City of Des Moines

Shoreline Inventory and Characterization

Public Review Draft

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INTRODUCTION

Background and Purpose

The purpose of this study is to conduct a baseline inventory of conditions in the shoreline jurisdiction of the City of Des Moines (City), Washington. This inventory and characterization provides a basis for updating the City's Shoreline Master Program to comply with the Shoreline Management Act (SMA), Revised Code of Washington (RCW) 90.58 and its implementing guidelines, Washington Administrative Code (WAC) 173-26. This characterization will help the City identify existing conditions, evaluate functions and values of resources in its shoreline jurisdiction, and explore opportunities for conservation and restoration of ecological functions. These findings will help provide a framework for future updates to the City's shoreline environment designations and shoreline management policies and regulations.

Shoreline Jurisdiction and Study Area Boundary

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 greater than 20 acres.

This characterization includes those marine shorelines within the city limits of the City of Des Moines. This includes approximately 4.8 miles along Puget Sound within the City limits, between the City of Normandy Park to the north, and the City of Federal Way to the south (Figure 1). There are no "shorelines of the state" associated with rivers or streams in the City. The portions of Puget Sound within the city limits are defined as "shorelines of statewide significance" waterward of the line of extreme low tide (RCW 90.58.030(2)(e)(iii)). Under the SMA, the shoreline area to be regulated under the City's Shoreline Master Program must include marine waters and 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. Intertidal wetlands have been mapped throughout the City limits along Puget Sound. 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)).

For purposes of this report, this area is shown on Figure 2 as the approximate shoreline jurisdiction.

Methodology

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

- Greater Des Moines Comprehensive Plan (2001; 2004);
- City of Des Moines Comprehensive Stormwater Management Plan (1991; 1998);
- Comprehensive Marina Master Plan (2001);
- Washington State ShoreZone Inventory (2001);
- Marine Shoreline Inventory Report (WRIA 9) (2001);
- Coastal Zone Atlas of Washington, King County (1979)
- The Catalog of Washington Streams and Salmon Utilization, Volume 1, Puget Sound Region (1975); and
- Washington State Department of Fish and Wildlife Priority Habitats and Species, Streamnet, and Marine Resource Species information (2004).

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

- Reconnaissance Assessment of the State of the Nearshore Report: Including Vashon and Maury Islands (WRIAs 8 and 9) (2001);
- Occurrence and Quality of Ground Water in Southwestern King County, Washington (1995);
- Geology and Ground-Water Resources of Southwestern King County, Washington (1969);
- Soil Survey of King County Area, Washington (1979);
- Washington Trout Water Type Survey Results, South King County (2004);
- Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island) (2000); and
- Coastal Bluffs and Sea Cliffs on Puget Sound, Washington (2004).

Historic and current mapping and aerial photographs of the study area were consulted, and staff biologists, geologists, and planners conducted a reconnaissance field survey of the City's shoreline jurisdiction at existing public access locations. Historic mapping and aerial photography integrated with GIS data included:

- Topographic "T-sheet" Coastal Mapping; U.S. Coastal Survey, 1876-1877;
- Vertical aerial photography by U.S. Army Map Service, 1942;
- Vertical and oblique aerial photography by Department of Ecology, 1977;
- Oblique aerial photography by Department of Ecology, 2000; and
- Vertical aerial orthophotography by U.S.G.S, 2002.

Sources of information on cultural and historic resources included the Des Moines Historical Society website and consultation with the King County Historic Preservation Program and the Washington Office of Archaeology and Historic Preservation.

Report Organization

This report is divided into seven main sections. After Section 1.0, which provides background and introductory information, Section 2.0 discusses the regulatory context for shoreline planning. Section 3.0 is a general characterization of watershed conditions and ecosystem-wide processes affecting the shoreline. Section 4.0 focuses on existing land use and built environment conditions in the shoreline jurisdiction, while Section 5.0 describes nearshore processes and the natural and altered physical conditions along the shoreline. Section 6.0 describes the biological resources and habitat conditions in the shoreline jurisdiction. Finally, Section 7.0 summarizes conditions for each segment, and identifies and discusses potential opportunity areas for protection, enhancement, restoration, and enhanced public access.

Also accompanying this report are several figures that identify the City's approximate shoreline jurisdiction; identify shoreline planning segments; and document various biological, land use, and physical elements at watershed, city-wide, and nearshore environment scales. Figures are referred to throughout the document and are contained in Appendix A, Map Folio.

Shoreline Planning Segments

For the purposes of this study, the City's shoreline jurisdiction was organized into seven distinct segments (A through G) based primarily on existing land uses and zoning designations, and more broadly on the physical distinction along the shoreline and level of ecological functions provided by each segment. Shoreline Planning Segments are described in Table 1 and depicted on Figure 2.

Table 1. Shoreline Planning Segments

Segment	General Boundaries	Approximate Length (feet)	Approximate Percentage of City's Shoreline Jurisdiction
A	**Des Moines Beach Park:** from the northern city limits to the Des Moines Marina, including the mouth of Des Moines Creek	859	3%
B	**Des Moines Marina**	3000 (length does not include separate length around breakwater)	12%
C	**Zenith:** from the marina south to Saltwater State Park, including the mouth of Massey Creek	8412	33%
D	**Saltwater State Park:** includes the mouth of McSorley Creek	1241	5%
E	**Woodmont / Redondo North:** from Saltwater State Park to the Redondo Marina, including the mouth of Woodmont Creek	8656	34%
F	**Redondo Boat Launch / Beach Park:** includes the mouth of Redondo Creek	520	2%
G	**Redondo South:** from Wooten Park to the southern city limits, including the mouth of Cold Creek	3096	12%

CURRENT REGULATORY FRAMEWORK SUMMARY[1]

City of Des Moines Regulations

Current Shoreline Management Act Compliance

The Shoreline Management Act is implemented through the development of local Shoreline Master Programs (SMPs). The City of Des Moines adopted regulations contained in Ordinance No. 715 (October 15, 1987) as its Shoreline Master Program. Goals and policies are incorporated into the Greater Des Moines Comprehensive Plan by reference. Development regulations contained in the SMP are adopted by reference as part of the Des Moines Zoning Code (18.90 DMMC).

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. Generally, environment designations should be based on existing and planned development patterns,

[1] This discussion of regulatory requirements is not intended to be a complete list of all permits or approvals necessary for work within the City's shoreline jurisdiction or other areas within the City. Other portions of local code and state and federal regulations may apply to development projects within the City. The permits and approvals necessary for construction may vary from parcel to parcel regardless of shoreline jurisdiction and may vary depending on the type and intensity of the work proposed. Prior to any construction an applicant should contact the City and the applicable state and federal agencies to determine actual permit requirements.

biological and physical capabilities and limitations of the shoreline, and a community's vision or objectives for its future development. During development of its first SMP in 1988, the City evaluated the natural and built characteristics of its shoreline jurisdiction and developed two shoreline environment designations:

- Conservancy (from the northern city limits to the marina, and from approximately South 230th Street to the southern city limits at Saltwater State Park); and
- Urban (the marina and adjacent multi-family developments).

City of Des Moines Ordinance No. 1176 (1996) amends the City's SMP to include the Woodmont/Redondo annexation area (i.e., from Saltwater State Park south to the current city boundary adjacent to the City of Federal Way). The ordinance recognizes the King County Shoreline Master Program environment designation of "Urban" for the annexed shoreline area of Woodmont and Redondo.

According to Substitute Senate Bill (SSB) 6012, passed by the 2003 Washington State Legislature, cities within King County are required to amend their local shoreline master programs consistent with Ecology's revised guidelines. With the assistance of a grant administered by the Department of Ecology (SMP Grant No. G0400332), the City is conducting a comprehensive SMP update, consistent with the current guidelines. This baseline inventory and analysis will inform development of the goals and policies and will provide a basis for the update of shoreline environment designations during the comprehensive SMP update process, anticipated to occur through June 2005.

Comprehensive Plan, Zoning and Other City Regulations

Greater Des Moines Comprehensive Plan – The City's existing Comprehensive Plan was last amended in 2004. The City is currently updating the Comprehensive Plan, as required under the Growth Management Act. The Comprehensive Plan establishes goals and policies that define the community's vision for the physical, economic, and social development of the City for the next 20 years. The Comprehensive Plan land use designations near the Puget Sound shoreline include Park, Single Family, Multifamily, Commercial, and Public Facility / Utility. City land use designations are relevant to this shoreline characterization as they establish the general land use patterns and vision of growth the City has adopted for areas both inside and outside the shoreline jurisdiction. The City's Shoreline Master Program goals and policies are adopted by reference as one element of the Comprehensive Plan.

City of Des Moines Municipal Code, Title 18: Zoning – Title 18 of the Des Moines Municipal Code establishes zoning designations. Zoning designations near the Puget Sound shoreline include Downtown Commercial, Single Family Residential, and Multifamily Residential. Park and open space areas are typically designated as Residential - Suburban Estates.

City of Des Moines Municipal Code, Chapter 18.86: Environmentally Sensitive Areas – Chapter 18.86 of the Des Moines Municipal Code establishes development standards, construction techniques, and permitted uses in environmentally sensitive areas and/or their buffers (i.e., geologic hazard areas, fish and wildlife conservation areas, wetlands, flood hazard areas, aquifer recharge areas, and stream areas) to protect these areas from adverse impacts.

Designated environmentally sensitive areas are found throughout the City's shoreline jurisdiction, particularly streams, flood hazard areas, and geologic hazard areas.

City of Des Moines *Comprehensive Stormwater Management Plan* – The City's Surface Water Management Program utilizes both the adopted *Comprehensive Stormwater Management Plan* (1991) and a draft updated plan (1998) to guide stormwater management in the city. The City has adopted the King County Surface Water Design Manual for controlling stormwater runoff from new development.

State and Federal Regulations

A number of state and federal agencies may have jurisdiction over land or natural elements in the City's shoreline jurisdiction. Local development proposals most commonly trigger requirements for state or federal permits when they impact wetlands or streams; potentially affect fish and wildlife listed under the federal Endangered Species Act (ESA); result in over five acres of clearing and grading; or affect the floodplain or floodway. As with local requirements, state and federal regulations may apply throughout the City, but regulated resources are common within the City's shoreline jurisdiction. The state and federal regulations affecting shoreline-related resources include, but are not limited to:

Endangered Species Act: The federal ESA addresses the protection and recovery of federally listed species. The ESA is jointly administered by the National Oceanic and Atmospheric Administration (NOAA) Fisheries (formerly referred to as the National Marine Fisheries Service), and the United States Fish and Wildlife Service (USFWS).

Clean Water Act (CWA): The federal CWA requires states to set standards for the protection of water quality for various parameters, and it regulates excavation and dredging in waters of the U.S., including wetlands. Certain activities affecting wetlands in the City's shoreline jurisdiction or work in the adjacent rivers may require a permit from the U.S. Army Corps of Engineers and/or Washington State Department of Ecology under Section 404 and Section 401 of the CWA, respectively.

Hydraulic Project Approval (HPA): The Washington Department of Fish and Wildlife (WDFW) regulates activities that use, divert, obstruct, or change the natural flow of the beds or banks of waters of the state and may affect fish habitat. Projects in the shoreline jurisdiction requiring construction below the ordinary high water mark of Puget Sound or streams in the city could require an HPA from WDFW. Projects creating new impervious surface that could substantially increase stormwater runoff to waters of the state may also require approval.

National Pollutant Discharge Elimination System (NPDES): Ecology regulates activities that result in wastewater discharges to surface water from industrial facilities or municipal wastewater treatment plants. NPDES permits are also required for stormwater discharges from industrial facilities, construction sites of five or more acres, and municipal stormwater systems that serve populations of 100,000 or more.

WATERSHED CHARACTERIZATION

Ecosystem Wide Processes

To understand shoreline processes and functions within the regulated shoreline jurisdiction, it is useful to understand the natural, ecosystem-wide processes that contribute to the conditions found along the shoreline and affect the natural, ecological functions occurring in the nearshore environment[2]. Alterations that affect the larger area may affect the natural shoreline processes. As water flow drives many ecological processes, a useful area for evaluation is the watershed. For purposes of this report, the Des Moines area watershed is defined as those stream basins that flow directly to Puget Sound and discharge in the shoreline jurisdiction of the City of Des Moines. These include Des Moines Creek, Massey Creek, McSorley Creek, Woodmont Creek, Redondo Creek, and Cold Creek drainage basins (Figure 3). Surface and groundwater flow in the watershed is naturally controlled by climate, topography, vegetation, soils, and geologic conditions, but is also altered by land use activities.

Climate

The Puget Lowland has a maritime climate with cool winters, dry summers, and a distinct rainy season. Precipitation in the Lowland varies considerably because of mountain effects. The Des Moines area watershed receives between 35 and 40 inches of rain per year on average, with 75 percent of the precipitation falling from October to March (Woodward et al., 1995). Winds are generally from the southwest during the rainy season and from the northwest during the dry summer months.

Topography

The Des Moines area watershed is located on the western portion of the Des Moines Plain, a broad northerly-trending upland area located between the Duwamish-Green River valley and Puget Sound. The upland plateau area has relatively low relief and largely lies 300 to 400 feet above sea level. The upland area is bounded to the east and west by steep bluffs (Figure 4).

The watershed comprises the western two thirds of the Des Moines Plain. The upland ground surface has local closed depressions occupied by lakes and poorly drained areas occupied by wetlands and peat bogs. Streams draining the watershed are relatively short and flow directly to Puget Sound.

Vegetation

As the watershed is largely covered with medium to high density, residential and commercial development, much of the natural land cover has been altered (Figures 6a and 6b). Large areas of native vegetation within the watershed are generally restricted to steep slopes along streams. Stream valleys that have not been significantly developed have been incorporated into parks or other government property. Other areas of native vegetation include larger institutional

[2] The Puget Sound "nearshore" is generally considered to be an area that runs from the top of bluffs on the land across the beach to the point where light penetrates the Sound's water.

properties. Native vegetation in undeveloped areas include trees, such as Douglas fir, Western red cedar, Western hemlock, Pacific madrone, big leaf maple, and alder. Such trees remain in residential areas but have been thinned considerably to accommodate housing. Common understory plants in undeveloped areas include salal, ferns, Indian plum, Oregon grape, elderberry, oceanspray, and salmonberry.

Geology and Soils

The geology of the Des Moines vicinity is well documented by Waldron (1961 and 1962). More recent geologic mapping of the area has been conducted by the University of Washington's Pacific Northwest Center for Geologic Mapping Studies (Booth and Waldron, and Booth et al., in press). The geology along the shoreline is also documented in the Coastal Zone Atlas of King County (Washington State Department of Ecology [Ecology], 1979). Soils are shown on Figure 3, surficial geologic units on Figure 4.

The Des Moines Plain is underlain by a complex sequence of glacial and nonglacial deposits that overlie Tertiary bedrock. The depth to bedrock in the vicinity of the project area is approximately 1,000 to 1,500 feet (Jones, 1996). The area has been glaciated 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 most recent incursion of glacial ice into the central portion of the Lowland is called the Vashon Stade of the Fraser glaciation, which receded from the area about 13,500 years ago. Since then, present-day geologic processes, such as erosion and deposition by streams and landsliding, have modified the ground surface and further complicated the geology. In addition, fill has been placed across much of the area for constructions of roads, businesses and Sea-Tac airport.

Most soils exposed at the ground surface within the study area were deposited by the last glacial episode (Waldron, 1961 and 1962). Lodgment till mantles much of the upland area of Des Moines (Figure 4) but is generally absent along the steeper portions of the bluff at the edges of the upland. Lodgment till is an unsorted mixture of sand, gravel, silt, and clay deposited at the base of a glacier and has been compacted to a very dense state by the great weight of the overriding ice. Lodgment till has very low permeability and typically acts as an aquitard, restricting the downward flow of groundwater and reducing recharge of deeper aquifers.

Recessional outwash and recessional lacustrine (lake) deposits of variable thickness commonly overlie the till. These sediments were deposited in topographic lows in the till surface where meltwater streams drained from the receding glacier, such as along the headwater areas of Des Moines and McSorely Creeks (Figure 4). Areas of recessional outwash and lacustrine deposits are where recent peat and muck have accumulated and are the sites of the larger wetlands within the watershed (Figure 3).

Underlying the till are thick deposits of sand and gravel separated by finer grained layers of clay and silt or tight, well-graded soils, such as till. These layers comprise several aquifers and aquitards within the subsurface and control subsurface water movement to the shoreline.

Surface and Groundwater

The Des Moines watershed lies within the South King County Groundwater Management Area (GWMA). Groundwater and hydrology of the watershed is well described in Luzier (1969) and Woodward et al. (1995). Additional analysis and groundwater protection planning are being conducted under King County's Groundwater Management Program.

The upland surface has several small lakes and numerous streams that flow short distances from the upland area to the shoreline (Figure 5). Precipitation falling within the watershed is conveyed directly to lakes and streams by surface runoff or travels in the subsurface as groundwater flow. Small amounts of rainfall soak into the ground, but during heavy rainfall, the ground quickly becomes saturated, inhibiting further infiltration. Water that is unable to infiltrate travels down slope across the ground surface as stormwater runoff. Surface runoff may erode soil, which is conveyed to streams and eventually to the shoreline of Puget Sound.

Poorly drained areas of the upland plateau are the sites of former or existing wetlands. Wetlands regulate the flow of water within a watershed by storing water during precipitation events, slowing the conveyance of water from the upland to the shoreline, and increasing infiltration. Development has reduced the number and area of wetlands in the upland plateau, causing higher volumes and peak rates of stormwater runoff.

Impermeable surface such as pavement, rooftops, or compacted ground increase stormwater runoff. Conversely, vegetation promotes infiltration by intercepting rainfall, effectively spreading precipitation events over longer periods of time and reducing peak flows and associated sediment transport. Vegetation also reduces erosion by holding soil in place and reducing splash erosion.

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 to underlying more permeable soils or aquifers. Because of the complex stratigraphy of the soils in Puget Sound, several aquifers exist within the subsurface. For the uppermost aquifer beneath the till, groundwater flow is radially outward from two groundwater highs that lie beneath the upland plateau. One groundwater high is located just east of Sea-Tac airport; the other is located east of Redondo (Woodward et al., 1995).

Coastal Processes

The coastal zone is a dynamic environment, and human actions can easily alter the natural system. Therefore, it is important for communities to understand potential impacts of land use. General coastal processes are well summarized in the *Coast of Puget Sound* by Downing (1983) and by Shipman (2004). Steep, gradually receding bluffs commonly back the shoreline along Des Moines. Over time, the bluffs erode and recede landward providing sediment to the shore. Prior to construction of bulkheads and other structures that were intended to protect property from wave and tidal action, intermittent landslides occurred along bluff shores, although natural bluff recession rates were generally quite slow in most of Puget Sound. Sediment that accumulates at the base of the bluff helps to protect the bluff from further erosion and reduces

the recession rate. Sediment from eroded bluffs may enter the intertidal zone within the nearshore, where it is subject to transport by waves and water currents.

Prevailing winds and waves cause littoral drift, which is the movement of loose sediment along the shore, primarily within the intertidal zone. Sediment that is sufficiently small, typically sand, is suspended for short durations by wave action and is transported along the shore parallel to the beach. Gravel is transported by rolling (saltation) as a result of storm waves, and plays an important role in beach stability. The direction of drift transport is generally in the direction of prevailing winds, which may differ in the summer and winter. The predominant, or net-shore drift direction is the most important consideration for coastal processes. Net-shore drift north of the Woodmont neighborhood is northerly and south of Woodmont the predominant net-shore drift is southwesterly. A mapped transition zone is located near Saltwater State Park (Ecology, 2000). There is a short section of shoreline with net-shore drift to the south just north of the Des Moines marina.

Where natural net-shore drift is blocked, beach processes are altered. Transported sand and gravel accumulates on the updrift side of shore obstructions (the side opposite the net-shore drift direction) and is depleted on the downdrift side of obstructions by blocking the transport of drift material. Such obstructions include human-built structures such as bulkheads, breakwaters, groins, docks, and boat ramps. In areas where the beach is depleted, erosion accelerates.

Owners of property adjacent to the shore commonly construct rock or concrete bulkheads to protect the bank or bluff from erosion. Such measures can increase beach depletion as wave energy is reflected rather than absorbed. The shoreline processes and conditions along Des Moines are summarized in the *Net-shore Drift of King County* (Chrzastowski, 1982) which updated the coastal drift section of the *Coastal Zone Atlas of King County* (Ecology, 1979) and are currently being reevaluated by Johannessen and others (personal communications) in work underway for WRIA 9 and WRIA 8. Specific conditions in Des Moines are discussed in the section of this report titled Nearshore Physical Characterization.

Historic Land Use Development

The Des Moines area was traditionally used by Native Americans for salmon fishing and clamming in the streams and shoreline before European settlement. Europeans began to arrive in the early 19th century, first as explorers and later as settlers. The first homestead claim certificate in the Des Moines area was granted to John Moore in 1872. In 1889 the plat of the Town of Des Moines was recorded (Des Moines Historical Society, 2004).

Land use in the area has always focused on the shoreline. By the early 20th century the Puget Sound had become a busy waterway as Seattle and Tacoma grew as port cities. The Sound provided transportation for recreation, food, and natural resources. During World War I, Des Moines became a destination for summer visitors, many of whom built large homes. Also at this time an existing dock was enlarged to accommodate a ferry that made runs between Vashon Island and Des Moines. Food and recreation continued to be the main attractions in the 1920's and 1930's. Des Moines Beach Park and Salt Water Park were developed during this time (Des Moines Historical Society, 2004).

During and after World War II the population of Des Moines boomed. The City was officially incorporated in 1959. Commercial development in the upland areas was further spurred first when Highway 99 (Pacific Highway South) was built in the 1920's, and then when Interstate-5 and its associated interchanges were built in the 1960's. Development in recreation continued as well. In the 1970's the City built the Marina and fishing pier.

Development along the Des Moines shoreline has historically been dominated by single-family housing. Today the City is highly developed, predominantly by single-family homes, with multi-family, and commercial areas located in the Downtown/Marina area, along Pacific Highway, I-5, and arterial streets such as the Kent-Des Moines Highway (City of Des Moines, 2002). Figures 6a and 6b show the current city limits and surrounding area in 1942 and 2002 respectively. The air photos illustrate two important points in characterizing the Puget Sound shoreline in Des Moines. First, development at the water's edge has been in place for decades (see the downtown Des Moines, Zenith, Woodmont, and Redondo areas in 1942). Second, upland development throughout the Des Moines area watershed has removed vegetation and increased impervious surface area. These conditions are characteristic of western King County and the Puget Sound shoreline. The City's development and urbanization have resulted in increased stormwater runoff and peak flows with associated flooding and increased pollutant loads in streams. These conditions affect fish and wildlife habitat and natural stream morphology. The City is expected to experience continued economic and population growth in the coming decade and these issues will continue to require attention (City of Des Moines, 2002).

Major Land and Shoreline Uses

Generalized existing land use, according to King County assessor codes, is shown on Figure 7. Single-family housing is the most dominant land use within the City's shoreline jurisdiction, representing approximately 57 percent of the City's shoreline. Another nine percent of the shoreline is vacant but zoned for single-family residential development. The second major shoreline use in Des Moines is described as public facilities, which includes the Des Moines Marina near downtown, and the beach, boat launch, and Highline Community College Marine Science and Technology Center in the Redondo neighborhood. Public facilities comprise approximately 16 percent of the Des Moines shoreline. Commercial properties are located adjacent to the Des Moines Marina and the Redondo beach and boat launch areas. Parks make up the third largest shoreline use in the City of Des Moines, including Des Moines Beach Park and Saltwater State Park, which represent approximately nine percent of the City's shoreline. Multi-family residential development near the south end of the Des Moines Marina and in the Redondo neighborhood comprise the remaining area (approximately five percent) along the shoreline.

Water Quality

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. The Washington Department of Ecology maintains a 303(d) list, composed of waterbodies where tested pollutants have exceeded thresholds established by the state surface water quality standards (WAC 173-201A). 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 are tested as part of this process.

Therefore absence from the 303(d) list may not necessarily indicate that the waterbody is not impaired. The 1998 303(d) list was the last one submitted to and approved by EPA. A preliminary draft of Washington State's 2002/2003 303(d) list is currently available for public review (January 15 through March 15, 2004). Although not yet approved, the listings have been included below.

Several of the streams that discharge into the Puget Sound through the Des Moines shoreline jurisdiction are included on Washington State's 303(d) list. Some are listed for multiple pollutants. Table 2 shows the waterbodies listed in both the 1998 approved 303(d) list and the proposed 2002/2003 list, as well as the pollutants that impair their use and the medium for which they were tested.

Table 2. 303(d) List of Waterbodies in Des Moines, WA

Waterbody Name	Parameter	Year	Medium
Puget Sound (S-Central, East Passage)	Fecal Coliform	98' 02'	water
	Ammonia-N	98'	water
	pH	98'	water
	2,4-Dimethylphenol	02'	sediment
	2-Methylphenol	02'	sediment
	Benzyl Alcohol	02'	sediment
Des Moines Creek	Fecal Coliform	98', 02'	water
Massey Creek	No impairment reported		
McSorely Creek	Fecal Coliform	98', 02'	water
Woodmont Creek	No impairment reported		
Redondo Creek	Fecal Coliform	98', 02'	water
Cold Creek	No impairment reported		

In 1994 the City of Des Moines implemented a water quality-monitoring program. The objectives of the program were to evaluate water quality in three streams over a five-year period at upstream and downstream locations. The data were to be used to assess the effects of a program of stormwater management and non-point source pollution control implemented under the *City of Des Moines Comprehensive Stormwater Management Plan* (Parametrix, 1991). The monitoring continues to be ongoing. Water quality monitoring also occurs at the Highline Community College Marine Science and Technology Center, located in the Redondo waterfront area.

NEARSHORE LAND USE PATTERNS

The City of Des Moines is located in southwest King County. Des Moines is highly developed and has a well established pattern of land use. The City is bounded by approximately 4 miles of Puget Sound shoreline to the west and Pacific Highway South and Interstate-5 (I-5) to the east. The cities of Normandy Park and SeaTac form Des Moines' northwest and northeast borders respectively, the City of Kent is to the east and the City of Federal Way is to the South. The City's shoreline jurisdiction is composed of a variety of natural and human-modified landscape features that include natural and modified beaches, concrete, wood and rock bulkheads, roads, and the marina facility.

Existing Land Use

The City of Des Moines is predominantly developed as single-family residential, with multi-family and commercial developments located in limited areas. The City has a diversity of housing types. Slightly less than half of the housing units are single family; approximately the same proportions of units are apartments, condominiums, and retirement and group homes. Mobile homes comprise the remainder of the housing units (City of Des Moines, 2002). Existing land use is shown in Figure 7.

Single family residential development is the dominant land use, it occupies approximately 53 percent of the land area in the City of Des Moines. Multi-family development occupies seven percent and mobile homes occupy one percent. Commercial developments (including services, retail sales, and light industrial uses) occupy approximately six percent of the City's land area and are located primarily in the Downtown/Marina area, and along major transportation corridors including Pacific Highway South and Kent-Des Moines Road. Public Facilities (including the Marina, Redondo Beach area, and Schools) occupy seven percent of the City's land area. Vacant lands occupy approximately 18 percent of the City (City of Des Moines, 2002).

Several of Des Moines' neighborhoods are located along the Puget Sound shoreline. They include Downtown, Zenith, Woodmont West, and Redondo. The Downtown Neighborhood's shoreline includes both the Marina and Des Moines Beach Park. The majority of lands along the shoreline in both the Zenith and Woodmont West neighborhoods are occupied single-family development. The small number of multi-family developments and commercial developments along the Puget Sound shore are all located in the Redondo Neighborhood to the south and surrounding the Marina in the north. Public access to the shoreline in the City includes Des Moines Beach Park, north of the Marina, the Des Moines Marina, Saltwater State Park and the Redondo neighborhood.

The Des Moines Marina is the largest single facility/structure within the City's shoreline jurisdiction. The marina was built in 1970 and consists of permanent and temporary moorings, a public boat launch, restrooms and showers, a fishing pier, a fueling facility, and commercial areas and services. The Marina occupies approximately a half-mile of the Puget Sound shoreline. The upland shoreline of the Marina consists of a timber pile seawall. The pilings in the seawall are each attached to concrete weights buried under the pavement about 30 feet behind the wall. The Marina is sheltered by a rubble rock breakwater structure, approximately 2,000 feet long. The commercial facilities at the Marina include a boat repair yard, boat sales, restaurant, and the Des Moines Chamber of Commerce (business promotion office). According to the Marina Master Plan (2002), commercial development in the marina will increase in the course of implementing that plan.

Comprehensive Plan / Zoning Designations

Comprehensive Plan

According to the City of Des Moines Comprehensive Plan Map (2004), the City's shoreline jurisdiction is largely comprised of properties designated as low to medium-density residential (1–6 dwelling units per acre). Parks and Public Facilities/Utilities designations comprise the second largest portion of the shoreline. Small areas designated as commercial and multi-family, located in the Downtown and Redondo neighborhoods, comprise the remainder.

General goals and policies established in the City of Des Moines Comprehensive Plan (2002) relate to the preservation of existing residential neighborhood character, protection of environmental resources, and the promotion of economic development. The Comprehensive Plan seeks to balance these social, environmental, and economic goals through land use and zoning regulations, critical areas regulations using best available science, and development regulations. The Comprehensive Plan also seeks to protect surface water quality, shoreline and nearshore habitats, and aquatic, marine, and upland habitats by managing these resources using a watershed approach (City of Des Moines, 2004).

The City's existing Shoreline Master Program goals and policies are included as an element of the City's current Comprehensive Plan. These goals and policies encourage water-oriented uses and existing residential uses in balance with protection of the Puget Sound shoreline's natural resources (City of Des Moines, 1991). This document also establishes shoreline environment designations as either Urban Environment (UE) or Conservancy Environment (CE), depending on the land use and intensity of development (City of Des Moines, 1988). The existing shoreline environment designations are shown in Table 3. The City of Des Moines has grown since adoption of the 1988 Shoreline Master Program, therefore some areas of the current shoreline were not originally classified. The City adopted the King County SMP shoreline environment designation "Urban Environment" for areas annexed since 1988 (specifically, areas south of Saltwater State Park, Segments E-G).

Zoning Designations

Zoning designations in the City of Des Moines generally follow land use designations as discussed above under Comprehensive Plan Designation (Figure 8). Within the City's shoreline jurisdiction, Residential: Single Family (RS-15,000, RS-9,600, and RS-7,200) predominates. Areas in the shoreline jurisdiction that are not zoned Single Family include the Des Moines Marina, which is zoned Downtown Commercial (D-C) and a small number of properties in the Redondo Neighborhood, which are zoned Residential: Multi Family (RM-2,400, RM-1,800, and RM-900) and Community Commercial (C-C) (City of Des Moines, 2004). Table 3 identifies the relative percentages of existing land uses and zoning areas in each planning segment, based on current zoning maps.

Table 3 also identifies the estimated impervious area for each shoreline segment. This information is summarized from the marine shoreline inventory completed for WRIA 9 (Anchor Environmental, 2004). For that study, aerial photo interpretation was conducted to estimate the amount of impervious area within 200 feet of the shoreline. Segments were then designated as having High, Medium, or Low impervious area, where High represents greater than 75 percent impervious area; Medium represents between 10 and 75 percent; and Low represents less than 10 percent. This information was reorganized to estimate impervious area for each shoreline planning segment in Des Moines. For each segment, the percentage of the segment length classified as High, Medium, or Low is shown.

Table 3. Land Use, Zoning, and Shoreline Environments

Shoreline Segment	Existing Land Use		Comp. Plan Land Use Designation		Zoning		Estimated Impervious Surface*		Existing Shoreline Designation
A	PARK SFR VAC	74.8% 16.6% 8.6%	MF36 PARK	7.8% 92.2%	R-SE RM-900	91.9% 8.1%	Low Med High	0% 100% 0%	Conservancy
B	COM MFR PARK PF SFR VAC	12.1% 2.0% 10.1% 53.8% 1.7% 20.3%	COM MF18 MF36 PARK PF	10.0% 5.5% 2.1% 0.4% 82.0%	D-C R-SE RM-1800 RM-900 RM-900A	92.0% 0.4% 5.5% 0.7% 1.4%	Low Med High	0% 0% 100%	Urban
C	MFR SFR VAC	6.7% 88.0% 5.3%	MF18 SF3 SF6	8.4% 87.4% 4.3%	RM-1800 RS-15000 RS-7200	8.4% 87.4% 4.3%	Low Med High	25% 67% 8%	Conservancy
D	PARK	100.0%	PARK	100.0%	R-SE	100.0%	Low Med	25% 75%	Urban
E	MFR SFR VAC	5.9% 87.4% 6.7%	MF18 MF24 MF48 PARK SF4 SF6	0.3% 0.8% 0.7% 4.3% 16.7% 77%	RM-1800 RM-2400 RM-900 RS-7200 RS-9600	0.8% 3.0% 0.8% 78.7% 16.7%	Low Med High	29% 65% 6%	Urban
F	COM PF VAC	13.3% 69.2% 17.5%	COM PARK	30.8% 62.8%	C-C R-SE RM-900	30.2% 67.9% 1.9%	Low Med High	0% 0% 100%	Urban
G	MFR MH SFR VAC	13.0% 4.4% 78.7% 3.9%	MF24 SF4 SF6	7.9% 29.2% 62.9%	RM-1800 RS-7200 RS-9600	7.9% 62.5% 29.5%	Low Med High	0% 76% 24%	Urban

Key

Existing Land Use	Comp. Plan Land Use Designation	Zoning
COM: Commercial	Comprehensive Plan Designations:	Zoning Designations:
MFR: Multifamily Residential	COM: Commercial	C-C: Commercial
MH: Mobile Home	MF18: Multifamily (18 du/ac)	D-C: Downtown Commercial
PARK: Park	MF24: Multifamily (24 du/ac)	RM-900: Multifamily (900 sq.ft. lot area/du)
PF: Public Facility	MF36: Multifamily (36 du/ac)	RM-1800: Multifamily (1,800 sq.ft. lot area/du)
SFR: Single Family Residential	MF48: Multifamily (48 du/ac)	RM-2400: Multifamily (2,400 sq.ft. lot area/du)
VAC: Vacant	PARK: Park	R-SE: Residential – Suburban Estates
	PF: Public Facility/Utility	RS-7200: (Single Family Residential (7,200 sq.ft. min lot size)
	SF3: Single Family (3 du/ac)	RS-9600: (Single Family Residential (9,600 sq.ft. min lot size)
	SF4: Single Family (4 du/ac)	RS-15000: (Single Family Residential (15,000 sq.ft. min lot size)
	SF6: Single Family (6 du/ac)	

* Impervious surface categories - High = >75% or greater, Med = 10% – 75%, Low = <10% (Anchor Environmental, 2004)

Roads and Transportation Facilities

As described above the majority of the City's shoreline is occupied by low density single family development. Public shoreline access is available only at Des Moines Beach Park, the Des Moines Marina, Saltwater State Park and in the Redondo neighborhood. Limited shoreline access and uniformity in shoreline land use (single family) created a land use pattern with relatively few roads in the City's shoreline jurisdiction. Most of the roads that provide access to the shoreline are located outside the City's shoreline jurisdiction. The exceptions are Redondo Beach Drive South, and Sound View Drive South, which run along the shoreline in zone F and G, Redondo Way South, which enters the shoreline from the east in Segment F, and Cliff Avenue South, which accesses the Marina and Des Moines Beach Park in Segments A and B. All other streets in the City's shoreline jurisdiction are local streets.

North of Des Moines Beach Park are several homes located on the Puget Sound Shoreline in the City of Normandy Park. These homes owners access their property by driving along the beach from Des Moines Beach Park, a distance of approximately 2,000 feet. The beach access is a concrete ramp located in Des Moines Beach Park that allows cars on to the beach.

As defined by the City of Des Moines Comprehensive Transportation Plan (2001), Redondo Beach Drive South and Redondo Way South are classified as Collector Arterials and are the only major roadways within the City's shoreline jurisdiction (Segment F and G). However, several larger roadways influence the shoreline area by providing access, but are outside of the City's shoreline jurisdiction. East of the Marina (Segment B) 7th Avenue South and Marine View Drive South are signalized three lane roadways that run from South 216th South to South 227th Street, where 7th Avenue South ends. Both are classified as Minor Arterials. Marine View Drive South becomes a two-lane roadway, classified as a Collector Arterial, at its intersection with Kent-Des Moines Road. Also in Segment B, South 222nd Street and South 223rd Street are both two-lane streets that run east/west from 24th Avenue South to the Des Moines Marina. Marine View Drive South continues south, through Segments C, D, and E, to a terminus at Woodmount Drive South (City of Des Moines, 2001).

A system of sidewalks, marked asphalt paths, and on street bicycle lanes exist within the City of Des Moines. These features exist primarily in the vicinity if the Marina and Downtown neighborhood. Particularly along Marine View Drive South, 216th Avenue South, 222nd Avenue South, and 7th Ave South. Redondo Beach Drive South also has existing sidewalks for pedestrian and bicycle use (City of Des Moines, 2001). Transit services in the City of Des Moines are provided by King County Metro. The only transit route in the Des Moines shoreline vicinity is Route 130 that provides service along Marine View Drive South (City of Des Moines, 2001).

Wastewater and Stormwater Utilities

The Midway Sewer District (MSD), Southwest Suburban Sewer District (SSSD), and the Lakehaven Utility Districts (LUD) provide for the collection, treatment, and disposal of wastewater for the City of Des Moines.

The SSSD covers a northern portion of the City in the North Hill neighborhood, extending from the northern boundary with Burien, the western boundary with Normandy Park, and the southern

boundary at approximately South 208th Street. The SSSD does not have any facilities (pump stations, treatment plants etc.) within the City of Des Moines (City of Des Moines, 1995). Sewer lines convey effluent north to a treatment plant in Normandy Park and an outfall located west of Sea-Tac Airport.

The MSD covers the majority of the City of Des Moines. Wastewater collected in the MSD is treated at the Des Moines Creek Wastewater Treatment Plant, located in the Central Des Moines neighborhood between South 212th Street and South 216th Street, and then conveyed to an outfall located north of the Des Moines Marina. MSD wastewater facilities located in the City include the treatment facility as well as 13 pump stations. Five of the pump stations are in the vicinity of the shoreline (MSD, 2000).

The LUD covers a southern portion of the City, in both the Redondo and Woodmont West neighborhoods, generally south of Woodmont Drive South, and west of 16th Avenue South and extending south to the City boundary with Federal Way. The LUD also covers a portion of the Shoreline north of Woodmont Drive South to approximately South 260th Street. The Lokota and Redondo treatment plants provide secondary treatment of effluent. The Redondo Treatment Plant is located in the Redondo Neighborhood. Four pump stations and an outfall are also located along Redondo Beach, in the City's shoreline (City of Des Moines, 1995).

The City of Des Moines has jurisdiction over the storm and surface water management system located within the city boundaries, within and outside of roadways. Stormwater utilities generally consist of a mix of open ditches and channels, pipes, vaults and open retention/detention facilities, and outfalls to streams or Puget Sound.

Other utilities in the shoreline jurisdiction include electric power, gas, and cable. Puget Sound Energy owns and operates a power cable connection to Vashon Island. The cable runs underground through the north end of the Marina and underwater to the Island. According to City staff, Comcast Corporation is currently seeking permits to run a cable to Vashon in approximately the same location as the Puget Sound Energy power line.

Existing and Potential Public Access Sites

Approximately 25 percent of the City's shoreline is available for public access and use, the remainder being residential development. Figure 9 shows the locations of all the shoreline public access sites within the City's shoreline Jurisdiction. Existing parks, open space, and public facilities in the City's shoreline jurisdiction include the following:

- **Des Moines Beach Park** – This 19.6 acre Community Park is located directly north of the City of Des Moines Marina. The mouth of Des Moines Creek is located in the park. The park provides access to the Puget Sound waterfront and 2.7 acres of tidelands. The park also contains a picnic shelter, meadows, historic and recreation buildings, play equipment, parking and access to the Des Moines Creek trailhead (City of Des Moines, 2003).
- **Des Moines Marina and Fishing Pier –** The Marina and fishing pier occupy 13 acres along the City's northern Puget Sound shoreline. The marina offers boat moorage, a boat ramp, boat repair, restaurants, shops, walkways, parking/storage, a fishing pier, restrooms, benches and picnic tables (City of Des Moines, 2003)

- **South 239th Street Access –** This 0.1 acre mini-park offers access to the Puget Sound shoreline at the end of South 239th Street. Its amenities include a picnic table, stairway and ladder for beach access (City of Des Moines, 2003).
- **Saltwater State Park** – Saltwater State Park is an 88-acre marine camping park with 1,445 feet of shoreline on Puget Sound. The park provides two kitchen shelters without electricity, plus 147 unsheltered picnic tables. Most picnic sites are near the beach or along McSorley Creek. The park also has an underwater, artificial reef on Puget Sound. The area is often used for scuba diving and fishing (City of Des Moines, 2003).
- **Redondo Beach Park –** This 2.79 acre waterfront park provides access to the Puget Sound shoreline as well as a fishing pier, boardwalk, walking path, and boat moorage and launch. The park's other amenities include restrooms, picnic areas, scenic views, and parking (City of Des Moines, 2003).
- **Highline Community College Marine Science and Technology Center** - Located at the Redondo waterfront, this facility is occasionally open to the public for lectures, facility tours, guided experiments and interpretive displays intended to engage and educate the public about Puget Sound marine ecology and water quality.

Historical/Cultural Resources

The Historical/Cultural Element of the 1988 Des Moines Shoreline Master Program provides a general goal and policy to retain and protect shoreline features having historic, cultural, scientific, or education value and to encourage development and interpretation of those sites (City of Des Moines, 1988). The Des Moines Comprehensive Plan also addresses historic preservation. The Plan establishes goals to insure 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, which enable the identification of historic and archeological sites, and direct the City to preserve and protect these sites from incompatible land uses (City of Des Moines, 2004).

The King County Historic Preservation Program (KCHPP) maintains a list of King County and local landmarks. There are four historical building in the shoreline vicinity. The Van Gasken House (built in 1889) is located on South 222nd Street in the Downtown neighborhood. The FW Morse Summer House (1905) WD Cotter Summer House (1905), and the Lumber Mill Office (1900) are all located along Redondo Beach Drive South in the Redondo Neighborhood (KCHPP, 2004). Three recorded archaeological sites are located in the vicinity of the shoreline in the city. These sites, and the traditional use of the area by Native Americans for fishing and clamming suggest that there is a high probability for archaeological resources in the city's shoreline jurisdiction (KCHPP, 2004).

Washington State's Office of Archeological and Historic Preservation (OAHP) maintains the Washington State Inventory of Cultural Resources. A request for information on listed historic or archeological sites in the State's database has been made and will be reported at a later date.

NEARSHORE PHYSICAL CHARACTERIZATION

Nearshore Processes

Substrate composition in coastal areas is a dynamic result of sediment source, beach, or shoreline stability, and the predominant (or net-shore) drift direction. Critical to the shoreline environment is sediment supply. Streams entering the jurisdiction deposit sediment at the shoreline. Sediment is also supplied to the nearshore environment as shoreline bluffs erode. These areas are referred to as "feeder bluffs." Once in the nearshore, sediment is available for transport by shore drift (i.e., currents running parallel to the shoreline move sediment). Shoreline modifications can alter the natural processes affecting sediment transport.

The Washington Department of Natural Resources (WDNR) ShoreZone Inventory (2001) characterizes shoreline sediment as stable, erosional (areas where sediment is eroding or being depleted), or accretionary (areas where sediment is accumulating). ShoreZone identifies coastal sediment sources as fluvial, alongshore, and backshore. Fluvial sources are streams or rivers that deliver sediment to the nearshore. Alongshore source refers to sediment being transported parallel to the beach by net-shore drift. Backshore sources are onshore sources derived by mass wasting, such as eroding "feeder" bluffs or banks, but excluding fluvial sources. The Washington Digital Coastal Zone Atlas (Ecology, 2000) maps net-shore drift direction and areas without appreciable drift (which include highly modified, protected harbor shorelines), based on the work of Chrzastowski (1982) and others. Net-shore drift direction is mapped by Chrzastowski (1982) as generally to the north from approximately Saltwater State Park (Segment D) and to the south of Saltwater State Park (with a transition zone occurring in the north portion of Segment E). Chrzastowski also places a short drift reversal (to the south) on the north side of the Des Moines Marina with the drift transition centered approximately 750 feet north of the marina. Table 4 summarizes the approximate intertidal beach width, primary sediment sources, shore stability, and netshore drift direction.

Table 4. Shoreline Sediment Sources And Mobility

Shoreline Segment	Approximate Intertidal Width (ft.)	Estimated Sediment Source	Sediment Stability	Netshore Drift Direction
A	83	Fluvial (all of segment, at Des Moines Creek)	Accretional	South
B	2 – 40	Not determined at marina	Stable	No appreciable drift
C	30 – 80	Backshore and Alongshore	Stable	North
D	72	Fluvial (all of segment, at McSorley Creek)	Accretional	North
E	30 – 80	Alongshore (most of segment); Fluvial (at Woodmont and McSorley Creeks	Mostly stable; accretional at Woodmont Creek	Transitional/ South
F	42	Fluvial (all of segment, at Redondo Creek)	Accretional	South
G	20 – 80	Alongshore (most of segment); Fluvial at Cold Creek	Mostly stable; accretional at Cold Creek	Southwest

Source: Washington Department of Natural Resources (WDNR), 2001; Chrzastowski, 1982; Digital Coastal Zone Atlas, Ecology, 2000.

Geologic Units

The City is located on a broad upland plateau generally lying between 300 and 400 feet in elevation, and bounded to the east and west by steep bluffs (Figure 4). The City extends from the upland plateau on the east to the shoreline on the west. The steep bluff to the west and the shoreline at its base comprise the City's shoreline jurisdiction.

A sequence of glacial and nonglacial deposits underlies the ground surface in the vicinity of the jurisdiction. Waldron (1961 and 1962) mapped the Des Moines and Poverty Bay quadrangles, which includes the City jurisdiction. The geology shown on Figure 4 was obtained from King County's surficial geology GIS data (King County, 2002). The geology of these quadrangles has recently been remapped, and revised geologic maps are to be published soon (Booth and Waldron, and Booth et al., in press). The steep shoreline bluffs and stream valley walls within the jurisdiction segments A through E are generally mapped as fine and course Pre-Fraser deposits (Figure 4), i.e., they were deposited during glacial or interglacial times preceding the most recent glaciation. More gently sloped areas above and landward of these steep shoreline slopes are mostly mapped as till of the Fraser glaciation. Mass wasting deposits and recent landslide deposits are present in segment E, south of Woodmont Creek, and in segments F and G. Mass wasting is a generic term for transportation of sediment downslope by gravity, and includes slow displacement processes, such as soil creep, and rapid displacement processes, such as landslides or mudflows. Mass wasting deposits commonly refers to broad areas of soils on steep slopes that have undergone downslope movement but where discrete landslides cannot readily be mapped because of coalescing deposition from numerous landslides over time. Other recent deposits include beach at the base of the shoreline bluff and younger alluvium on the base of ravines entering the jurisdiction and in stream deltas.

Soils

Soils in all segments include coastal beach, which are flanked by steep bluffs of Alderwood and Kitsap soils with very steep slopes in segments A, C, D, and E (Figure 3). Alderwood soils generally form in till while Kitsap soils form in fine-grained lacustrine deposits. More gently sloped ground above the steep bluffs in these segments are mapped as Alderwood gravelly sandy loam with slopes from 0 to 15 percent. Alderwood soils on slopes of 6 to 15 percent are also mapped in segment F where no steep bluff exists.

Most of segment E south of Woodmont Creek is mapped as Kitsap silt loam on 15 to 30 percent slopes. A steep bluff is absent along this portion of the segment and the hillside along and above the jurisdiction is mapped geologically as mass wasting deposits. This portion of the bluff is a large landslide complex that may have failed during one or more large earthquakes.

Where not coastal beach, most of segments G and F are mapped as urban land. Smaller areas of urban land are also designated in segment A, along Des Moines Creek. The mouth of Massey Creek in segments B and C is mapped as Pilchuck loamy fine sand, which forms on alluvial terraces. Indianola loamy fine sand on slopes of 4 to 15 percent generally form on deposits of outwash sand. These soils were mapped in very small areas in segments A, B, and G.

Seismic Hazard Areas

Seismic hazard areas are defined in Chapter 18.04.557 of the Des Moines Municipal Code (DMMC) 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 cohesionless soils of low density, usually in association with a shallow groundwater table. No seismic hazard areas are identified within the shoreline jurisdiction in the King County Sensitive Areas Map Folio (King County, 1990). However, Washington Department of Natural Resources maps areas of liquefaction susceptibility in all segments except Segment F, often associated with the lower reaches and stream mouths of Des Moines, Massey, McSorley, Woodmont, and Cold Creeks (Figure 10).

Landslide Hazard Areas

Landslide hazard areas are defined in Chapter 18.04.363 of DMMC as those areas of the city subject to a severe risk of landslide. They are defined as any area with a combination of slopes greater than 15 percent, impermeable soils, and springs or groundwater seepage; any area showing movement during the last 10,000 years; or any potentially unstable area as a result of stream incision.

Landslide hazard area information for the City's shoreline jurisdiction was taken from the King County Sensitive Areas Map Folio (King County, 1990) and is shown on Figure 10. Designated landslide hazard areas include the shore bluff in segment D, segment E excluding the flatter slopes at the southern end of the segment in the community of Redondo, and the steep slopes on either side of Cold Creek in segment G.

Erosion Hazard Areas

Erosion hazard areas are defined in Chapter 18.04.262 of DMMC as those areas underlain by soils identified by the U.S. Department of Agriculture Soil Conservation Service as having "severe" or "very severe" erosion hazard potential. Such areas designated on King County GIS maps (King County, 2002) include all coastal bluffs and steep slopes within the jurisdiction, which includes all shoreline segments. These areas are shown on Figure 10.

Shoreline Slope Stability

The Department of Ecology Coastal Zone Atlas (Ecology, 1979) characterizes the slope stability of the entire shoreline along Puget Sound. Although the City does not regulate shoreline development based on slope stability characterization, the maps provide an additional source of documented landslide areas and stability. This mapping should not be considered comprehensive and does not include landslides that have occurred since the late 1970s.

In the Coastal Zone Atlas, slope stability is defined in terms of six separate categories: stable, intermediate, unstable, unstable recent landslide, unstable old landslide, and modified. Table 5 describes these slope stability categories. These designated areas are shown on Figure 11.

Table 5. Ecology Slope Stability Map Designations

Slope Stability Designation	Definition
Stable	Generally rise less than 15 percent in grade, except in areas of low groundwater concentration or competent bedrock. Include rolling uplands and lowlands underlain by stable material (i.e., unweathered till and/or peat deposits) with no significant slope.
Intermediate	Generally steeper than 15 percent except in areas where weaker material and/or abundant material exist. These areas include slopes of sand and gravel, till, or thin soils over bedrock with no known failures.
Unstable	Slopes that are considered unstable due to geology, groundwater, slope, and/or erosional factors which include areas of landslide and talus too small or obscure to be mapped.
Unstable Recent Landslide	Recent or historically active landslide areas (based on surveys conducted in the late 1970s).
Unstable Old Landslide	Post-glacial but prehistoric landslide areas.
Modified	Slopes that are highly modified by human activity and include areas of significant excavation or filling. Response of the slope to a combination of human activity and natural processes may be unpredictable.

Aquifer Recharge Areas

Only a small portion of the shoreline jurisdiction is in a critical aquifer recharge area. Segments A and B lie within an aquifer protection zone; however, only a small portion of the jurisdiction is designated as an area of high susceptibility, as indicated on Figure 5. These portions of the jurisdiction are restricted to the top of the steep shore bluff in Segment A and at the southern end of Segment B.

Streams

The DMMC (18.04.587) defines a “Stream” as:

> *an area where surface waters flow sufficiently to produce a defined channel or bed. A defined channel or bed is indicated by hydraulically sorted sediments or the removal of vegetative litter or loosely rooted vegetation by the action of moving water. Stream channels or beds show clear evidence of the passage of water and include, but are not limited to, bedrock channels, gravel beds, sand and silt beds, and defined channel swales. The channel or bed need not contain water year-round. This definition is not meant to include irrigation ditches, canals, storm or surface water runoff devices, or other entirely artificial watercourses unless they are used by salmonids or used to convey streams naturally occurring prior to construction. Swales, which are shallow drainage conveyances with relatively gentle side slopes and generally with flow depths less than one foot, shall be considered streams when hydrologic and hydraulic analyses done pursuant to a development proposal predict formation of a defined channel after development.*

Streams provide valuable wildlife corridors, a source of fluvial sediments to the marine shoreline (moved along the shoreline by currents), and support a range of fish species. The City of Des Moines is located in Water Resource Inventory Area (WRIA) 9, the Duwamish-Green River and Central Puget Sound Watershed. Information on stream conditions was drawn in particular from the following documents: *Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island)* (Kerwin and Nelson, 2000), *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region* (Williams et al., 1975). Shoreline Segment B does not contain streams. Des Moines Creek, which originates from groundwater seeps near the Sea–Tac International Airport, discharges to Puget Sound in Segment A. Massey Creek and an unnamed creek discharge to Puget Sound and are located within Segment C. McSorley Creek discharges to Puget Sound and is located within Segment D. Woodmont Creek discharges to Puget Sound and is located within Segment E. Redondo Creek discharges to Puget Sound and is located within Segment F. Cold Creek discharges to Puget Sound and is located within Segment G. Streams are depicted on Figures 5 and 12.

Three of the streams are currently listed on the state Department of Ecology's 1998 303(d) list, which lists streams that do not meet water quality standards for one or more parameters (Ecology Website, 2004). These include McSorley (previously known as Cold Springs Creek) in Segment E, Des Moines Creek in segment A, and Redondo Creek in Segment F. All three streams currently do not meet water quality standards for fecal coliform and a Total Maximum Daily Load (TMDL) analysis is required for each stream.

Flood Hazard Areas

Flood hazard areas are not defined in the DMMC. However, they are typically defined as those areas that are determined to be at risk of having a one percent or greater chance of experiencing a flood in any one year. These areas are typically identified on the Federal Emergency Management Agency (FEMA) flood insurance rate maps as the 100-year floodplain.

All coastal beaches within the City's jurisdiction are included within the 100-year floodplain (King County, 2002). Low areas along the corridors of the Des Moines and Massey Creeks within the jurisdiction are also designated as lying within the 100-year floodplain. The King County Sensitive Areas Map Folio (King County, 1990) shows the beach areas within the jurisdiction and the low area at the mouth of McSorley Creek as lying within the 100-year floodplain. Frequently flooded areas are indicated on Figure 12.

Shoreline Modifications

Shoreline modification refers to structural changes to the shorelines' natural bank. Examples include shoreline armoring (bulkheads, rip-rap, etc.), overwater structures (dock and piers), or dredging and filling. The following assessment of the extent of shoreline modification is primarily based on the Washington State Department of Natural Resources ShoreZone Inventory (2001). A field visit on October 6, 2004 was also used to verify the reported shoreline modifications in areas that were accessible. Figure 13 depicts WDNR determinations for primary ShoreZone modification type and locations of piers, docks, and boat ramps.

Shoreline Armoring

The term shoreline armoring often refers to bulkheads and seawalls. However it can also, more broadly, include the placement of structures in the nearshore in an attempt to intercept wave energy and/or control the movement of sediment (KCDNR, 2001). Shoreline armoring is typically used to protect upland property from wave induced erosion, to retain or stabilize unstable banks, or to create areas of calm water, stabilize entrances to harbors, , or establish moorage for vessels. However, shoreline armoring also has the adverse effects on the nearshore physical processes necessary to maintain native species habitats and shoreline functions. These effects include the loss of beach areas, impoundment of sediment, modification of groundwater regimes, lowering of beach elevations, redirection of wave energy, alteration of substrate, and loss of riparian vegetation and associated functions (KCDNR, 2001; MacDonald et al, 1994).

The increase in population in the Puget Sound area in recent years has resulted in the armoring of more than 29 percent of the Puget Sound's shoreline. According to the Washington State Department of Natural Resources ShoreZone Inventory (2001), approximately 64 percent of WRIA 9 (this includes the Green/Duwamish river systems) is armored and 87 percent of the shoreline has been armored or otherwise modified from historic conditions. These data were also used to estimate the level of armoring within the City of Des Moines shoreline jurisdiction. Approximately 75 percent of the City's Shoreline has been modified by riprap, concrete bulkhead, or wooden bulkhead. Table 6 displays the amount and percentage of shoreline modification in each of the Shoreline Segments.

Table 6. Shoreline Modification by Segment

	Segment Length (ft.)	Modified Shoreline		Modification Type (length and percent of total)					
				Rip rap		Concrete Bulkhead		Wooden Bulkhead	
Segment		Length	Percent	Length	Percent	Length	Percent	Length	Percent
A	859	859	100%	601	70%*	258	30%*	0	0%
B	7,931	7,931	100%	7,931	100%	0	0%	0	0%
C	8,412	4,247	50%	2,811	33%	0	0%	703	8%
D	1,241	885	71%	885	71%	0	0%	0	0%
E	8,656	6,689	77%	3,772	44%	2,794	32%	123	1%
F	521	506	97%	129	25%	188	36%	188	36%
G	3,096	2,903	94%	0	0%	2,695	87%	207	7%
Total	30,716	24,019	75%	16,386	51%	5,678	18%	1,222	4%

* Estimate based on field observation

Docks, Piers, and Over-Water Structures

Overwater structures include floating docks, covered moorage, piers, or marinas. Overwater structures are typically located in the nearshore. They change the levels of light, shoreline energy regimes, substrate type and stability, and water quality (Nightingale and Simenstad, 2001). These changes result in alterations in the abundance and diversity of species in the nearshore. Overwater structures, such as piers and breakwaters, can also alter wave energy and

sediment dynamics that affect plant propagation, fish foraging, spawning and migration, and shellfish settlement and rearing. Additionally construction materials associated with overwater structures can leach contaminants into the nearshore environment. Along with these direct effects, a number of indirect effects result from some overwater structures as well. Covered moorages and boathouse are associated with cleaning, pesticide, herbicide, paint, petroleum, and other maintenance products entering the water (Nightingale and Simenstad, 2001). The water quality within the Marina is affected by boat engine exhaust, fuel spills, sewage discharge, and contaminated stormwater runoff coming from adjacent parking lots (KCDNR, 2001).

According to the Washington State Department of Natural Resources ShoreZone Inventory (2001), there are 191 docks and piers in all of WRIA 9 and 81 docks and piers along the mainland shoreline (excludes Elliot Bay and Vashon/Maury). The Inventory was further broken down for the City of Des Moines. There are approximately 3 docks or piers (one in Segment B and two in Segment F) and 6 boat launches (One in Segment B, four in Segment E, and one in Segment F) in the City of Des Moines. The most significant of the City's overwater structures is the Des Moines Marina. The Marina covers approximately 8,600 feet of the shoreline with a combination of piers, docks and breakwater.

NEARSHORE BIOLOGICAL CHARACTERIZATION

Wetlands

Wetlands near the Puget Sound shoreline typically include tidal marshes and tidally influenced estuaries. Tidal marshes include salt and freshwater habitats that experience tidal inundation (KCDNR, 2001). Several wetlands have been mapped by various sources in the City's shoreline jurisdiction. According to the 1987 National Wetlands Inventory (NWI), the entire area of the City's shoreline jurisdiction in the city limits is designated as a Class 1 "estuarine intertidal regularly flooded unconsolidated shore" wetland or "estuarine intertidal regularly flooded aquatic bed" wetland (USDI, 1987a and 1987b) with the exception of Segment B which contains the built out marina. The King County Sensitive Areas Map Folio (King County, 1990) also identifies intertidal wetlands encompassing all of Segments C through G within the City's shoreline jurisdiction (Figure 12). Neither indicates the presence of tidal wetlands associated with the streams that occur within the City's shoreline jurisdiction. This is likely due to the presence of riprap along the stream channels extending from the mouth upstream for a majority of the streams, thus cutting off potential connections with interior wetlands. Seasonal palustrine emergent wetlands are associated with Des Moines Creek within the lower portion of Des Moines Creek (Segment A). Hydric soils are mapped along portions of Segments A, most of Segments C and D, and portions of Segment E (NRCS, 1973).

Much of the nearshore area within the City's shoreline jurisdiction is heavily developed (Segments B, C, E, F, and G), and the presence of the Marina (Segment B), moderate to steep cliffs (Segments C, D, and E), residential and commercial development, and shoreline armoring along most of segments A, C, D, E, F, and G have eliminated historical wetlands or prevent connections between interior wetlands and the nearshore area.

Critical Fish and Wildlife Areas

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 fish and wildlife habitat areas are defined in Chapter 18.04.287 (DMMC) as follows:

> *Fish and wildlife habitat conservation areas include: areas with which endangered, threatened, and sensitive species have a primary association; habitats and species of local importance; all public, and private tidelands or bedlands suitable for commercial or recreational shellfish harvest; kelp and eelgrass beds identified by the washington Department of Natural resources; Herring and smelt spawning areas as outlined in Chapter 220-110 WAC and the Puget Sound Environmental Atlas as presently constituted or as may be subsequently amended; Naturally occuring ponds under 20 acres and their submerged aquatic beds that provide fish or wildlife habitats; Waters of the state as defined in Title 222 WAC; Lakes, ponds, streams, and rivers planted with game fish by a govermental or tribal entity; and State natural area preserves and natural resource conservation areas as defined, established, and managed by the Washington Department of Natural Resources.*

The City has not specifically mapped critical fish and wildlife habitats. Critical fish and wildlife habitats in the City's shoreline jurisdiction are characterized throughout the following sections describing the nearshore biological characterization.

Marine Riparian Zones

Marine riparian vegetation is defined as vegetation overhanging the intertidal zone (KCDNR, 2001). Marine riparian zones function by protecting water quality; providing wildlife habitat; regulating microclimate; providing shade, nutrient and sources of food; stabilizing banks; and providing large woody debris (Anchor Environmental and People for Puget Sound, 2002).

The existing marina, residential and commercial development, and shoreline armoring have impacted the marine riparian zones of all the city shoreline segments. Marine riparian zones within the City's shoreline jurisdiction are typically associated with the high, steep cliff areas of segments C, D, and E where development is less desirable. Marine riparian zones are absent from all of segments A, B, F, and G due to shoreline armoring including concrete and wooden bulkheads, rip-rap seawalls, marinas, and boat ramps (WDNR, 2001) (Table A-3, Appendix A).

Banks and Bluffs

Banks and bluffs are part of the marine riparian zone and are generally the primary source of sediment to adjacent beaches (Downing, 1983), provide habitat to bluff-dwelling animals, rooting area for riparian vegetation, and a source of groundwater seepage to marine waters (KCDNR, 2001). Shoreline development and armoring, vegetation clearing, over-water structures, dredging, and changes in hydrology, among others, adversely impact the natural functions of bluffs.

The ShoreZone Inventory (WDNR, 2001) maps high, steep bluffs capped by till in Segments C and D and moderate height, inclined bluffs capped by till in Segment E (Table A-4, Appendix A).

Beaches and Backshore

Beaches are generally steeper than tidal flats and are often comprised of boulder, cobble, sand and silt areas that form a great majority of Puget Sound's shoreline (KCDNR, 2001). Backshore areas are immediately landward of beaches and are zones inundated by storm-driven tides. Beaches provide habitat for numerous organisms, including cutthroat trout, piscivorous birds (grebes, herons, and mergansers), and shorebirds (Dethier, 1990 in KCDNR, 2001). A typical profile of an undisturbed shoreline in Central Puget Sound would include an upper backshore or storm berm area that collects logs, algae, and other debris during storms (KCDNR, 2001). The intertidal portion of the beach is typically relatively steep and composed of a mixture of cobbles and gravel in a sand matrix (KCDNR, 2001). Sediment abundance throughout the shoreline segments is characterized as a mixture of "moderate" to "abundant" (Table A-1, Appendix A). Sediment stability within the shoreline segments is identified as both accretional and stable (Table 4). Accretional areas are described portions of Segments A, D, E, F, and G. Stable sediments are documented in all of Segments B and C and within portions of Segments D, E, F, and G (WDNR, 2001). Shoreline activities that may impact beaches and backshores (KCDNR, 2001) include:

- Unnatural erosion or deposition of sediment;
- Harvesting of shellfish and other marine life;
- Fecal and chemical contamination;
- Physical disturbances from shoreline armoring, marina construction, and upland development practices;
- Shading from overwater structures; and
- Loss of emergent and riparian vegetation to monoculture marshes.

The WDNR ShoreZone Inventory utilized the British Columbia ShoreZone Mapping System, which classifies the shoreline into homogeneous stretches (or units) based on key physical controlling factors (WDNR, 2001). Table 7 summarizes the general beach or shoreline substrate composition, based on the British Columbia classification, for each shoreline planning segment (WDNR, 2001). A more detailed characterization for each segment, based on WDNR ShoreZone data, is found in Tables A-1 and A-4, Appendix A.

Table 7. ShoreZone Classification (WDNR, 2001)

Segment	British Columbia Classification*
A	• Sand and gravel flat or fan
B	• Man-made, permeable
C	• Man-made, permeable • Sand and gravel flat or fan
D	• Sand and gravel flat or fan
E	• Sand and gravel flat or fan
F	• Sand and gravel flat or fan
G	• Sand and gravel flat or fan • Sand and gravel beach, narrow

*British Columbia Physical Mapping System (Howes et al., 1994 *in* WDNR, 2001)

Flats

Flats generally include gently sloping sandy or muddy intertidal or shallow subtidal areas (KCDNR, 2001), and are used by juvenile salmonids, shorebirds, and shellfish, among other species. Flats are generally located at the mouths of streams where sediment transported downstream is deposited, and in areas of low wave and current energy where longshore waves and currents deposit sediment (KCDNR, 2001). Sand and gravel flats are mapped in all of Segments A, D, E, and F and portions of C and G (in the vicinity of the Des Moines, McSorley, Woodmont, Redondo, and Cold Creek outlets). Shoreline activities that may impact tidal flats (KCDNR, 2001) include:

- Unnatural erosion or deposition of sediment;
- Harvesting of shellfish and other marine life;
- Fecal and chemical contamination;
- Physical disturbances from shoreline armoring, marina construction, and upland development practices;
- Shading from overwater structures; and
- Loss of emergent and riparian vegetation.

Subestuaries (Stream Mouths and Deltas)

Subestuaries are those areas of river and stream mouths that experience tidal inundation, including their deltas and any associated marshes (KCDNR, 2001). Deltas are formed by downstream sediment transport. This is an area where the stream or river broadens and fresh and saltwater mix. Subestuaries function to attenuate flooding, provide juvenile salmonid feeding and rearing habitat, acts as a transition area for migrating adult salmonids, support eelgrass beds

(depending on salinity), and provide refuge, feeding, and production areas to a wide variety of birds, fish, mammals, and invertebrates (KCDNR, 2001).

Subestuaries occur in all Segments within the City's shoreline jurisdiction with the exception of Segment B (marina), and are associated with the stream mouths of Des Moines Creek (Segment A), Massey Creek (Segment C), McSorley Creek (Segment D), Woodmont Creek (Segment E), Redondo Creek (Segment F), and Cold Creek (Segment G).

The growth of deltas and quality of habitat provided by the subestuaries is a factor of annual rainfall and the rate at which sediment is transported and deposited at the mouths of streams. High peak flows that occur as a result of increased impervious surface within the stream basin likely transport sediment further out into Puget Sound where depths are greater resulting in sediment accumulation beyond the stream mouth.

Shoreline activities which may impact subestuaries include:

- Physical disturbances from shoreline armoring;
- Physical disturbances from dredging and filling; and
- Changes in hydrology due to increased impervious surface within stream basins.

Eelgrass Meadows

The importance of eelgrass has been described in various sources, including the *Reconnaissance Assessment of the State of the Nearshore Environment* (KCDNR, 2001). Eelgrass beds are found in intertidal areas and provide feeding and rearing habitat for a large number of marine organisms. Eelgrass beds have been documented in Puget Sound in the City's shoreline jurisdiction, in Segment A, E, F, and G (WDNR, 2001 and KCDNR, 2001). Densities are considered patchy and not continuous. Shoreline activities that may impact eelgrass (KCDNR, 2001) include:

- Clam harvesting;
- Propeller scour and wash;
- Physical disturbances from shoreline armoring;
- Shading from overwater structures; and
- Physical disturbances from dredging and filling.

Kelp Forests

The function of kelp has been described in *Reconnaissance Assessment of the State of the Nearshore Environment* (KCDNR, 2001). Kelp provides habitat for many fish species, including rockfish and salmonids, potential spawning substrate for herring, and buffers to shoreline from waves and currents, among other functions. Kelp distribution is largely dependent upon the type of substrate. Kelp prefers a rocky substratum for attachment. In areas where there is a coarsening of substrate in the low intertidal and shallow subtidal zones, there is a more likely

occurrence of kelp. A change in kelp distribution may indicate the coarsening of shallow subtidal sediments (such as that caused by erosion related to a seawall) or an increase in nutrient loading (such as from sewage effluent). Kelp forests are not currently mapped within the City of Des Moines shoreline jurisdiction. KCDNR (2001) indicates that it is likely that kelp distribution has changed over time based on maps produced by the USDA in 1911-1912 and for the Coastal Zone Atlas during the mid-1970's (Thom and Hallum, 1990). Kelp was reported as occurring along a greater length of shoreline within all reaches of WRIA 9, which would include the City of Des Moines shoreline (KCDNR, 2001). KCDNR also noted data gaps in general knowledge of kelp and its biology, its role in nearshore ecological processes, lack of historical or recent studies, and lack of distribution data.

Shoreline activities that may impact kelp densities (KCDNR, 2001) include:

- Physical disturbances from shoreline armoring, marina construction, and harvesting;
- Shading from overwater structures;
- Beach nourishment; and
- Nutrient loading.

Priority Habitats and Species

The Washington Department of Fish and Wildlife (WDFW) maintains priority habitat and species information for Washington state, including the status of species as threatened or endangered. The City of Des Moines occurs within the WDFW Region 4. Priority habitats within Region 4 include consolidated marine/estuarine shorelines, cliffs, caves, snags, riparian areas, old-growth/mature forests, and urban open spaces. The following sections discuss some of the priority species and species of local importance that occur within the City's shoreline jurisdiction.

Shellfish

Geoduck clams are documented in subtidal areas adjacent to shoreline Segments A, B, C, D, the northern one-half of Segment E, and G. Segment F is the only segment not showing the presence of geoduck clams (KCDNR, 2001). WDFW (2004) Marine Resource Species (MRS) data does not indicate the use of Segment F or G by geoducks. Intertidal hardshell clams are documented as occurring along the shorelines of Segment A, B, and the northern one-half of Segment C (WDFW, 2004 and KCDNR, 2001). Dungeness crabs are not documented as occurring within any of the shoreline segments (KCDNR, 2001). The King County 1996/1997 Beach Assessment (KCDNR Website, 2004) performed at Saltwater State Park in Segment D documented shellfish use of these beach areas. Assessments of the Saltwater State Park shoreline (Segment D) resulted in the identification of 42 species of invertebrates, including native littleneck, macoma, manila, butter, horse, softshell, cockle, and geoduck clams; purple and green shore crabs, black-clawed crabs, red rock crabs, and graceful crabs; Sitka shrimp, and tubeworm hermit crabs. Macoma clams comprised nearly 40 percent of the population, but only accounted for three percent of the biomass. Conversely, horse and softshell clams only accounted for two percent of the population, but accounted for 28 percent of the biomass.

In general, shellfish populations are relatively low in all shoreline segments. Population data analyzed by KCDNR (2001) indicates the following shellfish densities throughout the City's shoreline jurisdiction: butter clams (<10/m²), native littlenecks (6-17/m²), manila clams (≤10/m²), Geoducks (1-2/m²), few Dungeness crabs (abundance decreases as you move south of Seattle), and no Olympic oysters or northern abalone. It should be noted that there is a data gap concerning the collection of population data, and this relates primarily to the differences in sampling methodology and lack of recent quantitative population studies within WRIA 9.

In July 2004 the Washington State Department of Health closed all of the Puget Sound shoreline in King County, including Saltwater State Park (Segment D) and Des Moines Beach Park (Segment A), to recreational shellfish harvesting for all species due to a pollution advisory and the presence of biotoxins in particular shellfish species. The Department of Health conducts an ongoing assessment of pollution and conditions related to shellfish harvesting. The latest update was in November of 2004, which maintained the closure of King County beaches to shellfish harvesting (Cox, F., Washington Department of Health, personal communication). Both beachparks in Des Moines are also closed for recreational swimming due to the pollution advisory. No portion of the City's shoreline is currently used for commercial shellfish harvesting.

Salmonids

The *Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island)* (Kerwin and Nelson, 2000), *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region* (Williams et al., 1975), and *Water Type Survey Results South King County May/June, 2003* (Washington Trout, 2004) identify the known presence of salmon in local streams. Des Moines Creek (Segment A) has documented salmonid use including Chinook salmon (listed as threatened under the ESA), chum salmon, coho salmon (Federal candidate species), coastal cutthroat trout, pink salmon, and steelhead. Segment B contains no streams. Massey Creek (Segment C) contains Chinook salmon, coho salmon, and coastal cutthroats. The unnamed creek in Segment C is not known to support any salmonid populations due to the elevation of the discharge point into Puget Sound. McSorley Creek (Segment D) has documented use by chum salmon, coho salmon, and coastal cutthroats. One possible juvenile sockeye was also documented in the creek (Washington Trout, 2004). Woodmont Creek (Segment E) has documented cutthroat trout. Redondo Creek (Segment F) has the habitat to support coho salmon and cutthroat trout although none have been observed (Kerwin and Nelson, 2000). Cold Creek (Segment G) has cutthroat trout and is reported by local residents as containing coho and chum salmon (Kerwin and Nelson, 2000). WDFW PHS and Streamnet data (2004) indicate that the only use of streams in the City's shoreline jurisdiction occurs in Des Moines Creek (Segment A) and McSorley Creek (Segment D) including, coho and cutthroat trout use of Des Moines Creek and coho use of McSorley Creek.

Nearshore habitat is an important environment for juvenile salmonids, where the shallow water depth obstructs the presence of larger, predator species (Kerwin and Nelson, 2000). All shoreline segments within the City's shoreline jurisdiction are known or expected to contain juvenile salmonids including bull trout (federally listed), Chinook, chum, coho, cutthroat, pink, and sockeye based on the knowledge of species life histories (KCDNR, 2001).

Forage Fish

Forage fish include species that as adults breed prolifically and are small enough to be prey for larger species. They are often non-game fish. Four primary sources were referenced in compiling information on potential forage fish spawning areas within the City's shoreline jurisdiction: Marine Resource Species (MRS) data maintained by WDFW (2004), the *Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island)* (Kerwin and Nelson, 2000), and the *Reconnaissance Assessment of the State of the Nearshore Environment* (KCDNR, 2001).

The five forage fish species most likely to occur in the City's shoreline jurisdiction include surf smelt, sand lance, Pacific herring, longfin smelt, and eulachon (Kerwin and Nelson 2000 and King County DNR, 2001). Different species utilize different parts of the intertidal and subtidal zones, with sand lance and surf smelt spawning primarily in the substrate of the upper intertidal zone, and Pacific herring spawning primarily on intertidal or subtidal vegetation (Lemberg et al., 1997). Information on the five potential forage fish species within the City's jurisdiction is summarized in Table 8.

Table 8. Forage Fish Species

Species	Documented Presence	Spawning Timing	Preferred Spawning Substrate	Spawning Location
Pacific herring	None (nearest is Quartermaster Harbor on Vashon I.)	Quartermaster Harbor stock spawn January through mid-April	Eelgrass	Upper high tide limits to depths of 40 feet (typically between 0 and –10 tidal elevation)
Sand lance	Segment F & G	November 1 to February 15	Fine sand, mixed sand and gravel, or gravel up to 3cm	From + 5 tidal elevation to higher high water line (from bays and inlets to current-swept beaches)
Eulachon	None	Late winter/early spring	Unknown	Freshwater streams
Longfin smelt	None	Winter	Sand with aquatic vegetation	Freshwater streams
Surf smelt	Segments C, D, E, F, and G	South Puget Sound stocks are fall-winter spawners (September to March)	Mix of coarse sand and fine gravel (1-7mm)	Upper intertidal

Sources: (Kerwin, 2001; O'Toole, 1995; KCDNR, 2001; Lemberg et al., 1997)

Information on documented forage fish spawning activity was available from the WDFW (2004). No Pacific herring, eulachon, or longfin smelt spawning areas are currently documented in any of the shoreline inventory segments (WDFW, 2004). However, it is fair to assume that they all utilize the nearshore areas for feeding and migration. King County DNR (2001), WDFW (2004), and Kerwin and Nelson (2000) document surf smelt spawning areas in a small stretch of Segment C, between the unnamed creek and McSorley Creek; in Segment D near the mouth of McSorley Creek; and from the lower portion of Segment E (south of the Woodmont Creek mouth) extending through Segments F and into portions of Segment G. A sand lance spawning

area is mapped along the shoreline from the mouth of Redondo Creek (Segment F) and throughout all of Redondo Beach (Segment G) (Kerwin and Nelson, 2000; WDFW, 2004; and KCDNR, 2001).

Nearshore modifications impact potential forage fish habitat in the following ways:

- Development impacts the shoreline, particularly marinas and boat ramps, which bury spawning habitat, introduce the potential for repeated disturbance, and potentially alter nearshore hydrology;
- Sewer outfalls introduce pollutants and nutrients to the nearshore;
- Overwater structures shade intertidal vegetation and may alter nearshore hydrology;
- Riprap revetments and bulkheads impound sediment in bluffs such that fine-grained spawning beach sediment is not replenished (ongoing net-shore drift decreases spawning habitat); and
- Riprap revetments and vertical bulkheads alter nearshore hydrology and may increase wave energy on intertidal areas.

The sand lance's habit of spawning in the upper intertidal zone of protected sand-gravel beaches throughout the increasingly populated Puget Sound basin makes it vulnerable to the cumulative effects of various types of shoreline development. The WAC Hydraulic Code Rules for the control and permitting of in-water construction activities in Washington State include consideration of sand lance spawning habitat protection.

Shorebirds and Upland Birds

Adjacent to the open waters of Puget Sound, the upland terrestrial environment provides habitat for birds, amphibians, reptiles, and insects. A variety of shorebirds utilize the nearshore environment for wintering and breeding. Seventy-five species of birds are associated with marine nearshore environments in Washington (O'Neil et al., 2001). The Washington Department of Fish and Wildlife Priority Habitat and Species (PHS) maps (2004) indicate the presence of blue heron (Status-State Monitor) nesting colony near the mouth of Des Moines Creek in Des Moines Beach Park (Segment A).

WDFW PHS data from 2001 also indicates the presence of pigeon guillemots (7 breeding individuals) in Saltwater State Park. WDFW personnel collected seabird colony data for the Des Moines area shoreline from 1999 to 2003 and have identified the use of cliff areas in Segments C, D, and E as containing a low of eight breeding pigeon guillemot adults in 2000 and 2003 to a high of 17 in 2002 (Evanson, personal communication, 2004).

Bird populations were surveyed twice in January 1995 at Saltwater State Park and fourteen species were identified including six species of diving birds (cormorants, mergansers, and grebes) and five species of surface feeders (KCDNRP, 2004). Adolfson biologists observed several bird species during an October 6, 2004 site visit including: American widgeons, American crows, several gull species, bald eagle, belted kingfisher, great blue heron, mallards, mergansers (Segment A), cormorants (Segments B and E), surf scoters (Segment C), rock doves (Segment F), and killdeer (Segment G).

The PHS maps also indicate a breeding occurrence of bald eagles (federally and state listed as threatened species) is located within one mile of the Puget Sound shoreline in the vicinity of the southern Des Moines city limits. The territory for nesting eagles likely extends into shoreline Segments G. It is likely that bald eagles utilize all shoreline segments for foraging.

SEGMENT SUMMARIES, ASSESSMENT, AND OPPORTUNITY AREAS

The following section summarizes the shoreline characterization for each planning segment, addresses whether ecological functions have been impaired, and discusses opportunity areas within each segment. The shoreline segments are shown in Figure 2 and opportunity areas are shown in Figure 14.

"Opportunity areas" are those areas in the shoreline jurisdiction that may be appropriate for protection and/or restoration, including elements such as wetlands, habitat, riparian (streamside) vegetation, and riverbanks/shoreline modified by riprap or bulkheads. The City could explore opportunities for protection, restoration, or increased public access through a variety of ways, including regulatory and non-regulatory methods. The City maintains the greatest flexibility for implementing protection or restoration efforts in publicly owned land. Funding sources such as Salmon Recovery Funding Board (SRFB) grants are available for such projects. Restoration opportunities on privately owned land may be pursued through the development of an incentive-based redevelopment program, and/or a public education program. Other opportunities throughout the City include stormwater utility capital improvement projects (CIPs), such as culvert replacements and daylighting creeks, planned to occur upstream and outside of the shoreline jurisdiction. These types of projects will affect conditions in the shoreline, and may have beneficial effects on habitat and natural shoreline functions.

Segment A - Des Moines Beach Park

Table 9 below summarizes the shoreline characterization for Segment A.

Table 9. Shoreline Segment "A" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Park: 75%, Single-Family Res.: 17%, Vacant: 9%; Park access, foot paths, beach/auto access	Des Moines Creek	Des Moines Beach Park	Erosion, Flood	Wetlands, Stream, Fish and Wildlife Areas (Salmonids, shorebirds and piscivorous birds, heron rookery, shellfish, eelgrass)

Shoreline functions within Segment A have been impacted by the following activities:

- Shoreline armoring including riprap (includes mouth of Des Moines Creek) and concrete bulkheads;
- Removal of marine riparian vegetation;
- Increased impervious surface within the Des Moines Creek basin at a watershed scale; and
- Changes to the direction of net-shore-drift caused by the Marina (Segment B)

Effects upon the nearshore environment include:

- Sediment supply to nearshore areas cut off by riprap and concrete bulkheads;
- Marine riparian vegetation provides wildlife habitat, microclimates (shade/prey), source of large woody debris, bank stability, improvements to water quality;
- Subestuaries and deltas depend upon rainfall to bring sediments from upstream to the nearshore area. High flow rates and volumes resulting from increased runoff from impervious surface can alter the formation and function of these features.
- Net-shore drift is the long-term direction of sediment transport along the shoreline. The construction of the Des Moines Marina (Segment B) has altered this natural process.

Opportunities to improve shoreline functions within Segment A are identified as areas A-1 and A-2 (Figure 14).

Opportunity Area A-1 and A-2

Opportunities in area A-1 could include the removal of the failing riprap revetment from the mouth of Des Moines Creek north to the northern City boundary and the removal of riprap from the mouth of Des Moines Creek. The artificial shoreline could be pulled back a bit with riprap replaced with alternative "soft shore protection" techniques. Such "biotechnical" or "bioengineering" techniques could include imported gravel and sand, anchored drift logs or other large woody debris and , combined with marine riparian plantings along the shoreline and on the north side of Des Moines Creek. This would allow sediment to migrate from upland areas to the shoreline, improve subestuary and delta functions, and increase habitat quantity and quality for both terrestrial and aquatic animals using the shoreline, as well as expanded beach recreation.

Opportunities in area A-2 could include the removal of the existing concrete bulkhead and former boat ramp. The bulkhead could be replaced with soft shore protection techniques and marine riparian plantings, but this would require removal of some fill material that is currently at the site. A pocket beach could be created that would be largely in the shelter of the marina breakwater. This would improve the subestuary and delta as well as provide additional aquatic (including forage fish spawning habitat) and terrestrial wildlife habitat.

Prior to implementing changes to the nearshore area, upstream CIP's related to stormwater detention and treatment need to be completed. The lower portions of Des Moines Creek experiences flooding during major storm events, and construction of restoration projects prior to flood control projects could prove costly to repair. It should also be noted that some Normandy Park residents to the north can only access their homes via the beach area in Segment A. Plans would have to maintain access for these residents.

Segment B - Des Moines Marina

Table 10 below summarizes the shoreline characterization for Segment B.

Table 10. Shoreline Segment "B" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Public Facility: 54%, Vacant: 20%, Commercial: 12% Park: 10%; Marina Access, parking, and circulation	None	Des Moines Marina & fishing Pier	Erosion	Fish & Wildlife Areas (Salmonids, piscivorous birds, shellfish)

All shoreline functions have been impaired by the construction of the marina, pier, breakwater, and associated facilities. Due to complete development of Segment B, there are no feasible opportunities for improving natural shoreline functions within this segment. Other opportunities are related more to improving pedestrian access to water-oriented uses that the marina provides. Informational kiosks could also be erected to educate the public on the importance of the nearshore area and coastal processes, what they can do to help preserve or improve what remains, and wildlife viewing opportunities that exist. These projects could be coordinated with projects in the Marina Master Plan that require mitigation. Additional opportunities are related to improvement of water quality in the marina, including development or refinement of operation Best Management Practices (BMPs) for handling of and storage of fuels, and other contaminants associated with boating.

Segment C - Zenith

Table 11 below summarizes the shoreline characterization for Segment C.

Table 11. Shoreline Segment "C" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Single-Family Res.: 88%, Multi-Family: 7%; Local streets	Streams: Massey Creek and unnamed creek near S. 239th Street	S. 239th Street Access	Erosion, Flood	Wetlands, Streams, Banks/Bluffs, Fish & Wildlife Areas (Forage Fish, Salmonids, seabird nesting, shorebirds and piscivorous birds, shellfish)

Shoreline functions within Segment C have been impacted by the following activities:

- Shoreline armoring including riprap (includes mouth of Massey Creek), concrete and wooden bulkheads;
- Removal/loss of marine riparian vegetation; and
- Increased impervious surface within the Massey Creek basin.

Effects upon the nearshore environment include:

- Sediment supply to nearshore areas cut off by riprap and concrete and wooden bulkheads;
- Marine riparian vegetation provides wildlife habitat, microclimates (shade/prey), source of large woody debris, bank stability, improvements to water quality; and
- Subestuaries and deltas depend upon rainfall to bring sediments from upstream to the nearshore area. High flow rates and volumes resulting from increased runoff from impervious surface can alter the formation and function of these features.

Opportunities to improve shoreline functions within Segment C are identified as areas C-1 and C-2 (Figure 14).

Opportunity Area C-1

Opportunities in area C-1 could include the removal of riprap from the mouth of Massey Creek on the south bank (the north bank is currently part of the Des Moines Marina breakwater). The riprap could be replaced with soft shore protection techniques combined with marine riparian plantings along the shoreline and on the south side of Massey Creek. The breakwater on the south side of the boat ramp area is already riprapped and would not likely require any additional protection measures. With net shore-drift to the north in Segment C, the beach should continue to accrete such that erosion is not a threat here. Stream flow would need to be quantified to allow analysis of the expected amount of creek mouth closure as compared to salmon return periods.

The removal of riprap would provide improvements to the subestuary and delta, and riparian plantings would increase habitat quantity and quality for both terrestrial and aquatic animals using the shoreline. The creation of a much larger estuary to provide additional habitat benefits would likely require purchasing the property and removing the building immediately south of the creek.

Prior to implementing changes to the nearshore area, upstream CIP's related to stormwater detention and treatment need to be completed. The lower portions of Massey Creek experiences flooding during major storm events, and construction of restoration projects prior to flood control projects could prove costly to repair. Implementing improvements to this area may be constrained by the fact that the land is privately owned.

Opportunity Area C-2

Opportunity area C-2 (not shown on Figure 14) is located at the existing South 239th public access area. It appears there is limited opportunity to improve natural shoreline functions due to the existing residential development, associated bulkheads, and presence of steep bluffs. However, the existing access area provides a walkway down to the waters edge, where the public can view the shoreline area. This would be an excellent opportunity to provide interpretive signs (wildlife education) or other Puget Sound shoreline educational materials.

Opportunity Area C-3

One failed bulkhead is present approximately at South 245th Street. (not shown on Figure 14). The wooden soldier pile wall is over a portion of the intertidal beach (Johannessen, in prep.) and is no longer functioning to protect the bluff from erosion. Simple pile removal would help restore natural beach conditions and bluff processes. Some of these may be creosoted piles, so additional water quality benefits could be reaped.

Segment D - Saltwater State Park

Table 12 below summarizes the shoreline characterization for Segment D.

Table 12. Shoreline Segment "D" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Park: 100%; Park access, foot paths	Stream: McSorley Creek	Salt Water State Park	Landslide, Erosion, Flood	Wetlands, Streams, Banks/Bluffs, Fish & Wildlife Areas (Forage Fish: McSorley Creek Mouth, Salmonids, seabird nesting, shorebirds and piscivorous birds, shellfish)

Shoreline functions within Segment D (Saltwater State Park) have been impacted by the following activities:

- Shoreline armoring (includes mouth of McSorley Creek)
- Removal of marine riparian vegetation; and
- Increased impervious surface within the McSorley basin.

Effects upon the nearshore environment include:

- Sediment supply to nearshore areas from upland areas is cut off by riprap armoring;

- Riprap revetments and vertical bulkheads alter nearshore hydrology and may increase wave energy on intertidal areas and increase the net shore-drift rate; and

- Subestuaries and deltas depend upon rainfall to bring sediments from upstream to the nearshore area. High flow rates and volumes resulting from increased runoff from impervious surface can alter the formation and function of these features.

Opportunities to improve shoreline functions within Segment D are identified as areas D-1, D-2, and D-3 (Figure 14).

Opportunity Area D-1

Opportunities in area D-1 could include the removal of the riprap armoring from the mouth of McSorley Creek north to the northern park boundary. This land is not owned by the City, but is a State operated park. The riprap could be replaced with soft shore armoring techniques and beach nourishment materials combined with marine riparian plantings along the shoreline. This would allow sediment to migrate from upland areas to the shoreline, provide additional forage fish spawning areas, and increase recreational opportunities. The removal of riprap and return of the area to more natural beach conditions would require the removal of some fill material behind the existing riprap wall and require the removal and replacement of the paved walkway. A similar project is scheduled to start at the southern portion of Seahurst Park in Burien in late fall 2004.

Opportunity Area D-2

Opportunities in area D-2 could include the complete removal of riprap in the lower reach of McSorley Creek and at the mouth of the creek, north of the channel, and excavation of some upland fill on the north side of the channel. Retention of some type structure or existing riprap on the south side of the creek channel would maintain the creek in or near its present condition, but removal of the riprap would allow for a more dynamic and functioning creek delta. This would increase the size and quality of the subestuary and delta and fish access to the creek, as well as provide additional aquatic and terrestrial wildlife habitat. This land is not owned by the City, but is a State operated park.

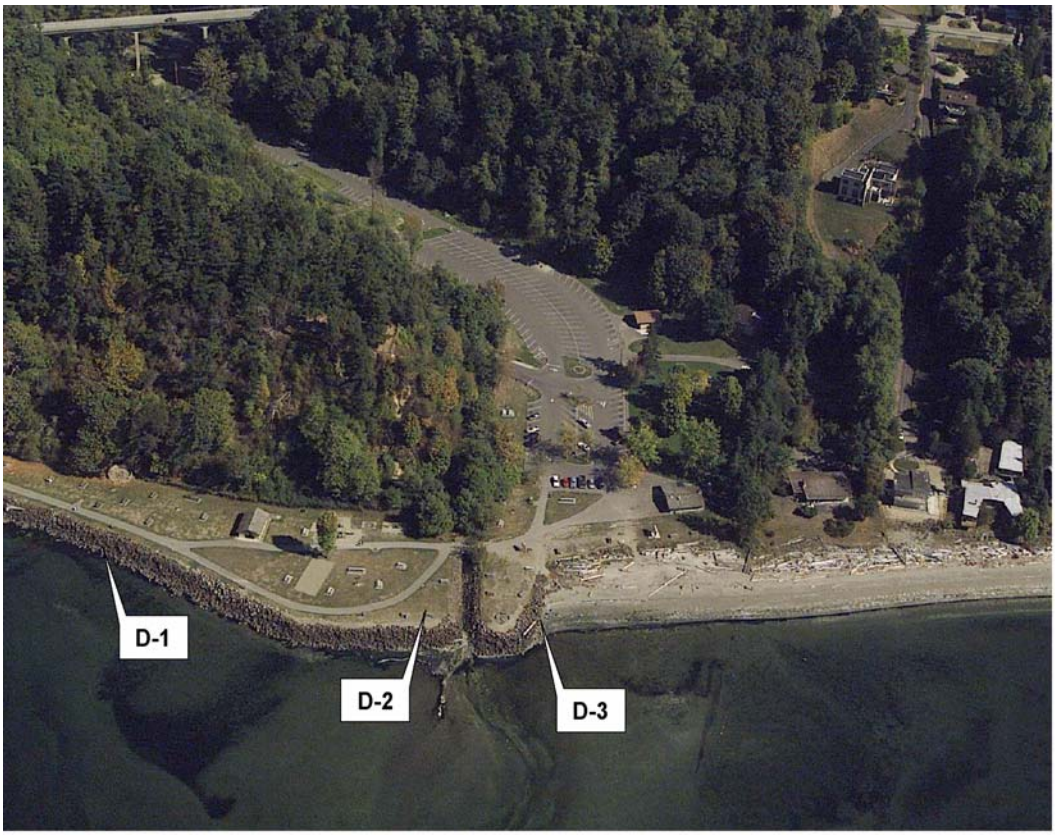
Prior to implementing changes to the nearshore area, upstream CIP's related to stormwater detention and treatment need to be completed. The lower portions of Des Moines Creek experiences flooding during major storm events, and construction of restoration projects prior to flood control projects could prove costly to repair.

Opportunity Area D-3

Opportunities in area D-3 could include the removal of riprap from the south side of McSorley Creek's mouth and replacement with soft shore protection. This land is not owned by the City, but is a State operated park. The existing riprap armoring at the mouth of McSorley Creek causes accretional deposits of sediments at the existing swimming beach to the south. A complete removal of the riprap armoring without any replacement structure may cause the existing beach to disappear. Net-shore drift currently moves sediments northward. The presence of the riprap wall, which extends the mouth of McSorley Creek into Puget Sound, causes some of these sediments to be deposited south of the wall instead of proceeding further north. The

placement of soft shore protection in place of the riprap will likely not produce accretional deposits at current rates associated with the riprap, but the soft-shore armoring would help to maintain the existing beach.

Prior to implementing changes to the nearshore area, upstream CIP's related to stormwater detention and treatment need to be completed. The lower portions of McSorley Creek may experience flooding during major storm events, and construction of restoration projects prior to completion of flood control projects could prove costly to repair.



Segment E - Woodmont / Redondo North

Table 13 below summarizes the shoreline characterization for Segment E.

Table 13. Shoreline Segment "E" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Single-Family Res.: 87%, Multi-Family: 6%; Local streets	Stream: Woodmont Creek	None	Landslide, Erosion	Wetlands, Streams, Banks/Bluffs, Fish & Wildlife Areas (Forage Fish, Salmonids, seabird nesting, shorebirds and piscivorous birds, shellfish, eelgrass)

Segment E provides few opportunities for restoration/enhancement of shoreline functions. Much of the shoreline in Segment E is privately owned with a majority being developed single-family residential areas and local streets. However, public education to promote the installation of native vegetation plantings versus manicured lawns along the shoreline portion of the private properties would be of value in restoring some shoreline function. Similarly, education or incentive for shoreline bulkhead removal in Segment E would help restore natural shoreline processes for significant lengths of the City shore in this formerly important reach of feeder bluff (Johannessen, in prep.)

Several failed bulkheads are present approximately 2,000 feet south of the southern boundary of Saltwater Stare Park. These include a cluster of three wooden soldier pile walls in the intertidal beach (Johannessen, in prep.) that are no longer protecting the bluff from erosion. Simple pile removal would help restore natural beach conditions and bluff processes. Some of these may be creosoted piles, so additional water quality benefits could be reaped.

The Woodmont Creek subestuary and delta have been severely impaired by shoreline armoring and shoreline development. Woodmont Creek is culverted beneath residential areas and roadways for a distance of approximately 500 feet from the mouth. This is likely a fish passage barrier to anadromous salmonids. Removal of the culverts and other barriers could be a good longer-term goal for restoration of the creek, but access to houses is a significant problem to overcome for this type of project.

Segment F - Redondo Boat Launch / Beach Park

Table 14 below summarizes the shoreline characterization for Segment F.

Table 14. Shoreline Segment "F" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Public Facility: 70%, Commercial: 13%, Vacant: 18%; Redondo Way S., Redondo Beach Drive S., and parking lot	Stream: Redondo Creek	Redondo Beach & Boat Launch	Erosion	Wetlands, Subestuary, Fish and Wildlife Areas (Forage Fish, Salmonids, shorebirds and piscivorous birds, shellfish, eelgrass)

Segment F provides few, if any, restoration/enhancement opportunities. A concrete bulkhead, piers, and other over-water structures have reduced shoreline functions within this segment. The migration of sediments to the nearshore area have been completely halted from the bank and decreased from the creek and the continued formation of the subestuary/delta for Redondo Creek has been impaired by culverting the outlet and the presence of concrete bulkheads. Opportunity areas within this segment are more oriented toward access and education (Figure 14 - Area F-1). There appears to be limited access to portions of beach north of Salty's Restaurant and it seems that access could be improved to this area. The public pier would also be an excellent opportunity to provide an educational kiosk, providing educational materials about the Puget Sound shoreline, its wildlife, coastal processes, its recreational opportunities, and how to protect and preserve this natural resource.

F-1

Segment G - Redondo South

Table 15 below summarizes the shoreline characterization for Segment G.

Table 15. Shoreline Segment "G" Summary

Land Use / Transportation	Stream Discharges	Public Shoreline Access	Hazard Areas	Habitat / Habitat Potential
Single-Family Res.: 79%, Multi-Family: 13%, Mobile Home: 4%; Redondo Beach Drive S., Sound View Drive S., and local streets	Stream: Cold Creek	Redondo Sea Wall & Beaches	Landslide, Erosion	Wetlands, Subestuary, Fish and wildlife Areas (Forage Fish, Salmonids,

Segment G provides for limited restoration/enhancement opportunities due to the existing seawall extending along much of the segment's length. However, opportunities do exist for public education targeted at private landowners along Cold Creek. Cold Creek, north of Redondo Beach Drive South (Figure 14 -Area G-1), travels through a residential area, has been channelized, and contains no structure and little riparian cover. An opportunity exists to educate landowners on the benefits to salmonids and other fish from adequate riparian habitats associated with the streams where they live, and to try to implement a creek restoration project. Landowners would be given the chance to improve habitat in an organized way and to have salmon spawn in their backyards. Removal or pullback of riprap, riparian plantings, and installation of large woody debris (LWD) would be the basis of a creek restoration project. The existing box culvert at the mouth of the creek should be further investigated, but seems to allow fish access from the beach under the road at high tide. The NOAA Community Based Restoration Program would be an ideal fit for funding this type of project.

Public access is fairly good in this area with a walkway extending almost the entire length of the seawall, however beach access appears to be nonexistent. Private beach access only appears to be available at the south end.

CONCLUSIONS

The Puget Sound shoreline in the City of Des Moines is characteristic of urbanized waterfront development elsewhere in the region. Public access to the shoreline, recreational opportunities, and water-oriented uses such as boating and fishing abound in Des Moines. In this regard, goals of the Shoreline Management Act related to public use and enjoyment of the state's shorelines have been met well in the City. However, the natural structure and functions occurring at the shoreline have been significantly altered through structural development of bulkheads and rip-rap revetments throughout most of the city's shoreline. These changes have altered the natural net-shore drift direction and the availability and distribution of beach sediment locally. Additionally, development on a watershed scale has affected the shoreline by increasing impervious area in uplands, resulting in increased peak flow velocities and volumes, impaired water quality, and erosion in streams that discharge to Puget Sound. Site-specific opportunities to protect, enhance, or restore shoreline functions appear to be concentrated at stream mouths, with many of those occurring in public parks. The type of opportunities at these locations would likely benefit habitat for salmonids, particularly when coordinated with upstream projects targeted to reduce localized flooding and improve fish passage such as culvert replacement projects. These site-specific projects would likely have a marginal effect on restoring ecosystem wide processes, particularly nearshore coastal processes, since so much of the city's shoreline is structurally modified, but would still be important and valuable efforts toward habitat enhancement and restoration of impaired ecological functions.

REFERENCES

Anchor Environmental, L.L.C. and People for Puget Sound. 2002. *Final Report Northwest Straits Nearshore Habitat Evaluation.* Prepared for Northwest Straits Commission (NWSC). Mount Vernon, WA.

Anchor Environmental, L.L.C. 2004. *Marine Shoreline Inventory Report - WRIA 9.* Prepared for Seattle Public Utilities and WRIA 9. Seattle, WA.

Booth, D.B., and Waldron, H.H., in preparation, Geologic map of the Des Moines 7.5-minute quadrangle, Washington, U.S. Geological Survey Open-File Report, scale 1:24,000, (in press).

Booth, D.B., Waldron, H.H., and Troost, K.G., in preparation, Geologic map of the Poverty Bay 7.5-minute quadrangle, Washington, U.S. Geological Survey, Open-File Report, scale 1:24,000, (in press).

Chrzastowski, M.J., 1982, Net shore-drift of King County, Washington: Western Washington University Master of Science thesis, 153 p., 1 plate.

Cox. F. Washington Department of Health Food Safety and Shellfish Programs. Personal communication with Steve Krueger, Adolfson Associates, Inc. on November 23rd, 2004.

Des Moines, City of, 2000, Environmentally Sensitive Areas, Des Moines Municipal Code Chapter 18.86, Des Moines, WA, November.

Dethier, M. N. 1990. *A marine and estuarine habitat classification system for Washington State*. Washington Natural Heritage Program, Department of Natural Resources, Olympia, Washington. 56 pp.

Downing, J., 1983, *The coast of Puget Sound: Its processes and development*: Univ. of Washington Press, Seattle, 126

Evanson, Joe. 2004. Washington Department of Fish and Wildlife. Telephone and e-mail correspondence of September 24, 2004.

Johannessen, J.W., 1992, *Net shore-drift in San Juan County and parts of Jefferson, Island, and Snohomish counties, Washington: final report*, Western Washington University, for Shorelands and Coastal Zone Management Program, Washington Department of Ecology, Olympia, 58 p., 25 maps.

Johannessen, J.W., in prep. *Wria 8 & 9 Feeder Bluff And Accretion Shoreform Mapping.* Underway now by Coastal Geologic Services, Inc.

Jones, M.A., 1996, Thickness of Unconsolidated Deposits in the Puget Sound Lowland, Washington and British Columbia, U.S. Geological Survey, Water Resources Investigations Report 94-4133.

Kerwin, John and Nelson, Tom S. (Eds.). December 2000. "Habitat Limiting Factors and Reconnaissance Assessment Report, Green/Duwamish and Central Puget Sound Watersheds (WRIA 9 and Vashon Island)." Washington Conservation Commission and the King County Department of Natural Resources.

King County Department of Natural Resources (KCDNR). 2001. Reconnaissance Assessment of the State of the Nearshore Report: Including Vashon and Maury Islands (WRIAs 8 and 9). Seattle, WA.

King County Department of Natural Resources and Parks (KCDNRP), Water and Land Resource Division. 2004. King County's 1996/1997 Beach Assessment Program. Available at: http://www.metrokc.gov. Accessed September 21, 2004.

King County Historic Preservation Program (KCHHP). 2004. Personal communication with Charlie Sundberg, Historic Preservation Planner.

King County, 1990, Sensitive Areas Map Folio

King County, 2002, Geographic information systems (GIS) data.

King County, 2002, Sensitive areas ordinance geographic information systems (GIS) data, Seattle, Washington.

King County. 1990. King County Sensitive Areas Map Folio.

Lemberg, N.A., M.F. O'Toole, D.E. Pentilla, and K.C. Stick. 1997. *Washington State Department of Fish and Wildlife, 1996 Forage Fish Stock Status Report. Stock Status Report No. 98-1*. Washington State Department of Fish and Wildlife, Olympia.

Luzier, J. E., 1969, Geology and ground-water resources of southwestern King County, Washington: Washington Department of Water Resources Water-Supply Bulletin 28, 260 p., 3 plates.

Macdonald, Keith, Simpson, David, Paulsen, Bradley, Cox, Jack, and Gendron, Jane, 1994, S*horeline armoring effects on physical coastal processes in Puget Sound, Washington*: Coastal Erosion Management Studies, Volume 5, Shorelands Program, Washington Dept. of Ecology, Olympia, DOE Report 94-78.

O'Toole, M. 1995. *Puget Sound Herring: A Review.* In Proceedings of Puget Sound Research. 1995. pp. 849-854. Puget Sound Water Quality Authority, Seattle, WA.

O'Neil, T. A., D. H. Johnson, C. Barrett, M. Trevithick, K. A. Bettinger, C. Kiilsgaard, M. Vander Heyden, E. L. Greda, D. Stinson, B. G. Marcot, P. J. Doran, S. Tank, and L. Wunder. *Matrixes for Wildlife-Habitat Relationship in Oregon and Washington*. Northwest Habitat Institute. 2001. In D. H. Johnson and T. A. O'Neil (Manag. Dirs.) *Wildlife-Habitat Relationships in Oregon and Washington*. Oregon State University Press, Corvallis, Oregon, USA. 2001.

Shipman, H., 2004, Coastal bluffs and sea cliffs on Puget Sound, Washington, U.S. Geological; Survey Professional Paper 1693.

Soil Conservation Service, 1979, Soil survey of King County Area, Washington; United States Department of Agriculture.

United States Department of the Interior (USDI). 1987a. *National Wetlands Inventory, Des Moines, Washington 7.5-minute USGS Quadrangle*.

United States Department of the Interior (USDI). 1987b. *National Wetlands Inventory, Poverty Bay, Washington 7.5-minute USGS Quadrangle*.

Washington Department of Ecology (Ecology Website). Final 1998 Section 303(d) List – WRIA 9. Available online at: http://www.ecy.wa.gov/programs/wq/303d/1998/wrias/wria9.pdf (accessed September 2004).

Washington State Department of Ecology, 1979, Coastal Zone Atlas of Washington, King County, v. 6.

Washington State Department of Ecology. 2000. Drift Cells mapping in the Digital Coastal Zone Atlas of Washington. Available online at http://www.ecy.wa.gov

Washington State Department of Fish and Wildlife. 2004. *Habitats and Species, Streamnet, and Marine Resources GIS Databases*. Washington State Department of Fish and Wildlife, Olympia, Washington.

Washington State Department of Health. 2004. Beach closure data available at: http://www.doh.wa.gov. Accessed September 21, 2004.

Washington State Department of Natural Resources (WDNR). 2001. *Washington State ShoreZone Inventory*. Nearshore Habitat Program, Washington State Department of Natural Resources. Olympia, WA.

Washington Trout. 2004. Water Type Survey Results South King County May/June, 2003. Web data available at: http://www.washingtontrout.org/kcpuget/index.shtml. Accessed September 20, 2004.

Williams, R. W., R. M. Laramie, and J. J. Ames. 1975. *A Catalog of Washington Streams and Salmon Utilization - Volume I, Puget Sound Region*. Washington Department of Fisheries (currently Washington Department of Fish and Wildlife).

Woodward, D.G., Packard, F.A., Dion, N.P., and Sumioka, S.S., 1995, Occurrence and quality of ground water in Southwestern King County, Washington: Water-Resources Investigations Report 92-4098, prepared in cooperation with State of Washington Department of Ecology, Regional Water Association of South King Co., and Seattle – King County Dept. of Public Health, Tacoma.

MAP FOLIO

<u>City-wide maps:</u>

Figure 1. City of Des Moines

Figure 2. Shoreline Jurisdiction and Planning Segments

<u>Watershed Scale maps:</u>

Figure 3. Soils and Potential Wetlands

Figure 4. Geology and Topography

Figure 5. Surface Water and Aquifer Recharge Areas

Figure 6. Land Use Change - 1942-2002

<u>Reach Scale maps:</u>

Figure 7. Existing Land Use

Figure 8. Zoning Designations

Figure 9. Public Access

Figure 10. Geologic Hazard Areas

Figure 11. Slope Stability

Figure 12. Streams, Wetlands, and Frequently Flooded Areas

Figure 13. Shoreline Modifications

Figure 14. Opportunity Areas

APPENDIX A

WDNR SHOREZONE INVENTORY
SUMMARY TABLES BY SHORELINE PLANNING SEGMENT

The following shoreline characterization information has been compiled from the Washington Department of Natural Resources *ShoreZone Inventory* GIS database (WDNR, 2001). Each table is organized by shoreline planning segment and the ShoreZone Units falling within each shoreline planning segment. The length of each unit shown in the tables indicates the length of the ShoreZone unit occurring within that shoreline planning segment. Some ShoreZone units cross shoreline planning segment boundaries and/or extend beyond the study area for this shoreline characterization.

Table A-1. Beach Sediment Characterization (WDNR, 2001)

Planning Segment	WDNR ShoreZone Unit ID	Length of ShoreZone Unit within Segment	Estimated Sediment Source	Sediment Abundance	*Dominant Sediment Transport Direction	Stability
A	2620	859.1	Fluvial	Abundant	Northwest	Accretional
B	2624	2783.3	Could not determine	Scarce	Undetermined	Stable
B	2621	580.7	Fluvial	Moderate	Undetermined	Stable
B	2623	2223.0	Could not determine	Scarce	Undetermined	Stable
B	2622	2343.9	Could not determine	Scarce	Undetermined	Stable
C	2624	734.0	Could not determine	Scarce	Undetermined	Stable
C	2627	3003.7	Backshore	Moderate	Undetermined	Stable
C	2625	1161.1	Alongshore	Moderate	Undetermined	Stable
C	2626	3513.2	Alongshore	Moderate	Undetermined	Stable
D	2627	356.3	Backshore	Moderate	Undetermined	Stable
D	2628	884.8	Fluvial	Abundant	Undetermined	Accretional
E	2628	194.0	Fluvial	Abundant	Undetermined	Accretional
E	2633	514.6	Alongshore	Moderate	Undetermined	Stable
E	2629	946.4	Fluvial	Abundant	Undetermined	Accretional
E	2630	3231.5	Alongshore	Moderate	Undetermined	Stable
E	2631	615.7	Fluvial	Abundant	Undetermined	Accretional
E	2632	3153.6	Alongshore	Moderate	Undetermined	Stable
F	2633	143.7	Alongshore	Moderate	Undetermined	Stable
F	2634	376.9	Fluvial	Abundant	Undetermined	Accretional
G	2634	221.0	Fluvial	Abundant	Undetermined	Accretional
G	2635	1907.2	Alongshore	Moderate	Undetermined	Stable
G	2636	967.8	Fluvial	Abundant	Southwest	Accretional

* Washington Coastal Atlas (2003) documents “net shore drift” from south to north in all planning segments

Table A-2. Shoreline Modifications (WDNR, 2001)

Planning Segment	WDNR ShoreZone Unit ID	Length of ShoreZone Unit within Segment (feet)	Total % Modified	Primary Type of Modification	% Primary Modification	Secondary Type of Modification	% Secondary Modification	Tertiary Type of Modification	% Tert. Modification	# Boat Ramps	# Piers/Docks
A	2620	859.1	0		0		0		0	0	0
B	2624	2783.3	100	Riprap	100		0		0	0	0
B	2621	580.7	100	Riprap	100		0		0	0	1
B	2623	2223.0	100	Riprap	100		0		0	0	0
B	2622	2343.9	100	Riprap	100		0		0	1	0
C	2624	734.0	100	Riprap	100		0		0	0	0
C	2627	3003.7	0		0		0		0	0	0
C	2625	1161.1	0		0		0		0	0	0
C	2626	3513.2	80	Riprap	60	Wooden Bulkhead	20		0	0	0
D	2627	356.3	0		0		0		0	0	0
D	2628	884.8	100	Riprap	100		0		0	0	0
E	2628	194.0	100	Riprap	100		0		0	0	0
E	2633	514.6	90	Concrete Bulkhead	90		0		0	0	0
E	2629	946.4	0		0		0		0	0	0
E	2630	3231.5	70	Riprap	70		0		0	3	0
E	2631	615.7	100	Riprap	60	Wooden Bulkhead	20	Concrete Bulkhead	20	1	0
E	2632	3153.6	100	Concrete Bulkhead	70	Riprap	30		0	0	0
F	2633	143.7	90	Concrete Bulkhead	90		0		0	0	0
F	2634	376.9	100	Concrete Bulkhead	50	Wooden Bulkhead	50		0	1	2
G	2634	221.0	100	Concrete Bulkhead	50	Wooden Bulkhead	50		0	1	2
G	2635	1907.2	100	Concrete Bulkhead	100		0		0	0	0
G	2636	967.8	80	Concrete Bulkhead	70	Wooden Bulkhead	10		0	0	2

Table A-3. Marine Riparian Zones (WDNR 2001)

Planning Segment	WDNR ShoreZone Unit ID	Length of ShoreZone Unit within Segment (feet)	Estimated % with Riparian Vegetation	Estimated Length of Riparian Vegetation	Estimated Intertidal Zone Width (ft)
A	2620	859.1	0	0	83
B	2624	2783.3	0	0	2
B	2621	580.7	0	0	2
B	2623	2223.0	0	0	2
B	2622	2343.9	0	0	40
C	2624	734.0	0	0	2
C	2627	3003.7	75	2519.98	30
C	2625	1161.1	0	0	80
C	2626	3513.2	20	702.64	45
D	2627	356.3	75	2519.98	30
D	2628	884.8	0	0	72
E	2628	194.0	0	0	72
E	2633	514.6	0	0	32
E	2629	946.4	20	189.29	80
E	2630	3231.5	30	969.44	32
E	2631	615.7	0	0	42
E	2632	3153.6	0	0	32
F	2633	143.7	0	0	32
F	2634	376.9	0	0	42
G	2634	221.0	0	0	42
G	2635	1907.2	0	0	20
G	2636	967.8	0	0	80

Table A-4. Beach Type and Composition (WDNR, 2001)

Planning Segment	WDNR ShoreZone Unit ID	Length of ShoreZone Unit within Segment (feet)	Shoreline Type (BC classification)	Supratidal-Upper Component	Intertidal-Upper Component	Intertidal-Lower Component	Intertidal-Lowest Component	Subtidal
A	2620	859.1	Sand and gravel flat or fan	Beach Berm (Pebble, Sand)	BEACH FACE (PEBBLE, SAND)	DELTA FAN WITH CHANNEL AND BARS (PEBBLE, SAND); DELTA FAN WITH CHANNEL AND BARS (VENEER OF SHELL OVERLYING PEBBLE, SAND)		
B	2624	2783.3	Manmade, permeable	BREAKWATER (RIPRAP)	BREAKWATER (RIPRAP); BEACH FACE (SAND)			BREAKWATER (RIPRAP)
B	2621	580.7	Manmade permeable	SEAWALL (RIPRAP)	SEAWALL (RIPRAP)			
B	2623	2223.0	Manmade permeable	BREAKWATER (RIPRAP)	BREAKWATER			BREAKWATER (RIPRAP)
B	2622	2343.9	Manmade permeable	SEAWALL (RIPRAP, WOOD)	SEAWALL, MARINA (RIPRAP, WOOD)			
C	2624	734.0	Manmade permeable	BREAKWATER (RIPRAP)	BREAKWATER (RIPRAP); BEACH FACE (SAND)			BREAKWATER (RIPRAP)
C	2627	3003.7	Sand and gravel flat or fan	HIGH STEEP CLIFF (TILL)	BEACH FACE (PEBBLE, SAND)	BEACH WITH LOW TIDE TERRACE (SAND,TILL)		
C	2625	1161.1	Sand and gravel flat or fan	BEACH BERM (LOGS OVERLYING PEBBLE, SAND)	BEACH FACE (PEBBLE, SAND)	BEACH WITH LOW TIDE TERRACE (VENEER OF SHELL OVERLYING SAND, PEBBLE)		
C	2626	3513.2	Sand and gravel flat or fan	SEAWALL (RIPRAP, WOOD); HIGH STEEP CLIFF (TILL)	BEACH FACE (PEBBLE, SAND)	BEACH WITH LOW TIDE TERRACE (VENEER OF PEBBLE, COBBLE OVERLYING SAND)		
D	2627	356.3	Sand and gravel flat or fan	HIGH STEEP CLIFF (TILL)	BEACH FACE (PEBBLE, SAND)	BEACH WITH LOW TIDE TERRACE (SAND,TILL)		
D	2628	884.8	Sand and gravel flat or fan	Seawall (Riprap)	Seawall (Riprap)	DELTA WITH CHANNEL AND BARS (VENEER OF COBBLE, BOULDER OVERLYING SAND)		
E	2628	194.0	Sand and gravel flat or fan	SEAWALL (RIPRAP	Seawall (Riprap)	DELTA WITH CHANNEL AND BARS (VENEER OF COBBLE, BOULDER OVERLYING SAND)		
E	2633	514.6	Sand and gravel flat or fan	SEAWALL (CONCRETE, WOOD); BEACH BERM (SAND)	BEACH FACE (VENEER OF PEBBLE OVERLYING SAND); SEAWALL (WOOD)	BEACH FACE (VENEER OF PEBBLE OVERLYING SAND)		
E	2629	946.4	Sand and gravel flat or fan	BEACH BERM (LOGS OVERLYING PEBBLE, SAND)	DELTA WITH CHANNELS AND BARS (PEBBLE, SAND, COBBLE)	DELTA WITH CHANNELS AND BARS (SAND)		
E	2630	3231.5	Sand and gravel flat or fan	SEAWALL (RIPRAP);	BEACH FACE (PEBBLE, COBBLE, SAND); SEAWALL	BEACH WITH LOW TIDE TERRACE (PEBBLE, COBBLE, SAND)		

Planning Segment	WDNR ShoreZone Unit ID	Length of ShoreZone Unit within Segment (feet)	Shoreline Type (BC classification)	Supratidal-Upper Component	Intertidal-Upper Component	Intertidal-Lower Component	Intertidal-Lowest Component	Subtidal
				BEACH BERM (LOGS OVERLYING PEBBLE, SAND, COBBLE); INCLINED CLIFF OF MODERATE HEIGHT (TILL); BOAT RAMP (CONCRETE)	(RIPRAP); BOAT RAMP (CONCRETE)			
E	2631	615.7	Sand and gravel flat or fan	SEAWALL (RIPRAP, WOOD, CONCRETE); BOAT RAMP (CONCRETE)	SEAWALL (RIPRAP, WOOD, CONCRETE); BOAT RAMP (CONCRETE)	DELTA WITH CHANNEL AND BARS (PEBBLE, SAND)		
E	2632	3153.6	Sand and gravel flat or fan	SEWALL (CONCRETE, RIPRAP)	SEAWALL (CONCRETE, RIPRAP)	BEACH FACE (VENEER OF PEBBLE, COBBLE OVERLYING SAND)		
F	2633	143.7	Sand and gravel flat or fan	SEAWALL (CONCRETE, WOOD); BEACH BERM (SAND)	BEACH FACE (VENEER OF PEBBLE OVERLYING SAND); SEAWALL (WOOD)	BEACH FACE (VENEER OF PEBBLE OVERLYING SAND)		WHARF, BOAT RAMP (WOOD, CONCRETE)
F	2634	376.9	Sand and gravel flat or fan	SEAWALL, WHARF, BOATRAMP (CONCRETE, WOOD)	SEAWALL, WHARF, BOAT RAMP (CONCRETE, WOOD, RIPRAP)	BEACH FACE (PEBBLE, SAND		WHARF, BOAT RAMP (WOOD, CONCRETE)
G	2634	221.0	Sand and gravel flat or fan	SEAWALL, WHARF, BOATRAMP (CONCRETE, WOOD)	SEAWALL, WHARF, BOAT RAMP (CONCRETE, WOOD, RIPRAP)	BEACH FACE (PEBBLE, SAND)		
G	2635	1907.2	Sand and gravel beach, narrow	SEAWALL (CONCRETE, WOOD)	SEAWALL (CONCRETE, WOOD); BEACH FACE (PEBBLE, SAND)	BEACH WITH LOW TIDE TERRACE (VENEER OF BOULDER, COBBLE OVERLYING PEBBLE, SAND)		
G	2636	967.8	Sand and gravel flat or fan	SEAWALL, WHARF (CONCRETE, WOOD); BEACH BERM (PEBBLE, SAND); BRAIDED RIVER CHANNEL (SAND, PEBBLE)	DELTA WITH CHANNELS AND BARS (PEBBLE, SAND); WHARF (WOOD)	DELTA FAN WITH CHANNEL AND BARS (PEBBLE, SAND); BRAIDED RIVER CHANNEL (SAND, GRAVEL)		

Table A-5. Biological Assemblages (WDNR, 2001)

Planning Segment	WDNR ShoreZone Unit ID	Length of ShoreZone Unit within Segment (feet)	Summary of Biological Assemblages
A	2620	859.1	Barnacles (BAR), Green Algae (ULV), Eelgrass (Zos)
B	2624	2783.3	Lichen (VER), Rockweed (FUC), Barnacles (BAR), Green Algae (ULV)
B	2621	580.7	Rockweed (FUC), Barnacles (BAR), Green Algae (ULV)
B	2623	2223.0	Barnacles (BAR), Green Algae (ULV)
B	2622	2343.9	Barnacles (BAR), Green Algae (ULV)
C	2624	734.0	Lichen (VER), Rockweed (FUC), Barnacles (BAR), Green Algae (ULV
C	2627	3003.7	Mussels (BMU), Green Algae (ULV), Sargassum (SAR)
C	2625	1161.1	Barnacles (BAR), Green Algae (ULV), Red Algae (GCA)
C	2626	3513.2	Barnacles (BAR), Green Algae (ULV), Sargassum (SAR)
D	2627	356.3	Mussels (BMU), Green Algae (ULV), Sargassum (SAR)
D	2628	884.8	Barnacles (BAR), Green Algae (ULV)
E	2628	194.0	Barnacles (BAR), Green Algae (ULV)
E	2633	514.6	Barnacles (BAR), Green Algae (ULV), Eelgrass (Zos)
E	2629	946.4	Barnacles (BAR), Green Algae (ULV), Eelgrass (Zos)
E	2630	3231.5	Barnacles (BAR), Green Algae (ULV), Sargassum (SAR), Eelgrass (Zos)
E	2631	615.7	Barnacles (BAR), Green Algae (ULV), Sargassum (SAR)
E	2632	3153.6	Rockweed (FUC), Barnacles (BAR), Green Algae (ULV), Sargassum (SAR)
F	2633	143.7	Barnacles (BAR), Green Algae (ULV), Eelgrass (Zos)
F	2634	376.9	Barnacles (BAR), Green Algae (ULV)
G	2634	221.0	Barnacles (BAR), Green Algae (ULV)
G	2635	1907.2	Barnacles (BAR), Green Algae (ULV), Sargassum (SAR), Eelgrass (Zos)
G	2636	967.8	Barnacles (BAR), Green Algae (ULV), Eelgrass (Zos)