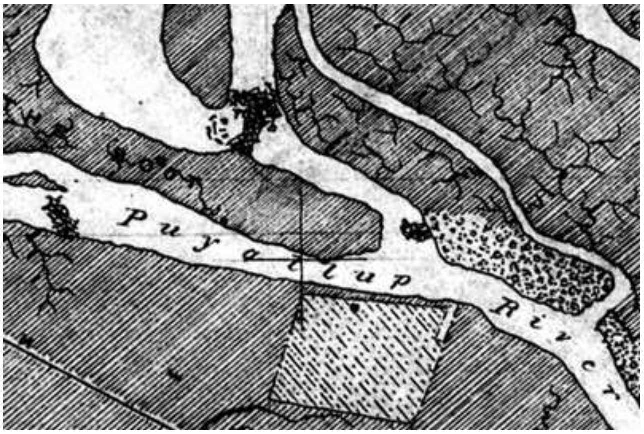
PUYALLUP RIVER WATERSHED ASSESSMENT (DRAFT)



PREPARED BY

PUYALLUP River Watershed Council

WATERSHED ASSESSMENT COMMITTEE

OCTOBER 2014

COVER PHOTOS:

UPPER LEFT – MOUTH OF THE PUYALLUP RIVER AND ESTUARY NEAR COMMENCEMENT BAY – FROM GOVERNMENT LAND OFFICE (GLO) LAND SURVEY MAP (1877)

UPPER RIGHT – MOUNT RAINIER (EMMONS GLACIER AND WHITE RIVER HEADWATERS) PHOTO BY CHRIS MAGIRL, USGS

LOWER LEFT – CHINOOK SPAWNING IN PUYALLUP RIVER NEAR CHAMPION BRIDGE (NEAR RIVER MILE 29) – PHOTO BY TOM NELSON, PIERCE COUNTY

LOWER RIGHT – LOWER PUYALLUP LEVEE CONSTRUCTION (CIRCA 1910) – PHOTO COURTESY OF PIERCE COUNTY RIVER MAINTENANCE COLLECTION

CHAPTER ONE
INTRODUCTION AND WATERSHED OVERVIEW

This watershed assessment presents historical and current information on the physical, biological, cultural, and economic landscape in the Puyallup River watershed. Elements of the watershed include historical conditions (pre-European and from the 1850s to present), current socio-economic and cultural conditions, geology and geomorphology, hydrology and water use, aquatic habitat, fish and wildlife populations, water quality, floodplains, agricultural and forest lands, and key watershed features. Some information is summarized for the watershed as a whole and other information is provided by sub-basin.

There are two main purposes of this watershed assessment: (1) to provide a compilation of existing information on watershed conditions (i.e., how the watershed functions in an ecological and human context) in a single document; and (2) to inform the Puyallup River Watershed Council (PRWC) and its partners in the development of a guiding document or strategic plan to manage the watershed in the future. A key part of the analysis is to compare historical conditions with current conditions, quantify changes, and look forward to desired future conditions that are necessary to achieve agreed-upon watershed goals (e.g., clean water, healthy habitats, and thriving communities). The PRWC will then identify focus areas for targeted work related to water quality improvement, aquatic and terrestrial habitat protection and restoration, floodplain management, and protection and wise utilization of resource lands (farmland, forests). The PRWC will also use the information for education and outreach, and prioritize council-sponsored activities and projects.

It is important to understand that this document is designed to provide a scientific framework for understanding human impacts on the watershed landscape so that decision makers and people can make informed choices regarding land use, public and private property, and government, business, group or personal actions that affect watershed conditions.

The Watershed Assessment was developed using the best available technical information, an inclusive process, and a multi-disciplinary team of PRWC scientists, planners, and policy experts. It considered complex environmental, economic, social, and cultural conditions in the watershed.

1.1 WATERSHED OVERVIEW

The Puyallup River and its two main tributaries, the White River and Carbon River, drain a watershed of approximately 1,040 square miles (665,000 acres) and flows from several of the glaciers on Mount Rainier with an elevation of 14,411 feet to Commencement Bay and Puget Sound (Figure 1.1) . The Puyallup River runs through the cities of Tacoma, Fife, Puyallup, Sumner, and Orting, and large areas of unincorporated Pierce County. The Puyallup Tribe of Indians owns the river bed within the 1873 survey area from approximately RM 1.4 to RM 7.2. The lower reaches of the Puyallup River were historically straightened with levees and revetments for flood control purposes. Mud Mountain Dam on the White River at RM 29.6 provides storage of up to 106,000 acre-feet of water to reduce flooding on the White and Lower Puyallup Rivers.

The White River drains an area of approximately 475 square miles. It flows about 75 miles from its source on the Emmons Glacier on the northeast side of Mount Rainier to its mouth at the City of Sumner. The river has several tributaries including Huckleberry Creek, Greenwater River and Clearwater River. It flows through the community of Greenwater, the Muckleshoot Indian Reservation, and the cities of Buckley, Auburn, Pacific and Sumner before joining the Puyallup River at RM 10.3. Approximately 75 percent of the White River basin lies within Pierce County and the remaining 25 percent is within King County. The White River forms the county line separating King and Pierce counties between the confluence of the Greenwater River and White River at RM 45.8 downstream to near the City of Auburn.

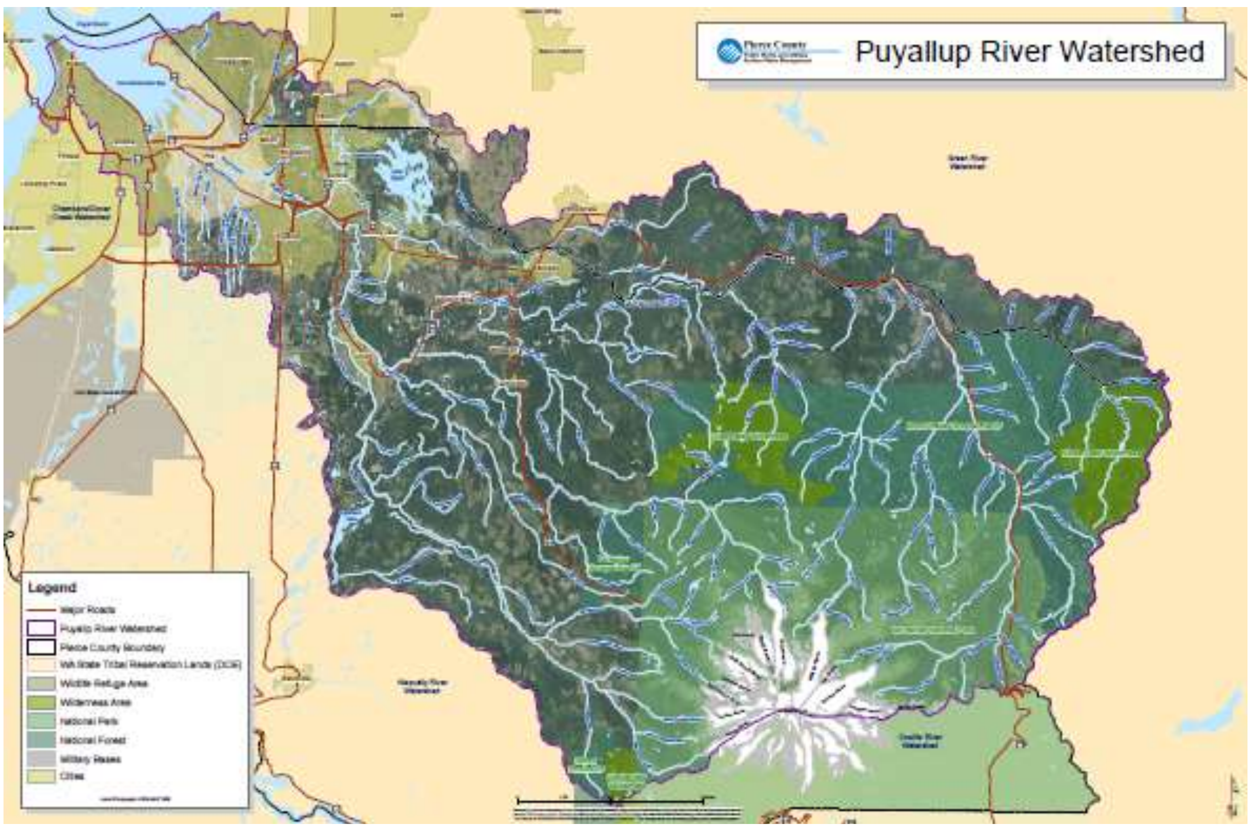


Figure1.1 Puyallup River Watershed

The Greenwater River lies in northeastern Pierce County and enters the White River at RM 44.6. The headwaters of the Greenwater River are on Castle Mountain in the Cascades (elevation of 6700 feet) and it flows northwest for 21 miles to the community of Greenwater. The drainage basin is approximately 75 square miles. The Greenwater River forms the boundary between

King County (north of the river) and Pierce County (south of the river) upstream of its confluence with the White River.

Boise Creek flows from North to South beginning in the hills north and slightly east of Enumclaw, WA, and converges with the White River near the State Highway 410 Bridge on the right bank, just north of Buckley. It has a drainage area of approximately 15 square miles.

The Carbon River drains an area of 230 square miles that originates on the north face of Mt. Rainier at the Carbon Glacier. It flows 33 miles downstream joining the Puyallup River below the City of Orting at RM 17.4. The lower 8.4 miles of the Carbon River is in the Orting valley in unincorporated Pierce County, except along the left bank of the lower 3.5 miles, which flows along the City of Orting. Above RM 11.0, the river is contained within steep canyon walls up to the community of Fairfax at RM 17.5.

South Prairie Creek lies in the center of the Puyallup River Basin, east of the City of Orting. South Prairie Creek has a drainage basin of 90 square miles and ranges in elevation from 285 feet above sea level to 5,933 feet at the summit of Pitcher Mountain.

Table 1.1 Watershed and sub-basins in the Puyallup Watershed

Watershed/Basin	Area (square miles)
Puyallup Watershed	1,040
White River Basin	475
Carbon River Basin	230
South Prairie Creek Basin	90
Greenwater River Basin	75
Nearshore/Commencement Bay drainages	~50
Total	**1,090**

1.2 CHAPTER DESCRIPTIONS

The following is a description of the chapters of this report:

Chapter 2, Historical Conditions Assessment – Pre-European focuses on the historical conditions that existed post glacial retreat (Holocene period) during occupation by Native American tribes. This is the natural conditions in terms of land cover, natural hydrology, aquatic and terrestrial habitat, healthy salmon and wildlife populations, and a relatively small human population. Floodplain and estuarine habitat are described based on available information.

Chapter 3, Historical Conditions Assessment – 1850s to present focuses on the historical conditions and changes during the period from European settlement to the present. This includes land cover changes due to logging, agricultural activities, urbanization, and shoreline development. It also includes changes to the natural environment such as river channelization, water diversions and groundwater withdrawals, water quality and habitat degradation, and declines in fish and wildlife populations.

Chapter 4, Current Socio-Economic, Cultural, and Land Use Conditions focuses on population growth and development trends, current land use and land cover (urban, rural, agricultural, forest, and transportation), economic conditions (e.g., jobs and various business sectors including resource-based, manufacturing, and Port activities), leadership structure and human capital, and tribal lands (including usual and accustomed fishing areas).

Chapter 5, Geologic and Geomorphologic Conditions focuses on the regional geology and Mount Rainier, glaciers, river system geomorphology (including river channel conditions), sediment erosion, transport, and deposition; and the estuary and marine shorelines. This chapter includes information on stream channel modifications including straightening, armoring, and gravel removal.

Chapter 6, Hydrology and Water Use describes how local climate, geology, and topography influence stream flow patterns in the watershed. Data on stream flow (e.g., peak flood flows, instream low flows) and water use is presented to identify potential problems related to flooding and floodplains, water supply, and in-stream flows for salmon.

Chapter 7, Riparian and Aquatic Habitat, Wetlands, and Fish and Wildlife Populations focuses on the current conditions of riparian zones, in stream habitat (e.g., spawning and rearing habitat, pools, riffles, and off-channel habitat), wetlands, and the status of fish and wildlife populations, including listed salmonids (e.g., Chinook salmon, steelhead, and bull trout) and other species (e.g., marbled murrelet, spotted owls). This chapter also includes information on viable salmonid parameters (e.g., abundance, productivity, diversity, spatial structure) and habitat limiting factors.

Chapter 8, Water Quality describes current and historical water quality and stream health data collected by local, tribal, and state agencies and organizations. Both point and nonpoint (diffuse) sources of pollution are examined. Parameters analyzed include water temperature, bacteria, sediment and nutrients, metals and trace organics (e.g., pesticides, herbicides, combustion by-products), as well as macro-invertebrates (and the benthic index of biotic integrity).

Chapter 9, Floodplains focuses on the valley floor of major rivers, including flood plain and channel migration zone mapping, risk assessment, floodplain development regulations, levees, revetments, and river corridors.

Chapter 10, Resource Lands (Agricultural Lands and Forests) focuses on current agricultural and forest land base, conversions, traditional and organic farming, farmland and forest preservation, and future job outlook in the natural land economy.

Chapter 11, Key Watershed Features focuses on summarizing in map and descriptive form the forests (Mt. Rainier National Park, Norse and Clearwater Wilderness Areas, National Forests, private timber lands, small forests), agricultural lands (Puyallup and Orting Valleys), salmon strongholds (e.g., South Prairie Creek, Boise Creek, White River, Greenwater/Huckleberry/ Clearwater Rivers, etc.), key floodplain management areas (Puyallup, Lower White, and Carbon Rivers, South Prairie Creek), and water quality focus areas (e.g., South Prairie Creek, Clarks Creek, Boise Creek, Fennel Creek, Swan Creek, etc.).

1.3 METHODS

The overall scope and methods used in this assessment were guided by the Oregon Watershed Assessment Manual (OWEB 1999) and Protecting Watershed Ecosystems: A Guide for Puget Sound Planners to Understand Watershed Processes (Ecology and EPA 2005). This assessment attempts to compile information from many existing sources, mostly generated over the past 20 years, with minimal or no new data collection.

CHAPTER TWO
HISTORICAL WATERSHED CONDITIONS

The Puyallup watershed began to form about 6 million years ago. The Cascade Mountains, including Mount Rainier were a line of fire up and down the coast as the oceanic plates were colliding and pushing up the continental plates. Glaciers shaped the Puyallup watershed as they scoured, gouged, and polished the landscape. As the glaciers advanced, they deposited delta sand and rock; when they retreated sea level rose filling the low areas with water, sand, and gravels. The last glacier retreated approximately 16,000 years ago, leaving glacial Lake Puyallup filling the lower valley (Bretz 1910). The melting of the glaciers caused the landmass to rise, producing some of the geomorphology of the watershed. It was during this period that the early ancestors of the indigenous tribes were beginning to settle in Puget Sound (Sato 1997).

Approximately 5,600 years ago, Mount Rainier produced the Osceola mudflow that resulted in about 2000 feet of the mountainside collapsing. The mudslide flowed down from the mountain through the White River valley forcing the White River north into the Green River valley. The White River flowed north until the flood of 1906, when a debris jam blocking the White River channel near Auburn resulted in diversion of most of the flood waters into the Puyallup River. In 1916 this diversion was made permanent by the construction of a flood wall.

Great floods reworked the river valleys and deltas where much of the future settlement would occur, and the daily tides nourished the deltas to create expansive marshes (Collins et al. 2003). The landscape consisted of glacially carved hills and large river valleys carpeted with old growth forests that extended from the mountains to the tideflats (Zehfuss et al. 2003). During this time of considerable change, Pacific salmon were evolving and developing traits to maximize their survival in different habitats. Eventually, around 3,000 to 5,000 years ago, the changing habitat and the evolving Pacific salmon converged into an ecological harmony. The result was a great abundance of fish that is ranked as one of the natural wonders of the world (Lichatowich 1999).

The Puyallup Indians, whose ancestors came to the Puget Sound region thousands of years ago, were a river people, and their livelihood was largely bound to the salmon runs of the Puyallup River and its tributary streams. The name “Puyallup” is derived from the Salish word *S’Puyalupubsh*, which translates as “generous and welcoming,” referring to the Puyallup Tribe of Indians’ reputation for generous dealing with friends and strangers (Puyallup Tribe of Indians, 2010). The fundamental concept of the immortality of the salmon and the related desire not to offend it and endanger its return was a driving force in the spirituality of the Puyallup people. The First Salmon Ceremony was a major celebration held at the time of the first yearly salmon runs. Salmon affected the lives and quality of life for all tribal members. The adult men caught the fish, the women cleaned and smoked the fish, and children gathered wood for the smoking fires. Salmon made up 80 – 90% of the Puyallup Indians’ year-round diet (Thomas 2012).

The rivers, estuaries and Puget Sound formed the basis for the Puyallup and other tribes’ sustenance and transportation network (Willingham 1992). The estuaries and rivers provided the most reliable source of food for the tribes. Salmon runs occurred at predictable times throughout the year on many rivers, providing a stable and abundant food source. The tribes developed technologies and methodologies to efficiently harvest and sustainably manage available food resources.

2.1 HISTORICAL HABITAT CONDITIONS

The White, Puyallup and Carbon rivers are located in the snowmelt transition hydro region, and therefore are fed by a mix of snowmelt and rainfall. They are also glacially fed rivers so they carry a large amount of sediments that were deposited along the banks during overbank flooding events that created natural levees along the banks.

Collins and Sheikh (2004) reconstructed historical riverine environments of the White River from General Land Office (GLO) surveys from 1867-1874, including early maps and extensive notes. The White River flows in a canyon from RM 8 to 28 that was cut within the late Holocene (last 5,000 years). The floodplain in the canyon had a complex network of sloughs, ponds, wetlands, and tributary streams. Hardwoods dominated riparian forests, based on GLO notes, but Western redcedar composed 16% of trees mapped in the floodplain. The other common trees were red alder, black cottonwood, Douglas fir, and bigleaf maple. Downstream of the canyon, the river flows onto a large alluvial fan near the City of Auburn (called the "White River fan" by Collins and Sheikh 2004), in the Duwamish-Puyallup trough (see red-blue fan area between 102 and 111 in Figure 2.1).

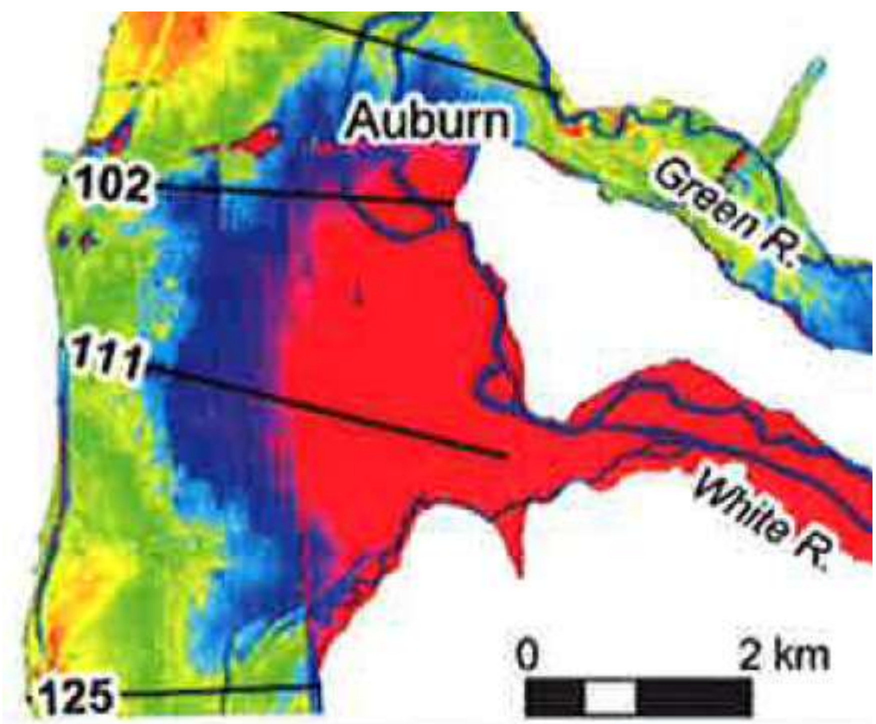


Figure 2.1 – White River Fan near River Mile 5 at the County line (shown in red)

The Puyallup and Carbon river valleys also likely had complex networks of sloughs, ponds, wetlands, and tributary streams, as well as extensive riparian forests.

The Puyallup estuary at Commencement Bay was historically an extensive expanse of tidal marshes and mudflats. An 1884 inventory of tidal wetlands by Eldridge Morse estimated that there were over 2600 acres of "tidal marsh, tide channels, and salt ponds." Figure 2.2 shows the historic and present extent of the Puyallup estuary and lower river. One of the major characteristics of the large Puyallup River delta was the estuarine transition zone which provided ideal conditions for the proliferation of many different species, including juvenile salmonids (Simenstad 2000). The most significant species that was affected by changes to Commencement Bay was the Chinook salmon, particularly juveniles that rely on estuarine shallow marsh and mudflat habitat for rearing and abundant food resources. Figure 2.3 shows a 19th century painting of Commencement Bay, the lower Puyallup estuary, and Mt. Rainier. This gives another perspective of the historical habitat conditions. Figure 2.4 is a historical Topographic sheet from a 1877 survey of the Puyallup estuary by the GLO.

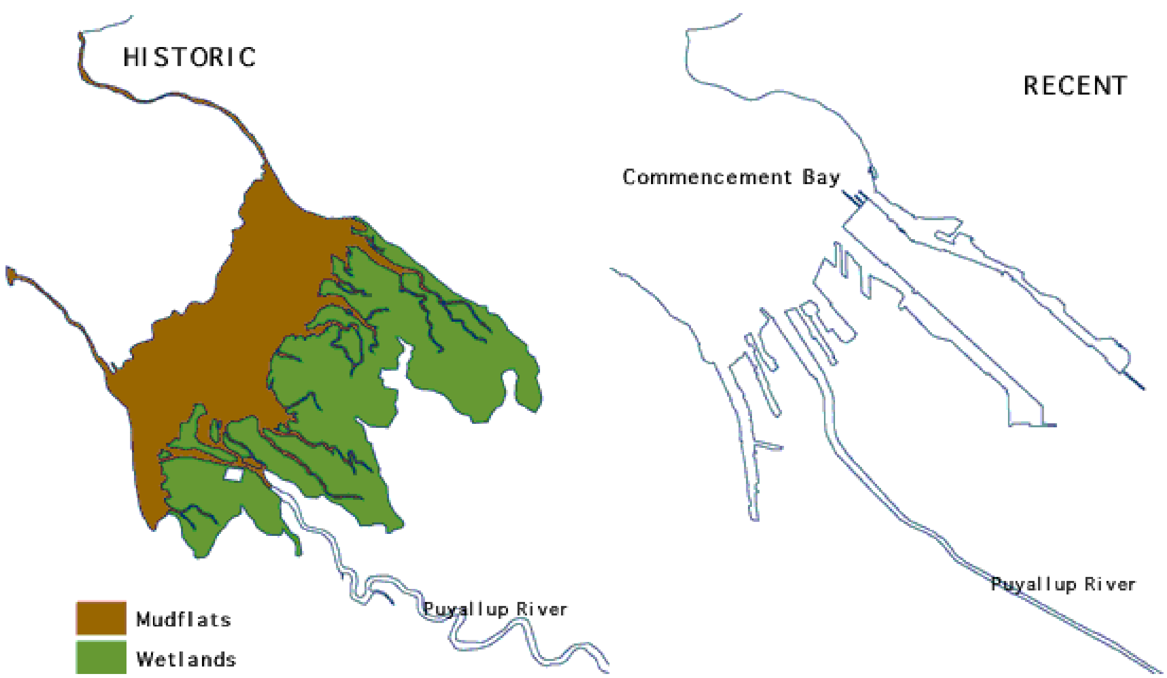


Figure 2.2 (a) and (b) – Historic and present Puyallup Estuary and Commencement Bay (People for Puget Sound 1997)

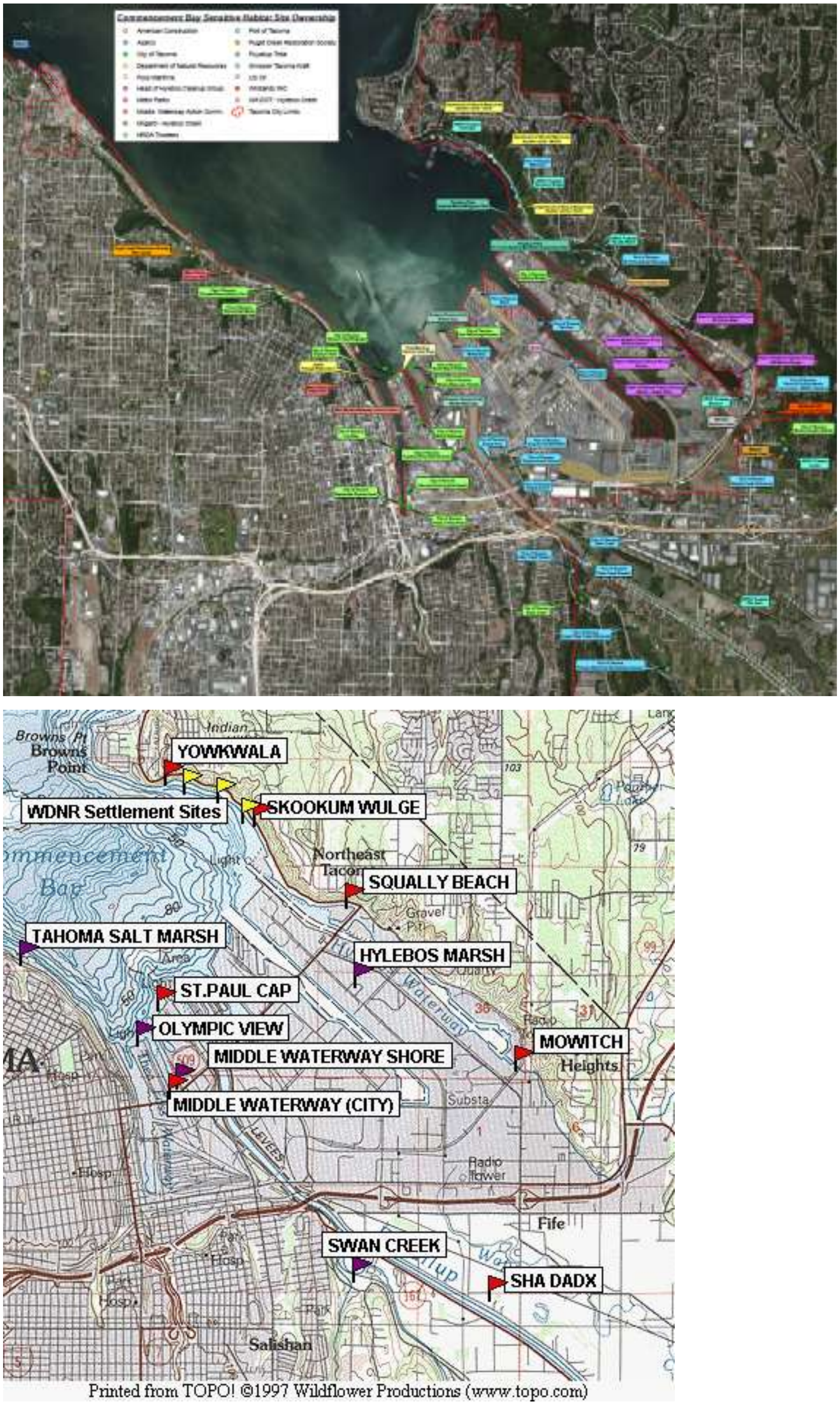


Figure 2.3 NRDA Restoration sites in Commencement Bay, and along tidal waterways and estuaries

Figure 2.3 – City of Tacoma, Commencement Bay, and Puyallup Estuary

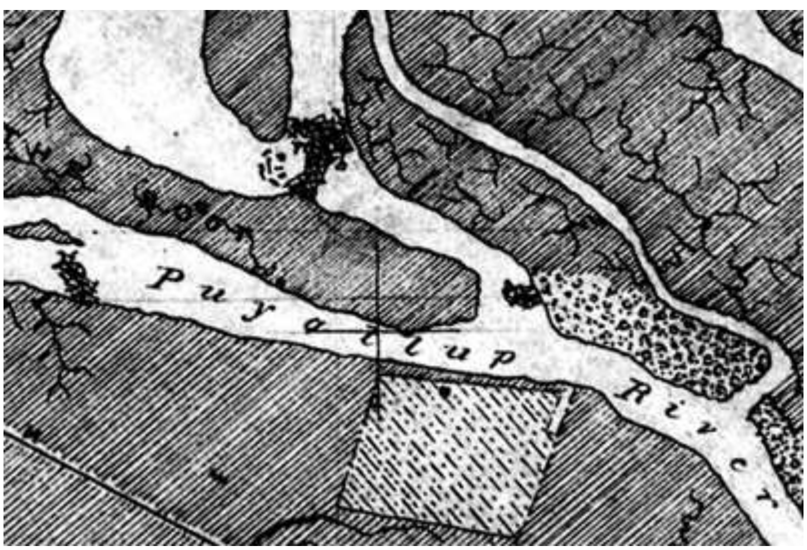


Figure 2.4 - "Detail from topographic sheet 1453, "Topography of Commencement Bay, Puget Sound, Wash. Ter." Surveyed in 1877 at a scale of 1:10,000 by Eugene Ellicott, it shows an agricultural field on the river's left bank surrounded by salt marsh.

The middle and upper Puyallup watershed was historically heavily forested with extensive trees and shrubs. In the adjacent Green River watershed, the forests were described as "heavily timbered with hemlock, fir, cedar, and pine. Dense undergrowth … with salal and huckleberry and vine maple." (Brown 1891). Riparian vegetation was frequently characterized as a "dense growth of alder, cottonwood, and maple on (valley) bottom" (Brown 1891). Historically, large woody debris in streams may have ranged from 240 to 2080 pieces per kilometer (Cederholm 1989; Fox 2001). These quantities would have provided critical structure and habitat complexity for salmonid rearing.

2.2 HISTORICAL SALMON ABUNDANCE

No quantitative information exists on historical Chinook abundance in the Puyallup watershed prior to the early 1900s. The information that exist beginning in the 1900s is fish catch or pack data for Puget Sound as a whole. The WRIA 9 watershed used these data in its Strategic Assessment to estimate historical abundance for Chinook based on watershed size, as a proxy. Meyers et al. (1998) reviewed fish canning data from the early 1900s and observed a peak harvest in 1908 that resulted in 95,210 cases of Chinook salmon packed from Puget Sound. They calculated that this number corresponds to a run size of approximately 690,000 Chinook.

By using 690,000 as the historical run size for Puget Sound, they estimated possible historical abundance for the Puget Sound watersheds. Given that Puyallup/White watershed is about 11% of the Puget Sound river watersheds, they estimated the historical Chinook estimate of 78,000 (see Figure 2.4 and Table 2.1).

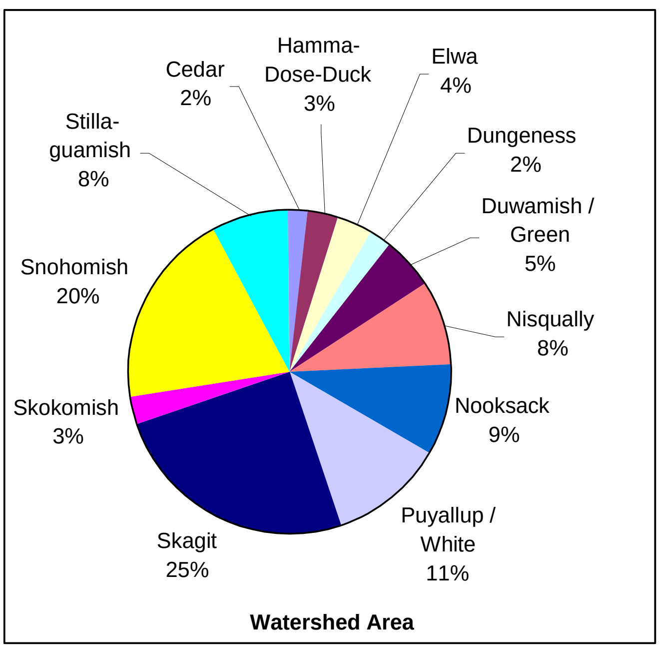


Figure 2.4 – Percentage of total Puget Sound land area for watersheds with Chinook populations.

Table 2.1 – Historical estimates of Chinook [summer/fall run] in Puget Sound watersheds based solely upon land area. Similar distributions in each watershed are assumed (Source: WRIA 9 Strategic Assessment).

Watershed	Acres	square miles	ratio	Chinook Estimate
Cedar	114,219	178	0.02	13,486
Hamma-Dose-Duck	178,486	279	0.03	21,075
Elwa	205,651	321	0.04	24,282
Dungeness	128,717	201	0.02	15,198
Green/Duwamish	319,115	499	0.05	37,679
Nisqually	486,970	761	0.08	57,498
Nooksack	516,408	807	0.09	60,974
Puyallup/White	**664,559**	**1038**	**0.11**	**78,467**
Skagit	1,449,832	2265	0.25	171,187
Skokomish	156,839	245	0.03	18,519
Snohomish	1,172,099	1831	0.20	138,394
Stillaguamish	450,910	705	0.08	53,241
Totals	5,843,805	9131	1	690,000

Another estimate of historical Chinook abundance in the Puyallup watershed was made using the Ecosystem, Diagnostic and Treatment (EDT) Model by Mobrand Biometrics, Inc. (2004). They estimated historic abundance based on habitat conditions of 42,000 in the Puyallup River watershed, 15,600 in the Lower White, and 6,700 in the Upper White. This is a total abundance for the Puyallup watershed of 64,300.

The planning range for Chinook abundance for the Puyallup River fall Chinook (for low productivity = 1.0) is 17,000 to 33,000 adults. The planning range for high productivity (2.3) is 5,300 adults (see Table 1, Pierce County Lead Entity 2012).

CHAPTER THREE
WATERSHED CONDITIONS – POST 1850 SETTLEMENT

3.1 EUROPEAN SETTELMENT (1850-1900)

European settlement of the Puyallup watershed began around 1850. The location of many early settlements depended on the presence of natural resources. Soil fertility in the lower valley near Puyallup was excellent due to the buildup of smooth, organic-laden silt in the floodplain of the Puyallup and White rivers. The soils become increasingly rocky and hummocky around Orting and farther up the valley because they represent a large outpouring of mud and volcanic debris from Mount Rainier. Puyallup became the farming center of the region because the river valley provided flat, rich farm land and it was located at a point where the Puyallup River could be easily forded. Orting, Sumner and Fife were also located in the floodplain. Carbonado and Wilkeson developed around coal mining operations in the upper basin.

The main overland transportation routes in the area included Naches Pass, for which the federal government appropriated money in 1853 to connect Fort Steilacoom to Walla Walla. Old Military Road was constructed in the mid-1850s to connect Fort Steilacoom to Bellingham. The road crossed the Puyallup River near the current location of the City of Puyallup and headed directly north through what is now Federal Way.

In 1865, the Meeker family planted hops in the valley. Hops soon became the major agricultural product of the area (see Figure 3.1). The hops were sold on an international level with valley farmers reaping huge profits and the Port of Tacoma developing into a significant trade center. The Northern Pacific Railroad Company constructed a track across the valley in 1875 when coal was discovered in Wilkeson. Coal mining reached its peak between 1880 and 1900 and continued at a reduced level for many years afterward.

Figure 3.1 – Hops growing near Puyallup

The arrival of the railroads also expedited the clearing of timber from the valley bottomlands. It was soon learned that the cottonwood trees which abounded there provided a superior raw material for manufacture of barrel staves. The timber industry was located in Tacoma where its port enabled easy transportation of logs (see Figure 3.2).

Figure 3.2 – Tacoma Lumber Trade - 1887

The relationship between railroads and town development has been close everywhere, although it is most readily apparent in the case of Orting. This settlement, originally called Whitesell's Crossing after the Naches Pass immigrant train member who filed a claim there, later received its present name from an Indian word meaning "*a prairie in the woods*". The Northern Pacific Railroad recognized the strategic value of this location and built large facilities there. The arrival of the railroads was promptly followed by the construction of shingle factories and lumber mills, and the town grew rapidly.

Sumner, on the White River near its junction with the Puyallup River, also originated on a land claim which had been occupied by a member of the Naches Pass party. The railroad reached it in 1884, and rapid growth ensued. A large sawmill opened in 1883 by the Ryan family quickly grew into one of the principal industries of the valley and was Sumner's chief source of income and employment.

The Alderton-McMillin area grew rapidly as soon as the railroad line was completed. Alderton developed quickly as a service center for the miners in the upper valley and McMillin began to industrialize. The economy in McMillin soon became centered on two manufacturers. One was the Stone Mill, which drew upon original timber resources of the valley and the adjacent hillsides and provided a variety of building materials for houses in the area. The other was a large lime kiln owned by John McMillin, which gave the community its original name.

The first section of the Northern Pacific Railroad, which selected Tacoma as its northwest terminus to connect Tacoma to Kalama, Washington, was completed in 1873. The completion of the railroad caused a significant population increase in Tacoma and the surrounding area. Tacoma's population jumped from 73 in 1870 to 1,098 in 1880 to 36,006 in 1890. Roads were built linking Tacoma, Puyallup, and Sumner. Northern Pacific constructed a branch line connecting Tacoma, Puyallup, Wilkeson and Carbonado to transport coal. In 1887 Northern Pacific completed tracks over the Cascades at Stampede Pass. The main line went through Orting and down the Puyallup Valley into Tacoma.

Figure 3.3 – Tacoma and the Puyallup Estuary

The early development of electric power in the Pacific Northwest surpassed nearly all other areas of the U.S. through the 1930s, due to the abundance of cheap, available hydroelectric power. Private electric light companies began forming in the 1880s. By 1889, Tacoma had an electric railway system and a branch railway to Steilacoom. Tacoma City Light was founded in 1893.

In 1891, an epidemic of plant lice ravaged extensive stretches of hop fields ending the phenomenal prosperity of the region's farmers. It may be that the monoculture in the valley, which had been brought about by the boom of a cash crop and the desire to profit from it, contributed to the ultimate demise of the crop by providing a concentrated and uninterrupted breeding ground for the destructive lice.

The Panic of 1893 dealt a devastating blow to the region's economy. While the difficulties associated with depression were national in scale, their impacts in this area were perhaps more pronounced than in many other agricultural regions because the economic downturn was preceded by several disasters in the valley towns as well as by the fall of the hops industry. In 1890, there was a large fire in the business district of Puyallup and another fire destroyed the lumber mill in Sumner. The depression resulted in the closing of industries in Orting, McMillin and Puyallup, and was probably the chief reason why Alderton and McMillin never became incorporated communities. All of the transcontinental railroads except the Great Northern declared bankruptcy. The region was just beginning to recover when the Klondike gold strike was announced in 1897.

Soon after the turn of the century, the growth of berries expanded quickly in the valley. Because there were several different kinds of berries, the agricultural pattern was considerably more diverse than before. The poultry industry grew rapidly during the early years of the 20^{th} Century and its expansion was encouraged.

3.2 EARLY 1900: A PERIOD OF RAPID GROWTH

The first hydroelectric plant on the Puyallup River was constructed at Electron in 1904. Tacoma's deep water harbor attracted shipping and water-oriented industry. The Municipal Street Railway serving the docks and shops in the port area was acquired by the City of Tacoma in 1914. The Port District of Tacoma was formed in 1918.

During the 1920s the bulb industry in the Puyallup Valley became established. The U.S. Department of Agriculture had been experimenting with bulb culture in Western Washington for a number of years and was particularly interested in finding a suitable crop for the Puyallup Valley to fill the void that had been left by the demise of the hops industry.

In 1930, Puyallup and Sumner were connected by road with building of the bridge spanning the Puyallup River. River Road from Puyallup to Tacoma was constructed about 1933. In the 1930s the Puyallup Valley was served by four major railroads and was criss-crossed by a network of roads. Marketing agricultural products was easy for the farmers with this transportation system. The Valley was still mainly agricultural with industry centering on food processing and lumber. The industrial base began to shift when in 1939 the Ports were given the power to acquire and develop land for industrial purposes.

From 1940 to 1950 another boom period for Pierce County occurred. The population increased from 182,081 in 1940 to 275,876 in 1950. The boom can mostly be attributed to World War II and military activity at Fort Lewis, McChord Air Force Base, and the Tacoma shipyard.

3.3 RIVER DIVERSION AND CHANNELIZATION

At the time of European settlement of the valleys, main river flow patterns in the Lower Puyallup Waterway were substantially different from current configurations. The White River flowed north through Auburn before intersecting with the Green River. The Stuck River connected the White River to the Puyallup River. White River flood overflows into the Stuck River were common and had created a floodplain seemingly oversized for the Stuck River's regular flow levels. Log jams, mud slides and floods caused the contributions of the White to the Stuck to fluctuate over the years following the earliest settlement.

It was not long before residents in both valleys became aware of the White River's vacillations and took advantage of the opportunities to redirect the flood waters of the White River. The *Twenty-Years War* began in 1887 when a group of White River farmers from north of Auburn got some dynamite and blew a hole in the west side of the river, diverting it down the Stuck

River and into the Puyallup River. The following year, a group of Puyallup Valley farmers used explosives to reroute the White River back through Auburn. The channel shifted back and forth several times between 1887 and 1899 with the level of explosive power increasing with each attack. (Spiedel, 1981)

The Army Corps of Engineers found it necessary to intervene and develop a resolution to the flooding problems when in November 1906 a flood lodged a massive log jam into the main stem of the White River and effectively sealed off its northerly flow into the Green River. Aware of the hostilities between the White and Stuck River valley residents, the Army Corps of Engineers decided that mediation was needed in order for an agreement to be reached. In 1907, the Corps proposed a solution: route the White River through the Stuck River valley permanently and take advantage of the much shorter 20 mile path to Puget Sound through the Stuck and Puyallup Valleys. Also, the engineers recommended that 3 ½ miles be cut from the meandering Puyallup River and that it be enlarged and channelized to handle the increased flow levels. In return, it was agreed that King County would provide the majority of project funding. (Spiedel, 1981)

The Inter-County River Improvement District was formed in 1914 and the Puyallup River channelization/White River diversion project was completed in 1919 (see Figure 3.4).

Development of the Port of Tacoma began in 1905 with the creation of the Thea Foss Waterway (formerly City Waterway). The waterway was 500 feet wide and 29 feet deep. Port of Tacoma development continued with the creation of Hylebos Waterway which is 3.1 miles long and 30 feet deep. The initial project was completed in 1931.

In 1909, the Puget Sound Power and Light Company posted notices of water appropriation for the White River. This preceded the diversion at Buckley of the majority of the flow of the White River into the Lake Tapps basin for power generation. Diversion began in 1911 and the work was completed in 1912. Roughly two-thirds of the annual flow of the White River was diverted from a 21-mile section of the river known as the bypass reach. This reach includes the portion of the river that runs through the Muckleshoot Indian Reservation. During periods of low flow (defined as flows less than 1800 cubic feet per second (cfs), the diversion took virtually all of the flow except for 30 cfs between the years 1907 – 1986. A court order increased the minimum flow to 130 cfs in 1987 (King County Public Works Department, 1988).

In 1933, the Puyallup River experienced a flood which exceeded current estimates of a 100-year event flows. This spurred the US Congress to pass the 1937 Flood Control Act. The Act provided funding and authorization for the channelization and diking of the first three river miles of the Puyallup River as well as the construction of the Mud Mountain dam. (Pierce County River Improvement, 1991)

The Mud Mountain Dam was constructed by the Corps of Engineers solely for the purpose of providing flood control for the Puyallup River. Construction began in August 1939. The earthfill-rockfill dam forms a plug 425 feet above the river bedrock and creates and approximately 1200-acre lake behind the dam that is roughly 5.5 miles long when full. Work on the dam was halted in 1942 due to the war but resumed in 1947 and completed in 1948. (Wetzel, 1990)

Paving Bank Slope with Concrete

Finished Bank Slope at Sumner, Type No. 4

Figure 3.4 – Levee construction along White River (a) near Countyline and (b) finished bank in Sumner

Construction of dikes and the channelization of the first three river miles of the Puyallup River began in 1946. The Blair Waterway was completed in 1965, extending the deep water of Commencement Bay into the Port of Tacoma. Most of the diking, channelization and diversion structures installed remain in place today.

3.4 HABITAT DEGRADATION AND FISH POPULATION DECLINE

The Puyallup River basin has been substantially altered from its historic condition. In particular, the lower river bears little resemblance to its historic past condition. Extensive urban growth, heavy industry, a large modern marine port, an extended revetment and levee system and agriculture have combined to significantly alter the natural landscape. (Kerwin 1999). Kerwin also provided a chronology of Events (see Table 3.2)

3.4.1 Summary of Fish Population Information Excerpted from Kerwin (1999)

Since 1967, run sizes of fall Chinook, coho, pink, chum, and winter steelhead have been highly variable. Escapement trends for fall Chinook and chum have trended upwards while coho have decreased significantly. Winter steelhead run sizes decreased throughout the 1980s and have not recovered since that time (SASSI 1994). The White River spring Chinook population has been in a rebuilding process for much of this period with run sizes increasing from historic low levels in the 1970s (Muckleshoot Indian Tribe 1996). Figure 3.5 shows the Chinook returns to the Buckley fish trap from 1941-2008. More detail on fish populations is provided in Chapter 7.

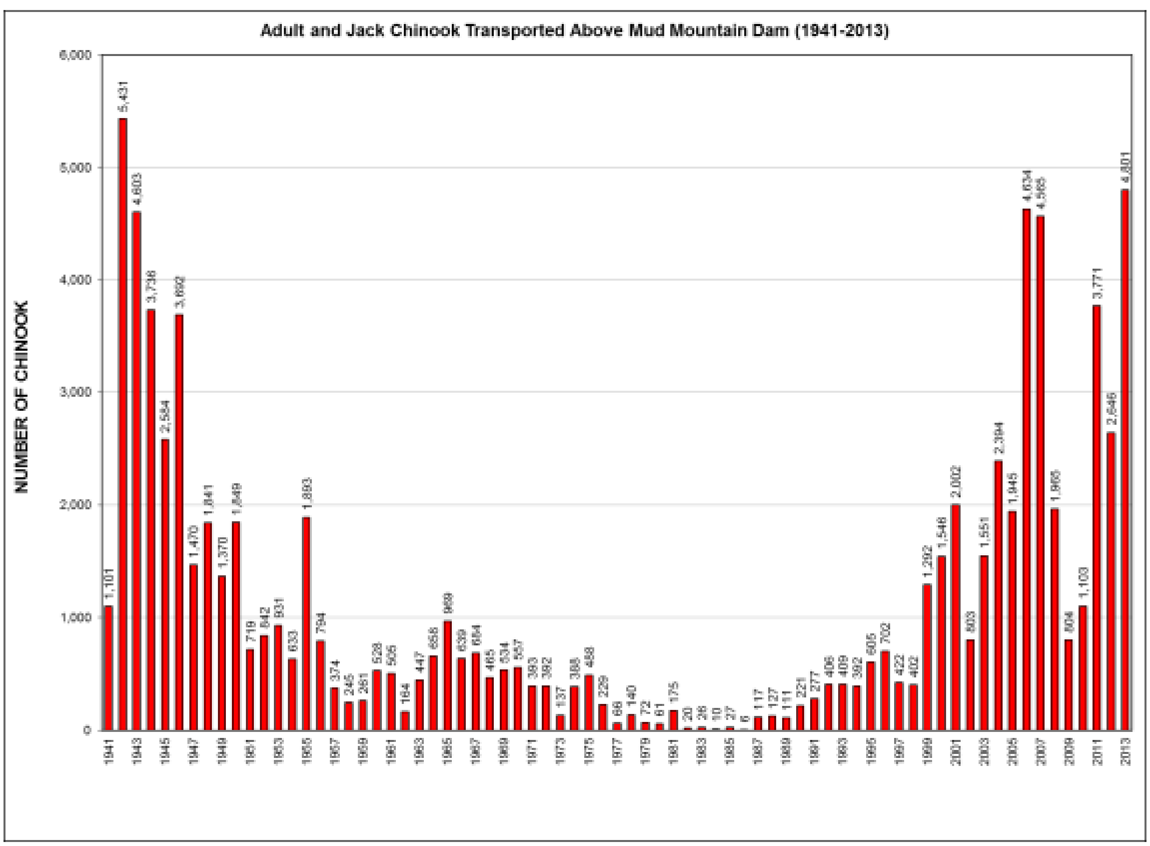


Figure 3.5 – Historical Chinook returns to the Buckley fish trap transported above MMD.

Table 3.2: Puyallup River Basin Chronology of Events (Kerwin 1999)

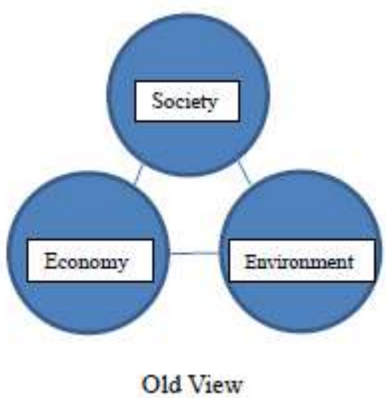
Date	Event	Impact(s)
1792	First European description of the Puyallup River mouth	Initial description of attributes of Commencement Bay as a possible port
1850	Donation Land Claim Law	Encouraged settlement of Oregon and Wash.
1851	Initial European settlers arrive in vicinity of Tacoma	Land clearing and farming begins
1852	Pierce County organized	First citizen based government formed
1852	First commercial lumber mill constructed	Timber harvest begins.
1853	First railroad surveys conducted	First mapping attempts of historical habitat
1854	Medicine Creek Treaty signed	Large tracts of land are given up by the Puyallup Tribe
1858	Laws permitting draining passed	Wetlands drainage begins.
	Coal discovered in upper Carbon River subbasin	Mining was initiated in 1873.
1870	Irrigation of agricultural lands begins	Water withdrawals from surface waters
1873	First railroad into Puyallup R. valley	Allows easy access into and out of Tacoma and Puyallup River valley
1874	Initial railroad construction across Commencement Bay tidal marshes	First filling of tidal marshes and tideflats in Commencement Bay
1883	First report of RR bridge across White River	Railroad is constructed east/west in the then White/Green river valley
1890's	Tacoma Land Co. began dredging of western channel of Puyallup River	Significant loss of estuarine environment and function in Commencement Bay
1899	Mt. Rainier National Park established	Headwaters of Puyallup and White rivers preserved.
1903	Electron Power Project construction started.	26 miles of spawning and rearing habitat lost and 10 miles of mainstem river habitat impacted due to reduced flows.
1906	Flood event (probably a 10 year flood event)	Log jam on White R. diverts White into Stuck River and Puyallup River basin

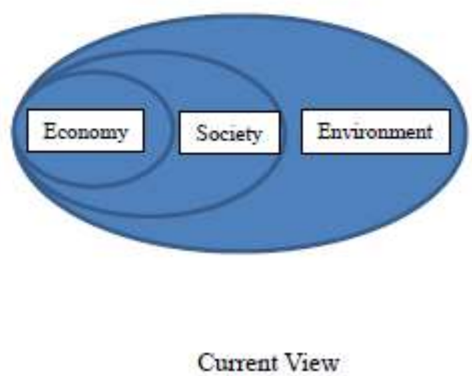
1907	Washington State Legislature grants county governments authority to do flood protection work	Pierce County River Improvement District (PCRI) formed and channelization efforts begin between White River and Puyallup River mouth.
1908	Channel realignment, bank stabilization and diking projects started in Puyallup, Carbon and White rivers	Instream habitat losses associated with each project.
1911	Debris barrier constructed in White R. upstream of the 1906 diversion	Removed LWD from portions of the White and lower Puyallup Rivers
1913	State Legislation passed permitting Inter-County River Improvement District to be formed (1914)	Pierce and King counties work together to perform flood control projects
1914	Concrete Diversion constructed at Auburn permanently diverting White River into Stuck River	Increased Puyallup River flows by approximately 50% at confluence with Stuck River.
1917	Puyallup River Relocation Project complete	Channel relocation, diking alterations to salt/freshwater mixing, erosion and changes to the estuarine environment. 1,800 acres of tidal marsh lost.
1930's	Work on St. Paul, Wapato (Blair) and Hylebos waterways	Estimated 570 acres of mudflats and 121 acres of salt marsh were filled in.
1939	Mud Mountain Dam construction begins	Barrier to anadromous fish migration.
1946	Army Corps of Engineers' channelization and diking projects	Lower three (3) river miles of Puyallup River diked
1940's – 70's	Major logging activities in the upper watersheds	Logging road construction and impacts to riparian buffers and habitat
By 1970's	Major channelization projects completed.	45 miles of the three rivers had been channelized (14.7 miles of dikes with concrete armoring, 57.3 miles of dikes and river banks with rock riprap.
1974	County gravel removal projects started	Rivers maintained by lowering of riverbed instead of raising heights of dikes.
1988	Puyallup Land Claims Settlement	Major property ownership issues settled.
1999	Puget Sound Chinook Listed as Threatened under the Endangered Species Act	

CHAPTER FOUR
SOCIO-ECONOMIC, CULTURAL AND LAND USE CONDITIONS

The economy is the lifeblood of our watershed providing goods, services, and jobs for area residents. However, the economy is intertwined with cultural, environmental and social/cultural aspects. Figure 4.1 shows the old and current view of this intersection. In a sustainable economy, careful measurement of resources preserves and protects them for future generations. This definition emerged from concern that we often rely too heavily on economic measures of performance that do not reflect the complete spectrum of social and environmental well-being. While we provide an overview of the traditional economic measures, this chapter will mainly focus on examining sustainable community indicators in order to assess our watershed's progress towards long-term health and vitality. Sustainable community indicators are measurements that provide information about past and current trends and assist planners and community leaders in making decisions that affect future outcomes. While currently, many of these indicators and measurements are not being tracked, we will identify those that will be most useful for purposes of assessing watershed health. In the future, we will strive to produce, monitor and update them.

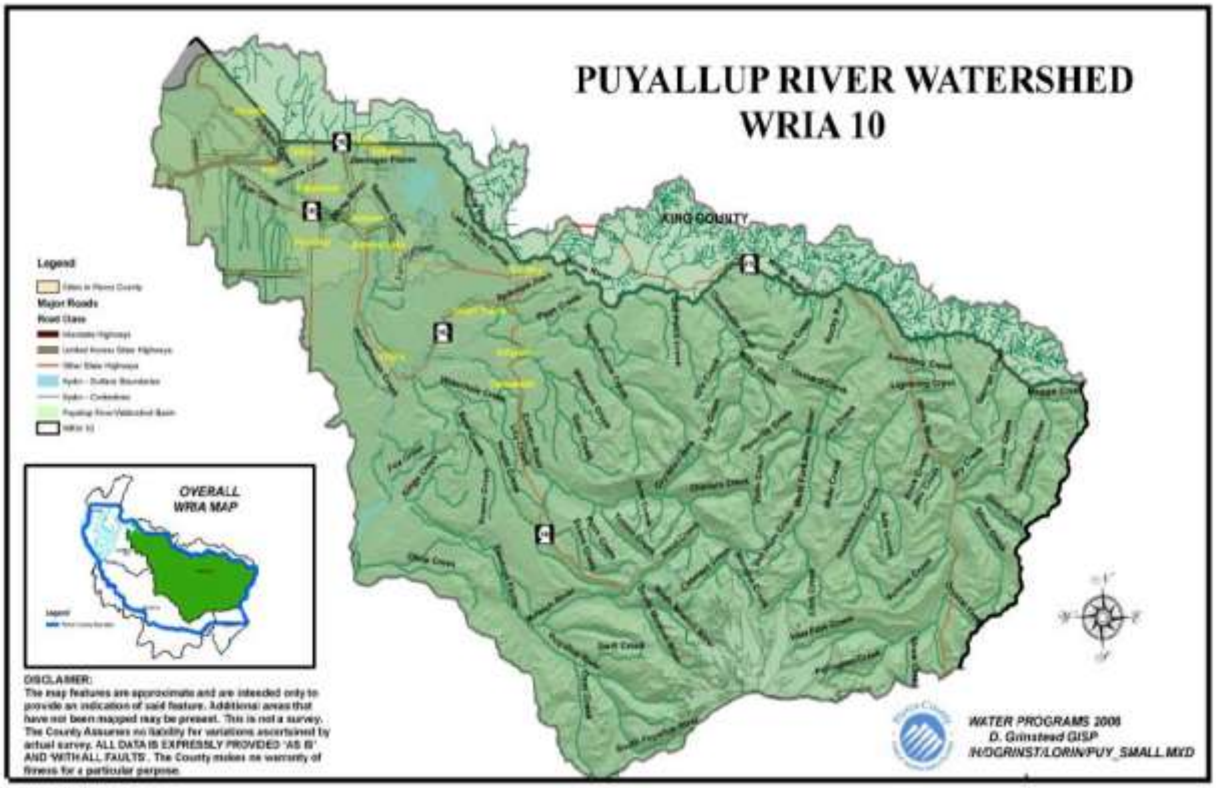
Figure 4.1 – Old and Current View of Sustainability





One significant challenge in understanding socioeconomic conditions within a watershed is that comprehensive data by watershed is not commonly collected or easily compiled. Where there is no precise data within the Puyallup River Watershed, information on population trends, land use patterns, and economic factors within Pierce County will be used to provide insights for the entire watershed. See Figure 4.2 in order to understand the magnitude of error using this approximation. The insert highlights the Puyallup River Watershed in green as compared to the entire Pierce County boundary outlined in blue.

Figure 4.2 Pierce County vs Puyallup River Watershed Boundary



4.1 TRADITIONAL ECONOMIC OVERVIEW

(Pierce County) ***(source: Paul Turek, 'The Pierce County Economy' April 2013)***

4.1.1 Local Economy – Historical

The founding of Pierce County in 1872 encouraged a slow but steady stream of new settlements in the Puyallup Watershed. Family farming was essential to the survival of early pioneers. Commercial farming evolved over time as the county's population grew and the economy diversified. Over time, agricultural production has included hops, flower bulbs, berries, dairy cattle, and Christmas trees.

In 1859, Samuel Wilkeson, Secretary of the Northern Pacific Railroad visited the area and his namesake, the Town of Wilkeson, became the first center of local coal mining which later extended into other localities such as Fairfax and Carbonado and became known as the Puyallup River Coal Field. Containing the largest known resource of coking coal in the Pacific states, the Puyallup River Coal Field fueled the growth of the Northern Pacific Railroad and the City of Tacoma.

Tacoma began as a project started by developer/entrepreneur Morton McCarver shortly after his arrival to the area in 1868. McCarver, who had purchased claims to the area, purchased more surrounding land, and then started a campaign to attract settlers and the Northern Pacific Railroad. In 1873, the Northern Pacific Railroad chose Commencement Bay for its western terminus. The transcontinental link came through in 1887, and statehood arrived for Washington in 1889. The area's fast-growing lumber industry, dominated by the St. Paul and Tacoma Lumber Company, helped spur what was called the greatest boom in Tacoma's history. In 1917, World War I brought about another industrial boom as the region's lumber fed shipyards on the tide flats and new residents moved in.

The Port of Tacoma was created in 1918, facilitating the development of some 240 acres of tide flats into a municipally owned system of dredged waterways, storage sheds, warehoused, a cold storage facility, and modern piers. The port became an important link to Alaska and Asia in the 1970s during the construction of the Trans Alaska Pipeline and with the shift to containerization. The tide flats offered the space needed to construct buildings that would be shipped to the pipeline and oil fields. Container terminals required real estate to store and move the big boxes, and Tacoma had the capacity to take advantage of the new technology. Today, the Port encompasses about 2,400 acres of land on the Tacoma Tideflats.

The Puyallup Fair began in 1900 with the intent of publicizing and celebrating the Puyallup Valley's agricultural, dairy, stock-raising, mining, and manufacturing industries. The fair quickly built a steadily increasing following, flourishing even during the Great Depression of the 1930s. Until 2006, the fair was officially known as the "Western Washington Fair." Starting in 2013, the fair was renamed the "Washington State Fair." Attendance over the years has grown significantly to over one million people annually. It continually ranks in the top ten largest fairs in the country.

The Puyallup Tribe owned Emerald Queen Casino opened in 1997 on an authentic paddlewheel riverboat, the *Emerald Queen*, which was berthed on tribal land in the Port of Tacoma. The casino operation was relocated to a Tacoma location in 2001. An additional casino was added in Fife which underwent a major expansion in 2007. The Emerald Queen Casino is now one of the largest in the state and is a major local employer.

4.1.2 Key Industries

The Puyallup Watershed economy today continues to maintain its own individual economic identity based upon traditional strengths as well as a regional component of the Puget Sound economy. The area possesses several advantages that have supported its past economic development, and which should contribute to its growth in the near future. Among these advantages are:

- An excellent job-training and educational infrastructure, including colleges and vocational technology institutions;
- A prime Puget Sound location on the I-5 corridor that connects it with counties up and down the Puget Sound;

- Close proximity to Sea-Tac Airport, the region's major international airport;
- A highly developed railway and trucking web; and
- An excellent deep-water port with growing trade volume supporting truck and rail distribution, and significant backup land including the Fredrickson Industrial Area.

Its proximity to King County has given watershed residents more opportunities to access the labor market in both King and Pierce counties. While the Joint Base Lewis McCord is located outside the Puyallup River Watershed it still influences our watershed economically. The base functions as a purchasing agent of locally produced goods and services. Military personnel serve to bolster local housing demand throughout the watershed and the continual need to upgrade facilities at the base offer contract work for the construction industry.

The economy over time has transitioned out of the manufacturing and resource-based economy and more toward a services oriented economy. Population growth and an aging demographic cohort have placed a greater premium on healthcare and retail services in addition to supporting the demand for housing units. Although manufacturing industries represent a smaller proportion of the economy as gains from trade have increased, the presence of manufacturing is still critical to economies where the basis for comparative advantage exits. Key industries are a mix of the traditional and the contemporary and are listed as:

1. *Government Services*: Tribal owned casino establishments were reclassified under the North American Industry Classification System as being part of local government. Technically the casinos provide entertainment, and accommodation and food services, but the casino employees are counted in the government services category. The Emerald Queen Casino is one of the largest local employers with approximately 2,200 employees.
2. *Construction*. Local area construction activity gets a large boost from the neighboring military base on an annual basis. Additionally, King County with it higher land values and housing costs, has given its workers a financial incentive to live in Pierce County and beyond. This has increased the demand for housing and residential construction, and has helped hasten the development of communities like South Hill and Bonney Lake in the watershed. The continued development of both King and Pierce Counties has created a strong construction industry locally. Employment in this industry accounted for over 6 percent of all non-farm employment in Pierce County in 2011, compared to 4.9 percent across the state and 4.2 percent in King County.
3. *Transportation and logistics*: Much of this industry category flows from the Port of Tacoma and the expanding role it has assumed in the global economy. The Port's primary identity relates to its marine cargo support role but the trade activity of the Port also necessitates the use of rail and truck transportation to move cargo to and from the Port, as well as the need for warehousing and storage facilities. The Port is a major center for bulk, project and heavy-lift cargoes, as well as automobiles and medium-duty trucks. In 2011, the Port handled 1.5 million containers, contributing to nearly $35

billion in international trade and an estimated $3 billion in trade to Alaska. A new report from the port shows container traffic up nearly 16 percent in 2012 over 2011 to 1.711 million container units. That container volume was pumped up by the recent move of the Grand Alliance container shipping combine to the port from Seattle. Four container shipping lines, NYK. Hapag Lloyd, OOCL and Zim, share shipping capacity in service from Asia to the West Coast. Two other associated shipping services also moved to Tacoma along with the Grand Alliance.

4. *Health care and Social Assistance:* Pierce County serves as a regional provider of health care for the South Puget Sound. MultiCare Health System, which absorbed Good Samaritan Hospital in 2006, and Franciscan Health System are the largest providers of health care across the county. Both have been consolidating recently and have been reducing their payrolls, but still rank within the top five in terms of the number of people each employed. Davita, another significant area employer is the nation's second-largest kidney care company. Its business headquarters are located in downtown Tacoma, but has recently announced intentions to move a portion of their workers to Federal Way in King County.
5. *Retail Trade*: The number of retail establishments tends to track closely with population growth and movement. The watershed has one major mall located at South Hill in Puyallup. Other establishments have proliferated outward, as outside malls, or ‘strip’ malls as they are known, have followed the population growth.

4.1.3 Employment by Industry

Employment statistics for Pierce County are generated by state government in cooperation and coordination with the federal Bureau of Labor Statistics (BLS). Pierce County is classified by the BLS as a metropolitan area and is generally referred to as the Tacoma, WA Metropolitan Division. Pierce County employers provided 266,300 non-farm jobs on average in 2011, making the division the state’s second largest labor market behind King County. Since 1990, average annual non-farm employment for the division has grown an average of 1.5 percent annually, exceeding both the state and national averages during this time.

Average annual non-farm employment peaked in 2007 at 281,300 before the “Great Recession” settled into the area. The local area continued to shed jobs each year thereafter on average until 2011, when average employment rose gradually. Due to the nature of the recession and the associated housing and financial services near-collapse, employment in construction was hit quite hard. Construction employment was still down by 9,300 jobs in 2011 on average from its peak. Financial services in Pierce County employed 1,300 fewer people in 2011, although 900 or so of these jobs left with Russell Investments when they departed to King County.

Manufacturing jobs were also affected by the downturn in the economy. The average number of jobs in this category was 4,100 less than in 2007. Health care service employment, which is generally considered to be acyclical, or less affected by downturns in business cycles, continued to add jobs since 2007, and provided most of the 3,500 jobs added to the Educational and Health Services industry category.

Table 4.1 - Composition of Pierce County non-farm economy in terms of non-farm employment

Industry Sector	% of all non-farm employment 2011	% Annual Employment Growth/Decline since 1990
Public Sector (government)		
Federal (includes military bases)	5	
Local (includes casino)	17	
Total	**22**	
Private Sector Industries		
Goods producing		
Construction	7.9	+ 1.8
Manufacturing industries	7.9	- 0.6
Services producing		
Retail	15.2	+ 1.2
Transportation & Warehousing	5.4	+ 2.6
Professional & Business Services	11.3	+2.4
Healthcare Services	12	+3.0
Total	**78**	

The civilian labor force in Pierce County vs. Unemployment Rate is shown in Table 4.2.

Table 4.2 - Civilian labor force vs. Unemployment Rate 2010-2013

	2010	2011	2012	2013 (Feb)
Unemployment rate %	10.2	9.8	8.8	9.7
Civilian labor force	392,440	386,660	385,470	386,510

4.1.4 Economic Outlook

Economic conditions impacting the State of Washington and Pierce County should continue to display moderate improvement. The state and local labor markets have improved as higher levels of non-farm job growth have occurred from 2010 to 2012 on an average annual basis. On a monthly basis over-the-year employment gains have been registered for the last 20 consecutive months.

On balance, the Pierce County economy is likely to gradually move forward in 2013. The housing market situation has begun to trend upward as the area has seen the decline in housing prices abate and even begin to rise. The outlook for residential construction has brightened a bit even though there still appears to be an ample number of foreclosures left in the pipeline. Homebuilders should be better positioned or a more normal recovery.

The Port of Tacoma should continue to see a trade volume increase in 2013. China and South Korea, two of the port's principal trade partners, are experiencing strong economic growth and could provide better markets for the U.S. and local regional exports. The port also has recently moved to diversify its operations and has moved more aggressively into transporting, storing and distributing oil produced near the Great Plains.

Local spending on the part of consumers and businesses is likely to remain subdued. Businesses still appear to be on the cautious side when it comes to investment and expansion decisions. Consumer spending should get a boost from the improving job market, however. The state and local area both appeared to have added more jobs in 2012 than in 2011 despite a weaker fourth quarter in both labor markets and in national economic growth. State and local claims data still point to an improving job market, and if no significantly negative effects from national fiscal policy tightening occur, this should have the effect of reducing the area's unemployment rate to the same degree that occurred over 2012.

Government spending and employment will continue to lag and most likely decline at the local and state levels, as federal revenues to the states have tightened considerably, and tax revenue streams from sales and property taxes continue to be restrained.

4.1.5 Population and Demographic Trends

Population trends are useful for interpreting other changes in the watershed such as development. Demographic trends involve not only whether a population is increasing or decreasing, but also how a population is changing, such as whether it is growing older or younger as a result of the increase or decrease of older residents, younger residents, and households with children.

The Puyallup watershed covers over 1,000 square miles and has a total population estimated at over 375,000, making it the third most populous watershed in Washington. The watershed's population in incorporated areas is most concentrated in Tacoma, Fife, Puyallup, Sumner, Auburn, and Bonney Lake. The population grew by over 10 percent from 2000 to 2010. Annual population change is the sum of natural increase (the number of births minus the number of deaths) in a year, and net migration (the number of people that move into a region minus the number of people that leave a region). The area has proportionately more young people (below the age of 18) and fewer older residents (65 and older) than the state.

4.2 SUSTAINABLE COMMUNITY INDICATORS

The most widely accepted definition of ‘sustainable development’ is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The purpose of this section is to identify indicators for assessing socioeconomic attributes of our watershed. By monitoring these we can make an assessment as to whether it is growing in a sustainable fashion. Community indicators are bits of information that, when combined, generate a picture and provide insight into the overall direction of community sustainability: whether it is improving, declining, or staying the same, or a mix of all three.

After reviewing numerous studies, we decided to focus on five key socioeconomic conditions of watersheds and suggest indicators for each of these conditions, and metrics for measuring indicators. The five conditions chosen are:

- Watershed character
- Public health
- Income and impoverishment
- Economic vitality
- Capacity to address watershed conditions and stressors

4.2.1 Watershed Character

Watershed stakeholders identify the rural and agricultural nature, the remarkable scenic and recreational opportunities and the historical and cultural character as important watershed conditions that they want to be maintained. The extent, density, and location of residential development were identified as potential stressors on these conditions. Table 4.3 shows indicators and measures that can be used to assess watershed character in the Puyallup River Watershed.

Table 4.3 – Indicators and measurements of watershed character

Indicators	Measures
Land use	Acres of publicly owned land Acres of forest lands Acres of land enrolled in agricultural preserves Acres of land covered by conservation easements Percent of buildings in floodplains Residential housing densities Number of subdivisions/new parcels created Number of building permits issued Commuter miles, vehicle miles travelled
Unique characteristics	Total number of historic and cultural (including tribal) given for federal, state, or local designation Biodiversity areas protected

Why Is This Important?

Permitted land uses within the Puyallup River Watershed are enacted through city or county zoning ordinances. These land use regulations create areas where the type, location, density and lot coverage are restricted. Land use zoning (potential land use) helps determine where future growth and development will occur and which rural areas are protected for farming and forestry. Open space lands and biodiversity management areas also help manage our natural resources through habitat conservation and endangered plant and wildlife protection.

The Puyallup River Watershed is rich in unique historic and cultural resources and local residents have a keen interest to see these protected. These can include historic buildings, landmarks, and Native American historic sites whose ancestors lived in or utilized resources from the watershed.

Local governments' land use decisions have far reaching impacts on long-term sustainability. The Puyallup River Watershed is quite varied from the industrial Port of Tacoma area to Rainier National Park, and from forest land to agricultural and suburban. Although largely suburban in its existing land use, future choices about the locations of new housing, businesses, schools, and parks can influence everything from how much residents drive to how healthy their diet is. With many towns and cities in the watershed fully built-out, the focus on future development should largely be on designing more sustainable in-fill projects that bring residents and businesses into already developed areas rather than increasing sprawl. Continued pressure will be exerted to convert private forest and agricultural lands to new subdivisions.

Motor vehicles are one of the largest sources of pollution in the Puyallup River Watershed, impacting air and water quality and public health. On-road transportation accounts for almost half of the total greenhouse gas emissions . Vehicle Miles of Travel (VMT) is the total number of miles driven by all vehicles in a given time period and geographical area. Traffic congestion lengthens commute times, reduces worker productivity, and causes increased air pollution for nearby residents. Moving away from single-occupancy vehicle travel towards alternatives such as public transit, carpooling, walking, and biking can improve regional air quality, neighborhood vitality, and public health.

What Is a Sustainable State?

In a sustainable state, land use policies accommodate growth, protect public health, open space and agriculture, support local businesses, and direct development to areas that provide easy access to services, jobs, and transit. Use of conservation easements and transfer of development rights in addition to transit-oriented development (TOD) are strategies to accommodate future growth. TOD aims to create compact, walkable communities with close proximity to public transit. These communities are mixed-use with both commercial and residential buildings in the same area. TOD can reduce car-dependency, traffic congestion, and air pollution. In a sustainable state, vehicle miles of travel and fuel consumption decline over time as more residents work closer to home, take public transit, carpool, walk, and bike.

4.2.2 Public Health

Many cities and counties around the country are adding a "health component" to their General Plans. A health component links land use decisions to the health impacts on residents by guiding the location and development of parks, schools, groceries, and other businesses. Health components can include community health, access to healthy foods, active living and recreational opportunities, children's health and safety. See Table 4.4 for those indicators we will use in our assessment.

Why is this Important?

Water quality, availability of drinking water, and tracking of air quality are public health conditions that rank high in public awareness and concern. Communities need an adequate supply of water to meet their residential and economic needs. Our watershed relies predominantly on the Green River (City of Tacoma Water) and municipal water supplies from springs, groundwater, and surface water diversions for its water supply. While this supply is not expected to increase over time, the watershed's population and economy are projected to grow. Increased conservation of local water resources will be essential for meeting future demand.

Table 4.4 – Indicators and measures of public health

Indicators	Measures
Water availability for human consumption	• Number of water shortages per year (building moratoriums, mandatory conservation)
Water quality	• Number of fishing and/or swimming advisories placed on local waterways per year by the Dept of Health
Air quality	• Number of days the region violates the particulate matter 2.5 standard for air quality as set by the EPA
Availability of active recreational opportunities	• Number of miles of trails • Percentage of residents living within a half mile of a park or recreational area
Access to healthy foods & fresh produce	• Number of community gardens • Number of farms or farmers markets where fresh products are sold

Parks and open space lands strengthen communities by providing a place for people to gather, enjoy outdoor exercise, and increase their connection to and understanding of the natural world. As an added benefit, parks and open space lands also help manage our natural resources through habitat restoration and endangered plant and wildlife protection.

Urban trails systems can reduce vehicle miles traveled within a city and improve health and activity of a community. Urban trails can include sidewalks, bike paths, or traditional trails through parks and open space. An urban trails system coordinates these different elements to allow residents better non-motorized mobility.

Farmers' Markets and community gardens are ways to give communities direct access to healthy and locally produced fresh foods. Farmer's Markets are an important way for farmers to sell their food directly to consumers. Farmers' Markets have grown across the United States from 1,755 in 1994 to an estimated 5,274 in 2009. Currently, there are 14 farms and 7 Farmers' Markets in the Puyallup River Watershed (see pugetsoundfresh.org) where fresh foods are available for purchase. A community garden is defined as any piece of land gardened by a group of people. These gardens can be urban or rural and located on public or private land. Currently there are 25+ gardens within the Puyallup River Watershed (see piercecountycd.org/community gardens).

Community Supported Agriculture programs (CSAs) are a relatively new way to distribute food directly to local consumers. Farmers offer shares, which are usually a box of produce, but can often contain other items from the farm such as eggs, meat or honey. Customers purchase a membership and establish a schedule to receive their box of food. The system benefits farmers as they have guaranteed income and local, direct distribution, and consumers enjoy the taste and health benefits of fresh, seasonal, local food. Across the United States, the number of CSAs has increased from 60 in 1990 to more than 3,500 in 2010. Currently there is one CSA in the Puyallup River Watershed.

What is a Sustainable State?

- In a sustainable state, water supply and demand are in balance, and there is adequate infrastructure and storage to reduce the risk of shortages.
- In a sustainable state, water and air quality is of consistent quality with no adverse impacts to human health
- In a sustainable state, agriculture is economically viable for both owners and laborers, and agricultural practices conserve natural resources, maintain fertile soils, and provide healthy food for local communities
- In a sustainable state, parks and open space are abundant, of good quality, and readily accessible to all residents.

4.2.3 Income and Impoverishment

Table 4.5 – Indicators and measures of income and impoverishment

Indicators	Measures
Income	• Median household income
Impoverishment	• Percent of labor force unemployed • Percent of population with income below poverty level • Percent of students enrolled in free and reduced lunch program • Percent of households receiving public assistance

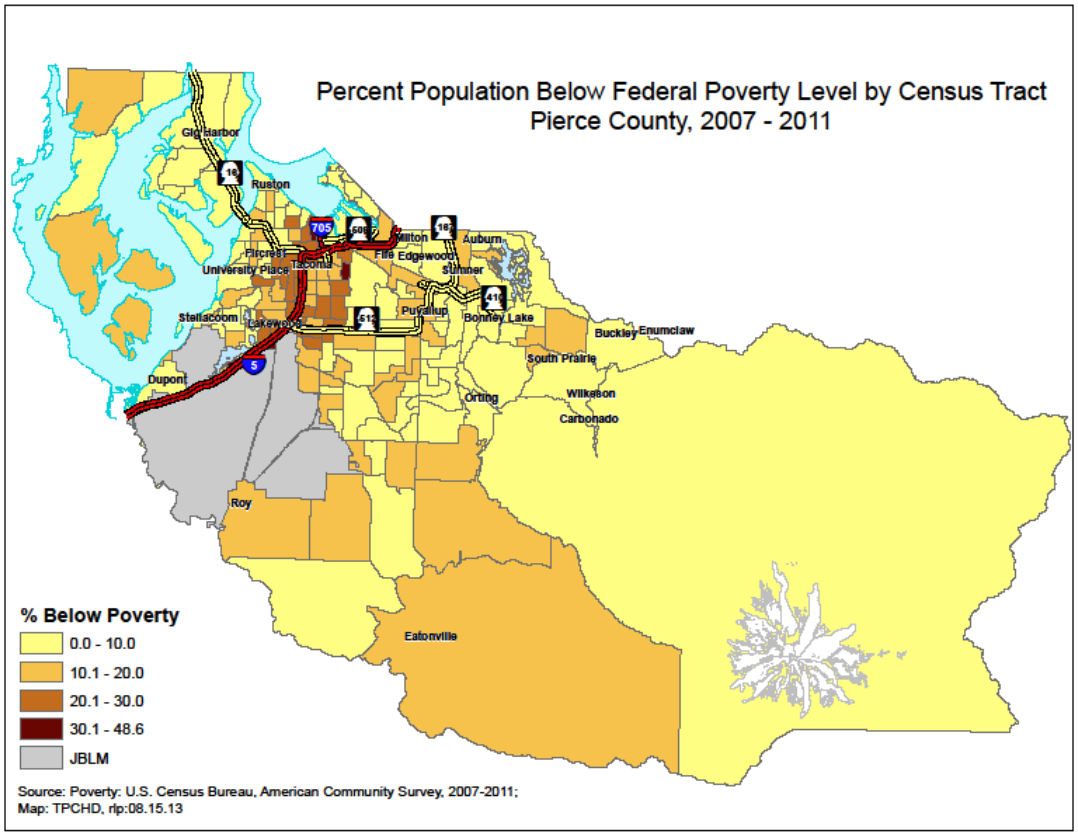
Why Is This Important?

Income distribution, or income inequality, refers to the extent to which income is spread unevenly across the members of a population. Economists use the Gini coefficient to measure the distribution of income across a population. A value of zero reflects total income equality (each person earns the same) and a value of one signals absolute inequality (one person has all the income). While there is no optimal level of income inequality, research suggests that high values can cause social tensions and lead to reduced economic growth in the future, while complete equality would impede entrepreneurship and economic mobility. A widening gap in the income distribution is associated with other forms of exclusion such as lack of quality education and health care and may even be associated with reduced economic growth potential.

Unemployment and the resulting economic insecurity can affect the health of the watershed. Residents who have little income are less likely to pursue involvement in watershed restoration or other conservation practices since they perceive that there is some sort of cost (in time or money) for participation. Repairing leaking septic tanks, for example, requires financial resources that may be beyond the means of residents who are unemployed.

What Is a Sustainable State?

In a sustainable state income inequality is low and not impeding upward mobility and further economic growth.



4.2.4 Economic Vitality

Table 4.6 – Indicators and measures of economic vitality

Indicators	Measures
Personal income sources	• Proportion of personal income from salaries and wages vs. transfer receipts
Job Growth & Business Diversity	• Employment growth by Industry
Resource preservation	• Green Certified Buildings • # of jurisdictions that have mandatory green building ordinances • Solid Waste Recycle Trends

<u>Why is this Important?</u>

Typically, an aging population derives a higher proportion of its income from sources other than wage and salary income. A vibrant and diverse economy provides jobs to people, revenues to businesses and cities, and opportunities for cultural amenities that add to the vitality of communities. Job growth expands a community's overall economy. At the same time employment that is spread across many industries reduces the impacts of a recession. A growing economy with high employment rates leads to increased business investment and generates revenues for local and state governments to fund public services. Rising wages raise the standard of living for workers, which can further accelerate economic growth.

What is a Sustainable State?

In a sustainable state, businesses are thriving and employment is not concentrated in just a few industrial sectors but is diverse and strong in areas with likely growth potential now and in the future. Maintaining this position requires continued development of a diversified and high-value economic base coupled with protecting the natural environment and ensuring social diversity. There is concern that as the economy recovers there will once again be an increased demand for energy, water, and other natural resources. In a sustainable state, buildings are resource efficient, produce minimal waste, have healthy indoor environments, and are sited to minimize their impacts on the environment.

In a sustainable state, waste prevention and diversion help to conserve natural resources, and solid waste disposal rates continue to decline over time. Greening the economy by aligning economic recovery with environmental health is, therefore, vitally important. Innovative planning and investments in energy efficiency, transit-oriented development, and green building design can help create jobs, reduce greenhouse gas emissions, revitalize neighborhoods, produce needed housing, and improve air quality.

In the United States, buildings are responsible for an estimated 68 percent of electricity consumption and 33 percent of carbon dioxide (CO_2) emissions. Green building practices minimize environmental and health impacts throughout the building's entire life cycle. Green buildings create less solid waste in the construction phase, and once built, provide healthier indoor air quality. By using less energy and water than traditional buildings, they also save on operating costs. A green building ordinance amends a jurisdiction's municipal code to require that new construction as well as major renovations meet certain minimum green rating levels.

4.2.5 Capacity to address watershed conditions and stressors

Table 4.7 Indicators and measures of capacity to address watershed conditions and stressors

Indicator	Definition
Financial capital	Dollars available and allocated to watershed issues
Physical capital	The condition of the built environment and how well it contributes to or detracts from watershed health
Human capital	Watershed-related skills, education, experiences, and general abilities (including having both the time and energy) of people who live and work in the watershed.

Organizational capital	The existence of watershed-related organizations, programs, plans, and projects and the extent to which they are being implemented.
Social capital	The ability and willingness of people, agencies, and organizations to work together on watershed goals and projects

Relative to human and social capital, there are numerous groups and organizations that work on environmental issues within the Puyallup River Watershed. For example, within the Puyallup River Watershed Council there are representatives from federal, state, county, city and tribal governments and agencies, non-profit citizen groups, various small community based "friends-of " groups, universities, and businesses all mostly working on water or fish-related issues. With close access to universities and centers of research specializing in environmental sciences, there is a wealth of resident knowledge that continues to attract even more professionals with environmental expertise and students wanting to acquire it. Residents live in this area because they value the outdoor life-style and beautiful surroundings. Many recognize their role as watershed stewards and are more willing to participate as citizens in supporting local environmental projects to preserve their quality of life.

People within these organizations and agencies are willing to work together, but the organizational infrastructure to do this efficiently and effectively has not been developed sufficiently. Opportunities to work in a more organized and coordinated fashion on a watershed level could be improved. Sharing resources, setting watershed-wide goals and reviewing progress require additional organizational infrastructure and personnel.

Additionally in order to make better decisions and understand trade-offs, socio-economic and sustainablity issues must be included in the analysis. This requires adding social scientists and economists that have not typically or historically been working together within these organizations on environmental issues. The Russell Family Foundation's Puyallup Watershed Initiative offers an opportunity to accomplish this.

Because of the historical importance of salmon and water resources to the economic health of our watershed and to the entire Puget Sound area in general, financial capital has generally been available. However, recent economic downturns have decreased both government budgets and charitable contributions directed toward environmental projects. Additionally, difficult projects (higher cost) which might have been bypassed in favor of lower cost ones can no longer be postponed.

4.3 THREATS AND OPPORTUNITIES

4.3.1 Social and Economic Trends and Watershed Health

The population of Pierce County is expected to reach over 980,000 by 2020 which means it will have more than doubled since 1980 (see Table 4.8).

Table 4.8 – Pierce County Population (Source: U.S. Census Bureau QuickFacts)

	1980	2000	2010	2020 (projected)
Total population	485,643	700,820	795,225	982,230

This population growth has and will continue to affect the Puyallup River Watershed. Attracted by the convenient commuting to nearby cities and the beauty of the area, families will continue to locate in the watershed. Development pressure will primarily focus on areas within and surrounding the incorporated cities of Tacoma, Puyallup, Sumner, Edgewood, Auburn and Bonney Lake. There will also be increased development pressure in the outlying rural areas surrounding these communities within the urban growth boundaries.

The growth of the urban and rural population will offer challenges for maintaining and restoring water quality and fish and wildlife habitat within the Puyallup River Watershed. Continued urban and rural development, if poorly planned, can affect floodplains, riparian areas and water quality.

The watershed will continue to struggle economically with sub-par economic growth and unemployment as the economy continues to recover. Local spending by consumers and businesses will likely remain subdued. Government spending will most likely decline at the local and state levels, as federal revenues to the state tighten and tax revenue streams from sales and property taxes continue to be restrained.

4.3.2 Opportunities

The following opportunities have been identified:

- Develop organizational infrastructure to facilitate watershed-wide planning
    - share resources
    - leverage efforts by coordinating programs
    - ensure large important projects get funded and implemented
- Engage social scientists and economists in watershed planning discussions & decisions

- ◦ identify business diversity opportunities that provide good income
- ◦ work with organizations such as Earth Economics to educate local jurisdiction planners and elected officials on the economic value of ecosystems services and how a healthy environment contributes to a healthy economy
- ◦ revitalize neighborhoods, promote transit-oriented development

- Step up efforts to preserve farms and fresh food distribution mechanisms
- Increase efforts to conserve natural resources
  - ◦ promote and incorporate green technologies
  - ◦ investigate conservation programs that offer economic incentive

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CHAPTER FIVE
GEOLOGY, GEOMORPHOLOGY, AND HUMAN LANDSCAPE CHANGES

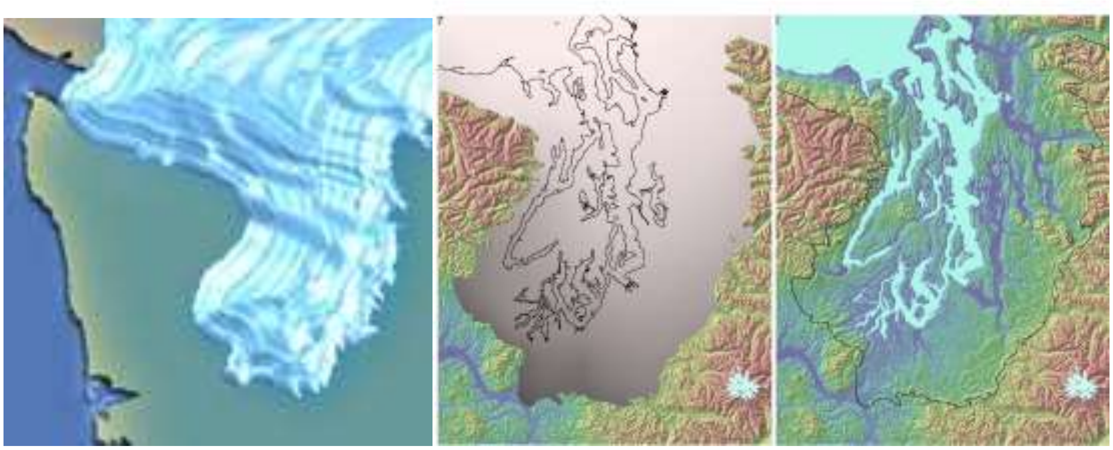
The Puyallup River Watershed lies within two distinct physiographic areas formed by very different geologic mechanisms. The eastern, southern, northern, and upper portion of the watershed lies within the southern Cascade Mountain Range, and is dominated by Mount Rainier. The western and downstream portion of the watershed lies within the Puget Sound Lowland, and constitutes the center of urban and agricultural development. These areas were formed by tectonic, glacial, and volcanic activity.

5.1 GENERAL WATERSHED GEOLOGY

Tectonic plate subduction offshore of western Washington gave rise to the Cascade Mountain range. At the convergence zone between the North American and Juan de Fuca plates, the heavier Juan de Fuca plate plunges deep into the earth's mantle, heating and producing magma that rises to the surface to form the Cascade volcanic mountain range. Volcanic activity in the Cascade Range began roughly 27 million years ago, forming the base upon which the large volcanoes formed. Present day Mt. Rainier, the largest of the Cascade volcanoes, formed between 600,000 to 400,000 years ago.

5.1.1 Glaciation

Pleistocene glaciation played an important role in sculpting the landscape of both the Puget Sound Lowlands and the Cascade Mountain Range. Reaching a maximum extent during the Vashon stage of the Fraser Glaciation approximately 16,000 years ago, an ice sheet advanced southward into present day Puget Sound (Pringle 2008). Multiple advances and retreats of the ice sheet formed the Puget Sound Lowlands, depositing a complex sequence of glacial and inter-glacial sediments. The advancement of the alpine glaciers carved out the characteristic U-shaped valleys that form the upper and middle reaches of the present day White, Puyallup, and Carbon river valleys.



5.1.2 Present Geomorphic Condition

The three primary geomorphic variables that contribute to the overall character of rivers in the Puyallup watershed include: gradient, sediment supply, and hydrology. Mt. Rainier is the driving influence of all three of these variables (Figure 5.2). The height of the mountain (14,411 ft) creates high slopes for much of the watersheds draining the mountain. High rates of both physical and chemical weathering result in an abundant supply of sediment. The rate of sediment supply to rivers is intricately linked to climate, rainfall and runoff. The mountain's height and size creates a physical barrier to advancing weather, forcing higher precipitation amounts and rates compared to adjacent areas. These high precipitation amounts translate into high runoff and river flow. The large volumes of available sediment high on the mountain are mobilized downstream via the rivers and transported into the lower watersheds (Figure 5.2).

Figure 5.2 – Mt. Rainier, and White and Puyallup Rivers (downstream sediment and wood transport)

5.1.3 Climate Change

On Mount Rainier it has been observed that climate change is influencing the geomorphic processes acting on the mountain. These changes include higher annual temperatures, and a greater variability in rainfall. The alpine glaciers are retreating, and at an increasing rate (approximately 10% greater) particularly on the southern side of the mountain (Nylen, 2004). As the glaciers retreat they expose sediments eroded from the mountain by the glaciers. These sediments are typically on very steep slopes and are easily transported downslope by runoff into the watershed feeding the rivers.

This large flux of sediment into the rivers has impacted the river systems, resulting in rapid sediment deposition and lateral bank erosion. Further exacerbating the issues related to glacial retreat is the effect recent climate change is having on rainfall distribution. Recent studies have found that the variability of rainfall amounts is increasing, resulting in both drier drought and more frequent large storms (Barnett et al. 2008, Parzybok et al. 2009). The impact of more frequent large storms is both higher flows during floods and mobilization of large quantities of newly exposed sediment on Mount Rainier into the upper watersheds.

5.1.4 Historical Context

Under natural conditions rivers are dynamic and change continuously in response to flood events, changes in sediment supply (e.g., landslides, bank erosion), and recruited woody debris. Many ecologic functions have evolved to depend on the natural variability within river systems. Prior to European settlement, the lowland rivers of the watershed would have been multi-threaded channels with old-growth floodplain forests across the entire valley. Log jams were abundant within the active channel. The upper reaches would be similar to what is seen today within Mount Rainier National Park.

The middle reaches would have marked the transition from the upper braided reaches to the multi-threaded lowland reaches. This pre-settlement condition of the rivers would be much different than what can be observed today. Human alteration of the riverine landscape has occurred as a result of historical logging, river confinement and disconnection of river floodplain by levees, channel straightening, maintenance activities (e.g., clearing woody debris, dredging). In addition to these direct alterations to the river, floodplain development has replaced the old-growth floodplain forests with cleared land.

5.2 RIVER AND STREAM CHARACTERISTICS

The major drainage basins of the Puyallup River Watershed can be divided into those with glacial headwaters and those that are non-glacial. The major glacial rivers include the Puyallup, White, and Carbon. Major non-glacial rivers include the Greenwater, Clearwater, and South Prairie Creek. Figure 5.3 shows the major rivers and drainages of the Puyallup watershed.

5.2.1 Puyallup River

The Puyallup River originates at the Puyallup and Tahoma Glaciers on the western summit of Mt. Rainier. The upper reaches from the glacial terminus to approximately river mile (RM) 20 the river channel is braided, where the amount of sediment exceeds the transport capacity of the river. Downstream of the braided reach below the Carbon River confluence, the river transitions to a low-gradient meandering pattern which continues to its mouth at Commencement Bay. This lower meandering reach of the river would have been heavily forested and swampy, prior to European settlement, with frequent overbank flooding and abundant logjams.

Development of the Puyallup River Basin from the 1860s to its current condition has dramatically altered the system from historical conditions. Forest clearing began for small farms and residences in the lower and middle reaches of the watershed in the mid-to-late 1800s. Most of the valley bottom and adjacent hillslopes were cleared downstream of RM 24 by the early 1930s (Geoengineers 2003). Early attempts to train and confine the river began in the 1920s through construction of some levees. Significant channel straightening and more extensive levee confinement began in the 1960s in an attempt to increase conveyance of sediment and floodwaters (Geoengineers 2003). From the 1970s to the present day, conversion of residential land in the lower basin to industrial and more urban land-use practices is occurring. The middle reaches are undergoing conversion from rural to suburban land use.

5.2.2 Carbon River

The Carbon River originates at the terminus of the Carbon Glacier on the northwestern summit of Mt. Rainier and discharges into the Puyallup River approximately 2.5 miles northeast of Orting, WA. The entire river system is a complex and braided, indicative of high sediment loads. Historically the Carbon River valley would have been densely forested with a wide largely unvegetated active floodplain running down the valley bottom. Given the high sediment loads in the Carbon system, the historic channel would have been very dynamic, undergoing periods of rapid sediment deposition and widening in response to large floods. The lower four miles of the river are confined to the northern side of the valley due to the Electron Mudflow deposit along the southern side of the valley.

Timber and coal mining were the primary industries driving the initial development of the Carbon River Basin. The Northern Pacific Railroad established a line up the Carbon River Valley up to Carbonado in the late 1800s. Most of the basin west of Carbonado was cleared for timber and farmland by 1931. Early efforts to direct and confine the river included riprap groins and concrete block in and around Orting by 1931. Significant channel straightening and levee confinement began on the Carbon River in the 1960s in an attempt to increase conveyance of sediment and floodwaters (Geoengineers 2003). Much of the Carbon River Basin remains undeveloped today, minus pockets of rural residential land use.

5.2.3 White River

The White River originates at the terminus of the Emmons and Winthrop Glaciers on the northeastern summit of Mt. Rainier. The river flows generally in a northerly direction until the confluence with the Greenwater River, where the river turns and flows to the west toward Buckley. Historically, the White River flowed northwesterly from Buckley to the confluence with the Green River just north of the present day Pierce/King County Line near Auburn. A large flood and subsequent channel avulsion in 1906 diverted the flow of the White river down the Stuck Valley and into the Puyallup watershed. Construction of a diversion dam in 1914 prevents the river from flowing back northward into the Green River valley. (Geoengineers 2003). From 1907 to the 1940s several projects were initiated to dredge, confine, and riprap this new alignment to the confluence with the Puyallup River.

The White River Diversion Dam began diverting water from the White River near Buckley in 1912 for the Dieringer Hydroelectric Plant. Water is diverted to form Lake Tapps where sediment falls out prior to returning to the White River near Dieringer, WA. Water is diverted to form Lake Tapps where sediment falls out prior to returning to the White River near Dieringer, WA. Between 1912 and 1986, summer low flows were as low as 30 cfs in the bypass reach of the White River from the Buckley diversion to Dieringer. Today, a new minimum flow agreement limits summer low flow to 500 cfs. A flood control dam at Mud Mountain was constructed on the White River approximately 6 miles upstream from Buckley in 1945. The dam is designed to pass water, sediment, and debris through the structure up to 12,000 cfs until dam inflows recede (Geoengineers 2003). Gravel mining was conducted from the mid-1910s to the 1990s downstream to help maintain flow conveyance and reduce flood levels.

5.2.4 South Prairie Creek

The South Prairie Creek Basin present today was established during the Osceola Mudflow approximately 5,600 years ago. Prior to this event, the White River occupied the present day South Prairie Creek Valley as it drained to Puget Sound. This massive lahar diverted the White River into its historic course down the present day Green River and created the much smaller South Prairie Creek watershed. The result of this is an undersized river lacking the power to mobilize the large alluvium of the valley floor deposited by the White River. This condition has prevented large changes to the location of the South Prairie Creek over time by limiting channel migration.

Prior to European settlement the South Prairie Creek Basin was forested with a prairie on the valley bottom that was maintained by Native Americans (GeoEngineers 2005). Development in the South Prairie Creek Basin largely centered around resource extraction from coal mining and logging. Transportation infrastructure supporting these industries was developed between the 1870s and 1930s, with bank revetments used as protection from erosion and flooding. Historic coal mining from 1874 to the 1960s resulted in increased sediment loads as tailings were transported downriver. Logging operations had cleared most of the valley by 1900 (Geoengineers 2005).

5.2.5 Greenwater River

The Greenwater River Basin historically was heavily forested with old-growth stands primarily of Douglas Fir, Western Hemlock, and Western Red Cedar. The river channel was a complex network of channels with numerous large and deep pools formed primarily by large abundant log jams (Laurie 2002). During the late 1940s timber harvesting was initiated in the Greenwater watershed, and included both the valley bottom and adjacent hillslopes. Logging access roads were constructed throughout the watershed, further destabilizing the soil. The result of these disturbances was increased landslides and rapid channel migration, and loading of coarse sediment into the river. The effects of these changes were pronounced during the flood of 1977, where the channel widened nearly 180 ft and severe flooding impacted the town of Greenwater at the confluence with the White River (Entrix 2007).

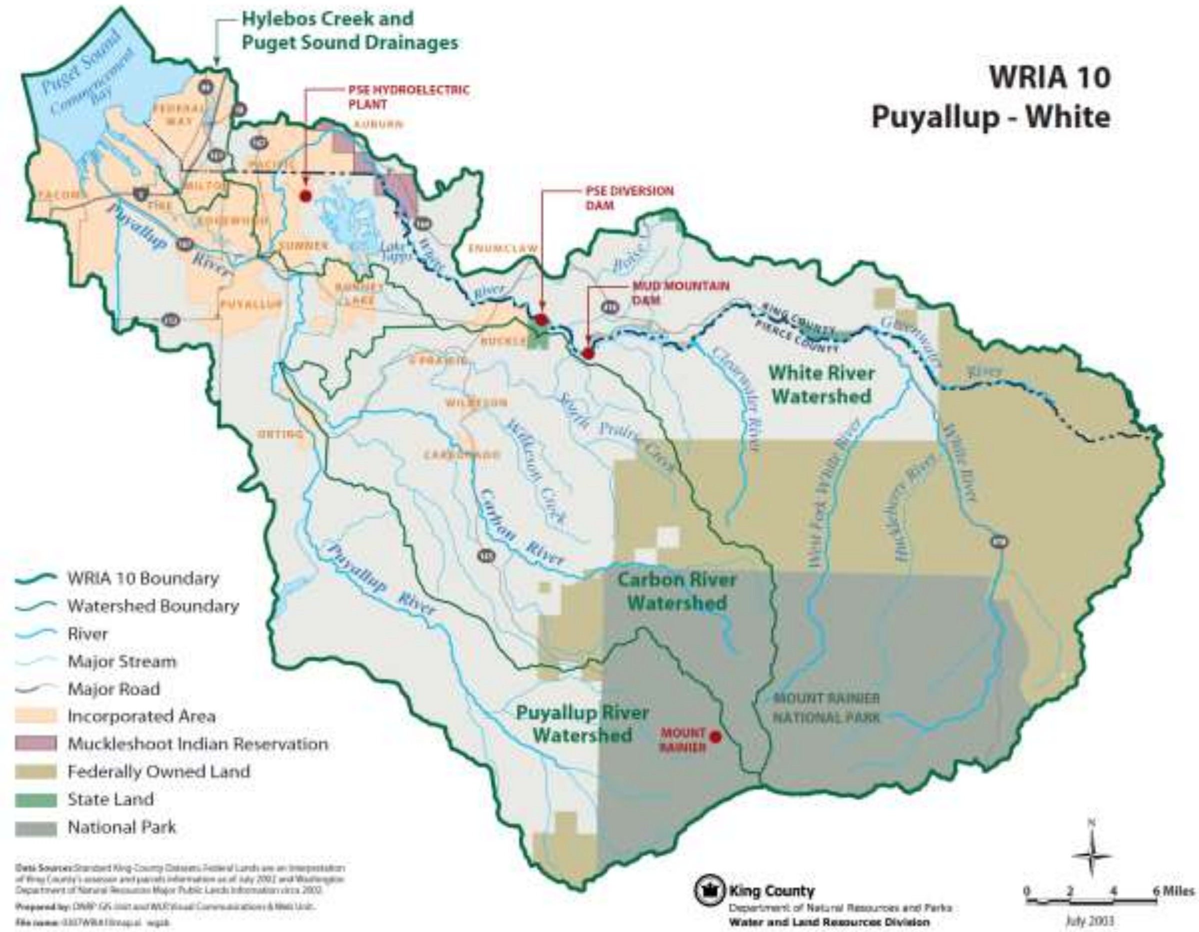


Figure 5.3 – Major rivers of the Puyallup watershed (King County 2003)

CHAPTER SIX
HYDROLOGY AND WATER USE

This chapter includes a summary of hydrologic conditions, instream flows and water supply/use in the Puyallup River watershed. The amount and timing of runoff and stream flows are influenced by precipitation (falling as rain or snow), groundwater and surface water runoff and interactions, glaciers and meltwater, and seasonal conditions that influence evapotranspiration, and soil and vegetation conditions.

6.1 HYDROLOGY AND STREAM FLOW

Annual precipitation ranges from 30-40 inches near Tacoma to over 120 inches in the Cascades (Ecology 2011). The Puyallup River and its two main tributaries (White and Carbon rivers) drain a watershed of approximately 1,040 square miles. These three main rivers are the largest surface water sources in the watershed. The mean annual flow of the Puyallup River is approx. 3000 cubic feet per second (cfs) (Puyallup Tribe of Indians 2009). The largest flood of record was in 1933 with a flow of 57,000 cfs (USGS) measured at the Puyallup gage on the Puyallup River (at river mile (RM) 6.6), but peak flows have ranged from 40,000 to 48,000 cfs on eight occasions since the 1960s (Figure 6.1). The primary period of runoff and major floods extends from October through March.

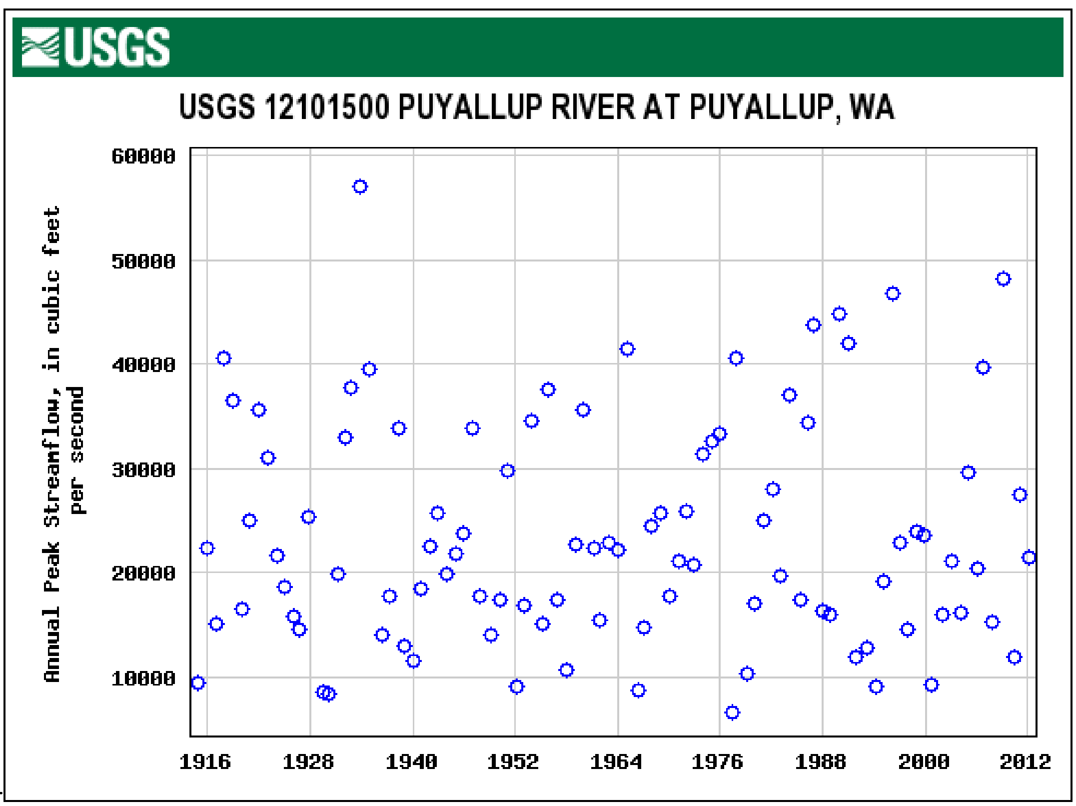


Figure 6.1 – Peak streamflow on the Puyallup River at the USGS Puyallup gage

There are three water quantity diversion/control structures in the Puyallup watershed: (1) the U.S. Army Corps of Engineers (USACE) operates a flood control dam (Mud Mountain) on the White River at RM 29.6; (2) the Buckley diversion dam, operated by the Cascade Water Alliance, at RM 24.3 on the White River diverts water to Lake Tapps; and (3) the Electron diversion dam, operated by Puget Sound Energy, diverts water for power generation on the Upper Puyallup River. Since 1948, MMD has provided a mechanism for flood control on the lower Puyallup River, with storage capacity up to 106,000 acre-feet of water. Releases from MMD are based on maintaining a maximum flow of 45,000 cfs at the Puyallup River gage.

Major groundwater aquifers are found in the Puyallup Valley and its tributary valleys that are filled with porous sand, silt, and gravel deposits (Ecology 1995). Summer base flows in the rivers and tributaries are sustained by groundwater on most of the lower-elevation tributaries and glacier and snow melt on the mainstem rivers (Puyallup, Carbon, and White) that drain Mt. Rainier.

6.1.1 Instream Flows

WRIA 10 (the Puyallup watershed) has an Instream Resources Protection Program rule (WAC 173-510 – http://www.ecy.wa.gov/biblio/wac173510.html) that establishes instream flows on the Upper and Lower Puyallup River and Carbon River, including all tributaries. The purpose of the instream flow rule is to retain perennial rivers, streams, and lakes in the Puyallup River basin at instream flows and levels necessary to provide protection for wildlife, fish, scenic-aesthetic, environmental values, recreation, navigation, and to preserve water quality standards (WAC 173-510 1988). Instream flows in the Puyallup and Carbon Rivers are shown in Table 6.1.

For the White River, the instream flows are based on the White River Management Agreement between the Cascade Water Alliance and the Puyallup and Muckleshoot Tribes. The agreed upon instream flows apply at the Buckley Diversion dam at River Mile 24.3 on the White River (see Table 6.2). The agreement provides for higher flows that more accurately follow the natural flow conditions in the White River, (compared to flows provided during hydropower operations) by establishing new minimum flows in the White River and limiting diversions into Lake Tapps. Minimum flows range from 875 cubic feet per second (cfs) down to 500 cfs throughout the year.

All future water withdrawals are subject to the instream flows (Ecology 2011). All water uses that have impacts to surface waters will be interrupted when stream flows fall below levels set in rule unless the impacts are offset through mitigation.

A few key provisions of WAC 173-510 follow. WAC 173-510-080 addresses future water rights, specifying that “no rights to divert or store public surface waters of the Puyallup WRIA 10 shall hereafter be granted which shall conflict with the purpose of this chapter.” WAC 173-510-050 addresses groundwater and notes that “in future permitting actions relating to groundwater withdrawals, particularly from shallow aquifers, a determination shall be made as to whether the proposed withdrawal will have a direct, and measurable, impact on stream flows in streams for which closures and instream flows have been adopted."

Table 6.1 – Instream Flows in the Puyallup River Basin (WAC 173-510)

INSTREAM FLOWS IN THE PUYALLUP RIVER BASIN

(cubic feet per second)

Month	Day	12-0965.00 Puyallup River (At Alderton)	12-1015.00 Puyallup River	12-0957.00 Carbon River
Jan	1	700	1400	600
	15	700	1400	550
Feb	1	750	1400	550
	15	800	1500	550
Mar	1	800	1600	550
	15	850	1700	550
Apr	1	900	1800	600
	15	950	1900	700
May	1	950	2000	900
	15	1000	2000	900
Jun	1	1050	2000	600
	15	1050	2000	500
Jul	1	1050	2000	450
	15	1050	1750	400
Aug	1	900	1500	350
	15	800	1300	350
Sep	1	600	1150	350
	15	500	1000	350
Oct	1	500	1000	350
	15	500	1000	550
Nov	1	600	1000	550
	15	700	1100	600
Dec	1	700	1200	700
	15	700	1300	700

Table 6.2 – White River Instream Flows

Time Period	Minimum Flow in cfs	Time Period	Minimum Flow in cfs
January 1-14	650	July 1-23	800
January 15-31	525	July 23 - Aug 6	650
February 1-14	550	August 7-14	500
February 15-29	500	August 15-31	500
March 1-14	550	September 1-14	500
March 15-31	725	September 15-30	500
April 1-14	775	October 1-14	500
April 15-30	825	October 15-31	500
May 1-14	875	November 1-14	500
May 15-31	875	November 15-30	550
June 1-14	800	December 1-14	550
June 15-30	800	December 15-31	600

6.2 WATER SUPPLY/USE

Annual precipitation ranges from 30-40 inches near Tacoma to over 120 inches in the Cascades (Ecology 2011). Only a fraction of this precipitation becomes available for human and economic uses. Most of the precipitation occurs during the winter months (October to March), when water demands are lowest. During the summer the snowpack is gone, there is little rain, and naturally low stream flows are dependent on late summer glacial melting and groundwater inflow (Ecology 2011). This means that groundwater and surface water are least available when water demand is highest in the summer.

The Puyallup watershed is one of the most intensely populated and farmed basins in western Washington, and much of the water in the Puyallup-White watershed has already been spoken for (Ecology 2011). There is little water available for new uses, especially given that river levels need to be maintained to ensure adequate water quality and fish migration. Increased demands from population growth, naturally low summer and early fall streamflow levels, and impacts of climate change add to the challenge of finding new water supplies in the Puyallup watershed (Ecology 2011). Figure 6.1 shows closed basins and instream flow basins in the Puyallup watershed (Ecology 2011).

The major surface water uses in the watershed are for irrigation and municipal and domestic supplies. The major groundwater uses are public water supply and single wells.

The number of pending water right applications as of February 2011 was 30. Types of water source applications were: surface water (15); groundwater (15). The purpose of requested use was: commercial/industrial (8), municipal supply (8), domestic supply (4), instream flow (3), irrigation (2), mining (2), trust water (1), wildlife and recreation (1).

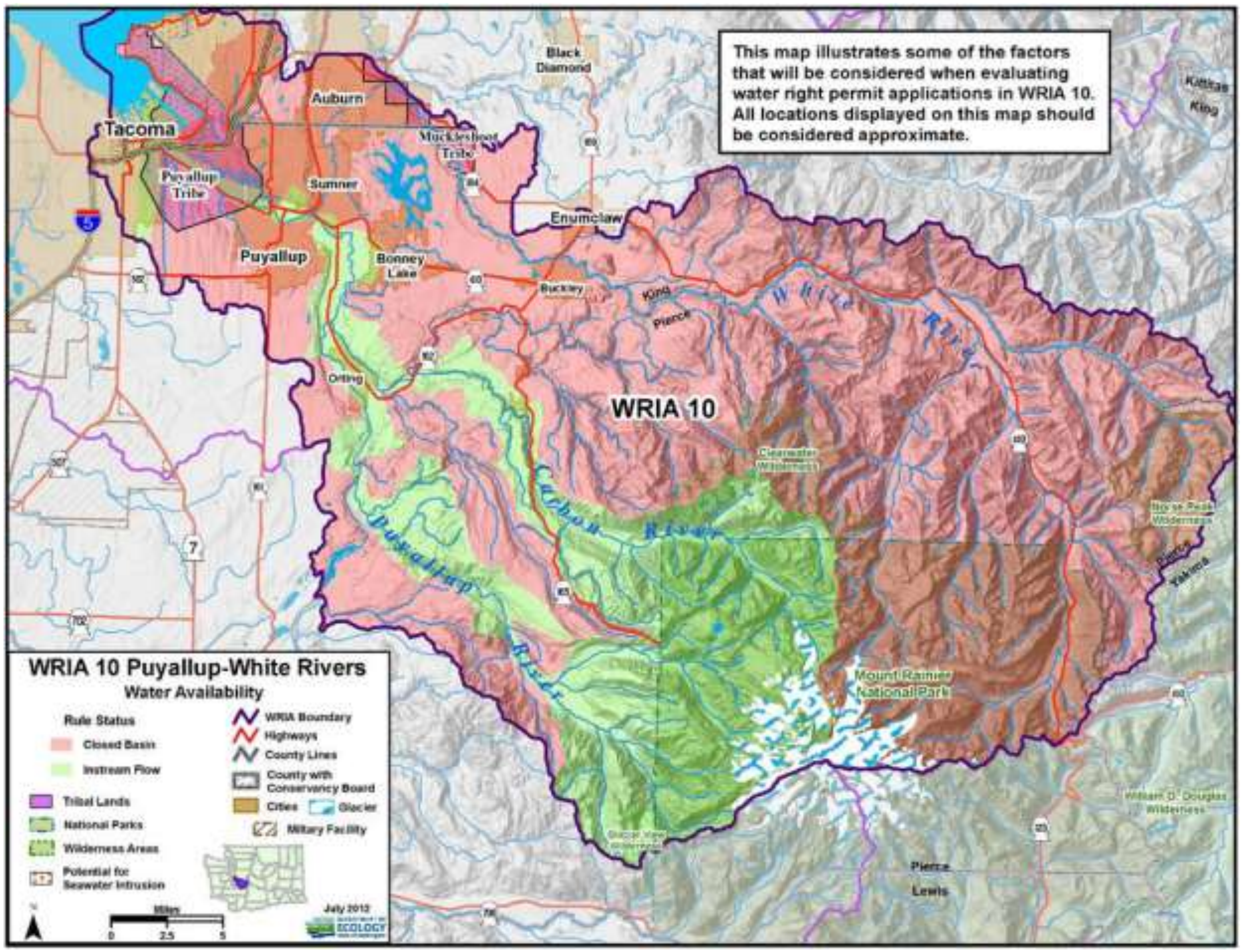


Figure 6.1 – WRIA 10 Puyallup-White River basin water availability map (Ecology 2011)

6.3 USGS CHARCTERIZATION OF WATER RESOURCES IN THE PUYALLUP WATERSHED

The USGS and partners are carrying out a study entitled "*Characterization and Numerical Simulation of the Water Resources in the Puyallup River Watershed.*" The goals of the study are to: (1) compile and analyze all hydrologic data to characterize the groundwater flow system and interaction with surface water features, and (2) construct a numerical flood model (ground and surface waters) to contribute to an improved understanding of current and future water resources in the watershed.

The objective of the study is the establishment and operation of a network of monthly groundwater-level and synoptic stream baseflow measurement sites. It is anticipated that these data will be integrated, along with other information, into a numerical flow model to contribute to an improved understanding of water resources in the Puyallup River Watershed.

CHAPTER SEVEN
AQUATIC HABITAT AND FISH POPULATIONS

7.1 FISH POPULATION OVERVIEW

Fish stocks in the Puyallup river watershed demonstrate a wide range of population variability and abundance. Two species that typify this range are pink salmon stocks that have reached peak abundance in the past two return cycles (2009-2011) to steelhead which have hopefully reached their population nadir. Because of species specific difference in life history and habitat dependency it's easy to paint broad brush explanations for trends. However, history has demonstrated that these explanations are seldom satisfactory when subjected to scientific scrutiny. Rather than speculate, the attached graphs provide a glimpse of some of the empirical data observed to date.

7.1.1 Chinook

Chinook have unquestionably received the greatest degree of recovery attention both in terms of enhancement efforts and harvest management restrictions. Hatchery returns of White River spring Chinook have demonstrated impressive increases in recent decades (see Figure 7.1). However, the response of their wild counterparts to ongoing recovery efforts has been lethargic at best. The ratio of wild (unmarked) Chinook at Buckley averages less than 24% of the run size which suggests that abundance in general remains fueled by ongoing enhancement and supplementation efforts. Were these efforts to be discontinued its likely Chinook numbers would decline. Genetic monitoring efforts over the past decade have focused on the distinguishing characteristics of the spring stock and note that fall stocks are very similar to regional fall populations that have a history of artificial propagation and inter-basin transfers. Ongoing hatchery practices for White River Spring Chinook involve close genetic monitoring to ensure out of basin stocks are not introduced into their genetic makeup. The use of natural origin recruits (NOR's) has also been expanded and now involves the introduction of 5% wild brood stock into the hatchery each year.

Based on both field observation and genetic testing we know that fall and spring stocks hybridize. What we don't know is whether this has always occurred and if so, to what degree? Theoretically stocks are isolated spatially, temporally or by both factors. We do know that Chinook return timing to Buckley has changed markedly since record keeping began in the 1940's. At that time, Chinook were abundant in May and peaked in June. Today we see only a handful of fish in May and the run peaks in late July. Presumably, 94 years of hydro-electric generation and resultant instream flow reductions played a part in this shift. Whether the selective pressures which favored early return timing are still at play is anyone's guess.

Now that instream flows within the White River bypass reach (Buckley to Dieringer) have been restored to a more normative regime it will be interesting to observe any future changes.

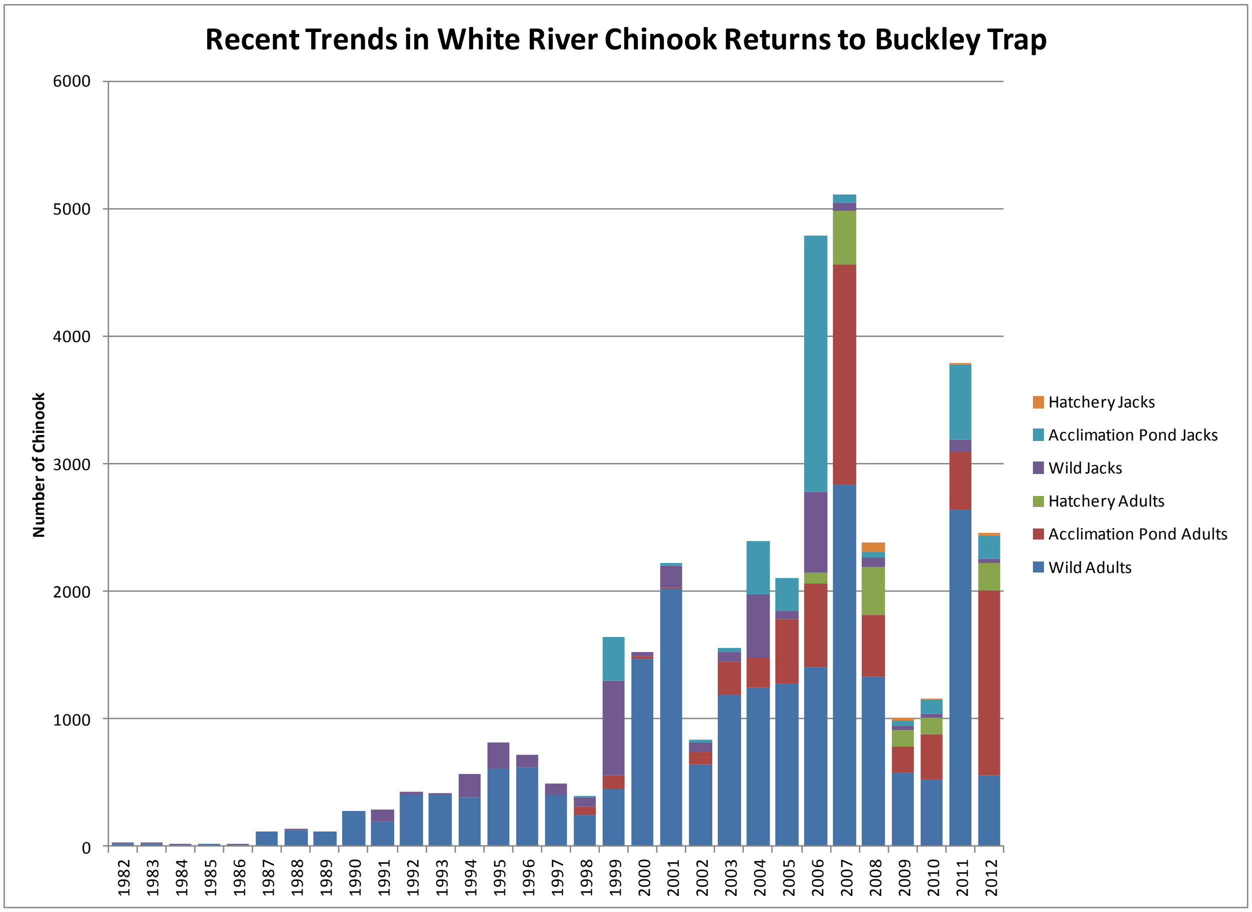


Figure 7.1 – Trends in White River Chinook Returns to Buckley Trap (1982-2012)

7.1.2 Coho

Coho numbers have declined markedly in the last 15 years. Where hatchery stocks throughout the south Puget Sound had delivered abundant returns with survival rates averaging 10-15%, they have in recent years declined to less than five percent. Wild coho returning to the White River however, are doing quite well. Although we have no data to compare outmigrant numbers against, adult returns to the Buckley trap are stable, healthy and are at near record abundance. Wild coho also have the broadest return timing of any stock in the watershed. Typically the first coho of the season are observed at Buckley in July and they continue to be present through March with a peak return time in late September. The 2012 return cohort has a history of strong run sizes dating back to 1997 and 2000 which was the return of record flowed closely by 2012 currently at 22,000 fish. Wild coho which typically are later running fish than hatchery coho have exhibited strong abundance basin wide in 2012. Graphs of coho throughout the watershed are attached to illustrate the high abundance this year.

Coho abundance in the small urban tributary watersheds like Swan, Fennel, Hylebos, Salmon, Jovita and Kapowsin Creeks is severely depleted. Because coho reside in freshwater for a full year before emigrating they are exposed to a wide range of watershed impairment pressures such as heavy metals, elevated water temperatures, flood flows and any and all storm water pollutants. Impervious surfaces also lead to diminished summer base flow condition which is also a long recognized bottleneck for coho production. Many small urban stream have an overly simplified channel type as a result of frequent high flow events that result in bank erosion, channel incision and the absence of large wood pieces that would otherwise serve to strengthen and stabilize the stream bed and banks and also provide an element of habitat complexity.

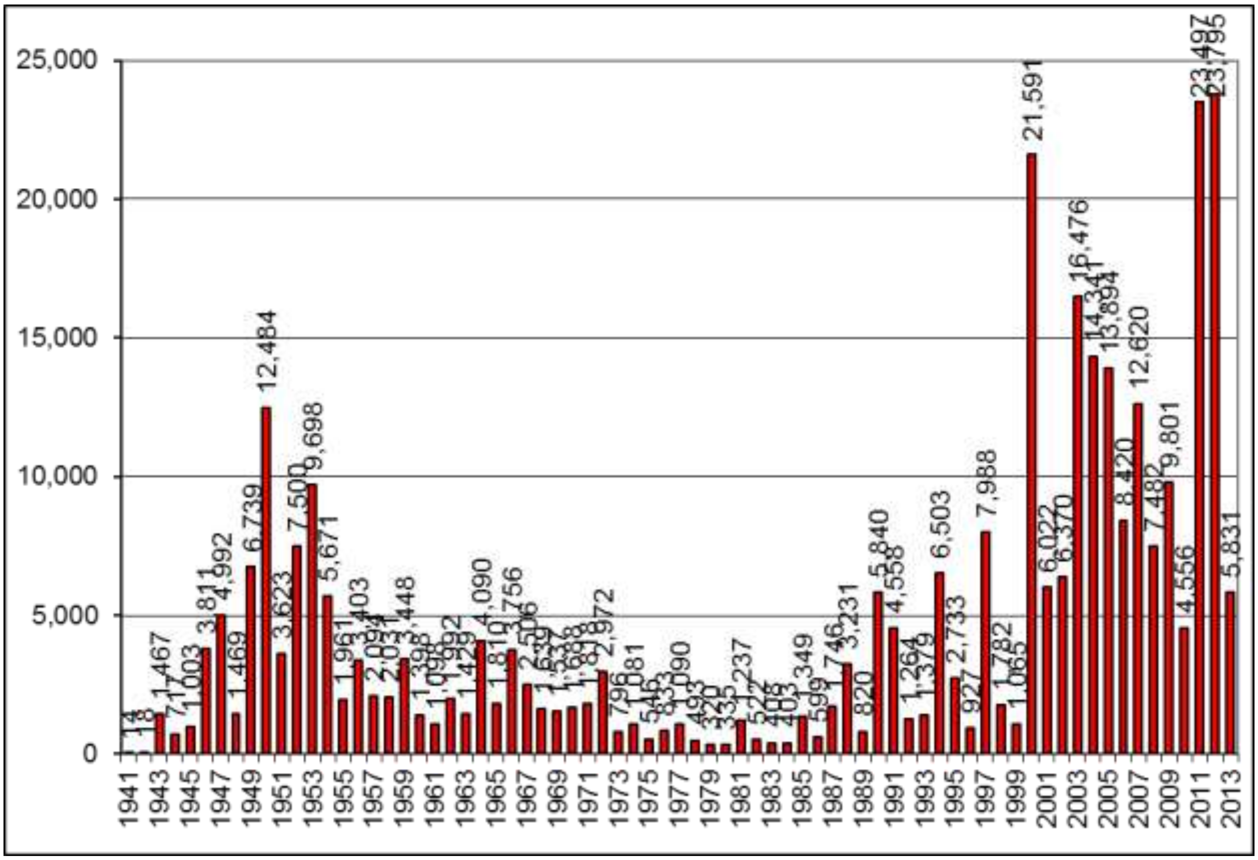


Figure 7.2 – Coho Returns to the Buckley Trap transported above MMD (1941-2013)

Figure 7.3 illustrates the ongoing trend toward earlier return timing of coho to the Buckley Fish Trap. Possible explanations for this include the increase in minimum instream flows within the White River downstream of the Buckley Diversion Dam. The Muckleshoot Tribes settlement with Puget Sound Energy in 1986 resulted in an increase in minimum flow from 30-cfs to 130-cfs. These changes in flow make a profound difference in both the path way upriver as well as the habitat suitability for incubation, rearing, holding and spawning. Prior to these increased flows many pools in the river were disconnected creating a physical barrier to upstream passage. Furthermore, absent any ramping rate requirements, the rate of flow change within the 20.6 mile bypass reach could change almost instantly.

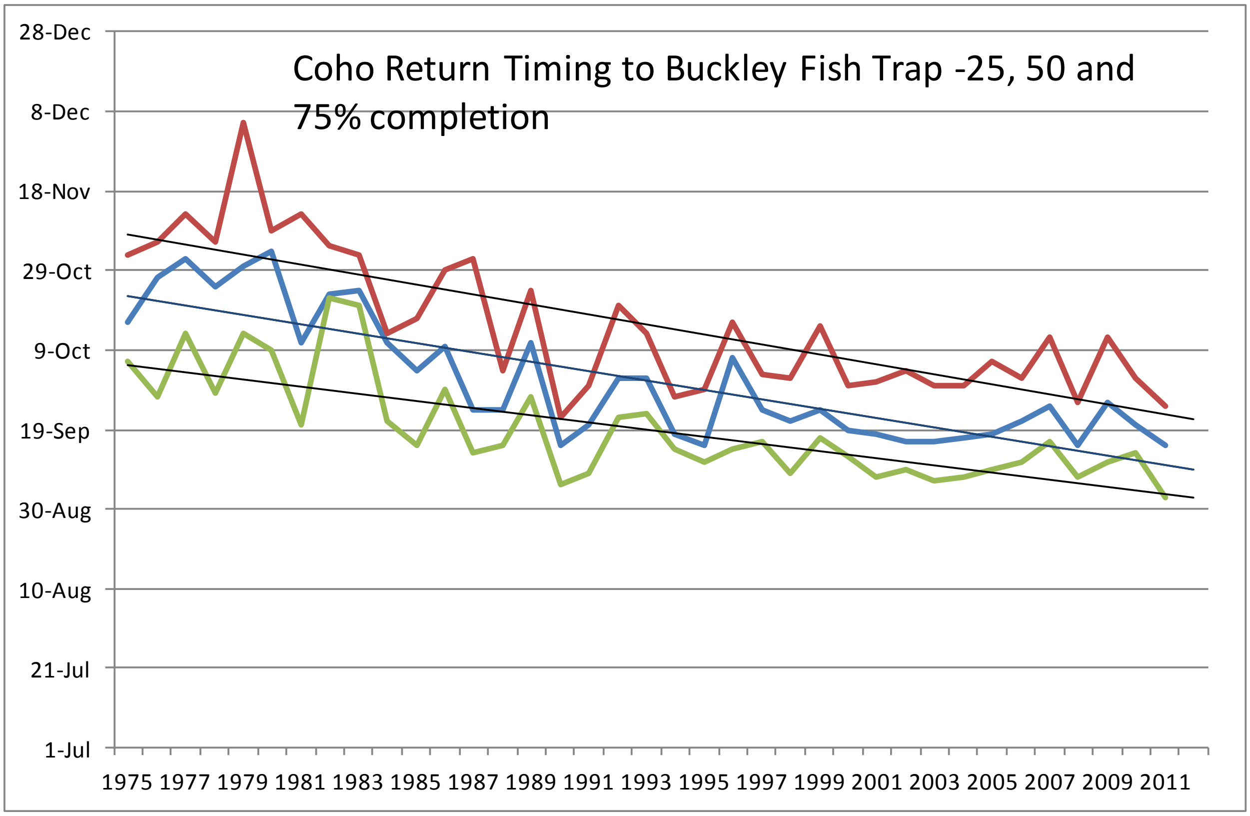


Figure 7.3 – Coho Return Timing to Buckley Trap (1976-2012)

The cohort chart shown in Figure 7.4 illustrates the strength of this particular year class of fish. Notice that coho started to rebound in the 1988 return. This most likely is a consequence of the increase in stream flows established when the Muckleshoot Tribe reached a settlement with PSE in 1986 that resulted in increased minimum flow within the White River bypass reach from 30-cfs to 130-cfs. Although the historical run graph shows the 2011 return as the largest, the precision of this count is highly suspect given the number of pinks present at the same time.

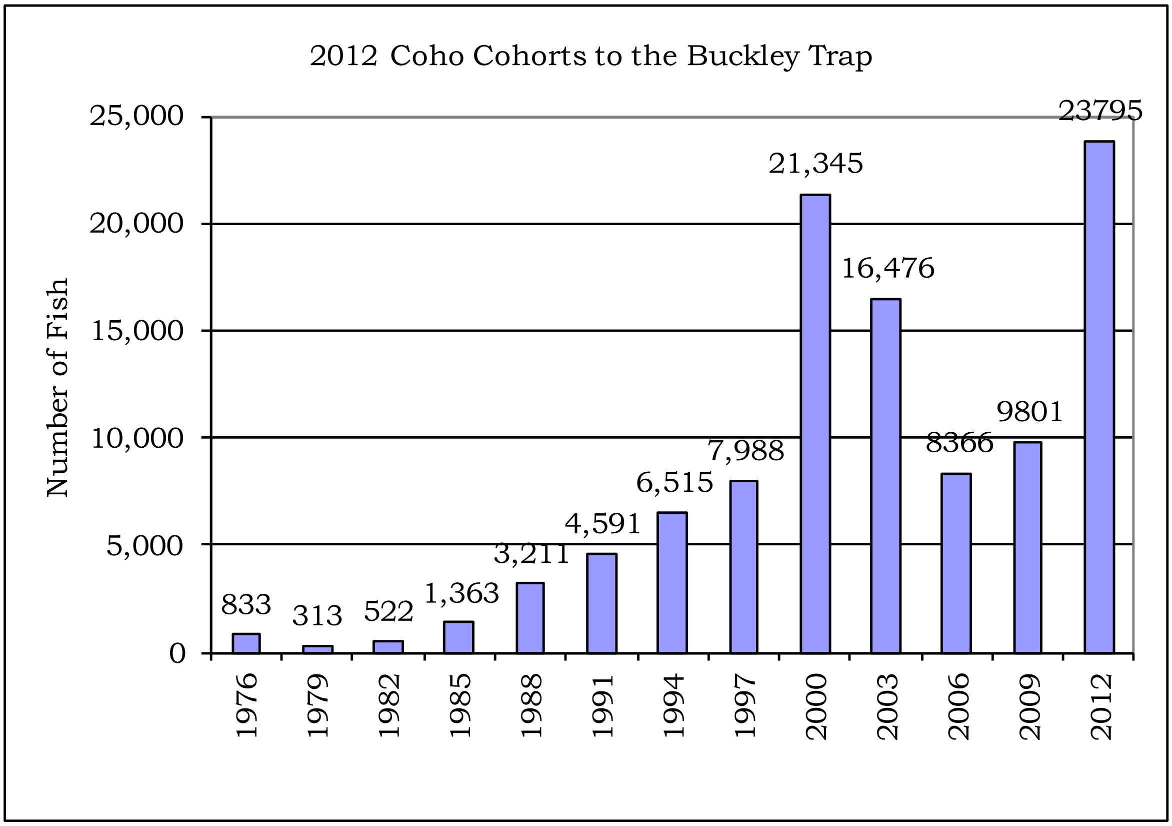


Figure 7.4 – 2012 Coho Cohorts to Buckley Trap (1976-2012)

7.1.3 Chum

Wild chum returns have been very poor in recent years throughout the basin with no obvious explanation. Presumably the occurrence of damaging flood flows has impacted their numbers. Chum in the Puyallup watershed are usually three or four years of age at return with a roughly 50/50 age ratio.

It was expected that the normative flow regime established following the closure of the PSE White River Hydroelectric plant and improvements in habitat and flow conditions would foster rapid recovery of chum that were once prevalent throughout the bypass reach (RM 3.6-24.3) (Salo, 1980). Several miles of the White River above and below the Muckleshoot Indian Tribe reservation boundary consist of broad, braided floodplain with seemingly ideal chum spawning habitat. Unfortunately, chum are less abundant now then during power generation. South Prairie Creek, Fennel Creek, and the Carbon River mainstem near Voights Creek were the primary spawning location for chum. The White River between RM 9 and 16 has hosted concentrations of chum as well but this population has been in decline for the past decade. Although they can still be found at these locations, their numbers are only a fraction of what they were 10-15 years ago.

Wild chum should not be confused with hatchery chum produced at the Puyallup Tribe's Diru Creek Hatchery which is the only chum production facility in the watershed. Diru chum are a separate stock originating from Chambers Creek and continue to exhibit excellent survival rates and contribute to a popular in-river sport and commercial fishery. Having the only chum facility in the watershed sited low in the system lessens the likelihood of these hatchery fish interbreeding with wild stocks that target both the glacial mainstem and numerous non-glacial tributaries.

7.1.4 Steelhead

Both wild and hatchery steelhead returns are at record low abundance (see Figure 7.5). Hatchery returns are easy to explain-they are no longer being produced in this watershed. Wild fish remain an enigma but it is important to realize that declines are not just limited to the Puyallup watershed but are prevalent throughout Puget Sound and British Columbia as well. This widespread geographic decline suggests a marine survival problem. However, in contrast, the Columbia River steelhead runs are experiencing relatively high survival rates similar to those that occurred in previous decades.

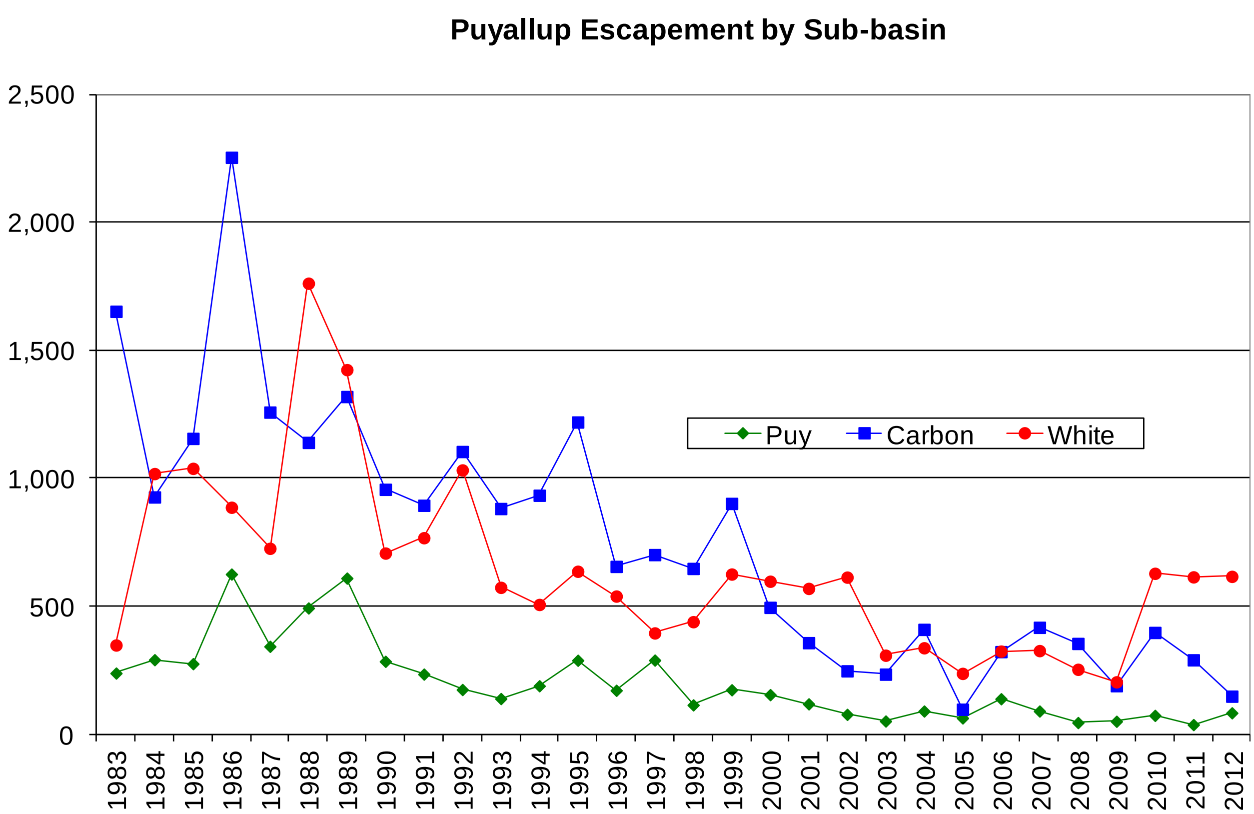


Figure 7.5 – Puyallup, Carbon, and White River steelhead escapement

Whether the problem is predators or prey abundance is also unknown. We do see a sharp decline in hatchery steelhead survival rates from their mid-1980s peaks near 10-12% down to less than one percent when the program was terminated in 2007. However, the redd scour exposure differences of coho and steelhead to flood events is much different due to the reduced likelihood of high flows in the spring months when steelhead eggs are incubating and emerging. Because of their protracted freshwater residency, at least 2 years for wild steelhead, they are often assumed to act as a barometer of freshwater conditions and habitat quality.

Recent findings using acoustic tagging technology in smolts suggest steelhead are not making a successful exit from Puget Sound. Only one study of steelhead genetics has been conducted in the past 20 years and the findings from this effort are not conclusive due to the absence of sufficient samples outside of the White River. The Puyallup Tribe and WDFW have been jointly working to collect more samples from the Carbon and Puyallup Rivers and their tributaries.

Table 7.1 White River Wild Steelhead Brood Program (2006-2011) – Egg take and outplants

Egg to smolt survival rates			
Brood Year	Egg Take	Outplants	Percent Survival
2006	47,000	25,631	54.53%
2007	58,000	56,378	97.20%
2008	38,508	31,531	81.88%
2009	28,881	26,310	91.10%
2010	32,090	27,876	86.87%
2011	35,299	31,129	88.19%

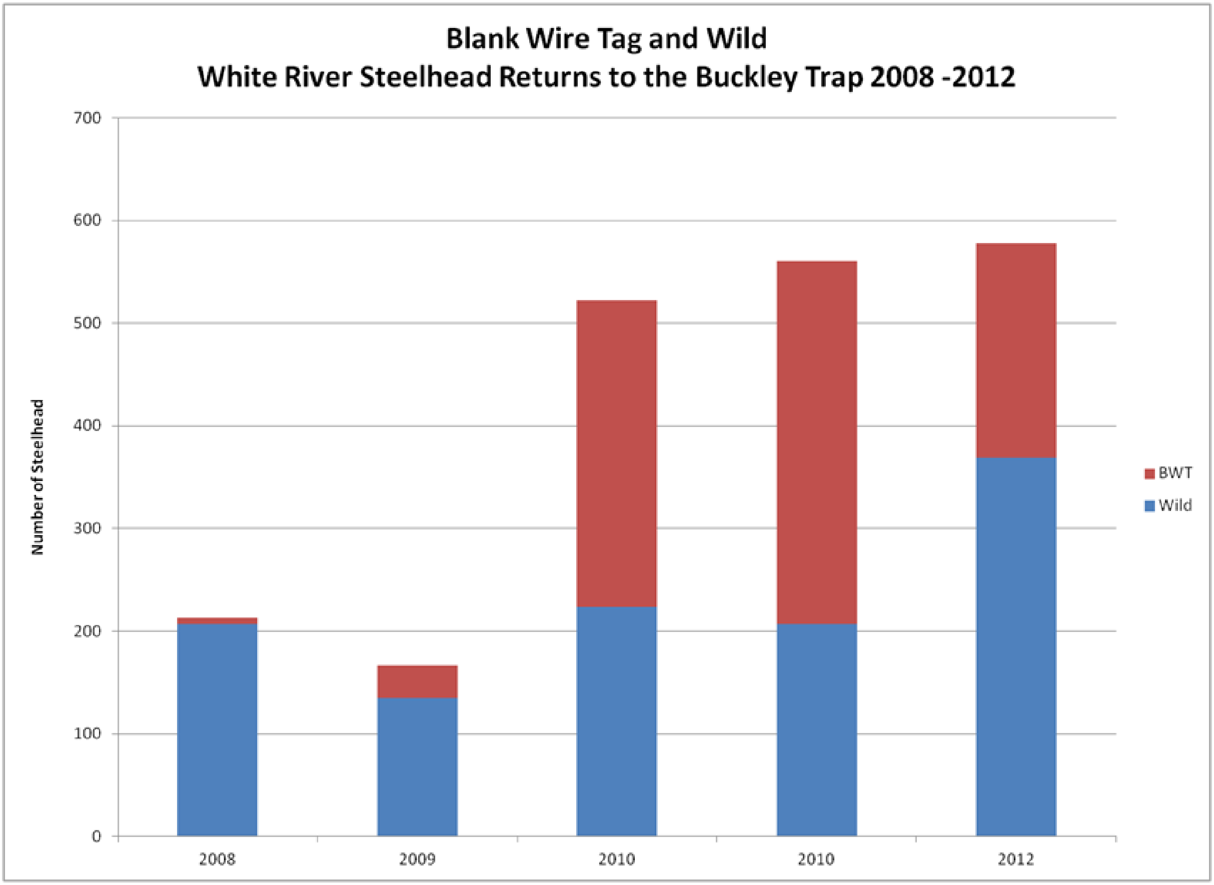


Figure 7.6 – White River steelhead returns to Buckley Trap (2008-2012)

7.1.5 Bull Trout

Bull trout research in the Puyallup watershed has been done only by the Puyallup Tribe and the National Park Service. Findings shed light on a species with remarkably different life history strategies when compared to other salmonids, as well as bull trout elsewhere in Washington State. From what we know, it appears that bull trout exhibit both a resident and fluvial life history. The Buckley fish trap provides an ideal facility for collecting, enumerating, sampling and tagging the fluvial (migratory) forms of this species. Although bull trout are observed moving upstream through the trap any month of the year, there is a prominent peak migration during the months of June and July (Figure 7.7). The fluvial bull trout, as well as their much smaller resident cousins, spawn exclusively in non-glacial tributary streams at elevations above 2600 feet during the month of September and the first week of October.

In 2012, the largest bull trout migration since records began was observed at the Buckley Trap with over 160 fish being passed upstream (Figure 7.8). Population age structure remains unclear as we have not had the opportunity to perform age analysis using otoliths which provide more reliable information than is possible through non-lethal scale analysis. While we suspect a percentage of the fluvial bull trout observed at Buckley are anadromous, we lack conclusive evidence of this life history type.

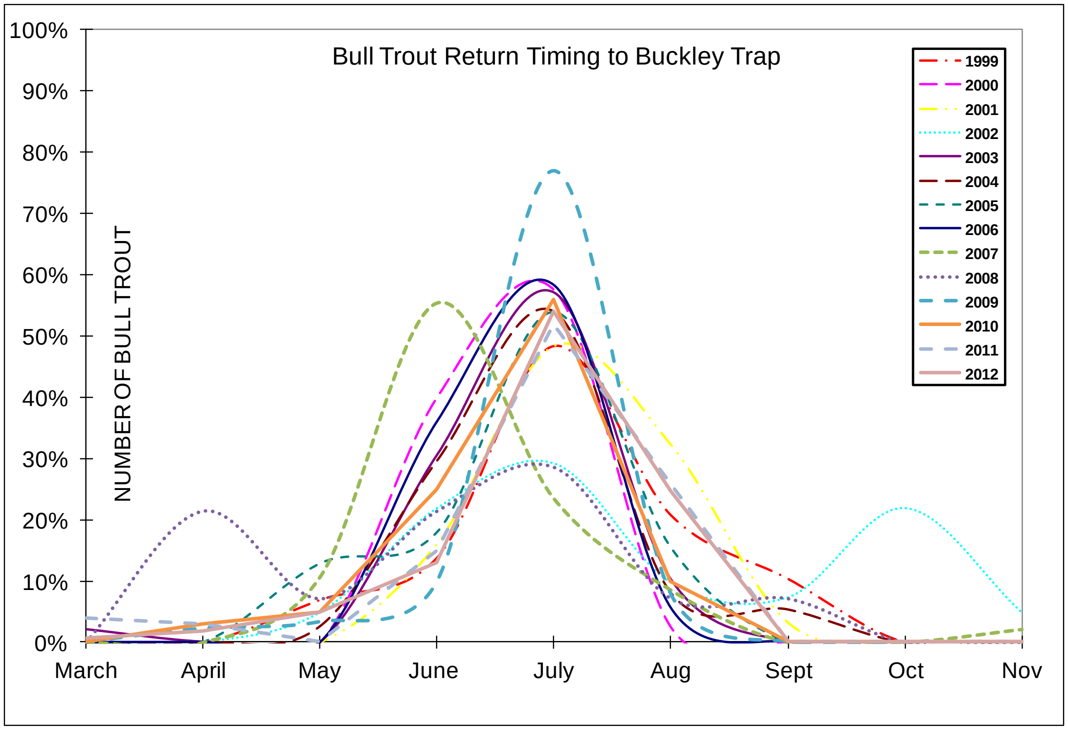


Figure 7.7 – Bull trout return timing to Buckley Trap

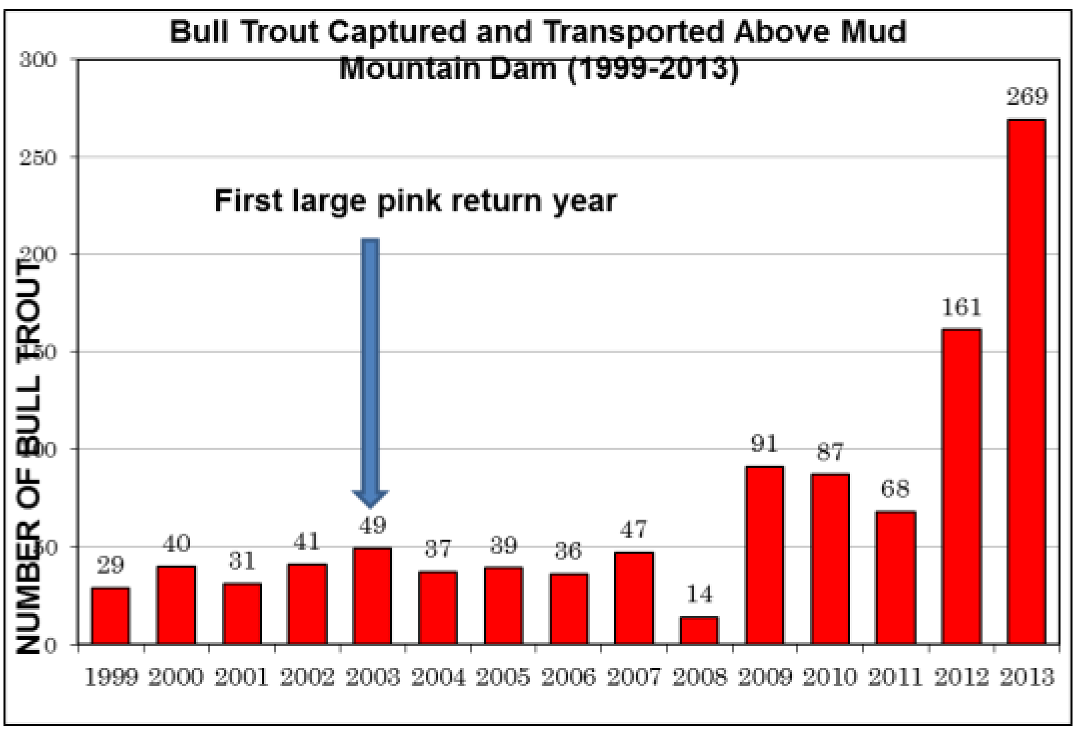


Figure 7.8 – Bull Trout captured and transported above MMD (1999-2012)

7.1.6 Pink Salmon

Pink salmon are the most prolific of the Pacific salmon. They also have the highest stray rate which allows them to rapidly colonize suitable habitat. The growth in abundance of pinks over the last decade within the Puyallup River and south Puget Sound is nothing short of astounding. Pink salmon escapement in South Prairie Creek has increased dramatically since 2001 (see Figure 7.9). Pinks have a very rigid two-year life cycle and exhibit a dominant odd-year return cycle in Washington State. Even-year pinks are unusual in the south Puget Sound but are more common in the Snohomish River system.

Historically pinks were found almost exclusively in South Prairie Creek with only small infrequent observations elsewhere in the watershed. With the removal of the Tacoma Public Utilities Pipeline No. 1 concrete armoring in 2003, the final hurdle was eliminated and pinks were able to reach the Buckley Fish Trap. Pink salmon migration timing at the Buckley fish trap is typically from mid-August to mid-October (see Figure 7.10). Since 2003, pink salmon have flourished throughout the White River with hundreds of thousands of fish spawning in all the major non-glacial tributaries above the Buckley Trap (See Figure 7.11). The Puyallup Tribe has observed pinks spawning in Mount Rainier National Park at elevations of 2800 feet, upstream of the Electron Dam and downstream to tidally influenced reaches of the mainstem Puyallup River below Clarks Creek. They easily exhibit the widest geographic spawning distribution of any species in the watershed.

Pinks are entirely wild with no history of hatchery production or enhancement in the South Sound. This fact combined with their success strongly contrasts with all other species-particularly many declining hatchery supplemented stocks such as fall Chinook, coho and steelhead. To further confound this, pink salmon are highly estuarine and shoreline habitat dependent. Given all the alterations to such areas in Commencement Bay and throughout Puget Sound, this population explosion seems even more remarkable.

Pinks provide for a tremendously popular sport fishery and this fact is quite apparent in August and September when fishermen are lined up shoulder to shoulder for miles along the Puyallup River. The economic contribution of this fishery to the local community is significant with local sporting goods dealers reporting increased sales of tackle when “the pinks are in”!

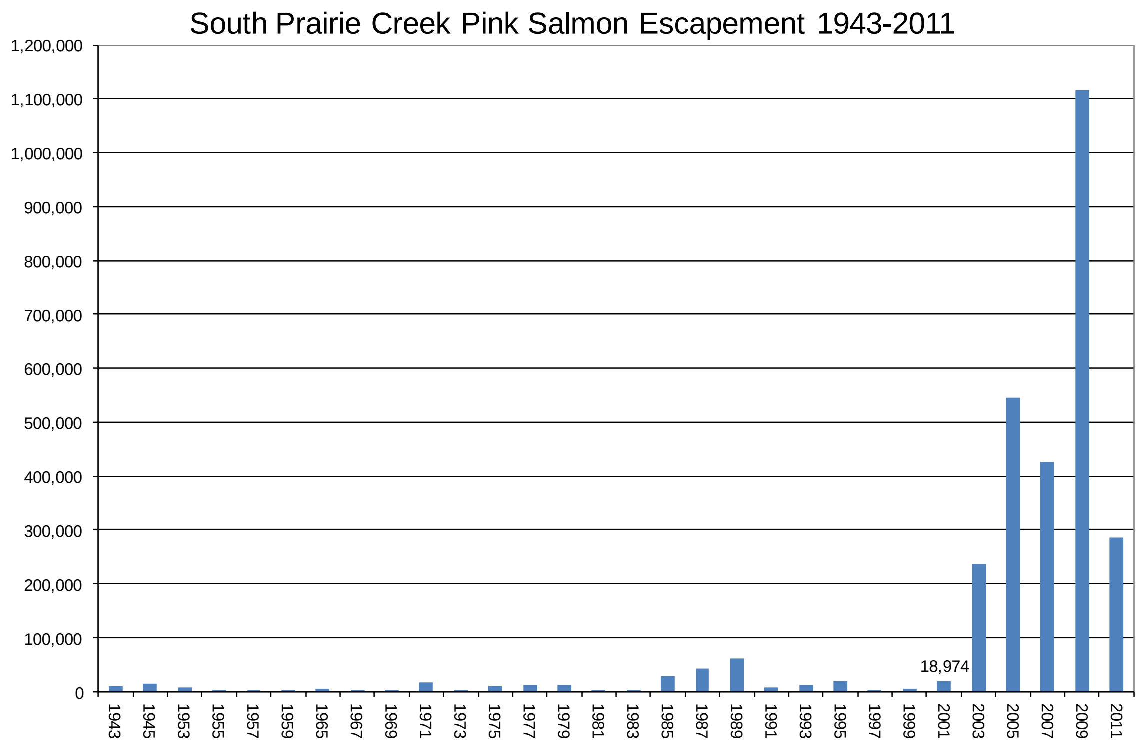


Figure 7.9 – South Prairie Creek Pink Salmon Escapement (1943-2012)

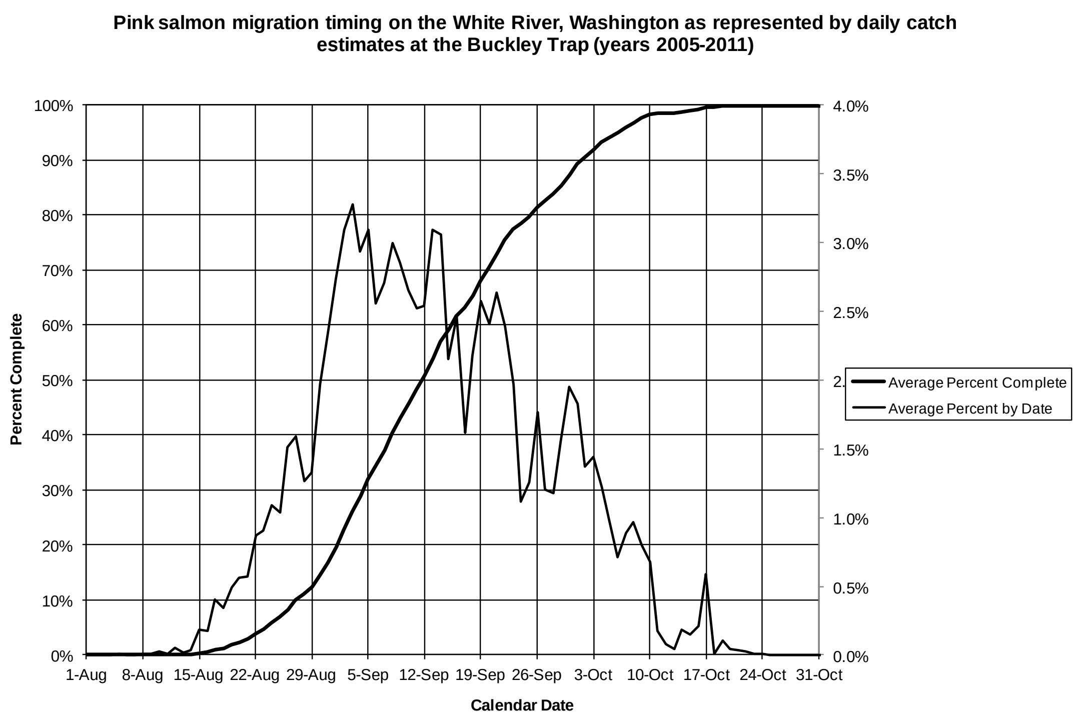


Figure 7.10 – Pink Salmon Migration Timing at the Buckley Trap (2005-2011)

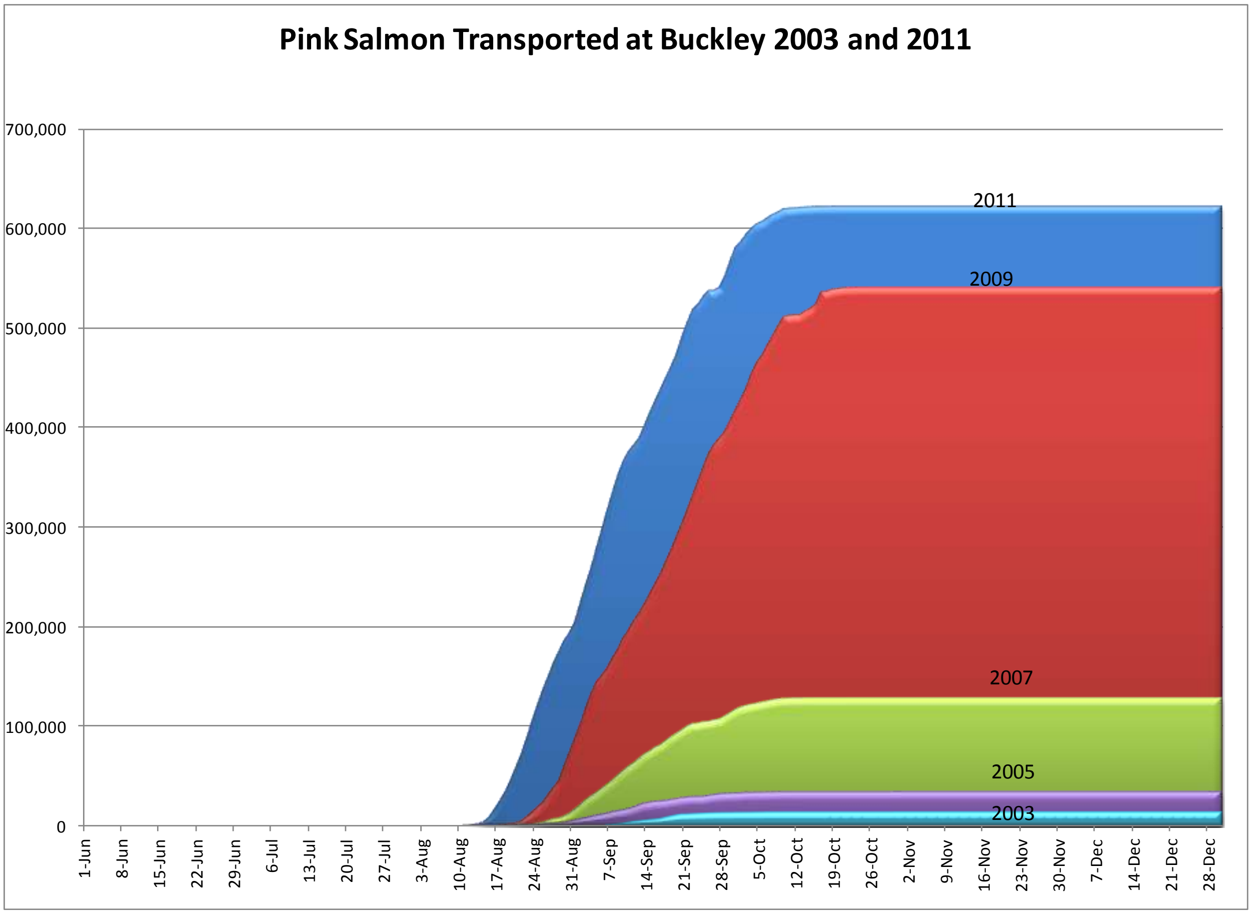


Figure 7.11 – Pink Salmon Transported at the Buckley Trap (2003-2011)

7.2 DAM AND HATCHERY CONCERNS

The following is a summary of ongoing concerns related to the three primary dams in the Puyallup watershed and hatchery production concerns related to steelhead in the watershed.

7.2.1 Electron Diversion Dam Project

Current operations at the Electron Diversion Dam are better than what existed prior to 1997. Historically, Puget Sound Energy did not have to comply with a minimum instream flow level which during periods of discharge resulted in a dry channel with disconnected pools. The Puyallup Tribe and PSE reached a settlement in 1997 resulting in a Resource Enhancement Agreement (REA) which was composed of four primary components: (1) upstream fish passage, (2) in-stream minimum flows, (3) Chinook and coho enhancement efforts and acclimation program, and (4) a downstream fish collection facility. Currently the project is for sale and is currently being considered for acquisition by Tollhouse Energy. Because the REA is not transferable to another entity, acquisition of the Electron project by any party will require renegotiation of settlement terms with the Puyallup Tribe. It will also require finalization and approval of an HCP with the federal services-NOAA and USFWS. Although PSE had developed several chapters of a draft HCP, the document was never completed or formally submitted for review by the Services. The Electron HCP process remains frozen with no current indication of activity.

Another option for the Electron Project is abandonment. Because of its age, certain elements of the project will likely be considered under the State's Historic Preservation Office programs. The dam itself, which is almost entirely constructed of timber cribbing except for concrete side-walls, will, in the absence of constant maintenance, rapidly succumb to the perpetual grinding of rock and bed load. Much of the 10.5 mile long wooded flume used to convey water from the dam to the powerhouse will also rot away. The steel bents and support trusses that have been installed to replace the original wood support structure will undoubtedly persist for decades. Some of these will erode and collapse into the river gorge which already has a collection of steel bents and rail tracks from earlier mishaps and washouts.

The right bank fish ladder which is a reinforced concrete structure completed in 2000 will likely remain but would be unnecessary in the absence of a blocking structure in the river. The powerhouse itself (Figure 7.12) would also likely remain for decades since it is above the floodway and has been only impacted by slope stability problems in its 107 year history. The 20-acre forebay would likely become a wetland area since it is located in a low lying area and collects several seeps. Fish and wildlife resources will be the immediate beneficiaries of project closure.

The goal of the Tribe's REA was and still is to reconnect isolated habitat upstream of the Electron Dam (RM 41.7) and provide for safe upstream and downstream passage to all species in this reach. In 2012, there was the largest return of spring Chinook salmon to the upper Puyallup since the ladder was completed. Most of these fish returned to Rushingwater Creek, a left bank Mowich River tributary that originates in Mt. Rainier National Park. These Chinook are thought to have originated from a release of spring Chinook from the Puyallup Tribe's acclimation pond located there. The sudden pulse of spring Chinook returns has led the tribe to reconsider the use of fall Chinook in the upper watershed. Perhaps better survival rates can be sustained through the release of spring Chinook that are better adapted to the colder water regime of this high elevation site.

Figure 7.12 – Electron Powerhouse along the Puyallup River

7.2.2 Mud Mountain Dam

The value and importance of Mud Mountain Dam as a flood control tool is without question (Figure 7.13). However, the ancillary effects of storing flood flows and providing a protracted release of sediment laden water have not been well studied. During large flood events which trigger discharge reductions and the storage of water behind the dam, a profound change in sediment transport dynamics occurs. Instead of the natural coincident transport peak of sediment with flow, what occurs during the reservoir drafting process is a sudden and protracted discharge of unnaturally turbid water and sediment (Figure 7.14). Furthermore, as the reservoir level drops, the river begins to erode and cut through the freshly deposited sediment (Figure 7.15). The situation can almost resemble a lahar in terms of discharge consistency. This slug of sediment does not have the peak flood volume of water to transport it and therefore much of the material falls out in pools en-route downstream resulting in sand dunes forming in the river channel. What affects this has on invertebrate ecology and salmonid egg/alevin survival remains unknown because it has not been studied here.

Figure 7.13 – Mud Mountain Dam during flood storage in February 1996

Figure 7.14 – Mud Mountain reservoir discharge following a flood

Figure 7.15 – White River flow through sediment deposited in MMD reservoir

In contrast, the roll of Large Woody Debris (LWD)and its importance in channel function, stability, morphology and salmonid ecology has received considerable attention in the scientific literature. Thus it is astonishing that even today Mud Mountain Dam continues to operate as it has without any mitigation requirements for the loss of this essential material to the watershed downstream (Figure 7.16). Mud Mountain Dam acts like a filter that blocks out the opportunity to recruit LWD to downstream reaches effectively starving the system of this crucial habitat component.

Figure 7.16 – Mud Mountain reservoir and woody debris during November 2006 flood

Although LWD collected behind the dam is no longer burned in the way it once was, considerable room exists for improvement to the manner in which LWD is managed. Ideally, LWD would be collected, trucked downstream and returned to the river at a location below the Buckley Diversion Dam. Depending on the severity of fall and winter rain events, a significant volume of large woody material can be recruited from sources within Mount Rainier National Park. Because of their large size, these old growth trees are precisely the type of large woody material necessary to provide long term stabilizing and habitat forming functions in a river with the size and energy of the White.

7.2.3 Buckley Diversion/Barrier Dam and Fish Trap

The Buckley Fish Trap is 72 years old and is no longer capable of meeting the needs required to provide safe, effective fish passage (Figure 7.17). Beginning in 2003 it was apparent that the truck and haul loading system was being overwhelmed by the large number of returning pink salmon resulting in the delay of other concurrent ESA listed and non-listed species. The design is antiquated and the facility itself is not capable of providing for the capture and transfer of all fish present. Even today with the addition of more trucks, drivers and 24 hour hauling operations, the arrival rate during the peak return can far exceed the transport capacity resulting in large backups, delay and loss of hundreds of thousands of fish. Arrival rates of pinks were estimated as high as 100,000 fish per day in 2009. The record one day haul achieved in 2011 was just under 20,000 fish.

The diversion dam was built by Puget Sound Energy in 1910 using a timber crib and concrete footing design (Figure 7.18). Despite annual maintenance efforts, it is in a decrepit condition, and its ability to survive another large flood is in question. Furthermore, the performance of basic maintenance to the dam requires flow reductions through storage at Mud Mountain that results in stranding mortality of fish and invertebrates along 29.6 miles of the White River.

Additionally, the surface features of the dam apron and foundation, in particular the wood cribbing, steel pins and abraded concrete, form an insidious gauntlet when combined with continuous attraction flows. Water spilled over the dam crest creates a lethal diversion or false attraction because fish expend precious energy trying to move upstream repeatedly harming themselves along the apron instead of moving toward the fish ladder (see Figures 7.19 and 7.20 taken July 18, 2012). It is hard to conceive of a more deadly situation in the realm of Pacific Northwest salmon passage and handling. This situation has persisted far too long in the midst of countless individual recovery efforts and enhancement programs.

Because the functionality of the fish trap is linked to the operating performance of the dam the two projects are integral. Furthermore, frequent failure of the diversion dam allows fish to pass upstream where they are blocked by Mud Mountain Dam and prevented from reaching their natal spawning streams. Each year an unknown number of fish are lost here when the panels are down and when favorable flow conditions prevail. Species like bull trout and steelhead which excel at surmounting difficult obstacles such as panel failures at the barrier dam are likely more at risk to getting past than others. However, crews did capture a couple dozen spring

Chinook that managed to ascend the apron and jump the crest during the maintenance outage in July, 2012.

Figure 7.17 – Buckley fish trap facility

Figure 7.18 – White River Buckley Diversion Dam

The presence of three ESA listed species at the facility makes accurate enumeration and accounting imperative. The days of having a single tank truck driver stand over the hopper entrance counting fish with a couple tally counters are long gone. Biologists from the Muckleshoot Tribe, Puyallup Tribe and WDFW regularly meet to go over the records and work to identify and resolve any discrepancies that may occur. Chinook and steelhead recovery planning requires knowing not just how many fish are present but sampling and recording a range of information including: scales for age composition, lengths, weights, check and test for presence of marks/tags, DNA sampling , and sex ratios. This information necessitates continuous sampling at the trap which in turn requires staffing levels which the Tribe is unable to provide.

It would be most helpful if the Corps would dedicate staff biologists to coordinate trap operations with tank truck drivers and non-Corps fisheries managers. Corps personnel could also assist state and tribal staff with record keeping as well as necessary sampling programs. During periods of multiple trip days it would be beneficial to have biologists counting and identifying the species loaded. While enumeration discrepancies are infrequent, they do occur more often when the haul rate picks up during pink runs and or large coho returns. Tribal and WDFW staff are generally not present on weekends, week nights and holidays when much of the peak run hauling work is conducted. During such periods which may involve the transfer of thousands of fish, no sampling whatsoever takes place. In this era of ESA listings, catch allocation and minimum escapement goals, a data gap of this magnitude is unacceptable.

Figures 7.19 and 7.20 – Buckley Dam apron and foundation

CHAPTER EIGHT
WATER QUALITY

The quality of water throughout the Puyallup River Watershed influences its use by humans, fish, and wildlife. Water is essential for life and clean water ensures habitat, drinking water, and other human uses for water supported beneficial uses throughout the watershed. Degraded water quality conditions can result in some portions of the watershed being incompatible with human, fish and wildlife needs. This can be especially true in summer when species are most stressed and water levels are low. Water quality parameters of concern include elevated water temperatures, low dissolved oxygen, excess nutrients (phosphorus, nitrogen), suspended sediment, bacteria, metals (e.g., copper), and trace organics (e.g., pesticides, combustion by-products).

Fish (primarily salmon and trout) are most affected by degraded conditions due to temperature, dissolved oxygen, suspended sediment, copper toxicity, and some elevated trace organics. Humans are at risk from excess bacteria levels in water used for drinking, swimming or contact recreation, and shellfish consumption. Excess nutrients, metals, or trace organics in drinking water can also pose substantial health risks to humans. Finally, elevated nutrient levels in streams, lakes, and Puget Sound can result in eutrophication (nutrient enrichment) that leads to algal blooms, aquatic plant growth, and low dissolved oxygen levels.

Distinguishing between natural and human-caused conditions in water quality parameters is sometimes difficult, but examination of variations across the watershed (and between sub-basins) can help isolate what is due to human actions. An equally challenging task is determining how fish and wildlife are affected by incremental changes in water quality, and what thresholds are important in the natural environments. Additionally, cumulative or synergistic effects of multiple pollutants are difficult to quantify or isolate. Human-caused changes in water quality may not be fatal to fish and wildlife, but the changes can decrease the amount of desirable habitat available throughout the watershed, or decrease reproductive success, thereby gradually reducing a population.

In this chapter, we examine water quality conditions throughout the watershed based on water quality data, 303d listed (impaired) water bodies, benthic index (B-IBI) data, and other metrics or grades assessing conditions. We summarize the main threats contributing to degraded water quality conditions and the barriers and/or challenges in achieving clean water. We also identify desirable future water quality conditions in the watershed to enable various beneficial uses. Finally, an overview of the regulatory framework for water quality is discussed.

8.1 EXISTING WATER QUALITY CONDITIONS

This sub-section provides an assessment of the water quality conditions in the Puyallup River watershed from existing water quality reports, including the watershed characterizations from the Lower and Upper Puyallup watershed action plans (LPWMC 1992, UPWC 2002), Salmon

Habitat Limiting Factors Report (Kerwin 1999), the 2013 Surface Water Health Report Card (Pierce County 2014), and other water quality and biological data. Water quality data were compared to Washington State water quality standards (WAC 173-201A), EPA water quality criteria, and appropriate toxicity screening thresholds to assess potential for biological significance. Available aquatic insect data were evaluated as a measure of the aquatic ecosystem condition of selected streams. There is a brief summary of sediment quality issues.

The analysis divides water bodies into streams or creeks, rivers, lakes, and estuary/marine nearshore. The Water Quality Standards for Surface Waters of the State of Washington (Ecology 2011) define use designations for aquatic life, recreation, water supply and miscellaneous. Table 8.1 shows the use designations for the Puyallup-White (WRIA 10) watershed by water body and location.

8.1.1 Impaired Water Bodies (303d List)

Numerous stream systems throughout the Puyallup River watershed are listed on the State's 303(d) list of impaired water bodies (see Figure 8.1). Section 303(d) of the Clean Water Act requires Washington State to identify those water bodies that do not meet water quality standards. The state is then responsible for prioritizing the list and developing Total Maximum Daily Loads (TMDLs) for every water body and pollutant on the list. In the Puyallup watershed, water body segments have been listed for failing to meet water quality standards for one or more of the following parameters: fecal coliform, temperature, dissolved oxygen, pH, turbidity, metals (arsenic, copper, lead, mercury, zinc), nutrients (ammonia-N, total phosphorus), and benzene. The three most common listings for water are fecal coliform, temperature, and dissolved oxygen. Inner Commencement Bay is listed for benzene, copper, tetrachloroethylene, and trichloroethylene. In addition, there are habitat listings (invasive exotic species, instream flow, fine sediment) and tissue listings (e.g., dieldrin, PCB, chlorinated pesticides, DDT, arsenic).

8.1.2 Surface Water Health Report Card

Pierce County publishes an annual report card of surface water health that summarizes data for 14 streams in the Puyallup watershed (see Figure 8.2). Stream grades are based on two indexed scores, the Water Quality Index (WQI) and Benthic Index of Biotic Integrity (B-IBI), with a penalty for each parameter listed on the State's 303(d) list. Grading based on a combination of the WQI, B-IBI, and 303(d) list paints a more representative picture of stream health than each factor viewed separately. The report card grades range from "A" (excellent health) to "F" (very poor health). Grades of B, C, and D are good, fair, and poor stream health, respectively. Grades for the 12 streams assessed in water year (WY) 2013 ranged from B (Fennel and Squally creeks) to B- (Voight, Kapowsin, and Wilkeson) C+ (Canyon, Clarks, Diru, Fiske, Rody, Spiketon, and Swan) to C (Canyon Falls) to C- (Clear Creek) (see Table 8.2). This provides a baseline for trends analysis for streams monitored, with a focus on the unincorporated areas of Pierce County. It is important to note that Pierce County annually monitors additional streams within the Puyallup Watershed, but those streams may not have both BIBI and WQI data to generate a grade. The Pierce County Surface Water Health Report Card, which includes grades back to

2008, can be accessed at www.piercecountywa.org/watershedhealthdata. No other jurisdictions in the watershed apply this compound index to streams they monitor.

Beginning in 2012, no penalties have been assigned for 303(d) listings made after 2008. This change was made because the 303(d) list is based on historical data and is not an indexed score like the WQI and BIBI.

Table 8.1 – Use Designations for Fresh Waters in Puyallup-White (WRIA 10)

TABLE 602	Aquatic Life Uses						Recreation Uses			Water Supply Uses				Misc. Uses				
Use Designations for Fresh Waters by Water Resource Inventory Area (WRIA)	Char Spawning /Rearing	Core Summer Habitat	Spawning/Rearing	Rearing/Migration Only	Redband Trout	Warm Water Species	Ex Primary Cont	Primary Cont	Secondary Cont	Domestic Water	Industrial Water	Agricultural Water	Stock Water	Wildlife Habitat	Harvesting	Commerce/Navigation	Boating	Aesthetics
WRIA 10 Puyallup-White																		
Carbon River and tributaries above latitude 46.9998 longitude -121.9794, downstream of the Snoqualmie National Forest or Mt. Rainier National Park.	✓							✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Carbon River and tributaries above latitude 46.9998 longitude -121. 9794 that are in or above the Snoqualmie National Forest or Mt. Rainier National Park.	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Clarks Creek and tributaries.		✓						✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Clear Creek and tributaries.		✓						✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Clearwater River and Milky Creek: All waters (including tributaries) above the confluence.	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Greenwater River from confluence with White River to headwaters (including all tributaries).	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Puyallup River from mouth to river mile 1.0.				✓					✓		✓	✓	✓	✓	✓	✓	✓	✓
Puyallup River from river mile 1.0 to confluence with White River.		✓						✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Puyallup River and tributaries from confluence with White River to Mowich River (Except where designated char).		✓						✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Puyallup River at and including Mowich River: All waters (including tributaries) above the confluence.	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
South Prairie Creek and all tributaries above the Kepka Fishing Pond, except those waters in or above the Snoqualmie National Forest.	✓							✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
South Prairie Creek and all tributaries above the-Kepka Fishing Pond that are in or above the Snoqualmie National Forest.	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Swam Creek		✓						✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Voight Creek and Bear Creek: All waters (including tributaries) above the confluence that are downstream of the Snoqualmie National Forest or Mt. Rainier National Park.	✓							✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
Voight Creek and Bear Creek: All waters (including tributaries) above the confluence that are in or above the Snoqualmie National Forest or Mt. Rainier National Park.	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
White River from mouth to latitude 47.2438 longitude -122.2422 (Sect. 1 T20N R4E).			✓					✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
White River from latitude 47.2438 longitude -122.2422 (Sect. 1 T20N R4E) to Mud Mountain dam (including tributaries).		✓						✓		✓	✓	✓	✓	✓	✓	✓	✓	✓
White River from Mud Mountain Dam (river mile 27.1) to West Fork White River at (latitude 47. 3699 longitude -121.6197) except where designated Char.		✓					✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
White River from and including West Fork White River: All waters (including tributaries) above the confluence.	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Wilkeson Creek and Gale Creek: All waters (including tributaries) above the confluence.	✓							✓		✓	✓	✓	✓	✓	✓	✓	✓	✓

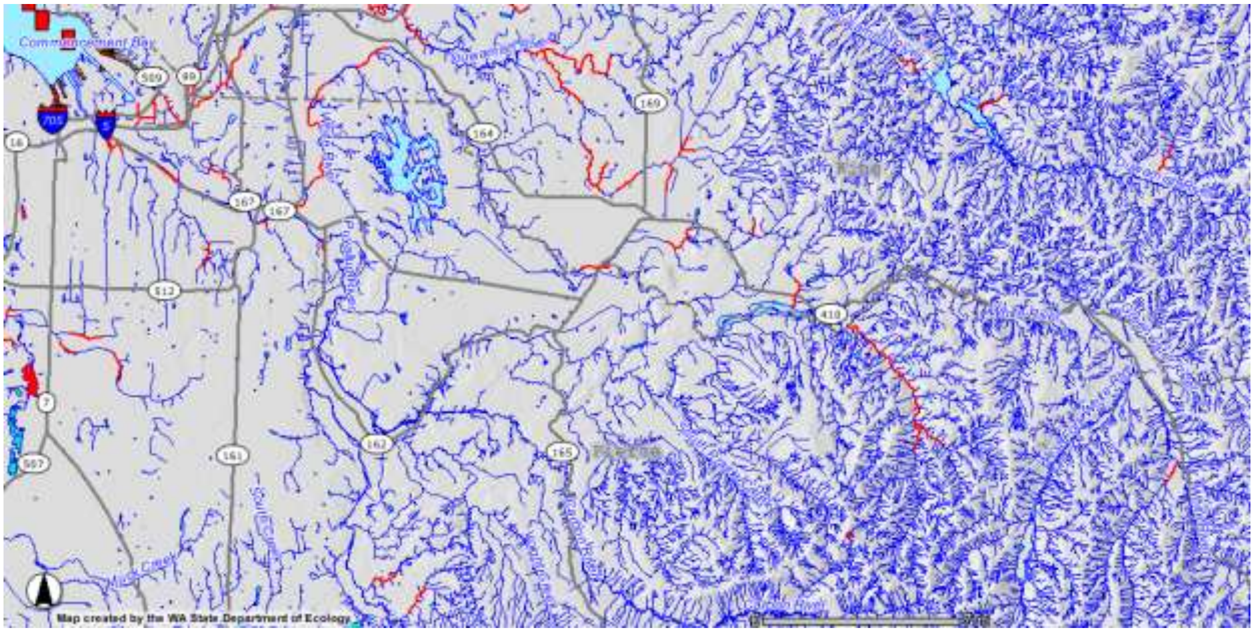


Figure 8.1 – 303(d) listed water bodies (shown in red) in the Puyallup watershed (Ecology 2008)

Table 8.2 – Pierce County Stream Health Report Card Grades for Puyallup Watershed Streams

Name	2008	2009	2010	2011	2012	2013
Canyon Creek	B-	B	B+	C	C+	C+
Canyon Creek Falls	C+	C+	C+	C+	C-	C
Clarks Creek			B-	C+	C+	C+
Clear Creek	D+	C-	C	C	C-	C-
Diru Creek	C	C+	B	B	B-	C+
Fennel Creek	C+	B	B	B+	B-	B
Fiske Creek					B+	C+
Kapowsin Creek	C	C	C	B-	C+	B-
Rody Creek	C	C	C+	C+	C+	C+
Spiketon Creek	C+	B+	C+	B-	C+	C+
Squally Creek	B-	B	B	B	B-	B
Swan Creek	C	C	C	C+	C+	C+
Voight Creek	C+	C	C	B-	C+	B-
Wilkeson Creek	B-	C	C-	B-	B-	B-

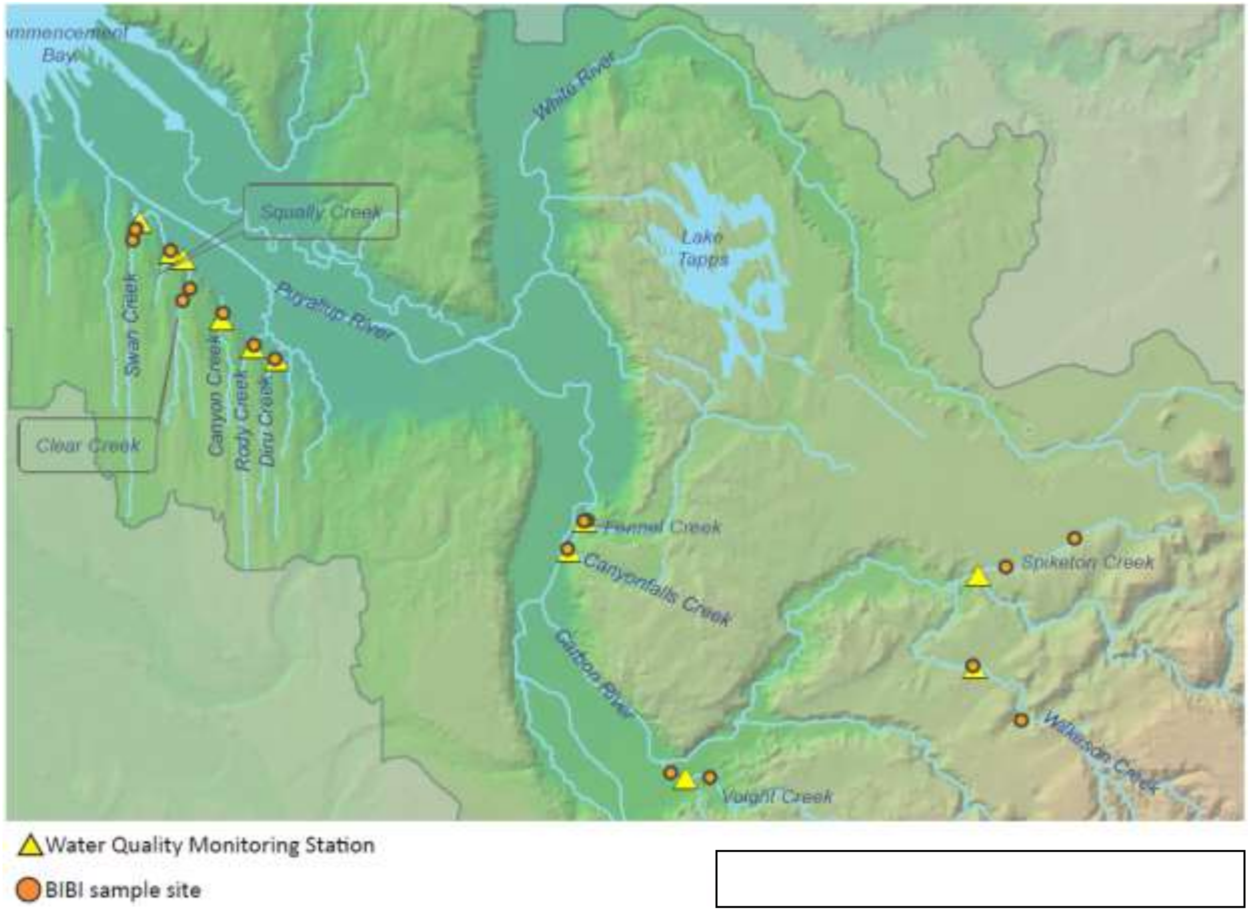


Figure 8.2 – Streams in Puyallup watershed with surface water health report card grades (Pierce County 2014) Note: three monitored streams are not indicated on the map.

8.1.3 Benthic Index of Biotic Integrity Monitoring

Pierce County Surface Water Management, along with Pierce County environmental educators, the Pierce Conservation District, and the Puyallup Tribe of Indians, have collected aquatic insect data for 14 streams in the Puyallup watershed since 1999. The B-IBI is based on surveys of aquatic insects (macroinvertebrates) that live on the stream bottom. The health of the stream can be assessed based on the types and populations of insects that live there. A number of biological attributes, called metrics, are analyzed and consolidated into a score for the stream. By using the scoring systems the streams can be compared with each other and against an accepted scoring system (Kleindl, W.J. 1995).

Table 8.2 shows the BIBI scores for the period from 2001 to 2011 for 14 streams monitored in the Puyallup watershed. The BIBI data is included in the regional Puget Sound Benthos database. For more information, visit www.pugetsoundstreambenthos.org.

Table 8.2 – BIBI scores for Puyallup Watershed Streams

Stream	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Avg.
Voight Creek	34			19			27	30				28
S Prairie Creek	41	32	35				33	25	35	33		33
Spiketon Creek	31			33						27		30
Wilkeson Creek				31		27		29	28	27	31	29
Boise Creek	40	35			32							36
Canyon Creek	19				27			33			19	25
Canyonfalls Creek				15	14	15	16	15	15		14	15
Clarks Creek	31	23	25	22						29		26
Clear Creek					13			12				12
Diru Creek			17		22					25		21
Fennel Creek			23	35		30		24			32	29
Squally Creek					25	25	28		24	27	29	26
Swan Creek	21	11			20	17	26	28	22			21
Kapowsin Creek						19		19	31			23

B-IBI score: 46-50 (excellent); 38-44 (good); 28-36 (fair); 18-26 (poor); 10-16 (very poor)

8.1.4 Other Sources of Water Quality Data

In addition to the data presented above, Pierce County Surface Water Management, Puyallup Tribe of Indians, Muckleshoot Indian Tribe, Pierce Conservation District, Tacoma-Pierce County Health Department, King County Water and Land Resources, Washington State Department of Ecology, and U.S. Geological Survey have all collected water quality data in the Puyallup watershed. The location, time period, frequency, and parameters analyzed varied widely across the watershed and the agencies carrying out the monitoring. The water quality data available dates back to the 1970s, but older data may not be very reflective of current conditions.

The Lower Puyallup Watershed Phase 1 Report (LPWMC 1992) summarized data collected in five subwatersheds: Commencement Bay, Hylebos Creek, Clear/Clarks Creek, Lower White River, and Middle Puyallup River. In 1981, Commencement Bay was grouped within the 10 highest priority hazardous waste sites in the United States. The USGS did extensive testing in 1983-84 and found problems with dissolved oxygen in Fife Ditch which never met the 6.5 mg/L DO standard and values measured were as low as 1.5 mg/L. Tetra Tech (1985) also found extensive contamination in the Port of Tacoma waterways.

Extensive monitoring of the Hylebos Creek watershed (East and West Branch Hylebos Creeks) occurred in the mid- to late-1980s, including work by USGS (1987), Ecology (1990), KC SWM (1990), and PCD (1990). Elevated water quality parameters included fecal coliforms (geometric mean of 751 org/100mL), total phosphorus, total suspended solids (32% of samples exceeded 50 mg/L threshold with a mean of 58 mg/L), and toxicity exceedances for copper, lead, and zinc. King County SWM identified metals as the most significant water quality problem in West Branch Hylebos Creek (KCSWM 1990). Wapato Creek had temperature readings that were as high as 24.5^{o}C and DO readings that regularly were below 8 mg/L and as low as 0.9 mg/L. PCD found median fecal coliform levels of 2850 org/100 mL.

Pierce County monitors standard water quality parameters monthly in a number of streams within the Puyallup Watershed. These parameters include DO, pH, fecal coliform, total suspended solids, conductivity, nutrients (phosphorus and nitrogen), and turbidity. This data is available at www.piercecountywa.org/watershedhealthdata.

8.2 THREATS TO WATER QUALITY

This sub-section focuses on the major threats to water quality including broad categories such as point source and nonpoint-source pollution. Point sources of pollution enter receiving waters through a pipe, ditch, channel or other well-defined conveyance. Nonpoint source pollution enters water from dispersed land-based or water-based activities. Point source pollution includes discharges from wastewater treatment plants, industrial discharges, and stormwater runoff. Nonpoint sources include agricultural, construction, timber harvesting, mining, on-site sewage disposal, and marina/boating sources. The nonpoint action planning process (WAC 400-12) applied widely in Washington State from the late 1980s through the early 2000s, focused on the following types of nonpoint source pollution: farm practices, stormwater and erosion, on-site sewage disposal, forest practices, marinas and boats, and other sources.

Point sources of pollution in the Puyallup watershed include fish hatcheries, wastewater treatment plant discharges from the Tacoma central and City of Puyallup plants (located on the Lower Puyallup River), City of Sumner treatment plant (located on the Lower White River), City of Orting plant (located on the Middle Puyallup River), City of Buckley plant (White River), and treatment plants operated by the cities of Carbonado, Wilkeson, and Enumclaw, Town of South Prairie, and Rainier School. There are also many industrial discharges requiring point-source NPDES permits, including Simpson Tacoma Kraft pulp and paper mill.

8.2.1 Threats identified by Puyallup/Commencement Bay Scientists

In 2008, a panel of scientific experts was convened to assess threats in the Puyallup/ Commencement Bay watersheds relative to the health of Puget Sound (Pierce County 2008). Two of the seven threats they identified as the most significant were related to water quality, including:

- Stormwater impacts on natural systems – hydrologic alteration of streams and delivery of pollutants/toxics to receiving waters causing impacts on freshwater, estuarine and marine ecosystems
- Nonpoint source pollution – water quality impacts from urban activities, transportation (vehicle usage), septic systems, agricultural and forestry activities

A complete list of water quality threats identified by the panel of experts is presented in Table 8.3

In the final portion of the workshop, the scientists were asked to identify the ecological significance of these threats and their level of confidence in our ability to address these threats with various programs. The scientists identified six solutions or approaches, two of which address water quality issues:

- Ban or substantially reduce phosphorus products, phthalates and copper products; use public education to reduce pollutant sources
- Use Low Impact Development (LID) techniques and approaches on new development and redevelopment to address stormwater impacts, reduce flooding and recharge groundwater

Table 8.3 – Water Quality threats, stressors and problem areas in the Puyallup/Commencement Bay Watershed

Key Threats	**Causes (Stressors)**	**Problem Areas**
Pathogens, bacteria (indicator: fecal coliforms) - levels over WQ standards impacting human health	Onsite septic systems; leaking sewer systems; animal waste management; wild animals	Boise Creek; Clarks Creek; Clear Creek; Commencement Bay; Fife ditch; Hylebos Creek; WF Hylebos; Meeker Ditch; Puyallup River; Swan Creek; Unnamed Creek; Wapato Creek; White River; Urban developed areas
Temperature (increased water temperatures impacting salmonids)	Loss of riparian cover; land conversion; impervious surfaces; groundwater withdrawals; surface water diversions	Boise Creek; Clearwater River; Fox Creek; Kings Creek; Lyle Creek; Milky Creek; Scatter Creek; White River
Dissolved Oxygen (low DO	Wastewater discharges;	Commencement Bay; Fife ditch;

impacting salmonids)	Increased temperature conditions; sediment oxygen demand; animal waste	Wapato Creek; Puyallup River
Nutrients (eutrophication)	Wastewater discharges; onsite septic systems (that do not treat for nutrients - N, P); stormwater discharges; fish hatcheries; construction sites; animal waste; (I&I) inflow and infiltration	Fife ditch;
Turbidity and sediment transport	Construction site runoff; agricultural activities; instream erosion; scour caused by high flows; glacial meltwater; steep slopes/landslides	Upper White River; Lower Puyallup River; White River at Mud Mtn. Dam
Metals, organics, EDCs, pharmaceuticals	Automobiles; pesticide/herbicide applications; industrial and commercial activities; hazardous wastes; wastewater discharges (due to inadequate treatment)	Inner and outer Commencement Bay (tissue); Dalco Passage/Poverty Bay; Hylebos waterway
Contaminated marine and estuarine sediments	Shoreline development; historical contaminant dumping; industrial discharges; stormwater discharges; Asarco	Commencement Bay;

8.2.2 Threats identified by the Puget Sound Partnership Action Agenda

The Puget Sound Partnership Action Agenda (2008) identified everyday activities of humans as the source of Puget Sound's decline. Sources of water pollution were identified as one of the three main problems contributing the degraded health of Puget Sound. The report noted that this is caused in part by "how we have covered up the land with houses, buildings and parking lots; how we live and prosper; how we treat our waste; and how we transport ourselves."

One of the priorities identified was to **prevent water pollution at its source.** Many of our efforts have focused on cleaning up degraded waters and sediments, but insufficient resources have been devoted to stopping pollutants before they reach our rivers, beaches, and species. They went on to say we need to control and manage stormwater runoff in an integrated way with protection of vegetated land cover and reduction of pollutants before they reach water. Many Puget Sound citizens and science groups have emphasized stormwater runoff as a major threat to ecosystem health. The Action Agenda includes large-scale regional approaches that call for: the creation of consistent protection and restoration standards for the region; reducing pollutant inputs at the source; prioritizing and retrofitting existing stormwater management facilities (particularly in areas that were urbanized long ago); and ramping up low impact development techniques in urbanizing areas.

8.3 CURRENT WATER QUALITY IMPROVEMENTS UNDERWAY

Over many decades work has been done to improve water quality. In the past the focus was on removing pollution that was regulated such as direct discharges to the water via pipes and outfalls. The National Pollutant Discharge Elimination System (NPDES) Program has regulated those discharges for 40 years. The more difficult pollution to control is non-point pollution. This pollution comes from daily activities such as walking the dog, washing the car, changing your own oil, and small hobby farm operations. All of these activities can contribute to pollutants entering the stormwater drainage system (pipes, ditches, etc.) and our natural waterways without treatment to remove pollutants.

The Department of Ecology is responsible for writing Total Maximum Daily Load (TMDL) Reports for waterways that have been listed as impaired on the federal 303(d) list. There are currently six TMDLs in the Puyallup River Watershed they are:

Upper White River Sediment and Temperature TMDL

The Upper White River TMDL was completed in 2004, and the implementation report was completed in 2006. The recommendations in the implementation plan were to plant riparian areas and remove forest service roads.

Most of the recommendations in the implementation plan were assigned to the US Forest Service (USFS). They are decommissioning roads as funds allow and plantings have occurred, but it takes time to grow trees to a level where they will produce effective shade.

Lower White River pH TMDL

Several areas of the White River are on Washington State's list of polluted waters (303(d) list) for pH. Past studies have documented excursions of the upper pH criteria (8.5) and suggest these conditions are the result of nutrient inputs to the river.

To develop a TMDL for the river, the Washington State Department of Ecology (Ecology) conducted a series of water quality surveys between August and October of 2012. Ecology will use this data to develop and calibrate a numerical water quality model of the river to simulate continuous pH and other water quality parameters.

This TMDL is being developed with a Memorandum of Agreement between the Muckleshoot Tribe, Ecology, and EPA. A draft technical report will be available in July 2015.

Puyallup River Fecal Coliform Bacteria TMDL

Ecology worked with many different local governments, citizens groups and permit holders to come up with actions to reduce fecal coliform inputs in the Puyallup River Watershed. The resulting water quality improvement report (WQIR) contains the results of the TMDL study and an implementation plan. The plan identifies implementation activities for various partners, many of which are already underway. After Ecology addressed the comments received and the appropriate updates were made, we submitted the final WQIR to EPA for approval on June 30, 2011. EPA approved the TMDL on September 20, 2011.

Some of the projects underway are:

Phase I and Phase II communities are working on illicit discharge detection programs to minimize fecal contamination reaching streams through stormwater conveyances;

The King and Pierce County Conservation Districts are working with local farmers to minimize manure reaching streams.

Bowman and Pussyfoot Creeks are currently being monitored by Ecology to determine fecal coliform sources.

Clarks Creek Fecal Coliform Bacteria TMDL

Ecology, working with local governments, developed a draft water quality improvement report. The report consisted of a study outlining the nature of the fecal coliform impairment, with recommendations on how much fecal coliform input to Clarks Creek would need to be reduced so that the creek would meet state water standards. The TMDL also included an implementation strategy on how to reduce the amount of fecal coliform entering Clarks Creek.

After holding a public comment period Ecology reviewed and responded to comments received, then submitted the final WQIR to the EPA. The EPA approved the WQIR on June 4, 2008.

Ecology, working with residents, local jurisdictions, and other interested parties, then developed a draft implementation plan (WQIP). This plan described how the implementation activities discussed in the WQIR will be carried out. Ecology held a public comment period to review the draft implementation plan. After addressing the comments, the finalized implementation plan was sent to EPA on December 23, 2009.

Stakeholders have been working towards keeping fecal coliform from reaching Clarks Creek. Riparian plantings, programs to keep residents from feeding ducks at DeCoursey Pond, and frequent stormwater sweepings are some of the implementation actions underway.

South Prairie Creek Fecal Coliform and Temperature TMDL

Ecology performed a total maximum daily load (TMDL) study on South Prairie Creek. The study recommended various strategies to control fecal coliform and improve the water temperature, along with monitoring to check the progress of the strategies to help the creek meet state water quality standards. A water cleanup plan, or TMDL, which includes the study and an implementation strategy, was submitted to EPA. After EPA approved the TMDL, Ecology worked with local governments, tribes, and local interest groups to develop a detailed implementation plan, which was also sent to EPA. The detailed implementation plan spelled out what would be done to act on the recommendations in the study. Implementation activities began in 2006.

Ecology conducted follow-up monitoring on two tributaries of concern. Monitoring found unusually high levels of fecal coliform bacteria at a drain tile leading into a tributary to Inglin creek. A Pierce County Health Department investigation uncovered a septic system failure in the area. It was corrected as of January 2010. Monitoring verified that the fecal coliform load from the septic system has been eliminated.

Currently we still do not meet the fecal coliform water quality standards on the tributaries of South Prairie Creek. Ecology will continue to try to find where the sources are coming from.

Clarks Creek Dissolved Oxygen and Sediment TMDL

Ecology, working with the Puyallup Tribe and EPA, determined that there are human-caused sources of low dissolved oxygen. A TMDL was initiated in October 2010 using stormwater reductions to improve dissolved oxygen. To improve conditions in Clarks Creek, action is needed to reduce elodea (an aquatic weed) density, decrease sediment and nutrients that come into Clarks Creek from urban stormwater, improve instream habitat, and increase native tree and shrub canopy cover to shade the stream.

Some of the key targets to improve water quality and habitat in Clarks Creek include the following:

- Reducing the amount of elodea in Clarks Creek
- Increasing streamside shade
- Reducing urban stormwater in Clarks Creek
- Reducing sediment inputs into Clarks Creek

Stakeholders have been meeting for about 3 years to work out a plan. A final TMDL is scheduled for mid-2014.

8.4 PARTIES ENGAGED IN WATER QUALITY ISSUES

The main parties engaged in water quality issues in this watershed include the following:

Local governments: Pierce and King Counties; Tacoma, Fife, Puyallup, Sumner, Auburn, Orting, Port of Tacoma

Tribes: Puyallup and Muckleshoot tribes

Other local entities: Pierce and King Conservation districts; Tacoma Pierce County and Seattle-King County health departments, water purveyors

State and Federal Agencies: WA Depts. of Ecology and Health, Puget Sound Partnership, EPA

Businesses: particularly those with industrial wastewater or stormwater discharge permits

Non-profit groups: Puyallup River Watershed Council, Citizens for a Healthy Bay, People for Puget Sound, local watershed or "friends of" groups, The Russell Family Foundation

8.5 WHAT CAN YOU DO TO HELP THE PUYALLUP WATERSHED

Pollution generated by everyone's daily activities, such as not picking up dog waste, spraying chemicals in our yards, and letting car wash water run down storm drains, – has a devastating effect on the quality of our water. With the many impairments that plague the Puyallup Watershed you may ask, what can I do to help?

There are many things that the average citizen can do to assist in the improving the watershed. Some things start with our own habits. A large part of the pollution we experience in the watershed are nonpoint sources; pollution that comes from our daily activities. We all make choices that affect the environment we depend upon, and cumulatively they add up to big effects.

Simple things we can all do to help protect water quality:

- Recycle (motor oil too!)
- Carpool, bus, bike, walk
- Pick up pet waste
- Install low-flow devices in toilets, showers and faucets
- Maintain your car
- Maintain your septic system

- Avoid toxic products
- Reduce fertilizer and pesticide use
- Take your car to a carwash instead of washing it in the street
- Plant native plants in bare areas susceptible to erosion
- Keep farm animals away from creeks, and manage manure
- Get involved in a water cleanup planning effort in your watershed
- If you live in a community with a Homeowners' Association, support the Association's maintenance of your stormwater ponds, catch basins, and infiltration swales

There are also many different volunteer opportunities around the watershed. You can sign up to help with a rain garden installation, a riparian restoration planting, or join a "friends of" group. Check the Puyallup Watershed Council website for current opportunities in your area http://puyallupriverwatershed.com/.

CHAPTER NINE
FLOODING AND FLOODPLAIN MANAGEMENT

The Puyallup watershed has hundreds of miles of rivers and streams with corresponding floodplains. As the word implies, a floodplain is the surrounding flat area that is periodically flooded with water in excess of a river or stream channel's capacity. Floodplains are pressure-release mechanisms for rivers when large amounts of precipitation, falling mostly as rain, occur in a short period of time. In November 2006, for example, 18 inches of rain was recorded at Paradise on Mt. Rainier during a 36-hour period. The result was significant flooding of the three major rivers of the Puyallup watershed (Puyallup, White, and Carbon) draining large areas downstream of the mountain.

Of the myriad of floodplain processes that are critical to a river's structure and ecological function, the most prominent and important is flooding. Flooding triggers recruitment and transport of sediment and woody debris, recharge of shallow aquifers in the floodplain and channel migration. These processes help to create side channels, wetlands, and other complex valley floor topographic features which help to dissipate a river's powerful erosive forces. Floodplain processes also create diverse aquatic and riparian habitats that sustain productive and diverse native plant, fish and wildlife populations. Biological responses such as plant community succession, fish and wildlife reproduction, rearing, migration, and refuge are aided by habitat-forming processes of floods in floodplains.

9.1 OVERVIEW OF PUYALLUP WATERSHED FLOODING

Major river flooding is natural, occurring when heavy rainfall falls over a large watershed, but extensive floodplain development by humans over the past century and in particular during the past several decades has put substantial public infrastructure and private structures at risk. Levees and revetments built along the major rivers have contributed to floodplain development and also adversely impacted aquatic and riparian habitat, disconnecting side-channels, tributaries and floodplains.

Over the 20-year period from 1991-2011, there were three large floods that caused substantial damage in February 1996, November 2006, and January 2009. During this same period, the total cost of the river management program and estimated damages to public and private property in Pierce County, resulting from flooding and channel migration, exceeded $155 million (Pierce County 2013). The vast majority of this cost was in the Puyallup watershed on the Puyallup, White and Carbon rivers.

The Puyallup, Carbon and White rivers behave differently than many other rivers because they originate from glaciers on the slopes of Mt. Rainier. As the glaciers move downslope, they erode the terrain, pick up rocks and gravel, and finer sediment and transport these materials downstream. When steep river channels meet broad, flat, valley floors, flow velocities decrease, and the ability of the rivers to move sediment is reduced.

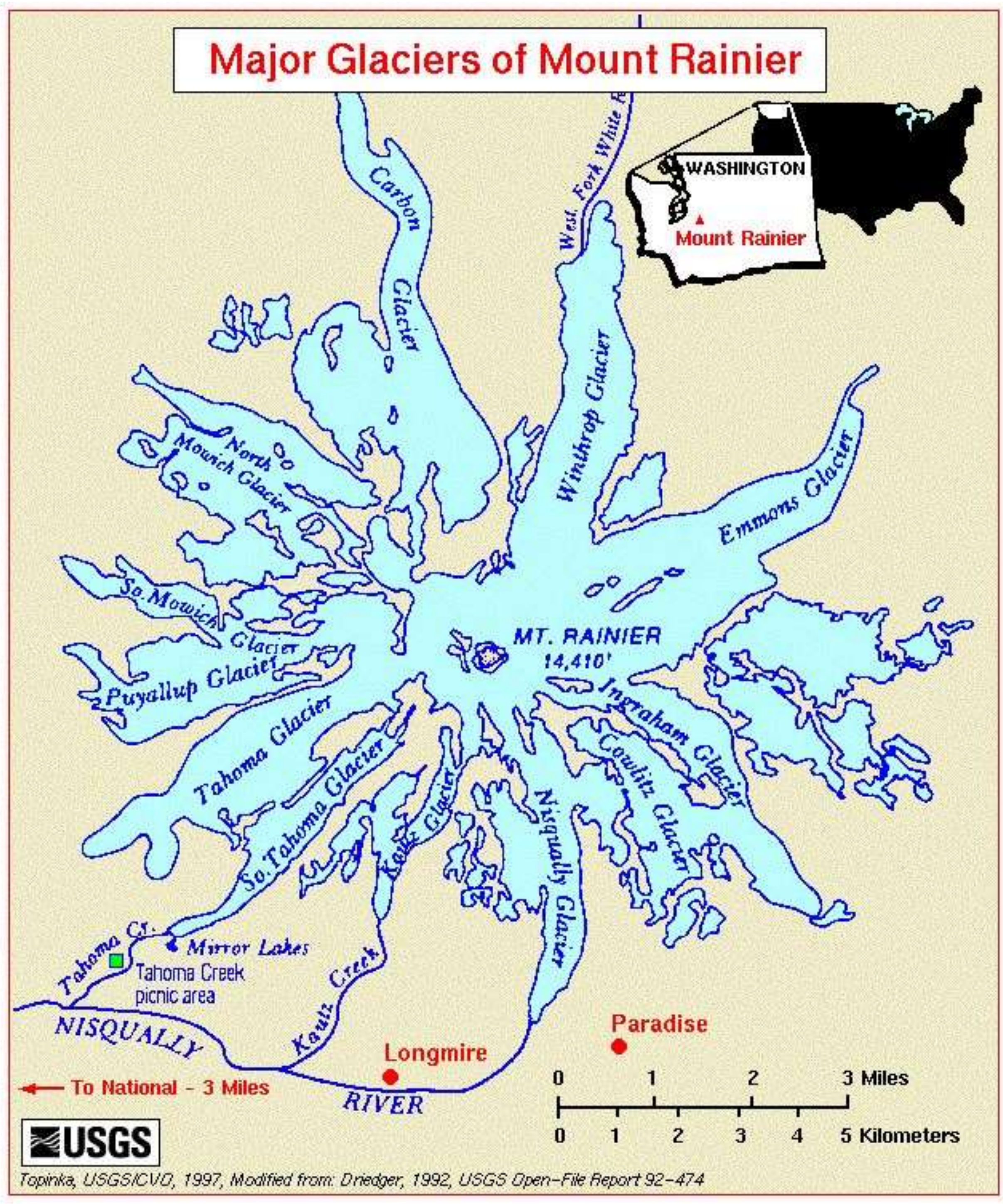


Figure 9.1 – Glaciers of Mt. Rainier

Throughout history, flooding has been a natural characteristic of the climate, topography, and hydrology of the Puyallup watershed. In the relatively short time period since European settlement began in the mid-1800s, the floodplains have been developed extensively. By 1931, most of the Puyallup River valley and surrounding hills had been harvested for timber and the valley was cleared for agriculture northward of river mile (RM) 24, near the old Ford farm, upstream of Orting (GeoEngineers 2003). In the 1930s and 1940s, rip rapped levees and revetments were constructed to prevent migration of river channels through agricultural lands. The approach to river management changed in the 1960s. Extensive portions of the middle and upper Puyallup River and Carbon River were straightened and confined with levees and revetments, decreasing channel width to an average of 250 feet (GeoEngineers 2003). The new levees changed land use practices in many areas adjacent to the river. Residential developments now occupy portions of the historical zone of channel occupation. The conversion of lands from rural to suburban land use started in the 1970s and continued into the 2000s with conversion of large tracts of farmland (formerly floodplain) to residential, commercial, or industrial development.

Major flood events in the Puyallup River watershed result in two types of flood hazards: flooding and channel migration. Flooding consists of overbank flow, levee overtopping or breaching that inundates the floodplain in areas not normally covered by water. The flooding of February 1996 was the worst that Pierce County has faced, with flows on the Puyallup River reaching nearly 47,000 cubic feet per second (cfs). Estimates by the Corps of Engineers indicate that the Puyallup River flows in the lower valley would have exceeded 75,000 cfs, without the flood control at Mud Mountain Dam.

9.1.1 Floodplain Management in the Puyallup Watershed

Pierce County, in its recently developed flood plan established the following goals for floodplain management:

- Reduce risks to life and property
- Implement flood hazard management activities in a cost-effective and environmentally sensitive manner
- Support compatible human uses, economic activities, and improve habitat conditions in flood-prone and channel migration areas

A key challenge of floodplain management efforts is to reduce risks to public safety, reduce public and private property damage while improving habitat conditions and protecting/ maintaining the regional economy.

CHAPTER TEN
RESOURCE LANDS (FORESTS AND AGRICULTURE)

This chapter focuses on resource lands, including the current forest and agricultural land base. Working resource lands benefit the public by providing food and wood products while helping to prevent flooding of rivers, protecting water quality, providing open space, offering passive recreation experiences, and serving as a buffer between developed lands and other natural areas.

10.1 FOREST LANDS

The Puyallup River watershed has some of the best forest growing conditions in the country; a major reason for European settlement of the watershed. The watershed has a long history of commercial timber harvest beginning in the 1850s and the first commercial lumber mill was built in 1852. The invention of steam donkeys (steam-powered engines to haul logs with winches) and the arrival of railroads in the late 1800s stimulated the commercial logging industry. By 1905, Commencement Bay was lined with mills and the timber industry was key to Tacoma's economy.

Timber harvesting has been an instrumental part of the local economy for over 150 years. During the 1940s through the 1970s, major logging activities occurred in the upper watershed with significant logging road construction and impacts to riparian habitat. State and federal policy changes enacted in the 1980s and 1990 greatly restricted timber harvest on state and federal forestland. While also reduced on private forestland, timber harvest continues to be an important source of revenue and jobs, especially in rural, timber-dependent towns within the watershed.

The watershed has more than 400,000 acres of forestland. The vast majority of forestland is located in the upper watershed. About half of this forestland is privately and/or Tribal owned and actively managed for timber. Much of the remaining half is owned and managed by the federal government, including Mt. Rainier National Park and wilderness areas.

The lower reaches of the watershed are highly developed and much of the land base has been converted to urban development. The urban forest canopy, smaller forested area, forested parks, and street trees, are often highly valued due to their proximity to populations centers and environmental benefits. In a recent survey of Pierce County residents, 82% of survey participants believe "retaining trees and wooded areas for beautification, clean air, and public enjoyment" and 81% believe "open space such as farmlands, working forests and other natural areas" are important or extremely important.

10.1.1 Forest Ownership

Forestland ownership falls under three primary ownership types: (1) local, state and federal governments; (2) private industrial; and (3) private non-industrial.

The U.S. Forest Service manages 142,162 acres of forestland within the watershed – 109,837 acres within the Mt. Baker-Snoqualmie Forest District (16,133 of those acres are located within the King County portion of the watershed). Almost all of this forestland is designated “Late-Successional Forest Reserve” which is managed to provide habitat for species, such as the northern spotted owl, associated with older forests. Some timber harvest occurs in these areas (e.g., thinning), but occurs only to help meet habitat management goals. Timber harvest from the Mt. Baker-Snoqualmie Forest District has been reduced by more than 90 percent since the early 1980s. The USFS also manages 32,324 acres within wilderness areas (Norse and Clearwater) in the watershed.

Approximately 130,000 acres of Mount Rainier National Park is within the watershed. Ninety-seven percent of the park is designated wilderness. The park is managed for stewardship of the natural resources while providing a range of visitor experiences.

Private industrial timber companies own large tracts of land which is managed primarily for the production of timber products. Industrial timberlands also provide a broad range of public benefits including hunting, recreation, non-timber forest products and wildlife habitat. The largest industrial forestland owner is Hancock Timber Resources which owns approximately 96,600 acres in the watershed. Other major industrial forestland owners include Longview Timberlands, Manke Timber Co., and the Muckleshoot Indian Tribe.

Approximately 18% of the private forestland in the watershed is owned by small forest landowners. The state defines a small forest landowner as someone who harvests less than 2 million board feet per year on average. These non-industrial forestlands generally occur at lower elevations and border urban growth areas and thus are often subjected to significant conversion pressure. Small forest landowners typically have 10-100 acres. Figure 10.1 shows the distribution of forest lands in the Pierce County portion of the Puyallup watershed.

In addition, some forestland is protected by nonprofit conservation groups, such as Forterra (http://www.forterra.org/where_we_work/protected_properties/county/pierce).

The WA State Department of Natural Resources (DNR) owns and manages a limited number of acres (near the City of Buckley). An accurate account of forestland ownership for local governments is unavailable at this time.

In 2013, the Muckleshoot Indian Tribe purchased 86,501 acres of forestland in the White River watershed from Hancock Natural Resource Group. Of that forestland, 76,901 acres are within the Puyallup River watershed. The Muckleshoot Tribe plans to manage the land for long-term sustainable timber harvest and other resources.

Overall, Pierce County has 800,881 acres of forestland. Of that, 414,955 acres are considered “working forest” providing nearly 10,000 jobs (direct and indirect). Pierce County has the second highest number of working forest related jobs in the state (Washington Forest Protection Association 2013).

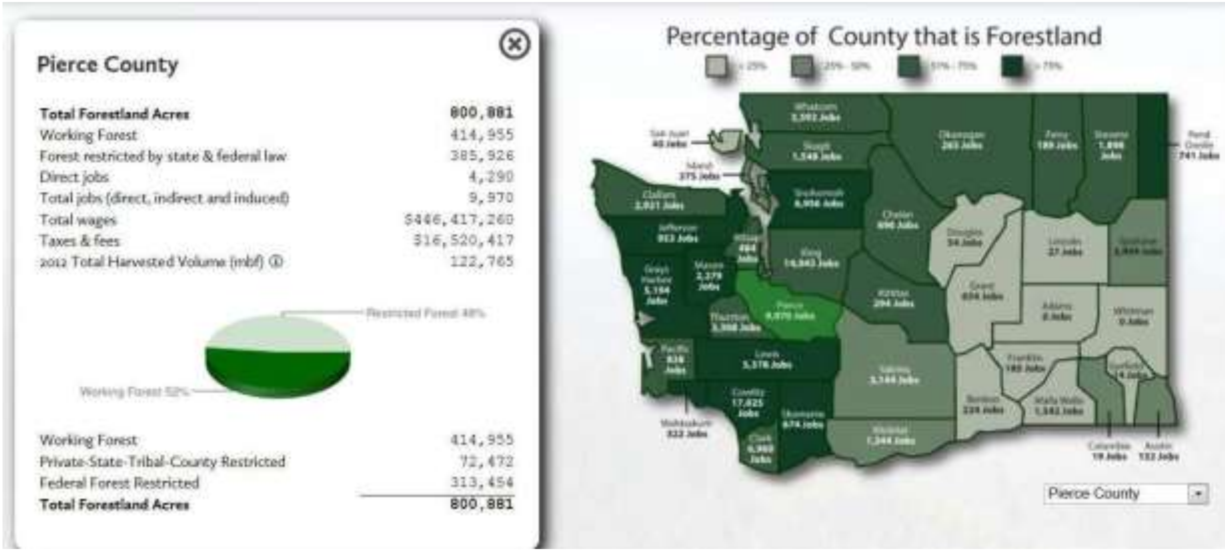


Figure 10.1 – Pierce County Total Forestland Acres and Jobs Produced by Working Forests

10.1.2 Forest Practices Regulation

Forest practices on state and private lands have been regulated since 1974 when the state adopted the Forest Practices Act. Since then, forest management activities in the watershed are regulated by both state and local regulations, based on the future use of the property.

The DNR is responsible for regulating forest practice activities on primarily all non-federal and non-tribal forestland that is not being converted for development or other non-forest use. This timber harvesting is subject to the WA State forest practices rules, but is exempt from County Development Regulations. For more information visit: http://www.dnr.wa.gov/businesspermits/forestpractices/Pages/Home.aspx

The Pierce County Planning and Land Services (PALS) is responsible for regulating forest practice activities on forestland, within unincorporated Pierce County, that is being converted for development or other non-forest use. PALS has administered County code (Title 18H – Forest Practices) since January 1, 1999. For more information visit: http://www.co.pierce.wa.us/index.aspx?nid=918

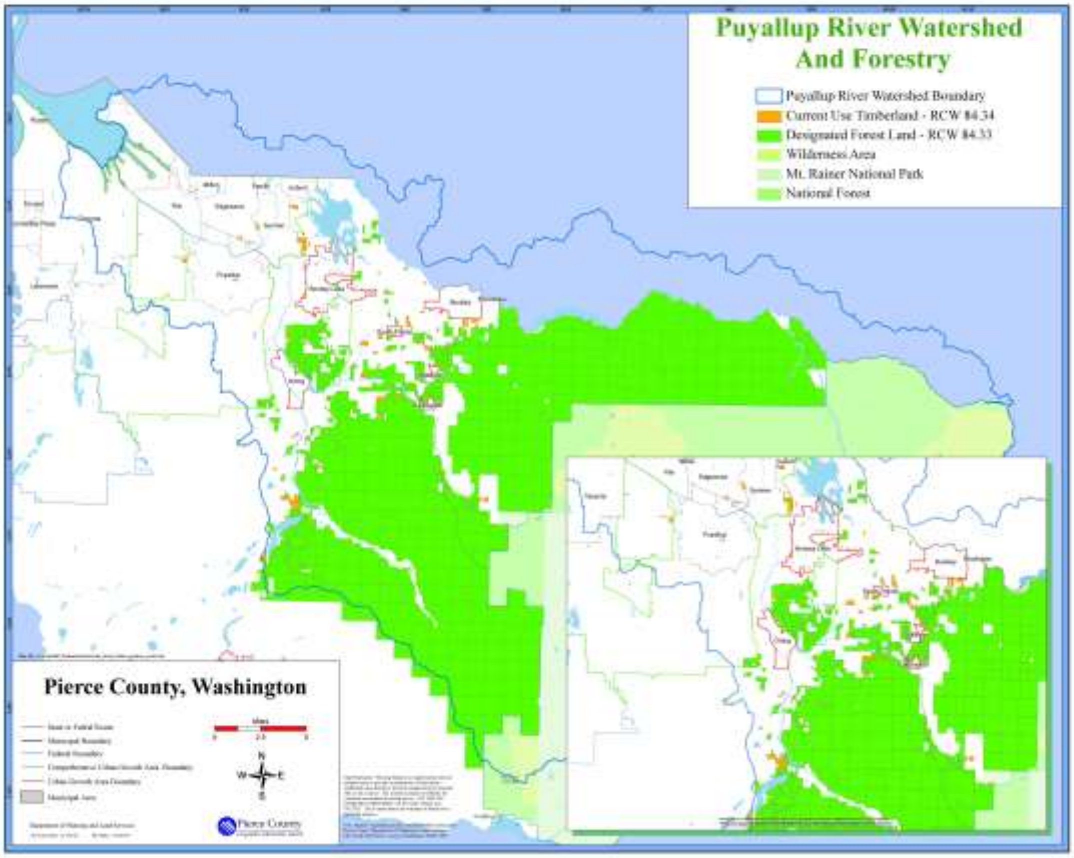


Figure 10.2 – Puyallup Watershed Designated Forest Land Zoning (bright green)

Threats and Opportunities

Healthy forestland is vital to the health of the watershed. A healthy, forested canopy provides numerous benefits such as water quality and quantity, flood reduction, and fish and wildlife habitat. The following are threats and opportunities for a sustainable, forested watershed:

- **Loss of forestland as a result of conversion to development and other non-forest uses** - In Western Washington, it is estimated that 80 acres/day is converted to non-forest uses. Maintaining land in a forestry-related land use provides many of the benefits while avoiding the impacts of an urbanized landscape. The primary factors driving forestland conversion in Washington stem from population growth, urbanization and development, and the economic pressures felt by private forest landowners.
- **Maintaining working forests** – Working forests benefit the public by providing jobs and wood products, while also providing many of the benefits of protected forests. Ensuring that sufficient timber is available from the working forests to support long-term operations of mills in Pierce County is important for the local economy.

- **Invasive non-native plant species** are a substantial threat to forest health, especially in the near urban areas. Plant species such as English ivy can kill or topple mature trees. Himalayan blackberry can prevent establishment of young trees in open areas.
- **Need for a comprehensive assessment and analysis of forestland** - There is a need for a comprehensive assessment and analysis of forestland ownership, forest canopy cover, and federal and state regulations affecting management in the watershed. This would establish a baseline of data and maps from which to assess future progress and identify opportunities.
- **Need to promote landowner incentive programs that encourage forestland ownership** – There are state and local programs which encourage forestland ownership and improve habitat. Pierce County administers a tax program for land used for the commercial growth and harvest of trees. http://www.co.pierce.wa.us/index.aspx?NID=685. In addition, the DNR administers programs that provide financial assistance to small forest landowners to replace fish (blocking structures) (passage barriers?) and purchase riparian easements.
- **Need for education and outreach** – There is a need to increase awareness of forest benefits in order to build support and action for sustainable forest in the watershed.
- **Need to establish a Pierce County Forestry Program** – There is a need to have a forestry program staffed with foresters to advise landowners with technical needs, provide help with stewardship plans, and facilitate forest-related financial incentive programs. King County has two staff foresters providing these services to small forest landowners owning approximately 171,150 acres. Pierce County has approximately 180,364 acres owned by small forest landowners and no forestry program.

10.2 AGRICULTURAL LANDS

The Puyallup River watershed has a long history of farming dating back to the 1880s which has helped shape the culture and lands of the watershed. In the mid-1800s, subsistence farming was prevalent. By the late 1880s, hops were a valuable crop with more than 100 hop growers in the Puyallup River valley. Hop growing ended abruptly in 1892, when aphids (or “hop lice”) invaded the valley’s fields. Berries had been introduced to the valley in the late 1870s and succeeded hops as the primary cash crop, followed later by flower bulbs.

As the century turned, poultry and dairy farms appeared in the valley. Dairies were most prevalent in the 1940s and 1950s. By 1912, the Puyallup and Sumner Fruitgrowers’ Association had 1,300 members and was considered the largest association of fruit growers in the world. In 1910, daffodils were introduced in the valley and by 1927, the valley was producing 23 million bulbs and by 1929, 60 million. The type of crops grown continues to change over time. Pierce County leads the United States in rhubarb production, raising about 50 percent of the nation's supply. A majority of the rhubarb is grown in the Puyallup Valley and Sumner, which boasts itself as "Rhubarb Pie Capital of the World."   In the last five to ten years, there's been an increase in the number of small farms that grow organic fruits, vegetables and livestock.

Between 1913 and 1940s, major modifications to the Puyallup River, and its largest tributary the White River, were made to reduce flood damage to protect agriculture and other lands and property. In the 1930s and 1940s, chronic flooding led to the significant construction of levees and revetments to prevent migration of river channels through agriculture lands.

At the peak of agricultural activities in the 1940s, there were more than 160,000 acres of productive agriculture land Pierce County.   Between 1950 and 2007, the USDA Agricultural Census documents a loss of more than 115,000 acres of agriculture land, much of which was converted during the major growth spurts in the 1970s and 1980s. Today less than 50,000 acres of agriculture land remains in Pierce County with about 29,000 acres still in production.

The number of acres that are farmable and currently being farmed varies, depending on criteria used to determine acreage and source of data:

- Pierce County – Zoned Agricultural Resource Land (ARL) = **23,208 acres**
- Pierce County Current Use Farm Taxation Program = approx. **27,000 acres**
- PCD 2008 Prengrueber Study – "farmable lands" = approx. **38,000 acres**
- WSDA – 2007 Ag Census "Land in Farms"= **47,677 acres**
- NRCS "Prime soils" – soils well suited for agricultural production = approx. **200,000**

Agriculture lands in the Puyallup River watershed make up nearly 30% of Pierce County's total agricultural lands. The Puyallup Valley and the Bonney Lake-Buckley Plateau are two of the most concentrated areas of agricultural activity in the watershed. The Puyallup Valley includes the area along the Puyallup River from near the City of Orting to Commencement Bay. The valley supports about 4,900 acres of productive agriculture land. The valley leads Washington State in the production of cabbage, lettuce, and many other vegetables, berry fruits and nursery plants. The Bonney Lake-Buckley Plateau area lies roughly between Buckley, Bonney Lake, Carbonado and the Muckleshoot Reservation. About 3,700 acres of this area is used for agriculture activities.

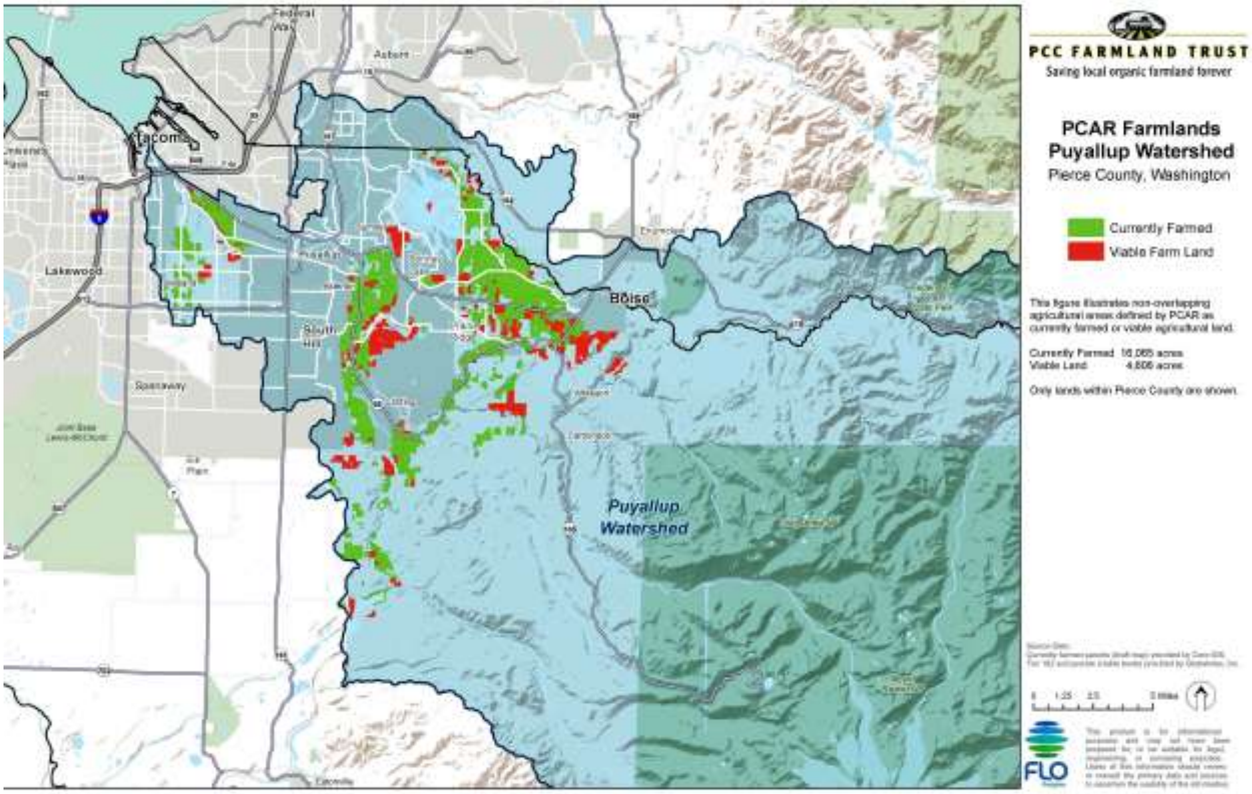


Figure 10.3 – Currently Farmed and Viable Farm Land in the Puyallup watershed. (See also Figure 11.5)

Agriculture Lands and Land Use Zoning Designations

The Washington State Growth Management Act requires Pierce County to designate three types of resource lands through its County Comprehensive Plan; forest lands, agricultural lands, and mineral lands. Pierce County adopted criteria and established an Agricultural Lands land use designation through its 1994 Comprehensive Plan. The focus of the initial criteria was on existing farming activity. Approximately 17,900 acres were designated as Agricultural Lands countywide.

In 2004 the County revised its agricultural lands criteria and replaced the Agricultural Lands designation with a new resource designation, Agricultural Resource Lands (ARL). The revised criteria emphasize prime agricultural soil with high productivity yields, with or without existing agricultural activity. The result being 23,028 acres designated as ARL countywide. Approximately 45% (10,392 acres) of the ARL designated lands is located within the Puyallup River watershed. The ARL land use designation is implemented through the Pierce County Development Code as Agricultural Resource Lands zoning classification.

The Pierce County Comprehensive Plan also establishes a rural land use designation focused on agricultural preservation, Rural Farm (RF). This designation is intended to extend the benefits of the ARL designation to parcels with existing agricultural activity absent the specified prime soils/yield. This land use designation has been incorporated through the adoption of community plans, and thus is not currently applied countywide. Approximately 1,200 acres within the Puyallup River watershed are designated as RF.

Threats and Opportunities

Healthy, sustainable agricultural land and a thriving agriculture industry are vital to the health of the watershed. A key to this is maintaining both agriculture land in active production, infrastructure and local markets and a community of farmers. Agricultural land can provide positive environmental and open space benefits. Agricultural land and activities can also negatively impact water quality and fish and wildlife habitat. The following are threats and opportunities for a maintaining sustainable agriculture lands in the watershed:

This land is farmed by diversified small- to mid-scale sized operations producing vegetables, fruits, eggs, meats, nursery products and more. The economic viability of local agriculture is often challenged by regulations, changing regional and global markets and an aging farmer population. Farmland is also at risk of conversion for non-farm uses.

However, prime agricultural soils and close proximity to markets present great opportunity to Pierce County's farm industry. New farmers are joining long-term producers to grow diversified, value-added and innovative products. The development of new market channels and increased consumer demand for local products provides new sales outlets. Additionally, numerous organizations throughout the watershed, county and western Washington are working to provide support and tools for farmers to increase profitability and more successfully and affordably transfer farmland to a next generation.

CHAPTER ELEVEN
KEY WATERSHED FEATURES

This chapter summarizes in map and descriptive form the key watershed features in the Puyallup watershed that are focus areas for protection and management. Based on overall knowledge about the watershed, data from technical reports, and information contained in the watershed assessment, these are areas of importance as (1) salmon strongholds, (2) water quality protection and improvement, (3) floodplain management, (4) agricultural preservation, and (5) forest resource management.

11.1 SALMON STRONGHOLDS AND FOCUS AREAS

The White River spring Chinook population is identified as a primary population for Puget Sound Recovery by NOAA Fisheries, the Puget Sound Regional Implementation Technical Team (RITT), and the Puget Sound Partnership. White River spring Chinook are the only spring Chinook stock existing in the Puget Sound region and are unique due to their genetic and life-history traits (WDFW et al. 1996)

The majority of documented spawning occurs in the larger clear water tributaries to the White River, including the Greenwater and Clearwater rivers, and Huckleberry and Boise creeks. Some mainstem spawning in the Upper White River has also been documented by PTF biologists via radio telemetry studies (Ladley et al. 1996).

Documented Chinook redds and adults (dead plus live fish) are shown in Table 11.1.

Table 11.1 – Chinook Redds and Adults (Live + Dead) Ranges for 2000-2008 (from PTF, 2009)

River/stream	Redds (annual range)	Adults
Clearwater River	29-139	91-350
Greenwater River	25-318	117-729
Huckleberry Creek	5-84	24-437
Boise Creek	27-325	170-1520
White River (check with Russ p. 127)	1-117	10-299

Note: Boise Creek contains both fall and spring run Chinook

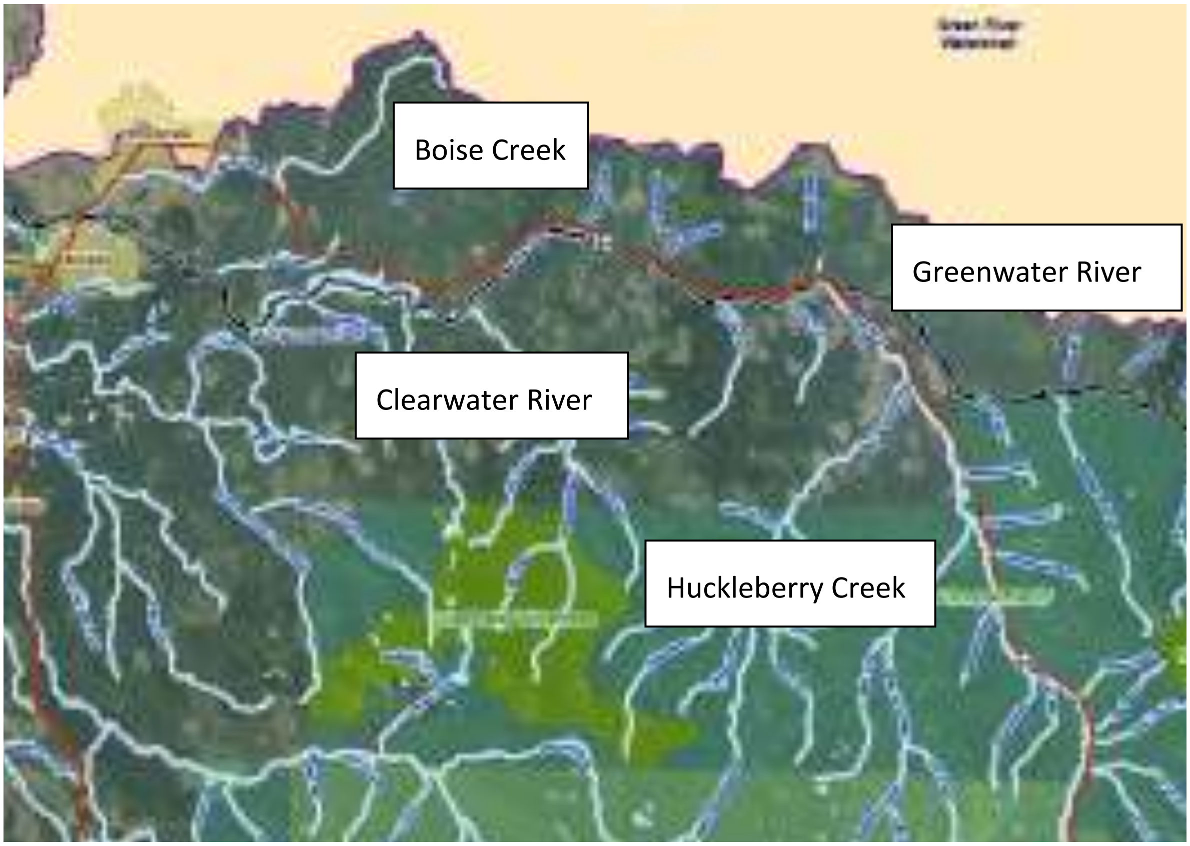


Figure 11.1 – Spring Chinook spawning areas in the White River basin (Greenwater and Clearwater Rivers, Huckleberry and Boise creeks)

The Salmon Habitat Protection and Restoration Strategy for WRIA 10 (Puyallup watershed) (Pierce County Lead Entity 2012) identifies protection and/or restoration on presently functional salmon streams, including: South Prairie Creek and its tributaries, Boise Creek, Greenwater River, Huckleberry Creek and Clearwater River as near-term high priority actions. The high-priority areas for restoration in WRIA 10 are the lower and middle Puyallup River, the lower White River, the lower Carbon River, and the Puyallup estuary.

South Prairie Creek, the primary tributary to the Carbon River, is the most important salmonid spawning area in the Puyallup watershed, producing nearly half of all the wild steelhead in the Puyallup River system, the only significant run of pink salmon, and important returns of Chinook, Coho, chum salmon and sea-run cutthroat trout (Kerwin 1999). South Prairie Creek has acted as refugia for salmonids and it's the major source of natural salmonid fish production in the Puyallup River system (Kerwin 1999). South Prairie Creek also has a very high productivity for Chinook salmon.

The PTF report (2009) documents Chinook redds and adults in South Prairie Creek from 1998-2008. The range of annual redd counts is from 27-503, and the range of adults counts (live + dead) is 262-1,465.

11.1.1 Restoration Priorities for Salmon Habitat

The WRIA 10/12 Lead Entity strategy identifies levee setbacks, estuarine habitat creation, and correction or removal of upstream and downstream migration barriers as the most beneficial types of restoration actions needed for recovery of Chinook in the Puyallup watershed (WRIA 10). Restoration of habitat diversity (including pool/riffles and large woody debris) and riparian conditions in tributary streams is another priority.

Levee setbacks can result in re-connecting large areas of floodplain to the mainstem river. They allow natural processes to create side-channel and off-channel habitat areas. Oxbow and off-channel habitat reconnections can provide similar benefits by providing water and fish access to existing habitat. Improved upstream fish passage at the Buckley diversion dam, screening the Electron diversion dam, and removal of other artificial barriers are high priorities.

11.2 WATER QUALITY FOCUS AREAS

Based on the information summarized in Chapter 6 and the input from water quality experts in the Puyallup watershed (including the Puyallup Tribe, Pierce County, Department of Ecology, Tacoma-Pierce County Health Department, and Citizens for a Healthy Bay), the following types of systems were identified as warranting particular focus.

1. Streams and rivers with high risk to salmonids
2. Areas with high risk due to bacteria contamination
3. Areas with TMDL implementation plans

The following five geographic focus areas were identified:

11.2.1 South Prairie Creek

South Prairie Creek has some of the best salmonid habitat in the Puyallup River system. It also has a great diversity of salmon, including steelhead in the Puyallup River system, the only significant run of pink salmon, and important returns of Chinook, Coho, chum salmon and sea-run cutthroat trout. South Prairie Creek has a moderately high B-IBI score (average of 33 between 2001 and 2010). South Prairie Creek is listed as impaired for bacteria and temperature and a TMDL was developed in 2003 (Ecology 2003) and a detailed implementation plan in 2006 (Ecology 2006). For these reasons, South Prairie Creek is identified as a high priority for both water quality protection and improvement.

11.2.2 Boise Creek

Boise Creek has some of the best salmonid habitat in the lower White River system. Boise Creek has often proven to be highly productive over the past several years despite its numerous impairments (PTF 2009). A good deal of the lower 4.5 miles of the creek provides suitable habitat for several anadromous and resident species including spring and fall Chinook, coho, pink, sockeye, steelhead and cutthroat trout (PTF 2009). Boise Creek has a moderately high B-IBI score (average of 34 between 2001 and 2012). Boise Creek is listed as impaired (303 d list) for fecal coliform (FC). In the Puyallup River fecal coliform TMDL (Ecology 2011), Boise Creek was the largest FC bacteria loading source for any tributary in the study area (King County 2012). For the above reasons, Boise Creek is identified as a high priority for both water quality protection and improvement.

11.2.3 Clarks Creek

Clarks Creek is an urban tributary flowing into the lower Puyallup River at RM 5.8. The anadromous reach of Clarks Creek is a low gradient spring-fed system (Maplewood Springs) with cool clear water. Chinook, coho, and chum are the most common species that spawn in Clarks Creek (PTF 2009). Clarks Creek has a B-IBI score classified on the upper end of poor (average of 26 between 2001 and 2010). Clarks Creek is listed as impaired (303 d list) for fecal coliform and dissolved oxygen. A Fecal Coliform TMDL and water quality implementation plan was developed in 2009 (Ecology 2009) and a TMDL for dissolved oxygen is under development. For the above reasons, Clarks Creek is identified as a high priority for both water quality protection and improvement.

11.2.4 Fennel Creek

Fennel Creek flows nearly eight miles from its source of wetlands and lowland lakes located near Bonney Lake. The lower reach of Fennel Creek, below Victor Falls, is accessible to salmon. Coho and chum are the most common spawners, with occasional Chinook, including a very large return of Chinook in 2007 (PTF 2009). Fennel Creek has a B-IBI score classified as fair (average of 29 between 2003 and 2010). Fennel Creek is listed as impaired (303 d list) for fecal coliform. In the Puyallup River fecal coliform TMDL (Ecology 2011), Fennel Creek was noted as needing a relatively low reduction in FC bacteria loading (22-26%). For the above reasons, Fennel Creek is identified as a high priority for both water quality protection and improvement.

11.2.5 Swan Creek

Swan Creek is a moderate sized tributary located within the larger Clear Creek basin. The Swan Creek basin drains a moderately developed (rural residential and recreational, Swan Creek Park) land area of 4 square miles. Chum and cutthroat trout are the most common species present, with chum spawning in the lower creek. Swan Creek has a B-IBI score classified as poor (average of 21 between 2001 and 2009). Swan Creek is listed as impaired (303 d list) for fecal coliform. In the Puyallup River fecal coliform TMDL (Ecology 2011), Swan Creek was noted as needing a moderate reduction in FC bacteria loading (54%). Swan Creek was selected by Pierce

County in 2011 for its "Raise the Grade" program in the Puyallup watershed. Pierce County is working with partners to improve water quality in terms of both bacterial and nutrient loadings. For the above reasons, Swan Creek is identified as a high priority for both water quality protection and improvement.

11.3 FLOODPLAIN MANAGEMENT FOCUS AREAS

The most flood-prone areas in the Puyallup watershed are along the mainstem rivers in the lower valleys where the river gradient flattens out and extensive development has occurred over the past century, and more recently since the 1980s. This includes three primary areas:

(1) Lower Puyallup River from river miles (RM) 3.0 to 10.4, where there is $1.8 billion of assessed value in the floodplain in the cities of Fife and Puyallup, and unincorporated Pierce County;

(2) Lower White River from RM 0.0 to 5.5, where there is over $600 million of assessed value in the floodplain in the cities of Sumner and Pacific, and unincorporated Pierce and King counties;

(3) Upper Puyallup River (from approximately RM 17 to 22) and Lower Carbon River (from RM 0.0 to 4.0) in the vicinity of Orting, where there is over $300 million of assessed value in the floodplain in the cities of Orting and unincorporated Pierce County.

The highest amount of flood insurance claims paid to date (from 1978 to 2010), according to the Bureaunet database are:

(1) Lower Puyallup (RM 0-10.4) – $4.1 million

(2) Middle Puyallup (RM 10.4-17.4) – $1.15 million

(3) South Prairie Creek (RM 0-6.2) – $188,000

Some key activities that should be promoted to reduce flood risk and improve watershed health include: (1) Setback of levees to reduce flood risk and improve habitat; (2) Adoption of consistent floodplain development regulations across jurisdictions in the watershed, (3) Acquisition of flood-prone structures/lands to permanently remove flooding and channel migration risks, and (4) Education of floodplain residents on the risks they face, how they can protect themselves during floods, and how they can avoid purchasing property at high risk of flooding.

11.3.1 Levee Setbacks to Reduce Flood Risk and Improve Habitat

The setback of levees along the lower rivers offers an opportunity to both reduce the risk of flood hazards and improve habitat through reconnection of floodplains and off-channel habitat, and restoration of natural riverine processes. Specific focus areas include:

Lower Puyallup, along North Levee Road – This includes a setback from RM 2.8 to 8.15 which incorporates both the Union Pacific and Freeman Oxbow levee setbacks – this would reduce the risk of flooding in Fife, Tacoma, and the Clear Creek area, while also improving salmonid rearing and refuge habitat along the lower river.

Lower White at the Countyline and within the City of Sumner – This includes setbacks on the left bank of the White River near the Countyline and multiple setbacks in the City of Sumner

11.3.2 Adoption of Consistent Floodplain Development Regulations Across Jurisdictions

Actions in one jurisdiction can adversely affect the frequency, duration, and magnitude of flood hazards in downstream, upstream, or adjacent jurisdictions (Pierce County 2013). Flood hazard management regulations are the basic regulatory tool to practice sound flood hazard management related to new development and redevelopment. A 2010 analysis of flood hazard regulations across the Puyallup watershed indicated significant differences across the 16 categories evaluated (Pierce County 2013). Cities and towns in the Puyallup watershed should adopt policies and regulations that are consistent for critical area regulation of flood hazard areas.

11.3.3 Acquisition of Flood-prone Structures/Lands

There are two types of acquisition that reduce flood hazard risks: (1) home or structure buyouts to remove people and structures from flood hazard and channel migration hazard areas, and (2) open space acquisition in flood hazard areas to prevent development and preserve the floodplain's capacity to support floodwater conveyance and storage, and protect habitat. These should both be priorities for floodplain management in the lower rivers of the Puyallup watershed, since they are often the most effective action for reducing long-term flood risks.

11.3.4 Education of Floodplain Residents

Flood Hazard education and outreach is an important tool that can increase awareness and motivate actions that improve public safety, reduce flood and channel migration risks, and protect natural floodplains (Pierce County 2013). This will help residents and citizens make informed decisions about property purchases, and land use, be prepared for future flood events, and know what to do during and after a flood.

11.4 NATURAL AND RESOURCE LANDS MANAGEMENT AREAS

This section focuses on priority areas for natural and resource lands management. This includes biodiversity management areas, and resources lands (forest and agricultural management areas).

11.4.1 Biodiversity Management Areas

The Pierce County Biodiversity Network Assessment (Brooks et al. 2004) identified and evaluated lands that provide the greatest biological diversity of terrestrial species (mammals, birds, amphibians, and reptiles) and provide special consideration for salmonids. The methodology used to identify the biodiverse areas was based on principles of conservation biology and landscape ecology protocols (GAP analysis) for species richness and representation as predicted by primary land cover derived from review of satellite imagery.

The Puyallup River watershed includes six of the 17 biodiversity management areas in Pierce County (see Table 11.2 and Figures 11.2 and 11.3).

A Lower White River Biodiversity Bioblitz was carried out in 2006 and 2007 http://naturemappingfoundation.org/natmap/projects/bma/lower_white_river/ and a Lower White River Biodiversity Management Area (BMA) Stewardship Plan (Dvornich and Burgess 2009) was completed in 2009.

Table 11.2 – Biodiversity Management Areas in Puyallup River Watershed

#	Name	Land area (acres)	Location/Description
4	Greenwater River	20,857	Located in north central Pierce County near Buckley. In the Southwest Cascade ecoregion and western hemlock vegetation zone.
9	Norse Peak	10,163	Located in far eastern portion of Pierce County. In East Central Cascades and Southwest Cascades ecoregions. In the western redcedar/western hemlock, mountain hemlock and alpine/parkland vegetation zones
11	Puyallup River	46,702 (not all in Puyallup watershed)	Located in south central Pierce County in the Southwest Cascade ecoregion and western hemlock vegetation zone.
15	Rainier	54,052 (not all in Puyallup watershed)	Located within Mount Rainier National Park and in the Southwest Cascade ecoregion and alpine/parkland and subalpine fir vegetation zones.
16	White River	8,586	Located in the Cascade Mountains and in the Southwest Cascade ecoregion and western hemlock and mountain hemlock vegetation zones.

17	Lower White River	1,593	Located along the White River west of Greenwater in the Puget Trough ecoregion and Puget Sound Douglas fir vegetation zone.

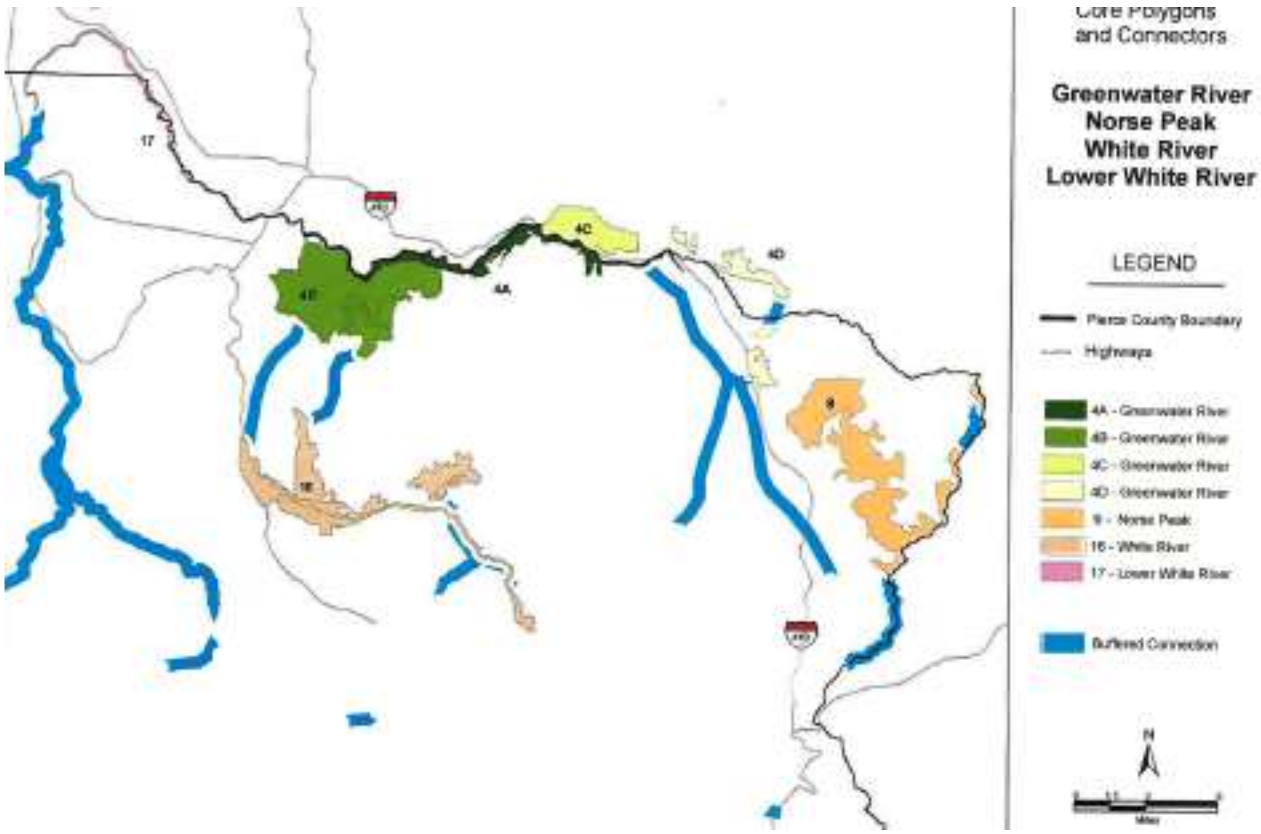


Figure 11.2 – Greenwater River, Norse Peak, White River and Lower White River Biodiversity Management Areas

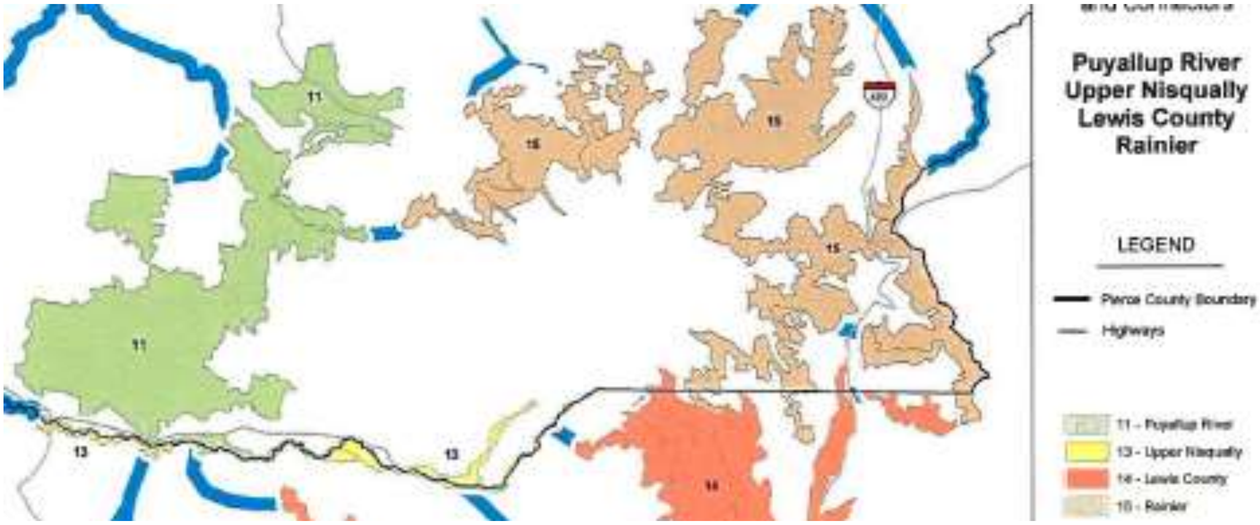


Figure 11.3 – Puyallup River and Rainier Biodiversity Management Areas

11.4.2 Forest Management Areas

Based on the information summarized in Chapter 10 and input from the Puyallup Watershed Initiative (PWI) Forest Roundtable Community of Interest (COI) participants, the following was identified as warranting particular focus.

1. **Upper and Middle Watershed**

    There is significant risk of conversion of forestland to non-forest uses in the upper and mid watershed. The area most at risk are the lands on the fringe of commercial forest lands (e.g., near Carbonado, South Prairie, Orting and Buckley). These lands have experienced significant conversion over the past 15 years due to increased interest in home ownership in rural, forested areas.

    Focus on working with interested partners, such the PWI Forest Roundtable, to maintain these lands as "working forests" through tools such as forest-related financial incentive programs, technical assistance, reinforcing county and state regulations, and development of community forest trusts will reduce the risk of conversion.

2. **Lower Watershed**

    The tree canopy coverage in the lower watershed is significantly reduced due to conversion of forestland to non-forest uses such as agriculture and commercial/residential development. Most of the urban streams have greatly reduced riparian tree canopy coverage which has led to water quality and aquatic species concerns. Most urban stream riparian areas are also impacted by English ivy and other invasive species which threaten to weaken and topple large existing trees.

> The City of Tacoma, along with other cities in the watershed, is working to increase the tree canopy coverage within their city limits. The City of Tacoma's urban forestry program is piloting a tree planting program to encourage residential landowners to plant trees in their yards. If successful, this program could be replicated in other urban areas in the lower watershed. Targeting streamside landowners should be a priority.
>
> Another focus area is to work with public entities that manage public land, such as parks, schools, and open space, to identify opportunities to increase tree canopy coverage.

11.4.3 Agricultural Management Areas

Agricultural lands in the Puyallup watershed are concentrated in the Puyallup and Orting Valleys, south of Sumner and Puyallup, and along the left bank of the Lower Puyallup River, and in the Bonney Lake/Buckley/Enumclaw vicinity (Figure 11.5). The Puyallup watershed has a history of robust agricultural activity, however farmland, especially highly productive soils in the Puyallup Valley, is under threat of conversion to other developed uses.

Crops grown in the Puyallup Valley include relatively high value horticultural (e.g., small fruits (raspberries and rhubarb), fruit trees, vegetables, and ornamental production), followed by land that supports livestock and pasture land. The per-acre value of crops varies from $2000 to $80,000 (Pierce County Rivers Flood Hazard Management Plan Economic Analysis 2010). There are 6,600 acres in the Puyallup Valley in agricultural use, but nearly 25% of this land is located within incorporated areas or within the urban growth boundary, and therefore under threat of development (Pierce County Economic Development Division 2006).

Pierce County is estimated to have lost more than 70% of its farmland between 1950 and 2007. The percent lost in the Puyallup Watershed is likely similar.

In recent years, efforts have focused on purchase of farms or development rights on farmland and preservation of farming. In 2011, the Orting Valley Farm (100 acres) was purchased by Pierce County and PCC Farmland Trust. In 2012, the Reise Farm (120 acres) near Orting at the headwaters of Ball Creek was purchased. . In 2013, the former Sturgeon property, now Dropstone Farms (95 acres) near Orting was also purchased by a new farmer with the assistance of PCC Farmland Trust.

PCC Farmland Trust has also recently completed a new study, Sustainable Agriculture in the Puyallup Valley (Globalwise/Prengrueber): http://www.pccfarmlandtrust.org/new-study-sustainable-agriculture-in-the-puyallup-valley/

Maintaining agriculture land in farming and reducing loss of farm land to development helps preserve open space, maintain quality soil, and protect the rivers and streams of the Puyallup watershed. With ongoing pressure to develop land on the urban fringe, it is important to limit urban growth into viable farm land, especially in the fertile valleys. Below is a quote from the Pierce County Executive upon the purchase of the Reise Farm (Puyallup Patch 2012):

> "This is prime agricultural soil, and agricultural preservation and sustainability are a priority for our citizens and county," said Pierce County executive Pat

McCarthy. “We have the best soil in the state and must continue to provide locally-grown food for our citizens, into the future.”

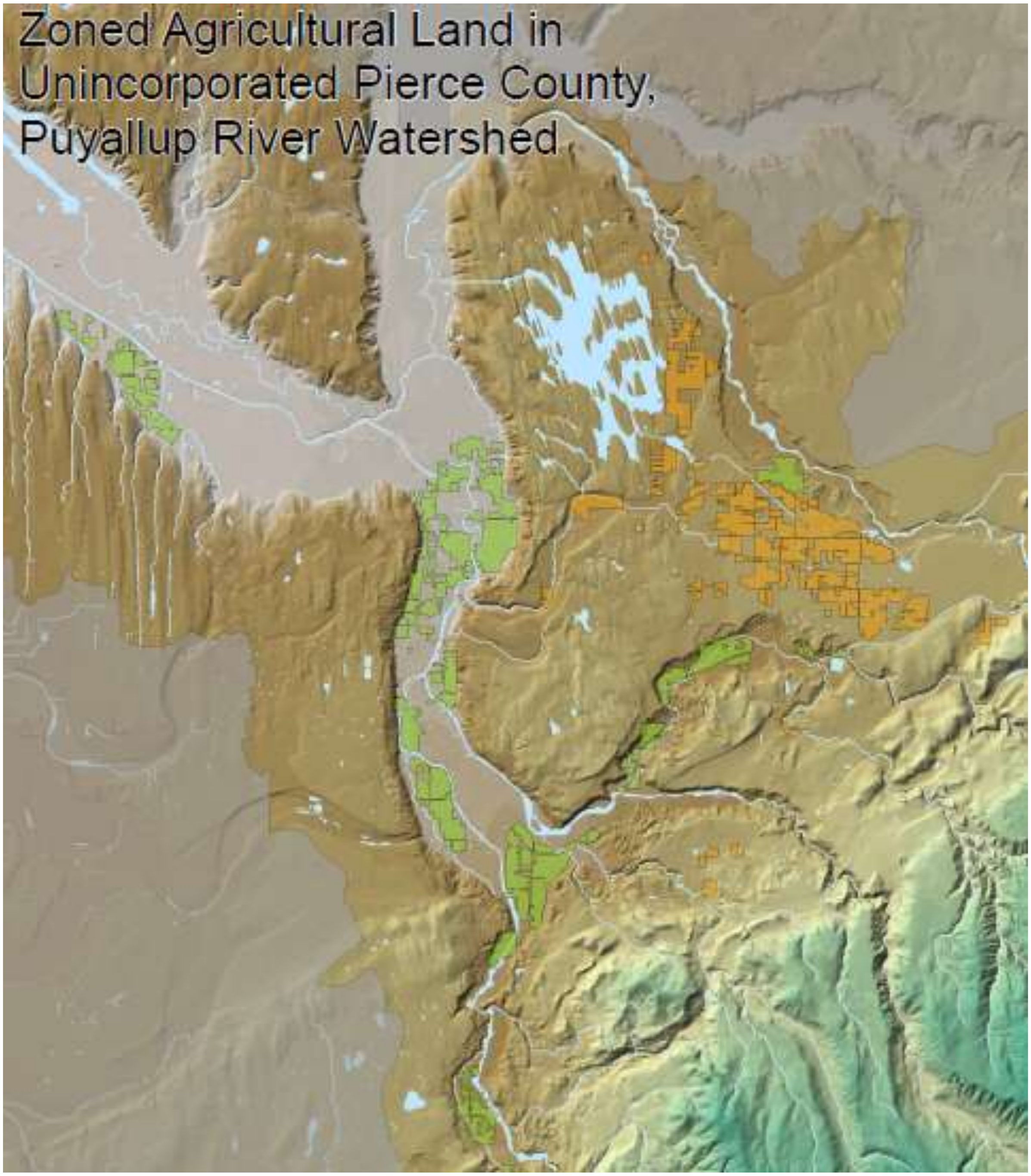


Figure 11.5 – Zoned Agricultural Lands in the Puyallup watershed (green = valley; orange = plateau)

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