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1. INTRODUCTION

Background and Purpose

The purpose of this study is to conduct a baseline inventory and characterization of conditions relevant to the shoreline resources of the City of Puyallup (City), 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. The City is conducting a comprehensive SMP update with the assistance of a grant administered by Washington State Department of Ecology (CZM Grant No. G0500027). A first step in the comprehensive update process is development of a shoreline inventory and characterization. The inventory and characterization documents current shoreline conditions and provides a basis for updating the City's SMP goals, policies, and regulations. This characterization will help the City identify existing conditions, evaluate existing functions and values of its shoreline resources, and explore opportunities for conservation and restoration of ecological functions.

This study characterizes ecosystem-wide processes and how these processes relate to shoreline functions. Processes and functions are evaluated at two different scales: a watershed or landscape scale, and a shoreline reach scale. The purpose of the watershed or landscape scale characterization is to: 1) identify ecosystem processes that shape shoreline conditions; and 2) to determine which processes have been altered or impaired. The intent of the shoreline reach scale inventory 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 technical baseline understanding of existing conditions to inform policy and regulatory updates to the City's shoreline master program.

Report Organization

The information in this report is divided into seven main sections. The introduction discusses the purpose of this report and describes the regulatory context for shoreline planning. The second section describes the methods, approach, and primary data sources used for this inventory and characterization. The third section describes the regional context, general landscape setting (climate, topography, etc.), and watershed conditions. The fourth section provides an overview of ecosystem-wide processes and how they affect shoreline ecological functions in the City of Puyallup. The fifth section addresses 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). The sixth section summarizes conditions for the portions of the Puyallup River and Clarks Creek in the City's planning area, provides an assessment of shoreline functions, and identifies and discusses potential opportunity areas for protection, enhancement, restoration, and enhanced public access. Section 7 identifies data gaps and provides recommendations for addressing those gaps. References are contained in Section 8.

Regulatory Overview

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 by encouraging 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 are implemented through use regulations. 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 shoreline area will be managed over time.

Shoreline Jurisdiction

Under the SMA, the shoreline jurisdiction includes areas that are 200 feet landward of the ordinary high water mark (OHWM) of waters that have been designated as "shorelines of statewide significance" or "shorelines of the state." These designations were established in 1972 and are described in WAC 173-18. 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. "Shorelines of the state" are generally described as all marine shorelines and shorelines of all other streams or rivers having a mean annual flow of 20 cfs or greater and lakes with a surface area 20 acres or greater.

Under the SMA, the shoreline area to be regulated under the City's SMP 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). "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 under their SMPs for all areas within the 100-year floodplain or a smaller area as defined above (RCW 90.58.030(2)(f)(i)). The City's current SMP regulates shorelines of the state in Puyallup according to the definition above (i.e., 200-feet from the floodway or ordinary high water mark (where the floodway is not established) and associated wetlands).

City of Puyallup Shoreline Master Program

Two waterbodies in Puyallup, the Puyallup River and Clarks Creek, are regulated under the SMA and the City's SMP. The Puyallup River is designated as a "shoreline of statewide significance." Clarks Creek is designated as a "shoreline of the state." The City of Puyallup first adopted its SMP in 1974. The City's current SMP was adopted in 1987. Development regulations contained in the SMP are adopted by reference as part of the City of Puyallup critical areas ordinance (Puyallup Municipal Code [PMC] 21.06.1010 (3)(a)(i)).

Local SMPs establish a system to classify shoreline areas into specific "environment designations." The purpose of shoreline environment designations is to provide a uniform basis for applying policies and use regulations within distinctly different shoreline areas. In a regulatory context, shoreline environment designations provide the governing policy and regulations that apply to land within the SMP jurisdiction. Portions of individual parcels that are outside SMP jurisdiction are governed by zoning and other applicable land use regulations. Generally, environment designations should be based on existing and planned development patterns, biological and physical capabilities and limitations of the shoreline, and a community's vision or objectives for its future development. During development of its current SMP in 1987, the City evaluated the natural and built characteristics of its shoreline jurisdiction and developed three shoreline environment designations: Conservancy, Rural, and Urban. All three designations are applied to portions of Clarks Creek and the Puyallup River within the City's municipal boundaries.

A variety of other regulatory programs, plans, and policies work in concert with the City's SMP to manage shoreline resources and regulate development near the shoreline. The City's Comprehensive Plan establishes the general land use pattern and vision of growth the City has adopted for areas both inside and outside the shoreline jurisdiction. The Growth Management Act provides that SMP goals and policies are integrated as an element of the Comprehensive Plan (RCW 36.70A.480). As such, SMP goals and policies should be consistent with general goals and policies for land use, environment, and other elements contained in the Comprehensive Plan, and vice versa. Various sections of the City's municipal code are relevant to shoreline management, such as zoning, flood damage prevention, and stormwater management. The City's development standards and use regulations for environmentally critical areas are particularly relevant to the City's SMP. Designated environmentally critical areas are found throughout the City's shoreline jurisdiction, including streams, wetlands, aquifer recharge areas, and geologic hazard areas.

2. METHODS

Data Sources

A number of City of Puyallup, Pierce County, and state and federal agency data sources and technical reports were reviewed to compile this inventory and characterization including, but not limited, to the following:

- City of Puyallup Shoreline and Critical Areas Inventory (Parametrix, 2003);
- City of Puyallup Comprehensive Plan (1994 and updated elements);
- City of Puyallup Storm Drainage and Basin Modeling (KCM, 1996);
- City of Puyallup Sanitary Sewer Comprehensive Plan (Gray and Osborne, 1997);
- The Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region (Williams et al., 1975); and
- Washington State Department of Fish and Wildlife Priority Habitats and Species database, StreamNet database (WDFW, 2005).

A number of sources were also reviewed to characterize overall watershed conditions and to assess the ecological function of Puyallup's shorelines in an ecosystem-wide context. Watershed-level condition sources reviewed for this report include:

- Mid-Puyallup Basin Plan (Entranco, 2003);
- Clear/Clarks Creek Basin Draft Characterization Report (CH2M Hill, 2002; subsequently incorporated into the Clear/Clarks Creek Basin Plan, adopted by Pierce County in 2006);
- Upper Puyallup Watershed Characterization and Action Plan (Upper Puyallup Watershed Committee, 2002);
- Lower Puyallup Watershed Action Plan (Lower Puyallup Watershed Management Committee, 1993);
- Pierce County River Improvement: Puyallup River Basin Comprehensive Flood Control Management Plan (Montgomery, 1991);
- Puyallup River Total Maximum Daily Load (TMDL) (1993);
- Soil Survey of Pierce County Area, Washington (SCS, 1979); and
- Salmon Habitat Limiting Factors Report for the Puyallup Basin (WRIA 10) (Kerwin, 1999).

Mapping and aerial photographs of the study area were also consulted. Mapping and aerial photography integrated with GIS data included

- Vertical aerial photography by U.S. Army Map Service, 1942 (through University of Washington River History Project);

- Vertical aerial orthophotography by Triathalon, Inc., for Pierce County, 2001;
- LIDAR topographic mapping of Pierce County lowlands by Puget Sound LIDAR Consortium (PSLC), 2004; and
- Draft flood hazard map revisions for the Puyallup River and Clarks Creek (prepared by FEMA, 2005). (As of August 2007, FEMA has not yet asked that the City adopt this map.)

A complete list of data sources used is included in the reference list (Section 8) of this report.

Approach to Characterizing Ecosystem-wide Processes and Shoreline Functions

The SMA guidelines require local jurisdictions to evaluate ecosystem-wide processes while updating its SMP. Ecosystem-wide processes that create, maintain, or affect the 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. These processes are qualitatively described using available reports and maps related to topography, geology, soils, land cover, and other themes. This approach is most appropriate at a county or watershed scale. However, it can be used in a simplified form to support local planning processes by providing a broader understanding of the processes at work that maintain the aquatic resources being regulated by a local jurisdiction.

Natural processes, and alterations to those processes, are described at a variety of geographic scales based on existing reports and readily available mapping information. For example, conditions, processes, and functions may be described at the following scales: 1) the entire Puyallup River watershed; 2) the Lower or Upper Puyallup River watershed; 3) the Puyallup vicinity or the extent of the City's UGA; and 4) the shoreline planning area or reach scale (Figure 2). Additionally, alterations to processes are described in terms of historical development, past land use, and existing development.

Approach to Inventory and Characterization of Regulated Shorelines

The inventory of the Puyallup River and Clarks Creek at the shoreline reach scale, or within the limits of the mapped shoreline planning area as described above, is intended to characterize conditions adjacent to the regulated waterbody. The shoreline planning area roughly approximates the regulatory limits of the City's SMP as described above. GIS data and analysis were used to quantify certain conditions in this area (e.g., acres per zoning or land use designation). Aerial photography and review of existing reports and planning documents were used to qualitatively describe conditions in this area.

The portion of the Puyallup River shoreline running through the City is generally homogenous and was characterized as one reach. The Clarks Creek shoreline is less homogenous, but was also characterized as one reach. Clarks Creek's total length is less than four miles, shorter than the portion of the Puyallup River in the City. The analysis of shorter reaches did not appear warranted. This approach should not suggest that only one regulatory shoreline environment designation in the City for either Clarks Creek or the Puyallup River would be appropriate.

3. REGIONAL CONTEXT

The City of Puyallup is in the Puyallup-White River watershed (WRIA 10) (Figures 2 and 3). The Puyallup River travels approximately 54 miles from its headwaters on the southwest slopes of Mount Rainier to its mouth at Commencement Bay. The entire Puyallup River basin covers 1,065 square miles and consists of 728 rivers and streams, with the largest tributaries being the White and Carbon Rivers (Kerwin, 1999). The Puyallup River is fed primarily by the Tahoma and Puyallup Glaciers on the southwest slope of Mount Rainier. The Carbon River originates from the Carbon Glacier located on the north slope of Mount Rainier, and the White River is fed primarily by the Emmons Glacier on the northeast slopes of Mount Rainer.

The City of Puyallup lies between River Miles (RM) 5.7 and 11.4 on the Puyallup River in the lowest third of the Mid-Puyallup River basin. The City and its UGA occupy approximately 17.8 square miles, or 1.7 percent of the land area included in WRIA 10. The portion of the Puyallup River within the City and its UGA is approximately 10.5 percent of the total length of the river.

Hydrogeologic Setting

Key processes that form and maintain aquatic ecosystems generally operate at a landscape or watershed scale. A framework for identifying and understanding these processes in western Washington is provided in *Protecting Aquatic Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes* (Stanley, et al., 2005). The framework is based on the concept that climate, topography, geology, and soils determine the general patterns of surface and groundwater flow between upland and aquatic areas. These factors form the hydrogeologic setting and play a major role in shaping the structure and function of shoreline environments. For the Puyallup River watershed and the City of Puyallup, these characteristics are described below.

Climate

Puyallup is located in the greater Puget Lowlands of western Washington. This area surrounding Puget Sound has a maritime climate with cool winters, dry summers, and a distinct rainy season through fall and spring. Precipitation in the Puget Lowlands varies considerably because of the effects of mountains. The Puyallup area receives on average between 37 and 42 inches of rain per year, with approximately 70 percent of the precipitation falling between October and March (Jones, M.A. et al., 1999). Precipitation volumes generally increase in association with higher elevations in the watershed. Annual precipitation at Mount Rainier is reported between 80 and 105 inches (Upper Puyallup Watershed Committee, 2002). Winds are generally from the southwest during the rainy season and from the northwest during the dry summer months. These conditions generally result in greater volumes of flow and seasonal flooding in the Puyallup River. Peak flow events are typically driven by storms during the rainy season and, at times, in conjunction with spring snow melt in the upper watershed.

Topography

Elevation in the Puyallup watershed ranges from sea level at the mouth of the Puyallup River in Commencement Bay to the summit of Mount Rainier at approximately 14,411 feet above sea level. The watershed consists of three principal physiographic provinces: 1) mountains occupy the eastern half of the watershed; 2) the western half of the watershed includes upland terraces divided by major rivers; and 3) the rivers and their associated lowland valleys (Upper Puyallup Watershed Committee, 2002).

Topography in the vicinity of Puyallup consists of a broad lowland floodplain along the Puyallup River and the White River (Figure 4). Upland plateaus lie to the north and south/southwest of the Puyallup River floodplain. Relatively steep slopes are located between the upland plateau and lowland floodplain. The floodplain bordering the Puyallup River lies at 50 feet above sea level or lower, and is relatively featureless except for minor swales that are remnants of former Puyallup River meander channels.

The upland plateau is a broad area with relatively low relief lying largely between elevations of 400 to 500 feet above sea level. The upland plateau is bounded to the north and east by moderately steep to very steep slopes that descend to the Puyallup River floodplain below. Stream channel orientations in this area are strongly controlled by the upland landforms, discussed further under Geology and Soils below. The upland ground surface has numerous closed depressions, some occupied by small lakes and poorly drained areas.

Geology and Soils

Geology of the Puyallup Watershed is the product of mountain building, volcanic activity, glaciation, and post-glacial alluvial deposits (Lower Puyallup Management Committee, 1992; Upper Puyallup Watershed Committee, 2002). Outcrops of volcanic and sedimentary bedrock are concentrated in the eastern portions of the upper watershed. Soil mapping is limited in the upper watershed. Elsewhere in the watershed, bedrock is buried by sequences of glacial till and outwash materials, mudflow deposits, and alluvium with various overlying soils (Upper Puyallup Watershed Committee, 2002).

The Lower Puyallup Watershed lies within the southern portion of the Puget Lowlands, an elongated basin bordered by the Cascades and Olympic Mountains. Glaciers have advanced south from British Columbia into the area six or more times in the past 2 million years. Each glacial advance may have deposited a sequence of fine-grained lacustrine deposits, outwash sand and gravel, and till. Each of these deposits may have been partially to completely eroded in places by subsequent glaciations or erosion during interglacial periods.

The topography and near-surface geology in the Lower Puyallup Watershed are largely the product of the last glaciation (known as the Vashon Stage of the Fraser glaciation), which receded from the area about 15,000 years ago. The Vashon glaciation left a layer of till and recessional sand and gravel deposits that mantle the upland plateau south of the Puyallup River. The till and recessional deposits overlie Vashon outwash sand and gravel, and older glacial and nonglacial deposits that overlie bedrock at great depths.

The Puyallup River lies in a deep valley cut into the glacial till. The valley is a former arm of Puget Sound that has been filled with fluvial sediments since retreat of the last glaciation. Sediment filling the valley includes ordinary alluvium and overbank flood deposits as well as lahar (mudflow) deposits originating from the flanks of Mount Rainier. One such lahar is the Osceola Mudflow, which occurred approximately 5,700 years ago and extended the valley fill seaward, forming the present tide flat area at the mouth of the Puyallup River (Brocher et al., 2004). The large volume of sediment from lahars filled and altered the Puyallup River channel.

As a result of glacial activity, alluvial soils are found in the river valley. Soil units in the valley consist of silt loams, fine sandy loams, and loams. Gravelly loams and gravelly sandy loams are found on the valley walls and plateaus.

Aquatic Resources

Rivers and Streams

The Puyallup River watershed is subdivided generally into the Upper and Lower Puyallup Watersheds. Major tributary systems include the White River, Carbon River, and South Prairie Creek (tributary to the Carbon River). The Upper Puyallup River watershed makes up three-quarters of the entire watershed and is dominated by forest cover. It extends generally from Orting east to the Cascade Mountain crest and southeast to the peak of Mount Rainier. In contrast, the Lower Puyallup River watershed is generally located in the Puget Lowlands and is significantly urbanized (Upper Puyallup Watershed Committee, 2002). The Lower Puyallup River watershed includes the Cities of Buckley, Puyallup, Sumner, Bonney Lake, Edgewood, Fife, Milton and portions of Auburn, Tacoma, and Federal Way. The mouth of the Puyallup River is heavily urbanized and modified at Commencement Bay.

The Puyallup River watershed (WRIA 10) is subdivided into 12 drainage basins. The City of Puyallup is located within three of the drainage basins in the Lower Puyallup River watershed. The eastern portion of the City and its UGA are situated within the Mid-Puyallup River basin. The western portion is situated in the Clear/Clarks Creek basin. A portion of the City north of the Puyallup River lies within the Hylebos Creek basin and drains to the northwest.

In the City, surface water flow is generally to the northwest with the flow of the Puyallup River. There are several tributary streams that flow to the Puyallup River through the City's UGA. Most streams draining the upland plateau are relatively short and flow directly to the floodplains below, where they commonly flow in constructed channels or ditches to either the Puyallup River or Clarks Creek. Tributary streams include Wapato Creek; Wildwood Creek; Deer Creek; Clarks Creek and its tributaries Woodland Creek, Diru Creek, Rody Creek, Meeker Creek, Silver Creek; and smaller unnamed streams. The UGA also includes the Potholes, an area without obvious external drainage at the southernmost portion of the upland. Clarks Creek flows to the north from the upland plateau to its confluence with the Puyallup River at RM 5.8. Clarks Creek originates from groundwater surfacing at Maplewood Springs. A portion of surface water carried by these smaller streams infiltrates and flows downgradient within the floodplain deposits of the Puyallup River. Wapato Creek is the one stream that does not originate on the uplands within the Puyallup River basin and instead flows within the Puyallup River floodplain, north of and parallel to the larger river. Wapato Creek may flow within a former historic channel of the Puyallup River.

Wetlands

At a watershed scale, wetlands are concentrated in the Lower Puyallup River watershed where topography is relatively flat and the gradient is low. Mapped soil units classified as poorly drained or hydric can be used to approximate the extent of potential or historic wetlands. In the lower watershed, areas of Buckley loam, Dupont muck, Norma fine sandy loam, and Bellingham silty clay loam represent the largest areas of poorly drained, hydric soils. The largest concentration is an extensive area of Buckley loam found southeast of Lake Tapps in the Lower White River basin.

Wetlands in the City of Puyallup were identified and mapped by Parametrix in the *City of Puyallup Shoreline and Critical Areas Inventory* (Parametrix, 2003). Most of the wetlands identified in the inventory and classified as "palustrine" or freshwater wetlands according to the Cowardin wetland typing system (Cowardin et al., 1979) were also considered to be "depressional" using the hydrogeomorphic (HGM) classification system. The HGM approach is based on the position of the wetland in the landscape (geomorphic setting), the hydrologic source of water, and the flow and fluctuation of the water once in the wetland (hydrodynamics). Depressional wetlands are those that form in topographically low-lying areas without natural outlets or with constrained outlets. While the majority of the wetlands in the watershed are depressional wetlands, some riverine wetlands and slope wetlands are present. The City wetland mapping does not classify wetlands as depressional or by other HGM categories. The mapping does not classify wetlands by the Cowardin wetland system either. Instead, wetlands are displayed as "field-verified" or "unverified."

Depressional wetlands are present in the northeastern portion of the City and UGA (and south of the Puyallup River) as well as at the base of the steep valley walls. Depressional wetlands also occur on the plateau in the southern portion of the City and UGA.

Riverine wetlands are associated with a stream or river that frequently experience overbank flooding. Riverine wetlands are found along Clarks Creek and within the levees along the Puyallup River. Many of the wetlands behind the Puyallup River levees are functionally depressional because their connections to the riverine systems have been disrupted.

Few slope wetlands are present in the watershed. Slope wetlands, which typically occur on hills or valley slopes, result from side slope seepage or groundwater expression. Within the City of Puyallup, slope wetlands occur as seeps and springs on the steep slopes between the valley floor and the upland plateau to the south.

Land Cover

Historically, vegetation within the Puget Lowlands was coniferous forest, marsh, wetland, and other native habitat types. Vegetation is currently dominated by Douglas-fir forests with western hemlock and redcedar as the primary late-successional species. Oregon white oak, Pacific madrone, big-leaf maple, and red alder forests are other frequent components of the landscape (WDNR, 2003). Other special habitats within the region include wetlands, riparian areas, bogs, and estuaries.

Within the Lower Puyallup River watershed, vegetation existing today is largely a function of the type and degree of agricultural, residential, and commercial development. Little natural vegetation remains in the lowland as the floodplain has been extensively farmed or developed in light industrial or business, and low- to high-density residential development.

Within the City's UGA, the uplands have been developed and natural vegetation has been altered in many areas but is still present in some areas. The areas preserving the greatest amount of native vegetation are the steeper slope between the upland and lowland areas, including the steeper slopes along the upper reaches of Clarks Creek, and in open space areas, including parks .

Cottonwood trees are the primary native tree species remaining in the floodplain. Native vegetation in undeveloped or less developed areas of the upland and steep slope areas comprise trees, such as Douglas-fir, western redcedar, western hemlock, big-leaf maple, and red alder. Western redcedar, once dominant in river floodplains, now occurs less commonly. Common upland understory plants include salal, ferns, Indian plum, Oregon grape, elderberry, oceanspray, salmonberry, and snowberry. Native vegetation in riparian corridors is concentrated in undeveloped strips of land along Clarks Creek and the Puyallup River and in, or adjacent to, abandoned meander channels of the Puyallup River.

Non-native plant species, such as Himalayan blackberry, cut-leaf blackberry, Scot's broom, and reed canarygrass, are also present within the forested habitats. Vegetation present in developed areas may include native plant species, but ornamentals or landscaping varieties are more prevalent.

Land Use

Approximately 96 percent of the Upper Puyallup River watershed consists of publicly and privately held forestland. Predominant activities are logging and recreation. Of those forestlands, 57 percent is in private ownership; 14 percent is in the Mount Baker/Snoqualmie National Forest; and 25 percent is in Mount Rainier National Park. The western portions of the upper watershed contain agriculture and rural/suburban residential development (Upper Puyallup Watershed Committee, 2002). At the time the Lower Puyallup Watershed Assessment was developed (1992), the predominant land uses upstream of the City of Puyallup were vacant forestland and agriculture, while the City and its surroundings were dominated by residential and agricultural uses, with commercial uses concentrated in Puyallup (Lower Puyallup Watershed Management Committee, 1992).

The predominant land use in and around the City of Puyallup is residential. Residential uses constitute 51 percent of the City's urbanized area and 66 percent of the unincorporated urbanized area. Most of the residential area in the UGA is dedicated to low-density single-family uses. Table 2 provides a summary of current land use in the Puyallup UGA, based on the City of Puyallup's Comprehensive Plan (City of Puyallup, 2004) and data from the Pierce County Assessor and Treasurer.

Table 1. Existing Land Use, Puyallup UGA

Category	Acres	Percent
Residential	6,499	54.2
Open Space (vacant, parks, fair & unbuildable critical areas)	2,214	18.5
Industrial (manufacturing, light manufacturing & business/industrial park)	1,605	13.4
Commercial (retail, office)	871	7.3
Agriculture	805	6.7
Total	**11,994**	**100**

Source: City of Puyallup Comprehensive Plan, 2004

4. RELATIONSHIP OF ECOSYSTEM-WIDE PROCESSES TO SHORELINE FUNCTIONS

A number of key ecosystem processes work in concert to maintain aquatic ecosystems. Alterations or land use activities that occur across the landscape can affect ecosystem-wide processes and shoreline functions. Much watershed planning and assessment work has been conducted in the Puyallup River basin. A review of this work is useful in understanding the condition of the City's shoreline resources and identifying activities that influence those conditions but which may be beyond the City's jurisdiction and regulatory authority.

Overview of Key Processes

The processes that form and maintain the Puyallup River and its tributary systems are focused on hydrology (i.e., the quantity and timing of surface flow and groundwater flow characteristics). The movement of water and the hydrogeologic characteristics that control flow drive the input and distribution of sediment, water quality processes (influence of nutrients, toxins, and pathogens), and the input of large woody debris (Stanley et al., 2005). These processes and the factors and mechanisms that control them are discussed below. Geographic areas that are important in maintaining these processes are discussed at the watershed scale generally, and more specifically in the vicinity of Puyallup or throughout the City's UGA.

Processes occurring at a landscape or watershed scale form, maintain, or influence shoreline ecological functions. Examples of shoreline functions include habitat structure, nutrient removal, and vegetation (which provide temperature control and organic inputs). Changes in land use patterns and development across the landscape, not solely at the river's edge, may change these processes and alter shoreline functions. Alterations in the Puyallup River watershed and in the City's UGA and their effects on shoreline functions are discussed in the following section called "Major Alterations to Key Processes."

Hydrology – Surface and Groundwater Flow

Water naturally enters a watershed through rain, snow, or movement of groundwater. Water moves within a watershed by surface water flow in rivers and streams, infiltrates and becomes groundwater, or is stored in wetlands, lakes, and floodplains. In a natural system, the movement and storage of water is generally controlled by physical conditions such as climate (precipitation patterns and volumes), topography (gradient), land cover (vegetation) and the permeability or infiltration capacity of soils and the underlying surficial geology (Stanley, et al., 2005).

Important areas for hydrologic processes include:

- Recharge areas with high amounts of precipitation and rain-on-snow zones provide delivery of water;
- Areas with high permeability provide groundwater recharge;
- Saturated areas or areas with low permeability provide overland or shallow subsurface flow;

- Lakes, low-gradient floodplains, depressional wetlands, and groundwater recharge and discharge areas provide surface water storage; and
- Topographic slope breaks or contact areas between geologic deposits of differing permeability provide groundwater discharge (i.e., return to surface flow) (Stanley, et al., 2005).

Hydrologic processes influence the following shoreline functions:

- Quantity and timing of flow affects hydrologic functions such as channel incision and flood storage;
- Quantity and timing of flow affects instream habitat functions such as channel complexity and habitat availability; and
- Groundwater flow affects hydrologic and hyporheic functions such as baseflow and temperature, as well as habitat and vegetation functions related to species diversity. Groundwater flow affects these functions in both riverine and wetland ecosystems.

General groundwater and hydrology in the vicinity of Puyallup are described in Walters and Kimmel (1968). Surface and groundwater are also documented in the reports *City of Puyallup Storm Drainage Basin Modeling* (KCM, 1996) and *City of Puyallup, Shoreline and Critical Areas Inventory* (Parametrix, 2003).

Most of the precipitation that provides water to the Puyallup River watershed originates in the upper portions of the watershed. Peak rain-on-snow events occur typically in spring when snowmelt coincides with rainfall storm events. These events produce large quantities of water to the river systems and can cause flooding and landslides. Peak rain-on-snow zones generally correspond to elevations ranging from 2,000 to 3,000 feet in the upper portions of the watershed (WDNR, 1991). Average annual rainfall is reported at 70 inches at the Electron Diversion Dam, compared to 40 inches in the City of Puyallup (Kerwin, 1999).

Surface water in the Puyallup River watershed flows generally from Mount Rainier northwest toward Commencement Bay. Precipitation falling within the watershed is conveyed directly to small lakes, ponds, streams, and rivers by surface runoff, or water travels subsurface as groundwater flow. Water that is unable to infiltrate travels downslope across the ground surface as sheetflow. Small amounts of rainfall soak into the ground, but during heavy rainfall, the ground quickly becomes saturated thus inhibiting further infiltration. Dams on the upper Puyallup and White Rivers affect surface water flow volumes, downstream flow durations and frequencies, and transport of sediment and wood to downstream areas. However, periodic flooding occurs in the Lower Puyallup River watershed due to rainy wet season cycles, as in much of the Puget Lowlands, when large storm events pass through the area.

As described earlier, the Vashon and older glacial and sedimentary deposits in the vicinity of Puyallup form a sequence of sand and gravel layers separated by finer grained layers of clay and silt or tight, well-graded soils, which are exposed in places along the steep slopes that lie between the upland plateau and the lowland floodplain. The Vashon and older deposits comprise several aquifers and aquitards within the subsurface. These interspersed permeable and impermeable layers control subsurface water movement from the upland to the lowland (Walters and Kimmel, 1968). Water that infiltrates into the ground generally flows downward until impeded by less permeable soils and then flows laterally to a body of water or to a slope face where it may emerge as springs or seeps on the hillside. A portion of the groundwater, however, will percolate downward through lower-permeability soils, recharging underlying aquifers. Springs discharge along the steep slopes at the edge of the upland plateau area, primarily from Vashon Advance outwash, which underlies the Vashon till, and recessional outwash, which overlies the till (Jones et al., 1999).

Lodgment till from the Vashon glaciation mantles much of the upland area but is generally absent from the steeper slopes at the edge of the upland and in the lowland. Lodgment till is an unsorted mixture of sand, gravel, silt, and clay deposited at the base of a glacier that has been compacted to a very dense state by the great weight of the overriding ice. This type of till has very low permeability and typically acts as an aquitard, restricting the downward flow of groundwater and reducing recharge of deeper aquifers. Till occurs at or very near the ground surface where strong north-south ridges and swales were left by the passage of glacial ice. Such areas are evident west and southwest of the Puyallup City boundary (west of Fruitland Avenue). Surface runoff in this portion of the upland is likely to be rapid, with very little infiltration of precipitation.

Large areas of the upland in the Puyallup vicinity are underlain by a veneer of recessional outwash and ice contact deposits that cover the till below. These deposits allow infiltration, control subsurface flow, and localize the ponding of water and wetland formation on the upland surface.

Ice contact deposits were created during stagnation and melting of the ice sheet. These deposits consist of sand and gravel, similar to recessional outwash, but are more variable and often contain lenses of very silty material, till, and lacustrine silt and clay, which impede infiltration and groundwater flow. Such ground has an irregular surface and may be marked by closed depressions. These areas are concentrated in the southeast portion of the upland in the Puyallup vicinity. Water infiltration and subsurface flow within these deposits are variable, and water is commonly ponded in closed depressions.

Natural surface and groundwater flow paths from the base of the steep slope out into the floodplain have been altered or disrupted by constructed levees along the Puyallup River, by culverts, and by drainage ditches. Such constructed features disrupt hyporheic flow, which is subsurface water that travels in more permeable soils below or adjacent to river or stream channels. Former channels of the Puyallup River or its tributaries may influence hyporheic flow because more permeable soils commonly lie within the former channels. These former channels were abandoned as the river or stream suddenly changed locations. Sudden channel shifts (avulsions) are a natural stream process, but are also associated with the rapid influx of large amounts of sediment, such as from lahars flowing down the Puyallup and White Rivers. Former channels were also created during the straightening of the Puyallup River channel in 1908 (Parametrix, 2003). Locations of former channels of the Puyallup River and Wapato Creek and Clarks Creek are visible in places and partially delineated by soil series mapping (SCS, 1979).

Under natural conditions, important areas for water storage in the vicinity of Puyallup's UGA include the floodplain and wetlands. Poorly drained soils generally correspond to hydric soil units. These areas approximate the extent of potential wetlands under natural conditions. Areas of Bristcot loam, Snohomish silty clay loam, Shalcar muck, and Semiahmoo muck at the base of the upland plateau slope and across the valley floor may have provided important storage for surface water. Historic river channel mapping of the Puyallup River from 1895 indicates that the Puyallup River was much more sinuous prior to channelization in the vicinity of Puyallup (Kerwin, 1999). At that time, the natural floodplain would have been much broader than it is today, and would have been important for surface water storage during peak flow events.

Sediment Delivery

Sediment is naturally delivered to river systems through three primary processes: surface erosion (from overland sheet flow in upland areas), mass wasting (landslides), and in-channel erosion (eroding banks or streambeds). The delivery, movement, and storage of sediment is largely driven by hydrology and generally controlled by physical conditions such as topography (gradient), land cover (vegetation), soil characteristics (erodibility), and the transport capacity or velocity of moving water (Stanley, et al., 2005).

Important areas for sediment delivery and movement include:

- Steep slopes with erodible soils provide sediment input through surface erosion or landslide (mass wasting) events;
- Natural or unconfined channels move sediment by eroding cut-banks and/or depositing point bars; and
- Lakes, depresssional wetlands, floodplains, and depositional channels provide sediment storage (Stanley, et al., 2005).

Sedimention influences the following shoreline functions:

- Sediment delivery affects hydrologic and hyporheic functions such as channel morphology and hyporheic exchange; and
- Sediment delivery affects instream habitat functions by maintenance, loss, or homogenization of habitat availability. That is, sediment delivery is a natural process but too much sediment input can adversely affect habitat.

At a landscape or watershed scale, most sediment processes that influence conditions in the Puyallup River are driven by conditions in the upper watershed. Glacially fed rivers in the Puyallup River watershed are naturally high in suspended sediment. The combination of large flow volumes, glacial action, high gradient, and erosion of materials deposited by volcanic mudflows results in very high volumes of suspended sediment in the Puyallup and White Rivers (Upper Puyallup Watershed Committee, 2002). Natural sources of sediment delivery may include lahars (such as the Osceola mudflow), landslides, and avulsions, which provide large amounts of sediment rapidly. Soil mapping by NRCS and the Washington Department of Natural Resources Forest Practices Division indicates important areas for sediment inputs in the Puyallup River watershed. These include areas with high mass wasting potential, unstable slopes, and areas with high erosion potential. These areas are most extensive and most concentrated in the upper portions of the watershed. Dams in the upper watershed store or impound sediment that would be transported downstream under natural conditions.

Across the City's UGA, important areas of potential sediment sources include steep slopes with erodible soils and/or identified erosion or landslide hazard areas. Critical erosion hazard areas are lands underlain by soils identified by the NRCS as having "severe" or "very severe" erosion hazards. These include, but are not limited to, the following group of soils when they occur on slopes of 15 percent or greater: Alderwood gravelly sandy loam; Indianola gravelly loam; Kapowsin gravelly loam; Kitsap silt loam; and Xerochrepts (PMC 21.06.020). Landslide hazard areas occur when the combination of slope inclination and relative soil permeability creates susceptibility to landsliding (PMC 21.06.220). Erosion and landslide hazard areas are generally concentrated along the transition between the upland plateau in the southern half of the City and the Puyallup River valley floor. Several streams that drain across this boundary, including the upper reaches of Clarks Creek, have the potential to erode streambanks where these conditions exist.

The majority of the Puyallup River shoreline is mapped as having slopes steeper than 15 percent, due to the presence of man-made levees and dikes. While the banks of these levees and dikes are typically steep enough to create landslide hazards, the underlying soil conditions would indicate these areas are of only moderate landslide risk.

Landslide hazard areas along Clarks Creek are limited in geographical extent to the uppermost reaches, south of 15th Avenue SW. There are mapped steep slopes in this area underlain by Kitsap silt loam, which would indicate this area is at high risk for landslide activity. There are several areas extending north from Stewart Avenue toward the mouth that are mapped as having 15 to 40 percent slopes. Soils in these areas consist primarily of Puyallup fine sandy loam and Sultan silt loam, which would put these areas at a moderate to high risk for landslide activity. These areas would represent important areas of potential sediment sources to Clarks Creek.

Land use development and other uses can also result in sediment input to waterbodies. Surface runoff from agricultural land can erode soils and deliver sediment to receiving waterbodies. Vegetation clearing associated with urban development can result in erosion temporarily during construction activity if not properly managed or more long-term if exposed soils are not replanted. Uncontrolled or under-controlled stormwater runoff from impervious surfaces may also result in increased volumes and peak flow rates during storm events, which can erode stream banks or scour channels of receiving waterbodies.

Water Quality

There are many processes at work that maintain or affect water quality in a watershed. This report focuses on the movement of phosphorus, toxins, nitrogen, and pathogens. Key processes include biotic uptake and decomposition, adsorption, and denitrification. These processes are largely driven by the movement of water and sediment, and they are generally controlled by physical characteristics such as biotic cover and composition, soil characteristics, and bacterial activity (Stanley, et al., 2005).

Important areas for water quality related processes include:

- Depressional wetlands with organic, mineral, or clay soils provide adsorption of phosphorus, toxins, and pathogens (fecal matter);

- Depressional wetlands can both provide nitrogen (nitrification) and remove nitrogen (denitrification);
- Riparian areas with a consistent supply of shallow groundwater provide denitrification; and
- Headwater streams and wetlands can provide biotic uptake and decomposition, and/or adsorption of nitrogen (Stanley, et al., 2005).

Water quality processes influence the following shoreline functions:

- Delivery and storage of nitrogen, phosphorus and toxins, and pathogens affect hyporheic and vegetation functions such as denitrification and nutrient cycling. Habitat functions such as invertebrate abundance and diversity, and food sources for fish, are also affected; and
- Delivery of nitrogen, phosphorus, and pathogens affects these functions in both riverine and wetland aquatic ecosystems.

In addition, the function of pathogen transport affects water quality. High-permeability geologic deposits allow subsurface transport of pathogens while low-permeability deposits retain pathogens via slower subsurface flow velocity. The survival and transport of pathogens depends on the depth of groundwater, water content, and hydrology of the area. Higher temperatures kill pathogens and longer distance to groundwater filters pathogens.

At the watershed scale, important areas for water quality processes are concentrated in the lower portions of the watershed. Under natural conditions, these lower gradient areas would provide surface water storage and nutrient cycling and removal. In the vicinity of the Puyallup UGA, these areas would generally correspond to those areas important for surface water storage and hyporheic exchange. As described in the bullets above, the extent of historic wetlands can be approximated by the mapped extent of poorly drained or hydric soil units. Within the City's UGA, these are mostly concentrated on the valley floor. The extent of the hyporheic zone generally corresponds to areas of alluvium or advance glacial outwash in the historic floodplain, which are also concentrated on the valley floor. Finally, areas that provide groundwater recharge are generally concentrated in the southeast portion of the upland area as described in the bullets above.

Large Woody Debris and Organics

Large woody debris (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 influencing stream morphology by changing the pattern of flow and associated habitat characteristics (e.g., pools and riffles). Riparian vegetation is the key source of LWD. Large woody debris 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), bank erosion, wildfires, or volcanic eruptions (Stanley, et al., 2005).

Important areas for LWD delivery and movement include:

- Channel migration zones where unconfined channels allow streambank erosion and associated delivery of LWD;
- Forested mass wasting or landslide hazard areas deliver LWD during slide events;
- Forested areas adjacent to aquatic resources can provide LWD via windthrow; and
- Low-gradient channels (less than 4 percent slope) provide storage of LWD and organic material, subject to the transport capacity of water (flow velocity) (Stanley, et al., 2005).

The presence, movement, storage, and decomposition of LWD influence the following shoreline functions:

- Delivery of wood and organics affects vegetation and habitat functions such as instream habitat structure (pools and riffles), species diversity, and fish distribution and productivity; and
- Riparian vegetation, especially 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 wildlife species.

Historically, the upper portions of the Puyallup River watershed were important for LWD recruitment and movement. The lower portions of the watershed, characterized by lower gradients and broader floodplains, and coniferous riparian habitat, would have been important for LWD recruitment, as well as storage and accumulation. Within the City's UGA, important areas for LWD historically included forested riparian corridors along the Puyallup River and tributary streams. Additionally, landslide-prone areas adjacent to the river or tributary streams would have been important for delivery of LWD.

Major Alterations to Key Processes

The condition of shoreline functions is a product of alterations to an ecosystem at both the watershed scale (such as deforestation and increased impervious surface) and at the immediate shoreline (such as construction of levees, roads, bulkheads, and removal of riparian vegetation). Key processes that maintain aquatic ecosystems in the City of Puyallup have been altered. Alterations to the landscape and to key processes are driven by land use activities. Current shoreline conditions are the product of both historic and current land use throughout the watershed and in the City of Puyallup. Historic alterations and current activities in upstream portions of the Puyallup River watershed cannot be addressed directly under City of Puyallup shoreline regulations. Nonetheless, understanding alterations to ecosystem-wide processes is important in assessing shoreline ecological functions.

Historic development of the Puyallup watershed has been well documented through watershed planning efforts (Kerwin, 1999; Lower Puyallup Watershed Management Committee, 1992; Upper Puyallup Watershed Committee, 2002). Throughout the late 19th and 20th centuries, alterations to the Puyallup River coincided with forest clearing, forest road construction, agricultural development, railroad building, dam building, and urbanization in the basin. Extensive urban development, heavy industry, a large modern marine port at Commencement Bay, an extensive revetment and levee system, and agriculture have combined to significantly alter the natural landscape along the river. Existing land use patterns in the watershed and in the

City of Puyallup described earlier are the legacy of this historic development. Increased urbanization, particularly in the lower watershed, is expected to occur in the future. This may include the conversion of agricultural or forested land to roads, housing, and commercial development. In this context, past and ongoing land use activities are described below as they relate to each key process.

Hydrology - Surface and Groundwater Flow

Significant alterations to hydrologic processes at a watershed scale include construction and ongoing operations of dams and diversions and forest harvest practices in the upper watershed, channelization and urbanization in the lower watershed, loss of wetland and floodplain storage in the lower watershed, and groundwater withdrawals throughout the watershed.

Flow volumes in the upper watershed have been altered by a reduction in forested land cover and by construction of dams and diversions on the Puyallup and White Rivers. Removal of forest cover and native vegetation during logging and the existence of a dense network of forest roads reduce the upper watershed's ability to process and store water, resulting in increased runoff and peak flows. At the same time, dams and diversions control and reduce peak surface water flows in the upper watershed. Two hydroelectric dams (Electron Dam on the upper Puyallup River, and the Lake Tapps Hydroelectric Project on the White River), as well as an extensive system of levees, dikes, and revetments, were completed shortly after 1900. In 1906, the White River was diverted into the Puyallup River, nearly doubling the flow in the lower Puyallup (Kerwin, 1999). In an effort to control flooding in the lower Puyallup, the U.S. Army Corps of Engineers completed the Mud Mountain Dam on the White River in 1948. The capacity of the diversion at Electron Dam is approximately 300 cubic feet per second (cfs), but an agreement between Puget Sound Energy and the Puyallup Tribe establishes minimum instream flows between 60 and 80 cfs (Upper Puyallup Watershed Committee, 2002). The Lake Tapps Hydroelectric Project is no longer in service Puget Sound Energy decided to not renew its hydroelectric license from the Federal Energy Regulatory Commission. PSE still owns the lakebed and the surrounding system of dikes and diversion infrastructure. It is anticipated that lake levels would be maintained in summer and White River water would continue running down PSE diversion flumes and canals into Lake Tapps. Long-term changes may include use of diversion facilities to support potable water supply by other utilities (Einstein, W., personal communication).

Based on USGS gages on the Puyallup River, there has been a continuous decline in low-flow volumes (Kerwin, 1999). Although the source of declining flows has not been quantified or carefully examined, it can be attributed at a watershed scale to increased demand for groundwater withdrawals through unregulated wells (5,000 gallons or less a day) and increased impervious surface which limits groundwater recharge and base flows (Kerwin, 1999).

In the lower watershed and in the vicinity of Puyallup, the effects of urbanization and channelization have significantly altered hydrologic processes. Loss of natural vegetation and increased impervious surfaces have altered surface water flow, increased stormwater runoff, and reduced infiltration for groundwater recharge and hyporheic flow.

Impervious surfaces prevent water from infiltrating into the soil, reducing the flow path and flow time. This results in increased peak flows and velocities and the loss of hyporheic flow. Runoff will flow very quickly over impervious surfaces, thereby changing the flow dynamics in local rivers and streams. Impervious surface estimates are not available at the watershed scale. Generally, the Upper Puyallup River watershed has relatively low impervious surface, while the greatest amount of impervious surface is found in densely urbanized portions of the Lower Puyallup River watershed such as Tacoma and Puyallup.

In the Puyallup City limits and UGA, developed areas on the plateau and in the valley bottom have greater areas of impermeable surfaces and less vegetation to intercept precipitation, resulting in less infiltration and greater surface runoff. Where impervious surfaces coincide with alluvial or glacial outwash soils, less infiltration results in a loss of recharge to underlying aquifers that would be expected under natural conditions. Groundwater flow within the floodplain has been altered by development and increased impervious surface, resulting in disrupted interactions between the riverine ecosystems and the hyporheic zone. Previous studies estimated the "effective impervious area" (EIA) within the City and its UGA as approximately 18 to 28 percent. Future EIA is projected to be approximately 27 to 43 percent by 2010 (KCM, 1996; Parametrix, 2003). EIA is defined as impervious area directly connected to a stream or drainage system.

Ditching and channelizing streams within the City of Puyallup has also increased the rate of surface flow and reduced the opportunity for surface water to infiltrate. Ditching and channelization have also eliminated much of the biological and physical structure of the streams, resulting in impaired habitat functions. Most of Clarks Creek downstream of its headwaters has hard armoring (bulkheading) that channelizes its flow.

Surface water storage has been altered throughout the lower Puyallup River watershed, including the City of Puyallup, by the loss of historic wetlands and floodplain areas. Construction of levees along the Puyallup River has limited the lateral flow of surface water from the river to its historic floodplain. Connectivity between the Puyallup River and its floodplain wetlands and other floodplain areas has been eliminated, resulting in a reduction in opportunity for overbank flooding. Loss of overbank flooding prevents the opportunity for floodplain deposition, which is related to increased water quality and fertile soils. The loss of wetlands and floodplain areas has a direct impact on salmon species that use such areas for rearing and refugia. Channelization of the river has also increased peak flow velocities and disrupted habitat functions. Increased velocities combined with a lack of LWD recruitment or storage have limited in-channel habitat structure and complexity, thus eliminating refugia and spawning habitat for salmonids. Fast flowing floodwater also causes sediment to stay in the river channel. This creates a potential aggradation problem downstream and in Commencement Bay.

Wetlands store excess surface water from storm events. Due to urbanization, much of the historic wetland habitat has been altered within the City. Few wetlands exist in the river valley west of SR 512, because of heavy development and past agricultural uses. Mapped areas of hydric soils (SCS, 1979) approximate the historical extent of wetland in the vicinity of Puyallup . However, much of the area mapped as hydric soil has been developed and is not currently wetland. Wetlands temporarily store water, and they provide water recharge and discharge functions. Wetlands slow the runoff of surface water, allowing greater amounts of water to infiltrate. Wetland loss in the vicinity of the City has resulted in loss of storage area that might function to moderate peak storm flows and recharge groundwater.

Sediment Delivery and Removal

Development in the watershed has altered the process of sediment delivery and transport. In the upper watershed, harvesting timber, mining, and road building can increase potential sediment sources from landslides and surface erosion. At the same time, flood control dams impound sediment, restricting natural transport processes. In the lower watershed, converting forest vegetation to agricultural land and loss of vegetation on erosive slopes can increase sediment inputs. Increased levels of fine sediments can affect habitat functions by eliminating spawning habitat (which requires gravel substrate). Salmonid use of the lower mainstem Puyallup River is largely restricted to migration and rearing along some portions of the river (Kerwin, 1999).

Channelizing the Puyallup River and tributary streams has accelerated sediment transport processes as a result of increased peak flows and the reduction of available overbank flows. Additionally, reduction of LWD, in-channel structure, and off-channel habitat has reduced the sediment storage capacity of the river.

Throughout most of the 20th century, dredging in the lower watershed generally, and in the lower reaches of the Puyallup River in particular, was used as a means of flood control (Kerwin, 1999; Montgomery, 1991). Between 1974 and 1988, a total of 2.3 million cubic yards of streambed material was removed from the lower portions of the White, Carbon, and Puyallup Rivers (Montgomery, 1991). Significant dredging activity in the Puyallup largely ceased by the early 1990s, and as a result the lower Puyallup River has been aggrading downstream of the City of Puyallup (NHC, 2004). This aggradation has raised the streambed elevation and further increases the potential for flooding.

Water Quality

Impairments to water quality within the waters of the City of Puyallup have a variety of point and non-point sources. Many of these sources may also result from land uses and activities upstream of the City's jurisdictional boundaries. Agriculture, gardening practices, and property development can result in excessive nutrients (nitrogen and phosphorous) entering surface and groundwater, which promote algae growth and too much organic waste in the water. This reduces dissolved oxygen needed by fish. Failing septic systems and livestock are the typical sources of fecal coliform bacteria, which can indicate a risk to human health. Land development, roads, logging, and agriculture increase sediment in streams, cloud the water, and cover aquatic habitat. Although these activities may occur both upstream of the City and within the City's UGA, they both affect water quality in the City's waterbodies.

Within the City's UGA, contributing sources of increased nutrients could include agricultural land, areas using on-site septic systems, and residential lawns immediately adjacent to streams. In addition, stormwater discharged to streams and the Puyallup River can contain contaminants such as heavy metals, oil, grease, and organic compounds.

Loss of depressional wetlands within the watershed has reduced the total area available to take up and store excess nutrients. The lack of connectivity between wetlands and streams due to ditching within the watershed has altered this process as well. Wetlands in urban areas or in agricultural use are often degraded or poorly vegetated and are less able to function in biofiltration of surface waters. This results in a reduction in the wetlands' ability to improve water quality.

Excess nutrients, in the form of fecal coliform, are present in both the Puyallup River and Clarks Creek. Within the Puyallup River, fecal coliform likely comes from developed areas upstream in the watershed (from such sources as rural septic systems and livestock grazing) as well as within the City (from such sources as failing septic systems, livestock, and waterfowl). Initial DNA analysis performed as part of the Clarks Creek/Meeker Creek Total Maximum Daily Load (TMDL) study suggests that waterfowl (ducks and geese) are likely a primary contributor of fecal coliform within the watershed, as opposed to livestock from the nearby fairgrounds, or septic systems (Repp, 2005). This finding is supported by the fact that improvements to the fairgrounds in recent years have included collection and conveyance of stormwater runoff to the sanitary sewer system. Prior to these improvements, untreated runoff drained to Meeker Creek.

Within Clarks Creek, excess nutrients have resulted in prolific growth of waterweed (*Elodea* sp.). This plant impedes water flow through the channel, resulting in overbank flooding of some adjacent residential lots in the spring and summer between DeCoursey Park and W. Stewart Avenue.

The Washington Department of Ecology maintains a 303(d) list of waterbodies where tested pollutants exceed thresholds established by the state surface water quality standards (WAC 173-201A). Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water, such as drinking, recreation, aquatic habitat, and industrial use, are impaired by pollutants. Streams that do not appear on the 303(d) list may fall short of that pollutant threshold, but may not be free of pollutants. In addition, not all streams or all stream reaches are tested as part of this process. Therefore, absence from the 303(d) list does not necessarily indicate that the waterbody is not impaired.

Ecology's 2002/2004 Water Quality Assessment identifies and reports on tested waterbody segments as they relate to state water quality standards for a variety of parameters, including temperature, pH, dissolved oxygen, metals, etc. Waterbody segments are classified as Category 1, 2, 4, or 5. Category 5 waters are polluted waters that require a TMDL study. In November 2005 the U.S. Environmental Protection Agency approved the list of Category 5 waters, which represents the state's 303(d) list of impaired waters. Category 4 waters are polluted but do not require a TMDL study (because a TMDL or pollution control plan is already in place or the waterbody is impaired by a non-pollutant such as low streamflow, dams, etc.). Category 2 waters are considered "waters of concern," where pollution is present but may not violate state water quality standards. Category 1 waters meet tested standards for clean waters, but may not be free of all pollutants.

Table 3 shows the waterbodies within the City UGA that were evaluated for the 2002/2004 Water Quality Assessment and appear on the approved 303(d) list. The Puyallup River, Clarks Creek, Meeker Ditch (not a shoreline of the state), and Wapato Creek (not a shoreline of the state) are included on the list.

Table 2. 2002/2004 Water Quality Assessment in Puyallup, WA

Waterbody	Category Listing	Water Quality Parameter
Puyallup River	5	Fecal coliform; mercury
	2	Dissolved oxygen; turbidity; temperature; lead; mercury; copper
	1	Dissolved oxygen; temperature; pH; lead; mercury; copper; arsenic; cadmium; chromium; zinc; nickel
Clarks Creek	5	Fecal coliform (lower reaches); pH (upstream of Meeker Ditch)
	2	Dissolved oxygen (lower reaches)
	1	Temperature
Meeker Creek	5	Fecal coliform; pH
	2	Fecal coliform; temperature; dissolved oxygen
Wapato Creek	5	Dissolved oxygen; fecal coliform;
	4C	Bioassessment; instream flow
	2	Benzene; fecal coliform

Source: Washington State Department of Ecology, 2005

In the early 1990s, Ecology conducted a TMDL study for the Puyallup River. The TMDL study and clean-up plan established criteria and loading parameters to address water quality issues in the Puyallup River. For point-source pollution, the TMDL is implemented through requirements for water quality of wastewater effluent discharges to the river. These are established as requirements for industrial National Pollutant Discharge Elimination System (NPDES) permits. Following the TMDL study, the City of Puyallup determined that it needed significant upgrades to its wastewater treatment facility to comply with the new NPDES permit requirements. As a result, the City upgraded its wastewater treatment plant. Improvements included increased capacity and improved treatment technology. The project was completed in 2000 and, through its NPDES permit for wastewater discharge, the City is currently in compliance with the pollutant loading parameters established in the TMDL plan (Lange, 2005).

The City is currently working with Ecology on a TMDL study for Clarks Creek and Meeker Creek. The City has completed water quality monitoring and sampling and has drafted a technical report. Bacteria and contamination are the main issues on Clarks Creek, and bacteria, temperature, and low dissolved oxygen are the main issues for Meeker Creek. Ecology will analyze the technical report to establish pollutant-loading thresholds and work with the City to develop a clean-up implementation plan and complete the TMDL for Clarks Creek and Meeker Creek. Development of the TMDL study and clean-up plan is ongoing and may be completed in late 2006 or 2007 (Repp, 2005; McKee, 2005; James, 2006).

According to the City, a municipal garbage dump was located along the Puyallup River near the turn of the century. The dump occupied a 9.7-acre site on the south shoreline of the Puyallup River near the confluence of the Puyallup and White Rivers. The City identified several other historical dumping sites along the Puyallup River shoreline.

Large Woody Debris and Organics

Alteration of riparian areas has occurred most extensively in the Lower Puyallup River watershed. Removal of woody material from the riparian zones and floodplains for residential, commercial, and agricultural development has limited the potential for woody debris being delivered to the Puyallup River and its tributary streams, including Clarks Creek. Additionally, construction of levees and revetments along the lower Puyallup River, as well as roads and trails on the upland side of such structures, has altered riparian vegetation and limited recruitment of woody debris.

The lack of LWD results in a lack of stream structure (such as formation of pools) that is important for instream habitat. LWD can also provide in-channel sediment storage functions. LWD provides food sources and habitat for aquatic insects and wildlife along shorelines. The lack or reduction of LWD, LWD recruitment potential, overhanging vegetation, and functioning riparian habitat in the Lower Puyallup River watershed is considered a limiting factor to the production of salmonids (Kerwin, 1999).

A 1985 legally binding agreement between the Puyallup Tribe of Indians and Pierce County requires that vegetation not be removed from the banks of any river, stream, or gravel bar in the Puyallup River drainage basin unless permitted by the Puyallup River Vegetation Management Program. Prior to the agreement, Pierce County Water Programs maintained a debris removal program, which involved cutting, piling, and burning of riverbank vegetation. Since the early 1990s, the County's removal practices has been limited to select removal work only when the wood debris is found to be of detriment to a flood control structure (Fantello, 2005). Although the density and size of the trees currently present along the Puyallup River within the City is less than what occurred there historically, the agreement encourages greater retention of woody material in the river system to improve fish habitat.

5. SHORELINE PLANNING AREA INVENTORY

The purpose of this section is to inventory and characterize conditions within the approximate boundaries of the City's shoreline jurisdiction in greater detail and in the context of the larger watershed or landscape scale characterization of ecosystem-wide processes. The intent is to inventory elements of the natural and built environment as described in WAC 173-26-201(3)(c). Additionally, this section identifies how existing conditions in the shoreline jurisdiction influence or contribute to alterations of processes that maintain aquatic ecosystems or alter shoreline functions.

Physical Features

Physical features in the shoreline planning area include natural landforms (steep slopes, floodplains, etc.) and structural alterations to the shoreline (bulkheads, levees, etc.). Landform features are shaped by natural processes and may influence or maintain shoreline functions. Alterations or shoreline modifications may affect natural processes and shoreline functions. Both natural features and modifications are related to biological resources (such as wetlands and streams) and land use patterns, which are described in subsequent sections.

Many physical and biological features of the shoreline (e.g., steep slopes, floodplains, wetlands) are subject to development standards or regulations by the City of Puyallup Municipal Code and/or other regulatory requirements. The following discussion focuses on how these features are defined, their location relative to regulated shorelines, and their relationship to shoreline ecological functions.

Geologic Hazard Areas

As described in previous sections, the geologic history and formation of the Puyallup River watershed resulted in landforms within the City of Puyallup that are considered geologic hazard areas, regulated under the City's Environmentally Critical Areas Code (PMC 21.06). These include landslide and erosion hazard areas, seismic hazard areas, and volcanic hazard areas.

Landslide hazard areas are defined in Chapter 21.06.220 of the Puyallup Municipal Code as areas that, due to a combination of slope inclination and relative soil permeability, are susceptible to landsliding. City code defines erosion as a process whereby wind, rain, water, and other natural agents mobilize and transport soil particles (PMC 21.06.220). "Critical erosion hazard areas" means lands or areas underlain by soils identified by the NRCS as having "severe" or "very severe" erosion hazards. As described in the previous section, much of the Puyallup River shoreline itself is mapped as having slopes greater than 15 percent. However, these conditions exist due to the presence of man-made levees and dikes, and the underlying soil conditions would indicate these areas are of only moderate landslide risk. These areas do not contain soils classified as having severe or very severe erosion hazards. The Puyallup River shoreline in the City would not be considered an important area for bank erosion or sediment input to the river.

Landslide and erosion hazard areas along Clarks Creek are located in the uppermost reaches, south of 15th Avenue SW. There are mapped slopes of 15 to 40 percent in this area underlain by

Kitsap silt loam, which would indicate this area is at high risk for landslide and/or erosion activity. There are several areas extending north from Stewart Avenue toward the stream mouth that are mapped as having 15 to 40 percent slopes. Soils in these areas consist primarily of Puyallup fine sandy loam and Sultan silt loam, which would put these areas at a moderate to high risk for landslide activity. Thus the uppermost reaches and lowermost reaches of Clarks Creek may be important areas of potential sediment sources to the stream.

The entire Puyallup River valley floor is generally considered a volcanic hazard area. The topography of the valley essentially forms a channel that would carry mudflows or lahars from Mount Rainier toward Commencement Bay as a result of volcanic activity. Similarly, mapped seismic hazard areas include the entire valley floor, as well as portions of the upland plateau. Seismic hazard areas are defined as those areas subject to severe risk of earthquake damage as a result of seismically induced settlement or soil liquefaction. These conditions occur in areas underlain by non-cohesive soils of low density, usually in association with a shallow groundwater table. All of the Puyallup River and most of the Clarks Creek shoreline planning area are mapped as containing seismic hazard areas due to underlying soil conditions (Pierce County, 2003). The area is underlain by alluvial soils, which puts these areas at a high risk for movement and/or liquefaction during an earthquake event. The uppermost reaches of Clarks Creek, including those areas underlain by sedimentary deposits, are at less risk of liquefaction due to the dense/hard nature of the sediments deposited here, but maintain some risk due to steeper slopes.

Aquifer Recharge Areas

A new section has been recently added to the City's Environmentally Critical Areas Code (PMC 21.06) that addresses protection of groundwater and aquifer resources. Pierce County maps critical aquifer recharge areas (CARA) from a combination of previous studies and mapping. These include all of the mapped extent of the Chamber's/Clover Creek Aquifer, 10-year time of travel zones for wellheads, and areas mapped as having the highest risk of groundwater pollution potential, based on modeling by the County (Pierce County, 2003). The entire Puyallup River and Clarks Creek shoreline planning area occurs within a critical aquifer recharge area as mapped by Pierce County. The aquifer recharge area is relatively large and extends well beyond the shoreline planning area.

Flood Hazard Areas

Flood hazard areas are defined in the Puyallup Municipal Code as "the land in the floodplain within a community subject to a one percent or greater chance of flooding in any given year" (PMC 21.07.030(3)). These areas are typically identified on the Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRMs) as the 100-year floodplain. Because of its hydrologic association, jurisdictions may regulate all areas within the 100-year floodplain for shoreline management under the SMA. Within the Puyallup River watershed, water traveling down the mountainsides travels at a higher velocity until it reaches the lower valley where the stream broadens and velocities slow. It is at this point that sediments begin to fall out of the water column, causing the lateral spread of water and associated flooding.

FEMA has developed draft updates to flood hazard mapping on the Puyallup River. As sediment has been deposited over the years and with no current dredging occurring within the channel, the subsequent sedimentation has raised the streambed elevation and reduced the flood carrying capacity of the river. In other words, if the elevation of the streambed is increased, it is only natural for the water surface to also increase, resulting in an increased flood water level elevation for this lower portion of the river.

Puyallup River

Levees in the shoreline planning area downstream of Meridian Street were designed to contain the 100-year flood event. However, the U.S. Army Corps of Engineers (ACOE) no longer recognizes any levee section along the lower Puyallup River as meeting the 100-year flood protection levels. Levee owners will need to provide ACOE documentation that shows the levees meet design, operation and maintenance standards in order to be considered protected from the 100-year flood event. Until the levees are reviewed the areas downstream of Meridian Street will no longer be primarily mapped as within the 500-year floodplain but as moderate risk areas. The levees will be labeled as Provisionally Accredited Levees. The portion of the Puyallup River between Meridian Street and SR 512 upstream contains approximately 500 feet of shoreline within the 100-year floodplain on the north bank and approximately 1,700 feet of shoreline within the 100-year floodplain on the south bank. The majority of the Puyallup River shoreline planning area upstream of SR 512 lies within the 100-year floodplain (FEMA, 2004; FEMA, 1995). This is related to levees being lower in elevation as well as lack of levees in some areas, especially around the Linden Country Club Golf Course.

Openings in the levees occur in areas where major streams enter the Puyallup River (Clarks Creek and Deer Creek). When flooding occurs in the mainstem Puyallup River, water backs up in Clarks and Deer Creek causing localized flooding near the mouths of these creeks and up to their tributaries within the river valley, including Diru Creek, Woodland Creek, and Meeker Ditch. Smaller streams flowing from the upland plateau to Clarks Creek are also mapped within the 100-year floodplain due to overbank flooding.

Clarks Creek

Clarks Creek is a low-elevation stream deriving the majority of its flow from groundwater sources in the headwaters and surface runoff. Flood events of the Puyallup River generally cause water to back up into Clarks Creek, causing flooding at its mouth and lower sections. As water backs up into Clarks Creek and several of its tributaries, their velocity slows and sediments drop out of the water column causing aggradation of the channel bed. This reduces the streams' overall flow capacity and encourages instream vegetation growth, which can further reduce the water carrying capacity of the channel.

The areas surrounding and within the Clarks Creek subbasin are developing, which translates into additional impervious surface and increased peak flows/reduced base flows. Surface water that is directed to Clarks Creek during high precipitation events is discharged at higher velocities and during a shorter time period than would occur under natural conditions. Less rainfall is now required to cause flooding and the flood stages can be much higher (Lower Puyallup Watershed Management Committee, 1992). Residents in proximity of Clarks Creek have also experienced flooding in the summer that is typically not associated with storm events, but rather the presence of excessive instream vegetation growth. As vegetation grows, the carrying capacity of the stream decreases (water is displaced by vegetation) and can cause flooding. The City currently has a vegetation control program in place to remove this vegetation; however, the work windows are restricted to times when salmonids are least likely to be present within the system, and removal may not occur when needed to alleviate localized flooding (i.e., summer months). Ultimately, increases in stormwater runoff to Clarks Creek may exceed the capacity of the channel to convey flows regardless of the instream vegetation and/or sediment input.

Clarks Creek within the City's shoreline jurisdiction is mapped within the 100-year floodplain upstream from the confluence with the Puyallup River to approximately 15th Avenue SW. This also includes a large area between Meeker Creek and 15th Avenue SW extending eastward to 5th Street SW, and tributary streams within the Clarks Creek shoreline planning area. FEMA is currently remapping the Clarks Creek floodplain. Initial surveys have been completed and draft mapping is being prepared but is not available for inclusion in this report.

Channel Migration Zones

The channel migration zone refers to the area along a river or stream within which the channel can be expected to migrate over time. Local geology, soils, and hydrologic conditions are principal forces driving channel migration. For example, a stream channel that occurs in areas underlain by bedrock or some other erosion-resistant soil would be relatively stable and not subject to channel migration. A stream channel that is underlain by highly erodible soils is more likely to migrate. Channel migration zones are generally greatest where stream channels exit steep terrain onto a broad valley floor. In a natural setting, channel migration zones provide important shoreline ecological functions, most notably aquatic habitat formation. These areas can provide the linkage between terrestrial (riparian) zones and aquatic systems, and regulate the entry of water, sediment, nutrients, and organic material into aquatic habitats (Gorsline, 2001). A method for delineating channel migration zones for the purposes of identifying areas of potential future erosion and to assist with maintenance of natural fluvial processes has been developed by Ecology (Rapp, C. and Abbe, T., 2003).

Puyallup River

The Puyallup River shoreline planning area is not within an active channel migration zone. In its natural state and due to existing underlying geology, the Puyallup River would be expected to have a fairly wide channel migration zone. However, existing flood control projects (dikes and levees) have confined the channel to its present location. This channelization has eliminated shoreline functions that channel migration may have provided in an unaltered state, such as formation of off-channel habitat, large woody debris (LWD) recruitment and storage, flood storage, and sediment delivery and storage.

Clarks Creek

Clarks Creek is essentially a low-gradient stream with a wide floodplain valley deriving most of its hydrology from groundwater seepage. This in combination with highly erodible soils likely created some active channel migration zone within the lower portions. However, bank armoring has reduced the migratory capacity of the stream channel. The channel in the lower portions has also become more entrenched, which also limits channel migration. The only portion of Clarks Creek that maintains limited channel migration capacity is directly below Maplewood Springs. This area remains relatively undeveloped, but the stable hydrology combined with steep gradient limit flooding and sediment transport, and ultimately results in the channel being naturally confined. Shoreline functions provided by channel migration are generally absent in Clarks Creek.

Shoreline Modifications

Shoreline modification refers to structural changes to the shorelines' natural bank. Examples include shoreline armoring (bulkheads, riprap, etc.), overwater structures (dock and piers), or dredging and filling. The following assessment of the extent of shoreline modification is primarily based on the information presented in the *City of Puyallup Shoreline and Critical Area Inventory* (Parametrix, 2003) and the *Clarks Creek Photographic Inventory* (City of Puyallup, 2000).

Shoreline armoring within the City's shoreline jurisdiction is primarily in the form of revetments, dikes, and levees. These structures are typically used to protect upland property from flooding and to retain or stabilize unstable banks. However, shoreline armoring also has adverse effects on the physical processes necessary to maintain native species habitats and shoreline functions. Dikes and levees do not allow stream access to floodplains and thus cut off side channel areas and wetlands that support natural processes and are vital to a number of species. Maintenance of dikes and levees often includes vegetation removal, which can reduce the recruitment of LWD that would facilitate the formation and maintenance of habitat. In addition to the loss of shoreline functions that channel migration would provide (as described above), constrictions to a channel can alter rates of sediment and LWD transport, change sediment composition, change distribution of LWD pieces, and increase flow velocities.

The Puyallup River and Clarks Creek contain man-made channel crossings via roads/bridges and footbridges. Support structures for bridges and other stream crossings, and bridge abutments that are placed within the active stream channel can cause a decrease in stream velocity, thereby increasing sediment deposition upstream of the structure. This can potentially constrict flow in the channel, resulting in localized scouring and erosion of the streambed. If improperly constructed, some instream support structures can cause water to back up upstream of the bridge or crossing and result in localized flooding. Bridges can also restrict wood transport if the bridge is not large enough to allow for wood to naturally pass through. Maintenance of bridges typically results in the loss of wood through the removal of instream wood near abutments.

Puyallup River

The entire reach of the Puyallup River within the City's shoreline jurisdiction has been confined by a system of dikes, levees, and revetments. Pierce County Water Programs is responsible for the bank armoring activities and their maintenance. As described previously, levee maintenance by the County is limited to the removal of wood debris if it is detrimental to the flood control structure. There are five bridges crossing the Puyallup River in the City's shoreline planning area. Most bridges have footings constructed in or on the levees, rather than in the river channel.

Clarks Creek

The lower portion of Clarks Creek contains naturally occurring high banks and does not require levees to protect surrounding areas from flooding. However, most residential areas along the stream have constructed revetments (armored banks) to protect their homes from channel migration and the subsequent potential for erosion and loss of property. Armoring in residential areas varies from solid concrete to riprap to stacked sandbags. Bank armoring is also found in public parks. The only portion of Clarks Creek that has undisturbed banks is adjacent to and upstream of the WDFW hatchery.

Biological Resources

Wetlands

The City of Puyallup wetland inventory (Parametrix, 2003) identifies field-verified wetlands (as well as unverified potential wetlands) within the City of Puyallup and the UGA. The inventory was based on several sources, including a 2001 Buildable Lands Study by Pierce County, the 1991 City Inventory, the Pierce County Wetland Inventory, National Wetland Inventory mapping, and field reconnaissance surveys.

Puyallup River

Few wetlands occur within the Puyallup River shoreline planning area, which can likely be attributed to the impacts of levees located along the riverbanks and past agricultural practices. Of the wetlands that are mapped within the shoreline of the Puyallup River, most are located upstream (east) of the SR 512 Bridge near the confluence of the Puyallup and White Rivers. These wetlands are palustrine (freshwater) wetlands containing forest, shrub, and/or emergent (herbaceous) vegetation. The wetland inventory identified three wetlands west of the SR 512 Bridge. These wetlands are forested and occur within a heavily developed area south of River Road. In addition to the wetlands identified in the City wetland inventory, three small wetlands were identified and delineated within the south bank of the shoreline, in the vicinity of 11th Street SW (Adolfson 2003). These are palustrine emergent or scrub-shrub wetlands. Hydric soils are mapped along a portion of the north side of the Puyallup River shoreline. South of the river, hydric soils are not mapped within the shoreline. However, extensive areas of hydric soils are mapped east and west of Deer Creek on the valley floor immediately outside of the shoreline planning area. The wetlands within the shoreline area function by detaining surface water flows, maintaining groundwater recharge/discharge interactions, providing habitat, and improving water quality.

Areas with forested vegetation located within the levees of the Puyallup River may also be considered potential wetlands. The levees are tiered, and these riparian areas are perched on the high-flow channel of the river. They are primarily vegetated with black cottonwood trees.

Clarks Creek

A number of wetlands occur in the Clarks Creek shoreline planning area. Most of these wetlands are palustrine, but one large wetland is potentially a riverine wetland associated with Clarks Creek. This wetland occurs in the northernmost portion of the stream reach as a palustrine/riverine wetland complex. Palustrine wetlands within the shoreline consist of forested, scrub-shrub, and/or emergent vegetation. Most of the forested and scrub-shrub wetland vegetation is associated with Clarks Creek, while the wetlands south of Meeker Ditch and east of the stream are primarily palustrine emergent wetlands. Hydric soils are mapped in a portion of the shoreline in the southern (upstream) portion of Clarks Creek. Wetlands within the shoreline of Clarks Creek function in moderating peak storm events, protecting the shoreline, improving water quality, and providing wildlife habitat.

Critical Wildlife Habitat and Species

Critical fish and wildlife habitat areas are those areas identified as being of critical importance in the maintenance and preservation of fish, wildlife, and natural vegetation. Critical habitat, or critical wildlife habitat conservation areas, means habitat areas with which endangered, threatened, sensitive, or monitored species of plants or wildlife have a primary association (e.g., feeding, breeding, rearing of young, migrating) (Chapter 21.06.220 PMC). These areas may contain lands essential for preserving connections between habitat blocks and open spaces or habitats and species of local importance.

State and Federally Listed Species

Several state and federally listed species are known to occur or could potentially occur within the City's shoreline jurisdiction. Federally listed species that have been documented within the City's shoreline jurisdiction include bald eagle, Chinook salmon, Puget Sound steelhead, and bull trout. Puget Sound/Strait of Georgia coho salmon, a federal species of concern, also occurs in the area.

On December 14, 2004, the National Oceanic and Atmospheric Administration - National Marine Fisheries Division (NOAA Fisheries) proposed designating "critical habitat" for Puget Sound Evolutionarily Significant Unit (ESU) Chinook salmon within the portion of the Puyallup River in the City (Federal Register, Vol. 69, No. 239).

Priority Habitats and Species

The Washington Department of Fish and Wildlife (WDFW) publishes the Priority Habitats and Species (PHS) list for Washington State, which includes a catalog of habitats and species considered to be priorities for both conservation and management. Priority species include those species that, due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance, require specific protective measures to perpetuate their existence. This includes State Endangered, Threatened, Sensitive, and Candidate species; species congregations considered vulnerable; and those species of recreational, commercial, or tribal importance that are vulnerable. Priority habitats are those habitat types or elements with unique or significant value to a diverse assemblage of species, which may consist of unique vegetation types or dominant plant species, a described successional stage, or a specific structural element (WDFW, 2005).

Priority species documented in the City include several anadromous fish species, bald eagle, and concentrations of waterfowl. The City's shoreline planning area contains the following priority habitats: riparian areas, urban natural open spaces, and wetlands.

Puyallup River

Chinook salmon are documented as occuring throughout the entire reach of the Puyallup River within the City's shoreline jurisdiction (Williams et al., 1975; WDFW, 2005; Kerwin, 1999). The predominant use of the Puyallup River within the City's shoreline jurisdiction is limited primarily to rearing and migration. The StreamNet database (2005) indicates no spawning below the White-Puyallup River confluence at river mile (RM) 9.7. Spawning does not occur within the City's shoreline planning area primarily due to the presence of the system of levees, which have resulted in the creation of a uniform channel that is devoid of habitat conducive to spawning (such as spawning gravels and side channel habitat). The levees have essentially removed much of the riparian vegetation, and LWD presence and recruitment are limited. Channel migration and contributions of new sediment, especially gravels, have been eliminated by the levee system. In addition, spawning gravels that do exist are heavily embedded with fines, making for undesirable spawning conditions. There is some potential for spawning to occur upstream of the White-Puyallup River confluence within the City's shoreline jurisdiction. Kerwin (1999) indicates that there is a lack of site-specific information on the life history and habitat utilization of salmonids within this system. Sporadic spawning of Chinook and other salmonids between the White River confluence and Orting has been documented in recent years (Puyallup Tribe of Indians, 2005).

No bald eagle nests or breeding territories are located within the City's Puyallup River shoreline jurisdiction. It is likely, however, that bald eagles use the area for foraging.

In addition to the state and federally listed species discussed above, the Puyallup River within the City's shoreline planning area contains several salmonid species that are not considered endangered or threatened, but are listed as priorities for conservation and management including: chum salmon, pink salmon, and coastal cutthroat trout. Existing instream conditions limit the use of the Puyallup River within the City's shoreline planning area to rearing and migrational corridors (WDFW, 2005). Deer Creek, a Puyallup River tributary, is also documented as containing priority resident and anadromous salmonids.

Waterfowl concentrations are also mapped within the City's shoreline jurisdiction west of North Levee Road and are likely associated with open agricultural fields adjacent to the river.

Riparian habitat is limited along the Puyallup River within the City's shoreline jurisdiction. This is primarily due to development, the presence of levees/dikes, and agricultural areas. No priority riparian habitat is mapped along the Puyallup River in this area.

Clarks Creek

Fall Chinook use the entire portion of Clarks Creek within the City's shoreline jurisdiction for spawning, rearing, and migration (Williams et al., 1975; Kerwin, 1999; Marks et al., 2002, and WDFW, 2005). All spawning occurs from the Clarks Creek headwaters at Maplewood Springs to an area one-third mile downstream (Marks et al., 2002), with the remainder of the stream downstream to the mouth being utilized for rearing and migration. StreamNet (WDFW, 2005) identifies that the lower one mile of Clarks Creek is primarily used for migration while the remainder of the stream up to its headwaters at Maplewood Springs is used for spawning and rearing. Marks et al. (2002) indicates that adult spawner counts from 1994-2001 showed a range in abundance between 26 to 307 individuals and 10 and 100 redds, respectively, over that same timeframe. Meeker Creek, a tributary to Clarks Creek, is reported as also supporting small numbers of spawning adult Chinook (Parametrix, 2003).

Winter steelhead generally use the lower two miles of Clarks Creek for migration only and spawn from river mile (RM) 1.90 to RM 3.78 (WDFW, 2005). Tributary streams, Diru Creek, and Rody Creek are documented as supporting steelhead (CH2M HILL, 2002).

A bald eagle breeding territory extends from the headwaters of Clarks Creek and downstream to the confluence with Meeker Creek. However, eagle nesting occurs outside the shoreline planning area (approximately one-half mile away to the south) (WDFW, 2005).

In addition to the state and federally listed species discussed above, Clarks Creek within the City's shoreline jurisdiction contains several salmonid species that are not considered endangered or threatened, but are considered priorities for conservation and management including: chum salmon, and coastal cutthroat trout. Chum salmon utilize the lower one-half mile for migration only, and spawn and rear from river mile (RM) 0.54 to RM 3.28. Coho utilize the lower 2.4 miles for rearing and migration, and spawn typically from RM 2.39 to RM 3.78. Tributary streams, Diru Creek, and Rody Creek are documented as supporting chum, and coho (CH2M HILL, 2002).

Great blue herons are known to breed and roost near the WDFW hatchery near the uppermost extent of the City's shoreline planning area in the Clarks Creek basin (WDFW, 2005). The riparian corridor of Clarks Creek is mapped as priority habitat as well as a small portion of Rody Creek within the City's shoreline jurisdiction. Mapped urban natural open space is also found adjacent to and on the west side of Clarks Creek near the WDFW hatchery.

Instream and Riparian Habitats

Rivers and streams provide valuable wildlife corridors, a source of fluvial sediments to the marine shoreline, recreational opportunities, and support for a range of fish species. Information on stream conditions was drawn in particular from the following documents: *Salmon and Steelhead Habitat Limiting Factors Report for the Puyallup River Basin (Water Resource Inventory Area 10)* (Kerwin, 1999), *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region* (Williams et al. 1975), and the *City of Puyallup Shoreline and Critical Areas Inventory* (Parametrix, 2003). The following characterization of the Puyallup River and Clarks Creek is focused on conditions relative to fish and wildlife habitat.

Puyallup River

A habitat assessment was performed for the mainstem Puyallup River within the City's shoreline planning area as part of the City's first shoreline inventory (Parametrix, 2003). The two main factors influencing the Puyallup River within the City's shoreline planning area are the channelization of the main channel and the rapid rate of urbanization. The impacts of agricultural development, urbanization, and channel modifications have impaired and effectively limited the ecological functions that the Puyallup River provide. Overall, habitat conditions are degraded compared to historical conditions. This is due in large part to increased urbanization within the entire watershed, and historical and current flood control practices. The habitat assessment indicated the following disturbances as having the most impact on the riverine aquatic system:

- Diking of riverbanks has occurred along entire length through the UGA;

- Shoreline areas are highly developed with little riparian vegetation present and vegetated areas that are present are not contiguous;
- LWD was routinely removed as part of Pierce County's river maintenance program but has been limited in recent years;
- Channel straightening has resulted in lack of habitat complexity (e.g., proper pool to riffle ratios, LWD); and
- Bank stability is good and erosion is minimal, however, this is due primarily to diking and other modifications. These modifications do not allow the stream to form natural meanders and limit floodplain connections to adjacent wetlands and off-channel habitats.

Clarks Creek

Clarks Creek drains an area of approximately 6.5 square miles and includes a large portion of the City of Puyallup and the heavily developed commercial South Hill Mall area near SR 512 and 39th Avenue SW (CH2M HILL, 2002). Clarks Creek experiences many of the problems associated with streams found in urban areas including water quality degradation, altered hydrology, lack of habitat complexity, and inadequate riparian buffers.

Habitat in Clarks Creek is affected by agricultural uses and urban development within and outside of the City's UGA. Increased development of the basin has resulted in an overall increase in impervious surface, with increased peak flows and decreased base flows in Clarks Creek. Issues include:

- Increased peak flows cause erosion, excessive turbidity, scouring or downcutting of the channel bed, loss of pool habitat, and reduction in habitat complexity;
- Decreased base flows can cause low flow during the dry summer months. The presence of impervious surfaces including areas that have experienced a loss of vegetation and soil compaction does not allow the water to infiltrate, but rather the water is collected in man-made collection systems that direct the water to the streams at a much faster rate than would occur naturally;
- Removal of riparian vegetation has occurred throughout much of the stream length, which reduces the recruitment of habitat forming LWD, removes potential sources of food and nutrients to the system, increases overall stream temperatures, and increases risk of predation to salmonids and other aquatic biota;
- Streambanks have been armored to confine the channel, thus the stream has lost much of its access to its former floodplain and off-channel habitat including wetlands; and
- High sediment loading and nutrient levels promote growth of aquatic vegetation.

Clarks Creek within the City's shoreline jurisdiction differs from the Puyallup River in its overall complexity. The lower portion of Clarks Creek below W. Pioneer Avenue (RM 0.0 to RM 2.5) is low gradient (less than 1 percent) and predominantly surrounded by agriculture on the west and residential development on the east. Historical and current agricultural practices as well as residential shoreline armoring have resulted in the channelization and confinement of the stream channel, and silt/sand are the dominant substrates throughout this reach (CH2M HILL, 2002). The stream still maintains some off-channel connections with wetlands, which may provide for some juvenile salmonid rearing. LWD is lacking or non-existent throughout most of this reach; however, the stream between W. Stewart Avenue and W. Pioneer Avenue has a 50-foot-wide riparian buffer containing primarily shrub/emergent vegetation. While providing some cover, it is currently not sufficient to provide thermal protection and LWD.

Clarks Creek between W. Pioneer Avenue and the WDFW fish hatchery at approximately RM 3.7 contains better, but still degraded, habitat. Like the lower reaches, sands and silt are the predominant substrates. Aquatic vegetation is prevalent throughout this reach due to presence of fine sediments and high nutrient levels. The source of the nutrients is under debate, but it has been suggested that the hatchery, Meeker Creek, and high nitrate levels within the stream have encouraged this aquatic vegetation growth. The stream naturally receives nitrates from groundwater but it is unclear if the nitrate levels in the groundwater are naturally occurring (CH2M HILL, 2002). LWD is lacking throughout much of the reach resulting in reduced habitat complexity (e.g., few pools); however, riparian cover is primarily intact on the western side of the stream at Clarks Creek Park (Parametrix, 2003). Channel confinement and access to off-channel habitat are still impaired by the presence of shoreline armoring along residential properties on the east bank and throughout much of Clarks Creek Park on the west bank.

The most functional portion of Clarks Creek within the City's shoreline jurisdiction is the portion upstream from the WDFW hatchery to the source of Clarks Creek at Maplewood Springs (RM 4.0). This area begins along the hillside slopes, and as the creek flows from the hillside slope into the valley, a shallow pond is formed from interaction with local topography. Sediment carried from the hillside drops out to form an alluvial fan in the pond. It is the area upstream of this pond that provides the only spawning habitat within Clarks Creek. Riparian conditions are intact with red alder providing the dominant streamside cover. LWD present within the system is still below desired levels. This area provides good gravel composition, off-channel habitat is available, and habitat complexity (pool/riffle ratio) is higher than in the lower portions of the stream.

Land Use Patterns

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

Existing Land Use

Existing land use was derived from Pierce County Assessor parcel data (Pierce County, 2004). Existing or current use categories for each parcel were regrouped into generalized existing land use categories that correspond to the future land use categories used in the City's Comprehensive Plan. Additional categories of existing land use that do not have a corresponding Comprehensive Plan land use designation are vacant, agriculture, and unknown.

Puyallup River

According to the Pierce County Assessor information for existing land use, nearly a third of the Puyallup River shoreline planning area is currently used for agriculture (34 percent) (Figure 8). Another third is vacant (29 percent). The other common land uses are Commercial (12 percent) and Low-Density Residential (11 percent). Commercial land uses are concentrated west of SR 512 along River Road.

Clarks Creek

Nearly half (43 percent) of the shoreline planning area for Clarks Creek is currently low-density residential (Figure 8). Public Facilities, Open Space, and Parks compose 23 percent of the shoreline planning area. Most of this area is associated with Clarks Creek Park, DeCoursey Park, WDFW-owned land, and lands owned by Washington State University (WSU) on the west side of Clarks Creek.

Comprehensive Plan

The City's Comprehensive Plan contains 24 goals to be achieved by implementing future land use policies. These include accommodating growth while conserving environmentally sensitive and flood prone areas. To meet its planning policies, the City redefined land use categories for future conditions. Future land use does not include agriculture, most of which will be converted to light-industrial manufacturing, commercial, multi-family development or business parks. Residential development is predicted to make up almost two-thirds of future land use. Combined commercial and industrial uses are expected to nearly quadruple at maximum build-out, from about 688 acres to a predicted total of 2,623 acres. To accommodate residential and commercial development, open space will shrink by approximately 31 percent to 1,070 acres, or less than 10 percent of the total UGA.

In general, existing land use follows the Comprehensive Plan land use designations. A planned transition from less intense to more intense land uses in the shoreline planning area is found where existing land use is agricultural or vacant. These lands are designated High-Density Residential, Light Manufacturing/Warehousing, Business/Industrial Parks, or Auto-Oriented Commercial (City of Puyallup, 2004). This transition in land use is more prevalent in the Puyallup River shoreline planning area than along Clarks Creek.

Puyallup River

The north bank of the Puyallup River shoreline planning area is designated as Light Manufacturing/Warehousing, Moderate-Density Residential, and Low-Density and Rural Buffer Residential with portions also within an Agricultural Overlay District.

The south bank of the Puyallup River shoreline planning area is predominantly designated Auto-Oriented Commercial and High-Density Residential, with Low-Density Residential just west of SR 512. Portions of the south bank in the UGA are predominantly designated Moderate-Density Residential and Business/Industrial Parks.

Clarks Creek

Future land use designations in the Clarks Creek shoreline planning area more closely follow existing land use patterns. Parks and Open Space designations surround the headwaters and correspond to the WDFW-owned land and City parks. Most of the shoreline planning area is designated Low-Density or Rural Buffer Residential. Some properties are designated Public Facilities. The easternmost portion of the shoreline planning area (i.e., the fairgrounds) is designated Fair. Areas of planned transition are in the UGA and include the WSU property, designated Public Facilities, and the lower reach near the Puyallup River, designated Moderate-Density Residential.

Zoning Designations

Zoning designations in the City of Puyallup and UGA generally follow the land use designations established in the City's Comprehensive Plan. Pierce County zoning designations apply in the UGA until those areas are incorporated through annexation. County zoning designations in the Puyallup River shoreline planning area are primarily Moderate-Density Single-Family Residential and Employment Center, with smaller areas zoned for Mixed Use. All of the Clarks Creek shoreline planning area in the UGA is zoned by Pierce County as Moderate-Density Single-Family Residential. City zoning in the Puyallup River shoreline planning area is consistent with the Comprehensive Plan land use designations: Limited Manufacturing and Medium Density Residential on the north bank, and Commercial and Medium- to High-Density Residential on the south bank. City zoning in the Clarks Creek shoreline planning area is also consistent with the Comprehensive Plan with designations ranging between very low density to medium urban density Single-Family designations. Low-Density Residential. Table 4 compares the estimated percentages of existing land uses, Comprehensive Plan land uses, and zoning designations in the shoreline planning area.

Table 3. Land Use, Comprehensive Plan, and Zoning Designations

Shoreline Segment	Existing Land Use		Comprehensive Plan Land Use Designation		Zoning Designation	
	Type	%	Type	%	Type	%
Puyallup River	Agriculture	34.0	High Density Residential	24.1	RM-20: Residential Multi-Family: High Density	35.9
	Vacant	28.9	Auto-Oriented Commercial	17.2	Limited Manufacturing	20.3
	Auto-Oriented Commercial	11.7	Business/Industrial Park	14.5	General Commercial	20.1
	Low Density Residential	10.8	Limited Manufacturing/ Warehouse	13.4	Public Facility	10.4
	Open Space/Public Park	4.1	Rural Buffer Residential	9.5	Residential Single-Family min. lot size 6,000 sq. ft	9.2
	Limited Manufacturing/ Warehouse	2.3	Public Facility	7.0	Community Business	3.7
	High Density Residential	2.1	Low Density Residential	6.8	Residential Multi-Family: Medium Density	0.5
	Public Facility	2.0	Moderate Density Residential	4.4		
	Other	1.9	Waters of the State	3.2		
	Pedestrian-Oriented Commercial	1.0				
	Moderate Density Residential	0.8				
	Business/Industrial Park	0.2				
	State Road	0.1				
Clarks Creek	Low Density Residential	43.7	Open Space/Public Park	24.1	Residential Single-Family min. lot size 8,000 sq. ft.	42.1

Shoreline Segment	Existing Land Use		Comprehensive Plan Land Use Designation		Zoning Designation	
	Type	%	Type	%	Type	%
	Fair	16.8	Western Washington Fair Grounds	17.2	Public Facility	27.2
	Open Space/Public Park	13.8	Low Density Residential	14.2	Western Washington Fair Grounds	14.7
	Public Facility	9.3	Rural Buffer Residential	13.4	Residential Single-Family min. lot size 10,000 sq. ft.	8.5
	Vacant	9.2	Public Facility	6.8	Residential Single-Family min. lot size 8,000 sq. ft., Fair Parking Overlay	7.4
	Agriculture	4.7	Moderate Density Residential	0.3	Residential Single Family min. lot size 35,000 sq. ft.	0.1
	Moderate Density Residential	1.2				
	Business/Industrial Park	1.0				
	Other	0.3				
	State Road	0.1				

Roads and Bridges

Roads and transportation infrastructure in the shoreline planning area reflect the existing land use patterns described above. Five bridges cross the Puyallup River in the City and its UGA. Moving upstream from west to east, they include the Melroy Bridge (at the western edge of the City's UGA), Meridian Street (SR 161), East Milwaukee Avenue, SR 512, and East Main Street. Both SR 167 and North Levee Road parallel the river from the eastern edge of the UGA to Meridian Street. The density of roads is relatively high along the south side of the river because of commercial developments near SR 167 and Meridian Street, and the residential developments from Meridian Street east to SR 512. East of SR 512, the presence of the Linden Country Club Golf Course and vacant land has resulted in a lower road and transportation density in the shoreline planning area. The north shoreline has a low density of roads west of Meridian Street and east of Milwaukee Avenue. Between these two roads, manufacturing and residential land uses have led to higher road density.

Transportation facilities in the Clarks Creek shoreline planning area include eight roads, one railroad, and a footbridge across the stream. The largest road is River Road (SR 167), which crosses just upstream of the mouth. The stream passes under 66th Avenue East three times. Farther upstream, Clarks Creek flows under W. Pioneer Way and 7th Avenue SW near the north end of Clarks Creek Park. Overall, the Clarks Creek shoreline planning area has lower road density than the Puyallup River area. The highest road density in the Clarks Creek shoreline is found along the eastern shoreline from Valley Avenue (65th Street East) to 10th Avenue. This area is characterized by low-density residential development and contains streets and driveways.

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

City's shoreline planning area is estimated to be approximately 26 percent (158 acres). The estimated EIA percentage in the Puyallup River shoreline is 22 percent (67 acres) and in the Clarks Creek shoreline it is 30 percent (91 acres). These figures are generally consistent with those for the entire Puyallup UGA described earlier in the process alterations section.

Wastewater and Stormwater Utilities

The City of Puyallup provides sanitary sewer service within the City's boundaries. The City operates and maintains a wastewater treatment facility, 12 sewage pump stations, and several miles of interceptor and collection sewers, ranging in size from 8-inch to 48-inch diameter. Wastewater collected in Puyallup is treated at the City of Puyallup's secondary wastewater treatment plant located in the northwest corner of the City, south of River Road and west of 18th Street NW. The treatment facility is approximately 500 feet from the Puyallup River. Treated effluent is piped to the river and discharged at RM 6.85 near 83rd Avenue East (Gray and Osborne, 1997).

Of the 12 pump stations, five are in close proximity to the City's shoreline planning area. The North Puyallup lift station and the Riverside lift station are near the Puyallup River. The 23rd and Tacoma Road lift station, 19th Street NW and Pioneer lift station, and the Clarks Creek lift station are near Clarks Creek. The only sewer line in the shoreline jurisdiction is a force main that originates at the north Puyallup lift station, crosses the Puyallup River at the Meridian Bridge, and then follows River Road to the treatment facility (Gray and Osborne, 1997).

The City of Puyallup's *Sanitary Sewer System Comprehensive Plan* was last updated in 1997 (Gray and Osborne, 1997). Sanitary sewer served most of the City at the time the plan update was developed. Urban growth areas made up approximately 42 percent of the City's land base. These areas were primarily a mix of agriculture and low-density rural or single-family residential development and mobile home parks. Residential areas in the Puyallup UGA at that time primarily utilized septic tanks and drainfields. Current land use information indicates that about half of the unincorporated UGA (or approximately 15 percent of the City's land base) is residential. Sanitary sewer now serves some of these areas. Other areas still utilize septic tanks and drainfields.

The plan update provides recommendations for upgrades and expansion of the City's wastewater collection and treatment system to meet projected population and land use demands in the UGA over the 1990-2010 period. Recommendations include the expansion and upgrade of existing treatment and conveyance facilities, and installation of new conveyance facilities to provide service to areas in the UGA using on-site septic systems.

The City of Puyallup also operates a stormwater management system. Overall, there is little in the way of regional detention or treatment facilities serving the City. Chapter 21.10 of the Puyallup Municipal Code establishes stormwater standards for new development. The Puyallup River has 22 stormwater outfalls maintained by the City (City of Puyallup, 2001). Most outfalls are found at bridges or roads ending at the river. Four outfalls are also located along River Road in the northwest UGA. Clarks Creek receives stormwater from several pipelines and tributaries (KCM, 1996). Meeker Creek conveys much of the City's stormwater runoff to Clarks Creek. In addition, there are large outfalls at W. Pioneer Avenue and 7th Avenue SW. Numerous other private storm drain pipelines and ditches were observed along Clarks Creek during a field survey in 2003 (Parametrix, 2003). The City also operates two stormwater pump stations along Meeker Creek, just upstream of 14th Avenue SW.

Undetained and untreated stormwater runoff can deliver pollutants to waterbodies, including heavy metals and other pollutants associated with automobiles and roadways. Water quality impairments described in previous sections include the presence of mercury and other metals in the Puyallup River. Untreated stormwater discharging to the Puyallup River is likely a contributing factor.

Other Utilities

Puyallup maintains water supply production facilities at Maplewood Springs, the source of Clarks Creek. The City has five wells and an intertie water supply line with Tacoma. In addition, the City of Tacoma, Fruitland Water District, and several private landowners own production wells. Numerous private landowners and agricultural enterprises have installed pumps that withdraw water, some of which may be in violation of City ordinances and state water rights. WDFW maintains a fish hatchery at 15th Avenue SW that withdraws 14 cfs of water from an impoundment at Maplewood Springs and returns 13 cfs of water farther downstream. A significant source of base flow in Clarks Creek is provided by groundwater, but flooding during summer months (typically a low flow period) suggests withdrawals are not significantly adversely affecting base flow in the stream.

The 7th Avenue SW Bridge and W. Pioneer Avenue Bridge on Clarks Creek both have pipelines underneath the bridges that may obstruct the stream at high flows. A variety of gas, telephone, electric, and related utilities serve the existing residential and commercial developments within the Puyallup River and Clarks Creeks shoreline planning area.

Existing and Potential Public Access Sites

The City of Puyallup has a diversity of parks, open space, and public facilities, some of which provide shoreline access. Access to the Puyallup River is largely limited to the south bank along an existing trail. There is greater shoreline access to Clarks Creek through developed parks and publicly held land. The City’s 2002 Parks Plan Update (City of Puyallup, 2002) describes the following parks, open space, and public facilities in the City’s shoreline planning area.

Clarks Creek Watershed

The Clarks Creek watershed covers 113 acres of state-owned land located entirely within the City. It is located directly south of and contiguous with Clarks Creek Park. This land is owned and managed by the WDFW to protect the watershed upstream of the state fish hatchery on Clarks Creek. In general, WDFW encourages public access to their lands to the extent that no resource degradation would occur as a result of such access. Portions of the hatchery are open to the public and it serves as an important educational resource for the Puyallup area.

Clarks Creek Park

Clarks Creek Park is a 55-acre park site located along Clarks Creek. The park is divided into two areas: Area 3 and the Clarks Creek Natural Area. Area 3 is a major activity area and includes facilities for picnicking, parking, and restrooms. The Natural Area is the southernmost portion of the park and abuts a large tract of land owned by WDFW. The vast majority of this area functions as an important wildlife habitat and surrounds some active portions of the park. It has areas of open water, wetlands, and typical Northwest forestlands. Future development in this area is planned to be limited in scope and designed to avoid impacts.

DeCoursey Park

DeCoursey Park is a 7.3-acre community park immediately north of Clarks Creek Park. Park facilities consist of a duck pond with fishing piers, a restroom building, a picnic shelter, play equipment, and a path system around the pond's edge. The park also has a sports area with four lighted tennis courts, a lighted softball field, and exercise stations.

Skate Park Facility

In 2001 Puyallup Parks opened a skate park facility near the Riverfront Trail. The site is part of the existing Puyallup Parks Maintenance Yard at the north end of 4th Street NW. The juxtaposition of the trail and the skateboard facility provides skateboarders and in-line skaters the opportunity to eventually reach the facility using a City trail network.

Riverfront Site

The 12.81-acre undeveloped riverfront site lies between the future Riverfront Trail, the Linden Golf Course, and Riverside Village, a residential apartment complex off East Main Street. This parcel is the site of the old City landfill. This site has been identified as a candidate for a small community park along the Puyallup River, although there are no current plans to develop a park. Principal concerns over development of the property as an active park are associated with the former landfill (City of Puyallup, 2002). The City's 2005 Capital Improvement Program includes funding for construction of the Riverwalk Trail. This site may also present a restoration opportunity area.

Riverfront Trail

The Riverfront Trail is the planned and partially built, non-motorized trail along the south bank of the Puyallup River from the City's westerly limits to its easterly limits. It will form a key linkage between the planned Puyallup River Levee Trail and the Foothills Trail that will eventually extend from Tacoma to Buckley. It will also be a key component of the City of Puyallup's non-motorized Transportation Plan.

The Riverfront Trail will be implemented in four phases. The first Riverfront Trail (also known as Riverwalk) phase was completed in 1998. This trail section stretches two-thirds of a mile from near 4th Street NW east to 5th Street NE. The trail passes beneath SR 161 via its own pedestrian bridge. For the most part, the trail sits on top of the Puyallup River levee along the river's south bank. Pedestrian access to the riverbank and river is permitted through gates in a fence. In some areas, the trail corridor widens, with trail rest stops that include benches, picnic tables, and a lawn area. The trail provides access to the river for fishing in numerous locations.

Other Properties

Other open space properties that are in or near the shoreline planning area include the Western Washington Fairgrounds and the Linden Golf and County Club. The fairgrounds are over 160 acres of privately owned open space just south of the City's downtown, and is partially within the Clarks Creek shoreline planning area (west of 5th Street SW), but does not provide direct access to the shoreline. The Linden Golf and Country Club is adjacent to the south bank of the Puyallup River near the confluence with the White River. This property is considered open space and provides recreational uses but is privately owned and does not provide public access to the shoreline.

Historical/Cultural Resources

The existing Puyallup Shoreline Master Program provides a general goal to identify, protect, and restore those shoreline areas and facilities that are of historical, cultural, or educational value (City of Puyallup, 1987). The City of Puyallup Comprehensive Plan (2004) also addresses historic preservation. The plan establishes goals to ensure that historic properties and archeological sites are protected from undue adverse impacts associated with incompatible land uses, transportation facilities, and detrimental noise levels. Policies in the Comprehensive Plan define characteristics that enable the identification of historic and archeological sites, and direct the City to preserve and protect these sites from incompatible land uses.

There are no known archeological or historical resources within the area subject to shoreline jurisdiction. As part of the 2003 shoreline and critical areas inventory process, the City contacted the Puyallup Tribe and the Washington Department of Archeological and Historical Preservation (DAHP) for information on the presence of these resources, but no information was provided (Parametrix, 2003). However, native use of waterbodies throughout western Washington has been well documented. As a fishery resource, native peoples undoubtedly used the Puyallup River and its tributaries. The river itself could be considered a significant traditional cultural place. As such, there is a high probability of archaeological resources near the shoreline of the Puyallup River and near its confluence with the White River, as well as along Clarks Creek. These resources, if existing in the City UGA, may have been removed or destroyed during construction of the levees, or they may be below areas previously disturbed by construction. The City requires review of archeological and historical resources on a parcel-by-parcel basis during development review.

6. ASSESSMENT OF SHORELINE FUNCTIONS AND OPPORTUNITY AREAS

This section summarizes key findings concerning how shoreline functions of Clarks Creek and the Puyallup River have been impaired, both by land use activities and alterations occurring at an ecosystem-wide scale, and by activities within the City, its UGA, and its shoreline planning area. This section also identifies opportunities for the protection or enhancement of areas where shoreline ecological functions are intact, and opportunities for restoration of impaired shoreline functions, at both a programmatic (i.e., City or UGA-wide) and site-specific level. Opportunities for enhanced or expanded public access to the shoreline are also discussed.

Puyallup River

Status of Shoreline Functions and Programmatic Restoration Opportunities

Table 5 provides a summary of shoreline ecological functions for the Puyallup River. Causes of impairment and the relative scale at which impairments are occurring (e.g., watershed, UGA-wide, shoreline reach scale, or multiple scales) are identified. Finally, general or programmatic restoration opportunities to address impairments are described. Following Table 5 is a more detailed discussion of site-specific restoration opportunities.

Table 4. Summary of Shoreline Functions and Programmatic Restoration Opportunities, Puyallup River

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
Base flows may be impaired. Summer low flows in the Puyallup River have declined continuously since 1980; however, the reason for summer low flows has not been well understood. Potential causes include increased impervious area and increased demand for groundwater withdrawals in the lower watershed.	Watershed scale	Hydrologic Hyporheic	Protect groundwater sources to the river, particularly in the Clarks Creek basin.
Movement and storage of water has been highly altered. Channelization via dikes and levees has isolated the river from its former floodplain and associated wetlands, reducing flood storage capacity and increasing flow velocities. Levees constructed of or on compacted fill have likely altered groundwater movement, infiltration capacity, and capacity for groundwater exchange.	Watershed scale	Hydrologic Hyporheic	Set back levees to reestablish connectivity to former floodplain and associated wetlands.

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
Wetlands cut off from the river can no longer provide essential storage, recharge, or water quality functions.	Watershed, UGA-wide, and reach scale	Hydrologic Hyporheic Water quality	Target local wetland restoration and mitigation so they provide storage, detention, and water quality functions. Restore and reconnect wetlands adjacent to tributary streams of the Puyallup River.
Channel migration has been eliminated by the levee system along the river and the ability to incorporate new sediments (gravels) has been impaired.	Watershed scale	Hydrologic Instream habitat structure Off-channel habitat formation	Opportunities are limited. Localized setback levees could reestablish some sediment delivery processes.
Sources of suspended sediment in the river are natural, but increased flow velocities from channelization has resulted in increased bedloads, habitat homogenization, and lack of refugia for rearing and migrating salmonids.	Watershed scale	Hydrologic Instream habitat structure	Protect tributaries to the river, which provide off-channel habitat.
Habitat is impaired. Channelization via dikes and levees has reduced riparian and off-channel habitats thus reducing instream habitat types. The lack of instream structure has limited the lower Puyallup River to providing rearing and spawning habitat.	Watershed scale	Instream and riparian habitat structure	Set back levees to restore off-channel habitats and protect tributaries to the river which currently provide off-channel habitat.
Forested riparian vegetation exists along the Puyallup River, although it is largely limited to the area within the levees. Past vegetation management practices for the levees included eliminating large woody debris recruitment potential.	Watershed and reach scale	Instream and riparian habitat structure	Restore riparian habitats, particularly conifers, through shoreline plantings. Minimize future tree removal within the levees. Restore forested habitat outside of levees.
Water quality (i.e., contamination by fecal coliform) is impaired due to a variety of factors including leaking septic systems and animal wastes entering the stream (in the City and upstream in the watershed). Agricultural runoff and residential landscaping (in the City and upstream in the watershed) may be delivering increased nitrates and phosphorus. Dissolved oxygen, turbidity, temperature, and other heavy metals are issues of concern.	Watershed, UGA-wide, and reach scale	Water quality	Limit permitting of new septic systems; require new development to connect to sanitary sewer. Monitor existing septic systems through city-wide programs to ensure compliance. Continue to expand City's wastewater

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Programmatic Restoration Opportunities
Stormwater related pollutants (concentrated in urbanized areas including the City) may be primary cause of metals. Wetlands cut off from the river can no longer provide essential water quality functions.			services to areas traditionally served by septic. Manage, detain and treat stormwater discharging to the Puyallup. Use low impact development techniques. Develop BMPs with existing agricultural property owners to reduce runoff and pollutant loading. Target wetland restoration and mitigation in areas where they would provide water quality functions.

Site-Specific Restoration Opportunities

Site-specific restoration opportunities on the Puyallup River are limited. Pierce County Water Programs owns and maintains the levees along the river throughout the City's shoreline planning area. Pierce County has implemented at least one restoration project in the form of a levee set back to provide off-channel habitat and flood storage upstream of the City. While the County would like to pursue additional similar restoration projects, there are many constraints to doing so within the City's shoreline planning area. Specifically, existing road and utility infrastructure, and residential and commercial development, limit the land area where a setback levee project would be practical and feasible.

Several site-specific opportunities along the Puyallup River have been previously identified (Parametrix, 2003; Puyallup Tribe of Indians et al., 1999). Moving upstream, from west to east, these are described below. These areas were identified and described primarily as a result of field reconnaissance by Parametrix staff.

- **P-1.** There are potential opportunities to enhance the existing riparian corridor on the south bank for several hundred yards downstream of Meridian Street. This would involve planting native species on the banks and protecting the area from future encroachment or disturbance. The planting would have a somewhat limited effect on instream habitat in the near term because it would not influence flow dynamics or enhance floodplain connectivity or channel complexity; however, it would serve as a future source for LWD and provide bank cover, which would improve habitat conditions in the local area.

- **P-2.** Protecting remaining riparian corridors between Milwaukee Avenue and Meridian Street is imperative. Replacing riparian vegetation on the north bank would improve habitat, partially mitigating the effects of increased stormwater runoff associated with increased impervious surface. Existing development limits the area available along the north bank for vegetation enhancement to between approximately 50 and 100-feet adjacent to the river. The benefits of the planting activity would be similar to those described in P-1 above.
- **P-3.** A backwater area on the south bank just upstream of the SR 161 Bridge provides relief to fish during high flows. This backwater area has no vegetative bank cover and appears to have no in-water structures that provide cover. This area could be enhanced with native plantings to improve habitat for rearing fry, migrating smelt, and returning adults. The added riparian cover would provide shade to help maintain favorable stream temperatures, contribute organic nutrients, and stabilize the banks.
- **P-4.** Puyallup Tribe of Indians et al. (1999) identified two riparian areas just downstream of the White River mouth that have high restoration potential. One site on the north bank contains an emergent wetland that has been disconnected from the river with a concrete levee. Reconnecting this area to the river would provide both off-channel rearing habitat and flow refuge. The wetland would be supported through overbank flows and interflows, which would enhance its long-term sustainability. The other site is directly across the river and contains an oxbow adjacent to the Linden Golf Course. Breeching the existing levee would add off-channel rearing habitat and flood storage capacity. The oxbow occurs in an alluvial zone just downstream of the confluence with the White River. Reconnecting it to the main channel would restore a type of habitat that has been lost as a result of diking.
- **P-5.** There is a large undeveloped, but mostly cleared, area on the south shore of the Puyallup River at its confluence with the White River. This area appears to contain emergent wetlands, but has a relatively narrow riparian community of mixed-age cottonwoods and Pacific willow along the banks. Depending on the ownership and the City's ability to acquire fee title or an easement, this area could be planted and/or reconnected to the river channel.
- **P-6.** On the south bank, upstream of the confluence with the White River, is what appears to be an old meander bend directly across the river from River Street in Sumner. A 50-foot-wide riparian corridor of red alder and a large open field characterize the site. A depressional scrub-shrub wetland dominated by willows lies adjacent to the bank. This wetland is not directly connected to the river, but could be with some bank modification. Reconnection of this area may also provide off-channel habitat for salmonids and flood storage. Seasonally inundated depressional wetlands and side channels were common on the floodplain prior to the channel modifications. Reconnecting this area to the river would enhance its long-term sustainability.

Clarks Creek

Status of Shoreline Functions and Programmatic Restoration Opportunities

Table 6 provides a summary assessment of shoreline ecological functions for Clarks Creek. Causes of impairment and general or programmatic restoration opportunities are described. Following Table 6 is a more detailed discussion of site-specific restoration opportunities.

Table 5. Summary of Shoreline Functions and Programmatic Restoration Opportunities, Clarks Creek

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Restoration Opportunities
Agricultural and residential development has resulted in the use of shoreline armoring to limit channel migration and protect private properties. This channelizes flow, limits sediment supply to the stream, reduces habitat complexity, and reduces off-channel habitat. Reduction in connectivity between streams and off-channel and riparian wetlands can reduce overall flood storage capacity, water quality, reduce biotic diversity, and simplify habitat types.	Reach scale	Hydrologic Instream habitat structure Off-channel habitat formation Water quality	Further development of streamside properties could be limited. This should be accomplished in part through the implementation of the City's updated Environmentally Critical Areas Code (e.g., adequate buffers would be applied to new development). Removal of bank armoring (riprap/concrete) and replacement with soft armoring and bioengineering measures (i.e., riparian plantings).
Agricultural and residential development (including bank armoring) has resulted in the removal of riparian vegetation. Riparian vegetation serves to protect water quality by providing thermal cover, serves to attenuate flooding by reducing rate of flow entering streams, provides nesting, roosting, and foraging habitat for a variety of wildlife, and improves channel complexity by contributing LWD to streams, which is essential for forming pools.	Reach scale	Hydrologic Instream and riparian habitat structure Water quality	LWD could be introduced into the stream to increase habitat complexity. Public purchase of easement on Clarks Creek could be established to preserve and enhance riparian corridor. Given the density of residential land use encroaching on the stream buffers, public outreach and education promoting stream-friendly practices should be a component of long-term shoreline management. Educational materials and outreach could be made available to all streamside landowners addressing the importance of maintaining a vegetative buffer around

Condition and Causes of Impairment	Scale of Alterations and Impairment	Shoreline Ecological Functions Affected	Restoration Opportunities
			streams.
Clarks Creek suffers from fecal coliform contamination and high pH levels. Stormwater runoff, leaking septics, and animal wastes (predominantly waterfowl) contribute to fecal coliform contamination. Excessive nutrients in the sediment are believed to cause overgrowth of elodea during summer months, restricting channel capacity and leading to periodic overbank flooding. Improvements to stormwater system at fair grounds have likely improved potential historical contaminant sources entering Meeker Creek and Clarks Creek. Dissolved oxygen levels are of concern. Runoff from agricultural lands in the lower reaches appear to be contributing to the high total suspended solids (TSS) concentrations in the stream.	UGA-wide and reach scale	Water quality Instream habitat quality	Limit permitting of new septic systems; require new development to connect to sanitary sewer. Monitor existing septic systems through city-wide programs to ensure compliance. Continue to expand City's wastewater services to areas traditionally served by on-site septic systems. Continue off-site stormwater improvements; runoff should be treated and detained prior to release to streams. Use low impact development techniques. Identifying and mitigating the source of the high total suspended solids should be a high priority. Use of BMPs and management of runoff and from agricultural lands, particularly in the lower reaches could improve conditions. Educational materials and outreach could be made available to all streamside landowners addressing proper use of fertilizers and herbicides.

Site-Specific Restoration Opportunities

While much of the Clarks Creek shoreline is developed as residential or agricultural properties, a number of large parcels are publicly owned and are largely undeveloped. This includes over 120 acres near the headwaters owned by WDFW, approximately 65 acres developed as City parks, and approximately 90 acres owned by Washington State University (WSU). A number of measures employed at these locations could improve shoreline conditions, including increased buffer width in parks; removal of shoreline armoring and replacement with softshore, or bioengineered, armoring techniques; and removal of invasive plant species and replacement with native species. Public outreach and educational materials addressing these issues and how to promote these measures could be developed and targeted to land owners along Clarks Creek.

Opportunities in both public and privately owned areas along Clarks Creek are discussed further below.

Several site-specific opportunities have been previously identified along Clarks Creek (Parametrix, 2003). Moving upstream, from north to south, these are described below. These areas were identified and described primarily as a result of field reconnaissance by Parametrix staff.

- **C-1.** The strategic addition of LWD throughout the reach could have a favorable impact on instream conditions if it is used as an alternative to bank armoring. Unlike hardened banks, LWD facilitates the growth of riparian vegetation and adds needed roughness to the stream, while still maintaining bank stability. Maintenance and protection of existing riparian wetlands could play an important role in managing sediment and nutrient delivery to the stream from nearby agricultural areas. Protection of the undeveloped floodplain areas and wetlands along the channel margins will allow overbank flow and sediment retention processes to be maintained. In addition, the reed canarygrass-dominated wetland downstream of 56th Street East could be enhanced by planting native woody vegetation. The disturbed areas near 66th Avenue East and North Levee Road, which are dominated by Himalayan blackberry, also could be replanted with native trees and shrubs. The City could provide technical assistance or subsidize the reintroduction of native species along this reach.
- **C-2.** Agricultural areas on the west bank in the WSU property have left a vegetative buffer (50 to 100 feet wide) near the stream. Maintaining this buffer during future development will help preserve floodplain functions associated with overbank flows and interflow, which in turn maintain wetlands. Although the buffer is present, it contains few mature trees. Trees that will provide shade, cover, and biotic energy to the stream should be planted where possible. Protecting the existing stand of medium-sized cottonwoods along the west bank near W. Pioneer Avenue is recommended.
- **C-3.** The City has an opportunity to use its ownership of Clarks Creek Park and DeCoursey Park to enhance disturbed areas and protect remaining open space. The banks could be restored to natural conditions by removing revetments. If bank erosion occurs in this area, ecologically friendly materials such root wads, logs, and jute netting could be used to stabilize newly planted native riparian species (such as cottonwood) that will also stabilize banks over time. Education of streamside landowners could play an important role in enhancing habitat and promoting ecologically sustainable practices.
- **C-4.** The habitat near the headwaters and WDFW fish hatchery remains largely intact. This reach should be protected from encroachment. Given that spawning is the most important function of this reach, enhancement efforts should be focused on improving existing spawning areas and creating additional spawning habitat. Although some tributaries have been routed around this reach and now enter Clarks Creek through Meeker Creek, large amounts of sediment are still being introduced into spawning gravel, as evidenced by the amount of sediment deposited by the alluvial fan.

7. DATA GAPS AND RECOMMENDATIONS

This section describes data gaps identified during development of the shoreline inventory and characterization. It also provides recommendations for addressing data gaps as the City continues the process to update its Shoreline Master Program.

- **Floodplain Mapping and Flood Hazard Management:** Accurate mapping of flood hazard areas is important in order to minimize potential harm to human life and protect property. Since the location of the floodplain is integral to the definition of the City's shoreline management jurisdiction and planning area, accurate mapping is also critical to the City's SMP. FEMA is remapping flood hazard areas for both Clarks Creek and the Puyallup River in the City's shoreline planning area. Updated draft mapping for the Puyallup River has been incorporated in this report. . Additionally, Pierce County has initiated a Puyallup River Flood Protection Investigation to further address flood hazard issues. The project intends to characterize existing conditions, quantify sediment aggradation and flooding in the lower Puyallup, and identify flood management options and alternatives. Coordination with Pierce County on the findings of these studies, once completed, would enhance the City's understanding of baseline conditions as it continues to update its SMP.
- **Clarks Creek and Meeker Creek TMDL:** The City is completing the first step of the TMDL (or clean-up plan) addressing water quality issues in Clarks Creek. Working with Ecology, the City hopes to complete the TMDL and its associated implementation plan in 2007. The TMDL study will help identify sources of contaminants in the stream affecting water quality, and will identify potential restoration opportunities along Clarks Creek and Meeker Creek.
- **Archaeological Resources:** Coordination with Puyallup Tribe and Muckleshoot Indian Tribe would help to identify the probability or likelihood that intact archaeological resources may be present in the shoreline planning area. In addition, the State Department of Archaeology and Historic Preservation recently completed a GIS-based predictive model for archaeological resources in the Hood Canal region. The model covers much of the Puget Lowlands in south Puget Sound, including all of the City of Puyallup. Use of this resource may assist with permitting and development review during administration of the City's SMP and other land use regulations.
- **Site-Specific Opportunity Areas:** Identification and additional analysis of land ownership would help identify and assess the feasibility of implementing site-specific restoration projects. This work could occur during development of the restoration planning element of the City's SMP later this year.
- **Puyallup River Flood Management and Levee Setback Program:** The City should continue its coordination with Pierce County Water Programs in determining flood management issues, assessing levee maintenance and setback programs, and identifying future opportunities for joint restoration projects.

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