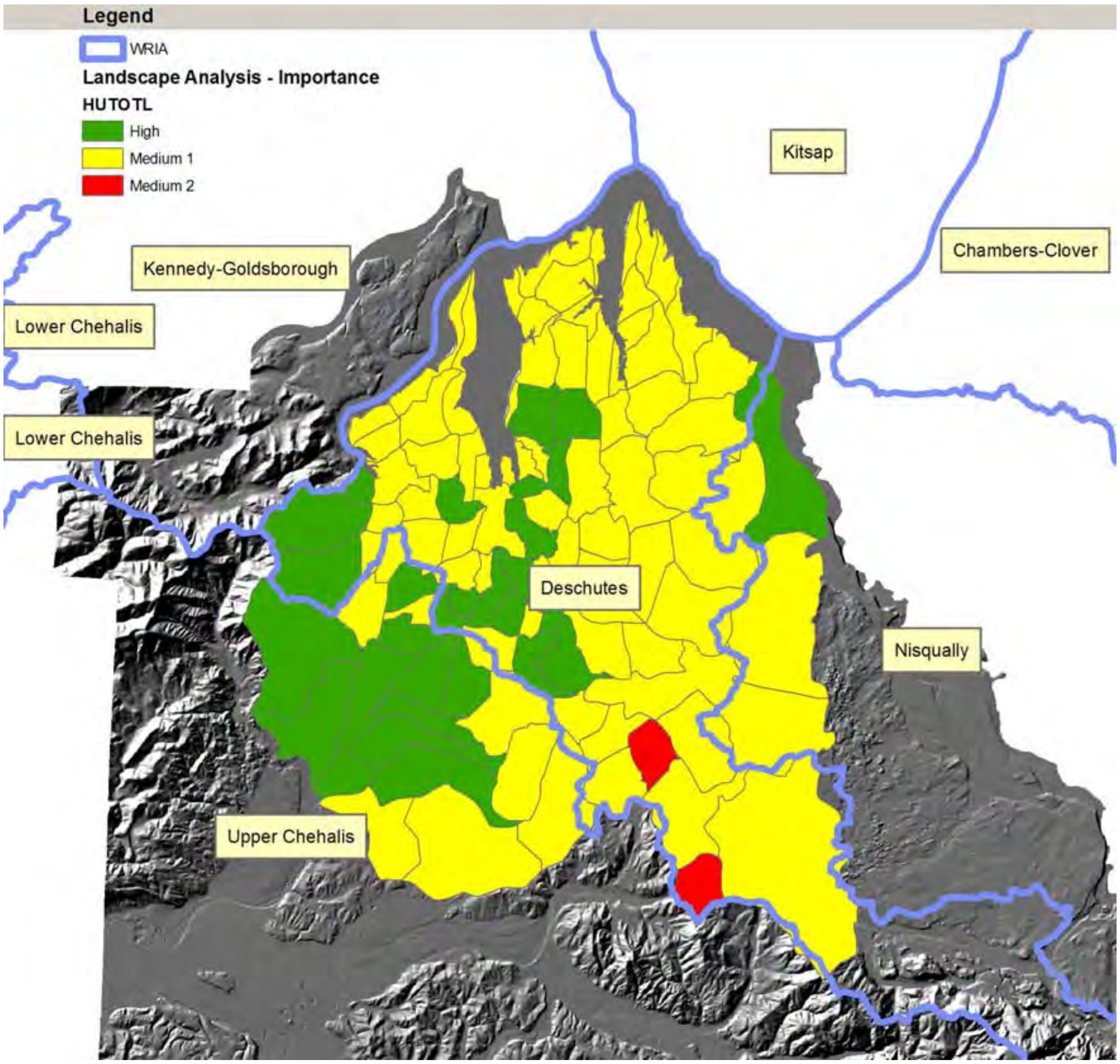

Figure 3-8. Relative importance ranking of each analysis unit. Using the current scoring mechanism, there are no "Low" importance areas.

As shown on Figure 3- 8, general patterns of importance include the higher elevation sub-basins within the study area that have greater yearly average precipitation, and include the few snow dominated and rain-on-snow areas. These sub-basins are focused generally in the western portion of the area in the upper Chehalis and Black Lake drainages. Some low-lying areas in the Deschutes basin likely score high due to highly permeable deposits, and the presence of an unconstrained river. Other pockets of 'high' importance include the portion of the Nisqually delta within the study area.

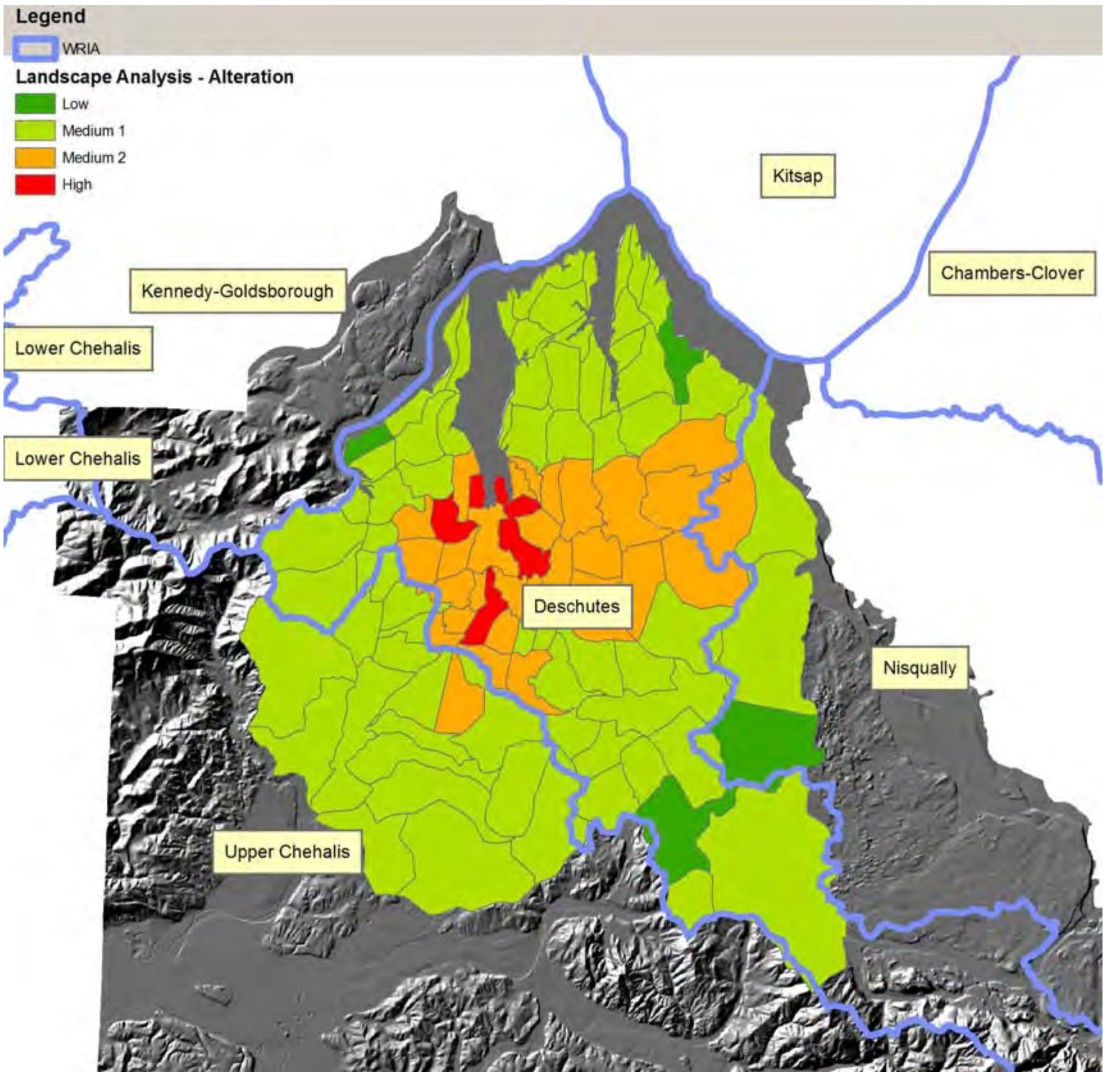

Figure 3-9. Relative alteration ranking for each analytical unit.

The majority of the sub-basins were ranked within the "Medium 1" category for alteration. The few "Low" alteration areas are focused in the upper Deschutes basin and along portions of the marine shoreline. Several "Medium 2" areas were identified, and these areas are typically found in the urban zones of the three cities. The units ranked as "High" alteration are focused in the urban core surrounding Budd Inlet.

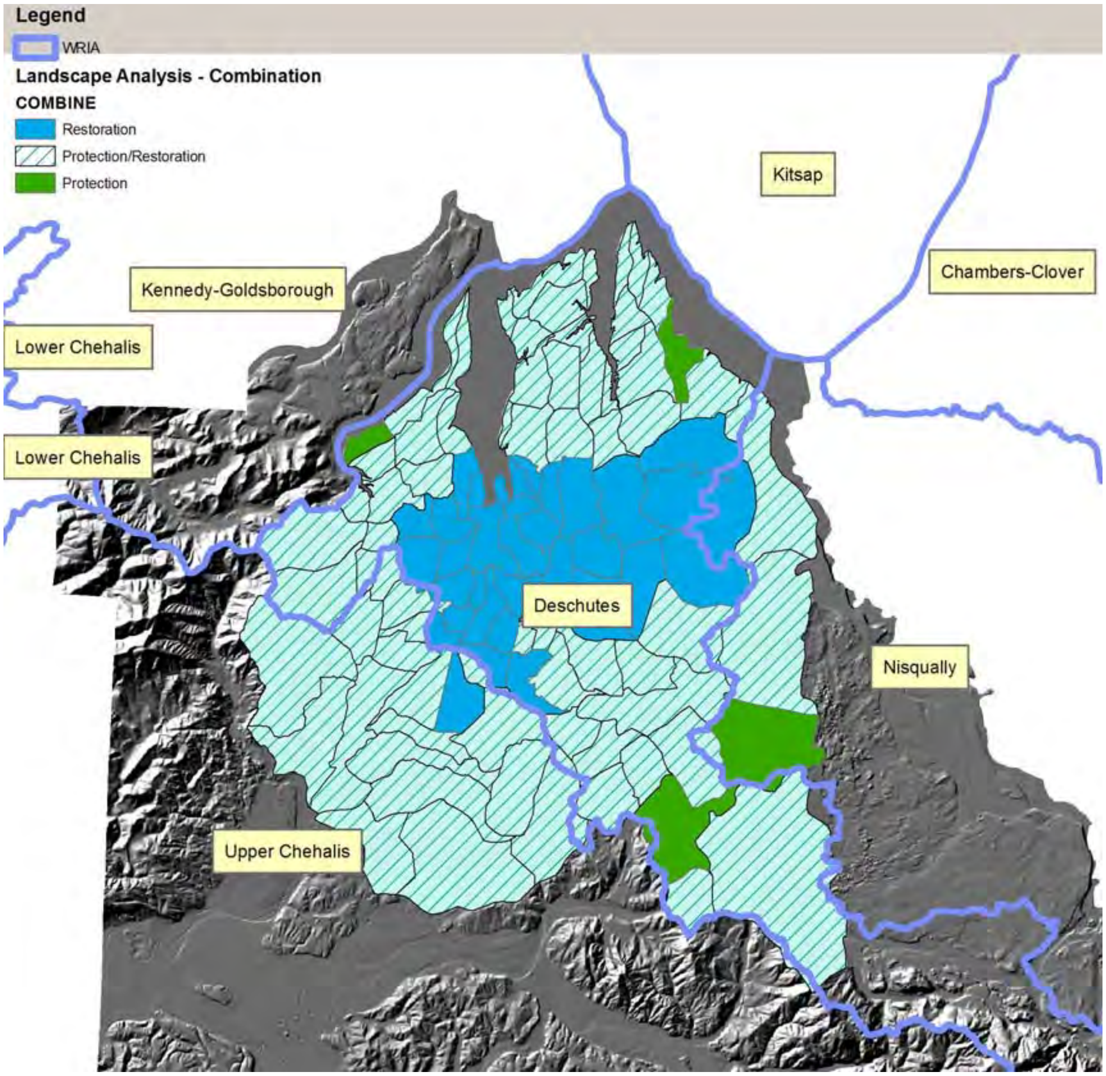

Figure 3-10. Integrated results of importance and alteration. Green indicates areas where preservation is most appropriate, green hatch for preservation or restoration, and blue for restoration only.

The integrated results shown on Figure 3-10 identify the highest restoration potential along the Deschutes River and within the urban core of the study area. Clearly, wholesale restoration of the area is difficult or impossible to achieve, given current infrastructure. However, the restoration of key aquatic areas within the urban area can provide important corridors and connections between the upper watershed and the marine nearshore. Preservation-only areas are limited to a sub-basin in the upper Deschutes basin, and three small sub-basins along the marine nearshore. The remainder of the area is located within the Preservation/Restoration area.

Please note that there are no “Development” subbasins, since there are no “Low” importance areas identified in the Thurston Regional Planning area. Since this is the case, we applied the Protection/Restoration category more broadly. These areas should be considered for a broad range of land uses, and site-specific information would be required to better identify specific areas for restoration or protection.

The freshwater landscape analysis has resulted in most areas being categorized as "Medium 2" or "High" for both importance (73 and 25 percent, respectively). Similarly, the majority of basins were "Medium 1" or "Medium 2" (combined 91 percent) for alteration. Further, no sub-basins were identified as "Low" for importance. These bunched results indicate the need for additional refinement of the scoring rationale for this particular study area.

Several opportunities exist to refine the analysis, including: (1) removing and/or addressing outliers from the normalization process, (2) running the analysis using the WRIA boundaries as distinct subareas (GUs in the model), and (3) revising some sub-basin boundaries. Some of these procedures have been incorporated into the newest version of the Ecology method, which is currently in peer review. The newer procedures incorporate an additional level of normalization, which ensures that all result levels will be represented in each GU.

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4.0 REACH ANALYSIS AND CHARACTERIZATION

4.1 Water Bodies in the Olympia, Tumwater, Lacey Shoreline Planning Area

Shoreline waterbodies in the cities of Lacey, Olympia and Tumwater have been described in detail within this chapter as required for the reach-scale assessment and analysis. Waterbodies are listed alphabetically by type of waterbody including marine shorelines, rivers and streams, and lakes.

4.2 Marine Shorelines

4.2.1 Budd Inlet

4.2.1.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Budd Inlet is located at the southernmost end of South Puget Sound. It encompasses both the West Bay and East Bay sub-basins within the Deschutes River watershed (WRIA 13). The total length of the Budd Inlet shoreline located in Olympia and the UGA shoreline planning area is 10.4 miles. Two bays, West Bay and East Bay, comprise the southern end of the inlet. The peninsula separating the bays is man-made created from fill placed in the early 1800s.

Shoreline topography varies along the shoreline of Budd Inlet. At the south end, in downtown Olympia, the shoreline is generally flat. The east and west sides of the inlet are characterized by steep bluffs (TRPC, 2008).

Several hydrologic features in these two sub-basins have been highly altered. Three main hydrologic alterations occur in this area. First is Capitol Lake (see 4.4.4, Capitol Lake), which is an artificial lake constructed in the Deschutes River estuary. Second, Indian Creek and Moxlie Creek join together at the business district of Olympia and drain underneath the business district through a piped section into East Bay. Third, the Black Lake Drainage Ditch drains Black Lake to the north into Percival Creek (TRPC, 2008).

Streams

The Deschutes River drains into Budd Inlet via Capitol Lake; this is the only major river that drains into Budd Inlet. Eight tributaries drain into Budd Inlet: Butler Creek, Schneider Creek, Garfield Creek, Indian Creek, Moxlie Creek, Ellis Creek, and both Black Lake Drainage Ditch and Percival Creek, which flow into Budd Inlet via Capitol Lake (TRPC, 2008).

Wetlands

Approximately 6.3 acres of wetlands are mapped within the floodplain of Budd Inlet. According to data provided by the TRPC, these wetlands are located at Reach BUDD-2 and BUDD-8, respectively, and are both palustrine forested (PFO) wetland habitat. The wetland area along Reach BUDD-8 is located along the beach south of Ellis Cove in Priest Point Park. This wetland includes a small patch of salt marsh located along the beach (TRPC, 2008).

Table 4-1. Wetland habitat and area by shoreline reach – Budd Inlet

Reach Number	Wetland Habitat Type[1]	Total Wetland Acres	Approximate Location
BUDD-2	PFO	1.9	West Bay
BUDD-8	PFO	4.4	Priest Point Park

[1.] PFO = palustrine forested wetland.

Two wetland mitigation sites are located in Budd Inlet. One mitigation site is located at the north end of the Port Lagoon (along West Bay Drive and north of the 4th Avenue Bridge); this is a mitigation site for the new 4th Avenue Bridge. In addition, the northern beach area of the Port Peninsula (adjacent to Cascade Pole) has undergone remediation (TRPC, 2008).

4.2.1.2 Geologic and Flood Hazard Areas

There are several geologic hazard areas in Budd Inlet, all of which pertain to steep slopes. There are steep slopes located in Priest Point Park and east of East Bay Drive. These areas are noted as landslide hazards on Map O-13. An existing steep slope is located along the west shore of the Port Lagoon and west of West Bay Drive, north of Schneider Creek. In addition, there are steep slopes adjacent to the shoreline located north of the fill areas along the west shoreline of West Bay. The main flood hazard associated with lower Budd Inlet is tidal flooding. Shoreline properties that are located along the perimeter of the inlet may be affected by tidal flooding (TRPC, 2008).

4.2.1.3 Coastal Bluffs, Beaches and Drift Cells

Feeder bluffs are mapped at Priest Point and south of Ellis Cove on the east side of Budd Inlet (Map O-14). Feeder bluffs are also found in small sections on the west side of the inlet south of Butler Cove. Beaches in Budd Inlet are generally depleted as sediment from the Deschutes River is captured in Capitol Lake, unable to pass into West Bay and feed the estuary. Drift cells mapped by Ecology show the net shore-drift in Budd Inlet to be to the north along the eastern side of East Bay and generally to the south along the western side of West Bay (Schwartz et al., 2002; Herrera, 2005). From Butler Cove, the net shore-drift is to the north toward Cooper Point.

4.2.1.4 Biological Resources

Critical or Priority Habitat and Species Use

The lower Budd Inlet area contains three levels of riparian habitat: high, medium, and low. Priest Point Park contains high quality riparian shoreline; the west shore of the Port Lagoon contains medium quality riparian shoreline; and the west shore north of the Dunlop Towing parcel ("the fills") along West Bay Drive contains low quality riparian shoreline. In the City of Olympia, these areas are designated as "Important Riparian Areas" (TRPC, 2008).

West Bay is characterized by a combination of open salt water, rocky shorelines, mudflats and salt marsh habitat, freshwater tributaries (including the Deschutes River via Capitol Lake), and vegetation consisting of deciduous, coniferous, and shrub vegetative cover (R.W. Morse, 2002).

Priority species associated with lower Budd Inlet include a variety of shorebirds and birds of prey. A study of birds observed in West Bay was undertaken in 2001 and 2002 (R. W. Morse, 2002). A total of 45 species of waterfowl, water birds, or raptors were documented in the West Bay bird survey. The greatest number of individuals of waterfowl observed in West Bay included: surf scoter, Barrow's goldeneye, Bufflehead, Common goldeneye, Double-crested cormorant, Great blue heron, Greater scaup, and mallard. Purple martins and osprey both nest in the vicinity of the inlet. Great blue heron have been observed in the area and roost as well. Shorebird concentrations are located along the original shorelines of both East Bay and West Bay. Ellis Cove is designated as a relatively intact estuary. The log rafts located north of the West Bay Marina are utilized by seals as haul-out areas (TRPC, 2008).

The Budd Inlet area contains several critical saltwater habitat areas as shown on Map O-14. The steep slopes of Priest Point Park provide beach sediment for forage fish. The Ellis Cove estuary is relatively intact with a salmon-bearing stream. The west shore of the Port Lagoon has patchy salt marsh habitat. Forage fish spawning extends south from Priest Point Park along East Bay for approximately 0.5 mile. Forage fish spawning is intermittent from Butler Cove Creek (along the west shore of Budd Inlet) south for approximately 0.75 mile (TRPC, 2008).

Table 4-2. Nearshore habitats by shoreline reach – Budd Inlet

Reach Number	Reach Length (miles)	Important Riparian Areas (Percent)	Feeder Bluffs (Percent)	Salt Marsh (Percent)	Eelgrass Beds (Percent)	Forage Fish – Sand Lance (Percent)
BUDD-1	0.8	0	6	13	0	0
BUDD-2	0.8	16	5	0	0	0
BUDD-3	2.6	12	0	16	0	0
BUDD-4	0.3	0	0	0	0	0
BUDD-5	2.4	0	0	0	0	0
BUDD-6	0.9	0	0	0	0	0
BUDD-7	0.9	1	0	2	0	0
BUDD-8	1.6	100	12	16	0	15

Source: South Puget Sound Chinook Recovery Plan, 2004.

There are four salmon-bearing streams located in East Bay: Ellis Creek, Mission Creek, Indian Creek, and Moxlie Creek (Map O-14). Chinook, coho, and steelhead salmon all occur in Capitol Lake. Ellis Creek supports both Coho and chum. Indian Creek supports Chinook and coho. The

Washington Department of Fish and Wildlife (WDFW) stocks Indian Creek with coho and has observed resident coho along the entire length of the stream. Cutthroat trout and chum salmon may also inhabit Indian Creek. Mission Creek supports coho and chum salmon. In Moxlie Creek, the Olympia Stream Team has observed cutthroat trout, Chinook, and coho salmon. Schneider Creek supports coho salmon and cutthroat trout (TRPC, 2008). Shoreline armoring lines the shoreline of West Bay and intermittent sections of East Bay within Budd Inlet, which may affect Pacific sand lance and surf smelt spawning habitat (Haring and Konovsky, 1999).

Wildlife areas associated with lower Budd Inlet are divided into two areas: Priest Point Park and downtown Olympia. According to data provided by the TRPC, in Priest Point Park, various woodpecker species (including downy and pileated) have been observed as well as greater yellowlegs, western and least sandpipers, dunlin, Great Blue Heron, kingfisher, bald eagle, and pigeon guillemot. Osprey and brown creeper nests are located within the park. In downtown Olympia, willet and snowy egret species have been observed, and purple martin species have nested in piling-mounted nest boxes. Other birds observed in the area include rhinoceros auklet, Caspian tern, great blue heron, and belted kingfishers. Data recorded during a West Bay habitat assessment indicate there are three areas of high concentrations of shorebirds and waterfowl in West Bay: the west side shoreline, the cove, and the lagoon associated with the Port of Olympia (R.W. Morse, 2002).

Instream and Riparian Habitats

The lower Budd Inlet area contains a combination of mixed forested canopy and various types of development and disturbance along the shoreline. The north end of lower Budd Inlet, in both West Bay and East Bay, contains more forest cover than the south end (where downtown Olympia is located). Riparian vegetation in the north end of the inlet includes a combination of coniferous and deciduous forest, shrubs, and grasses. Developed shoreline areas in the southern portion of the inlet include a mixture of moderate and high density urban development. Several marinas, ten small docks, and several boat launches are located along the perimeter of the shoreline, particularly at the west and south portions of the inlet. The entire Olympia downtown shoreline is fill and is highly modified, containing high density urban development. Four marinas and the Port of Olympia are located in downtown Olympia, at the south end of the inlet. The 5th Avenue Dam, which separates the tidal waters of Budd Inlet from the fresh water of Capitol Lake, is located at the southwest corner of the inlet. The dam is located between high density development (to the east) and mixed development and riparian forested habitat (to the west) (TRPC, 2008).

A habitat assessment was completed in West Bay to assess potential impacts to wildlife during construction of the 4th Avenue Bridge in 2001 and 2002 (R.W. Morse, 2002). An alteration in Great Blue Heron roosting habits occurred following bridge construction. Herons that once roosted in the trees west of the Port of Olympia lagoon changed roosting locations to the small cove located south of Reliable Steel. However, herons, shorebirds, and waterfowl continued to feed in the lagoon following construction (TRPC, 2008).

4.2.1.5 Water Quality

Budd Inlet is located at the southernmost end of Puget Sound. South Puget Sound is shallower within numerous blind inlets and has slower flushing time than other parts of the Puget Sound. This results in lower dissolved oxygen (DO) and a deposition of finer sediments in the South Puget Sound (Llanso et al., 1998). As a result these shallow nearshore areas are susceptible to pollutant loading from man-made sources due to reduced circulation.

South Puget Sound marine waters, including Budd Inlet, have been identified as impaired through the Washington State Department of Ecology 303(d) list of impaired waterbodies for dissolved oxygen, fecal coliform bacteria, and other variables (Albertson et al., 2002). Budd Inlet is on the Category 5 303(d) list for dissolved oxygen.

Section 303(d) of the federal Clean Water act requires states to develop total maximum daily loads (TMDLs) for waterbodies not meeting designated uses due to pollution levels. Both point and non-point sources are expected to contribute pollutants to Budd Inlet. Eutrophication caused by increased nutrient concentrations can lead to water quality problems such as excessive algal blooms with resulting low dissolved oxygen in the bottom waters. Harmful algal blooms can result in Paralytic Shellfish Poisoning (PSP) and be harmful to human health.

Conditions in Budd Inlet have been studied since the 1980s and concern over eutrophication of marine waters has ultimately resulted in upgrades to the Lacey, Olympia, Tumwater, Thurston County (LOTT) wastewater treatment plant in the early 1990s. Due to degraded water quality in Budd Inlet and shellfish closures, the plant was required to remove nitrogen from its effluent. This upgraded significantly reduced nitrogen inputs to Budd Inlet.

The Budd Inlet Scientific Study was undertaken to evaluate circulation patterns, flushing and nutrient sources (Aura Nova Consultants et al., 1998). Results of the study indicate that circulation in Budd Inlet is much stronger than previously thought; however, it takes 8 to 12 days to replace the entire volume of water in Budd Inlet. Most of the fecal coliform (93%) appears to come from Capitol Lake/Deschutes River and Moxlie Creek.

Washington Department of Ecology has included Budd Inlet and Deschutes River in a total maximum daily load study (TMDL) which began in 2003. The TMDL project will identify pollution sources and recommend remedies for correction. Interim results are recently available from the TMDL study (Roberts and Pelletier, 2007). Near-bottom dissolved oxygen in central Budd Inlet has continued to decline over time. The possible restoration of the Deschutes River Estuary will be modeled as part of the TMDL study.

4.2.1.6 Land Use and Built Environment

Existing Land use and Shoreline Use

The shoreline planning area for Budd Inlet extends from Butler Cove on the western shoreline to Priest Point Park on the eastern shoreline. The Budd Inlet shoreline planning area contains a diverse land use pattern including residential, commercial, industrial, institutional, and open space uses. There are also privately owned vacant lands in the shoreline. The shoreline has been broken into eight reaches (BUDD-1 through -8) for this analysis.

Land use in the western most reaches (BUDD-1 and -2) is almost entirely low-density residential and vacant lands. The diversity of land uses increases south of the West Bay Marina. Reach BUDD-3 includes roughly equivalent amounts of commercial/industrial, parks and open space and vacant lands. The BUDD-4 shoreline consists of the north end of Capitol Lake and is predominantly in commercial use.

BUDD-5 includes the port of Olympia and a portion of Olympia's downtown. Most of the shoreline is occupied by the Port, and therefore land use in the reach is predominantly government/institutional. Some small areas of commercial uses occur in the reach. Percival Landing Park is also located in BUDD-5. The current land use pattern in BUDD-6 is a mix of government/institutional, residential, and open space. The Port of Olympia occupies most of the reaches' shoreline on the west side of East Bay. The east side of the East Bay in BUDD-6 is comprised of high-density residential uses and open space. The land use pattern in BUDD-7 is predominantly residential; a mix of low- to high-density. The most easterly shoreline reach of Budd Inlet (BUDD-7) consists entirely of Priest Point Park. Table 4-X shows the percentages of the major land uses within each shoreline reach.

Roadways comprise a large portion of the Budd Inlet shoreline planning area (33 percent of the entire shoreline area), particularly in the lower reaches around the port and downtown. Major roads in the planning area include East and Way Bay Drives. West Bay Dr also has an abandoned railroad right-of-way and trestle. The percentages of each shoreline reach covered by roadways are shown in Table 4-4.

There are numerous water-oriented uses in the Budd Inlet shoreline. Table 4-3 below lists each water-oriented use by category and by reach.

Table 4-3. Shoreline water-oriented uses – Budd Inlet

Reach Number	Water-Dependent Uses	Water-related Uses	Water-enjoyment Uses
BUDD-1	None noted	None noted	Community Access at Old Port Beach
BUDD-2	Log Booming	None noted	None noted
BUDD-3	West Bay Marina Evergreen State College Boathouse Log Yard Dunlap Towing	**West Bay** West Bay Marin – Boat repair service Private kayak rentals Brown-Minneapolis Tanks – tank manufacturer **Downtown Olympia** Yacht sales (Yacht club) Outboard motor sales Boat sales – Fidlehead Marina	**West Bay** Restaurants – Tug Boat Annie's Shred use trails Private Park – 1801 West Bay Drive West Bay Park Viewpoint at 234 West Bay Drive
BUDD-4	None noted	None noted	Viewpoint at 4th Ave Bridge Boardwalk – Percival Landing

Reach Number	Water-Dependent Uses	Water-related Uses	Water-enjoyment Uses
BUDD-5	Martin Marina One Tree Island Marina Fiddlehead Marina Swantown/East Bay Marina Evergreen State College Boathouse at Swantown Marina Olympia Yacht Club LOTT Sewer Outfall Port of Olympia Terminal Budd Bay Charters (boat tours)	None noted	Restaurants: Bayview Deli – Budd-4/5); Budd Bay Café; 2 Anthony's; Dockside Deli Port Plaza Walking Trails – East Bay Marina Viewing Tower – Port Plaza Boardwalk – Percival Landing
BUDD-6	None noted	None noted	Viewpoint: East Bay Waterfront Park
BUDD-7	None noted	None noted	None noted
BUDD-8	None noted	None noted	Priest Point Park

Future Land Use and Environment Designation

Land use in the Budd Inlet shoreline is anticipated to experience substantial change. The industrial uses in BUDD-3 along West Bay Dr and the eastern portion of the Port Peninsula are expected to be converted to mixed-use and commercial uses. A new park is planned for West Bay Drive (also BUDD-3). Redevelopment in downtown Olympia may increase the development density, but will not change the commercial uses.

The current shoreline designation for most of Budd Inlet (BUDD-3 through -7) is Urban. The shoreline from West Bay Marina to Butler Cove is designated Rural. Priest Point Park shoreline is designated Conservancy.

Shoreline Modification

The Budd Inlet shoreline is highly modified, particularly in and around the West and East Bays. Approximately 73 percent of the shoreline is modified. The West Bay shoreline is modified up to West Bay Marina. East Bay Drive residences are also highly armored. Olympia's downtown area is constructed over historic fill. Overwater structures include the Percival Landing Boardwalk, several marinas, and ten smaller docks.

Existing and Potential Public Access Areas

There are numerous existing and potential sites that offer both physical and visual access to the shoreline. Table 4-4 below lists the potential public access sites within each reach.

Table 4-4. Public access sites – Budd Inlet

Reach Number	Public Access Sites	Access Type
BUDD-1	None	N/A
BUDD-2	None	N/A
BUDD-3	West Bay Marina; 1801 West Bay Drive - small park; Seven Oars Art Site; West Bay Park (undeveloped); and Proposed waterfront trail.	Physical and Visual
BUDD-4	4th Ave Bridge; 5h Ave Damn; and Percival Landing Boardwalk	Visual
BUDD-5	Fiddlehead Marina; One Tree Island Marina; Martin Marina; Olympia Yacht Club; Swantown Marina; Port Plaza; Percival Landing Boardwalk	Physical and Visual
BUDD-6	East Bay Waterfront Park	Physical and Visual
BUDD-7	None	N/A
BUDD-8	Priest Point Park	Physical and Visual

Historic and Cultural Resources

There are two National Historic Districts located adjacent to Budd Inlet in Downtown Olympia. There are also numerous properties in the historic inventory or listed on local, state, or federal registers. Refer to the shoreline inventory for a complete list of historic properties.

Hazardous or Toxic Materials

Because of past and current industrial activities along Budd Inlet, there are numerous known and suspected sites with hazardous or toxic materials. The know sites are located along West Bay Drive (BUDD-1, -2, and -3) and Olympia's downtown (BUDD-5)

4.2.1.7 Reach Scale Assessment

Eight reaches have been identified within the Olympia and UGA shoreline planning area for Budd Inlet. These reaches are labeled BUDD-1 through BUDD-8 moving from the west UGA boundary around the perimeter of the shoreline to Ellis Cove and Priest Point.

Table 4-5. Shoreline reach-scale assessment – Budd Inlet

Reach Number	Reach Location	Reach Length (miles)	Armored Length (Percent)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
BUDD-1	West Bay – Butler Cove	0.8	74	SFR (73) Vacant (20) ROW (7)	Patchy salt marsh in Butler Cove, pocket estuary, forage fish spawning	Mixed coniferous and deciduous forest.
BUDD-2	West Bay- Shorezone unit boundary to Marina	0.8	34	SFR (41) Vacant (36) ROW (9)	Feeder bluffs, forage fish spawning	Mixed forest; forest cover limited in some areas.
BUDD-3	West Bay - Marina to Capitol Lake	2.6	88	Com/Ind (22) PPOS (19) Vacant (23) ROW (32)	Feeder bluffs, forage fish, salmon streams, patchy salt marsh. West Bay Park.	Riparian forested cover is limited.
BUDD-4	Capitol Lake mouth, including the existing dam	0.3	100	Com/Ind (42) ROW (49)		Riparian forested cover is limited.
BUDD-5	Capitol Lake to Port Peninsula	2.4	95	Gov/Inst (72) ROW (12)	This area of the inlet was filled for development. Percival Landing.	Riparian forested cover is limited.
BUDD-6	Head of East Bay	0.9	100	Gov/Inst (38) MFR (15) ROW (23)	East Bay Waterfront Park	Riparian forested cover is limited.
BUDD-7	East Bay - Residential Area along east side	0.9	94	SFR (50) ROW (29)	Forage fish spawning	Riparian forested cover is limited.
BUDD-8	East Bay - Ellis Cove and Priest Point	1.6	0	PPOS (99)	Priest Point Park, pocket estuary, feeder bluffs	Mixed coniferous and deciduous forest.

4.2.2 Nisqually Reach

4.2.2.1 Drainage Basin, Streams and Wetlands

Drainage Basin

The Nisqually Reach is located in the Nisqually basin within the Nisqually River Watershed (WRIA 13). The Nisqually Reach is a total of 1.75 miles long within the City of Lacey and the Lacey UGA. The marine shoreline along the Nisqually Reach is generally characterized by bluffs (TRPC, 2008).

Streams

Several small, unnamed tributaries drain into Butterball Cove and Mallard Cove (TRPC, 2008). Aerial photographs indicate that alluvial fans from each of these small tributaries can be observed in the nearshore environment. These streams appear to flow in steep ravines into the Puget Sound (Map L-4).

Wetlands

Approximately 8.5 acres of wetlands are mapped within the Nisqually Reach floodplain. According to data provided by the TRPC, this includes mostly forested wetlands. Reach NIS-1 contains one documented forested wetland area. Reach 2 contains a variety of wetland habitats that extend from the Mallard Cove area inland toward areas dominated by forested and shrub vegetation (TRPC, 2008).

Table 4-6. Wetland habitat and area by shoreline reach – Nisqually Reach

Reach Number	Wetland Habitat Type[1]	Total Wetland Acres	Approximate Location
NIS-1	PFO	1.6	West and east portions of shoreline
NIS-2	PFO	2.4	Central reach (forested cover)
	POW	0.8	Mallard Cove
	PSS	3.7	Central reach (shrub cover)

[1] PFO = palustrine forested; POW = palustrine open water; PSS = palustrine scrub-shrub.

Two pocket estuaries are located along Nisqually Reach: Butterball Cove, which contains a patchy salt marsh area; and Mallard Cove, which is an undesignated but degraded pocket estuary. Future plans for the tributary flowing to Beachcrest Pond include partial restoration of this area (TRPC, 2008).

4.2.2.2 Geologic and Flood Hazard Areas

There are no recorded landslide hazards for the Nisqually Reach (Map L-13). However, steeper slopes in stream ravines draining to this reach can be observed on the LiDAR maps for Butterball Cove and Mallard Cove (Map L-4). Shoreline properties may be affected by tidal flooding from the marine waters of the Nisqually Delta (TRPC, 2008).

4.2.2.3 Coastal Bluffs, Beaches and Drift Cells

Feeder bluffs in the Nisqually Reach are mapped at the headlands on either side of Butterball Cove (Map L-14). Beaches in the Nisqually Reach are fed by sediments from small tributaries and from the Nisqually River. Beaches here are Drift cells mapped by Ecology show the net shore-drift to be to the southeast from Butterball Cove to Hogum Bay. Hogum Bay is a convergence zone; drift from Nisqually Head converges at the bay (Schwartz et al., 2002; Herrera, 2005). From Butterball Cove, the net shore-drift is to the north toward Big Slough, another convergence zone. Herrera noted no appreciable drift along the Nisqually Reach, stating that the sediments moved in both directions in this area (2005).

4.2.2.4 Biological Resources

Critical or Priority Habitat and Species Use

The Nisqually Reach contains high quality riparian habitat, estuaries, and habitat that supports spawning for several species of forage fish. The longest segment of high quality riparian habitat occurs along DeWolf Bight, which is located between Butterball Cove and Mallard Cove. The Butterball Cove area provides sediment sources for forage fish spawning and is designated as a pocket estuary with areas of salt marsh. Salmon have not been observed in the tributary flowing into Butterball Cove, however. Mallard Cove is also a pocket estuary, although undesignated as well as degraded, and serves as a marina for the Beachcrest subdivision. Forage fish spawning has been recorded within Mallard Cove. Forage fish spawning beached are mapped also southeast of Mallard Cove, along with eelgrass beds, in the Lacey UGA (Map L-14). The segment of the Nisqually Reach within the drainage basin contains one commercial shellfish operation. Bald eagles have been recorded along the Nisqually Reach within this drainage basin. Unspecified salmon and trout species occur in this drainage area (TRPC, 2008).

Table 4-7. Nearshore habitat types by shoreline reach – Nisqually Reach

Reach Number	Reach Length (miles)	Important Riparian Areas (Percent)	Feeder Bluffs (Percent)	Salt Marsh (Percent)	Eelgrass Beds (Percent)	Forage Fish – Sand Lance (Percent)
NIS-1	1.2	0	6	35	0	9
NIS-2	0.7	0	0	0	0	52

Source: South Puget Sound Chinook Recovery Plan, 2004

Instream and Riparian Habitats

The Nisqually Reach shoreline is dominated by mixed coniferous and deciduous forest and shrub vegetation. A portion of the shoreline contains moderate density land use on the lower portion of the reach. In these areas, vegetation is dominated by shrubs and maintained lawns. Shoreline modification includes one old pier, one private marina located at Mallard Cove, and road infrastructure and armoring at the base of the bluff at Beachcrest subdivision (TRPC, 2008).

4.2.2.5 Water Quality

The Nisqually River and Nisqually Reach are on the 303(d) state list of waterbodies that do not meet water quality standards for fecal coliform bacteria. South Puget Sound, including Nisqually Reach, is designated "extraordinary marine water", formerly Class AA. Beneficial uses include extraordinary aquatic life use, shellfish harvest, and primary contact recreation (Ecology 2005, Nisqually river Water Quality publication no. 05-03-002). Water quality sampling has not been conducted specifically in Mallard Cove, Dewolf Bight or Butterball Cove. However, there are several known potential sources of bacteria along this shoreline, including Luhr Beach and several residential areas (James, 2007).

4.2.2.6 Land Use and Built Environment

Existing Land use and Shoreline Use

The Nisqually Reach shoreline planning area, within the City of Lacey and its UGA, is relative small (1.8 miles). The planning area is analyzed in two reaches (NIS-1 and -2), which are divided by Mallard Cove. Current land use within NIS-1 west of Mallard Cove is nearly all vacant (94 percent). Land use in NIS-2 east of Mallard Cove is predominantly open space (38 percent) and private vacant lands (39 percent). There is also a smaller component of low- and moderate-density residential development (17 percent). Roads make up approximately 7 percent of the planning area and include only local residential roads. A small private marina in Mallard Cove is considered a water-dependent use and community trails to the beach in NIS-2 are considered a water-enjoyment use.

Future Land Use and Environment Designation

The future land use pattern in NIS-2 is not anticipated to differ from its current use pattern. Uses in the NIS-1 shoreline are anticipated to change. A master planned community of moderate density residential development is planned for the vacant lands. The community would have approximately 214 homes. Under the current SMP, the Nisqually Reach shoreline is designated as Rural.

Shoreline Modification

Modifications to the Nisqually reach shoreline include one old pier, the marina at Mallard Cove and armoring at the base of the bluff at Beachcrest.

Existing and Potential Public Access Areas

Public access to the Nisqually Reach shoreline is very limited. There are no public parks or trails within the shoreline planning area. This shoreline is dominated by private residential properties without public access areas. Public lands and open space are mapped along a stream ravine west of and parallel to Beach Way NE, southeast of Mallard Cove (Map L-14).

4.2.2.7 Reach Scale Assessment

Two reaches have been identified within the City of Lacey and Lacey UGA shoreline planning area for Nisqually Reach. These reaches are labeled NIS-1 and NIS-2. These reaches extend from the west UGA/City of Lacey boundary to the east UGA boundary.

Table 4-8. Shoreline reach-scale assessment – Nisqually Reach

Reach Number	Reach Location	Reach Length (miles)	Armored Length (Percent)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
NIS-1	UGA/City boundary to Drift cell, near Shorezone unit break, and land use break at Mallard Cove	1.2	0	Vacant (94)	Butterball Cove, pocket estuary, feeder bluffs	Mixed coniferous and deciduous forest cover.
NIS-2	Mallard Cove to UGA boundary	0.7	23	PPOS (38) Vacant (36) SFR (17) ROW (7)	Mallard Cove, eelgrass beds	Riparian forested cover is limited.

4.3 Rivers and Streams

4.3.1 Black Lake Drainage Ditch

4.3.1.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Black Lake Drainage Ditch is located in the Percival Creek basin within the Budd/Deschutes Watershed (WRIA 13). The total length of the drainage ditch within the Olympia, Tumwater, and UGA is approximately 2.3 miles and topography along the drainage is generally flat (TRPC, 2008). This drainage ditch was constructed in 1922 to drain Black Lake to the north into Capitol Lake and Budd Inlet. Historically, prior to construction of the Black Lake Drainage Ditch, Black Lake drained to the south into Black River.

Streams

Black Lake Drainage Ditch drains Black Lake. Ken Lake also drains to the ditch. Black Lake Drainage Ditch flows into Percival Creek and eventually into Capitol Lake and Budd Inlet.

Wetlands

Black Lake Drainage Ditch contains approximately 161 acres of associated mapped wetland habitat. According to data provided by the TRPC, this includes a fairly even distribution of emergent, forested, and scrub-shrub wetland habitat along the stream. Emergent wetland areas occur mostly along the south sections of the stream; a portion of the emergent wetland habitat has been farmed. Moving to the north, associated wetland habitat changes to scrub-shrub vegetation with small forested patches. According to TRPC data, personal knowledge indicates that the forested wetland habitat supports pine tree species and this site was involved with a special mapping effort in 1987 (TRPC, 2008).

Table 4-9. Wetland habitat and area by shoreline reach – Black Lake Drainage Ditch

Reach Number	Wetland Habitat Type[1]	Total Wetland Acres	Approximate Location
BLDD-1	PEM	54.8	South end of stream
	PFO	52.8	South-central section of stream, east side
	POW	9.5	North end of stream
	PSS	38.1	South-central section of stream, west side
	R3OW	5.7	North end of stream

[1] PEM = palustrine emergent wetland; R3OW = riverine, upper perennial, open water wetland.

4.3.1.2 Geologic and Flood Hazard Areas

Black Lake Drainage Ditch is a channelized and straightened waterway from Black Lake to its confluence with Percival Creek. Geologic hazards are minor due to the overall level topography. However, there are minor slopes of filled land located east of Black Lake Boulevard and within the canyon from Mottman Road downstream to the confluence with Percival Creek. Black Lake Drainage Ditch is associated with a floodplain area and therefore overbank flooding may occur along the stream (TRPC, 2008).

4.3.1.3 Biological Resources

Critical or Priority Habitat and Species Use

Black Lake Drainage Ditch is located within a mapped riparian corridor linking Capitol Lake and Black Lake. Sensitive wildlife species associated with this waterbody include mink, which have been observed in the Percival Creek basin (TRPC, 2008).

Salmon species occurring in Black Lake Drainage Ditch include Chinook, coho, and chum. There have also been occasional observations of sockeye salmon along the stream (TRPC, 2008). One fish passage barrier (blocked culvert) has been identified along the ditch west of the intersections of R.W. Johnson Blvd. and Mottman Road (Haring and Konovsky, 1999).

Open water and associated wetland habitats along the drainage ditch provide opportunities for a wide variety of bird species to forage and nest. This includes shorebirds (e.g., greater and lesser yellowlegs, western and least sandpipers), cavity-nesters (e.g., chickadees, nuthatches, red-breasted sapsucker), waterfowl (e.g., northern pintail, American widgeon, green-winged teal), and a variety of songbirds and other bird species. In addition, dragonflies are frequently observed along this stream. There has been one reported sighting of the Pacific Clubtail, the second record in the state of Washington, and a highly sought-after dragonfly species in Washington (TRPC, 2008).

Instream and Riparian Habitats

Black Lake Drainage Ditch was constructed in 1922 to drain potential agricultural land north of Black Lake. As a result, instream habitats are degraded. The stream also captures the stormwater discharge from many of the commercial districts of West Olympia, through Yauger Park stormwater pond (constructed in 1981), and a regional stormwater detention facility located adjacent to Mottman Road (constructed in the mid-1990s). The City of Olympia stormwater facility was constructed adjacent to the drainage ditch in previously drained wetlands (TRPC, 2008). In 2006, Washington Trout and the City of Olympia worked together to plan and construct four engineered log jams to increase instream habitat complexity in Black Lake Drainage Ditch. The log jams were built closely associated with the stream bed so that they function both at high (winter-spring) flows and summer low flows to improve habitats for salmonids.

Riparian vegetation at the south portion of Black Lake Drainage Ditch is dominated by mixed coniferous and deciduous forest along with shrub vegetation. The north portion of the stream contains a combination of medium and high density urban development and shrub vegetation. One City of Olympia stormwater pond is located along the stream and mining activity occurs along the stream as well. A railroad runs parallel to the east section of the drainage ditch (TRPC, 2008).

4.3.1.4 Water Quality

Black Lake Drainage Ditch is on the 303(d) water quality list for temperature and has documented pollution problems related to fecal coliform concentrations. Because of high summer temperatures, dissolved oxygen in the ditch was found to be below standards in the summer of 2005. Black Lake Drainage Ditch is being studied by Ecology as part of a Total Maximum Daily Load Study (TMDL) to identify pollutant sources.

4.3.1.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Black Lake Drainage Ditch, which flows from Black Lake to Percival Creek, is analyzed as two reaches (BLDD-1 and -2). Land use in BLDD-1, the southern reach, is predominantly natural resource lands (45 percent); parks, preserves and open space (13 percent); and vacant lands (25 percent). There are some areas of industrial use, where mining operations are located. The land use pattern within BLDD-2 is a mix of parks, preserves and open space (28 percent), government/institutional (20 percent), and commercial and industrial uses (17 percent).

Roads make up approximately 2 percent of the shoreline land use in BLDD-1 and 26 percent in BLDD-2. Roadways in the shoreline vicinity include Black Lake Blvd, which parallels the ditch on the west side. Black Lake-Belmore Rd SW crosses the ditch immediately north of Black Lake. RW Johnson Blvd SW crosses the ditch in BLDD-2. Other private roads are also present in the shoreline.

There are no water-oriented uses in the drainage’s shoreline planning area.

Future Land Use and Environment Designation

The Black Lake Drainage Ditch shoreline is a heavily developed area. The future land use pattern is not anticipated to differ from the existing use pattern.

Shoreline Modification

The Black Lake Drainage Ditch is an artificial drainage ditch, as such, the entire structure could be considered modified. However, no structures modify the ditch such as dams, bulkheads or concrete lining. There are no over-water structures.

Existing and Potential Public Access Areas

Although there are no public parks in the Ditch's shoreline, most of the planning area is open space or natural resource land, which could offer access in the future.

Hazardous or Toxic Materials

There are four leaking underground storage tanks noted along the Black Lake Drainage Ditch. There are two sites listed on Ecology's confirmed and suspected contaminated sites list located in the vicinity of the Drainage Ditch (refer to Shoreline Inventory). Neither site is located within the shoreline planning area.

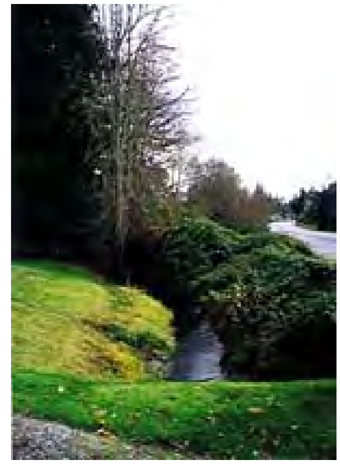
4.3.1.6 Reach Scale Assessment

Two reaches have been identified within the Olympia, Tumwater, and UGA shoreline planning area for Black Lake Drainage Ditch. These reaches are labeled BLDD-1 and BLDD-2. These reaches extend from the north end of Black Lake to Percival Creek.

Table 4-10. Shoreline reach-scale assessment – Black Lake Drainage Ditch

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
BLDD-1	Black Lake Drainage Ditch in wetland from Black Lake to Mottman Road	1.9	NRL (45) PPOS (13) Vacant (25)	Significant wetlands	Mixed coniferous and deciduous forest cover.
BLDD-2	Black Lake Drainage Ditch in ravine from Mottman Road to Percival Creek confluence	0.3	PPOS (28) Gov/Inst (20) Com/Ind (17) ROW (26)	Habitat conservation area	Riparian forest cover is limited. Stormwater pond and mining activity are present.

4.3.2 Chambers Creek



4.3.2.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Chambers Creek is a tributary to the Deschutes River and is located in the Chambers basin within the Budd/Deschutes Watershed (WRIA 13). The total length of this stream within the Tumwater and Olympia UGA urban planning area is approximately 1.6 miles. Topography along the stream is generally flat (TRPC, 2008).

Streams

Chambers Creek consists of two main sections: the mainstem and the South Tributary. The South Tributary originates in a wetland mosaic and is characterized by intermittent flow. This tributary flows north into Chambers Ditch at Rich Road and eventually feeds into the mainstem. In addition to the South Tributary, there are several other, unnamed, drainage ditches that drain Chambers Basin and flow into Chambers Ditch. During wet periods, groundwater tables rise to the level of Chambers Lake and Chambers Ditch, feeding both systems. This is feasible in part due to the flat topography along the stream channel. Chambers Lake drains south into Chambers Ditch and eventually into Chambers Creek (TRPC, 2008).

Wetlands

According to data provided by the TRPC, there are approximately 59 acres of wetland habitat along the Chambers Creek stream corridor. Extensive wetlands are present along the stream east of the confluence with Chambers Ditch. This is a wetland mosaic that includes patches of emergent, shrub, forested, and mixed vegetation. A separate, large wetland occurs near the confluence of Chambers Creek and Chambers Ditch. This wetland includes mostly shrub vegetation and some areas of mixed shrub and forested vegetation with acidic, organic soils (TRPC, 2008).

Table 4-11. Wetland habitat and area by shoreline reach – Chambers Creek

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
CHAMCRK-1	PFO	24.7	East of confluence with Chambers Ditch
	PSS	34.5	East mainstem near confluence of Chambers Ditch

4.3.2.2 Geologic and Flood Hazard Areas

Chambers Creek has undergone extensive excavation for drainage purposes. The mainstem channel is generally straight and has no active channel migration zone. No landslide hazard areas are recorded for this stream. However, Chambers Creek is located within the floodplain. As such, residential areas and other developments along the stream could be affected by overbank flooding during heavy flows (TRPC, 2008).

4.3.2.3 Biological Resources

Critical or Priority Habitat and Species Use

Priority habitat in the Chambers Creek area includes a designated Habitat Conservation Area. This is located within part of the riparian corridor connecting the wetland habitat near Rainier Road to the Deschutes River. There are no sensitive species recorded for this waterbody. Chambers Creek does provide habitat for coho and cutthroat salmon, which have been observed along the stream (TRPC, 2008).

Instream and Riparian Habitats

Chambers Basin hydrologic functions have been highly altered, including Chambers Creek. This stream has undergone extensive excavation to drain surface water into Chambers Ditch and eventually into the Deschutes River. According to the TRPC, Chambers Creek is located within an active Drainage Ditch District (TRPC, 2008).

Vegetation along Chambers Creek contains a variety of vegetative cover, including mixed forest, shrub, and coniferous forest cover. At the west SMA jurisdiction, the north stream bank is dominated by shrub vegetation and the south bank is dominated by mixed coniferous and deciduous forest. As the stream flows southeast, dominant riparian vegetation shifts to a coniferous forest canopy. At the confluence with the South Tributary and Chambers Ditch, shrub vegetation is dominant along the stream channel. The central portion of the mainstem contains some moderate density residential development on the north side of the stream. Other records of disturbance to this drainage area include the presence of one railroad that runs parallel to the north side of the stream and local road access, mostly on the north side of the stream. There are currently no waterfront properties along the stream (TRPC, 2008).

4.3.2.4 Water Quality

Chambers Creek is not listed on the 303(d) list for water quality issues. However, fecal coliform has known to be a problem in 2004 and 2005. Nitrate concentrations have been recorded to be high at the mouth of the creek.

4.3.2.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Chambers Creek shoreline planning area extends from the Olympia UGA to the Deschutes River in Tumwater's UGA. The current land use pattern in the planning area is predominantly vacant (44 percent). There are also areas of low-density residential (18 percent) and parks and open space (27 percent). Resources areas and opens spaces are primarily located along the southern shoreline and the residential uses are located along the northern shoreline. Roads make up approximately 6 percent of the planning area's land use and are limited to local residential roads. A BNSF railroad parallels the creek and passes through the northern planning area.

Future Land Use and Environment Designation

The future land use in Chambers Creek is anticipated to change as vacant land is converted to moderate density residential development. There currently several applications for residential development, particularly at the northern end of the creek, near its confluence with the Deschutes River. The creek does not have an existing shoreline environment designation because it was not included in the current shoreline master program.

Shoreline Modification

The shorelines of Chambers Creek are relatively unmodified. There are no known overwater structures.

Existing and Potential Public Access Areas

There are currently no public parks along Chambers Creek. There are several sites that are private subdivision open spaces along the creek. These may represent future potential opportunities for public access.

Hazardous or Toxic Materials

There is one site located in the vicinity of the planning area northeast of the creek (Keegan residence) that is listed on Ecology's confirmed contaminated sites list. Contaminants from the PCB group were found in the soil and groundwater. Remedial action was complete in 2004.

4.3.2.6 Reach Scale Assessment

Chambers Creek is represented by one reach which is approximately 1.6 miles long. Future land use is anticipated to include moderate density residential development around the vicinity of the stream, although access is limited (TRPC, 2008).

4.3.3 Deschutes River

4.3.3.1 Drainage Basin, Streams and Wetlands

Drainage Basin

The headwaters of the Deschutes River are located in the Snoqualmie National Forest, within Lewis County. The lower portion of the river flows through the City of Tumwater and the City of Olympia, draining into Capitol Lake and eventually into Budd Inlet. The Deschutes River drains a total of approximately 166 square miles. The portion of the river located in the Olympia/UGA and Tumwater/UGA shoreline planning areas flows through the Deschutes basin which lies in the Budd/Deschutes Watershed (WRIA 13) (TRPC, 2008). The Deschutes River is the largest drainage system within this watershed (Haring and Konovsky, 1999). The total shoreline length within the shoreline planning area is approximately 8.75 miles (TRPC, 2008).

Streams

There are several tributaries that flow north into the Deschutes River along its path from the Snoqualmie National Forest to Budd Inlet. Approximately four main tributaries occur along the river within the Olympia/UGA and Tumwater/UGA shoreline planning area (Anchor, 2008). These tributaries occur along the river from the south UGA boundary to the area near Tumwater Valley Road (TRPC, 2008).

Wetlands

According to data provided by the TRPC, approximately 172 acres of wetland habitat occur along the Deschutes River, most of which is dominated by either emergent or forested vegetation. The TRPC data states that existing wetland mapping within the river floodplain may not reflect all of the wetland units, however, particularly forested wetlands located on outwash soils. Also, the locations of some recorded wetland units may change over time (TRPC, 2008).

Several analyses have been conducted regarding future potential estuarine restoration along the Deschutes River where it flows through the dam into Capitol Lake. These have included statistical modeling and field sampling using reference sites in southern Puget Sound (Garono et al., 2006; George et al., 2006). Overall, studies have shown that dam removal would restore tidal and estuarine processes. Marine water from Budd Inlet would be carried into the North Basin and Middle Basin with rising tides and mudflats would be exposed during low tides. Within ten years following dam removal, hydro-geomorphology within the North Basin would be restored to its pre-dam state. However, conditions within the South Basin would be improved but limited due to extensive modification (George et al., 2006).

Riparian forests comprise the most extensive wetland units along the Deschutes River, although these are discontinuous. Wetland units identified as scrub-shrub wetland habitat are likely immature forested wetland habitat. There are several forested and emergent wetland habitats located within Pioneer Park and to the south of the Deschutes River (TRPC, 2008). Two wetlands are located at the west end of Pioneer Park, adjacent to the fish hatchery facility. These are designated North Polishing Pond/Wetland and South Polishing Pond/Wetland, respectively, and are located at the west end of the park. A community pond lies between these two wetlands and a community center (WDFW, 2007).

Table 4-12. Wetland habitat and area by shoreline reach – Deschutes River

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
DES-1	PEM	0.5	South UGA boundary on north stream bank
DES -2	PEM	0.7	Meandering reach in City of Tumwater near commercial district and open water
	PFO	10.1	Meandering reach in City of Tumwater
DES-3	PEM	41.5	Near tributary confluence at south end of reach
	PFO	39.5	North end of reach near confluence with Chambers Creek
DES-4	PEM	3.2	Pioneer Park
	PFO	29.1	Meander at south end of Pioneer Park
DES-5	PEM	9.4	Tumwater Valley Municipal Golf Course
	PFO	22.3	Possibly north and south ends of reach, excluding golf course
DES-6	PFO	6.8	Tumwater Falls Park
	POW	1.7	Approximately between golf course and Capitol Blvd. area

4.3.3.2 Geologic and Flood Hazard Areas

The southern portion of the Deschutes River, extending approximately from the south UGA boundary to Pioneer Park, contains meander zones generally occurring within the 100-year floodplain. Meander zones exceeding the width of the floodplain area occur in the Pioneer Park area. This southern portion of the river generally flows through a gently sloping glacial plain. According to TRPC data, personal accounts identify steep slopes and feeder bluffs located approximately at 79th Avenue SE. The northern portion of the river, extending from Pioneer Park to Budd Inlet, is associated with a channel migration zone and few meanders along the stream course. This portion of the river passes through Tumwater Canyon and Tumwater Falls, which is located just south of Capitol Lake near the mouth of the river. Tumwater Canyon contains steep slopes, although they are composed of basalt and are not considered to be unstable. Bluffs that provide significant sediment sources to the river have been mapped, according to TRPC data. Tumwater Falls is characterized by a dam and steep waterfalls located at the confluence of the mouth of the river and Capitol Lake. Floodplains and floodways are associated with the Deschutes River in low topographical areas along the channel (TRPC, 2008).

4.3.3.3 Biological Resources

Critical or Priority Habitat and Species Use

There is one existing and one proposed fish hatchery located along the Deschutes River. The existing Tumwater Falls Facility is located downstream of Capitol Blvd. and includes a spawning area, two rearing area raceways, and multiple fishways leading to Capitol Lake (WDFW, 2007b). The proposed facility would be located at Pioneer Park. The Pioneer Park Facility would be incorporated into the public park areas (e.g., community center and trails) and would include seven hatchery ponds and a clarifier pond (WDFW, 2007a).

No priority habitats or sensitive wildlife species have been recorded for the Deschutes River in the Olympia/UGA and Tumwater UGA areas (TRPC, 2008). However, there are documented occurrences of several sensitive wildlife species located east of the Tumwater UGA between the Deschutes River and Ayer Street. Documentation of these species occurrences was conducted during reports for the Elwanger Planned Rural Residential Development (Skillings Connolly and ESA Adolfson, 2008) and the Keeneland Park PRRD (ESA Adolfson, 2006). Documented occurrences include an active heron colony (documented through 2006) and an inactive heron colony located south, along Ayer Creek. In the vicinity of the active heron colony, a documented osprey nest and potential bald eagle nest are also present and have been recorded as active through at least June and July of 2007, respectively (ESA Adolfson, 2007).

The Deschutes River provides habitat for coho, Chinook, winter steelhead, and chum salmon (Haring and Konovsky, 1999; TRPC, 2008). The tide gate/dam located at 5th Avenue in Olympia is a barrier to winter steelhead, although other salmonids are able to pass through either the tide gate or fishway provided at this location. Two non-blocking culverts have been identified east of Capitol Blvd., between the Tumwater Valley Municipal Golf Course and the Tumwater Falls fish hatchery. The Chinook that occur in the Deschutes River are of hatchery origin (Haring and Konovsky, 1999). Chinook were introduced into the river in the 1950s and are released at the Deschutes Hatchery with limited release upstream (Haring and Konovsky, 1999). Coho populations also are not native to the Deschutes River and occurrences within the river have declined since their introduction between the 1940s and 1981. There have been no coho releases into the river since 1981 and natural production numbers have remained low for this waterbody. A watershed assessment of coho survival determined several factors were critical to restoring coho habitat and increasing survival rates: reduction of fine sediment rates in the Deschutes River; riparian re-vegetation and restoration to decrease summer water temperatures; and increasing large woody debris (LWD) availability along the river (Anchor, 2008).

Instream and Riparian Habitats

Riparian vegetation along the river within the shoreline management area can be described in relation to the north portion of the river (Pioneer Park to Budd Inlet) and the south portion (Pioneer Park to the south UGA boundary). The north portion of the river channel contains a combination of high density urban land use, mixed coniferous and deciduous forest, and maintained grass areas (particularly at the Tumwater Valley Municipal Golf Course). The south portion of the channel contains more vegetative cover along the river, including mixed coniferous and deciduous forest, shrubs, and grasses (TRPC, 2008).

The Deschutes River Watershed within the Olympia/UGA and Tumwater/UGA shoreline planning area is managed for timber harvest, farmland, and urban growth. The south portion of the river, near the UGA boundary, is managed for timber harvest by the Weyerhaeuser Company. Extending north (downstream) of this portion of the watershed, land is mostly used for agricultural purposes and contains some mixed coniferous and deciduous forest cover in these areas. The lower portion of the watershed, where the Deschutes River flows into Capitol Lake and into Budd Inlet at the City of Olympia, is managed as an urban growth management area (Anchor, 2008).

Alterations to the shoreline in the north portion of the river include shoreline modifications in urban land use areas and riparian restoration areas along the shoreline at the Tumwater Valley Municipal Golf Course. A railroad runs to the east of the north section of the river and several current and proposed roads and trails are located along the north section as well. There are no roads or railroad crossings in the south portion of the river, and the shoreline along the south reaches of the river are generally unaltered (TRPC, 2008).

Clear-cutting in the upper Deschutes Watershed over time has contributed to increased flow, accelerated rates of erosion, and sedimentation issues in the Deschutes River. In 1951, construction of Capitol Lake and the Fifth Avenue Bridge/Dam separated the lake from the Deschutes River (McNicholas, 1984). In 1954, a fish ladder was constructed at Tumwater Falls to allow anadromous salmonid populations to access the Deschutes River and its tributaries (Anchor, 2008). By 1976, sediment loads had increased at the dam located above the river's tidal flats and restricted activities relating to fish rearing and recreation along the river and in the lake.

A streambank erosion survey was conducted during 1982 and 1983 and determined that the majority of eroding material consisted of fine sands, silts, and clays that were transported along the river and deposited in Capitol Lake. A portion of eroding material was composed of coarse gravels, cobbles, and boulders, which were generally not transported to the lake. Almost fifty percent of sites contributing to erosion occurred between Lake Lawrence (River Mile [RM] 30) and the Deschutes Falls (RM 41) (McNicholas, 1984). A subsequent study using statistical modeling was conducted to determine whether surface erosion from unpaved, primarily forested roads in the Budd/Deschutes basin was contributing to high sediment load in the Deschutes River. Fine sediment within the river were found to originate from a variety of sources, including: erosion of glacial terrace banks; erosion and landslide occurrences due to record flood events; bank erosion in tributaries; increased levels of shoreline armoring that may contribute to scour; and other anthropogenic factors associated with shoreline modification and infrastructure that may lead to runoff, landslides, and downstream sediment input (Raines, 2007).

4.3.3.4 Water Quality

The Deschutes River is found on the Category 5 303(d) list of impaired waterbodies for temperature and fecal coliform. The Deschutes is also found on the Category 4 list for instream flow violations. The Deschutes is being monitored at its mouth above Tumwater Falls as part of Thurston County's long-term monitoring (Thurston County, 2006).

Washington Department of Ecology has included the Deschutes River in a total maximum daily load study (TMDL) which began in 2003. The TMDL project will identify pollution sources and recommend remedies for correction. Interim results are recently available from the TMDL study (Roberts and Pelletier, 2007). These indicate that the Deschutes River does fall below the target dissolved oxygen standard of 8.0 mg/L. The river is also warmer than the water quality standards would allow in the summer.

Nutrient concentrations in the river tend to increase as sample sites moved downstream (Roberts and Pelletier, 2007). This represented steady loading of the river. However, nutrient concentrations decreased when entering Capitol Lake, which indicated the lake acts to settle and assimilate nutrients. A full report is anticipated to be complete in 2008.

4.3.3.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Deschutes River shoreline planning area extends from Capitol Lake south to the boundary of Tumwater's UGA. The river has been broken into seven reaches (DES-1 through -7; numbered south to north) for analysis. In Reaches DES-1, -2, and -3 south of Olympia's UGA boundary, the shoreline planning area only includes the western shoreline. The Eastern shoreline is in Thurston County's jurisdiction.

In general, shoreline land use in the lower reaches (DES-1 through -4) of the River is a mix of low-density residential development, open space, resources lands, and vacant lands. There is also an area of commercial land use east of Old Hwy 99 SE in DES-2. The land use pattern in the northern reaches (DES-5 through -7) is more diverse. It includes a mix of open space in reaches DES-5 (golf course) and DES-7, industrial uses (Former Brewery) in DES-6 and DES-7, and some residential (low- and moderate- density) in DES-4. Table 4-13 below shows the percentages of the major land uses within each shoreline reach.

Roads make up a relatively small portion of the land use in the river's shoreline planning area (2.5 percent of the total planning area). Reach DES-7 is the only reach with a major roadway presence in the shoreline (35 percent of the reach). In addition to local access roads within the shoreline planning area, several roadways also cross the river via bridges, all in the northern reaches. These include Henderson Rd (DES-4), Capitol Blvd SW (DES-6), E Street SW (DES-6) and Custer Way SE (DES-6).

There are several water-oriented uses in the Deschutes River shoreline. Table 4-13 below lists each water-oriented use by category and by reach. Former uses in the brewery/water bottling plant in Tumwater were water-related. Both operations s are now closed. Future operation may be water-oriented.

Table 4-13. Water-oriented Uses – Deschutes River

Reach Number	Water-Dependent Use	Water-related Use	Water-enjoyment Use
DES-1	None noted	None noted	None noted
DES -2	None noted	None noted	None noted
DES -3	None noted	None noted	None noted
DES -4	Future Hatchery at Pioneer Park	None noted	Pioneer Park
DES -5	None noted	None noted	Tumwater Golf Course
DES -6	Fish Hatchery at Tumwater Fall	None noted	None noted None noted
DES -7	Fish Hatchery at Tumwater Fall	None noted	Tumwater Falls Park
DES -8	None noted	None noted	None noted

Future Land Use and Environment Designation

The future land use pattern in the Deschutes River shoreline is anticipated to change in some areas. In general future land use in the northern reaches is anticipated to remain largely unchanged. The Olympia Brewery site is expected to redevelop. Although the site is an industrial use zone, it is currently under review for a mixed use category. Moderate density residential subdivision is anticipated in currently vacant and resource land in the lower reaches (DES-1 and -2). Other vacant lands with the shoreline planning area are expected to be developed as low or moderate density residential development.

Under the current SMP, the Deschutes shoreline is designated as conservancy in reaches DES-1 through -4 and Deschutes Shoreline Management Area in the northern reaches. A small portion of the shoreline on the west bank of the river in DES-5 is designated Rural.

Shoreline Modification

The shoreline of the River is modified through the urban environment in the northern reaches. Specific data on shoreline armoring are not available for this area. The shoreline in the southern reaches is generally unaltered.

Existing and Potential Public Access Areas

Parks in the shoreline planning area include Tumwater Falls Park in DES-7 and Pioneer Park in DES-4. The Tumwater Valley Municipal golf course is also public and offer visual access to the river. There are several other sites categorized as open space that could provide public access in the future.

Historic and Cultural Resources

The Tumwater National Historic District is adjacent to the Deschutes River. It contains several properties that are listed in the inventory. One of the most famous landmarks in Tumwater is the Olympia Brewing Company. The existing brewhouse was built in 1906 to replace the original four-story brewhouse opened in 1896 as the Capital Brewing Company. The brewhouse remains standing as part of the Tumwater Historic District. The former Brewery is located in Reaches DES-6 and 7.

Hazardous or Toxic Materials

The All American Bottled Water Corp, located adjacent to the River in DES-6 is listed on Ecology's confirmed and suspected contaminated sites list. Petroleum products were found in soil below the cleanup level. The site is awaiting site hazard assessment.

The old Brewhouse Former Paint Shop also located adjacent to the River in DES-6 is listed on Ecology's confirmed and suspected contaminated sites list. Pollutants from the metals, priority pollutants and arsenic contamination groups were found in soil and groundwater.

4.3.3.6 Reach Scale Assessment

The Deschutes River has been assessed using seven reaches, designated DES-1 through DES-7. These reaches extend from the south UGA boundary in Tumwater, Washington to the South Basin of Capitol Lake.

Table 4-14. Shoreline reach-scale assessment – Deschutes River

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
DES-1	UGA boundary to end of straight reach	L (0.4) R (0.4)	SFR (31) NRL (40) Vacant (13)	Linear channel	Mixed coniferous and deciduous forest cover.
DES-2	Meandering reach to tributary confluence	L (3.0) R (2.8)	SFR (15) Com/Ind (11) PPOS (18) NRL (10) Vacant (48)	Ayer Creek confluence	Mixed coniferous and deciduous forest and shrub cover.
DES-3	Tributary confluence to Chambers Creek confluence	L (2.1) R (2.0)	PPOS (27) Vacant (62)	Large area of wetland and floodplain east of river	Mixed coniferous and deciduous forest cover and grasses.
DES-4	Chambers Creek confluence to the Municipal Golf Course	L (1.1) R (1.1)	SFR (46) PPOS (32) Vacant (18)	100 year floodplain extends to the north of the river	Maintained grass areas and mixed coniferous and deciduous forest cover.
DES-5	Tumwater Valley Municipal Golf Course	L (1.0) R (1.0)	PPOS (84)	Extensive floodplain	Riparian cover is limited.
DES-6	Municipal Golf Course to Tumwater Falls	L (0.7) R (0.7)	Com/Ind (60) PPOS (33)	Extensive floodplain	Riparian cover is limited.
DES-7	Tumwater Falls to South Basin of Capitol Lake	L (0.3) R (0.2)	Com/Ind (29) PPOS (36) ROW (35)		Riparian cover is limited.

4.3.4 Percival Creek

4.3.4.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Percival Creek is located in the Percival Creek drainage basin, which is the second basin in total area in the Budd/Deschutes watershed (WRIA 13). The headwaters of the stream are located at Trosper Lake and flow approximately 3.3 miles through agricultural, forested, and developed landscapes prior to its discharge into Capitol Lake at Percival Cove (Haring and Konovsky, 1999). The length of this stream within the Olympia and Tumwater shoreline planning area is 1.2 miles. The gradient along most of the stream is moderate. Percival Creek flows between two basalt outcrops prior to its confluence with Black Lake Drainage Ditch, at which point it enters a canyon. The canyon walls are deep beyond this confluence and the canyon is very steep. Eventually, the stream drains into Percival Cove, located west of the South Basin of Capitol Lake (TRPC, 2008).

Streams

Two primary tributaries drain into Percival Creek: a south branch originating in Trosper Lake and the Black Lake Drainage Ditch which approaches from the west. These two tributaries join near Mottman Road and enter the Percival Creek Canyon under Highway 101. There are other, unnamed, year-round and seasonal tributaries, springs, and seeps which also feed Percival Creek (TRPC, 2008).

Wetlands

One area of forested wetland habitat has been identified along Percival Creek, totaling approximately 8.6 acres. This is a riparian forested wetland area located within the canyon walls downstream of the pedestrian bridge that leads to Percival Cove. In addition, TRPC data indicates that emergent wetland habitat is appearing at the new fill area at the mouth of the creek. This area has not been mapped to date (TRPC, 2008).

4.3.4.2 Geologic and Flood Hazard Areas

Percival Creek has been highly altered due to construction of Black Lake Drainage Ditch and Capitol Lake. The flow pattern along this stream is generally confined and lacks meanders. Percival Creek is located within the 100-year floodplain and therefore may be affected by overbank flooding. Landslide hazard areas associated with the stream include significant steep slopes located on the south side of the creek. There are also steep slopes located north of the BNSF railroad, although these are more moderate and are located within a wider canyon.

4.3.4.3 Biological Resources

Critical or Priority Habitat and Species Use

One Habitat Conservation Area has been identified along Percival Creek: a riparian corridor linking Capitol Lake with Black Lake and Trosper Lake. Sensitive wildlife species occurring in the Percival Creek basin include mink (TRPC, 2008).

Cutthroat trout and spawning chinook, coho, and chum salmon are all present along Percival Creek. Chinook salmon are of hatchery origin from the Tumwater Falls Facility. Occasional sightings of sockeye salmon have occurred along Percival Creek as well (Haring and Konovsky, 1999; TRPC, 2008). In 1996, a fish passage blockage at the Mottman Road crossing was corrected. Following this restoration effort, salmon were observed spawning upstream of the road crossing. Salmonid habitat within Percival Creek is limited due to several factors, including lack of LWD recruitment; increased summer water temperatures; impaired fish passage, particularly for Chinook, at the Capitol Lake tide gate and seasonally installed Percival Cove screen; and hydrologic alteration along the stream corridor (Haring and Konovsky, 1999).

Instream and Riparian Habitats

The hydrologic conditions of Percival Creek have been highly altered by Black Lake Drainage Ditch, which was constructed in 1922 to drain potential agricultural land north of Black Lake. Prior to construction of the ditch, water flow from Black Lake to Percival Creek was minimal. Capitol Lake was constructed in 1951, which also altered the hydrologic conditions of this stream. Historically, Percival Creek discharged directly into Budd Inlet. Following construction of Capitol Lake, the estuary located at the mouth of the stream was lost. The first major alteration of the stream channel occurred in 1890, with the construction of the BNSF Railroad. The railroad defines the northern edge of the stream, extending from Percival Cove to Mottman Road. Additional alterations along Percival Creek include extensive urban development and a system of stormwater ponds that convey surface water throughout the Percival Creek basin.

Riparian vegetation along the stream generally consists of coniferous forest, mixed coniferous and deciduous forest, and shrub cover. The east side of the stream, between Percival Creek and Capitol Lake, contains high density urban land use areas and riparian cover is limited in these areas. Due to extensive development along the riparian corridor, LWD recruitment has been reduced along Percival Creek. This is due in part to removal of forested cover along streambanks that contribute to LWD recruitment, which is important for establishing stable and functional fish habitat (Haring and Konovsky, 1999).

4.3.4.4 Water Quality

Percival Creek is not listed on the Category 5 303(d) list and is considered to have good water quality. Percival Creek was tested in 2005 by Thurston County Health Department. This creek met all state water quality standards, including tests for fecal coliform (Thurston County, 2006). Water quality in the creek is at risk due to urban stormwater runoff and other non-point pollution sources. Percival Creek is included in a TMDL study by the Washington Department of Ecology to identify pollution sources and correct the problems.

4.3.4.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Percival creek extends from the end of the Black Lake Drainage Ditch near Highway 101 and empties into Capitol Lake at Percival Cove. Percival Creek flows through Percival Canyon, which is a public natural area owned by the City of Olympia. The canyon is categorized as open space and comprises approximately 52 percent of the reach shoreline area. Land use in the shoreline planning area beyond the canyon, is predominantly private vacant lands (12 percent), with small amounts of commercial/industrial (3 percent) and moderate- and high-density residential uses (5 percent).

Roads are a significant component of the Percival Creek shoreline area (26 percent). Both Highway 101 and Cooper Point Rd cross over the creek on bridges and the BNSF railroad runs parallel to the creek along its northern edge (within the shoreline planning area). There are no noted water-dependent or –related uses in the shoreline. The surrounding open space may be considered a water-enjoyment use.

Future Land Use and Environment Designation

The area around Percival Creek is highly developed and urbanized. Land use in the area is not expected to changes from its current pattern. The Percival Creek shoreline is designated as the Percival Creek Shoreline Management Area in the current SMP.

Shoreline Modification

The shoreline of Percival Creek is highly modified. The BNSF railroad, constructed in the 1890s, defines the northern shoreline of the creek.

Existing and Potential Public Access Areas

As stated above, the creek runs through an undeveloped canyon that is currently owned by the City of Olympia. The City has proposed development of a shared use trail within the canyon.

Hazardous or Toxic Materials

There are several leaking underground storage tanks in the vicinity of the Percival Creek Shoreline, although none of them are mapped with the shoreline planning area. Refer to the Shoreline Inventory for specific locations.

4.3.4.6 Reach Scale Assessment

Percival Creek has been assessed using one identified reach, labeled as PERC-1. This reach extends from the downstream confluence with Black Lake Drainage Ditch to Percival Cove. The area surrounding this stream is already highly developed; future land use plans for Percival Creek are to remain high density urban land use (TRPC, 2008).

4.3.5 Woodland Creek

4.3.5.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Woodland Creek is located within the Henderson Inlet Watershed (WRIA 13). The Woodland Creek headwaters originate from a large wetland mosaic and lake complex that includes Hicks Lake, Pattison Lake, and Long Lake. The stream meanders north beyond the boundary of the Lacey and UGA shoreline planning area and eventually drains into Henderson Inlet. The total shoreline length of Woodland Creek within the Lacey and UGA shoreline planning area is approximately four miles (although portions of the shoreline are not located within SMA jurisdiction areas). Total reach length within SMA jurisdiction is approximately 1.6 miles (TRPC, 2008). The Woodland Creek basin extends a total of eleven miles from its headwaters to the south end of Henderson Inlet, flowing through peat bogs, marshes, and beaver ponds. The highest point within the basin is Pattison Lake, at an elevation of 270 feet (Haring and Konovsky, 1999).

Streams

There are two tributaries located within SMA jurisdiction, located between Darhma Road NE and Pleasant Glade Road NE. In addition, the Nisqually Trout Farm discharges into Woodland Creek north of Martin Way. The trout farm contains a one-acre pond that provides a significant source of flow to the stream outside of SMA jurisdiction (TRPC, 2008).

Wetlands

Wetland habitat along Woodland Creek within the Lacey and UGA shoreline planning area is dominated by emergent and forested wetlands. Wetlands along the stream are generally confined to the area between I-5 and Martin Way, which falls outside of SMA jurisdiction. The largest designated wetland habitat within SMA jurisdiction is located along the southern reach, between I-5 and the confluence with a right-bank tributary (TRPC, 2008).

Table 4-15. Wetland habitat and area by shoreline reach – Woodland Creek

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
WOOD-1	PEM	3.7	Between I-5 and City of Lacey north boundary
	PFO	71.3	Between City of Lacey north boundary and confluence with tributary
	POW	1.0	Near confluence with tributary near Carpenter Road NE
WOOD-2	PFO	2.5	Confluence with tributary to Pleasant Glade Park
	PEM	0.7	Pleasant Glade Park

4.3.5.2 Geologic and Flood Hazard Areas

Woodland Creek meanders through gently sloping terrain through the Lacey and UGA shoreline planning area. As the stream approaches Henderson Inlet, the terrain becomes moderately steep. Woodland Creek is located within the 100-year floodplain and therefore developed areas are subject to potential overbank flooding during heavy storm or flood events. There are no landslide hazard areas identified for this stream within the Lacey and UGA boundary.

4.3.5.3 Biological Resources

Critical or Priority Habitat and Species Use

Spawning Chinook, chum, and coho occur in Woodland Creek. Chum salmon within the stream are a combination of natural and hatchery salmon. Steelhead salmon and cutthroat trout also occur along the stream and occasional sightings of spawning sockeye have occurred along the stream as well (Haring and Konovsky, 1999; TRPC, 2008). Sensitive wildlife species associated with Woodland Creek include wood ducks, which occur in the riparian corridor (TRPC, 2008).

Several factors contribute to reduced salmonid habitat within Woodland Creek. Two blocking culverts and one non-blocking culvert have been identified along Woodland Creek within the SMA jurisdiction area. The non-blocking culvert is located at Pleasant Grade Road NE and a significant drop-off has been observed at this culvert location, indicating a possible fish barrier. Summer low flows along the stream also present a habitat limiting factor for salmon and other fish using the stream. Urbanization and associated increased impervious surface along the stream within the basin is one of the greatest factors affecting salmon habitat in Woodland Creek. These alterations result in increased peak flows and stormwater runoff in the winter and low summer flows. Finally, lack of LWD recruitment and accumulation of fine sediments also contribute to reduced fish habitat along the stream (Haring and Konovsky, 1999).

Priority habitat associated with Woodland Creek includes a riparian corridor between the wetland adjacent to the Nisqually Trout Farm and its discharge downstream to Henderson Inlet. In addition, an intermittent stream channel has been identified upstream flowing to Lake Louise.

Instream and Riparian Habitats

Riparian habitat along Woodland Creek within the Lacey and UGA shoreline planning area is generally characterized by coniferous forest, mixed coniferous and deciduous forest, and shrub vegetation. On the west side of the stream, some areas of moderate density residential development are present and have altered the riparian habitat (TRPC, 2008).

Alteration along the stream within the Lacey and UGA shoreline planning area has included moderate density residential development and associated road infrastructure, most notably the I-5 overpass south of Reach WOOD-1. Reductions in LWD recruitment, accumulation of fine sediment, alteration of the natural hydrologic regime, increased summer water temperatures, and fish barriers all present issues affecting habitat for riparian vegetation and for fish and wildlife success within the stream (Henderson and Konovsky, 1999).

4.3.5.4 Water Quality

Woodland Creek is listed on the Category 5 303(d) list for dissolved oxygen, temperature and fecal coliform exceedances. Non-point pollutants, including urban stormwater runoff and failing on-site septic systems, appear to be contributing to the water quality problems on Woodland Creek and downstream to Henderson Inlet.

A recent study by Washington Department of Ecology has documented serious fecal coliform bacteria in Woodland Creek downstream of Martin Way (Sargent et al., 2006). Increasing fecal coliform bacteria levels in Henderson Inlet have resulted in shellfish harvest closures during the past 5 years. Studies indicate that both fecal coliform and nitrate contamination likely from human sewage, livestock waste, and/or other pollutants are entering the groundwater and Woodland Creek, eventually ending up in Henderson Inlet. None of the 19 sites sampled in Woodland Creek met the standard for fecal coliform during the wet season. The largest bacterial loading enters the creek at river mile 3.7 from the Martin Way stormwater outfall.

Thurston County, City of Lacey and LOTT Wastewater Alliance have begun an evaluation of the water quality problem in Woodland Creek.

4.3.5.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Woodland Creek shoreline planning area extends from I-5 north to the City of Lacey's UGA boundary. It was broken into two reaches (WOOD-1 through -2) for analysis. The land use pattern along both reaches is relatively similar. Land use is a mix of low-density residential, vacant land, and opened space, parks, and natural resources lands. An exception to the pattern is St. Martins University, classified as government/institution. It is located in WOOD-1 along the east shoreline adjacent to I-5. Table 4-16 below shows the percentages of the major land uses within each shoreline reach.

Roads make up only 3 percent of the Woodland Creek shoreline area. The most significant of the roadways in the shoreline is I-5, which crosses the creek at the southern end of WOOD-1. Other roadways in the shoreline planning area include local access and residential streets.

The Nisqually trout farm located in WOOD-1 is considered a water-dependent use. There is on public park (Pleasant Glade Park) located in WOOD-2, which would be considered water-enjoyment uses. There are no water-related uses in the Woodland Creek shoreline.

Future Land Use and Environment Designation

Future land use in the Woodland Creek shoreline is anticipated to remain generally the same as current land use, with one exception. A moderate-density residential development is proposed south of Pleasant Glade Park in WOOD-2. The creek is designate as Conservancy in the existing SMP.

Shoreline Modification

There is no noted shoreline modification along Woodland Creek.

Existing and Potential Public Access Areas

Pleasant Glade Park, located in WOOD-2 offers public access to the creek. The Park is currently undeveloped. Open Space in WOOD-2 (mapped as sub-division open space) may represent a potential public access site under certain circumstances.

Historic and Cultural Resources

There is one home located within the shoreline planning area that is listed in the Thurston County historic inventory. Refer to the shoreline inventory for more detailed information.

Hazardous or Toxic Materials

The creek passes through an area (in WOOD-2) that is mapped as having elevated nitrate levels. There are no other know sites with hazardous or toxic materials in the shoreline planning area.

4.3.5.6 Reach Scale Assessment

Two reaches have been identified within the Lacey and UGA shoreline planning area for Woodland Creek. These reaches are labeled WOOD-1 and WOOD-2 and extend from I-5 to the north UGA boundary. Additional moderate density residential land use is anticipated for the northern area of the stream (TRPC, 2008).

Table 4-16. Shoreline reach-scale assessment – Woodland Creek

	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
WOOD-1	I-5 to confluence with tributary	1.0	SFR (22) Gov/Inst (31) NRL (19) Vacant (15)	Extensive wetlands south of I-5	Mixed coniferous and deciduous forest; somewhat limited in areas.
WOOD-2	Tributary to UGA boundary	0.7	SFR (19) PPOS (27) Vacant (46)		Mixed coniferous and deciduous forest; somewhat limited in areas.

4.4 Lakes

4.4.1 Barnes Lake

4.4.1.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Barnes Lake is located in the Deschutes River basin within the Budd/Deschutes Watershed (WRIA 13). The lake encompasses a total of approximately 35 acres and is located in the City of Tumwater west of I-5 and south of Linwood Avenue SW. Mean and maximum depths within the lake are not available. Maximum elevation at Barnes Lake reaches 159 feet and topography surrounding the lake is generally flat. Barnes Lake is not currently designated under the Shoreline Master Program (TRPC, 2008).

Streams

There are no documented tributaries draining into Barnes Lake. Overland stormwater flow provides the main source of water to the lake. Barnes Lake discharges through the southeast corner into the Deschutes River (TRPC, 2008).

Wetlands

Wetland habitat data provided by TRPC indicates the open water of Barnes Lake associated with adjacent, pocket emergent wetlands located along the shoreline total approximately 35.1 acres (TRPC, 2008). This data is provided in table format below. A recent field study was conducted to determine the OHWM and associated wetlands at various lakes for the TRPC. A small area of associated wetland habitat was field verified at the southeast corner of the lake and contains young forest or shrub wetland habitat. The area of the lake concluded to occur below the OHWM totaled approximately 34.7 acres (Shanewise, 2008).

Table 4-17. Wetland habitat and area by shoreline reach – Barnes Lake

Reach Number	Wetland Habitat Type[1]	Total Wetland Acres	Approximate Location
BAR-1	LOW	34.7	Open water of lake adjacent to vegetated wetland
	PEM	0.4	Pocket emergent wetlands interspersed along the shoreline

[1] LOW = Lacustrine open water wetland.

4.4.1.2 Geologic and Flood Hazard Areas

There are no landslide hazard areas recorded for Barnes Lake. This waterbody is not located within the floodplain and no flood hazard areas are recorded (TRPC, 2008).

4.4.1.3 Biological Resources

Critical or Priority Habitat and Species Use

There are no priority habitats or sensitive fish or wildlife species documented within the Barnes Lake area (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation surrounding Barnes Lake is dominated by mixed coniferous and deciduous forest and shrub vegetation associated with wetland habitat. Little shoreline modification has occurred along the lake, although several single-family homes are located at the north end of the lake with four small, private docks. Extended beyond the lake shoreline, moderate and high density residential development is present on all sides of the lake. An elementary school with a maintained lawn is located on the northeast corner of the lake. A constructed berm restricts outflow from the lake during summer months and meters flow during periods of high water levels within the lake. Other alterations to the lake area include local road access (TRPC, 2008).

4.4.1.4 Water Quality

The Barnes Lake Management District (LMD) was formed in 2004 to address water quality issues and the control of invasive aquatic plants. Issues of concern to the citizens participating in the LMD Steering Committee are invasive plants, lack of public access, habitat management, and increasing the lake depth. Lake depth measured by residents indicates the lake varies between 8 and 12 feet in depth. The LMD has requested that Thurston County add the lake to its monitoring program. The City of Tumwater entered into an interlocal agreement in 2006 with Thurston County to provide water quality monitoring.

Barnes Lake was one of 71 lakes treated by legal application of herbicides in 1993 (Rector and Hallock, 1994). Rodeo, an aquatic herbicide, was used to treat Barnes Lake for water lilies as the target plant.

An Integrated Aquatic Vegetation Management Plan was prepared for the Barnes Lake Management District in 2007 (Barnes Lake Steering Committee, 2007). This report is available on the City of Tumwater's web page (http://www.ci.tumwater.wa.us/BLMD.htm). Sources of potential pollutants to the lake are discussed in this report including urban runoff, fertilizers from lawns, wildlife use, and stormwater outfalls. Baseline water quality testing by Thurston County in May 2006 indicates that dissolved oxygen is very low. Treatment and eradication of noxious weeds and nuisance aquatic plants is planned for 2008. There is also a conservancy group Barnes Lake Conservancy that is interested in preserving Barnes Lake for wildlife and natural habitat values. http://www.barneslake.com/.

4.4.1.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Current land use in the shoreline planning area of Barnes Lake is predominated by residential development (57 percent); both low- (42 percent) and high-density (15 percent). Government or institutional uses (Michael T. Simmons elementary school in the northeastern portion of the planning area and a WSDOT facility at the southern end of the lake) comprise 20 percent of the shoreline area.

Residential streets pass through the planning area northwest of the lake. In total road rights-of-way make up 15 percent of the shoreline area. There are currently no known water-oriented or –related uses in the shoreline planning area. A bike rental site at the southwest of the lake could be considered a water-enjoyment use.

Future Land Use and Environment Designation

Future land use largely follow the existing land use pattern, and are predominated by low-density residential development with some areas of government/institutional land use included. The lake does not have an existing shoreline environment designation because it was not included in the current shoreline master program.

Shoreline Modification

Most of the Barnes Lake shoreline is unmodified. There are four small docks on the lake along its northern shore.

Existing and Potential Public Access Areas

There are no existing public parks that provide public access to Barnes Lake.

Historic and Cultural Resources

There are 10 homes listed in Thurston County's historic inventory within the Barnes Lake shoreline panning area. The homes are not listed by the state or federally historic registers. Roads in the planning area are largely limited to access roads and driveways for the residences.

4.4.1.6 Reach Scale Assessment

Barnes Lake has been assessed using one designated reach, labeled BAR-1. This reach encompasses the entire lake shoreline, which totals approximately 1.2 miles in length.

4.4.2 Bigelow Lake

4.4.2.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Barnes Lake is located east of Budd Inlet in the Olympia UGA, northwest of the intersection of 12th Avenue NE and South Bay Road NE. This lake lies in the Indian Creek basin within the Budd/Deschutes Watershed (WRIA 13). The lake area encompasses 13 acres of open water. Mean and maximum depths for the lake are not available. The terrain surrounding Barnes Lake is generally flat and the maximum elevation is 165 feet. Bigelow Lake is not currently designated under the Shoreline Master Program (TRPC, 2008).

Streams

There are no apparent tributaries draining into Bigelow Lake. Overland flow provides the primary source of incoming water to the lake. The lake flows north into Indian Creek, which eventually discharges into Budd Inlet (TRPC, 2008).

Wetlands

The wetland habitat surrounding Bigelow Lake comprises a 140-acre peat bog with excellent hydrologic storage capabilities. The bog system has been extensively drained over time, however. Wetland habitat vegetation includes mixed forested and scrub-shrub, scrub-shrub, and emergent along the shoreline. A forested patch north of the lake is located on acidic organic soils and is reported to support pine trees. According to TRPC, data, dominant wetland habitat surrounding Bigelow Lake consists of shrub wetland. Wetland habitat adjacent to the lake totals approximately 112 acres, much of which has been historically ditched and drained (TRPC, 2008). A recent study conducted at Bigelow Lake verified the location of the OHWM and associated wetlands. The total area of the lake occurring below the OHWM was determined to be approximately 78.1 acres (Shanewise, 2008).

Table 4-18. Wetland habitat and area by shoreline reach – Bigelow Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
BIG-1	PEM	15.1	Pockets of emergent habitat north and south of the lake shoreline
	PFO	14.3	Pockets of forested canopy open space surrounding the lake
	POW	12.8	Open water of lake adjacent to vegetated wetland
	PSS	69.9	Surrounding open space extending out from lake, mostly to north and south

4.4.2.2 Geologic and Flood Hazard Areas

Bigelow Lake is located within the 100-year floodplain and may be affected by large storm events. There are no recorded landslide hazard areas in the vicinity of the lake (TRPC, 2008).

4.4.2.3 Biological Resources

Critical or Priority Habitat and Species Use

The headwaters of Indian Creek riparian corridor, extending to Pacific Avenue, are considered a Habitat Conservation Area. Sensitive species occurring in Bigelow Lake include wood duck. There are no recorded observations of salmonids or other sensitive fish species occurring in the lake (TRPC, 2008).

Instream and Riparian Habitats

Shrub vegetation associated with wetland habitat dominates the Lake Bigelow shoreline. General land cover also includes mixed coniferous and deciduous forest and wetland scrub-shrub vegetation. Low density residential development occurs beyond the shoreline to the northwest and east of the lake. Open space dominates the vicinity to the north and south (TRPC, 2008).

The natural hydrology of the urban area surrounding Lake Bigelow has been altered for development, although the lake shoreline contains intact wetland habitat. The hydrologic regime of Indian Creek, into which the lake drains, has been highly altered for many years. There is limited road access in the lake vicinity. Little modification has occurred along the shoreline overall, except for the four private docks and several trails providing access to the lake edge (TRPC, 2008).

4.4.2.4 Water Quality

Bigelow Lake is the headwaters to Indian Creek. Water quality in Indian Creek and Bigelow Lake were studied in 1993 (City of Olympia Public Works Department). Sediments in Bigelow Lake showed elevated levels of arsenic, cadmium, lead and zinc. Indian Creek exceeded state water quality standards for heavy metals in the Pacific Avenue area of the creek. Indian Creek and Moxlie Creek have been identified as the primary source of bacterial contamination to Budd Inlet. Fecal coliform exceeded water quality standards in Indian Creek especially during peak flows and storm events.

Water quality sampling was conducted in Bigelow Lake in 1991. Secchi disk readings indicate that the lake water clarity had been reduced indicating a trend toward eutrohpic conditions. Standard water quality parameters in Bigelow Lake were within state standards; however the presence of heavy metals in sediments may pose a threat to aquatic life.

4.4.2.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Bigelow Lake shoreline planning area extends south and west beyond the open water portion of the lake. Existing land use in the planning area is mix of low-density residential development (49 percent) and private vacant land (33 percent). There is also a component of open space (11 percent) in the planning area.

12th Ave NE passes through the southern potion of the planning area. Roads in rest of the planning area are limited to access roads for residences. Less than 6 percent of the shoreline area is in use as a right-of-way. There are no water-oriented uses in the shoreline planning area.

Future Land Use and Environment Designation

Future land use generally follows the existing land use pattern. Open space areas along the north and south shore of the lake are expected to remain in their current use. Vacant lands intermixed with existing low-density development along the lakeshore are anticipated to convert to low-density residential development in the future. The lake does not have an existing shoreline environment designation because it was not included in the current shoreline master program.

Shoreline Modification

Most of the Bigelow Lake shoreline is unmodified. There are some trails that extend to the lake edge within the open space areas. There are currently four small docks located in the northern half of the open water portion of the lake.

Existing and Potential Public Access Areas

There are no existing public parks along the lake. There are private subdivision open space areas both north and south of the lake. These are may represent potential public access sites in the future.

4.4.2.6 Reach Scale Assessment

Bigelow Lake was assessed using one designated reach labeled BIG-1 that extends around the entire shoreline, totaling approximately 2.5 miles in length. No future significant land use changes are anticipated along the lake shoreline (TRPC, 2008).

4.4.3 Black Lake

4.4.3.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Black Lake is located in the Black Lake basin within the Budd/Deschutes Watershed (WRIA 13) and is approximately 570 acres in size. Black Lake is 2.5 miles long and is fed by two perennial streams. The lake drains via Black Lake Ditch and Percival Creek to Budd Inlet. Black Lake has a mean depth of 19 feet and a maximum depth of 29 feet as determined by Ecology in a 1994 survey of the Lake (see http://www.ecy.wa.gov/programs/eap/lakes/wq/lake_assessments.html). The terrain on the east and southwest sides of the lake are flat. Steep hills occur on the northwest side of the lake. Maximum elevation at the lake is 130 feet (TRPC, 2008).

Streams

Two perennial tributaries flow into Black Lake from the west. The Black River has also been observed flowing into Black Lake on one occasion. Black Lake drains north into Black Lake Drainage Ditch, then into Percival Creek, and eventually into Capitol Lake and Budd Inlet (TRPC, 2008).

Wetlands

Designated wetland habitat is primarily located at the southeast area of Black Lake and totals approximately 46 acres of emergent, forested, and shrub wetland habitat. Wetlands located north of the lake are found along Black Lake Drainage Ditch and are separated from the lake by Black Lake Beltmore Road. The west shore of the lake is located outside of the UGA and is not included in the wetland analysis (TRPC, 2008).

Table 4-19. Wetland habitat and area by shoreline reach – Black Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
BLK-1	PFO	17.2	SE corner of lake in less developed area
	PEM	3.0	Kennydell Park area along east shoreline
	PSS	25.4	East side of lake south of Kennydell Park

4.4.3.2 Geologic and Flood Hazard Areas

Black Lake is located in the 100-year floodplain and therefore shoreline residences may be affected by large storm events when flooding may occur. There are no landslide hazard areas noted for this area in the inventory.

4.4.3.3 Biological Resources

Critical or Priority Habitat and Species Use

Associated wetlands located north and south of the lake are designated Habitat Conservation Areas. In addition, limited riparian habitat along non-wetland shoreline areas area also considered Habitat Conservation Areas. Bald eagles nests are located adjacent to the Black Lake basin. Associated wetlands south of the lake are waterfowl concentration areas and also have document use by Green Heron and mink (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation along the lake shoreline includes some shrub and grass cover. However, much of the shoreline has been highly modified and is characterized by a combination of moderate and high density urban land use. Eight community docks and 138 private docks, for single-family residences, are located along the lake shoreline. Local roads provide access to the lake area and powerlines are located just north of the lake. Additional shoreline development includes a camp, beach club, waterfront community areas, parks, boat ramps, and public areas. Recreational activities in the lake include swimming and boating. Two WDFW boat launches are located on the lake and used for boat and fishing access (TRPC, 2008).

Historically, Black Lake drained south into the Black River, but the hydrologic regime was altered when Black Lake Drainage Ditch was constructed in 1922. Beaver dams now restrict water flow to the south of the lake (TRPC, 2008).

4.4.3.4 Water Quality

Black Lake is on the 303(d) list as Category 5 for total phosphorus. Problems with algal growth in the lake have occurred in the late summer and fall, interfering with recreational uses of the lake. Based upon water quality samples taken in 1994 through 2005 and water clarity tested, the lake is considered eutrophic. Very few submerged aquatic plants were observed at Black Lake in 1994 and 1995. Water clarity and total phosphorus testing in Black Lake in 1998 indicated that Black Lake met criteria for a Mesotrophic lake status at that time. Thurston County Public Health and Social Services have posted data from 1993 to 2005 on several stations on Black Lake (see http://www.geodata.org/swater/wshed.asp?wshed=BUD).

Black Lake was considered to have fair water quality based upon water quality testing done by the Thurston County Health Department in 2005. Moderate to high nutrient concentrations result in blooms of blue-green algae in the late summer and fall which interfere with recreational uses. Black Lake's dark color means that the lake water gets warm. Surface water temperatures of 25.8 degrees Celsius were measured in August of 2005. The lake was considered eutrophic or highly productive in 2005 (Thurston County, 2006).

4.4.3.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Black Lake shoreline planning area consists of most of the eastern shore of the lake. The western shore is within the Thurston County shoreline jurisdiction. For this analysis, the lake is broken into two shoreline reaches (BLK-1 and BLK-2). Existing land use in the southern lake shoreline (BLK-1) is predominately low-density residential (80 percent). The northern shoreline planning area (BLK-2) is also predominated by low-density residential (60 percent). BLK-2 also includes a relatively large area north of 52nd Ave SW which is currently developed as high-density residential and an area characterized as a manufactured home park. There is also a small area of commercial land use at the northern end Reach BLK-2. Both reaches contain open space along the shoreline. Table 4-20 below shows the percentages of the major land uses by reach.

Right-of-way comprise a minor component of the Black Lake shoreline (less than 3 percent) Blake Lake Boulevard runs along the northwest portion of the shoreline planning area. Several other local roads pass through the remainder of the planning area. There are no water-dependent or –related uses within the planning area. Camps (BLK-1), waterfront community areas (BLK-1 and 2), parks and boat ramps (BLK-1) are all considered water-enjoyment uses.

Kenneydell County Park has 1,000 feet of shoreline on Black Lake. The park is 41 acres and includes a swimming beach with covered picnic shelters, ball fields, and a lodge.

Future Land Use and Environment Designation

Future land use along the lake follows the existing land use pattern, with one exception. A small area currently in commercial use located at the north end of the lake is expected to convert to a residential use. The southern portion of the lake shoreline is designated conservancy and the northern portion is designated rural in the current SMP. The wetland complex south of the lake is designated as Natural. A regional trail is proposed in Percival Canyon and about half a mile east of Black Lake (Thurston Regional Trail Plan 2007).

Shoreline Modification

Data on shoreline armoring is not available. There are 138 docks associated with single-family residences and eight community docks currently on the lake.

Existing and Potential Public Access Areas

There are several parks and open spaces along the Black Lake shoreline that offer public access. Kenneydell Park at the divide between BLK-1 and 2 provides physical access to lake and a swimming beach. There is also a WDFW boat launch at the south of Kenneydell Park.

Hazardous or Toxic Materials

While there are areas of with reported hazardous or toxic materials present in the general vicinity of Black lake. There are no known sites within the shoreline planning area.

4.4.3.6 Reach Scale Assessment

Black Lake has been divided into two reaches for this assessment and these are labeled BLK-1 and BLK-2. These reaches extend from the southeast corner of the lake to the residential, north portion of the lake. The west side of the lake occurs beyond the UGA boundary and is not included in the shoreline characterization and analysis. Additional moderate density subdivision development is anticipated along the east shoreline of the lake in the future (TRPC, 2008).

Table 4-20. Shoreline reach-scale assessment – Black Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
BLK-1	Less developed portion in southeast portion of lake	1.0	SFR (80) PPOS (9)	Kenneydell Park, extensive associated wetlands to the south	Mixed coniferous and deciduous forest; shrub cover.
BLK-2	Residential portion of northeast portion of lake.	1.9	SFR (60) MHP (16) PPOS (11)	Kenneydell Park	Riparian forest cover is limited.

4.4.4 Capitol Lake

4.4.4.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Capitol Lake is a 270-acre lake located on the State Capitol Campus in Olympia and Tumwater. The lake was created in 1951 when a dam was constructed at the mouth of the Deschutes River to form the reflecting pool for the Capitol Building. Capitol Lake is located in the heart of the City of Olympia and extends into the northern extend of the City of Tumwater. The lake is located in the Budd/Deschutes Watershed (WRIA 13). Capitol Lake encompasses approximately 275 acres, has a mean depth of 9 feet, and a maximum depth of 20 feet. The lake is divided into four basins: North Basin, Middle Basin, South Basin, and Percival Cove. The Department of General Administration (GA) manages the lake. The Capitol Lake Adaptive Management Plan (CLAMP) Steering Committee advises the GA on long-range planning for the lake.

Streams

Several tributaries drain into Capitol Lake, including the Deschutes River (from the south); Percival Creek (from the west via Percival Cove); and multiple stormwater outlets that discharge into the lake (TRPC, 2008).

Wetlands

Documented emergent wetland habitat in the Capitol Lake area is located primarily in the South Basin and adjacent to the Tumwater Historical Park. Capitol Lake wetlands total approximately 275 acres and include mostly open water associated with vegetated wetland along the shoreline. A narrow area of fringe estuarine wetlands also occurs along Deschutes Parkway. Approximately 275 acres of Capitol Lake (the total lake area) occurs below the OHWM. A wetland mitigation site is located in the southwest corner of the Middle Basin (TRPC, 2008).

4.4.4.2 Geologic and Flood Hazard Areas

Capitol Lake is located in the 100-year floodplain and is subject to tidal flooding and overbank flooding during large storm events. Elevation at Capitol Lake is approximately 9 feet (TRPC, 2008). Heritage Park, located on the east side of the North Basin, was landscaped to provide flood protection for downtown Olympia. Several landslide hazard areas have been documented for the Capitol Lake vicinity. Steep slopes surround the basin on all but the north side. Steep slopes occur along the shoreline on the east shoreline of the Middle Basin, the east and south shoreline of the South Basin, and the west shore of Percival Cove. Steep slopes occur to the west of Deschutes Parkway in the Middle Basin and North Basin. Finally, steep slopes also occur to the south and southeast of Heritage Park in the North Basin (TRPC, 2008).

4.4.4.3 Biological Resources

Critical or Priority Habitat and Species Use

Priority habitat areas associated with Capitol Lake include high quality riparian shoreline located along the east shore of the Middle Basin, the east and south shore of the South Basin, and the west shore of Percival Cove. The City of Olympia designates these priority habitat areas as "Important Riparian Areas". In addition, the forested hillside of Capitol Lake is the largest contiguous habitat unit within the City of Olympia or the City of Tumwater (TRPC, 2008).

Several sensitive species have been documented in the Capitol Lake vicinity. Bald eagles are located in the Capitol Lake basin (TRPC, 2008). Upland mixed forest habitat occurs in three main locations at Capitol Lake: the west shoreline of Percival Cove; the east shoreline of the Middle Basin; and the northeast shoreline of the South Basin. These mixed coniferous and deciduous forests provide high quality perching and nesting habitat for bald eagles. Two nest sites for bald eagle have been documented along the east shoreline of the Middle Basin. Up to two resident osprey have been documented in the North Basin and Middle Basin. Pileated woodpeckers and other woodpecker species are documented residents in the Middle Basin and South Basin of Capitol Lake. Percival Cove is designated as breeding territory for green heron and a regular concentration of mink. The lake provides forage habitat for several bat species, including long-legged myotis, western small-footed myotis, long-eared myotis, little brown myotis, and hoary bat. Painted turtle and western pond turtles have also been documented along the emergent wetland shorelines of Capitol Lake (Herrera, 2004).

Salmonid species occurring in Capitol Lake are those migrating from Puget Sound through Budd Inlet and upstream along the Deschutes River. Capitol Lake and the Deschutes River have been identified by WDFW as a migration corridor for anadromous fish (Herrera, 2004). Salmonids documented in Capitol Lake include fall Chinook, coho, winter steelhead, and sea run cutthroat trout (Herrera, 2004; TRPC, 2008). The South Basin is identified by WDFW as providing priority resident habitat for cutthroat trout (Herrera, 2004). The Deschutes River at Deschutes Falls is documented as containing riffle sculpin and is a breeding territory for wood duck. Aquatic species that live in the lake year-round include carp, three-spined stickleback, largemouth bass, and catfish (Herrera, 2004).

Instream and Riparian Habitats

The Capitol Lake shoreline has undergone significant alteration, including construction of road infrastructure, railroads, docks and piers, trails, the Tumwater Historic Brewhouse in the South Basin, and a pedestrian bridge that separates the North Basin and Middle Basin.

Historically (prior to 1929), the Deschutes River flowed north and discharged directly into Budd Inlet. In 1929, BNSF railroad tracks were constructed across the mouth of the Deschutes River. This project consisted of a berm and railroad trestle that separated the North Basin and Middle Basin. Railroad tracks were simultaneously installed that created Percival Cove and defined the west shoreline of the Middle Basin and North Basin. In approximately 1942, the 5th Avenue bridge was constructed using earthen fill. The 5th Avenue dam and tide gates were installed in 1951, creating the freshwater habitat of Capitol Lake. In 1956, the I-5 bridge was constructed which separated the Middle Basin and South Basin of the lake. In approximately 1965, a City park was constructed at the northeast corner of the North Basin. By 1974, Deschutes Parkway was constructed along the west shoreline of the lake and fill material was placed at the southwest corner of the North Basin to create Marathon Park. In 1999, Heritage Park was constructed along the north shoreline of the North Basin, which replaced some of the riparian vegetation with armoring and pedestrian trails (Herrera, 2004).

The tide gate and dam located at the mouth of the Deschutes River, at the south end of the Middle Basin, has led to sediment loading in this area. A sediment study conducted at Capitol Lake determined that these sediments would be classified by the Thurston County Heath Department as an "inert, non-dangerous, and non-high risk waste material that could be disposed of at an approved upland location" in the county (Herrera, 2000).

4.4.4.4 Water Quality

Water quality in Capitol Lake has long been studied (CH2MHill 1978). The lake has had long term problems with algae, turbidity, fecal coliform and sedimentation since it was created in 1951. Major sources of fecal coliform were thought to be from Deschutes River and waterfowl. Inputs of nutrients were identified to be from the Deschutes River. Dissolved oxygen was found to occasionally fall below standard in the lake. Non-point source pollution was also identified to be a problem. Dredging of the lake was considered a solution and portions of the lake were dredged in 1979 and 1986.

Water quality is a problem in the basin and the focus of a Total Maximum Daily Loading (TMGL) Study which is currently underway by the Washington Department of Ecology. Capitol Lake is on the Category 303(d) list of impaired waterbodies for fecal coliform and total phosphorus. The lake is also infested with the noxious weed, Eurasian water milfoil (Thurston County, 2006). The lake basins are considered eutrophic or highly productive based upon total phosphorus and chlorophyll a concentrations. Percival Cove showed the greatest productivity.

Sediment from the Deschutes River and Percival Creek are filling the lake, slowly converting it to a freshwater marsh. The lake is closed to swimming due to the health risk. Aquatic life is threatened by high levels of phosphorus, which tends to promote the growth of algae and aquatic weeds and reduce the dissolved oxygen content of the water. Objectives for managing Capitol Lake from the CLAMP include improving water quality in Capitol Lake.

USGS collected bathymetry data in Capitol Lake in September 2004. The goal of the study was to calculate sedimentation rates within the lake and develop bottom topography for use in modeling. Sediment samples were collected by USGS in 2005 to characterize the substrate for water quality and sediment modeling. Sediment samples indicated the bottom of Capitol Lake to be largely silt deposits. Percival Basin and South basin proved to be too shallow and choked with aquatic weeds for the survey methodology and could not be surveyed.

Soils adjacent to Capitol Lake are known to be contaminated with diesel, fuel oil and lead. Leaking underground storage tanks from former gas stations and repair shops have contributed to this contamination. In addition, numerous stormwater outfall pipes convey road runoff to the lake.

4.4.4.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Capitol Lake shoreline planning area is a diverse mix of land uses that includes open space, commercial, government, and low-density residential. The lake is divided into three basins (North, Middle, and South) by the BNSF railroad and Interstate 5 (I-5). The planning area is also divided between Olympia and Tumwater, with the southern end of the Lake in Tumwater. For this analysis, the lake shoreline planning area has been divided into seven reaches (CAP-1 through CAP-7). Percentages of the major land uses within each shoreline reach are shown in Table 4-21.

The existing land use in CAP-1 is almost entirely commercial within the City of Tumwater (60 percent) with a small portion of open space (Tumwater Falls Park) at the southern end. The north end of CAP-1, in the City of Olympia includes a mixed of low-density residential and the I-5 corridor. Land use in CAP-2 is almost entirely open space (73 percent) (Tumwater Falls Park and Historical Park). A small portion of the reach is within the I-5 corridor. CAP-3 includes the entire west bank of the Middle Basin. Land use in this reach is mostly low-density residential (48 percent) with government/institutional land use (20 percent) (Capitol Campus) at the north end.

Reach CAP-4 comprises the east side of the Middle Basin. Land use in the reach is a mix of open space (50 percent), government/institution (7 percent) and commercial (6 percent). The Deschutes Parkway and other roads make up a substantial portion of the CAP-4 planning area (38 percent). CAP-5 includes the shoreline of Percival Cove. Land uses surrounding the cove include the Deschutes Parkway, open space, a limited amount of residential development and a relatively large area of undeveloped government land (35 percent of the reach area). CAP-6 includes the western shore of the North Basin. Its shoreline planning area is predominantly open space (70 percent) (Heritage Park). CAP-7 includes the eastern shore of the North Basin. Land use in this planning area consists of the Deschutes Parkway and low-density residential west of the roadway.

There are several large rights-of-way within the Capitol Lake shoreline planning area. Rights-of-way comprise a significant portion of the shoreline area (30 percent). The Deschutes Parkway passes through the western shoreline of the North, Middle and South Basins. I-5 passes between the Middle and South Basin, where is also intersects with State Route (SR) 101. Numerous local roads, including Powerhouse Road SW, 5th Ave SW, and Lakeridge DR SW, also pass through the shoreline. Other transportation infrastructure the Capitol Lake shoreline planning area includes a BNSF railroad track and trail separates the North and Middle Basin and a railroad track located to the west of Deschutes Parkway in CAP-7. The percentages of each shoreline reach used for rights-of-way are shown on Table 4-21.

There are no water-dependent or –related uses in the Capitol Lake shoreline Planning area. The historic Tumwater Brewery is likely to have some water-enjoyment element when restored. Other water-enjoyment uses include trails and viewpoints in the lakeshore parks.

Future Land Use and Environment Designation

The anticipated future land use pattern in the Capitol Lake shoreline planning area follows the existing land use pattern very closely; major changes in the land use pattern are not expected. Minor changes in the land use pattern, include increased commercial and residential densities in Olympia's downtown core (CAP-6) and redevelopment of the Old Brewhouse in Tumwater (CAP-1). The Lake's shoreline is designated Conservancy with the northeast shoreline of the North Basin designated Urban in the existing SMP.

Shoreline Modification

Capitol Lake's shoreline is highly modified. The shoreline of the North Basin is armored by a bulkhead along Heritage Park on the east side and rip-rap supporting Deschutes Parkway on the west side, which extends along the western shoreline of the Middle Basin as well. I-5 crosses the lake on a bridge and fill between the South and Middle basins. A railroad and on till (with a pedestrian bridge) crosses the lake between the North and Middle basins. There are also three small docks (CAP-4 and CAP-7), and a public pier at the Interpretive Center near I-5.

Existing and Potential Public Access Areas

There are numerous parks, open spaces and other public access opportunities in the Capitol Lake shoreline planning area. Large parks with directs access to the lake include Historical Park (CAP-2), Capitol Lake Interpretive Center (CAP-4), Heritage Park (CAP-6), Marathon Park (CAP-7), and Tumwater Historical Park (CAP-4). Access is also provided by shared use trails along the entire western lake shoreline and the eastern shoreline of the North Basin. The 5th Ave Dam provides public overlooks to the lake.

Swimming is not currently allowed at Heritage Park due to water quality problems in the north basin of Capitol Lake. Poor water circulation and water quality conditions, existing contamination sources, and the presence of pathogens and bacteria eliminate the ability to provide safe swimming at Heritage Park (see http://www.co.thurston.wa.us/health/ehrp/index.html).

Historic and Cultural Resources

There are two National Historic Districts located along or adjacent tot the shoreline of Capitol Lake. There are numerous properties in the vicinity of the shoreline planning area that are listed in the historic inventory, or on local, state or federal registers.

Hazardous or Toxic Materials

Several sites with the presence of known or suspected hazardous or toxic material are located within the shoreline planning area. These are generally located in Olympia's downtown core, Heritage Park, and south of the Middle Basin.

4.4.4.6 Reach Scale Assessment

Capitol Lake has been divided into seven reaches for this assessment. These are labeled CAP-1 through CAP-7 and the reaches extend from the South Basin to the North Basin. The Capitol Lake shoreline area is currently fully developed. Future land use planning efforts may include redevelopment efforts in downtown Olympia and redevelopment of the Old Brewhouse in Tumwater (TRPC, 2008). Most of Capitol Lake lies within the City of Olympia.

Table 4-21. Shoreline reach-scale assessment – Capitol Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
CAP-1	East side of South Basin	1.3	Com/Ind (60) Vacant (18) ROW (17)	Tumwater Falls Park	Mixed coniferous/ deciduous forest and shrub cover.
CAP-2	West side of South Basin	1.0	PPOS (73) ROW (24)		Riparian forest cover present but interrupted by tide gate.
CAP-3	East side of Middle Basin	1.1	SFR (48) Gov/Inst (20) Vacant (15) ROW (13)	Landslide hazard mapped	Narrow riparian corridor of coniferous forest cover.
CAP-4	West side of Middle Basin	2.1	PPOS (50) ROW (38)	Landslide hazard	Dominant shrub vegetation.
CAP-5	Percival Cove	N/A	PPOS (9) Gov/Inst (44)* ROW (43)	Percival creek estuary, landslide hazards	Mixed coniferous /deciduous forest on the west; limited riparian cover on the east.
CAP-6	East side of North Basin	0.8	PPOS (70) ROW (22)		Riparian cover is limited.
CAP-7	West side of North Basin	0.7	SFR (9) PPOS (17) ROW (66)	Landslide hazards	Mixed coniferous and deciduous forest and shrub cover.

* Includes Government/Institutional and Undeveloped Government

4.4.5 Chambers Lake

4.4.5.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Chambers Lake is located in Chambers basin within the Budd/Deschutes Watershed (WRIA 13). The lake is divided into and East Basin and West Basin due to its location, which falls within both the City of Lacey (East Basin) and the City of Olympia (West Basin). The West Basin flows into the East Basin. Chamber Lake drains through Chambers ditch to Chambers Creek and eventually to the Deschutes River to the south. Mean lake depth is five feet and maximum depth reaches eight feet. Topography surrounding Chambers Lake is flat, although it becomes somewhat steeper on the southeast side of the lake. Elevation at the lake is 197 feet (TRPC, 2008).

Streams

There are no apparent tributaries flowing into Chambers Lake. Overland flow is the main water source for the lake (TRPC, 2008).

Wetlands

The East Basin and West Basins of Chambers Lake contain a wide variety of extensive wetland habitats. Modified emergent and shrub wetland habitats are present on the east and south shorelines of the East Basin (east of the Chehalis Western Trail). Emergent wetlands surround the south isthmus between the two basins and the south and east shorelines of the West Basin. The West Basin shoreline is dominated by shrub wetland habitat and the northwest area of the West Basin supports a unique wetland with acidic organic soils (TRPC, 2008).

A recent study was conducted to verify associated wetlands and the OHWM around the south end of the two basins comprising Chambers Lake. The lake has been drained in the past and is managed by an active Drainage District. Small areas of associated wetland habitat were identified on the west side of the West Basin and the southeast side of the East Basin. The OHWM of the lake was determined to be located between 10 and 100 feet farther out into vegetated wetland habitat, with a result of total lake area below the OHWM of approximately 151 acres (Shanewise, 2008).

Wetlands are described by shoreline reach for Chambers Lake in Table 4-22.

Table 4-22. Wetland habitat and area by shoreline reach – Chambers Lake

Reach Number	Wetland Habitat Type[1]	Total Wetland Acres	Approximate Location
CHAM-1	LOW	49.7	East Basin
	PEM	10.9	South isthmus between E and W Basin
	PSS	6.2	East Basin shoreline
CHAM-2	PEM	10.2	South shore of West Basin
	PFO	2.5	South and NW shoreline of West Basin
	PML	21.2	West Basin shoreline area
	PSS	28.2	SW and north shore of West Basin
CHAM-3	PEM	4.4	Central-east shore of West Basin
	PFO	2.1	Southeast corner of West Basin
	PSS	1.7	East shore of West Basin

[1] PML = Palustrine moss-lichen wetland.

4.4.5.2 Geologic and Flood Hazard Areas

Chambers Lake is located in the 100-year floodplain and therefore riparian areas, including shoreline residential developments, are potentially affected by high storm events. There are no designated landslide hazard areas for this lake (TRPC, 2008).

In 2006, the City of Olympia placed a moratorium on grading and subdividing in the area south and southwest of Chambers Lake. This area has been experiencing drainage and flooding problems related to groundwater and stormwater management. A final evaluation report has been prepared in March 2008 for the Chambers Basin Moratorium (City of Olympia Public Works). It was determined that the valley area south of Chambers Lake is not suitable for development at current zoned densities due to high groundwater and flat topography.

4.4.5.3 Biological Resources

Critical or Priority Habitat and Species Use

Documented priority habitat along the lake includes limited riparian habitat located along non-wetland shoreline areas. Wood ducks are documented within Chambers basin. Several game fish species are documented within the lake, including cutthroat trout and spiny rays (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation surrounding the lake is dominated by mixed coniferous and deciduous forest and shrub cover. The west shoreline along the West Basin contains more intact riparian cover, with forested components at the north and south ends of the basin and a shrub and maintained lawn component on the southwest portion of the basin. The east side of the West Basin has been highly altered to accommodate moderate density urban development. The East Basin shoreline is characterized by a narrow band of riparian vegetation surrounded by moderate density urban development on the north and east sides of the basin. The isthmus connecting the two basins is largely forested and shrub wetland habitat (TRPC, 2008).

The hydrology of Chambers Lake has been highly altered by the surrounding urban environment. Several ditches control surface flow in the surrounding Chambers basin and the lake is located within the Chambers Drainage District. Local roads provide access to the east side of the lake but road infrastructure is limited on the west side of the lake. The Chehalis-Western Trail (a former railroad right-of-way) divides the West Basin and East Basin. The railroad has been converted to a regional trail. Aside from the trail, little shoreline alteration has occurred along the lake. Recreational activities associated with the lake include boating and fishing. A WDFW boat launch is located on the lake to provide boat and fishing access (TRPC, 2008).

4.4.5.4 Water Quality

Chambers Lake is not listed at the Category 5 303(d) level for impaired waterbodies. However, the lake is listed as a Category 2 for total phosphorus.

Chambers Lake is known to have problems with over abundance of fragrant waterlily and other aquatic plants. The University of Washington experimented with using triploid grass carp to remove waterlilies from Chambers Lake. This test involved use of very high stocking rates of the carp. However, the experiment failed resulting in no impact on the waterlily observed in the lake (see Ecology web page http://www.ecy.wa.gov/programs/wq/plants/weeds/aqua005.html).

4.4.5.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Chambers Lake is located on the boundary of the Cities of Olympia and Lacey. The lake has been broken into three reaches (CHAM-1 through CHAM-3) for this analysis. The current land use pattern in the shoreline planning area is a mix of residential, open space, and vacant uses. Residential land uses in the shoreline occur in a variety of densities. Within Olympia, residential uses are primarily low-density. On the Lacey shoreline, residential uses are moderate- and high-density along the northern reach (CHAM-3) and moderate and low-density around little Chambers Lake (CHAM-1). A large portion of the CHAM-3 shoreline is a manufactured Home Park. Vacant lands are also present in both jurisdictions. Percentages of the major land uses within each shoreline reach are shown in Table 4-23.

Rights-of-way make up less than 2 percent of the shoreline planning area. There are only a few roads within the lake's shoreline. A former railroad right-of-way, now converted to a trail (Chehalis Western Trail), divides the East and West Basins. There are no water-dependent or –related uses in the shoreline. The mobile home park community area in reach CHAM-3 and the Chehalis Western Trail could be considered water-enjoyment uses.

Future Land Use and Environment Designation

The future land use pattern in the lake's shoreline is not expected to differ significantly from the existing pattern. Land use in the shoreline is expected to remain predominantly residential, although the density of residential development is expected to increase. Specifically increases in residential density are anticipated along the CHAM-2 shoreline in Olympia. Additionally, lands along the southern edge of the West Basin are expected to convert from vacant to government/institutional use. An area along the southwestern shore of the West Basin is currently under application to develop approximately 140 units. In the existing SMP Chambers Lake is designated Conservancy in the East Basin and along the southern lake shore in the East Basin. The remainder of the East Basin is designated Urban.

Shoreline Modification

There is very little reported shoreline modification along the lake's shoreline, with the exception of the Chehalis Western Trail, which is constructed on a fill bridge.

Existing and Potential Public Access Areas

In addition to the Chehalis Western Trail, several public open spaces exist within the Chambers Lake shoreline. These include park properties south of the West Basin, west of the West Basin and east of the East Basin. There is a WDFW boat launch at the northern end of the West Basin..

Hazardous or Toxic Materials

There is an area of elevated nitrate levels located to the east of Chambers Lake. It may extend into the shoreline planning area of Reach CHAM-2.

4.4.5.6 Reach Scale Assessment

Chambers Lake is represented by three reaches, labeled as CHAM-1 through CHAM-3. These reaches extend from the East Basin to the more developed, north side of the West Basin. Future land use planning for this area is currently under moratorium in the City of Olympia as moderate density urban zoning is re-examined (TRPC, 2008).

Table 4-23. Shoreline reach-scale assessment – Chambers Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
CHAM-1	East Basin, Little Chambers Lake	1.3	SFR (22%) PPOS (39%) Vacant (23%)	Wetland and floodplain to the south near Chambers Ditch	Narrow corridor of shrub cover limited by moderate density development.
CHAM-2	Less developed portion, generally within Olympia	2.3	SFR (21%) PPOS (46%) Vacant (18%) NRL (12%)	Wetland to the south of basin	Mixed coniferous and deciduous forest and shrub cover.
CHAM-3	Developed portion, generally within Lacey	0.8	SFR (39%) MHP (30%) PPOS (15%) Vacant (15%)	No mapped weland	Riparian forest cover is limited.

4.4.6 Grass Lake (Lake Louise)

4.4.6.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Grass Lake is part of a large wetland and pond system on the west side of the City of Olympia. The lake drains through Green Cove Creek into Eld Inlet. Grass Lake is located in the Green Cove Creek basin, which is part of the Eld Inlet Watershed (WRIA 13). The name Grass Lake is used somewhat interchangeably to refer to the wetland system and open water area located between the wetland complex and Kaiser Road NW. The open water area was created by peat mining in the 1950s by the Louise family and the pond was thereafter termed Louise Lake (also referred to in the literature as Lake Louise). TRPC data refer to these two habitats simply as Grass Lake, except in referencing bird occurrences at the lake. Therefore, Grass Lake will be used to refer to both the wetland and open water for this discussion (TRPC, 2008).

Mean lake depth is approximately 3.8 feet and maximum depth reaches up to approximately 11.4 feet during high lake levels (TCSSWP, 1998). Topography around the lake area is generally flat and the elevation at the lake (Louise Lake) is approximately 141 feet. The lake area encompasses approximately 64 acres, including 12.4 acres of open water (TRPC, 2008).

Streams

There are no apparent tributaries discharging to Grass Lake. The primary water source is overland stormwater flow (TRPC, 2008). When water levels in Green Cove Creek are higher than in Louise Lake, water flows east into the lake and provides a secondary water source for the Grass Lake wetlands (TCSSWP, 1998).

The sub-basins that drain into Grass Lake total approximately 939 acres, of which wetland habitat comprises approximately 8.8 percent. The Grass Lake wetland area drains west through a forested swale into Louise Lake. The west side of the lake is bounded by an upland berm which once served as a roadbed. When lake levels are high, the lake drains west through a 42-inch corrugated metal culvert into a forested ditch located between the berm and Kaiser Road NW. Water from the lake continues draining into Green Cove Creek. When the water level on the west side of the culvert is high, flow direction reverses and water drains east into the lake (TCSSWP, 1998).

Wetlands

Extensive shrub wetland habitat is interspersed with forested and small patches of emergent and open water habitats at the Grass Lake area. A special mapping effort conducted by Ecology was conducted in the mid-1990s to verify wetland locations in this area. Historically, Grass Lake was part of an extensive wetland system. Roads and culverts now have fragmented the habitat into a series of smaller wetland areas. Grass Lake Refuge now encompasses a large area east of the lake dominated by shrub wetlands. Total wetland habitat in the Grass Lake area is approximately 69 acres (including the refuge and lake areas). Total area of the lake area occurring below the OWHM is approximately 64 acres (TRPC, 2008).

Table 4-24. Wetland habitat and area by shoreline reach – Grass Lake (Lake Louise)

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
GRASS-1	PEM	2.0	Grass Lake Refuge area
	PFO	0.4	Forested swale between Grass Lake Refuge and Louise Lake
	POW	10.3	Louise Lake
	PSS	55.8	Central portion, Grass Lake Refuge

4.4.6.2 Geologic and Flood Hazard Areas

The Grass Lake area is located in the 100-year floodplain and therefore this area, including surrounding portions of urban development, may be affected by overbank flooding during large storm events (TRPC, 2008). In particular, some residential areas located north of Grass Lake are subject to occasional flooding issues due in part to unmaintained drainage facilities (TCSSWP, 1998). There are no designated landslide hazard areas associated with Grass Lake.

4.4.6.3 Biological Resources

Critical or Priority Habitat and Species Use

Grass Lake (and Lake Lousie) are located within the Grass Lake Refuge, a 164 acre city-owned park in Olympia. The refuge contains the headwaters of Green Cove Creek and is an important wetland system and habitat area in northern Thurston County. According to the city's web page, over 100 bird species and 200 plant species have been documented occurrence in the refuge. http://www.olympiawa.gov/cityservices/par/parks/GrassLake.htm

A large grove of quaking aspen is located at the south end of the Grass Lake Refuge, located north of Harrison Avenue (TCSSWP, 1998). Sensitive species associated with the Grass Lake area include wood ducks, which occur in the Green Cove Creek basin and breed in the Grass Lake wetland area (TCSSWP, 1998; TRPC, 2008). Green Heron nests are documented in the Grass Lake wetland area. Bald eagle and osprey have been documented perching and feeding in the area as well. Great blue herons and pileated woodpeckers are frequently observed in the wetland habitat areas. Other sensitive wildlife species that occur in the Grass Lake wetland area include western gray squirrel, Townsend's big-eared bat, red-backed salamander, and rough-skinned newt (TCSSWP, 1998). The Olympic mud minnow is present in Green Cove Creek downstream from the park.

Louise Lake provides winter and summer habitat for a variety of shorebirds and waterfowl. Several species observed at the lake include common snipe, Great Blue Heron, greater yellowlegs, pied-billed grebe, and bufflehead. Downy and hairy woodpeckers have been observed in the adjacent forest areas. Grass Lake Refuge provides habitat for a variety of raptors and songbirds, including western tanager, black-headed grosbeak, common yellowthroats, swallows, and warblers (TRPC, 2008).

No data is available regarding fish use in the Grass Lake area (TRPC, 2008). However, observations of chum and coho have been recorded in Green Cove Creek. When water level is high in Louise Lake and flows drain west, stormwater runoff is concentrated at Kaiser Road NW and flooding occurs (TCSSWP, 1998). This culvert is identified as a non-blocking culvert, although fish use east of Kaiser Road has not been documented (Haring and Konovsky, 1999). Stormwater runoff is associated with sedimentation, erosion, and increased peak flows, all of which may affect fish habitat in this area (TCSSWP, 1998).

Instream and Riparian Habitats

Riparian habitat in the Grass Lake area contains mixed coniferous and deciduous forest along with shrub and grass vegetation. The lake and refuge are surrounded by moderate and high density urban development. Historically, the central portion of the Green Cove Creek basin was characterized as a "willow swamp" by the General Land Office in the 1850s. The historic swamp was surveyed and estimated to cover about 560 acres, or approximately 21 percent of the basin (TCSSWP, 1998). The Grass Lake wetland system is now fragmented due to drainage ditching, construction of stormwater facilities, and road infrastructure associated with a highly altered urban environment. The City of Olympia owns much of the wetland habitat and these belong to the Grass Lake Refuge. Little modification has occurred along the Louise Lake shoreline and no recreational activities occur in the lake (TRPC, 2008).

4.4.6.4 Water Quality

Grass Lake and Lake Louise are not listed on the state's 303(d) list of impaired waterbodies. However, Grass Lake was studied and water quality testing done in 2001 by the Evergreen State College, Environmental Analysis program. This study included a benthic survey of the lake bottom and water quality testing for typical parameters (i.e., pH, dissolved oxygen, etc.). See http://academic.evergreen.edu/curricular/ENVANA/.

Students documented that four ponds for Grass Lake were observed in October. The lake areas then became interconnected into one body of water in November 2000. The pond areas include Lake Louise, Grass Lake West, Grass Lake East, and another unnamed pond area. No water quality problems were noted.

4.4.6.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Much of the planning area is in the Grass Lake Refuge, which extends from Keiser RD NW to Cooper Point RD. Open space accounts for more than half of the planning area (53 percent). Areas of low- and moderate-density residential development (8 percent) are located north and south of the lake and a small area of commercial development is located to the southeast. A large area south of the Grass Lake Refuge is classified as vacant. In total, private vacant land comprise 34 percent of the shoreline area.

Roads are limited within the shoreline planning area. The rights-of-way for Cooper Point DR to the east, Keiser RD to the west and Harrison Ave to the north may occupy a small portion of the shoreline planning area (5 percent).

There are no water-dependent or –related uses in the planning area. The Grass Lake Refuge provides passive recreation, although its primary functions are wildlife protection, wildlife viewing, and environmental education. Trails are located in the refuge for bird watching and otherwise it is undeveloped.

Future Land Use and Environment Designation

Much of the Lake's shoreline planning area is within the Grass Lake Refuge, which will not convert to a different use. Within the shoreline planning area south of the refuge, a large vacant area is expected to develop as low-density residential and commercial uses. Part of that area is currently under application for development of approximately 55 residential units. The Lake is designate as Rural in the existing SMP.

Shoreline Modification

There is little to no modification within the shoreline jurisdiction of Grass Lake.

Existing and Potential Public Access Areas

The Grass Lake Refuge offer public access to a large potion to Grass Lake/Lake Louise and its associated wetland system. Public trails are found within the refuge.

Hazardous or Toxic Materials

The Puget Power ELD Inlet Substation located immediately west of the planning area on 14th Ave NW is listed on Ecology's confirmed and suspected contaminated sites list. Petroleum products are confirmed in groundwater, soil, and suspected in drinking water. Polychlorinated Bi-phenyls are suspected in groundwater, soil and drinking water.

4.4.6.6 Reach Scale Assessment

Grass Lake and Louise Lake are represented by one reach, labeled GRASS-1. This reach extends around the perimeter of the wetland complex and open water (lake) area located east of Kaiser Road NW. Anticipated future land use in this area includes significant moderate residential development in the general vicinity. Residential development is allowed to occur under low impact development regulations in upland habitat surrounding the lake and wetland areas. However, much of this area is protected habitat within the Grass Lake Refuge (TRPC, 2008).

4.4.7 Hewitt Lake

4.4.7.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Hewitt Lake is located in the Chambers basin, which is part of the Budd/Deschutes Watershed (WRIA 13). The lake is within the City of Olympia UGA jurisdiction. Yelm Highway SE and Laura Street SE border the north and east sides of the lake, respectively. Ward Lake is located nearby to the northwest. Hewitt Lake encompasses approximately 29 acres, has a mean depth of 28 feet, and a maximum depth of 56 feet. Moderate slopes occur around the lake with adjacent flat topographical areas. Elevation at Hewitt Lake is 126 feet (TRPC, 2008).

Streams

Hewitt Lake is a spring-fed kettle lake. There are no tributaries discharging into the lake and there is no outlet draining out of the lake (TRPC, 2008).

Wetlands

Approximately 29 acres of lacustrine open water wetland habitat has been mapped at Hewitt Lake and includes the entire shoreline (Reach HICKS-1). The area of the lake located below the OHWM mark is also approximately 29 acres. The open water of the lake and associated emergent vegetation along the shoreline comprise this large wetland feature (TRPC, 2008).

4.4.7.2 Geologic and Flood Hazard Areas

There are no landslide hazard or flood hazard areas mapped for Hewitt Lake (TRPC, 2008).

4.4.7.3 Biological Resources

Critical or Priority Habitat and Species Use

The limited riparian habitat along non-wetland shoreline areas of Lake Hewitt is considered Habitat Conservation Areas. There are no documented sensitive fish or wildlife species occurring at the lake (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation along the lake shoreline consists mostly of mixed coniferous and deciduous forest, with some shrub and maintained grass lawn areas. The lake level fluctuates with precipitation levels, although more gradually compared to the nearby Ward Lake. Modifications to shoreline habitat include low density residential development and 23 private docks. Several local roads provide access to the lake area but no other alterations to the area are noted. No recreation activities occur within the lake (TRPC, 2008).

4.4.7.4 Water Quality

Hewitt Lake is not listed as a Category 4 or 5 303(d) list impaired waterbody.

4.4.7.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Existing land use in the Hewitt Lake shoreline is nearly all low-density residential (82 pecent). There are some very limited areas of vacant land (5 percent) and open space (6 percent). Roads in the planning area include only local residential roads and comprise approximately 4 percent of the shoreline area. There are no water-oriented uses in the Hewitt Lake shoreline planning area.

Future Land Use and Environment Designation

Future land use in the Hewitt Lake shoreline is not anticipated to deviate from the existing land use pattern. Future land use in the shoreline planning area will remain primarily low-density residential. Under the current SMP, the Hewitt Lake shoreline is designated as Rural.

Shoreline Modification

Data on shoreline armoring is not available. There are 23 private docks on the lake.

Existing and Potential Public Access Areas

Public access to Hewitt Lake is limited. Most of the lake shoreline is under private ownership. There are three sites on the lake that are private subdivision open space. While currently not publically available, these sites may represent potential opportunities for future public access.

4.4.7.6 Reach Scale Assessment

Hewitt Lake is represented by one reach, labeled Hewitt -1, which includes the entire lake shoreline. Future land use in the area is unlikely to change significantly, although residential redevelopment may occur along the shoreline. Moderate density residential development is anticipated to occur south of the lake (TRPC, 2008).

4.4.8 Hicks Lake

4.4.8.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Hicks Lake is located in the Woodland basin within the Henderson Inlet Watershed (WRIA 13). This lake is managed under the City of Lacey SMA jurisdiction and encompasses approximately 170 acres. Mean lake depth is 18 feet and maximum depth reaches 35 feet. Topography around the lake is fairly flat, with some moderately sloping areas occurring along the east side of the lake. Lake elevation is approximately 161 feet (TRPC, 2008).

Streams

There are no tributaries designated for Hicks Lake. The main water sources are groundwater seepage and surface flow. The lake discharges through a large wetland to the south (TRPC, 2008).

Hicks Lake belongs to a four-lake system connected by extensive wetlands that form a horshoe-shaped chain at the head of Woodland Creek. Hicks Lake flows south into Pattison Lake and then northeast into Long Lake, all of which lie at approximately the same elevation (160 feet). Long Lake discharges northwest into Lois Lake, which is located at a slightly lower elevation. Lois Lake then drains into Woodland Creek, which eventually flows north into Henderson Inlet (TRPC, 2008).

Wetlands

The area located between Hicks Lake and Pattison Lake is mapped as a 162-acre palustrine wetland. This wetland was once drained and used for agricultural purposes, but native vegetation has now been restored on the site. Associated wetlands are located to the southwest (which contain combinations of shrub, forested, and emergent wetland vegetation) and to the south. The south wetland complex is the largest wetland unit in the City of Lacey. Shrub wetland habitat dominates the south end of the lake and combines with forested wetland to create a corridor between the two lakes (Hicks and Pattison). Acidic organic soils are documented within this wetland as well. The area of the lake below the OHWM is approximately 169.6 acres and is considered lacustrine open water wetland habitat (TRPC, 2008).

Table 4-25. Wetland habitat and area by shoreline reach – Hicks Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
HICKS-1	LOW	170	Open water of lake associated with vegetated shoreline
	PFO	25.2	South end of lake
	POW	2.3	South end of lake
	PSS	128.5	South end of lake

Some small emergent wetlands are also located adjacent to Timberline High School, at the lower end of the south shrub-forest wetland unit. The wetland complex stops north of Mullen Road (TRPC, 2008).

4.4.8.2 Geologic and Flood Hazard Areas

Hicks Lake is located in the 100-year floodplain and therefore waterfront developments may be affected by flood events. For example, high lake levels may occur during higher than normal winter rainfall conditions. Extreme high lake levels cause flooding of some lakeshore structures. The outlet channel is located on private property, is not maintained, and restricts outflow from the lake. There are no landslide hazard areas documented for this waterbody (TRPC, 2008).

4.4.8.3 Biological Resources

Critical or Priority Habitat and Species Use

Several Habitat Conservation Areas are documented in the City of Lacey SMA jurisdiction area. One of these areas includes the entire upper portion of the Lacey Lakes Watershed. Also, a riparian corridor linking Pattison Lake and a ditch across Mullen Road via an associated wetland is considered priority habitat. Finally, the limited riparian habitat areas found along non-wetland shorelines are also considered priority habitat (TRPC, 2008).

Wood duck use is documented within the associated shrub and forested wetlands south of Hicks Lake. The following game fish are found within the lake: rainbow trout (stock species), brown trout, crappies, largemouth bass, rock bass, warmouth bass, perch, sunfish, and bullhead catfish. Low water levels occur in the lake during summer months, particularly during droughts such as that which occurred in 2001 (TRPC, 2008). These low water levels can potentially increase water temperatures, affect water quality, and therefore affect habitat quality for fish in the lake.

Instream and Riparian Habitats

Dominant riparian vegetation along the Hicks Lake shoreline includes mixed coniferous and deciduous forest on the south side of the lake; shrubs and mixed forest on the south and east side of the lake; and shrub and maintained lawns associated with moderate density urban development on the southeast and north sides of the lake (TRPC, 2008).

Hicks Lake is located in an urban environment and habitat alterations have occurred through much of the surrounding area, although the wetlands located south of the lake remain mostly intact. A 162-acre wetland is identified between Pattison Lake and Hicks Lake, which was drained and used for agricultural in earlier times. It has now been restored with native vegetation, although no distinct stream channels remain. Local roads provide access on all sides of the lake (TRPC, 2008).

Recreational activities associated with Hicks Lake include swimming, fishing, and boat access. Wanschers Park is located on the west side of the lake has limited access for swimming due to dense lilypad growth in this portion of the lake. Fishing and boat access are still accessible from the park. A WDFW boat launch provides access for swimming, fishing, and boating activities on the lake. There are 89 private docks located along the lake, although the south shoreline remains unaltered. The Thurston County Fairgounds are located between Hicks Lake and Long Lake (to the east), although this park property does not extend to the waterfront of either lake.

4.4.8.4 Water Quality

Hicks Lake is not listed on the 303(d) list of impaired waterbodies as Category 5. However, invasive exotic species have been documented at the Category 4 level. Hicks Lake was tested by Ecology in 1997 and water quality was considered good. However, due to water clarity and dissolved oxygen levels, the lake was considered meso-eutrophic at the time (see http://www.ecy.wa.gov/programs/eap/lakes/wq/docs/lkhicth1.html).

Hicks Lake water quality was considered generally good by Thurston County Health Department in 2005 (Thurston County, 2006).

4.4.8.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The current land use pattern in the Hicks Lake shoreline planning area is dominated by low-density residential uses. Other uses include open space (Wanschers Park) and government/institution (a church), both located along the western lake shore. Roadways and other infrastructure in the shoreline planning area are generally limited to local access and residential roads. Rights-of-way comprise less than 3 percent of the shoreline area. There are no water-dependent or –related uses in the shoreline. The church camp may considered a water-enjoyment use. Percentages of major land uses in each of the two shoreline reaches are shown in Table 4-26.

Future Land Use and Environment Designation

The future land use pattern along the northern half of the lake is expected to remain generally the same as the existing pattern. Several changes are anticipated along the shoreline in the southern half of the lake. Moderate increases in residential density are expected in areas along the western (immediately south of the park) and southern shoreline of the lake. An area in the southern shoreline is currently under application for development of approximately 20 new residential units. The southern portion of the shoreline is also anticipated to convert from residential to government/institutional use. Hicks Lake is designated Urban under the current SMP. The southern portion of the lake including associated wetlands is designated Conservancy.

Shoreline Modification

The southern shoreline of the lake is unaltered. A boat ramp is located in Wanschers Park. There are approximately 23 private docks on the lake.

Existing and Potential Public Access Areas

Wanscher's Park is a municipal park owned by the City of Lacey that offers access to the lake.

Historic and Cultural Resources

Lake resorts were popular in Thurston County in 1910 through 1920s. Hicks Lake, along with Long, Pattison, and Southwick, all had lakeside resorts. Hicks Lake alone supported seven resorts by 1926 (see http://www.historylink.org/essays/output.cfm?file_id=7979). Gwinwood Resort remains on the current site of a Christian summer youth camp.

There are 11 residential homes located on the Hicks Lake waterfront that are in Thurston County's historic inventory. None of them are listed on state or federal historic registries.

Hazardous or Toxic Materials

An area identified as having elevated nitrate levels are found northeast of the Lake and could be located within or connect to the lake's shoreline planning area.

4.4.8.6 Reach Scale Assessment

Hicks Lake was assigned two reaches for this assessment. These are labeled HICKS-1 and HICKS-2 and extend around the entire lake shoreline, from the south wetland area to the remaining, developed, shoreline areas. Some moderate density residential development is anticipated to occur in south of the lake, although density in land use development around the lake in other areas is not anticipated to change significantly (TRPC, 2008).

Table 4-26. Shoreline reach-scale assessment – Hicks Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
HICKS-1	Wetland along south rim	0.4	SFR (43) Gov/Inst (17) PPOS (34)	Associated wetland area to the south	Mixed coniferous and deciduous forest/ shrub cover.
HICKS-2	Residential area	2.2	SFR (76) PPOS (9)	Developed	Riparian forested cover is limited.

4.4.9 Ken Lake

4.4.9.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Ken Lake is located in the southwest area of Olympia in the Percival Creek basin, which is part of the Budd/Deschutes Watershed (WRIA 13). The lake consists of 26 acres, has a mean depth of 7 feet, and a maximum depth of approximately 11 feet. Steep hills occur along the west side of the lake, but otherwise topography around the lake is moderately flat. Elevation at Ken Lake is approximately 138 feet (TRPC, 2008).

Streams

There are no tributaries discharging to Ken Lake. The primary water sources for the lake include springs and stormwater runoff. The lake drains south into Black Lake Drainage Ditch.

Wetlands

The open water and associated vegetated shoreline areas of Ken Lake are mapped as lacustrine open water wetland. Total wetland area is approximately 26 acres, all of which occurs below the OHWM. Wetlands and wetland buffers create a riparian corridor extending generally from the Ken Lake shoreline south to the Black Lake Drainage Ditch riparian corridor (TRPC, 2008).

4.4.9.2 Geologic and Flood Hazard Areas

Ken Lake lies within the 100-year floodplain and therefore waterfront properties may be affected by high water levels in the lake. The lake experienced flooding issues in 2007. There are no landslide hazard areas recorded in the vicinity of the lake (TRPC, 2008).

4.4.9.3 Biological Resources

Critical or Priority Habitat and Species Use

There are no priority habitats or sensitive wildlife or fish species documented at Ken Lake (TRPC, 2008).

Instream and Riparian Habitats

Riparian forest cover around Ken Lake is limited. Some mixed coniferous and deciduous forest areas are located south and northwest of the lake. The entire lake, extending out to Lakemoor Drive SW, is surrounded by moderate density urban development with interspersed shrub and maintained lawn vegetation (TRPC, 2008).

Shoreline modification at Ken Lake has been extensive. The lake was dredged when the surrounding subdivision was developed to maximize recreational opportunities at the lake. Dredging activities have resulted in decreased water storage capacity in the lake during rain events. Combined with stormwater runoff, this has contributed to flooding issues at the lake.

The majority of the lake shoreline is dominated by residential back yards and is also characterized by 32 private, residential docks. Several roads provide access to the lake, including Highway 101, which is located nearby to the north (TRPC, 2008).

4.4.9.4 Water Quality

Ken Lake is not listed by Ecology on its 303(d) list of impaired waterbodies. In 2007, the Lakemoor Community Club established the Lake Committee to oversee water quality testing and aquatic plant management for Ken Lake. Water quality testing is designed to begin in 2008.

4.4.9.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Existing land use in the Ken Lake shoreline is nearly all low- and moderate-density residential development (75 percent). There are some very limited areas classified as open space (6 percent). Rights-of-way comprise a significant land use in the shoreline are (18 percent). Lakemoor DR SW rings the lake. Other roads in the planning area include only local residential roads. There are no water-dependent or –related uses in the shoreline planning area. Two community beaches would be considered water-enjoyment uses.

Future Land Use and Environment Designation

Future land use in the Ken Lake shoreline is not anticipated to deviate from the existing land use pattern. Future land use is anticipated to remain primarily low- and moderate-density residential. Under the current SMP, the Ken Lake shoreline is designated as Urban.

Shoreline Modification

Data on shoreline armoring is not available. The majority of the shoreline is residential back yards. There are approximately 32 private residential docks on the lake.

Existing and Potential Public Access Areas

Public access to Ken Lake is limited. Most of the lake shoreline is under private ownership. There are two open space sites on the lake which are subdivision open space. While not currently open to the public, these sites may represent opportunities for future public access.

4.4.9.6 Reach Scale Assessment

Ken Lake was assessed using one reach, designated KEN-1, which extends around the entire shoreline of the lake. Anticipated future land use around the majority lake does not include significant changes.

4.4.10 Lake Susan and Munn Lake

4.4.10.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Lake Susan and Munn Lake are located in the City of Tumwater and UGA shoreline jurisdiction area. This lies within the Deschutes River basin, which is part of the Budd/Deschutes Watershed (WRIA 13). The total lake area is approximately 56 acres. Mean depth in Munn Lake is approximately 10 feet and maximum depth reaches about 19 feet. Topography around the two lakes contains moderate slopes, and elevation is approximately 145 feet (TRPC, 2008).

Streams

Susan Lake and Munn Lake are both kettle lakes and are connected by a small wetland system. There are no surface tributaries draining into either lake; they are both fed by groundwater seeps and precipitation. There are also no surface outlets for either lake. According to recent personal accounts, Trails End Lake flows north into Munn Lake and therefore is not under SMA jurisdiction (TRPC, 2008).

Wetlands

Munn Lake contains interspersed patches of small fringe wetlands characterized by emergent and shrub wetland vegetation. Total wetland area at Munn Lake is approximately 7 acres and is dominated by shrub habitat. The shoreline of Lake Susan is similar to Munn Lake, containing a combination of emergent and shrub wetland habitat. The total wetland area documented at Lake Susan is approximately 12 acres, which is dominated by emergent wetland (Shanewise, 2008; TRPC, 2008).

Table 4-27. Wetland habitat and area by shoreline reach – Munn Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
MUNN-1	PEM	2.7	Northeast corner of Munn Lake
MUNN-2	PSS	3.8	Southwest side of Munn Lake
MUNN-3	LOW	4.4	Open water of Lake Susan
	PEM	5.9	East and west sides of Lake Susan
	PSS	1.2	East and west sides of Lake Susan

A recent field study was conducted to investigate whether or not Trails End Lake was connected to Munn Lake and therefore would qualify for SMA jurisdiction. The study determined that water flow through the road culvert connecting Trails End Lake and Munn Lake was unidirectional (flowing only north from Trails End Lake to Munn Lake), and therefore Trails

End Lake was determined not to be a part of the Susan Lake/Lake Munn system for purposes of SMA jurisdiction (Shanewise, 2008).

4.4.10.2 Geologic and Flood Hazard Areas

The Lake Susan and Munn Lake system is located in the 100-year floodplain. This area may be subject to flooding during large storm events and shoreline residences along the shorelines may be affected by high lake levels and flooding. There are no documented landslide hazard areas associated with this lake system (TRPC, 2008).

4.4.10.3 Biological Resources

Critical or Priority Habitat and Species Use

Habitat Conservation Areas documented in this area include the following: limited riparian habitat along non-wetland shorelines and a hydrologic connection between Lake Susan and Munn Lake. In addition, Munn Lake and Trails End Lake are connected by a ditch that passes through a connected wetland system (TRPC, 2008).

Wood ducks usage is documented along the east shoreline of Munn Lake. No sensitive fish species are documented in this lake system. However, several game fish are present in Munn Lake, including rainbow trout, largemouth bass, and bluegill (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation around the two lakes varies between forest and shrub habitats and grass areas associated with developed land use areas. The Lake Susan shoreline is dominated by shrub vegetation to the east and west, with a mixed coniferous and deciduous forest in some areas. The north and south sides of the lake contain limited riparian cover due to development of moderate density residential land use. This developed area also characterizes the west side of Munn Lake, leaving a narrow band of shrub vegetation. The remaining portion of the Munn Lake shoreline contains a narrow corridor of mixed coniferous and deciduous forest (TRPC, 2008).

The shorelines of Lake Susan and Munn Lake have undergone little modification overall. A combined total of 17 private docks are documented along the shorelines of the two lakes. Also, a camp dock is located on Trails End Lake (south of Munn Lake). Boat access is provided on Munn Lake via a WDFW boat launch, although boating is the only documented recreational activity at the lake. Road access to Lake Susan and Munn Lake is limited. Powerlines cross to the north of Lake Susan (TRPC, 2008).

4.4.10.4 Water Quality

Lake Susan and Munn Lake are not listed as Category 5 303(d) impaired waterbodies according to Ecology. However, Munn Lake is listed as a Category 4 impaired waterbody for invasive exotic species. Also, Munn and Trails End Lakes are Category 2 listed for total phosphorus.

4.4.10.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Lake Susan and Munn Lake are analyzed as three reaches (MUNN-3 for Lake Susan and MUNN-1 and -2 for Munn Lake). Existing land use in MUNN-2 and -3 is predominately low- and moderate-density residential, with some vacant and open space land. Land use in MUNN-1 is classified almost entirely as private vacant land. Percentages of major land uses in each of the two shoreline reaches are shown in Table 4-28.

Rights-of-way comprise a relatively small portion of shoreline land use (approximately 6 percent). The shoreline planning area is crossed by both Henderson Blvd E in MUNN-3 and 73rd Ave SE in MUNN-2 and -1. Other roads in the shoreline are local residential roads. There are no known water-oriented uses in the shoreline.

Future Land Use and Environment Designation

Large moderate density residential developments are planned to the east and west of the lakes. Within the shoreline planning area, the future land use pattern in MUNN-2 and -3 is not anticipated to change dramatically. Land use in the shoreline will remain primarily low-density residential. Land use in MUNN_1 is anticipated to convert from vacant to low-density residential. There is currently an application in for a proposed 327 home development extending from the shoreline. Under the current SMP the Lake Susan and Munn Lake shorelines are designated Conservancy.

Shoreline Modification

There is very little modification of the Lake shorelines. There are 17 docks on the lake.

Existing and Potential Public Access Areas

Public access to Ken Lake is limited. There is a WDFW boat launch located along the north edge of Munn Lake. There are four sites on the lake that are private subdivision open spaces. While not public, they may offer opportunities for public access to the lake in the future.

4.4.10.6 Reach Scale Assessment

Lake Susan and Munn Lake are represented by three reaches. These are labeled MUNN-1 through MUNN-3. The first two reaches include the Munn Lake shoreline and Reach MUNN-3 includes the entire shoreline of Lake Susan. Large moderate density residential developments are planned to the east and west areas of the two lakes in the future (TRPC, 2008).

Table 4-28. Shoreline reach-scale assessment – Munn Lake/Susan Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
MUNN-1	East side of Munn Lake	0.8	SFR (14%) Vacant (70%)	Wetland to the north and south	Narrow corridor of mixed coniferous and deciduous forest.
MUNN-2	West side of Munn Lake	0.5	SFR (51%) PPOS (19%) Vacant (23%)		Riparian forest cover is somewhat limited.
MUNN-3	Susan Lake	0.7	SFR (84%) Vacant (6%)	Wetlands to northwest and east	Riparian forest cover is limited on the north and south shorelines.

4.4.11 Long Lake and Goose Pond (Long Pond)

4.4.11.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Long Lake is located along the southeast edge of the City of Lacey and in a portion of the Lacey UGA. The lake lies within the Woodland basin, which is part of the Henderson Inlet Watershed (WRIA 13). Long Lake consists of two basins which are connected by a narrow neck. Mean lake depth is 12 feet and maximum depth is about 21 feet. Topography around Long Lake is moderately flat and the elevation is approximately 156 feet. Open water of the lake includes approximately 323 acres (TRPC, 2008). Long Lake is fed by Pattison Lake and drains via Woodland Creek to Henderson Inlet.

Streams

One tributary drains into Long Lake. A ditch was constructed between Pattison Lake and Long Lake many years ago to float logs to Long Lake; this ditch still connects the two lakes and drains north into Long Lake (TRPC, 2008).

Long Lake is part of a four-lake system connected by extensive wetland habitat, forming a horseshoe-shaped chain at the head of Woodland Creek. Hicks Lake flows south into Pattison Lake, and then north into Long Lake. All three lakes are at approximately the same elevation (160 feet). Long Lake drains northwest into Lake Lois, which lies at a slightly lower elevation. Lake Lois discharges into Woodland Creek, which then flows north into Henderson Inlet (TRPC, 2008).

Wetlands

Wetland habitat around Long Lake is dominated by shrub vegetation, which is largely concentrated along the riparian corridor linking Long Lake and Pattison Lake. The wetland areas located between Pattison Lake and Long Lake comprise the second largest wetland system in the City of Lacey. The area extending from Pattison Lake to Mullen Road is a large forested wetland. The area north of Mullen Road and the BNSF railroad is dominated by shrub vegetation with surrounding patches of emergent and native forested wetlands. A small patch of aquatic bed wetland habitat is located at the southwest corner of Long Lake. The east and west shorelines of the lake contain a few, small, isolated patches of shrub and emergent wetlands. The northern extent of the lake contains an aquatic bed wetland that is over 20 acres in size. The associated wetlands located north of the lake are dominated by shrub vegetation with some patches of forest and emergent wetland vegetation along the perimeter (TRPC, 2008).

Table 4-29. Wetland habitat and area by shoreline reach – Long Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
LONG-3	PEM	1.3	South end of Long Lake
	PFO	8.4	Southeast corner of Long Lake
	PSS	48.4	S. end of Long Lake to Mullen Road
LONG-6	PEM	6.2	North end of Long Lake near outlet channel
	PSS	8.6	North end of Long Lake

A recent study was conducted to field verify the OWHM at the north end of Long Lake and determine whether the Long Lake North SMA jurisdiction extended north to include Long Pond. The study concluded that the OHWM extended throughout shrub and emergent wetland areas, encompassing a total area of approximately 330.4 acres below the OHWM. The railroad dividing Long Lake North from Long Pond (to the north) was determined to provide a significant break in hydrology and a sustained unidirectional flow (from south to north). Therefore, the northern limit for SMA jurisdiction was established at the railroad embankment for Long Lake North (Shanewise, 2008).

4.4.11.2 Geologic and Flood Hazard Areas

Long Lake and the surrounding ponds all are located in the floodplain and may be affected by flooding during large storm events. Shoreline properties in particular may be affected by flood events. There are no documented landslide hazard areas for the Long Lake area (TRPC, 2008).

4.4.11.3 Biological Resources

Critical or Priority Habitat and Species Use

Long Lake is considered a Habitat Conservation Area because it is located in part of the Lacey Lakes Watershed. Another priority habitat associated with Long Lake includes a riparian corridor linking Lake Louise and Woodland Creek via associated wetlands north of Long Lake and a ditch. Limited riparian habitat is also present along non-wetland shorelines of Long Lake (TRPC, 2008).

The south basin of Long Lake provides habitat for bald eagles, likely due to waterfowl use of the lake. Wood ducks are located in the associated wetlands located north of Long Lake. There is no documented use of the lake by sensitive fish species. Several game fish species are present in the lake, however, including trout varieties, spiny rays, largemouth bass, rock bass, and warmouth bass (TRPC, 2008).

Instream and Riparian Habitats

Riparian forest cover is limited on the east and west sides of Long Lake due to moderate density urban development. The northeast area of the lake and portions of the east and west sides of the lake contain a mixture of coniferous and deciduous forest, shrubs, and grasses. The south end of the lake contains wetland habitat dominated by a mixed forest canopy (TRPC, 2008).

Shoreline modifications along the lake include moderate density residential development, including 245 associated private docks; five additional, larger docks and a boat ramp and walking trails. In addition, the Lacey Community Center and public docks have been constructed at Longs Pond and there is a public float at Long Lake Park. Recreational activities include swimming at Long Lake Park, youth fishing at the Lacey Community Center (Longs Pond), and boat access at a WDFW boat launch. Several local roads provide access to all sides of Long Lake and a railroad lies to the southeast of the lake. In addition, the Thurston County Fairgrounds are located between Hicks Lake and Long Lake, although the property boundaries do not extend to the shoreline of either lake (TRPC, 2008).

4.4.11.4 Water Quality

Long Lake is on the 303(d) list of impaired waterbodies for total phosphorus. Sampling conducted in 1997 by Ecology indicates that the lake is likely eutrophic based on algal blooms and low dissolved oxygen in the late summer months. According to Thurston County (2006), Long Lake has fair water quality. The lake experiences blue-green algae blooms and many areas of the lake are dominated by emergent plants that interfere with recreational uses.

The Long Lake Steering Committee is implementing the Long Lake Integrated Management Plan to accomplish: monitoring and management of recurring water milfoil, promoting best management practices, and conducting water quality monitoring.

4.4.11.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Long Lake and Goose Pond (Long Lake) are comprised of two basins (North and South) and have been broken into 6 reaches (LONG_1 through -6) for this analysis. The lake's shoreline is also with both the jurisdictions of Olympia and Lacey.

The lake's shoreline is highly urbanized. Land use is a predominantly low-and moderate-density residential, interspersed with parks, opens space, and vacant lands. In addition to the lakes' immediate shoreline, the shoreline planning area includes the large wetland complex at the south end of the lake (LONG-3). Land use in this area includes a relatively large area (15 acres; approximately 21 percent of the reach area) classified as undeveloped government land [is there any additional information on this property?]. An area with industrial uses is located along the northeast corner of the North Basin with in Lacey (LONG-6). Percentages of major land uses in each of the six shoreline reaches are shown in Table 4-30.

Rights-of-way comprise a relatively small portion of the lake's shoreline area (6 percent). Roads include local and residential streets that pass through the shoreline planning area. One of these, Holmes Island Rd SE, is a bridge to Holmes Island (Long-5). Two railroads are located both north and south of the lakes. Neither appears to be within the shoreline planning area. A railroad to the east has been converted to a trail east of Woodland Creek. There are no water-dependent or –related uses on the lake

Future Land Use and Environment Designation

The future land use pattern is not expected to change from the existing pattern. Residential redevelopment may occur within the shoreline, but the density is unlikely to change. Long Lake is designated Rural under the current SMP. The associated wetlands at the south end of the lake are designated Conservancy.

Shoreline Modification

There are 245 private docks on the lake (occurring in all reaches except LONG-6). There are five larger docks and a boat ramp in LONG-5. The shoreline has also been modified to accommodate the bridge to Holmes Island. Data on shoreline armoring is not available.

Existing and Potential Public Access Areas

Long Lake Park (LONG-5) provides public access to the lake. There is also a WDFW boat launch south of the park (LONG-5). The Lacey community Center, located in LONG-6 also aoofer access to the lake shoreline. There are four additional sites along the lake that are categorized as parks, preserves or open space, which may offer public access to the lake.

Historic and Cultural Resources

There are two properties on Long Lake that are on the Local Historic Register. These are lkner/Kolze house and the Holmes Island Water Tower.

Hazardous or Toxic Materials

Elevated nitrate levels are found both north (LONG-5 and -6) and south (LONG-4, -3, and -2) of Long Lake.

4.4.11.6 Reach Scale Assessment

Long Lake is represented by six reaches, labeled LONG-1 through LONG-6. These reaches extend from the residential area in the north basin of the lake, around the shoreline, to the wetland and outlet channel in the north basin. Residential redevelopment may occur along the Long Lake shoreline but density is not anticipated to change (TRPC, 2008).

Table 4-30. Shoreline reach-scale assessment – Long Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
LONG-1	Residential area in north basin	0.9	SFR (55%) MFR (16%) PPOS (24%)		Riparian cover is somewhat limited with some mixed coniferous and deciduous forest.
LONG-2	Residential area in south basin	1.2	SFR (80%) PPOS (11%)		Riparian cover is somewhat limited with some mixed coniferous and deciduous forest.
LONG-3	Residential, wetland area, and inlet channel/ditch in south basin	1.0	SFR (19%) PPOS (36%) Vacant (19%) Gov/Inst (21%)	Extensive wetlands to the south	Mixed coniferous and deciduous forest and shrub cover.
LONG-4	Residential area in south basin	0.8	SFR (70%) Vacant (11%)		Riparian forest cover is limited.
LONG-5	Residential area in north basin	2.9	SFR (78%) PPOS (8%)	Boat launch	Riparian forest cover is limited.
LONG-6	Wetland and outlet channel in north basin	1.0	SFR (20%) Com/Ind (26%) PPOS (37%)	Wetland connection to Goose Lake	Shrub vegetation with mixed forest cover.
* Includes Government/Institutional and Undeveloped Government					

4.4.12 Pattison Lake

4.4.12.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Pattison Lake is located in the southeast City of Lacey and Lacey UGA and is divided into a North Basin and South Basin. The lake is located in the Woodland basin within the Henderson Inlet Watershed (WRIA 13) and is approximately 272 acres in size including associated wetlands. Pattison Lake itself is approximately 81 acres of open water. Mean depth in the North Basin is 14 feet and maximum depth is 22 feet. In the South Basin, mean depth is 13 feet and maximum depth is 19 feet. Elevation at Pattison Lake is approximately 157 feet and topography around the lake is characterized by moderately sloping terrain (TRPC, 2008).

Streams

One tributary discharges into Pattison Lake, which flows as a drainage from Hicks Lake (located to the north) (TRPC, 2008).

Pattison Lake is part of a four lake system connected by extensive wetlands that form a horseshoe-shaped chain at the head of Woodland Creek. Hicks Lake flows south into Pattison Lake and then north into Long Lake. A ditch was constructed between Pattison Lake and Long Lake many years ago to float logs north into Long Lake. This ditch still connects the two lakes. All three lakes listed above (Hicks, Pattison, and Long) are at approximately the same elevation (160 feet). Long Lake drains north into Lake Lois, which lies at a somewhat lower elevation. Lake Lois flows into Woodland Creek, which eventually flows into Henderson Inlet (TRPC, 2008).

Wetlands

Wetland habitat along Pattison Lake is generally located along the dike separating the two basins and along the undeveloped portion of the east shoreline. These areas are dominated by emergent and forested wetlands, respectively. Small emergent and shrug wetlands are located along the perimeter of the BNSF railroad that bisects the North Basin and South Basin of the lake. A mixed forested and shrub wetland is located in the southwest corner of the South Basin. This wetland surrounds a native forest patch that contains acidic organic soils. The associated wetlands between Pattison Lake and Long Lake are dominated by shrub vegetation and contain some patches of forest and emergent vegetation along the perimeter. Approximately 272 acres of Pattison Lake occur below the OHWM (TRPC, 2008).

Table 4-31. Wetland habitat and area by shoreline reach – Pattison Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
PAT-1	PEM	78.2	Dike separating North Basin and South Basin
	PFO	1.4	Southeast corner of North Basin
PAT-3	PFO	23.1	Southeast side of South Basin
	PSS	10.2	Southeast shoreline of South Basin
PAT-4	PFO	50.1	Northeast corner of South Basin

4.4.12.2 Geologic and Flood Hazard Areas

Pattison Lake is located in the 100-year floodplain. As such, the lake may be subject to flooding during large storm events. In addition, blockages in the north outlet channel in previous years have resulted in high lake water levels, dock flooding, and flooding of shoreline properties (TRPC, 2008).

4.4.12.3 Biological Resources

Critical or Priority Habitat and Species Use

Pattison Lake is located in the Lacey Lakes Watershed and is therefore considered a Habitat Conservation Area. Other priority habitats include the riparian corridor linking Pattison Lake and Long Lake via the associated wetland and drainage ditch; and areas of limited riparian habitat located along non-wetland shorelines of Pattison Lake (TRPC, 2008).

Sensitive species associated with Pattison Lake include bald eagles, which are located in the Woodland basin. The South Basin provides habitat for bald eagles, likely due to waterfowl use of Pattison Lake. In addition, wood ducks have been documented at the associated wetlands to the north of Pattison Lake. There are no sensitive fish species documented for Pattison Lake. However, the following game fish are present: brown trout, rainbow trout (stock), largemouth bass, rock bass, perch, and crappies (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation surrounding Pattison Lake is generally confined to the southeast area of the lake. These areas are dominated by mixed coniferous and deciduous forest and shrub vegetation. Remaining areas have been developed with moderate density urban land use and are associated with shrubs and maintained grass lawns (TRPC, 2008).

The lake water level has risen in past years due to blockages in the outlet channel. This has led to flooding of docks and shoreline yard areas. Algal blooms have also occurred, presenting water quality issues in the lake, particularly in the South Basin (TRPC, 2008).

The north and west shoreline areas of Pattison Lake have been modified for residential development, including 143 private docks. A railroad that was constructed along a dike crosses the lake, dividing the lake into the North and South basins. A WDFW boat launch on the lake provides access for boats but no other recreational activities are documented for Pattison Lake. Several major (Mullen Road to the north and Yelm Highway to the south) and local roads provide access to the lake.

4.4.12.4 Water Quality

Pattison Lake is listed as Category 5 303(d) impaired waterbody for total phosphorus. In 1997, the lake was assessed as eutrophic by Ecology staff due to water clarity readings and severely depleted dissolved oxygen. A great deal of algal and macrophytes were observed. Water testing on North Pattison Lake indicates that water clarity has improved over time.

According to testing by Thurston County Health Department, general water quality in Pattison Lake is good to fair (2006). The lake experiences algae blooms and aquatic plant growth has impaired water clarity interfering with fishing and boating activities in the south basin.

4.4.12.5 Land Use and Built Environment

Existing Land use and Shoreline Use

Pattison Lake has been broken into 4 reaches (PAT-1 through -4) for this analysis. The Lake is divided into two basins (North and South) by a BNSF railroad. The Pattison Lake shoreline planning area is highly urbanized. Land use is nearly all low-and moderate-density residential (50 percent of reach area) interspersed with opens space and vacant lands. Percentages of major land uses in each of the shoreline reaches are shown in Table 4-32.

Numerous local and residential streets pass through the shoreline planning area. Rights-of-way make up approximately 9 percent of the entire shoreline area. Roads are most numerous in Reach PAT-3, where they comprise 15 percent of the shoreline area. A BNFS railroad passes through the lake splitting it into two basins. There are no water-oriented uses in the shoreline.

Future Land Use and Environment Designation

The future land use pattern is not expected to change from the existing pattern. Residential redevelopment may occur within the shoreline, but the general density is unlikely to change. Some moderate density residential development north of the lake and moderate density residential development in vacant areas east of the lake are anticipated. Pattison Lake is designated Rural under the current SMP. The associated wetlands at the south of the railroad and at the south end of the lake are designated Conservancy.

Shoreline Modification

Shoreline modifications include the railroad, which lies on a dike that crosses the lake. There are 143 private docks on the lake. There is also a boat launch on the east side of the lake. Data on shoreline armoring is not available.

Existing and Potential Public Access Areas

Public access to Pattison Lake is limited. There are four sites on the lake that are categorized as parks, preserves or open space, which may offer public access to the lake. At one of these sites (PAT-4) there is a WDFW boat launch.

Hazardous or Toxic Materials

The Pattison Lake EDB located in PAT-2 is listed on Ecology's confirmed and suspected contaminated sites list. Pesticides are confirmed in the soil, groundwater and surface water. The site has undergone remediation and is monitored. The west side of the lake is within an area contaminated by pesticides. The Lake is also fully contained in an area of elevated nitrate levels.

4.4.12.6 Reach Scale Assessment

Pattison Lake is represented by four reaches for this assessment. These reaches are labeled PAT-1 through PAT-4 and extend counter-clockwise from the residential area north of Mullen Road to the outlet located directly south of Mullen Road.

Table 4-32. Shoreline reach-scale assessment – Pattison Lake

Reach Number	Reach Location	Reach Length (miles)	Major Land Uses (% of reach area)	Unique Features	Riparian Zones
PAT-1	Residential area north of road crossing	1.6	SFR (74%)	Connection to Hicks Lake	Riparian forested cover is limited.
PAT-2	Residential area in southwest portion	1.2	SFR (84%)		Riparian forested cover is somewhat limited; shrub cover dominant.
PAT-3	Less developed and wetland area	0.5	SFR (25%) PPOS (61%) Vacant (14%)	Wetlands to the east of lake	Mixed coniferous and deciduous forest.
PAT-4	Mix of residential and wetland area, including outlet	1.1	SFR (38%) Gov/Inst (9%) Vacant (44%)	Wetlands to north of lake	Mixed coniferous and deciduous forest and shrub cover.

4.4.13 Southwick Lake

4.4.13.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Southwick Lake is located in the south portion of the City of Lacey and is under the City of Lacey and Lacey UGA SMA jurisdiction. The lake is west of Pattison Lake and lies in the Woodland basin, which is part of the Henderson Inlet Watershed (WRIA 13). Total lake area is approximately 36 acres, mean depth is 7 feet, and maximum depth reaches 17 feet. The terrain around Southwick Lake is moderately flat and the elevation at the lake is about 172 feet (TRPC, 2008).

Streams

There are no apparent tributaries (inlets) or outlets associated with Southwick Lake; it is a small kettle lake surrounded by public parks and a school (Timberline High School) (TRPC, 2008).

Wetlands

Wetland habitat at Southwick Lake is dominated by a lacustrine open water wetland associated with small areas of vegetated shoreline. The largest emergent wetland is located along Ruddell Road. This wetland contains some areas of emergent habitat along the west and north shorelines. The total area of Southwick Lake occurring below the OHWM is approximately 36 acres.

Table 4-33. Wetland habitat and area by shoreline reach – Southwick Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
SOUTH-1	LOW	27.2	Open water associated with vegetated shoreline
	PEM	8.8	Southwest side of lake

4.4.13.2 Geologic and Flood Hazard Areas

Southwick Lake is located in the 100-year floodplain. This waterbody may be subject to high lake levels during large storm events and adjacent structures may be affected by flooding. There are no documented landslide hazard areas for this area (TRPC, 2008).

4.4.13.3 Biological Resources

Critical or Priority Habitat and Species Use

Priority habitat in the Southwick Lake area includes limited riparian habitat along non-wetland shorelines of the lake. Wood ducks are located in the Woodland basin. There is no documented us of the Southwick Lake area by sensitive or game fish species (TRPC, 2008).

Instream and Riparian Habitats

Riparian vegetation surrounding Southwick Lake includes mixed coniferous / deciduous forest and shrubs. Riparian habitat is limited on the west and south sides of the lake due to moderate density urban development (including Puget Sound High School). High density development (including Timberline High School and Lakes Elementary School) is located east of the lake.

Shoreline modification along Southwick Lake has been minimal. One dock has been noted along the shoreline and Ruddell Road forms a portion of the west shoreline (providing lake access). Mullen Road, located north of the lake, also provides lake access (TRPC, 2008).

4.4.13.4 Water Quality

Southwick Lake is not listed as a Category 4 or 5 303(d) impaired waterbody according to Washington Department of Ecology. The lake is on the Category 2 list for total phosphorus.

4.4.13.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Southwick Lake shoreline planning area is highly urbanized. The current land use pattern in the lake's shoreline is a mix of low- and moderate density residential (38 percent), government/institution (9 percent), open space (18 percent) and vacant lands (11 percent). Portions of two high schools (Timberline and Puget Sound) are located within the shoreline. Ruddell Rd. to the west passes through the shoreline planning area. Other roads in the planning area are local residential roads. Rights-of-way comprise approximately six percent of the shoreline area. There are no water-oriented uses in the Southwick Lake shoreline planning area.

Future Land Use and Environment Designation

Land use in the Southwick Lake shoreline is not anticipated to change from the existing pattern. Moderate density residential development is likely in the lake vicinity. Under the current SMP, the Southwick Lake shoreline is designated as Conservancy.

Shoreline Modification

There is little apparent modification to the shoreline. Ruddel Rd. forms part of the shoreline.

Existing and Potential Public Access Areas

Public access to Southwick Lake is limited. Most of the lake shoreline is under private ownership. The schools are potential public access sites. In additional, there are three other sites on the lake which are subdivision open spaces, which represent potential future access sites.

4.4.13.6 Reach Scale Assessment

Southwick Lake is presented as one reach, labeled SOUTH-1. This reach extends around the perimeter of the lake.

4.4.14 Trosper Lake

4.4.14.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Trosper Lake is located in central Tumwater, southwest of Barnes Lake. Trosper Lake is in the Percival Creek basin which lies in the Budd/Deschutes Watershed (WRIA 13). The lake encompasses 17 acres, has an elevation of 160 feet, and is surrounded by generally even terrain. Mean and maximum depths for the lake are not available (TRPC, 2008).

Streams

There are no tributaries flowing into Trosper Lake. However, Trosper Lake forms the headwaters for the Percival Creek basin and the lake flows to the north through an outlet to Percival Creek (TRPC, 2008).

Wetlands

Trosper Lake wetland habitat is dominated by a combination of lacustrine open water and shrub wetlands. The open water of the lake is surrounded by large emergent and shrub habitats to the west and north of the lake. A combined shrub and forested wetland is located northeast of the wetland. The total area of the lake occurring below the OHWM is approximately 43.4 acres.

Table 4-34. Wetland habitat and area by shoreline reach – Trosper Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
TROS-1	LOW	18.2	Open water
	PEM	7.7	West and north shoreline
	PFO	2.8	NE corner of lake
	POW	0.4	NE corner of lake
	PSS	18.4	NW and NE lake shoreline

4.4.14.2 Geologic and Flood Hazard Areas

Trosper Lake is located in the 100-year floodplain. The lake may be subject to high water levels during large storm events and shorefront properties may be affected by flooding. No landslide hazard areas have been identified for the Trosper Lake vicinity (TRPC, 2008).

4.4.14.3 Biological Resources

Critical or Priority Habitat and Species Use

Trosper Lake is associated with two Habitat Conservation Areas. Trosper Lake forms the headwaters of Percival Creek and also establishes one end of a riparian corridor linking Trosper Lake to Capitol Lake (TRPC, 2008).

The lake provides habitat for wood duck and documented presence of osprey has been recorded in the Percival Creek basin. There are no sensitive or game fish species listed for Trosper Lake (TRPC, 2008).

Instream and Riparian Habitats

The majority of the Trosper Lake shoreline is dominated by a combination of coniferous and deciduous forest and shrub vegetation. Some moderate density development is present along the east and southeast shoreline; these areas are associated with shrubs and maintained lawns (TRPB, 2008).

Little modification has occurred along the north shoreline of Trosper Lake. Several single-family homes are interspersed along the south shoreline and include landscaped yards and a total of 11 private docks. Road access to the lake is limited. Major powerlines cross directly over the lake. No recreational activities are noted for this lake (TRPC, 2008).

4.4.14.4 Water Quality

Trosper Lake is not listed as a Category 4 or 5 303(d) impaired waterbody according to Washington Department of Ecology. The lake is on the Category 2 list for total phosphorus. Trosper Lake is the headwaters to Percival Creek which met all water quality standards in 2005 (Thurston County, 2006).

4.4.14.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The Trosper Lake shoreline jurisdiction is split between the City of Tumwater and Thurston County. Most of the lake’s shoreline is located in an unincorporated island of Thurston County and is outside Tumwater’s shoreline jurisdiction. Existing land use in the Tumwater shoreline area is primarily a mix of residential (mostly low-density) (48 percent), open space (16 percent) and commercial (19 percent) use.

Roads in the planning area include only local access roads; they comprise approximately six percent of the shoreline area. There are no water-oriented uses in the Trosper Lake shoreline planning area.

Future Land Use and Environment Designation

The future land use pattern in the Trosper Lake shoreline is not anticipated to differ from the existing land use pattern. Future land use in the shoreline planning is expected to be a mix of residential and open space. Under the current SMP, the Trosper Lake shoreline is designated as Conservancy.

Shoreline Modification

There is little apparent modification to the shoreline to the north. The shoreline to south is modified by single-family homes lawns and 11 docks.

Existing and Potential Public Access Areas

Most of the City's lake shoreline is under private ownership. The planned Trosper Lake Park will offer public access to the lake's eastern shoreline. The park is located immediately north of Tumwater Middle School and for the most part outside of the shoreline area. A small corridor from the park will provide access to the lake. A large private open space is located along the western lake shore. This area may represent a future opportunity for public access.

4.4.14.6 Reach Scale Assessment

Trosper Lake is represented by one reach, identified as TROS-1, which extends around the perimeter of the lake shoreline. Future land use at Trosper Lake includes a moderate density subdivision located at the northwest corner of the lake (TRPC, 2008).

4.4.15 Ward Lake

4.4.15.1 Drainage Basin, Streams and Wetlands

Drainage Basin

Ward Lake is located in southwest Olympia and is under the City of Olympia and Olympia UGA SMA jurisdiction. This lake encompasses 66 acres, has a mean depth of 33 feet, and reaches a maximum depth of 67 feet. This lake is situated immediately north of Hewitt Lake, a similar deep kettle lake. Topography surrounding the lake is moderately steep and elevation at the lake is approximately 126 feet (TRPC, 2008).

Streams

Ward Lake is a kettle lake and therefore has no surface inlets or outlets (Thurston County, 2006). The lake is spring-fed and occupies a closed pothole. Lake water levels correspond to flow from springs and from precipitation (TRPC, 2008).

Wetlands

Wetland habitat at Ward Lake is dominated by lacustrine open water areas. In addition, a large forested wetland is located at the southeast corner of the lake and is likely associated with Ward Lake Park. Approximately 65.7 acres of Ward Lake are located below the OHWM.

Table 4-35. Wetland habitat and area by shoreline reach – Ward Lake

Reach Number	Wetland Habitat Type	Total Wetland Acres	Approximate Location
WARD-1	LOW	65.7	Open water area
	PFO	6.1	SE corner of lake (Ward Lake Park)
	PSS	1.5	South and west lake shoreline near Henderson Road Neighborhood Park

4.4.15.2 Geologic and Flood Hazard Areas

Ward Lake is located within the 100-year floodplain. Lake water levels may become elevated during large storm events due to the lack of outlets. Shoreline properties and associated landscaped areas may be affected by flooding. Landslide hazard areas associated with Ward Lake include steep slopes, which occur along the west, north, and east shorelines of the lake.

4.4.15.3 Biological Resources

Critical or Priority Habitat and Species Use

There are no priority habitats or sensitive fish or wildlife species documented at Ward Lake. Several game fish are present, however, including rainbow trout, Kokanee, largemouth bass, and bluegill (TRPC, 2008).

Instream and Riparian Habitats

A narrow band of riparian vegetation lines the shoreline of Ward Lake. This is dominated by mixed coniferous and deciduous forest, shrubs, and maintained lawns. A large portion of the north, east, and south shorelines have been developed to accommodate single-family homes with landscaped yards and 48 private docks. Swimming and boating activities are permitted on the lake, although Ward Lake Park swimming facilities have not yet been constructed. One WDFW boat ramp provides public boat access to the lake (TRPC, 2008).

Ward Lake is located in a rapidly developing area of the City of Olympia and Olympia UGA. Stormwater runoff flowing directly into Ward Lake from high density residential areas has occurred in at least three locations. A planned urban village is currently under development on the west side of the lake that historically served as a landscape plant nursery. Spills and storm-related sewage spills flowing into Ward Lake have been documented in the past (TRPC, 2008).

4.4.15.4 Water Quality

Ward Lake water quality was monitored from 1992 through the spring of 1993 by Thurston County Storm and Surface Water Program (1995). This monitoring was part of the Chambers/Ward/Hewitt Comprehensive Drainage Basin Plan (see Thurston County Water and Wastewater, Water Resource Program web page for the link to the 1995 document: http://www.co.thurston.wa.us/stormwater/Water_Resources/Basin%20Plans/Chambers/Chambers.htm).

The lake met water quality standards for all conventional water quality parameters. Water temperatures measured in Ward Lake indicate that although surface temperatures were at a high of 23 degrees Celsius, the bottom of this deep lake remained at 7 degrees C. Ward Lake was considered a mesotrophic lake based upon lake clarity and phytoplankton measured. Ward Lake sediments were high for arsenic (above the severe health effects criteria) and contained the highest levels of cadmium, chromium, copper and nickel of any of the lakes in the basin (Thurston County Storm and Surface Water Program, 1995).

Ward Lake has low levels of nutrients and its water quality is considered excellent to good (Thurston County, 2006). However the lake is on the DOE 303(d) list of impaired waterbodies for PCB contamination of fish.

4.4.15.5 Land Use and Built Environment

Existing Land use and Shoreline Use

The current land use pattern in the Ward Lake shoreline is predominantly residential (low-and moderate-density) (57 percent). There are also smaller areas of parks and open space (15 percent), natural resource lands (15 percent) and vacant land (8 percent) within the shoreline area.

Henderson Blvd SE, to the west, passes within the shoreline planning area. Other roads in the shoreline are limited to local access roads. Rights-of-way comprise approximately six percent of the shoreline area. There are no water-dependent or –related uses in the Ward Lake shoreline planning area. The currently undeveloped Ward Lake Park at the south end of the lake would be considered a water-enjoyment use.

Future Land Use and Environment Designation

Land use in the Ward Lake shoreline is expected to change in the future. Most of the lake shoreline will remain residential; although vacant land will likely develop to moderate-densities. Along the west shoreline, an urban village is being developed. The development extends from the shoreline west to the City of Olympia boundary. The urban village is under application for 810 moderate-density residential units. The lake shoreline is designated as Rural in the current SMP.

Shoreline Modification

The lake shoreline is largely modified by single-family homes with lawns. There are approximately 48 private docks on the lake. There is also one boat ramp along the east shore.

Existing and Potential Public Access Areas

Much of the lake shoreline is under private ownership. Ward Lake Park (not yet constructed) offers public access to the lake shoreline. Once completed, the city park will include a swimming beach and other amenities. There are several other privet open space sites in the shoreline that could represent opportunities for public access in the future.

4.4.15.6 Reach Scale Assessment

Ward Lake is represented by one reach, designated WARD-1. This reach includes the entire shoreline of the lake.

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5.0 SUMMARY OF ISSUES AND RESTORATION OPPORTUNITIES

The shorelines of Lacey, Olympia and Tumwater are an important natural feature of the South Puget Sound area. Processes occurring at the watershed or landscape scale have affected the functions of shorelines in the South Puget Sound region over time. Development and urbanization can alter natural processes which maintain shoreline functions such as fish and wildlife habitat. Restoration of degraded shorelines (and restoring the processes which allow for natural shoreline function) is a required piece of the 2003 Ecology shoreline guidelines. This chapter outlines a summary of the shoreline functions and issues in the Cities of Lacey, Olympia and Tumwater, and provides an overview of restoration opportunities in the region. A more detailed analysis of restoration opportunities and planning will be undertaken by the Thurston Regional Planning Council during later phases of the SMP update process.

A number of shoreline restoration projects are currently underway or are in the planning stages in Lacey, Olympia and Tumwater. These projects have been initiated by various private, regional, state and federal entities, resulting in several successful shoreline restoration and enhancement projects.

Applying the watershed approach, key ecological functions have been identified that would benefit from special focus under the Shoreline Master Programs developed for each of the three cities. These functions are summarized in tables below, along with discussion of the overall level of historical alteration when compared to the pre-disturbance condition. General restoration opportunities to address the current impairment of shoreline functions, and the relative potential for restoration success, are also described.

Along with these summary tables, both programmatic and specific restoration actions are generally identified. These actions have been developed as part of other regional planning efforts, specifically through the Natural Resource Damage Assessment process for cleanup in Budd Inlet. These potential actions can be considered in the context of conditions and opportunities within individual shoreline reaches in each city. Shoreline reach summaries are provided, which identify key shoreline management issues and restoration potential.

5.1 Nearshore / Marine Environment

The following table (Table 5-1) summarizes the status of the Nearshore / Marine Planning Area and describes the shoreline functions, the level of alteration compared to historical condition, and the restoration opportunities to improve shoreline functions. This section addresses functions pertains to two shoreline planning areas: 1) Budd Inlet and 2) Nisqually Reach.

5.1.1 Status of Shoreline Functions Summary Table

Table 5-1. Assessment of Nearshore/Marine Functions within Lacey and Olympia

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Habitat: Estuarine habitat; subtidal and intertidal mudflats and salt marshes provide transition habitat between fresh and salt water environments	**High to Moderate** Physical modifications to Budd Inlet have changed the spatial mixing of fresh and salt water. The installation of roads, docks, and bulkheads has tended to disconnect freshwater seeps and wetlands from marine waters.	**Moderate to Low** The extent of physical modifications to the system has been substantial enough to preclude straightforward restoration measures to achieve pre-disturbance levels of ecosystem functioning. There is the potential to better connect freshwater seeps and wetlands to the marine shoreline, as part of shoreline rehabilitation projects. Inclusion of provisions in the updated shoreline program to provide such connections where seeps or wetlands are present will improve the habitat function as redevelopment occurs over time.
Hydrology: Attenuation of wave energy	**High** The general trend toward a 'harder' shoreline (e.g., bulkheads, revetments, docks, etc.) has resulted in less overall wave attenuation than in the pre-disturbance condition.	**Moderate** Encouraging the use of soft-armoring techniques and support of estuarine wetland restoration efforts can improve wave energy attenuation within the City's nearshore over time. Inclusion of a preference for soft-armoring in the updated shoreline program will encourage this transition.
Sediment Generation and Transport: Sediment delivery from coastal bluffs and streams	**Moderate** Bluff erosion processes have been modified as structures (e.g. roads, railroads, piers and docks, bulkheads) at the toe have reduced the frequency of tidal and wave interaction with the bluff. The lack of interaction at the toe has likely reduced smaller-scale erosion throughout the city. However, larger-scale erosion events (e.g., landslides due to seismic events) still have the potential to contribute significant quantities of sediment to the nearshore.	**Moderate** Maintenance of existing connections between bluffs and the nearshore is a high priority. Maintenance of the existing connections between stream mouths and the nearshore, for sediment delivery and other habitat benefits, is also a high priority. Reconnection of feeder bluff function to support nearshore processes is more difficult and expensive where the existing infrastructure protects public and private property, or where the existing infrastructure itself disconnects the bluffs from the nearshore (for example, railroad tracks and highways). The Restoration Plan may consider identifying and prioritizing individual projects to reconnect feeder bluffs to the nearshore.

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Water Quality: Wetland removal of pollutants through sedimentation and adsorption	**Moderate** Reduction in wetland area has reduced contact time of water with soil. This lowers the potential for filtering and cycling of pollutants, which adhere to soil particles.	**Moderate** Restoration of Capitol Lake and the natural processes at the mouth of the Deschutes River may provide opportunities to restore estuarine wetlands.
Water Quality: Delivery, movement, and loss or removal of nutrients, pathogens, and toxicants; storage of phosphorus and removal of nitrogen and toxins through sedimentation and adsorption.	**High** The delivery, transport, and disposition of nutrients, pathogens, and toxins have been significantly altered from the pre-disturbance condition. Upland sources of these pollutants have increased significantly as a result of urban and industrial land uses within and near the shoreline. Potential storage has decreased through wetland loss and installation of impervious surfaces.	**Moderate** Significant source control and remediation efforts are currently underway to remove and avoid pollutant discharge to the nearshore. These efforts will involve control of non-point source pollutants following TMDL studies. Use of low impact development and other water quality improvement techniques, both within the shoreline area and upland, will decrease pollutant loading from stormwater sources over time.
Habitat: Shoreline habitat for wildlife; vegetation provides structure for invertebrates, birds, amphibians, reptiles, and mammals.	**Moderate** While plant communities along the shoreline have been subjected to several phases of disturbance, they have recovered along the many areas of the shoreline.	**Moderate to Low** The presence of significant infrastructure such as roads and railroads limits the potential to recover this function. Opportunities include the inclusion of new measures in the updates shoreline program to include habitat features as redevelopment projects occur, and inclusion in the Restoration Plan of a process to identify and prioritize individual projects to expand shoreline habitat.
Habitat: Source and delivery of LWD	**High** Removal of mature trees from riparian areas, and from surrounding bluffs has significantly reduced the source of LWD to the nearshore system.	**Moderate** The source of LWD exists; however, restoring the connectivity between the bluff/forest system and the nearshore would require removal or modification to existing infrastructure (e.g., roads).

5.1.2 Key Management Issues

The key management issues within the South Puget Sound areas of Budd Inlet and Nisqually Reach include the following:

- Bluff erosion processes have been modified as hardened structures are built to protect the toe of the bluff. The lack of interaction at the toe has likely reduced small-scale erosion and contribution of sediments to the marine nearshore environment. Reconnection of the natural sediment supply through reconnection of landslides and bluff failures. Much of the marine shoreline is erosional due to sediment starvation.

- Nutrient input to the nearshore from upland sources and freshwater tributaries is contributing to the eutrophication of marine waters in the South Puget Sound. The flushing action and circulation of the South Puget Sound is slower than other parts of the Sound, resulting in sensitivity to nutrient loading.

- Removal of trees from the marine riparian areas and from surrounding bluffs and pocket estuaries has reduced the source and pathway of large woody debris to the nearshore environment. Portions of the marine nearshore are forested (i.e., Priest Point Park) whereas other areas lack forest cover.

- Alterations to the shoreline during development have reduced the extent of nearshore inwater habitats such as kelp and eelgrass beds in the intertidal areas. Kelp and eelgrass provide important habitat to forage fish and salmonids, including the Nisqually populations of Chinook salmon.

- Budd Inlet has reduced capacity as a natural estuary due to the construction of Capitol Lake and the historical alteration of the Deschutes River delta. More discussion regarding the Deschutes River estuary restoration is included in Section 5.2.

5.1.3 Restoration Opportunities

Restoration opportunities in the South Puget Sound have been identified in the Nearshore Sediment Survey conducted by Herrera (2005). High priority beaches for preservation and for restoration were identified.

- High priority preservation of Dewolf Bight, Butterball Cove and Mallard Cove in the Nisqually Reach.

- High priority restoration of Butler Cove and west side of West Bay shoreline.

- Removal of existing bulkheads and armoring to allow natural sediment processes.

- Preservation of unarmored shorelines to minimize further impacts to the South Puget Sound beach habitat.

The City of Olympia, Port of Olympia, Thurston County, LOTT Alliance and Washington State University are forming a partnership to develop an action plan for Budd Inlet restoration. This partnership formed in 2007 and is currently working on restoration opportunities in Budd Inlet.

5.2 Deschutes River System

5.2.1 Status of Deschutes River Functions Summary Table

This section summarizes the status of the Deschutes River Shoreline based upon the inventory information, and describes the shoreline functions, the level of alteration compared to historical condition, and the restoration opportunities to improve shoreline conditions (see Table 5-2). The Deschutes River system also includes, Percival Creek, and Black Lake Ditch as all important contributors to the river system and its health.

Table 5-2. Assessment of Deschutes River System Shoreline Functions

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Habitat: Estuarine habitat; subtidal and intertidal mudflats and salt marshes provide transition habitat between fresh and salt water environments	**High** Physical modifications to the Deschutes river delta have changed the spatial mixing of fresh and salt water. Construction of Capitol Lake has altered the river's estuary. Changes in flow regime due to upstream diversion and regulation, and changing land uses have modified timing and quantities of freshwater flows.	**Moderate to Low** The scope of the physical modifications to the system is significant enough to preclude straightforward restoration measures within in the city. Restoration projects to restore the Deschutes River estuary are being considered and have the potential to increase the area over which the fresh to salt water transition occurs.
Hydrology: Channel and floodplain connection	**High** The installation of dams and construction of Capitol Lake within the river's main channel has significantly reduced connections between the channel and the floodplain within the city.	**Low** The City's position at the lowest part of the watershed and the presence of the Port of Olympia combine to limit the potential for significant re-connection of channel and floodplain in this location.
Hydrology: Summer low flows	**High** Upstream land uses and development have resulted in less water flowing in the Deschutes and its tributaries during the summer low-flow periods.	**Moderate** The City of Olympia, Ecology and Thurston County have partnered to conduct the TMDL study on the Deschutes. Regional solutions to the low flow problem are required.

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Hydrology: Flood flow retention	**Moderate** As noted above, channel-floodplain interaction is modified, which has the potential to reduce flood flow retention. However, some areas of natural connection to the river floodplain exist.	**Low** The City's position at the lowest part of the watershed limits the potential to provide significant flood storage. The City could partner with regional watershed entities and Pierce County to address the flood storage issue.
Sediment Generation and Transport: Upland sediment generation	**Moderate to High** Fine sediment loading to Capitol Lake has increased due to build-up and wash-off from urban and industrial land uses. Sediment which historically was washed into the Budd Inlet at the river mouth is now captured in Capitol Lake, negatively affecting water quality and habitat.	**Moderate** Implementation and retrofit of water quality BMPs to the existing stormwater system can reduce fine sediment loading. Consideration of restoration of the Deschutes River Estuary or other options.
Water Quality: Wetland removal of pollutants through sedimentation and adsorption	**High** Reduction in wetland area and channel-floodplain connection has reduced water contact time of water with soil. This lowers the potential for filtering and cycling of pollutants.	**Moderate** Encouraging the restoration of riverine and other wetlands within the contributing basin can increase water contact time with soil.

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Water Quality: Delivery, movement, and loss or removal of nutrients, pathogens, and toxicants; storage of phosphorus and removal of nitrogen and toxins through sedimentation and adsorption.	**High** The delivery, transport, and disposition of nutrients, pathogens, and toxins have been significantly altered from the pre-disturbance condition. Upland sources of these pollutants have increased significantly as a result of urban and industrial land uses within and near the shoreline. Potential storage has decreased through wetland loss and installation of impervious surfaces. The development of the TDML for the Deschutes River has highlighted potential sources of point-source pollution and flow reduction.	**Moderate** Significant source control and remediation efforts are currently underway to remove and avoid pollutant discharge to the riverine environment. Restoration of riverine/estuarine wetlands can improve the system's ability to provide long-term storage of these pollutants.
Habitat: Shoreline habitat for wildlife; vegetation provides structure for invertebrates, birds, amphibians, reptiles, and mammals.	**Moderate** Native riparian vegetation has been removed during past river management projects. However, some sections of the river retain the natural riparian vegetation	**Moderate** Replanting and enhancement of riparian buffers and associated wetlands can increase habitat values for wildlife.
Habitat: Source and delivery of LWD	**High** Removal of mature trees from riparian areas, and removal from upstream bridges has significantly reduced the source of LWD to the Descutes River.	**Moderate** The potential to re-introduce LWD, either through planting or placement exists.

5.2.2 Key Management Issues

The key management issues for the Deschutes River system include the following:

- Reduction in wetland area in the basin has reduced water contact time with soil. This lowers the potential for filtering and reduces the removal of pollutants.
- The equation for excess nutrients, pathogens and toxins is significantly altered form the pre-disturbance condition. Sources of these pollutants are both point discharges (i.e., stormwater outfalls) and non-point discharges. Urban and industrial land uses have increased the sources of these pollutants, thereby worsening water quality in the Deschutes River, Capitol Lake, and Budd Inlet.
- Alteration to shorelines during urban development has reduced the extent of wetland and riparian habitat.
- Sediments from the Deschutes River settle in Capitol Lake and are unable to feed the estuary in Budd Inlet.

5.2.3 Restoration Opportunities for the Deschutes River System

Restoration planning is currently underway for the Deschutes River and will be coordinated with the Budd Inlet Restoration planning. A TMDL study is being undertaken by Ecology, Thurston County, and the Cities of Olympia and Tumwater. Restoration of the Deschutes River Estuary is one alternative being considered.

5.3 Woodland Creek System

5.3.1 Status of Woodland Creek Functions Summary Table

This section summarizes the status of the Woodland Creek Shorelines based upon the inventory information, and describes the shoreline functions, the level of alteration compared to historical condition, and the restoration opportunities to improve shoreline conditions (see Table 5-3). The Woodland Creek system includes Woodland Creek, Long Lake, Pattison Lake, and Hicks Lake as all important contributors to the river system and its health. Woodland Creek drains to Henderson Inlet, which lies within Thurston County Shoreline jurisdiction.

Table 5-3. Assessment of the Woodland Creek System Shoreline Functions

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Hydrology: Channel and floodplain connection	**High** Infrastructure such as railroad crossings and roads has significantly reduced connections between the Woodland creek channel and the floodplain. Furthermore, ditches and draining of wetlands have altered natural connections.	**Medium** In developed areas, floodplain connections will be difficult to restore. Existing floodplains and associated wetlands should be preserved.
Hydrology: Summer low flows	**High** Upstream land uses and development have resulted in less water flowing in urban streams such as Woodland Creek during the summer low-flow periods.	**High** Preservation of wetlands and headwater lakes will maintain base flows to Woodland creek. Use of stormwater management practices that encourage low impact development may minimize impervious surfaces in the basin.
Hydrology: Flood flow retention	**Moderate** As noted above, channel-floodplain interaction is modified, which has the potential to reduce flood flow retention. However, some areas of natural connection to the river floodplain exist.	**Low** Preservation of floodplain areas during development will assist in maintaining flow in the creek.
Sediment Generation and Transport: Upland sediment generation	**Moderate to High** Fine sediment loading has increased due to build-up and wash-off from urban and industrial land uses.	**Moderate** Implementation and retrofit of water quality BMPs to the existing stormwater system can reduce fine sediment loading.

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Water Quality: Wetland removal of pollutants through sedimentation and adsorption	**High** Reduction in wetland area and channel-floodplain connection has reduced water contact time of water with soil. This lowers the potential for filtering and cycling of pollutants.	**Moderate to High** Encouraging the restoration of riverine and other wetlands within the contributing basin can increase water contact time with soil.
Water Quality: Delivery, movement, and loss or removal of nutrients, pathogens, and toxicants; storage of phosphorus and removal of nitrogen and toxins through sedimentation and adsorption.	**High** The delivery, transport, and disposition of nutrients, pathogens, and toxins have been significantly altered from the pre-disturbance condition. Upland sources of these pollutants have increased significantly as a result of urban and industrial land uses within and near the shoreline. Potential storage has decreased through wetland loss and installation of impervious surfaces. The development of the TDML for Woodland Creek has highlighted potential sources of point-source pollution and flow reduction.	**Moderate** Significant source control and remediation efforts are currently underway to remove and avoid pollutant discharge to the riverine environment. Restoration of riverine/estuarine wetlands can improve the system's ability to provide long-term storage of these pollutants.
Habitat: Shoreline habitat for wildlife; vegetation provides structure for invertebrates, birds, amphibians, reptiles, and mammals.	**Moderate** Native riparian vegetation has been removed during past river management projects. However, some sections of the river retain the natural riparian vegetation	**Moderate** Replanting and enhancement of riparian buffers and associated wetlands can increase habitat values for wildlife.
Habitat: Source and delivery of LWD	**High** Removal of mature trees from riparian areas, and removal from upstream bridges has significantly reduced the source of LWD to the Descutes River.	**Moderate** The potential to re-introduce LWD, either through planting or placement exists.

5.3.2 Key Management Issues

The key management issues for Woodland Creek drainage system are the following:

- Increases in sediment, nutrients, pathogens and other pollutants have accelerated eutrophication of the lakes and reduced water quality in Woodland Creek. This has resulted in downstream impacts to Henderson Inlet, including shellfish closures. Fecal coliform is the main pollutant resulting from septic systems, urban runoff and/or agricultural sources.

- Increased sediments and nutrients in the lakes within this basin (Pattison, Southwick, Long, and Hicks) have encouraged growth of invasive aquatic plants and algae. Phosphorus loading is a problem, although water quality is improving on some lakes.

- Development has resulted in decreased riparian habitat along Woodland Creek and the lakes within its basin.

- Wetlands have been altered over time, reducing wetland habitats and connections with the creek and the lakes within the basin.

5.3.3 Restoration Opportunities for Woodland Creek

According to the Limiting factors analysis for WRIA 13 (Haring and Konovsky, 1999) for Woodland Creek, the following restoration opportunities exist:

- Take corrective action to improve water quality in the creek basin, specifically to control pollutants and sediment transport from urban runoff.

- Restore LWD to stream channels to improve in-stream habitat.

- Restore riparian habitat around lakes and creeks wherever feasible.

- Preserve and restore headwater wetlands so as to enhance habitat and protect water quality.

- Enhance fish passage by removing barriers.

In addition, Thurston County has initiated the Woodland Creek Pollutant Load Reduction project. Possible corrective actions noted to reduce pollution and restore Woodland Creek and the lakes within its basin included:

- Improving riparian vegetation;

- Improve septic systems and retrofit to improve water quality in basin;

- Encourage low impact development strategies to manage stormwater; and

- Review alternative stormwater conveyance systems.

5.4 Black and Capitol Lake Systems

5.4.1 Status of Black and Capitol Lakes Functions Summary Table

This section summarizes the status of the Black and Capitol Lake Shorelines based upon the inventory information, and describes the shoreline functions, the level of alteration compared to historical condition, and the restoration opportunities to improve shoreline conditions (see Table 5-4). Both Black and Capitol Lake drain to Budd Inlet. Black Lake is connected to Capitol Lake via the Black Lake Drainage Ditch and Percival Creek system. Capitol Lake connects to Budd Inlet via the control structure.

Table 5-4. Assessment of the Black and Capitol Lake Systems Shoreline Functions

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Hydrology: Hydroperiod	**High** Black Lake's drainage pattern has been altered with the installation of the Black Lake drainage ditch. Capitol Lake represents a highly altered form of the original Deschutes Estuary with the installation of a berm and tide gate system.	**High** Restoration of the Deschutes Estuary is possible; feasibility is being considered as part of the CLAMP.
Hydrology: Flood flow retention	**Low** Black Lake provides water storage during the winter. Capitol Lake, while highly altered, is too low in the system to provide flood flow retention.	**Moderate** Focus on preserving flood flow retention provided by Black Lake, and by limiting hydromodification of the area draining to the lake.
Sediment Generation and Transport: Sediment Retention	**Moderate to High** Black Lake likely receives elevated fine sediment loading as land cover alterations have occurred throughout much of the contributing area. Capitol Lake now retains a significant proportion of the sediments delivered by the Deschutes River and Percival Creek.	**Moderate to High** Implementation and retrofit of water quality BMPs to the existing stormwater system can reduce fine sediment loading. Restoration of the Deschutes Estuary is being considered.
Water Quality: Wetland removal of pollutants through sedimentation and adsorption	**High** Reduction in wetland area and channel-floodplain connection has reduced water contact time of water with soil. This lowers the potential for filtering and cycling of pollutants.	**Moderate to High** Encouraging the restoration of riverine and other wetlands within the contributing basin can increase water contact time with soil.

Process: Function	Level of Alteration	Potential Protection and Restoration Measures and Opportunities
Water Quality: Delivery, movement, and loss or removal of nutrients, pathogens, and toxicants; storage of phosphorus and removal of nitrogen and toxins through sedimentation and adsorption.	**High** The delivery, transport, and disposition of nutrients, pathogens, and toxins have been significantly altered from the pre-disturbance condition. Upland sources of these pollutants have increased significantly as a result of urban and industrial land uses within and near the shoreline.	**Moderate** Restoration of riverine/estuarine wetlands can improve the system's ability to provide long-term storage of these pollutants.
Habitat: Shoreline habitat for wildlife; vegetation provides structure for invertebrates, birds, amphibians, reptiles, and mammals.	**Moderate** Native riparian vegetation has been removed. There are portions of both lakes that are currently forested, and are under some level of public or private protection.	**Moderate** Replanting and enhancement of riparian buffers and associated wetlands can increase habitat values for wildlife.
Habitat: Source and delivery of LWD	**High** Removal of mature trees from riparian areas, and removal from upstream bridges has significantly reduced the source of LWD to both lakes.	**Moderate** The potential to re-introduce LWD, either through planting or placement exists.

5.4.2 Key Management Issues

The key management issues for Black and Capitol Lakes are:

- The Deschutes River Estuary has been highly altered, eliminating the river delta and typical estuarine processes in this area.
- Overall water quality is a concern for both lakes. Increased loading due to land cover conversion and associated uses has resulted in sedimentation and growth of invasive aquatic plants and algae. Phosphorus loading and temperatures are key parameters.
- Habitat is impaired as typical riparian habitat has been removed from significant portions of both lake systems.

5.4.3 Restoration Opportunities for Black and Capitol Lakes

- The Capitol Lake Adaptive Management Plan (CLAMP) is currently considering several restoration approaches for Capitol Lake, including significant changes to the current berm/tide gates.
- Take corrective action to improve water quality in the contributing basin, specifically to control pollutants and sediment transport from urban runoff.
- Protect and restore riparian habitat wherever feasible.
- Preserve and restore lacustrine wetlands to enhance habitat and protect water quality.

6.0 DATA GAPS

This section describes specific data gaps or limitations identified during development of the shoreline analysis and characterization as required by Ecology's guidelines. This data gap list is not considered exhaustive, rather a list of sources and/or information need for future updates. Data missing or not available for this report include:

- **Updated Floodplain Mapping – The floodplain has not been updated to include the FEMA remapping of flood hazard areas for Thurston County.**
- **Recent Water Quality Data for Lakes –** The statewide lake testing program is no longer active so recent water quality data for freshwater lakes is lacking.
- **Shoreline Modification Data for Lakes –** Bulkheads and shoreline modification data are available for nearshore shorelines and some rivers, but are lacking for many freshwater lakes.
- **Stormwater Planning –** This analysis does not describe whether any of the cities has a comprehensive approach or planning objectives for long-term capital improvements to stormwater management.

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APPENDIX A: ECOSYSTEM-WIDE PROCESS FIGURES

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APPENDIX B: ECOSYSTEM ANALYSIS DATA SUMMARY

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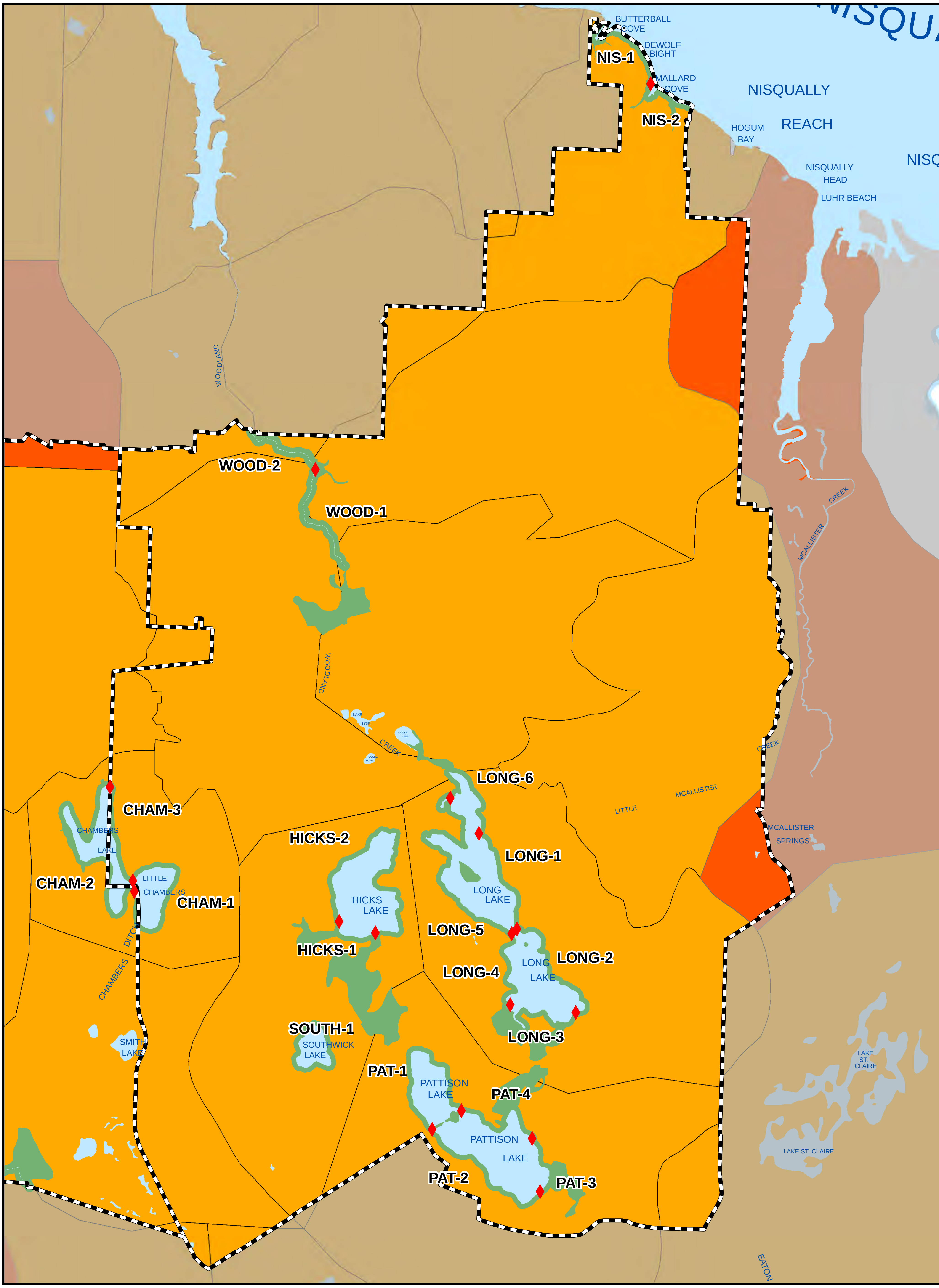
ECOSYSTEM ANALYSIS SUMMARY TABLE

		Climate			Areas of Different Permeability (acres)				Stream Confinement on High Permeabilities			Forest Cover			Roads		Impervious Surfaces		Urban Area on Various Permeabilities (acres			Forest Loss on Various Permeabilities (ac		
Subunit ID	Total Area (acres)	Weighted Average Annual Precipitation (in/year)	Percent in Rain On Snow or Snow Dominated	Historic Wetland Area (acres)	high	med	low	water	Unconfined (feet)	Moderately Confined (feet)	Confined (feet)	Area (acres)	Percent Forest Loss	Potential Wetland Loss (acres)	road length (mi)	road density (mi/mi^2)	Effective Impervious Surface (acres)	Percent EIS	High	Medium	Low	High	Medium	Low
11--1	7331.73	45.30	0	248.73	2694.41	4336.64	159.89	140.79	357.50	0.00	0.00	3609.01	49.22	2.06	38.29	3.34	182.77	2.49	119.22	124.32	4.48	1941.46	1456.66	88.28
11--2	4740.98	46.13	0	12.97	2179.23	2166.25	395.50	0.00	0.00	0.00	0.00	4109.77	12.86	0.03	9.27	1.25	9.78	0.21	11.64	1.81	0.00	518.20	73.70	14.52
11--3	2657.04	45.38	0	22.82	89.54	2309.97	257.54	0.00	0.00	0.00	0.00	504.51	81.01	1.83	50.18	12.09	591.15	22.25	30.97	656.95	72.24	84.67	1878.79	188.76
11--4	5175.19	44.38	0	459.66	2164.59	2662.85	191.35	156.40	60160.58	0.00	0.00	1803.15	64.91	2.74	30.57	3.78	222.86	4.31	110.73	178.86	7.04	1845.53	1262.62	109.18
13-1	1451.40	51.00	0	0.22	522.53	428.42	225.62	274.84	61.14	0.00	0.00	189.17	84.23	0.00	38.41	16.94	413.84	28.51	259.96	162.92	92.39	452.37	338.36	193.65
13-2	2323.30	49.11	0	63.98	1931.93	194.76	182.14	14.48	13488.70	0.00	330.49	575.13	75.03	2.66	44.17	12.17	339.38	14.61	366.59	63.50	16.76	1532.73	113.57	80.23
13-3	1146.40	53.00	0	18.53	0.00	0.00	1114.97	31.42	0.00	0.00	126.83	693.46	38.76	1.13	10.24	5.72	21.91	1.91	0.00	0.00	31.11	0.00	0.00	423.82
13-4	1199.09	53.00	0	40.20	479.16	0.00	715.66	4.28	2023.15	0.00	1131.21	518.97	56.57	1.47	7.34	3.92	47.13	3.93	19.48	0.00	44.54	267.52	0.00	406.07
13-5	1473.87	51.36	0	95.68	1263.50	0.00	200.11	10.26	5974.09	1321.77	962.16	672.57	54.18	2.63	10.23	4.44	53.01	3.60	70.47	0.00	2.79	756.08	0.00	34.27
13-6	1471.63	53.00	0	45.39	71.36	705.72	693.82	0.73	0.00	0.00	0.00	796.77	45.85	3.16	17.40	7.57	81.33	5.53	2.18	51.11	53.85	25.98	320.05	328.34
13-7	1726.76	49.87	0	35.63	48.53	587.41	1067.70	23.12	1080.27	0.00	367.45	920.44	46.68	0.70	7.57	2.81	36.75	2.13	4.33	23.37	23.03	36.55	348.95	402.18
13-8	809.21	51.00	0	0.27	809.21	0.00	0.00	0.00	1542.23	0.00	11411.46	188.36	76.72	0.03	22.46	17.76	179.16	22.14	236.11	0.00	0.00	620.61	0.00	0.00
13-9	1485.54	48.61	3.3	17.95	215.42	0.00	1155.39	114.73	3902.31	1419.31	655.97	1127.19	18.56	0.03	7.98	3.44	19.79	1.33	10.03	0.00	18.41	84.04	0.00	166.63
13-10	3289.60	61.64	22	32.60	179.79	1226.39	1882.80	0.62	4185.50	0.00	0.00	2294.47	30.23	0.32	8.50	1.65	27.13	0.82	6.14	22.24	12.29	132.39	464.35	396.28
13-11	359.01	51.00	0	3.83	327.99	0.00	31.02	0.00	0.00	0.00	0.00	106.73	70.27	0.11	7.51	13.39	66.78	18.60	88.65	0.00	1.46	244.07	0.00	7.50
13-12	862.39	51.00	0	10.51	0.00	5.10	853.47	3.82	0.00	0.00	0.00	525.26	39.03	0.63	6.79	5.04	22.40	2.60	0.00	0.00	31.90	0.00	0.45	332.31
13-13	900.84	51.88	0	17.02	35.47	696.09	169.28	0.00	0.00	0.00	0.00	89.05	90.11	6.64	16.24	11.54	438.59	48.69	5.32	391.68	128.67	27.68	618.63	165.15
13-14	3694.10	48.09	0	219.33	2349.47	240.26	1104.37	0.00	44551.56	2431.32	876.36	1950.64	46.90	3.65	22.66	3.93	87.57	2.37	63.85	18.02	38.74	1252.86	121.46	347.96
13-15	814.06	53.00	0	19.70	0.00	61.89	734.40	17.77	0.00	0.00	62.87	316.11	60.92	0.97	10.96	8.61	41.38	5.08	0.00	2.31	54.01	0.00	35.26	445.39
13-16	1370.16	50.92	0	60.99	965.13	201.90	203.13	0.00	16033.75	1470.27	595.04	499.60	63.54	1.95	12.08	5.64	78.40	5.72	68.81	20.58	17.70	594.88	153.37	122.28
13-17	2761.91	47.10	0	7.17	319.59	2358.47	83.84	0.00	3389.12	1228.51	6411.02	1184.86	57.09	0.06	24.33	5.64	310.53	11.24	3.50	381.73	5.71	145.66	1403.65	26.89
13-20	2206.53	48.20	0	22.83	1608.13	374.30	43.75	180.35	5981.07	0.00	0.00	444.59	78.18	1.90	39.93	11.58	516.76	23.42	563.76	98.21	15.43	1305.26	250.86	27.67
13-21	3350.81	47.09	0	19.93	2484.52	388.82	218.04	259.43	4293.58	0.00	0.00	761.48	75.54	0.64	33.02	6.31	324.19	9.67	333.83	84.34	9.42	1893.24	285.30	157.39
13-22	2879.41	46.47	0	26.46	130.85	2372.59	84.27	291.71	2936.24	0.00	0.00	662.28	74.60	6.14	40.27	8.95	372.96	12.95	8.34	484.83	1.60	61.66	1837.53	27.98
13-23	2352.22	46.97	0	14.66	445.54	1764.30	126.56	15.82	5603.50	0.00	3722.70	474.70	79.65	2.59	41.49	11.29	664.89	28.27	114.56	701.98	32.70	311.56	1447.48	97.36
13-24	2668.26	48.54	0	35.86	1804.96	113.23	750.08	0.00	4632.48	0.00	1070.29	789.44	70.38	2.89	45.40	10.89	657.65	24.65	560.57	30.34	240.75	1236.15	86.93	552.54
13-25	929.48	49.17	0	7.95	677.64	0.00	251.84	0.00	5545.69	209.68	4478.03	353.18	61.99	0.77	6.22	4.28	33.86	3.64	38.15	0.00	7.41	450.12	0.00	123.82
13-26	1729.06	48.97	0	16.79	532.60	589.21	607.25	0.00	3016.52	769.67	5364.08	919.50	46.82	1.06	12.12	4.49	80.69	4.67	11.77	45.37	51.34	163.19	315.40	328.86
13-27	1769.99	49.68	0	24.03	1315.93	0.00	454.07	0.00	15438.95	0.00	697.32	423.04	76.09	1.18	28.06	10.14	493.13	27.86	434.22	0.00	179.44	984.59	0.00	361.44
13-28	1339.03	52.11	0	37.28	589.18	0.00	749.84	0.00	2531.57	0.00	811.18	706.04	47.20	0.38	5.23	2.50	23.08	1.72	22.13	0.00	10.86	401.94	0.00	229.11
13-29	1153.41	51.12	0	43.15	770.37	0.00	382.70	0.34	824.77	0.00	22.25	349.83	69.21	0.88	5.31	2.95	22.50	1.95	22.87	0.00	8.60	533.08	0.00	252.48
13-30	573.81	52.98	0	10.65	124.66	0.00	436.29	12.85	0.00	0.00	382.11	373.76	33.55	0.02	3.22	3.59	6.11	1.06	2.95	0.00	5.93	85.57	0.00	99.36
13-31	340.02	53.00	0	4.49	0.00	0.00	335.20	4.82	0.00	0.00	0.00	166.20	50.98	0.16	1.89	3.55	8.70	2.56	0.00	0.00	11.83	0.00	0.00	169.70
13-32	1365.24	53.00	0	74.24	446.97	0.00	910.39	7.88	3753.45	0.00	0.00	811.28	40.36	2.36	3.90	1.83	15.28	1.12	5.72	0.00	16.46	188.59	0.00	358.30
13-33	345.66	53.00	0	1.66	1.22	0.00	342.62	1.82	0.00	0.00	0.00	190.08	44.96	0.11	4.92	9.11	17.28	5.00	0.00	0.00	23.35	0.00	0.00	153.28
13-34	666.91	53.00	0	18.94	304.11	0.00	358.27	4.52	1620.88	0.00	0.00	367.19	44.89	0.16	4.00	3.84	11.46	1.72	2.43	0.00	13.41	115.23	0.00	181.35
13-35	190.52	52.19	0	3.14	51.66	0.00	138.43	0.42	0.00	0.00	0.00	88.24	53.58	0.38	1.57	5.26	6.61	3.47	4.14	0.00	5.48	35.07	0.00	65.97
13-36	934.64	51.00	0	20.13	857.73	11.00	65.92	0.00	7048.74	0.00	0.00	82.90	91.12	2.49	20.93	14.33	331.37	35.45	373.11	5.23	35.08	775.04	10.43	65.27
13-37	327.05	47.89	0	4.60	194.61	1.11	130.89	2.94	181.82	0.00	0.00	252.53	2.31	0.19	1.66	3.24	11.59	3.54	12.98	0.02	1.27	46.90	0.64	26.73
13-38	352.84	51.00	0	0.82	352.84	0.00	0.00	0.00	0.00	0.00	0.00	106.63	66.80	0.10	3.99	7.23	30.57	8.66	40.92	0.00	0.00	214.24	0.00	0.00
13-39	668.47	51.00	0	12.74	661.19	1.47	5.81	0.00	6470.51	0.00	0.00	92.02	86.23	0.13	7.52	7.20	126.98	19.00	157.71	0.70	3.25	569.17	1.43	5.65
13-40	677.19	51.00	0	10.54	677.19	0.00	0.00	0.00	7153.97	0.00	390.21	182.47	73.05	1.28	7.02	6.64	112.24	16.57	143.34	0.00	0.00	494.70	0.00	0.00
13-41	661.22	51.00	0	42.97	661.22	0.00	0.00	0.00	17773.09	0.00	392.89	307.90	53.40	0.20	1.63	1.58	12.10	1.83	16.43	0.00	0.00	352.82	0.00	0.00
13-42	455.36	51.00	0	6.68	455.36	0.00	0.00	0.00	5642.17	0.00	495.35	70.83	83.98	0.35	6.20	8.71	68.14	14.96	88.33	0.00	0.00	371.17	0.00	0.00
13-43	800.78	51.00	0	36.46	451.48	0.00	349.30	0.00	6107.96	0.00	0.00	313.23	60.86	8.71	10.24	8.18	94.70	11.83	95.02	0.00	24.24	336.12	0.00	151.02
13-44	691.19	51.00	0	9.61	24.00	390.32	276.87	0.00	844.89	0.00	0.00	182.35	73.62	4.12	13.18	12.21	177.54	25.69	3.35	141.12	74.73	17.18	293.71	197.92
13-45	1246.71	51.91	0	50.59	410.81	422.81	413.09	0.00	9007.99	0.00	0.00	330.65	73.42	7.96	6.79	3.49	193.04	15.48	55.32	167.15	13.23	288.55	374.60	249.93
13-46	815.08	53.00	0	2.29	64.09	469.77	256.99	24.22	1673.70	0.00	0.00	359.84	54.48	1.03	9.70	7.62	99.99	12.27	9.92	111.26	5.43	37.50	318.09	73.89
13-47	854.54	50.47	0	1.12	563.34	115.73	175.48	0.00	0.00	0.00	0.00	172.70	79.78	0.00	16.56	12.40	174.47	20.42	173.30	33.69	24.93	499.45	91.52	90.37
13-48	1721.59	49.03	0	28.20	1717.65	0.00	3.94	0.00	7206.70	0.00	387.52	518.72	69.87	0.68	15.67	5.82	94.53	5.49	128.29	0.00	0.13	1200.50	0.00	2.29
13-49	1330.63	49.00	0	49.64	950.13	90.73	188.25	101.52	8187.93	0.00	0.00	260.11	79.45	4.55	23.93	11.51	298.09	22.40	300.80	44.92	45.73	778.98	78.47	125.30
13-50	690.52	51.00	0	28.44	677.92	0.00	0.00	12.60	6489.82	0.00	0.00	115.32	82.98	1.73	13.65	12.65	146.59	21.23	188.74	0.00	0.00	561.01	0.00	0.00
13-51	1452.07	51.00	0	1.86	1446.15	0.00	4.99	0.93	4945.32	0.00	2883.89	242.70	83.28	0.16	45.70	20.14	530.85	36.56	676.20	0.00	0.69	1202.75	0.00	4.60
13-52	678.80	53.06	0	8.00	0.48	0.00	676.94	1.38	0.00	0.00	0.00	370.59	45.40	0.07	9.48	8.94	29.99	4.42	0.01	0.00	41.89	0.45	0.00	306.37
13-53	777.46	52.06	0	10.52	0.26	435.97	340.66	0.57	0.00	0.00	0.00	137.99	82.25	4.84	16.90	13.91	200.06	25.73	0.11	176.81	82.84	0.24	374.29	264.27
13-54	1164.29	53.00	0	29.00	167.56	345.08	638.75	12.89	6213.58	0.00	0.00	488.41	58.00	3.16	14.37	7.90	106.46	9.14	4.96	25.71	109.39	65.80	186.03	418.42
13-55	1202.76	53.07	0	12.52	0.00	238.07	904.59	60.11	0.00	0.00	0.00	766.49	33.55	0.67	10.73	5.71	22.75	1.89	0.00	1.83	29.96	0.00	46.48	320.37
13-56	1210.84	53.00	0	50.69	179.02	795.73	183.74	52.34	1387.57	0.00	0.00	434.39	64.07	1.41	13.86	7.32	91.60	7.56	11.63	94.88	10.61	104.20	560.04	63.46
13-57	634.78	53.28	0	0.48	0.00	306.13	320.57	8.08	0.00	0.00	27.77	493.98	21.36	0.00	5.70	5.75	9.86	1.55	0.00	1.98	11.19	0.00	54.13	76.05
13-58	728.19	53.02	0	18.92	54.25	413.70	253.01	7.23	1031.11	0.00	0.00	477.26	34.46	0.63	5.49	4.82	20.97	2.88	1.83	10.23	16.37	30.48	131.94	82.89

		Climate			Areas of Different Permeability (acres)				Stream Confinement on High Permeabilities			Forest Cover			Roads		Impervious Surfaces		Urban Area on Various Permeabilities (acres			Forest Loss on Various Permeabilities (ac		
Subunit ID	Total Area (acres)	Weighted Average Annual Precipitation (in/year)	Percent in Rain On Snow or Snow Dominated	Historic Wetland Area (acres)	high	med	low	water	Unconfined (feet)	Moderately Confined (feet)	Confined (feet)	Area (acres)	Percent Forest Loss	Potential Wetland Loss (acres)	road length (mi)	road density (mi/mi^2)	Effective Impervious Surface (acres)	Percent EIS	High	Medium	Low	High	Medium	Low
13-59	568.75	53.00	0	7.50	51.68	0.00	516.63	0.44	21.20	0.00	0.00	325.80	42.69	0.06	0.76	0.85	3.06	0.54	0.83	0.00	3.80	29.17	0.00	212.88
13-60	530.14	53.41	0	85.91	246.46	222.91	29.22	31.55	2530.97	0.00	121.17	103.80	80.40	5.69	6.63	8.00	36.53	6.89	33.95	10.14	0.02	222.58	163.06	5.29
13-61	560.62	53.00	0	19.96	47.95	30.19	482.47	0.00	0.00	0.00	0.00	250.95	55.24	0.12	1.93	2.20	4.05	0.72	0.63	1.70	3.78	42.92	11.89	254.85
13-62	561.57	51.00	0	11.45	561.57	0.00	0.00	0.00	2875.85	0.00	0.00	92.02	83.61	0.74	8.24	9.39	74.13	13.20	97.66	0.00	0.00	469.55	0.00	0.00
13-63	746.94	51.00	0	0.00	746.94	0.00	0.00	0.00	0.00	0.00	0.00	39.99	94.65	0.00	4.64	3.97	120.40	16.12	144.99	0.00	0.00	706.90	0.00	0.00
13-64	1582.05	50.25	0	67.58	1582.05	0.00	0.00	0.00	18137.62	0.00	1426.03	635.74	59.73	0.63	4.55	1.84	33.91	2.14	47.22	0.00	0.00	942.90	0.00	0.00
13-65	1206.33	50.98	0	23.12	1163.48	0.00	42.85	0.00	3649.76	0.00	1536.45	273.60	77.32	1.12	12.14	6.44	148.98	12.35	189.94	0.00	1.16	916.57	0.00	16.03
13-66	1526.06	48.76	0	76.76	688.42	6.23	831.40	0.00	1692.25	0.00	0.00	710.81	52.99	0.76	11.06	4.64	62.69	4.11	40.74	1.96	41.22	425.32	5.89	369.63
13-67	1892.33	47.53	0	5.08	0.00	1544.16	345.16	3.00	0.00	0.00	0.00	1043.65	44.79	0.14	18.59	6.29	75.82	4.01	0.00	80.53	21.84	0.00	735.46	109.43
13-68	1250.11	49.12	0	7.22	0.00	711.60	536.30	2.21	0.00	0.00	0.00	843.13	32.50	0.22	11.89	6.08	43.20	3.46	0.00	35.63	22.66	0.00	256.39	146.96
13-69	656.72	51.00	0	13.92	0.00	0.00	650.00	6.72	0.00	0.00	0.00	407.81	37.79	0.45	4.52	4.41	14.65	2.23	0.00	0.00	19.79	0.00	0.00	243.98
13-70	514.23	51.52	0	4.64	0.00	0.00	503.00	11.23	0.00	0.00	0.00	302.43	40.74	0.21	3.71	4.61	13.48	2.62	0.00	0.00	18.25	0.00	0.00	200.99
13-71	761.67	51.00	0	5.73	0.00	0.00	750.91	10.76	0.00	0.00	0.00	452.75	40.35	0.13	6.24	5.25	17.41	2.29	0.00	0.00	24.84	0.00	0.00	300.89
13-72	570.89	51.00	0	1.96	14.78	0.00	545.08	11.03	343.03	0.00	0.00	323.47	43.29	0.01	3.74	4.19	7.26	1.27	0.43	0.00	9.92	7.72	0.00	232.03
13-73	330.36	50.87	0	0.76	161.43	0.00	168.35	0.59	1329.70	0.00	0.00	145.57	55.93	0.00	2.12	4.10	6.61	2.00	4.99	0.00	4.59	103.98	0.00	79.81
13-74	370.44	51.00	0	0.00	300.72	0.00	69.26	0.46	0.00	0.00	0.00	31.74	91.43	0.00	12.89	22.28	118.86	32.09	139.80	0.00	17.92	279.16	0.00	58.79
13-75	1296.50	49.00	0	22.84	767.35	94.89	434.25	0.00	17198.72	0.00	2175.10	770.48	40.56	0.14	5.83	2.88	16.97	1.31	19.98	0.79	3.22	389.93	24.12	111.67
13-76	3546.73	48.55	0	47.19	1480.57	0.00	2066.16	0.00	68735.27	3206.27	4726.78	2434.43	31.02	0.33	9.78	1.76	19.96	0.56	24.97	0.00	3.14	731.24	0.00	363.23
13-77	212.09	51.00	0	15.28	142.11	0.00	0.00	69.97	0.00	0.00	0.00	0.00	100.00	7.51	4.56	13.77	130.16	61.37	110.33	0.00	0.00	141.04	0.00	0.00
13-78	493.04	51.00	0	0.81	403.71	0.00	0.00	89.33	0.00	0.00	0.00	79.47	80.58	0.20	8.38	10.88	91.71	18.60	119.11	0.00	0.00	326.03	0.00	0.00
13-79	327.98	51.00	0	7.01	20.96	80.53	223.50	2.99	0.00	0.00	0.00	34.93	89.33	1.66	10.63	20.75	108.90	33.20	8.58	17.96	113.78	20.51	59.72	209.68
13-80	1838.57	49.00	0	45.67	721.39	361.18	567.66	188.34	18301.05	0.00	2171.38	1011.06	39.35	0.35	9.10	3.17	53.90	2.93	44.46	26.77	2.64	395.36	175.47	75.49
13-81	1345.12	49.00	0	11.02	413.25	26.78	870.26	34.84	6336.85	0.00	147.44	892.77	32.37	0.05	4.71	2.24	20.93	1.56	19.61	0.89	8.24	225.99	18.08	180.13
13-82	1161.53	49.48	0	8.68	819.80	0.00	341.72	0.00	10866.62	0.00	0.00	646.53	44.33	0.17	3.08	1.70	27.04	2.33	34.73	0.00	2.42	446.87	0.00	67.85
13-83	12766.27	46.24	11.1	42.44	8409.21	860.42	3496.64	0.00	34593.29	238.72	3673.96	5753.75	54.92	0.51	52.98	2.66	372.15	2.92	427.71	6.80	73.42	5754.43	231.73	1024.12
13-84	2909.25	59.27	49.22	57.80	376.08	432.65	2100.52	0.00	0.00	0.00	0.00	2193.72	24.58	0.83	7.18	1.58	24.96	0.86	24.69	2.91	9.54	223.55	148.20	343.25
13-85	2968.07	47.90	0	41.39	1751.50	10.03	1177.99	26.49	1636.39	0.00	0.00	2272.73	20.83	1.73	14.92	2.90	104.31	3.17	116.78	0.18	11.39	422.08	5.79	240.56
23-1	3765.44	49.35	0	109.23	2377.59	170.11	1217.74	26.26	8201.85	7896.87	31422.08	1442.27	61.58	2.54	10.84	1.84	69.74	1.85	83.09	1.23	11.51	1778.59	159.57	372.93
23-2	2695.90	51.00	0	111.98	1271.52	0.00	1398.12	0.00	5259.41	0.00	11634.30	1609.03	39.55	0.38	8.75	2.08	29.47	1.09	20.66	0.00	19.77	633.71	0.00	417.49
23-3	2718.57	51.00	0	186.12	1547.56	0.00	1171.01	0.00	1561.50	0.00	18868.78	1237.86	54.38	3.69	14.24	3.35	70.97	2.61	58.28	0.00	37.89	978.70	0.00	496.64
23-4	1588.89	51.00	0	104.68	1514.32	0.00	74.57	0.00	0.00	0.00	6970.73	349.87	77.98	6.56	14.50	5.84	156.75	9.87	188.32	0.00	11.68	1175.12	0.00	63.59
23-5	1804.69	51.11	0	94.16	1804.69	0.00	0.00	0.00	0.00	7708.46	0.00	488.08	72.80	5.43	11.47	4.07	119.09	6.60	154.82	0.00	0.00	1306.01	0.00	0.00
23-6	447.05	51.00	0	4.07	447.05	0.00	0.00	36.16	0.00	0.00	0.00	91.20	79.54	0.58	2.88	4.12	42.98	9.61	52.73	0.00	0.00	354.60	0.00	0.00
23-7	528.29	51.30	0	25.01	492.13	0.00	0.00	189.26	3390.58	0.00	6114.93	110.99	77.39	0.84	4.65	5.64	27.77	5.26	37.40	0.00	0.00	379.85	0.00	0.00
23-8	1145.56	51.76	0	103.99	920.06	22.04	14.20	89.36	8321.00	0.00	3419.00	233.48	75.62	14.45	7.37	4.12	110.27	9.63	135.47	6.12	0.27	691.10	20.47	9.98
23-9	687.75	53.00	0	0.38	257.03	0.00	341.37	176.68	2080.52	0.00	6656.26	182.66	69.54	0.03	1.88	1.75	11.82	1.72	14.40	0.00	1.50	177.02	0.00	239.04
23-10	1462.29	53.21	0	31.67	826.21	0.00	459.40	63.19	3334.76	0.00	4672.95	541.43	58.54	1.22	13.38	5.86	84.73	5.79	89.57	0.00	26.64	509.20	0.00	242.97
23-11	1140.58	51.63	0	70.53	1077.39	0.00	0.00	0.00	5458.25	3804.48	0.00	278.81	73.95	2.25	5.66	3.17	53.68	4.71	71.69	0.00	0.00	790.80	0.00	0.00
23-12	3525.17	52.86	0	283.73	3258.93	0.00	266.24	0.00	26754.77	4568.08	9321.59	1339.27	61.96	8.76	13.86	2.52	98.45	2.79	130.70	0.00	8.54	2018.42	0.00	162.72
23-13	5843.26	58.62	21.2	135.02	2097.80	1207.52	2537.94	0.00	15592.87	5406.93	25502.65	3732.06	35.92	2.23	19.54	2.14	70.81	1.21	45.38	37.83	22.81	1001.02	547.50	543.15
23-14	3498.06	53.45	0	157.42	1506.04	1022.75	969.27	0.00	32740.63	3235.92	537.70	1707.34	51.19	1.34	12.18	2.23	71.05	2.03	44.97	31.49	27.71	835.11	557.33	398.10
23-15	2889.23	53.00	0	103.78	952.94	1132.46	803.83	0.00	3278.13	0.00	3071.04	1123.31	61.12	6.60	18.10	4.01	117.62	4.07	77.53	56.06	17.55	690.54	657.89	417.49
23-16	6485.96	51.29	0	241.02	1115.06	237.41	5133.49	129.24	12108.90	0.00	13018.53	4134.27	35.66	4.37	21.36	2.11	85.69	1.32	41.65	3.11	75.06	503.10	75.68	1710.55
23-17	3418.65	51.79	0	407.01	2320.32	28.62	940.47	0.00	19041.09	3982.49	24546.33	1197.94	63.65	17.35	19.16	3.59	114.63	3.35	99.33	0.86	50.43	1520.16	20.44	548.16
23-18	2314.28	52.07	0	436.42	2054.70	0.00	259.59	0.00	8539.40	0.00	25143.76	751.49	67.31	8.10	12.24	3.38	56.02	2.42	72.99	0.00	3.78	1467.48	0.00	79.73
23-19	1231.54	51.47	0	144.03	1119.51	0.00	112.03		706.46	1322.63	12268.72	387.40	68.43	4.56	5.58	2.90	38.57	3.13	46.77	0.00	5.22	734.57	0.00	105.07



Shoreline Master Program - Lacey

Ecosystem-Wide Processes
Basin Ranking - Relative Importance

Urban Growth Boundary

Reach Break

Ordinary High Water Mark

Low (none in study area)

Medium 1 (none in study area)

Medium 2

High

SMA Jurisdiction

TRPC Thurston Regional Planning Council

0 0.5 1 Miles

Printing Date: March 18, 2008
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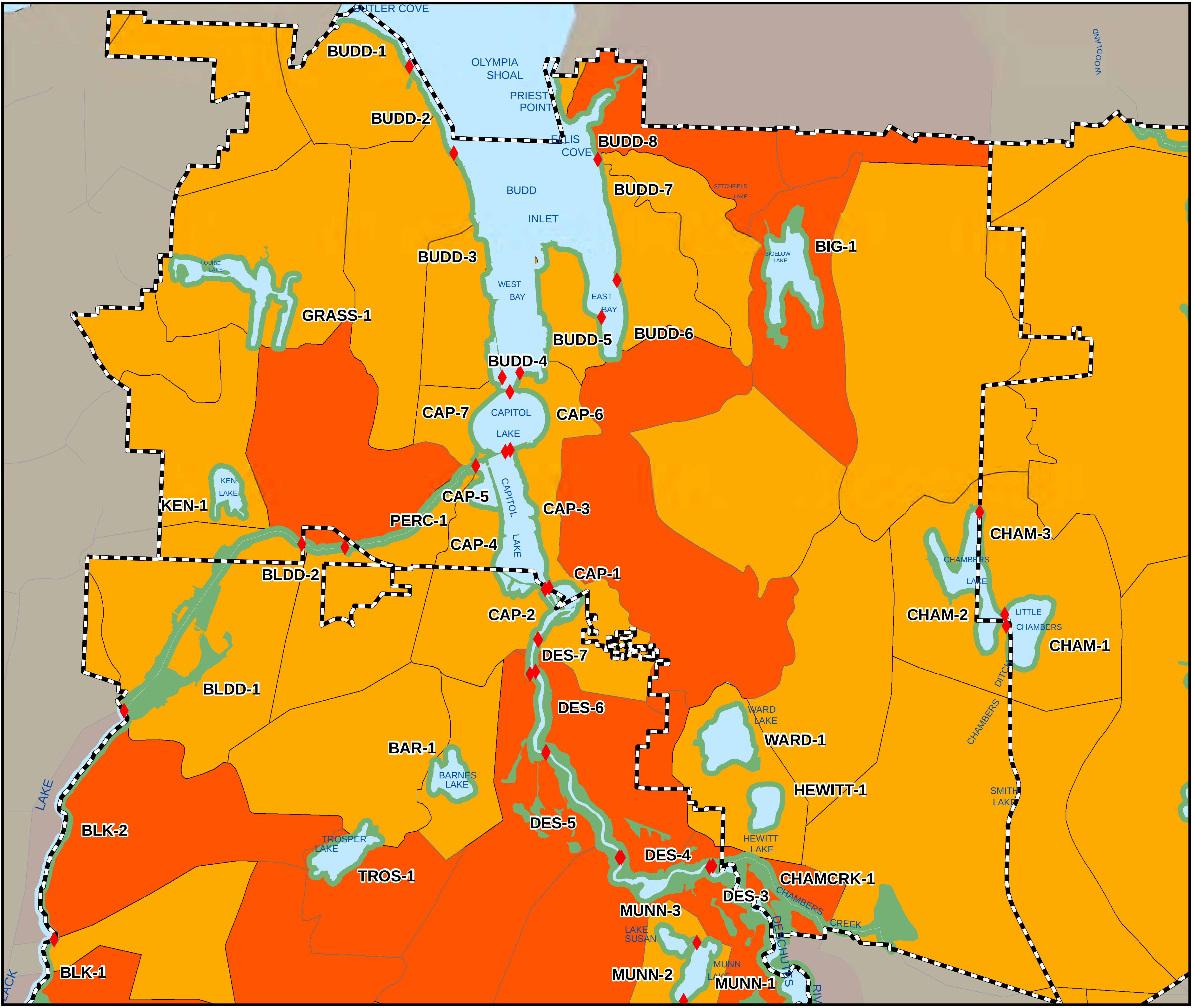
MAP # ESA L-1



Shoreline Master Program

Olympia

Ecosystem-Wide Processes
Basin Ranking - Relative Importance

- Low (none in study area)
- Medium 1 (none in study area)
- Medium 2
- High
- Reach Break
- Ordinary High Water Mark
- SMA Jurisdiction
- Urban Growth Boundary

TRPC
Thurston Regional Planning Council

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Miles
0 0.25 0.5 1

N W E S

MAP # ESA O-1

Printing Date: March 10, 2008
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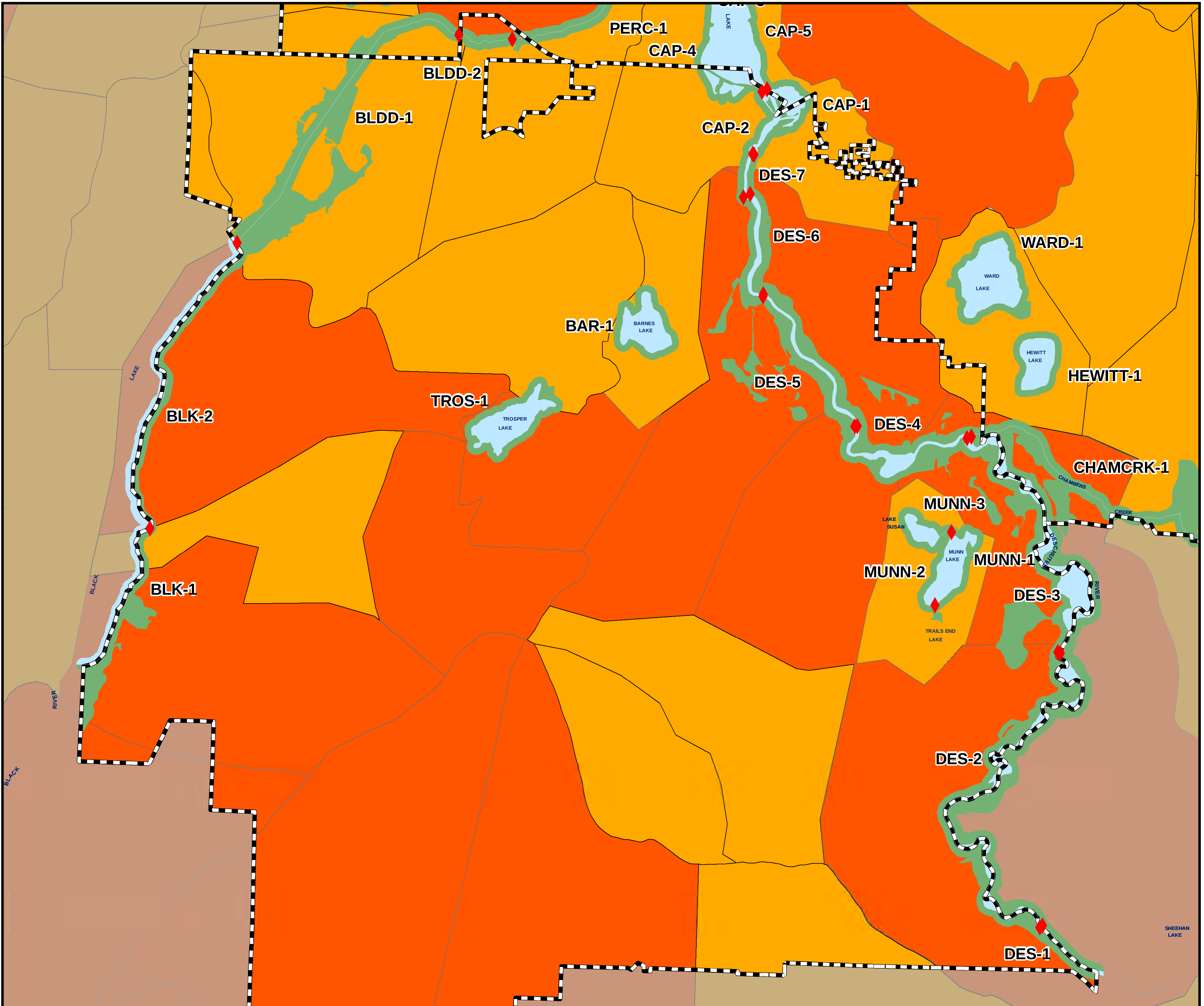

Shoreline Master Program

Tumwater

Ecosystem-Wide Processes
Basin Ranking - Relative Importance

- Low (none in study area)
- Medium 1 (none in study area)
- Medium 2
- High
- Reach Break
- Ordinary High Water Mark
- SMA Jurisdiction
- Urban Growth Boundary

TRPC
Thurston Regional Planning Council

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Miles
0 0.25 0.5 1

MAP # ESA T-1

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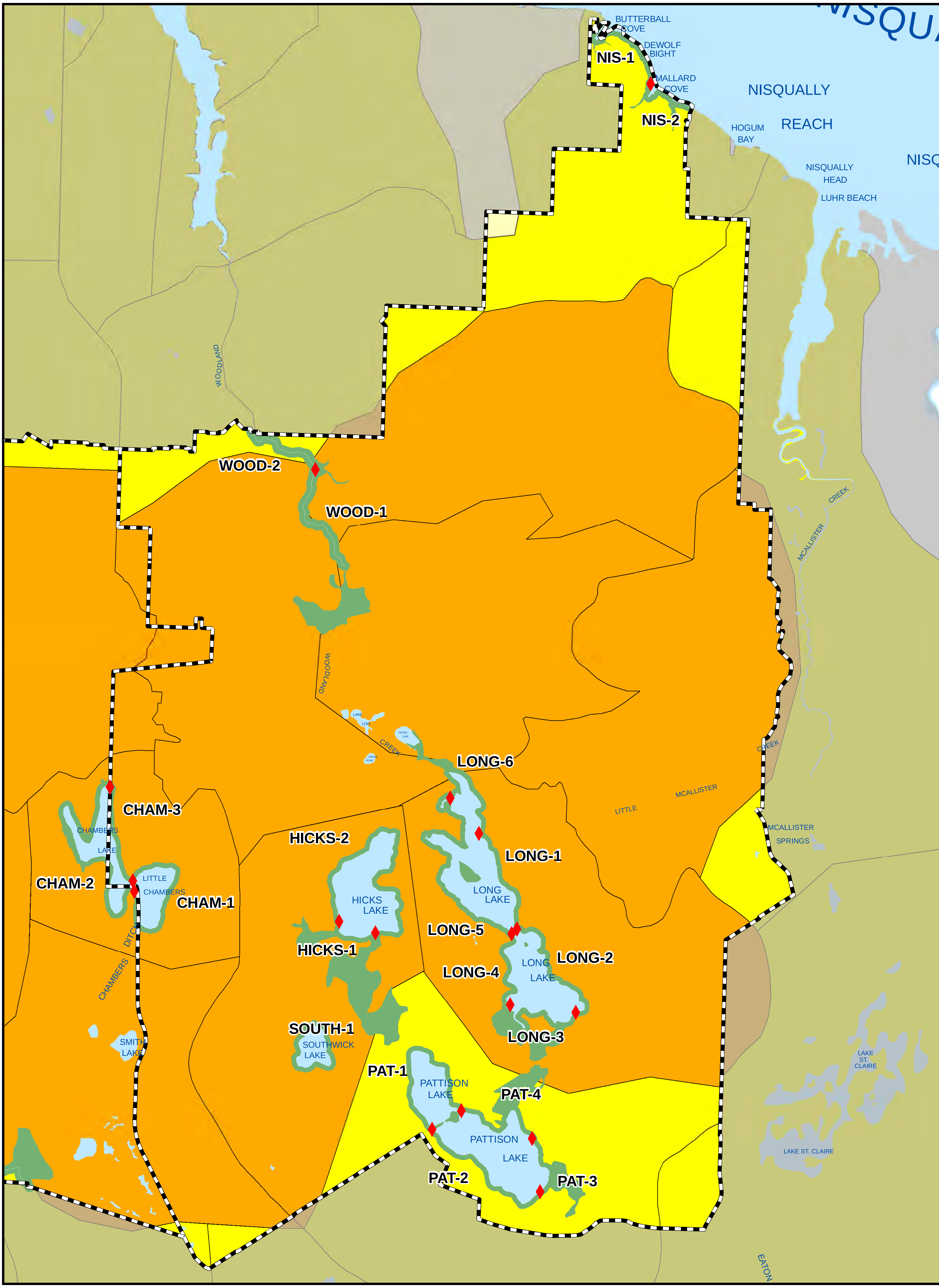

Shoreline Master Program - Lacey

Ecosystem-Wide Processes
Basin Ranking - Alteration

- Urban Growth Boundary
- Reach Break
- Ordinary High Water Mark
- Low (none in study area)
- Medium 1
- Medium 2
- High (none in study area)
- SMA Jurisdiction

TRPC Thurston Regional Planning Council

0 0.5 1 Miles

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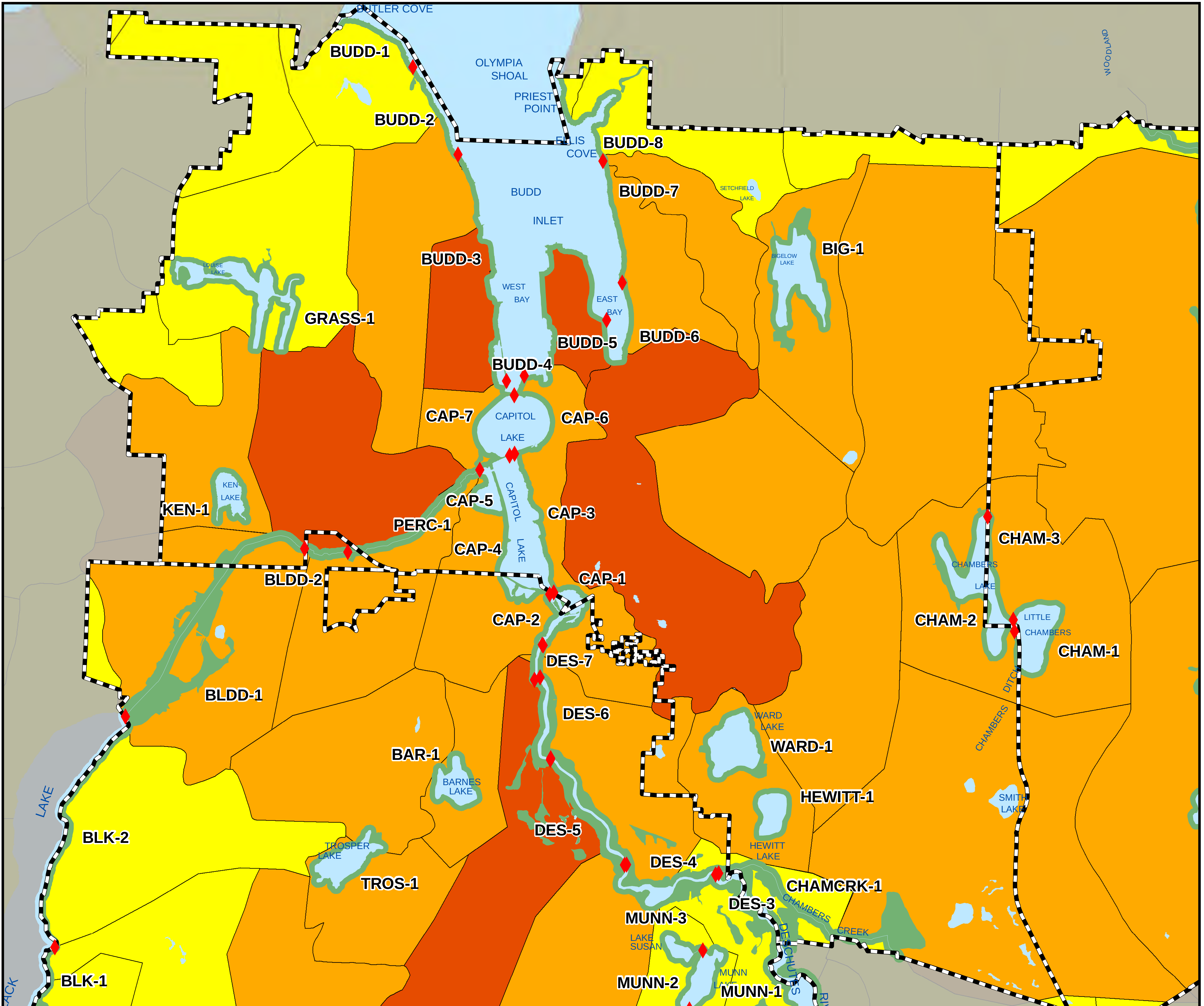
MAP # ESA L-2



Shoreline Master Program

Olympia

Ecosystem-Wide Processes
Basin Ranking - Alteration

- Low (none in study area)
- Medium 1
- Medium 2
- High
- Reach Break
- Ordinary High Water Mark
- SMA Jurisdiction
- Urban Growth Boundary

Thurston Regional Planning Council

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0 0.25 0.5 1 Miles

MAP # ESA O-2

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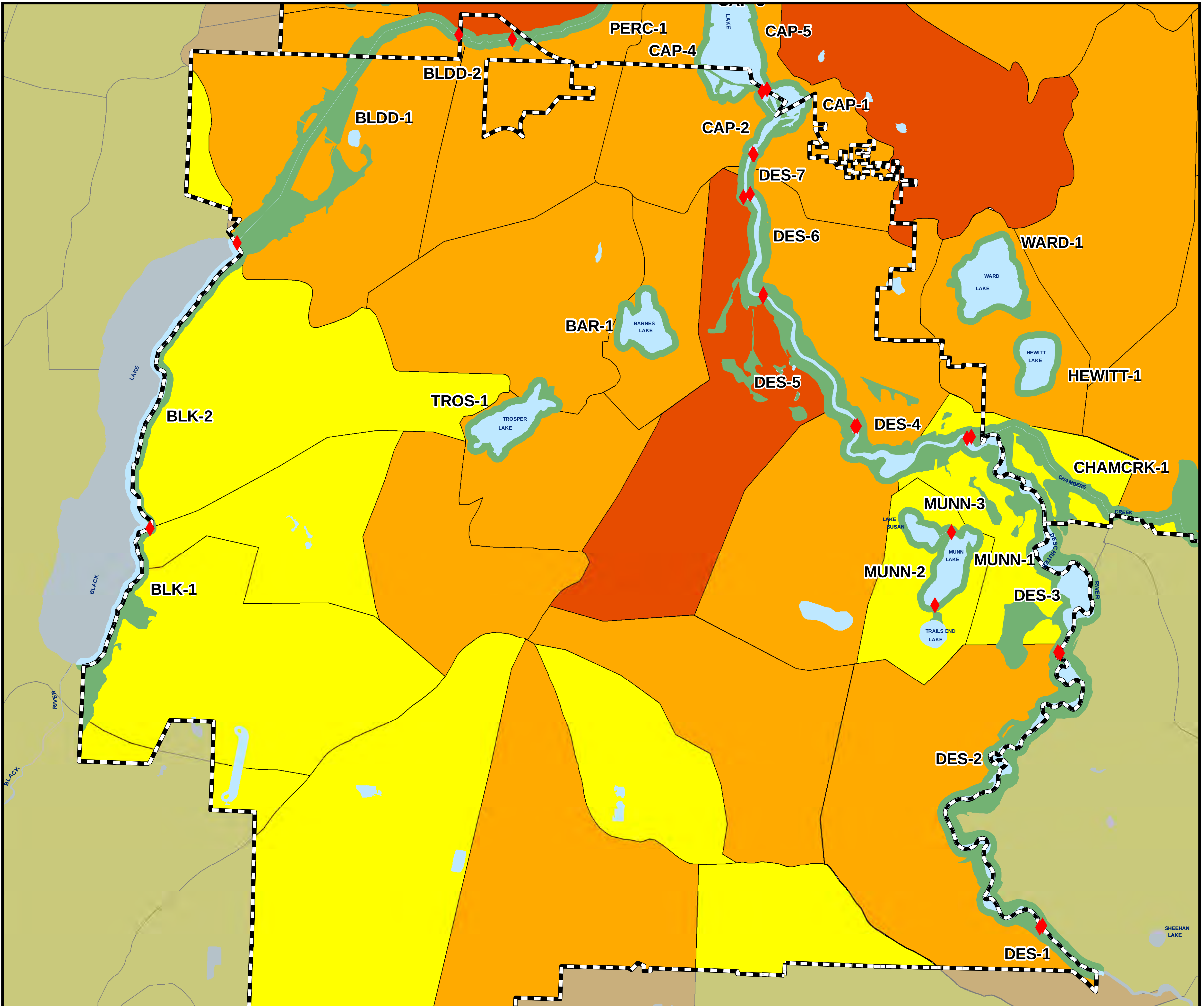


Shoreline Master Program
Tumwater

Ecosystem-Wide Processes
Basin Ranking - Alteration

- Low (none in study area)
- Medium 1
- Medium 2
- High
- Reach Break
- Ordinary High Water Mark
- SMA Jurisdiction
- Urban Growth Boundary

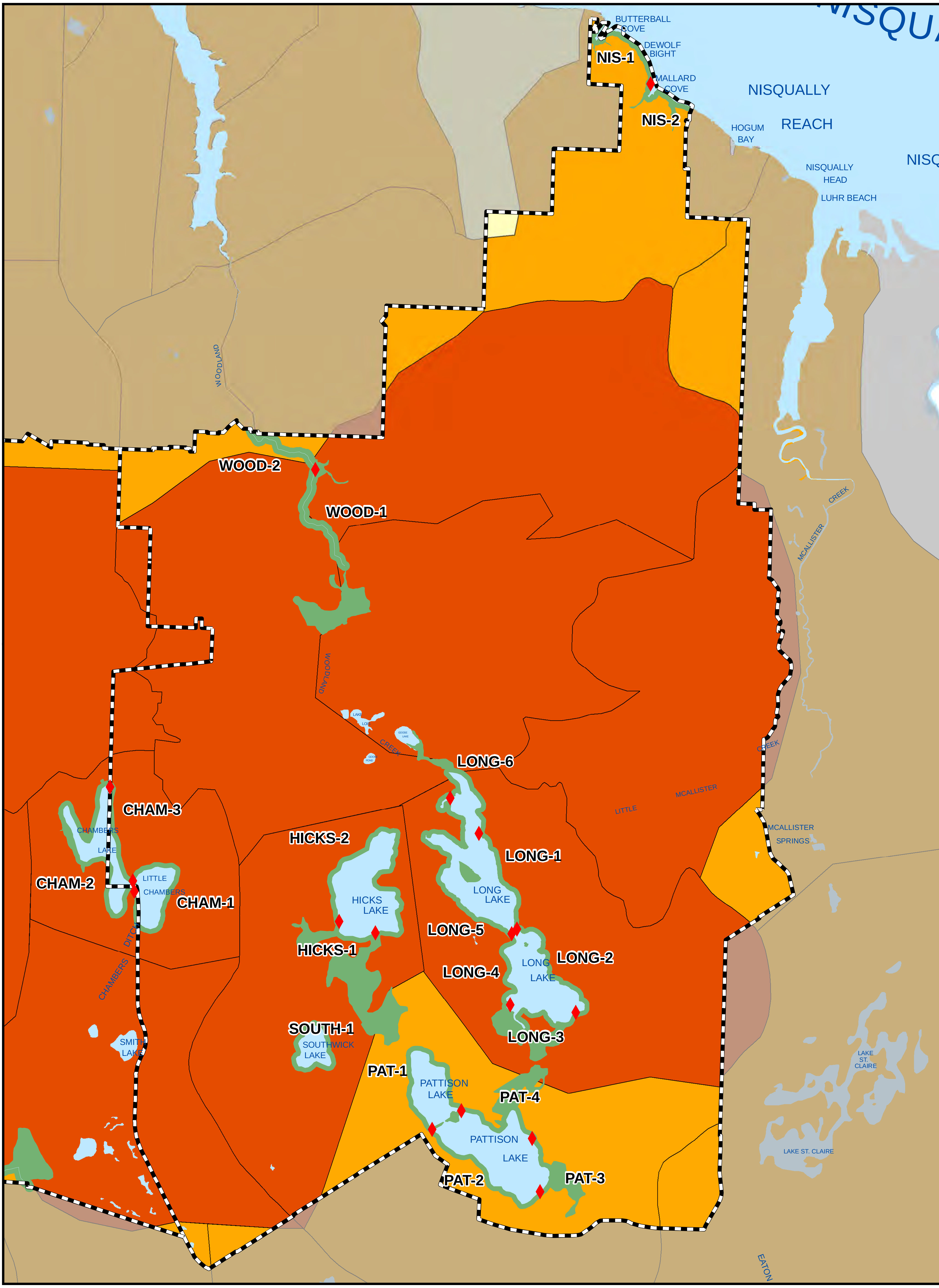
TRPC
Thurston Regional Planning Council

0 0.25 0.5 1 Miles

N W E S

MAP # ESA T-2

Printing Date: March 18, 2008
File: P:\ThurstonCounty\smp_update\maps_images\draft_smp_tumwater.mxd



Shoreline Master Program - Lacey

Ecosystem-Wide Processes
Basin Ranking - Combination

Urban Growth Boundary

Reach Break

Ordinary High Water Mark

Protection

Protection/Restoration

Restoration

SMA Jurisdiction

0 0.5 1 Miles

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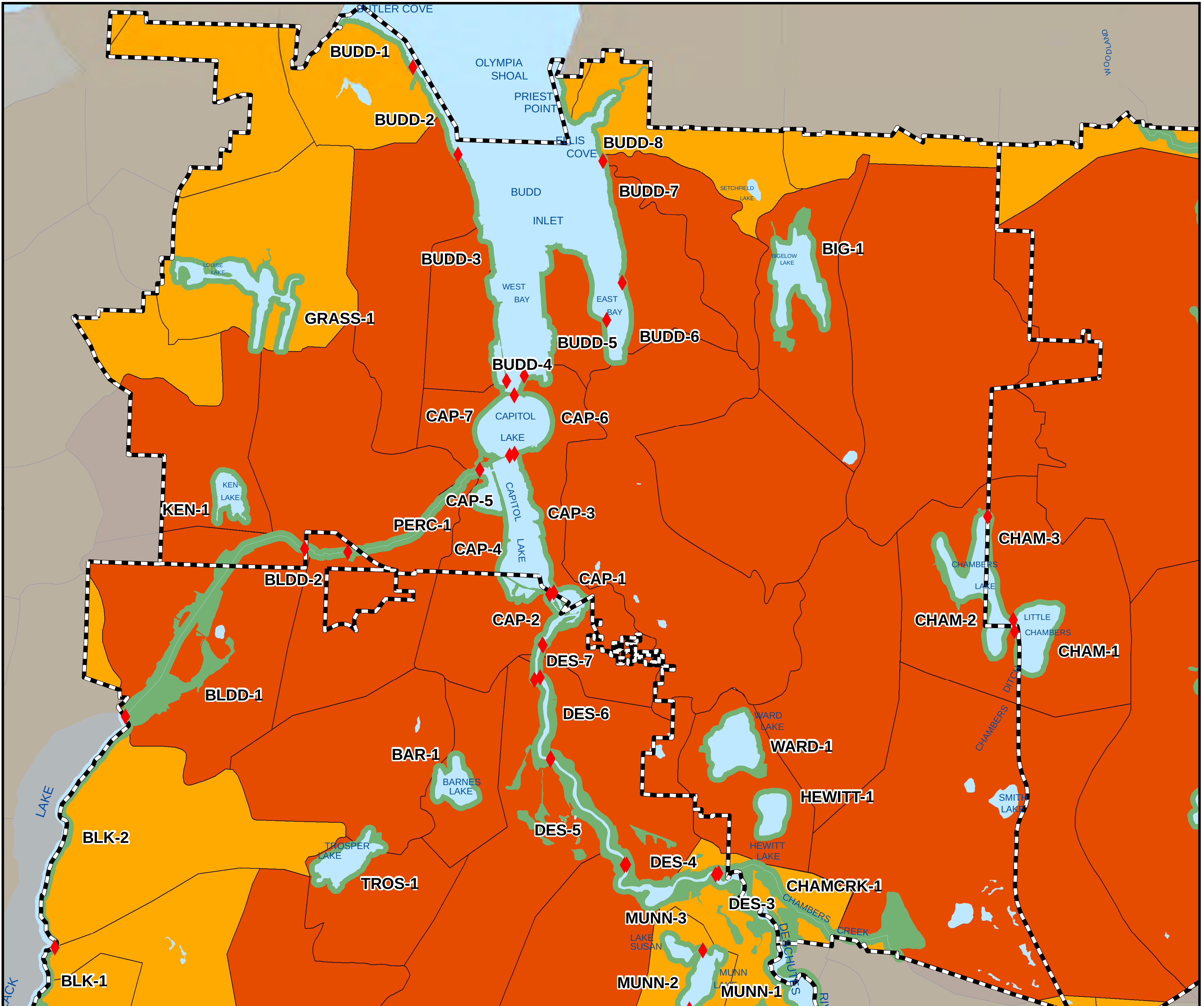
MAP # ESA L-3



Shoreline Master Program

Olympia

Ecosystem-Wide Processes Basin Ranking - Combination

- Protection
- Protection/Restoration
- Restoration
- Reach Break
- Ordinary High Water Mark
- SMA Jurisdiction
- Urban Growth Boundary

TRPC Thurston Regional Planning Council

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0 0.25 0.5 1 Miles

N W E S

MAP # ESA O-3

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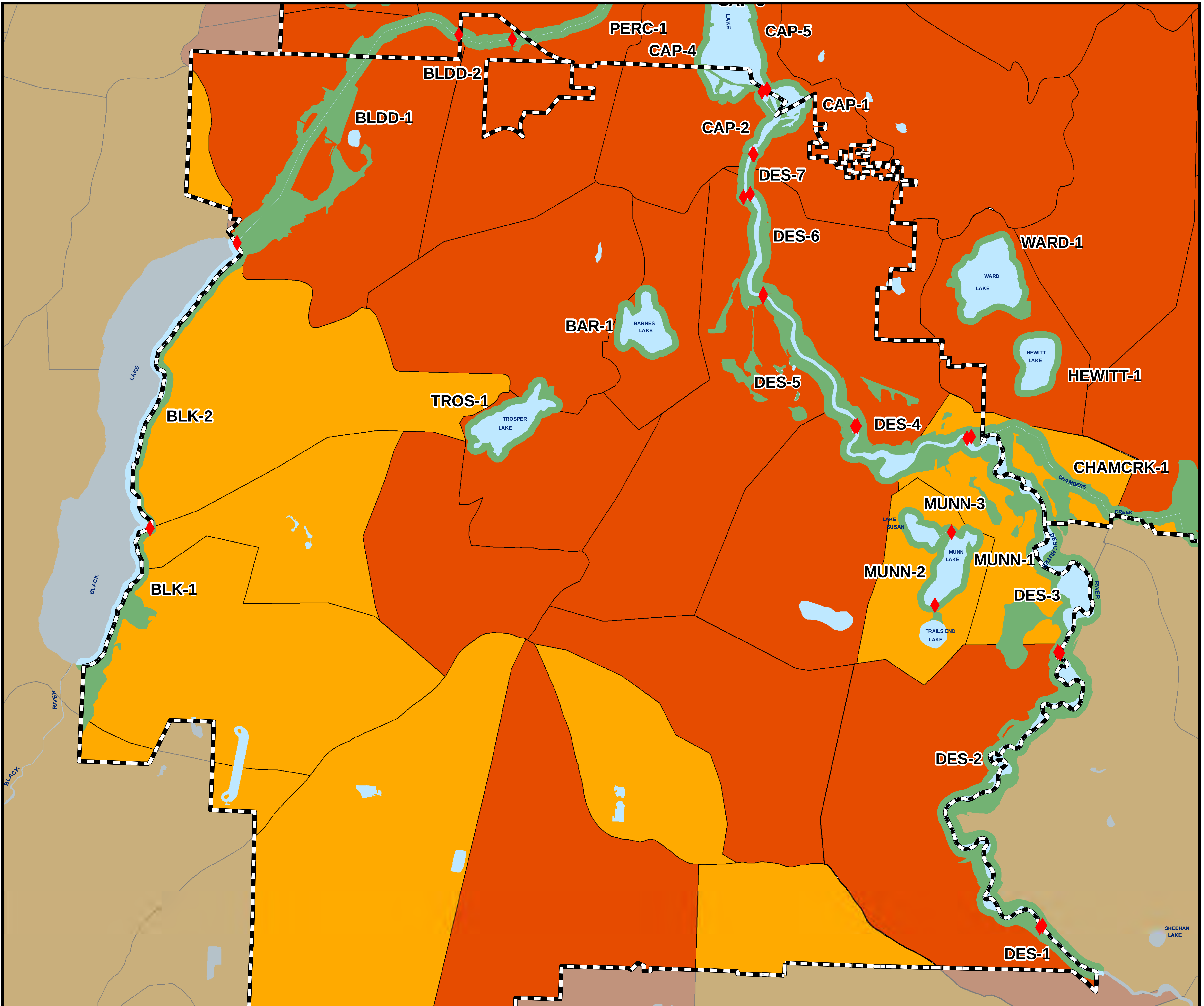

Shoreline Master Program

Tumwater

Ecosystem-Wide Processes
Basin Ranking - Combination

Protection

Protection/Restoration

Restoration

Reach Break

Ordinary High Water Mark

SMA Jurisdiction

Urban Growth Boundary

Thurston Regional Planning Council

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Miles
0 0.25 0.5 1

N W E S

MAP # ESA T-3

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