5 SHORELINE ANALYSIS AND CHARACTERIZATION

5.1 Ecosystem-wide Processes and Conditions

An ecosystem is a natural system consisting of biological (plants, animals, and microorganisms), physical, and chemical factors that together make up the environment. Ecosystem-wide processes are defined by statute as, "the suite of naturally occurring physical and geologic processes of erosion, transport, and deposition; and specific chemical processes that shape landforms within a specific shoreline ecosystem and determine both the types of habitat and the associated ecological functions" (WAC 173-26-020 (14)). Processes occur at multiple scales and are influenced by hydrology, geology, topography, soils, land cover, and land use characteristics. These processes determine the types and quality of shoreline functions or services that contribute to the maintenance of aquatic and terrestrial environments that make up an ecosystem (WAC 173-26-020 (13)).

The following sections discuss ecosystem processes and habitat structures that these processes form and maintain. This section also describes conditions, including alterations to the ecosystem process, for the Columbia and Snake rivers and shoreline within the City and the UGA boundary. Alterations to ecosystem processes can affect habitat structure and the availability of habitat services, especially during long periods of time. Ecosystem processes and conditions in the City are presented through the categories of hydrology, sediment, water quality, and habitat.

5.1.1 Hydrology

5.1.1.1 Ecosystem Process

The process of water delivery, movement, and storage within an ecosystem is largely affected by landform, geology, soil characteristics, and climate, including precipitation. Rain and snowmelt provide the hydrologic inputs into a watershed. This cycle affects other physical, chemical, and biological functions of the river system. The speed that water flows through the watershed also affects whether nutrients, sediments, or other materials are deposited or retained in the water and transported through the watershed.

Water is delivered to streams primarily from surface water runoff from higher elevations and, in some cases, from groundwater. The horizontal structure of river and stream channels includes the wetted channel zone where water is present during low-flow events, an active channel that is seasonally inundated, and the riparian zone located above seasonal high water elevations. The vertical structure of these systems includes a benthic zone along the surface of the bottom substrate and the hyporheic zone, which provides a transition between the surface and the groundwater, or phreatic zone. Hyporheic and benthic zones cycle out excessive nutrients and contaminants, store and transport water and sediment, maintain base flows, and can support vegetation and microorganism communities. The interaction of hydrologic and geomorphic processes contributes to habitat structures useful to aquatic species, including shallow water and off-channel refugia, gravel bars, pools, riffles, and the transport of organic material, including large woody debris.

5.1.1.2 Conditions in the City of Pasco

The Columbia River and Snake River are the City's two major surface water resources. Along the Columbia and Snake rivers, McNary Dam operations affect the hydrologic processes. Major alterations from this system include the artificial storage and release cycle that produces higher than natural flows in the late summer and fall and lower than natural flows in the spring and early summer. Riparian vegetation and aquatic species adapt to seasonal inundation fluxes, and these changes in the natural flows may adversely affect these systems and species.

Flood storage occurring in the upper Snake River and Columbia Basin outside of the City reduces the frequency, duration, and magnitude of floodplain inundation, while decreasing the floodplain size. This change in the hydraulic regime also affects the cycling of sediment, nutrients, and organic materials within the river, as discussed below.

5.1.2 Sediment

5.1.2.1 Ecosystem Process

Sediment delivery through a watershed is based on interactions among gravity, wind, and water across the various geologic features, soils, and land covers. Landslides and mass wasting are a function of slope, soil, and water interacting to create instability. Soil erosion is

a function of slope, soil cohesiveness, and ground cover interacting with water or wind forces. Sediments transported by water or wind are deposited wherever and whenever the water or wind transporting them slows. As the size of sediment increases, the water or wind force required to transport the sediment increases, so smaller sediment is able to travel farther than larger sediment when the transporting forces decrease. This is often within topographic depressions where sediment is deposited into lakes, stream pools, wetlands, and floodplains. The sediment erosion, transport, and deposition cycle is a major aspect of river and stream channel formation and channel migration.

The maintenance of shallow water habitat along the Columbia and Snake rivers is driven by the recruitment and transport of appropriately sized sediments. Shallow water areas with small and clean natural substrates (e.g., sand and pebbles) are important for benthic production and as refuge for juvenile fish. Coarser substrates tend to provide habitat for predatory fish. Fine sediment (e.g., silt and clay) can decrease water quality by creating turbidity that adversely affects some aquatic species.

Shoreline armoring typically exists in developed areas or in areas where significant infrastructure exists, such as overwater bridge crossings or boat ramps. These armoring structures tend to disconnect natural sediment sources from erosion by forming a physical barrier between the shore and the water itself. The wave energy reflected off of these types of armoring leads to the washing away of smaller substrate sizes that support small benthic animals and also prevents riparian vegetation establishment with associated habitat functions.

5.1.2.2 Conditions in the City of Pasco

Channelization of streams can include hardening of banks with levees or revetments, straightening of channels, deepening of channels, removal of roughness that impedes flow, and other efforts to minimize the migration of the channel while maximizing flow capacity. The McNary Levee System (also known as the Tri-Cities Levees), along the banks of the Columbia and Snake rivers, is located in the planning area.

Fine sediment inputs to the Columbia and Snake rivers are accelerated through agricultural tillage and disturbed, undeveloped lands adjacent to or upland of the planning area. Urban development adjacent to Reaches 2 through 7 may protect these reaches from agricultural runoff impacts.

Sediment transport is affected by diking of river segments. Dikes reduce spring flooding and associated sediment deposition within the surrounding floodplain. Dike grading occurs along the Columbia and Snake rivers to protect residential and commercial properties, as well as infrastructure. The dikes are topped with multi-use trails throughout much of the shoreline, allowing for public recreation and enjoyment of the waterfront. Sediment in the Columbia and Snake rivers is generally restricted by regulated operations upstream. Geologic units with higher landslide potential in some City areas could contribute to increased sediment input during storm events. Sediment may build up within the City areas due to generally slower velocities within the pool of Lake Wallula.

5.1.3 Water Quality

5.1.3.1 Ecosystem Process

The combined processes that deliver, transport, and store water and sediment in the ecosystem have a substantial impact on water quality. Impacts to water quality occur through land cover changes and development; chemical use in manufacturing, agriculture, and recreation; pathogens from waste; temperature; and natural processes such as plant respiration.

Human-induced changes to water quality (e.g., industrial effluents, sewer overflows, and runoff from upland areas) can alter river and lake water temperatures, turbidity, and oxygen content, as well as nutrient, toxin, and pathogen concentrations (Karr 1995; Welch and Lindell 1992). In general, these changes can affect the presence, abundance, and vitality of all aquatic organisms. Water delivery and water quality is affected by soil loss, soil compaction, and road and building construction typically associated with development and urbanization. These activities increase the amount of impervious surface (e.g., parking lots and roads), reduce the percolation of precipitation into the ground, and concentrate pollutants into stormwater discharge areas. Reduced water infiltration increases the amount

and rate of surface water runoff, causing high stream discharge or high direct delivery of water to the stream and lake shorelines (Dunne and Leopold 1978; Arnold and Gibbons 1996; Poff et al. 1997).

Fertilizers, pesticides, and automobile- and boat-generated pollutants are linked to runoff-borne pollution that enters streams and lakes. Toxins from these and other human-induced changes previously described can settle in river pools, contaminating the sediments of the benthic zone. This leads to toxins either directly affecting benthic species through illness and mortality, or indirectly affecting aquatic and terrestrial species through bioaccumulation from animals lower on the food chain.

Many pathogenic protozoa, bacteria, and viruses can be found naturally in the environment, some of which occur as a result of fecal wastes deposited by animals. These come from fecal material of wildlife and domesticated animals deposited within upland areas that drain into aquatic ecosystems or deposited directly into them (Sherer et al. 1992; Stanley et al. 2005). A higher concentration of domesticated livestock (such as in livestock farms or concentrated animal feeding operations) can increase the potential of fecal material draining to shoreline areas.

Solar energy input can be another important factor that impacts water quality, especially in the summer when high temperatures coincide with high nutrient loads from agricultural runoff and lower river flows. This can result in high water temperatures and very low levels of dissolved oxygen, both of which can alter the ecology of rivers and streams. Water temperature, a physical characteristic, affects the chemical process of breaking down organic material into nutrients, as well as the biological processes of phytoplankton and zooplankton reproduction and the metabolism of fish species.

Water temperatures, plant respiration, and biological decomposition are also inversely related to dissolved oxygen levels, which play a critical role in supporting aquatic organisms such as salmonids. Similarly, alkalinity/pH and nutrient concentrations influence biological processes, particularly phytoplankton production.

5.1.3.2 Conditions in the City of Pasco

The Columbia and Snake rivers are on the Ecology 303(d) list of impaired waters for temperature within the planning area. (See Section 4.6.2 for further description of water quality conditions in the City of Pasco.) Features within the City that may contribute to water quality concerns include impervious development over and near the river, recreational boating, and herbicide and pesticide use in residential landscaping.

5.1.4 Habitat

This section describes aquatic and terrestrial habitat conditions and the stressors that may affect the functions provided by these habitats in the City, focusing on habitat types such as aquatic, riparian, shrub-steppe; and functions such as foraging, breeding/nesting, and migration elements for terrestrial species; and spawning, rearing, and migration requirements for aquatic species.

5.1.4.1 Habitat Structures

Habitat is the natural environment in which particular species or populations have adapted to live. Habitat provides the physical conditions and biological functions needed to support the species as part of a larger ecosystem. The lifecycles of aquatic, avian, and terrestrial species vary, but are often interdependent, meaning the habitat requirements of a single species include other species on which they depend. A species may occupy several types of habitat throughout their life span, because the habitat requirements of a species can vary during different life stages and different seasons.

Habitat is often described in terms of the functions of reproduction, forage, and shelter (Morrison 1992):

- The reproduction needs of species vary greatly. All species have specific needs for areas to find a mate, reproduce, and successfully rear offspring (often referred to as breeding sites, birthing areas, and nest sites). Some species have very specific needs; for example, amphibians (frogs, toads, and salamanders) require water or moist areas for laying eggs and for larval development.
- Forage includes water and food sources. Water is a universal need of all species, while forage needs vary greatly by species. An important consideration is whether a

species is prey or a predator. Predators obviously require that the habitat needs for prey species are met.

- Shelter includes areas for safe resting, refuge or cover from predators, and shelter from environmental hazards (e.g., daytime or nighttime temperatures, extreme weather events, seasonal climate fluctuations, and unpredictable disturbances such as drought, fire, or flooding).

The shoreline zone within the City provides freshwater and terrestrial habitat, with a wide variety of habitat types and features within those types.

5.1.4.1.1 Aquatic Habitat

The aquatic habitat within the City consists of the Columbia and Snake rivers. The quality of the aquatic habitat within these systems is controlled by a number of key ecosystem features that combine to provide important ecological functions (or ecosystem services) and support an interconnected array of species, including numerous salmonids species listed as threatened under the ESA. Aquatic habitat features that support healthy salmonids stocks likely also support other aquatic dependent and aquatic-associated birds and terrestrial species. Some ecosystem features applicable to aquatic habitat within the shoreline management jurisdiction of the City include water quality (including presence of contaminants as well as water temperature); water depth; instream cover (such as presence of large rocks and woody debris); substrate size; aquatic and riparian vegetation; floodplain extent and health; and channel migration access.

Water quality is a primary ecosystem feature that affects presence and health of aquatic life. Within aquatic habitats, water quality can affect survival of fish through low dissolved oxygen conditions (less than 3 parts per million [ppm] in warm water streams, or less than 5 ppm in cold water streams), very low alkalinity, high turbidity conditions, presence of contaminants, and high temperatures. Freshwater fish in the Columbia and Snake rivers include cold water fish (including ESA-listed salmon and bull trout [*Salvelinus confluentus*]) that have an upper lethal limit of approximately 25 degrees Celsius (°C), warm water fish (e.g., largemouth bass[*Micropterus salmoides*]) that can tolerate temperatures as high as 36°C, and cool water fish (e.g., non-native smallmouth bass[*Micropterus dolomieu*]) that have

similar tolerances to warm water fish but require cooler average temperatures during the growing season.

Water depth and water quantity requirements vary by species and life stage; for example, areas near channel margins with shallow water depths are needed for migration of salmonids juveniles, while migrating adults may utilize deeper waters. Substrate requirements can vary by species, but many salmon cannot spawn in substrate smaller than gravel.

Instream cover increases the structural complexity of a system through presence of large wood and larger rocks or boulders that improve the habitat quality for most fish. Instream vegetation, similar to instream cover, can improve habitat as long as the amount of aquatic vegetation does not create a low dissolved oxygen issue; in general, native aquatic vegetation provides important habitat conditions while introduced species such as Eurasian watermilfoil (*Myriophyllum spicatum*) do not. As a result of habitat simplification arising from the completion of hydroelectric dams, these features of instream cover are largely absent from within the Columbia and Snake River systems within the City.

Riparian vegetation stabilizes banks, reduces summer temperatures, provides nutrients through leaf debris and insect fall, and provides in-stream cover through tree-fall. Floodplain habitat is required for many fish species during multiple life stages. Extensive and unaltered floodplains that are accessible to fish species are ideal. However, the aforementioned completion of hydroelectric dams have inundated original floodplain habitat within the City. Water levels of the Columbia and Snake rivers are tightly managed, and access to remaining floodplain habitat by aquatic species is generally rare.

Instream cover, presence of riparian vegetation, and alteration of shorelines also affect the quality and intensity of available light energy in freshwater systems. Light energy affects water temperature, animal behavior (such as the relationship between predators and prey), and plant photosynthesis and growth (Tilzer et al. 1975). Natural light is altered when riparian vegetation is removed or when structures such as docks are built that create shade and prevent natural light from reaching the water. Reductions in this natural light preclude plant colonization and growth beneath these structures and can cause changes in animal

behavior. Natural light can also be reduced by the presence of algal blooms caused by excess nutrient additions that can collect in slack water areas.

5.1.4.1.2 Terrestrial Habitat

Urban and agricultural development within the City has resulted in loss, fragmentation, and degradation of shrub-steppe habitat. Habitat fragmentation occurs through the building of roads, utility corridors, agricultural use (including irrigation channels), and urban development, all of which can affect, aquatic and riparian habitat types. Movement corridors, which are crucial to wildlife, are affected by development through fragmentation. The migratory movement through these corridors may be seasonal, depending on the species. The primary function of a corridor is to connect disjunctive areas of habitat by allowing migration and dispersal among the areas. Movement corridors provide the following functions essential to healthy wildlife populations:

- Connectivity and, thereby, genetic variation and biodiversity among differing populations and habitats, connecting isolated habitats, and allowing recolonization of extirpated species
- Varying habitats for migration patterns (e.g., foraging, mating and nesting, rearing, shelter, and wintering) and allowing populations to move in response to habitat changes, such as fires
- Potential habitat for corridor dwellers—species that live within corridors for extended periods (Beier and Loe 1992)

Shrub-steppe upland habitat is the largest native land cover type in Franklin County and is also found within the City as small remnant patches. In some areas, shrub-steppe communities abut or nearly abut the shoreline, and there are small remnants of shrub-steppe habitat interspersed among the irrigated agricultural fields that displaced the original habitat. The primary remaining shrub-steppe plant association type in the City area is the big sagebrush (*Artemisia tridentata*)-bunch wheatgrass association. The habitat structure of this association includes an overstory of 6-foot-tall big sagebrush, an understory of bluebunch wheatgrass (*Pseudoroegneria spicata*) and Sandberg's bluegrass (*Poa secunda*), and groundcover dominated by algae, lichens, and moss providing a microbiotic crust (Link et al. 2006).

Riparian areas are located along the shorelines of the City, with varying levels of structural diversity and productivity in terms of organic material, with reductions in diversity and productivity due to levees and upland developed areas. Habitat characteristics of healthy riparian areas include a connected corridor for fish and wildlife travel, vegetation types adapted to wetter soils, occasional flooding, and natural disturbance regimes. Riparian areas also offer important functions for species that inhabit the shrub- steppe, as well as species more limited in range to the riparian zone. For shrub-steppe species, they provide a critical water source and often a more productive environment for forage, escape, thermal cover, and nesting sites. For many species, they provide critical winter habitat. Riparian areas typically support larger flocks and a greater density of upland birds than shrub-steppe habitat due to the greater production of biomass and the more complex mosaic of vegetation (Stinson and Schroeder 2012).

The removal of native riparian vegetation in riparian and shrub-steppe habitat, the introduction and proliferation of invasive plant species, like Russian Olive (*Elaeagnus angustifolia*), and the filling or degradation of wetlands along shorelines impact the organic inputs that fuel production of the lower levels of the food chain and, therefore, can have impacts throughout the entire food web. Organic matter produced by these habitats supports terrestrial and aquatic insects and other organisms that are then eaten themselves by birds, juvenile salmonids, and various fish species. An example of invasive plants is the aquatic plant Eurasian water milfoil, which can cover lake bottoms and out-compete the native aquatic species (altering the plant community), deplete dissolved oxygen, and lead to fish mortality (Frodge et al. 1995).

5.1.4.2 Conditions in the City of Pasco

5.1.4.2.1 Important Wildlife and Priority Habitat and Species

Table 14 summarizes the ESA-listed fish species known to occur in the Columbia and Snake rivers in the City, and also includes Washington State Priority Habitat Species identified for Franklin County. Many of the non-aquatic species of animals and plants identified for Franklin County would not be expected to currently occur within the shoreline zone of the City due to the level of development along the shoreline.

Table 14

ESA-listed Fish Species and Washington State Priority Habitat Species in Franklin County

Species Category	Common Name	Scientific Name
ESA-listed Fish Species	Bull Trout	*Salvelinus confluentus*
	Chinook	*Oncorhynchus tshawytscha*
	Steelhead	*Oncorhynchus mykiss*
	Sockeye	*Oncorhynchus nerka*
Washington Priority Species – Fish	Coho	*Oncorhynchus kisutch*
	Giant Columbia River Limpet	*Fisherola nuttalli*
	Leopard Dace	*Rhinichthys falcatus*
	Mountain Sucker	*Catostomus platyrhynchus*
	Pacific and River Lamprey	*Lampetra tridentate; Petromyzontiformes*
	Rainbow Trout/Inland Redband Trout	*Oncorhynchus mykiss*
	Westslope Cutthroat	*Oncorhynchus clarki lewisi*
	White Sturgeon	*Acipenser transmontanus*
Washington Priority Species – Rare Plants[1]	Canadian St. John's-wort	*Hypericum majus*
	Common Northern Sweet Grass	*Anthoxanthum hirtum*
	Coyote tobacco	*Nicotiana attenuata*
	Desert Codder	*Cuscuta denticulata*
	Dwarf Evening Primrose	*Camissonia pygmaea*
	Grand Redstem	*Ammannia robusta*
	Gray Cryptantha	*Cryptantha leucophaea*
	Great Basin Gilia	*Aliciella leptomeria*
	Halfchaff Awned Sedge	*Lipocarpha aristulata*
	Lowland Toothcup	*Rotala ramosior*
	Mat Buckwheat	*Eriogonum caespitosum*
	One-cone Ground-pine	*Lycopodium lagopus*
	Pauper Milk-vetch	*Astragalus misellus var. pauper*
	Persistentsepal Yellowcress[2]	*Rorippa columbiae*
	Prairie Cordgrass	*Spartina pectinata*
	Piper's Daisy	*Erigeron piperianus*
	Red Poverty-weed	*Micromonolepis pusilla*
	Shy Gilly-flower	*Gilia inconspicua*
	Smooth Willowherb	*Epilobium pygmaeum*
	Snake River Cryptantha[2]	*Ryptantha spiculifera*
	Twincrest Onion	*Allium bisceptrum*
	Whited's Penstemon	*Penstemon eriantherus var. whitedii*

Table 14
ESA-listed Fish Species and Washington State Priority Habitat Species in Franklin County

Species Category	Common Name	Scientific Name
Washington Priority Species – Other	American White Pelican	*Pelecanus erythrorhynchos*
	Bald Eagle	*Haliaeetus leucocephalus*
	Black-crowned Night-heron	*Nycticorax nycticorax*
	Black-tailed Jackrabbit	*Lepus californicus*
	Burrowing Owl	*Athene cunicularia*
	Chukar	*Alectoris chukar*
	Columbia Pebble Snail	*Fluminicola columbiana*
	Columbia River Tiger Beetle	*Cicindela columbica*
	Ferruginous Hawk	*Buteo regalis*
	Golden Eagle	*Aquila chrysaetos*
	Great Blue Heron	*Ardea herodias*
	Juniper Hairstreak	*Callophrys gryneus*
	Loggerhead Shrike	*Lanius ludovicianus*
	Merriam's Shrew	*Sorex merriami*
	Mountain Sucker	*Catostomus platyrhynchus*
	Mule Deer	*Odocoileus hemionus*
	Peregrine Falcon	*Falco peregrinus*
	Prairie Falcon	*Falco mexicanus*
	Preble's Shrew	*Sorex preblei*
	Ring-necked Pheasant	*Phasianus colchicus*
	Sage Sparrow	*Amphispiza belli*
	Sage Thrasher	*Oreoscoptes montanus*
	Sagebrush Lizard	*Sceloporus graciosus*
	Striped Whipsnake	*Masticophis taeniatus*
	Townsend's Big-eared Bat	*Corynorhinus townsendii*
	Washington Ground Squirrel	*Urocitellus washingtoni*
	Western Grebe	*Aechmophorus occidentalis*
	White-tailed Jackrabbit	*Lepus townsendii*
	Yellow-billed Cuckoo	*Coccyzus americanus*

Notes:
1 = U.S. National Resource Conservation Service website, accessed February 12, 2014
2 = Species are also under federal listing.
ESA = Endangered Species Act

5.1.4.2.2 Aquatic Habitat

The Snake and Columbia rivers make up the border of the southern half of the City and provide the only shoreline jurisdictional aquatic habitat within the City. The aquatic habitat supports numerous resident and anadromous fish, aquatic invertebrates, and numerous migratory bird species.

Many ESA-listed anadromous salmonid species are found within the two rivers, including bull trout, steelhead, sockeye, and spring and fall Chinook salmon. Coho salmon are rare but may occur through reintroduction programs underway in the Yakima River Basin and this population segment is not ESA-listed. Pacific lamprey are present but have experienced population decline in recent years.

Resident fish include a mix of native and non-native species, such as smallmouth (*Micropterus dolomieu*) and largemouth bass (*Micropterus salmoides)*, northern pikeminnow (*Ptychocheilus oregonensis*), sculpin (*Cottoidea sp.*), mountain whitefish (*Prosopium williamsoni*), white sturgeon, catfish (*Ictalurus punctatus*), sucker (*Catostaomidae sp.*), walleye (*Sander vitreus*), chiselmouth (*Acrocheilus alutaceus*), dace (*Leuciscus leuciscus*), common carp (*Cyprinus carpio*), redside shiner (*Richardsonius balteatus*), peamouth (*Mylocheilus caurinus*), and various minnow species. Shellfish include the Columbia River limpet, spire snail (*Heleobia stagnorum*) and California floater (*Anodonta californiensis*). Non-native species found in the Columbia and Snake rivers that are managed by Washington Department of Fish and Wildlife (WDFW) as game species include bluegill (*Lepomis macrochirus*), bass, crappie (*Pomoxis*), shad (*Alosa sapidissima*), carp (*Cyprinus carpio*), channel catfish (*Ictalurus punctatus*), perch (*Perca*), and walleye.

The aquatic nearshore and riparian shoreline areas of the Columbia and Snake rivers near the City support concentrations of wintering migratory waterfowl, and primarily serve as resting and feeding areas for Canada goose (*Branta Canadensis*) and dabbling ducks (*Anas*); primarily mallard (*Anas platyrhynchos*), canvasback (*Aythya valisineria*), ring-necked duck (*Aythya collaris*), and wood duck (*Aix sponsa*). Some waterfowl nesting likely occurs in areas with wider riparian buffers, potentially near the confluence of the Snake and Columbia rivers and along reaches of the Columbia River where development is less intensive, such as residential zones, parks, and open spaces. The Columbia River in the vicinity of the City also provides a

breeding area for long billed curlew (*Numenius americanus*) and a variety of gulls, as well as a resting area with limited nesting for great blue heron (*Ardea herodias*) and egret (*Ardea alba*).

Aquatic invertebrate forage species found in the Columbia and Snake rivers near the City are typical of large river systems. The Columbia River in this reach supports larger invertebrates such as crawfish, as well as numerous aquatic insects, mollusks and gastropods. Significant studies have been conducted along the Hanford Reach, which includes some locations near the City. It is anticipated that presence of aquatic invertebrates may be somewhat representative, although likely differ due to land use changes at the transition from the Washington Department of Energy-managed Hanford Reach into the urban development boundary of the City. Mollusk surveys conducted in the Hanford Reach in 2003, 2004, and 2006 found 17 taxa (5 mussels and 12 snails); 3 taxa are considered to be special status species by federal or state agencies (Mueller 2014). Throughout the past 50 years, the macroinvertebrate fauna of the Hanford Reach has changed, with certain taxa and taxonomic groups increasing while others decrease: Mayfly (*Ephemeroptera*) diversity has increased; stoneflies (*Plecoptera*) have disappeared; caddisfly (*Trichoptera*) diversity and abundance remain high; dragonflies and damselflies (*Odonata*), true bugs (*Hemiptera*), butterflies and moths (*Lepidoptera*) and beetles (*Coleopteras*) are rare; and fly (*Diptera*) diversity remains relatively constant (Evans 2003).

Limitations to aquatic habitat in the City are the low habitat complexity along the shoreline due to water regime management on the Columbia and Snake rivers. The following aquatic restoration opportunities may be feasible in the City:

- Improve migration conditions in the lower Snake River by changing hydrograph of Snake River dam storage.
- Reconnect floodplain/side channels and oxbows near this reach, and investigate leasing/purchasing floodplain areas.
- Reduce influence of predatory fishes such as smallmouth bass and northern pikeminnow.
- Retain and recruit large woody debris or engineered logjams along the shoreline of both rivers to restore and enhance fish habitat, taking into consideration the risk of possible predation issues on juvenile salmonids.

- Restore riparian buffers where possible.
- Update irrigation intakes, as applicable, for protection of salmon from uptake and impingement.

5.1.4.2.3 Terrestrial Habitat

The City's population is generally concentrated around and near the confluence of the Columbia and Snake rivers, leaving little terrestrial habitat within the shoreline jurisdictional zone throughout much of City undeveloped. Irrigated agricultural lands are prevalent throughout the northern ends of the City.

Dam development on the Columbia and Snake rivers has altered these waterbodies, impacting the quantity and quality of water in these systems, as well as the shorelines within the City. Alterations specifically affecting the riparian zone in the City include reduced wood recruitment and transport within the river basins, and the lack of connectivity to floodplain habitats. In addition, levee systems along the Columbia and Snake River shorelines in the City further reduce the connectivity of the rivers to their floodplains and also limit the vegetation community development in the riparian zone.

Human-induced alterations to light transmission may interfere with plant production and aquatic animal behavior. Plants and animals are adapted to natural light intensities and timing of lighted periods. Light energy affects water temperature, animal behavior (such as the relationship between predators and prey), and plant photosynthesis and growth (Tilzer et al. 1975). Natural light is altered when riparian vegetation is removed or when structures such as docks are built that create shade and prevent natural light from reaching the water. Reductions in this natural light preclude plant colonization and growth beneath these structures and can cause changes in animal behavior. For example, shade cast by overwater structures may disrupt juvenile salmon migration in the Columbia and Snake rivers by creating visual barriers to their movement (Carrasquero 2001). Natural light can also be reduced by the presence of algal blooms caused by excess nutrient additions that can collect in slack-water areas.

Artificial light refers to the light that humans create at night, such as lights used for roads, parking lots, industrial complexes (including dams), houses, docks, piers, and sports fields. This light can interfere with aquatic and terrestrial animals' routines and change predator-prey relationships.

The shrub-steppe habitat common to Eastern Washington and historically prevalent throughout Franklin County provides many ecosystem services including soil stabilization, wildfire moderation, and overall biodiversity. The displacement of shrub-steppe plant species by cheat-grass (*Bromus tectorum*), Russian thistle (*Salsola tragus*), and other invasive species increases fire intensity and frequency which, in addition to the hazards this creates for humans and wildlife, also impacts the dominant shrub-steppe plant species big sagebrush (*Artemisia tridentata*), an important species for rare birds such as the sage grouse (*Centrocercus urophasianus*) (Link et al. 2006). While undisturbed shrub-steppe habitat is rare in the City, disturbed shrub-steppe communities remain in spaces between agricultural fields and adjacent to the rivers, within the shoreline jurisdictional area. Such areas have been affected to various degrees by grazing, invasive plant infestations, agriculture, and development.

Relatively undisturbed shrub-steppe habitat in the City area may still be dominated by native grasses and sagebrush. Undisturbed shrub-steppe lands are characterized by an intact cryptogam crust (a thin layer of moss and lichen that indicates an undisturbed community), mostly native shrubs (e.g., big sagebrush and bitterbrush), and a predominantly native grass understory. The shrub-steppe habitat communities in the City area, while damaged by a variety of activities, may still provide cover, food, and nesting habitat for many species of wildlife and insects. These shrub-steppe areas have been identified in other nearby areas to be particularly important during winter months when nearby and adjacent cultivated fields provide no vegetative cover for wildlife (YSFWPB 2004), and the same may be true for the disturbed, remnant shrub-steppe habitats in Pasco.

Recommendations for preserving shrub-steppe habitat consist of limiting development footprints, including agricultural land cover changes, limiting road and utility corridors to avoid fragmenting habitat, restricting vegetation clearing, keeping domestic pets and

livestock out of sensitive species habitat, limiting fencing to avoid barriers to native wildlife, and limiting irrigation canals through shrub-steppe habitat (Azerrad et al. 2011).

An abundant and diverse community of wildlife inhabits and utilizes shrub-steppe communities in the region, although few of these species are likely to exist along the shoreline areas of the City. In addition to the species identified in Table 14, species that may be found at the margins of the shoreline in less developed areas include reptiles such as the western rattlesnake (*Crotalus viridis*), Great Basin spadefoot toad (*Spea intermontana*), and northern sagebrush lizard (*Sceloporus graciosus*). Birds noted in Table 14 may be found at various times near the shorelines within the City. The City has many species that have adapted to urban environments, such as raccoons (*Procyon lotor*), possum (*Didelphis virginiana*), small rodents, coyotes (*Canis latrans*), pigeons (*Columbidae*), house sparrows (*Passer domesticus*), and crows (C*orvus*). Less common are other small mammals such as Townsend ground squirrel (*Urocitellus townsendii*), black-tailed jackrabbit (*Lepus californicus*), white-tailed jackrabbit (*Lepus townsendii*), Merriam's shrew (*Sorex merriami*); and large mammals such as badger (*Taxidea taxus*), mule deer (*Odocoileus hemionus*), and elk (*Cervus canadensis*).

Riparian and floodplain areas, as well as wetlands, are primarily associated with the mainstem Columbia and Snake rivers. Black cottonwood (*Populus trichocarpa*) is the dominant plant species in lowland riparian areas and plays a key role in the integrity of riparian systems (USBR 2008). Other species include a variety of willow species, red-osier dogwood (*Cornus sericea*), aspen (*Populus*), water birch (*Betula occidentalis*), serviceberry (*Amelanchier*), chokecherry (*Prunus virginiana*), rose (*Rosaceae*), hawthorn (*Crataegus*), and snowberry (*Symphoricarpos*), as well as invasive species such as Russian Olive. Reptile and amphibian species found in these habitats include western painted turtle (*Chrysemys picta*), spotted frog (*Rana pretiosa*), gopher snakes (*Pituophis melanoleuces*), garter snake (*Thamnophis sirtalis*), and others. Small mammals include beaver (*Castor canadensis*), river otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), mink (*Mustela vison*), porcupines (*Erethizon dorsatum*), raccoons, skunks (*Mephitis mephitis*), silver-haired bats (*Lasionycteris noctivagans*), and pallid bats (*Antrozous pallidus*). River otters are occasionally observed in the Hanford Reach. Common avian species include Wilson's phalarope (*Phalaropus tricolor*), belted kingfisher (*Megaceryle*

alcyon), peregrine falcon (*Falco peregrinus*), hairy woodpecker (*Picoides villosus*) and downy woodpecker (*Picoides pubescens*). Species of waterfowl that utilize the wetland and riparian habitats within the affected area include mallard, American wigeon (*A. Americana*), and others (USFWS 2008, 2012).

The City area is located in the Pacific Flyway and serve as a resting area for neotropical migrant birds, migratory waterfowl, and shorebirds. Other species observed in the area include great blue heron, American white pelicans (*Pelecanus erythrorhynchos*), egrets, double-crested cormorants (*Phalacrocorax auritus*), coots (*Fulica americana*), and common loons (*Gavia immer*) (USFWS 2008, 2012).

In the Lower Columbia Basin, wildlife resources are positively affected by several large public land holdings, including the Hanford Reach National Monument to the north and the McNary Wildlife Refuge, which provide large contiguous range for native species. For City shorelines, several factors affect the suitability of wildlife habitat:

- A lack of connectivity along the shoreline riparian habitat presents challenges for wildlife movement up the Columbia River from the Snake River confluence. Ongoing efforts to remove barriers to wildlife movement benefits species with a wider ranging territory.
- Islands in the Columbia River that are part of the McNary National Wildlife Refuge and provide resting areas for a range of migratory wildlife. The river provides a substantial buffer from human disturbance on these islands.
- Ongoing efforts to enhance existing habitat in areas where past disturbance has occurred, together with limiting access to critical nesting areas, provides the potential to substantially enhance habitat values in existing floodplain areas.

Table 15 summarizes the key stressors affecting ecological functions provided by the specific aquatic and terrestrial systems within the City.

Table 15
Key Stressors Affecting Ecological Functions

Key Stressors	Columbia River		Snake River	
	Aquatic	Terrestrial	Aquatic	Terrestrial
Recreational access – existing	X	X	X	X
Recreational area – potential development		X		X
Agricultural use – irrigation	X		X	X
Agricultural use – livestock			X	X
Residential development – existing shoreline development	X	X		
Residential development – land use change (e.g., development of new roads, utilities)		X		X
Residential development – future	X	X	X	X
Hydrologic management regimes	X	X	X	X

5.2 Reach Characterizations

Characterization of shoreline reaches and subreaches is provided in Appendix A. These reach and subreach characterization tables summarize existing physical conditions; characterizations and analyses for water quantity and sediment, water quality, and habitat and species; ecological functions analysis, including identifying functional conditions, stressors, and restoration and protection opportunities; preliminary shoreline environment designation considerations; existing public access and potential additional public access opportunities; and cumulative impact considerations.

Each reach was categorized overall in terms of ecosystem function. The categories include functioning, partially functioning, and impaired. The framework, definitions, and categories for this analysis were adapted from a system originally developed for Riparian Area Management guidelines proposed by the U.S. Bureau of Land Management (BLM; Prichard 1998). This assessment is a relative assessment with some degree of calibration to reflect the overall conditions found in the City.

The potential ecological function is defined as the highest ecological status a shoreline reach can attain given no development or management constraints, which takes into account the extent to which management (particularly water management) supports ecological function.

Ecological function is defined here as the degree of similarity between existing physical and biological conditions, and the potential ecological function of a site; the higher the ecological function, the closer the site is to potential. Potential, for this assessment, encompasses all the resources defined by the interaction of hydrology, vegetation, water quality, and erosion/deposition (soils), and aquatic and riparian habitat. For example, the potential of the hydrologic component includes the concept of a stream channel's physical characteristics (dimension, pattern, and profile) being within a normal or usual range (e.g., entrenchment, sinuosity, width, depth, and slope of the bankfull channel) as defined by landform and geomorphic stream type given current flows. The three categories of ecological function are as follows:

- **Functioning** is a state of resiliency that will allow a shoreline to hold together during high-flow events with a high degree of reliability. This resiliency allows an area to then produce desired values, such as fish habitat, bird habitat, or forage, over time. Riparian-wetland areas that are not functioning properly cannot sustain these values over time and are susceptible to stochastic disturbances such as fire.
- **Partially functioning** is a state in which the ecological function of the shoreline is somewhat compromised by development or management trends, or is particularly susceptible to future degradation due to development, management, or ecological conditions. A partially functioning shoreline has some ability to recover through changes in management or the removal of identified stressors on ecological function.
- **Impaired** is a state in which the ecological functions of the shoreline are heavily compromised by development or management of the reach. An impaired reach has a low probability of recovery through restoration due to the degree of structural change to the shoreline, waterbody, and surrounding shorelands. Impaired shorelines can be functionally improved, but are unlikely to be self-sustainable.

5.3 Future Land Use and Development Potential

5.3.1 Methodology

The future development potential is analyzed using existing City and Franklin County GIS data. GIS data used includes parcel, land ownership, existing land use, and zoning. These datasets were overlaid on the reach map with shoreline jurisdiction boundary. The overlaid map indicates parcels within the shoreline jurisdiction. These parcels were reviewed and analyzed for future development potential. In most cases, portions of the parcels fell within the shoreline. In some other instances, already subdivided and vacant lots were identified as developable land within the shoreline.

The undivided land within the shoreline jurisdiction was used to calculate the number of developable lots where applicable. Allowed densities were also taken into account to establish number of developable units. For non-residential lots (e.g., industrial), the portion of land within the shoreline jurisdiction was included in area calculations, which helped determine development potential.

5.3.2 Data Gaps

The analysis does not include the critical areas or steep slopes. Setbacks and other buffers were not factored in the calculation, as these are applied at the time of development. Analysis did not include the detailed area calculation for recreational improvements on public land.

5.3.3 Land Development Potential Summary

Table 16 indicates the future land development potential within the City's shoreline. The purpose of the analysis is to estimate potential development that may take place along shorelines in the planning timeframe, according to the existing land use and zoning designations. The analysis uses the existing GIS datasets provided by Franklin County and the City, existing planning documents, and current development trends. These results are intended to provide a general overview of the future development potential, but not to dictate how the development should occur. Future development potential may vary from this analysis based on the overall market condition, intent of the property owner, or other local or regional factors.

Table 16

Future Development Potential by Shoreline Reach

Reach	Area (acres)	Land Use	Future Development Constraints	Developable	Future Development
Reach 1	63.02	– Low Density Residential – Mixed Residential – Mixed Residential Commercial – Open Space Nature	– USACE ownership of land – Existing road – Gravel pit (Broadmoor) with long-term lease	– Entire SR 1a – Vacant parcels in SR 1b, 1d, and 1e	– 32 residential lots
Reach 2	34.39	– Low Density Residential – Open Space Nature	– Mostly build-out	– Vacant lots within the subdivision	– 3 residential lots
Reach 3	54.32	– Low Density Residential – Open Space Nature	– Chiawana Park – USACE ownership	– No developable land except for recreational facility improvements	– Park improvement for additional boat launch and beach area (Pasco 2012) – Trail improvement
Reach 4	50.65	– Low Density Residential – Open Space Nature	– USACE ownership of land and levee – Wade Park; mostly build-out	– Development on vacant lots behind the levee and the drainage ditch. These lots have portions within the shoreline area.	– 15 residential lots

Reach	Area (acres)	Land Use	Future Development Constraints	Developable	Future Development
Reach 5	59.54	- Low Density Residential - Mixed Residential - Mixed Residential Commercial - Industrial - Open Space Nature	- Public ownership of land by USACE - WSDOT - City of Pasco - Port of Pasco - BNSF Railway Company; existing levee and railtrack	Park development on vacant BNSF land: - Development of the industrial area only after the abandonment of the BNSF rail track - Portion of the industrial land within shoreline is approximately 0.35 acres	- 7,623 square-feet industrial area (approximately 50% land coverage)
Reach 6	95.91	- Industrial - Open Space Nature	- Remediation of the toxic spillage on the Port of Pasco property - BNSF railtrack	- The Port's vacant industrial property (SR 6a) could be developed to add about 11,000-square-feet area (approximately 50% land coverage) within the shoreline. However, this is contingent upon the spillage remediation process which progresses slowly. Future development is unlikely to take place within the planning timeframe. - Osprey Pointe development in SR 6c would include parking area development within the shoreline. Proposed buildings are mostly located outside the 200-feet shoreline jurisdiction with some portions of the buildings being within the shoreline.	- Park and trail improvements near the marina - Development of parking lot at Osprey Pointe - About 18,672 square feet of building area is proposed within the shoreline
Reach 7	62.78	- Industrial - Open Space Nature	- Washington State Parks Department ownership	- Park amenities could be improved	- Park and trail improvements

Reach	Area (acres)	Land Use	Future Development Constraints	Developable	Future Development
Reach 8	90.06	- Industrial - Open Space Nature	- BNSF railtrack Ainsworth historic town - Industrial area is mostly developed with fuel tanks	- Low development potential. Industrial area is less likely to have additional development within the planning timeframe - Potential for trail connection to the east	- Trail improvements

Notes:
BNSF = Burlington Northern Santa Fe
SF = square foot
SR = Subreach
USACE = U.S. Army Corps of Engineers
WSDOT = Washington State Department of Transportation

5.3.4 Preliminary Shoreline Environment Designation Considerations

The information in this report provides the foundation for developing the City's SMP. Information is organized by waterbodies and reaches to allow for SMP provisions tailored to local conditions found along shorelands. Goals, policies, and regulations will be established based on these conditions. Described in this section are background information on environment designations and a preliminary discussion on how elements of the Washington classification system may apply to conditions in the City.

Environment designations are applied based on specific criteria, and include a purpose statement, a description of the classification criteria, management policies, and environment-specific regulations.

5.3.4.1 State Recommended Classification System

Washington has identified a recommended classification system that can be used as a starting point in considering environment designations most applicable to the City. These consist of: high-intensity, shoreline residential, urban conservancy, natural, and aquatic as described in WAC 173-26-211.

The purpose for each of these environment designations is described in WAC 173-26-211:

- **High-intensity** – "...Provide for high-intensity water-oriented commercial, transportation, and industrial uses while protecting existing ecological functions and restoring ecological functions in areas that have been previously degraded."
- **Shoreline residential** – "...Accommodate residential development and appurtenant structures that are consistent with this chapter. An additional purpose is to provide appropriate public access and recreational uses."
- **Urban conservancy** – "...Protect and restore ecological functions of open space, flood plain and other sensitive lands where they exist in urban and developed settings, while allowing a variety of compatible uses."
- **Natural** – "...Protect those shoreline areas that are relatively free of human influence or that include intact or minimally degraded shoreline functions intolerant of human use. These systems require that only very low intensity uses be allowed in order to maintain the ecological functions and ecosystem-wide processes. Consistent with the

policies of the designation, local government should include planning for restoration of degraded shorelines within this environment."

- **Aquatic** – "...Protect, restore, and manage the unique characteristics and resources of the areas waterward of the ordinary high-water mark."

Local governments may also establish a different designation system or may retain their current environment designations, provided these are consistent with the purposes and policies of WAC 173-26-211. Parallel environments can also be used where appropriate, with shorelands divided into different sections generally running parallel to the shoreline or along a physical feature such as a bluff. In applying environment designations, the state reminds local governments that they should ensure that existing shoreline ecological functions are protected with the proposed pattern and intensity of development, and that restoration potential for an area is considered (WAC 173-26-211).

5.3.4.2 *Preliminary Considerations*

Developing and applying environment designations in the City will come in later steps in the SMP update process. In preparation for this, an initial description of shoreland areas with high intensity, residential, conservancy and natural characteristics is described in Table 17. This initial description will provide a starting point for drafting environment designations, which will be applied at the reach level in the future. The listing of these areas under the high intensity and other categories should not imply that this is what these areas will be designated in the SMP update process. Developing and applying environment designations in the City will occur with more detailed analysis of the information in this report, input from the City Planning Commission, Ecology, and from the public during the shoreline visioning process and other public forums.

Table 17
Preliminary Environment Designation Consideration

Shoreland Characteristics	Applicable Geographic Areas
High intensity	• Industrial areas, including water-dependent facilities on the Columbia (SR 6a) and Snake rivers (SR 8b) • Chiawana, Wade, Riverview, Schlagel, and Sacajawea parks (SR 3a, 5c, and 6b and portions of Reaches 7 and 8)
Residential	Several areas along the Columbia River (Reaches 1, 2; and SR 3b, 4a, and 4b, and portions of SR 5b and 6b)
Conservancy	Open space areas located in SR 1c, 3a, 3b, 5c, and 6c and portions of Reaches 7 and 8, which include lower intensity recreation areas at Chiawana and Sacajawea parks
Natural	All islands
Other	• Consider a special designation area for leveed areas along the Columbia River(portions of SR 5a, 5b, and 5d), where limited ecological function and future development potential exists, and the areas dedicated for public recreation as part of the regional trail system • Consider a recreation-based designation for the several park areas

Note:
SR = Subreach